MONITORING FINE SEDIMENT: GRANDE RONDE AND JOHN DAY RIVERS

Annual Report for 1999

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ABSTRACT

Fine sediment in spawning substrate has a major effect on salmon survival from egg to smolt. Basin-wide restoration plans have established targets for fine sediment levels in spawning habitat. The project was initiated to monitor surface fine sediment levels and overwinter intrusion of fine sediment in spring chinook salmon spawning habitat in the North Fork John Day (NFJDR) and Grande Ronde Rivers, for five years. The project is also investigating the potential relationship between surface fine levels and overwinter sedimentation. It will provide data to assess trends in substrate conditions in monitored reaches and whether trends are consistent with efforts to improve salmon habitat conditions. The data on the magnitude of overwinter sedimentation will also be used to estimate salmon survival from egg to emergence.

In September 1998 and 1999, sites for monitoring overwinter sedimentation in clean gravels were established in spawning habitat in the upper Grande Ronde River, Catherine Creek (a tributary to the Grande Ronde), the NFJDR, and Granite Creek (a tributary to the NFJDR). Surface fine sediment levels were measured in these reaches via the grid method and visually estimated to test the relative accuracy of these two methods for characterizing fine sediment levels. In 1999, pebble counts were also conducted in selected reaches concurrent with the grid method and visual estimates of surface fine sediment to assess the relative accuracy of the three methods. Substrate samples were collected in 1998 to estimate the amount of overwinter sedimentation in clean gravels in spawning habitat. Monitoring methods and locations are described.

Results from monitoring in previous years indicate that visual estimates of surface fine sediment levels are not biased and provide an accurate estimate of measured levels of surface fine sediment. The linear regression line through plot of data of visually estimated versus measured surface fine sediment had a slope of 1.0, and a standard error of 5.0%, and was statistically significant ($R^2 = 0.92$; $p < 0.01$) (Rhodes and Purser, 1998). Monitoring in 1998 and 1999 yielded similar results: the relationship between visually estimated and measured surface fine sediment levels was statistically significant at $p < 0.01$, but with a higher standard error (5.4-6.3%) and more variability ($R^2 = 0.71$-0.73) than in previous years. Therefore, we can recommend using visual estimates of surface fine sediments by trained observers in situations where extensive data is needed and time, effort, and expense are significant limitations. The grid method provides greater accuracy and is more amenable to statistical analysis, while not requiring substantially greater investments of time and effort.

Our data and analysis indicates that pebble counts are relatively insensitive to detecting differences in surface fine sediment levels among sites or over time. This result is consistent with other assessments of the accuracy of estimates of fine sediment conditions derived from pebble counts (Nelson et al., 1996; 1997). Pebble counts also require much more time and effort for data collection and analysis than the other two methods evaluated. For these reasons, we recommend using methods other than pebble counts for

monitoring surface fine sediment levels as part of assessments of the effects of land management on substrate conditions and/or salmonid survival.

Mean surface fine sediment levels in 1998 in the monitored reaches of the Grande Ronde were higher than the <20% surface fine sediment goal set in CRITFC (1995) and NMFS (1995), although this is not statistically significant at $p < 0.10$. However, at $p = 0.15$, the hypothesis that surface sediment levels in the Grande Ronde River were > 20% can be accepted as true. In 1998, it was also uncertain that the substrate goals of surface fine sediment < 20% were met in the NFJDR, using a statistical significance level of $p < 0.10$. At this same level of statistical significance, it can be accepted that the substrate goals are met in the monitored reaches of Catherine and Granite Creeks in 1998 and 1999.

In 1999, at $p < 0.10$, it can be accepted that the < 20% surface fine sediment substrate goal was met in the Grande Ronde River and not met in the NFJDR in monitored reaches. From 1998 to 1999 the decrease in surface fine sediment in the Grande Ronde River and increase in the NFJDR were statistically significant ($p < 0.10$). At this same level of statistical significance, it can be accepted that the substrate goals were met in the monitored reaches of Catherine and Granite Creeks in 1998 and 1999. There were no statistically significant changes in surface fine sediment levels in Catherine and Granite Creeks from 1998 to 1999.

Mean fine sediment levels in Catherine Creek were the lowest among the four study streams in 1998 and 1999; these differences were statistically significant ($p < 0.1$). In 1998, mean surface fines levels in the Grande Ronde were higher than in Granite Creek, in a statistically significant manner ($p < 0.1$), but not in the NFJDR. Differences between mean surface fine sediment levels in the NFJDR and Granite Creek were not statistically significant at $p < 0.10$ in Sept. 1998.

In Sept. 1999, mean surface fines were higher in the NFJDR than in all three other study streams; these differences were statistically significant ($p < 0.10$). In Sept. 1999, the differences between mean surface fine sediment levels in the Grande Ronde River and Granite Creek were not statistically significant at $p < 0.10$.

Bulk samples of substrate collected in Sept. 1998 indicate that fine sediment levels (percent by weight) at depth were generally higher than the amount of surface fine sediment, as is typical in many streams. Initial results indicate that surface fine sediment levels, both measured and estimated, are related to fine sediment conditions at depth in a statistically significant fashion. However, the apparent statistical significance may be an artifice of small sample numbers and/or inappropriately lumping samples from four streams into a single analysis population.

Samples collected in Dec. 1998 indicate that significant sedimentation occurs early in the incubation period for spring chinook salmon in the Grande Ronde and Catherine Creek. Although small sample numbers preclude a statistical assessment, the magnitude of overwinter sedimentation from Sept.-Dec. 1998 was higher in the Grande Ronde where surface fine sediment was higher than in Catherine Creek where mean surface fine sediment was lower.

Samples collected in April 1999 indicate that overwinter sedimentation consistently occurs in clean gravels in environments mimicking salmon redds in the Grande Ronde and Granite Creek. Due to delays caused by the large volume of sample containers, the collected samples from streams other than the Grande Ronde and Granite Creek have not been completely analyzed for particle sizes by weight with quality assurance/control. The mean amount of overwinter sedimentation in the Grande Ronde was higher than in Granite Creek and this difference was statistically significant ($p < 0.10$) for two of the three size fractions analyzed. Although limited sample numbers preclude statistical assessment, overwinter sedimentation in 1998-1999 was greatest in the Grande Ronde where mean surface fine sediment was higher, in a statistically significant manner ($p < 0.10$), than in Granite Creek. These results are consistent with those previously documented by Rhodes and Purser (1998) in the study streams.

The summary of the findings from monitoring in previous years (Rhodes and Purser, 1998) has now been published in a peer-reviewed conference proceedings. An overview of those findings is provided.

INTRODUCTION

Fine sediment levels in spawning substrate have a major effect on salmon survival from egg to smolt (Bjornn and Reiser, 1991). Assessments have consistently concluded that fine sediment is a major problem for salmon in the Grande Ronde (Anderson et al., 1993; NMFS, 1993; Huntington, 1994; Mobrand et al., 1995) and, to a lesser extent, the John Day rivers (OWRD, 1986). It is likely that fine sediment levels in these rivers must be reduced if salmon survival from egg to smolt is to be increased. The NMFS Biological Opinion (NMFS, 1995) for the USFS Land and Resource Management Plans (LRMPs) and the salmon recovery plan of Columbia River basin Treaty Tribes (CRITFC, 1995) both set goals for surface fine sediment in spawning habitat at <20%. The NPPC's (1994) recovery plan sets a goal of <20% fine sediments in salmon redds. However, despite these goals for fine sediment and the documented sediment-related problems, baseline and trends in surface fine sediment are not being monitored in these rivers. This project was initiated, with funding from the Bonneville Power Administration in 1998, to monitor surface fine sediment levels and overwinter intrusion of fine sediment into cleaned gravels in artificially constructed redds in spawning habitat. The project is also investigating the potential relationship between surface fine levels and overwinter sedimentation in cleaned gravel, possibly resulting in a more cost-effective monitoring tool than coring or other extractive, bulk substrate sampling methods.

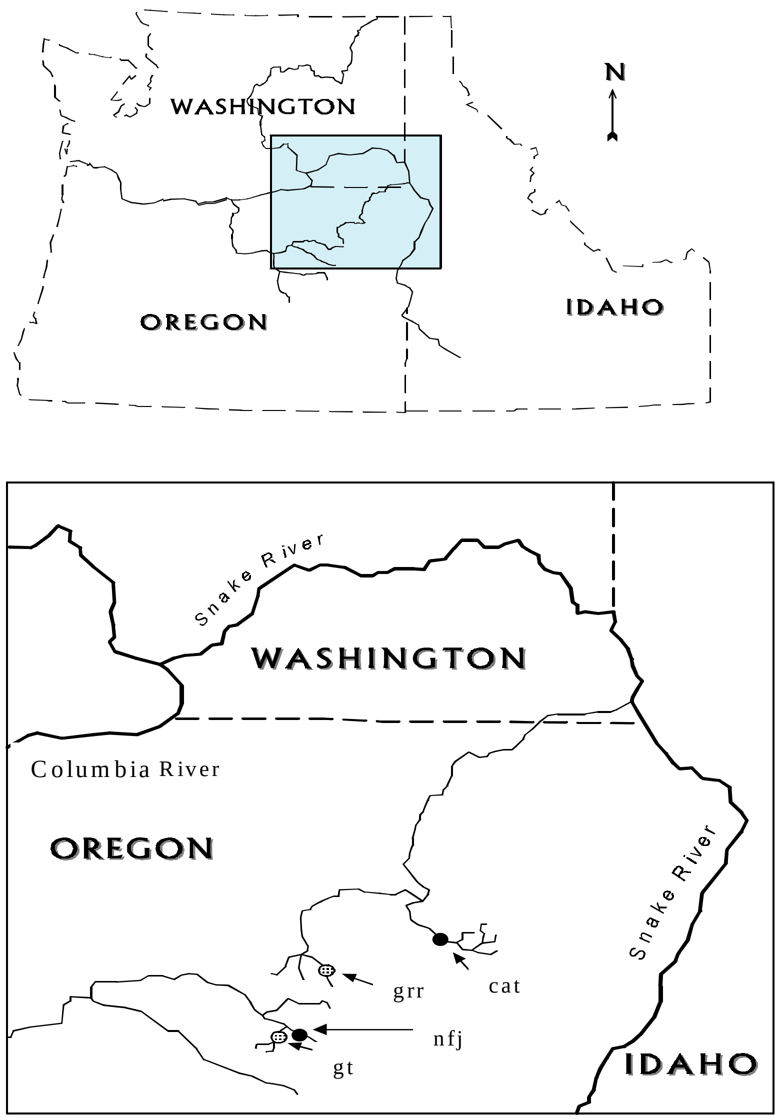
For five years, the project will annually measure surface fines and overwinter sedimentation during the incubation period in spawning gravels in the John Day and Grande Ronde Rivers. This will allow assessment of the following: 1) whether there is a trend in substrate conditions in spawning habitat in monitored reaches, and if so, whether it is consistent with efforts to reduce sedimentation and improve habitat conditions; 2) whether there is a relationship between levels of mobile surface fine sediment and the magnitude of fine sediment intrusion into cleaned spawning gravels; 3) whether substrate conditions and trends are in keeping with the quantitative substrate objectives of regional approaches to habitat restoration and protection (NPPC, 1994; NMFS; 1995; CRITFC, 1995).

The proposal will also test the following additional hypotheses: 1) the aggregate effectiveness of land management is adequate to meet fine sediment/substrate goals, prevent degradation of substrate conditions, and allow improvement in substrate conditions; 2) overwinter sedimentation in salmon redds is not occurring at magnitudes that reduce salmon survival; 3) watersheds with differing magnitudes of land disturbance, such as logging and road construction, do not have significantly different levels of surface fine sediment nor significantly different levels of overwinter sedimentation in cleaned gravels in spawning habitat; 4) temporal trends in surface fine sediment levels and the magnitude of overwinter sedimentation are not significantly different in watersheds with differing levels of land disturbance. Additionally, the project will also quantify the magnitude of overwinter sedimentation in cleaned gravels and use this data to estimate salmon survival from egg to emergence.

DESCRIPTION OF PROJECT AREA

The study reaches are in spawning habitat for spring chinook salmon in the Grande Ronde River, Catherine Creek (a Grande Ronde River tributary), the North Fork John Day River (NFJDR) and Granite Creek (tributary to the NFJDR). The general locations of the monitored streams and the study areas are shown in Figure 1.

Figure 1 General location of monitored reaches. Codes are as follows: grr = Grande Ronde River; cat = Catherine Cr.; nfj = NFJDR; gt = Granite Cr**.**



The area of Grande Ronde River watershed above the monitoring locations is about 90 km^2 and ranges in elevation from about 1200 m to 2400 m. The watershed is predominantly forested with mixed conifers. Soils are primarily derived from granitic parent materials. Snow is the dominant form of precipitation and spring snowmelt comprises the bulk of the annual hydrograph. The watershed of the upper Grande Ronde River has been extensively grazed, logged, and roaded over the past 30 years (Anderson et al., 1993; McIntosh et al., 1994). Portions of the floodplain and river were dredge-mined, in the early 1900s (McIntosh et al., 1994). Parts of the watershed have been burned by wildfire over the past 10 years; flash floods from thunderstorms have also affected spawning and rearing areas. Most of the watershed above the sampling areas is on the Wallowa-Whitman National Forest (WWNF).

The monitoring sites for surface fine sediment and overwinter sedimentation in the Grande Ronde River are located upstream of the decommissioned Woodley Creek Campground to the west of USFS Road 5125 on the WWNF. The latitude and longitude, as measured using a global positioning system (gps) unit, of the 1998 and 1999 monitored transects within the study reaches in the upper Grande Ronde River are shown in Tables 1, 2, 3, and 4.

The watersheds of the other three streams monitored are broadly similar to the Grande Ronde with respect to vegetation, geology, and climate. However, the ownership patterns, watershed area, and intensity of land use vary among watersheds.

The watershed area of Catherine Creek, above the most downstream monitoring site, is about 240 km^2. Much of the Catherine Creek watershed is within wilderness. Most of the watershed is grazed. Outside of the wilderness, the watershed has been logged and roaded but to a lesser extent than the Grande Ronde River watershed. Most of the watershed is on the WWNF. The most downstream monitoring sites on Catherine Creek are located to the east of state highway 203 at a latitude of 45^o 7.92’ N and longitude of 117^o 42.49’ W, as measured with a gps unit in 1999. The most upstream monitoring sites are on the North Fork, upstream of the confluence of the South Fork of Catherine Creek, south of USFS Road 7785. The locations of the 1998 and 1999 monitoring sites are shown in Tables 1, 2, 3, and 4.

The watershed area of the NFJDR above the most downstream monitoring site is approximately 80 km^2. Most of this watershed area is on the WWNF. The watershed has been extensively logged. Most of the watershed is also grazed by livestock. Some sections of floodplains and the stream have been intensively altered by gravel spoils from historic dredge mining. The most downstream monitoring site is to the south of county road 73, on the WWNF, about 0.8 km east of the junction of county road 73 and county road 52. The most upstream sites are also on the WWNF, south of county road 73, about 1.5 km east of the junction of county road 73 and county road 52. The locations of the 1998 and 1999 monitoring sites are shown in Tables 1, 2, 3, and 4.

The watershed area of Granite Creek, above the most downstream monitoring site, is approximately 200 km^2. The watershed of Granite Creek has been extensively roaded and logged. Dredge mining has intensively altered significant portions of the floodplain and stream, including the areas flanking the monitoring sites. Most of the watershed is grazed. Ownership of the watershed is interspersed and includes private land, the WWNF, and the Umatilla National Forest (UNF). The most downstream monitoring site is on the UNF to the south of USFS Road 1035, approximately 1.2 km to the west of the junction with state highway 24. The most upstream monitoring sites are to the south of USFS Road 1035 approximately 0.8 km from the junction with state highway 24. The gps locations of the 1998 and 1999 monitoring sites are shown in Tables 1, 2, 3, and 4.

Table 1. Locations and site characteristics of areas excavated Sept. 5-6, 1998 to mimic redds for monitoring of overwinter sedimentation in clean gravels in containers. Site numbers with an asterisk (*) had 3 containers of cleaned gravels placed within the excavated redd site, with one bucket collected in Dec. 1998. Sites marked with a plus sign (+) had bulk substrate samples collected by shovel in Sept. 1998.

Stream	"Redd"	Latitude		Longitude		Wetted Channel Width	Water Column Depth	Visually estimated surface fine sediment	Notes/Site Description
	No.	degrees	min	degrees	min.	(m)	(m)	(%)	
Grande Ronde	GR1	45	4.28	118	18.82	6.0	0.15	37	Glide tailout downstream of pool @ river bend
Grande Ronde	GR2*+	45	4.18	118	18.83	10.2	0.13	40	Glide tailout below log weir ~200 m upstream of G1
Grande Ronde	GR3	45	4.12	118	18.79	9.9	0.20	10	Tailout below pocket pool
Grande Ronde	GR4*+	45	4.06	118	18.79	6.5	0.10	35	Glide tailout
Grande Ronde	GR5	45	3.99	118	18.8	10.4	0.12	30	Shallow glide tailout.
Catherine Cr.	C1	45	7.92	117	42.55	7.7	0.05	5	Glide tailout downstream of exclosure fence
Catherine Cr.	C2*+	45	7.92	117	42.55	7.7	0.05	5	Glide tailout downstream of exclosure fence
Catherine Cr.	C3*+	45	7.44	117	41.99	13.3	0.12	2	Glide tailout
Catherine Cr.	C4	45	7.48	117	38.78	9.7	0.10	7	Shallow glide tailout
Catherine Cr.	C5	45	7.48	117	41.99	1.2	0.10	7	Shallow glide tailout, ~3 m upstream of C4
NFJDR	N1	44	54.81	118	23.39	10.6	0.14	25	Glide tailout below overhanging LWD
NFJDR	N2	44	54.69	118	23.31	8.05	0.10	20	Glide tailout
NFJDR	N3	44	54.63	118	23.27	11.3	0.10	15	Shallow glide tailout at riffle transition
NFJDR	N4+	44	54.73	118	23.25	10.3	0.10	30	Shallow glide tailout near N. bank
NFJDR	N5	44	54.68	118	23.23	10.1	0.07	30	Shallow glide tailout near N. bank
Granite Cr	GT1	44	49.75	118	27.43	7.7	0.15	6	Glide tailout
Granite Cr	GT2	44	49.49	118	27.3	10.0	0.10	10	Glide tailout
Granite Cr	GT3++	44	49.5	118	27.24	9.6	0.10	10	Glide tailout
Granite Cr	GT4	none taken				7.5	0.13	8	Shallow glide tailout at riffle transition
Granite Cr	GT5	44	49.36	118	27.13	7.5	0.13	8	Shallow glide tailout at riffle transition

Table 2. Locations and site characteristics of areas excavated Sept. 5-6, 1999 to mimic redds for monitoring of overwinter sedimentation in containers of clean gravels. Site numbers with an asterisk (*) had 3 containers of cleaned gravels placed within the excavated redd site, with one bucket collected in Dec. 1999. Sites marked with a plus sign (+) had bulk substrate samples collected by shovel in Sept. 1999.

Stream	"Redd"	Latitude		Longitude		Wetted Channel Width	Water Column Depth	Visually estimated surface fine sediment	Notes/Site Description
	No.	degrees	min	degrees	min.	(m)	(m)	(%)	
Grande Ronde	GR1	45	4.17	118	18.85	4.5	0.20	18	Low sand levels; redistributed onto point bars
Grande Ronde	GR2*	45	4.15	118	18.84	7.2	0.20	18	3 buckets / Pool tailout
Grande Ronde	GR3	45	4.12	118	18.81	5.7	0.20	21.5	Inboard of root wad, downstream of log weir
Grande Ronde	GR4*+	45	4.01	118	18.78	4.5	0.12	20	Green marker flag on downed log on E. bank, blue flag on downed log on road side
Grande Ronde	GR5+	45	4.04	118	18.78	6.9	0.27	32.5	Pool tailout
Catherine Cr.	C1*+	45	7.92	117	42.49	12.0	0.10	4.5	Pool tailout
Catherine Cr.	C2	45	7.92	117	42.49	12.0	0.21	4.5	Significant bank damage from grazing in Hall Ranch near buckets. Pool tailout
Catherine Cr.	C3*+	45	7.45	117	41.98	13.0	1.70	2	Pool/glide tailout
Catherine Cr.	C4	45	7.22	117	38.79	6.5	0.18	5	Pool tailout
Catherine Cr.	C5	45	7.22	117	38.79	6.5	0.17	2	Pool tailout
NFJDR	N1+	44	54.74	118	23.38	11.9	0.20	21	Pool tailout, cobble-size surface armor
NFJDR	N2+	44	54.71	118	23.33	10.6	0.20	30	Pool tailout
NFJDR	N3	44	54.67	118	23.23	12.1	0.12	30	Pool tailout
NFJDR	N4+	44	54.67	118	23.2	12.2	0.15	25	Pool tailout
NFJDR	N5	44	54.67	118	23.19	11.9	0.20	30	Pool tailout
Granite Cr	GT1	44	49.59	118	27.42	9.5	0.11	6	Glide tailout
Granite Cr	GT2	44	49.59	118	27.42	10.0	0.10	6	Glide tailout
Granite Cr	GT3	44	49.55	118	27.34	9.5	0.15	10	Pool tailout
Granite Cr	GT4+	44	49.53	118	27.33	8.5	0.33	10	Pool tailout
Granite Cr	GT5	44	49.49	118	27.26	9.6	0.35	10	Pool tailout

Table 3. Locations and results of monitoring of surface fine sediment in Sept. 1998. For locations of constructed "redds" in Sept. 1998, see Table 1.

Stream	Transect	Latitude		Longitude		Wetted Channel Width	Visually estimated surface fine sediment	Mean measured surface fine sediment	Location relative to "redds"
	No.	degrees	min	degrees	min	(m)	(%)	(%)	all distances approximate
Grande Ronde	**1**	45	4.17	118	18.81	7.2	37%	42%	7 m upstream of GR1
Grande Ronde	**2**	45	4.15	118	18.82	6.0	40%	34%	12 m upstream of GR2
Grande Ronde	**3**	45	4.14	118	18.81	4.8	19%	19%	43 m upstream of GR2
Grande Ronde	**4**	45	4.08	118	18.76	10.8	13%	27%	22 m upstream of GR3
Grande Ronde	**5**	45	4.09	118	18.76	6.6	21%	20%	44 m downstream of GR4
Grande Ronde	**6**	45	4.03	118	18.77	9.0	45%	30%	10 m upstream of GR4
Grande Ronde	**7**	45	4.02	118	18.77	4.8	23%	10%	36 m upstream of GR4
Grande Ronde	**8**	45	4.02	118	18.8	4.2	23%	14%	54 m upstream of GR4
Grande Ronde	**9**	45	3.98	118	18.79	9.0	46%	43%	25 m upstream of GR5
Grande Ronde	**10**	45	4.01	118	18.79	9.0	23%	16%	85 m upstream of GR5
Catherine Cr.	**1**	45	7.9	117	42.49	7.8	3%	1%	27 m upstream C2
Catherine Cr.	**2**	45	7.89	117	42.49	6.0	3%	1%	37 m upstream from C2
Catherine Cr.	**3**	45	7.45	117	41.99	8.4	3%	1%	75 m upstream from C2
Catherine Cr.	**4**	45	7.4	117	41.99	7.2	1%	2%	10 m upstream from C3
Catherine Cr.	**5**	45	7.4	117	41.99	6.0	2%	1%	63 m upstream from C3
Catherine Cr.	**6**	45	7.17	117	39.09	12.6	2%	1%	4.5 km above C3; 200 m downstream of C4
Catherine Cr.	**7**	45	7.22	117	38.79	10.2	2%	2%	165m downstream of C4
Catherine Cr.	**8**	45	7.22	117	38.77	5.4	2%	7%	32m upstream of C4
Catherine Cr.	**9**	45	7.24	117	38.75	5.4	2%	1%	72m upstream of C5
Catherine Cr.	**10**	45	7.24	117	38.73	8.4	2%	2%	115m upstream of C5
NFJDR	**1**	gps battery down				10.8	20%	13%	5 m upstream of N1
NFJDR	**2**	gps battery down				11.4	17%	13%	25 m upstream of N1
NFJDR	**3**	gps battery down				7.8	15%	10%	20 m downstream of N2
NFJDR	**4**	gps battery down				8.4	20%	22%	14 m upstream of N2
NFJDR	**5**	gps battery down				9.6	15%	22%	75 m downstream of N3; pocket pool in transect
NFJDR	**6**	gps battery down				11.4	20%	17%	60 m downstream of N3
NFJDR	**7**	gps battery down				12	18%	21%	30 m downstream of N3
NFJDR	**8**	44	54.63	118	23.22	11.1	27%	31%	8 m downstream of N3
NFJDR	**9**	44	54.64	118	23.22	11.1	20%	16%	11 m downstream of N4
NFJDR	**10**	44	54.67	118	23.17	10.8	15%	4%	8 m upstream of N5
Granite Cr.	**1**	44	49.51	118	27.32	8.4	5%	6%	100 m upstream of GT1
Granite Cr.	**2**	44	49.5	118	27.31	9.6	25%	41%	210 m upstream of GT1; pocket pool in transect
Granite Cr.	**3**	44	49.49	118	27.3	7.2	17%	17%	2 m downstream of GT2; 240 m upstream of GT1
Granite Cr.	**4**	44	49.5	118	27.26	7.2	12%	9%	25 m downstream of GT3
Granite Cr.	**5**	44	49.5	118	27.26	7.2	8%	5%	3 m downstream of GT3
Granite Cr.	**6**	44	49.58	118	27.2	7.8	6%	1%	21 m upstream of GT3
Granite Cr.	**7**	44	49.42	118	27.19	6.2	8%	3%	150 m upstream of GT3
Granite Cr.	**8**	44	49.34	118	27.08	11.4	12%	17%	6 m upstream of GT4
Granite Cr.	**9**	44	49.34	118	27.08	9.0	8%	0%	3 m downstream of GT5
Granite Cr.	**10**	44	49.41	118	27.32	7.8	17%	13%	10 m upstream of GT5

Table 4. Locations and results of monitoring of surface fine sediment in Sept. 1999. Transect numbers marked with an asterisk (*) also had pebble counts performed. For locations of constructed "redds" in Sept. 1999, see Table 2.

Stream	Transect	Latitude		Longitude		Wetted Channel Width	Visually estimated surface fine sediment	Mean measured surface fine sediment	Location relative to "redds"
	No.	degrees	min	degrees	min	(m)	(%)	(%)	all distances approximate
Grande Ronde	**1**	45	4.16	118	18.84	7.2	10%	16%	10 m upstream of GR1
Grande Ronde	**2***	45	4.18	118	18.84	6.0	14%	11%	20 m upstream of GR1
Grande Ronde	**3**	45	4.14	118	18.81	4.8	11%	4%	60 m upstream of GR1, 25 m below GR3
Grande Ronde	**4***	45	4.15	118	18.77	10.8	26%	14%	2 m upstream of GR3
Grande Ronde	**5***	45	4.13	118	18.8	6.6	22%	5%	40 m upstream of GR3
Grande Ronde	**6**	45	4.11	118	18.79	9.0	21%	23%	50 m upstream of GR3
Grande Ronde	**7**	45	4.07	118	18.76	4.8	8%	7%	55 m upstream of GR3
Grande Ronde	**8***	45	4.07	118	18.77	4.2	9%	9%	60 m upstream of GR3, 10 m downstream of GR4
Grande Ronde	**9**	45	4.03	118	18.77	9.0	10%	6%	5m upstream of GR5
Grande Ronde	**10**	45	4.01	118	18.75	9.0	6%	6%	15 m upstream of GR5
Catherine Cr.	**1**	45	7.9	117	42.49	7.8	5%	9%	20 m upstream of C1
Catherine Cr.	**2**	45	7.89	117	42.49	6.0	1%	1%	30 m upstream of C1, 10 m upstream of SF1
Catherine Cr.	**3***	45	7.45	117	41.99	8.4	2%	1%	2 m upstream of C3
Catherine Cr.	**4**	45	7.4	117	41.99	7.2	2%	0%	20 m upstream of C3
Catherine Cr.	**5**	45	7.4	117	41.99	6.0	1%	0%	23 m upstream of C3
Catherine Cr.	**6**	45	7.17	117	39.09	12.6	3%	1%	200 m downstream of C4
Catherine Cr.	**7**	45	7.22	117	38.79	10.2	5%	1%	1 m downstream of C4
Catherine Cr.	**8**	45	7.22	117	38.77	5.4	2%	4%	25 m upstream of C5
Catherine Cr.	**9***	45	7.24	117	38.75	5.4	2%	0%	35 m upstream of C5
Catherine Cr.	**10***	45	7.24	117	38.73	8.4	1%	2%	40 m upstream of C5
NFJDR	**1**	44	54.73	118	23.39	10.8	25%	27%	5 m upstream of N1
NFJDR	**2**	44	54.4	118	23.4	11.4	25%	31%	10 m upstream of N1
NFJDR	**3**	44	54.68	118	23.23	7.8	22%	17%	30 m downstream of N3, 45 m upstream of N2
NFJDR	**4***	44	54.68	118	23.23	8.4	20%	14%	25 m downstream of N3
NFJDR	**5**	44	54.67	118	23.22	9.6	25%	32%	5 m downstream of N3
NFJDR	**6**	44	54.67	118	23.2	11.4	29%	27%	15 m downstream of N4, 10 m upstream of N3
NFJDR	**7**	44	54.67	118	23.19	12	34%	34%	5 m downstream of N 5, 5 m upstream of N4
NFJDR	**8***	44	54.67	118	23.17	11.1	30%	29%	15 m upstream of N5
NFJDR	**9**	44	54.68	118	23.15	11.1	35%	42%	25 m upstream of N5
NFJDR	**10***	44	54.68	118	23.15	10.8	19%	24%	30 m upstream of N5
Granite Cr.	**1**	44	49.59	118	27.42	8.4	8%	4%	2 m downstream of G1 & G2
Granite Cr.	**2**	44	49.59	118	27.41	9.6	6%	3%	6 m upstream of G1 & G2
Granite Cr.	**3**	44	49.55	118	27.34	7.2	5%	5%	6 m downstream of G3
Granite Cr.	**4**	44	49.55	118	27.34	7.2	9%	8%	3 m downstream of G3
Granite Cr.	**5***	44	49.54	118	27.33	7.2	9%	10%	4 m downstream of G4
Granite Cr.	**6**	44	49.53	118	27.34	7.8	8%	8%	5 m downstream of G4
Granite Cr.	**7***	44	49.52	118	27.31	6.2	15%	11%	10 m downstream of G5
Granite Cr.	**8***	44	49.5	118	27.27	11.4	22%	11%	5 m upstream of G5
Granite Cr.	**9**	44	49.5	118	27.26	9.0	16%	6%	25 m upstream of G5
Granite Cr.	**10**	44	49.6	118	27.26	7.8	17%	7%	30 m upstream of G5

METHODS AND MATERIALS

Previous monitoring: 1992-1995

Previous to the onset of the present, funded project, we monitored overwinter sedimentation of fine sediment and surface fine sediment in the Grande Ronde River, Catherine Creek, and NFJDR, during the incubation periods of 1992-1993, 1993-1994, and 1994-1995. Sample collectors were installed in artificial redds after salmon spawning in the fall, and collected after fry emergence. Overwinter sedimentation was monitored by placing cleaned gravels in solid-walled containers in spawning habitat in sites excavated to mimic the dimensions and attributes of salmon redds, based on the data in Bjornn and Reiser (1991). This method has been used successfully to monitor fine sediment accumulation in channel substrate in northern California (Lisle, 1989) and provides an indication of the ultimate sediment conditions in salmonid redds (Lisle and Eads, 1991). Lisle and Eads (1991) discuss the relative merits and precision of this method of sampling fine sediment accumulation. Solid-walled containers prohibit lateral infiltration of very fine sediment into cleaned gravels, and, therefore, the amount fine sediment collected in cleaned gravels solid-walled containers has been considered a minimum estimate of actual amounts (Lisle, 1989). Cleaned gravels typically have larger pores than ambient channel substrate, which tends to increase the depth and amount of infiltration by fine sediment (Lisle, 1989). Although Lisle and Eads (1991) suggested the method may approximate conditions in redds, it is not known to what extent the gravels placed in the containers deviate from those found in actual redds in the streams we monitored.

The solid-walled containers were tapered cylinders with an average diameter of 0.102 m and a height of 0.127 m. The "redds" were constructed in pool or glide tailouts in spawning habitat. The constructed redds had an average area of about 4 m^2 and were designed according to the dimensions described in Bjornn and Reiser (1991). Specialists trained in the identification of redds, provided additional advice on the location and construction of the artificial redds and confirmed that the geometry and size were within the range found in natural salmon redds in the Grande Ronde River (Jeff Zakel, Oregon Dept. of Fish and Wildlife, pers. comm.). Three to six artificial redds were constructed in each stream reach monitored. Gravels with diameters >6.3 mm were taken from the ambient substrate and randomly packed into the containers. Two solid-walled containers of cleaned gravels were emplaced in each constructed redds in the fall after the cessation of spawning and retrieved in the subsequent spring after salmon emergence. The tops of containers were placed about 30 mm below the channel bed surface with a surface layer of gravel over the containers; the containers were placed in locations within the constructed redd where egg centrums are typically encountered, according to Chapman (1988). However, the egg centrums of spring chinook are typically at depths ranging from 0.2-0.3 m (Chapman, 1988), while the deepest part of the containers was at a depth of about 0.16 m

Concurrent with placement of sample containers into substrate in the fall, the fraction of the streambed covered by fine sediment was visually estimated (Platts et al., 1983), in all monitored reaches during the placement and retrieval of samples. Bauer and Burton (1993) noted that ocular estimates of surface fine sediment can have significant observer bias. In the summer of 1995, we tested the accuracy and precision of the ocular estimates of the percent of the streambed covered by surface fine sediment against measurements of surface fine sediment by the "grid method" (Bauer and Burton 1993). The grid method entails placing a sample grid on the channel substrate at equidistant points along a transect across the stream reaches and counting the number of grid intersections that are directly over surface fine sediment and dividing by the total number of intersections to determine the fraction of the surface occupied by fine sediment. In each reach, where the grid method was employed, three to five transects were monitored and three to five measurements were taken across the stream at each transect. We found that visual estimates of the amount of the substrate surface occupied by fine sediment were relatively accurate and showed no consistent bias (Rhodes and Purser, 1998). The slope of the linear regression line through points of visually estimated versus measured surface fine sediment (%) by the grid method was 1.0 and the relationship was statistically significant using a t distribution to test for the significance of the regression slope ($R^2 = 0.92$; $p < 0.01$); the absolute standard error was 5.0% (Rhodes and Purser, 1998). Due to the accuracy and precision of the ocular estimates, we subsequently dropped measuring surface fine sediment in every monitored reach via the grid method. For the purpose of analysis, individual estimates of surface fine sediment (%) were combined and averaged for each river reach monitored because the mean represents a more areally-integrated descriptor of fine sediment conditions within the reach than individual estimates at the subreach/transect scale.

The solid-walled containers, placed in the substrate in the fall, were collected from the monitoring sites in the following spring, after spring chinook emergence. We used a particle diameter of <6.35 mm to define the fine sediment fraction detrimental to salmon survival, after Stowell et al. (1983), although, many descriptors of fine sediment sizes and distribution have been used by a variety of researchers to characterize substrate and effects on salmonid survival (Young et al., 1991). The percent by weight of overwinter sedimentation <6.35 mm in the collected containers was determined using standard particle size analysis methods.

In the Grande Ronde River, streamflow was continuously measured at a stream-gaging station near the sampling points for overwinter sedimentation near the decommissioned Woodley Campground. Stream width, stream gradient, and depth was measured using standard methods (Dunne and Leopold, 1978). All sampling locations were sketched into a schematic map of the monitored reaches.

Present Project: 1998-2000

The present project uses the same methods as in previous years, with minor modifications. To increase the accuracy and precision of measurements of overwinter sedimentation, we used larger containers than in previous years. The increased depth of the containers also ensured that the bottom of the containers were within the range of depths that egg centrums within natural redds are typically encountered, according to Chapman (1988) and Bjornn and Reiser (1991).

The solid-walled containers were tapered cylinders with a diameter of 0.18 m at the opening, a bottom diameter of 0.16 m, and a height of 0.185 m. The larger size container increases the individual sample volume by more than four times, relative to previous years.

Delays in project funding resulted in the project being initiated in Jan. 1998. This precluded sampling during the 1997-1998 incubation season for three reasons. First, sampling overwinter sedimentation could not be accurately measured by sampling over only a portion of the incubation period. Second, placing samplers into the stream channel mid-winter presented significant logistical problems and safety risks. Third, during higher winter flows, there was a risk of disturbing incubating eggs during sampling in the incubation season. For these reasons, the delays in project funding forced us to defer sampling until the fall of 1998.

To measure overwinter sedimentation, artificial “redds” were excavated Sept. 5-6, 1998 and Sept. 5-6, 1999. The tops of the sample containers were placed about 30 mm below the surface of the channel substrate, as in previous years. Five “redds” were excavated in each stream monitored. Two containers of cleaned gravel were buried in each “redd,” except for two “redds” each in the Grande Ronde River and Catherine Creek, which had three containers so that one could be collected during the winter to provide some indication of the rate of sedimentation during the incubation period. Catherine Creek and the Grande Ronde River are the only two streams among the four study streams that are reasonably accessible during the winter period. The four samples in these two streams were collected in early December 1998 and 1999. The samples collected in Dec. 1998 were analyzed using standard particle size analysis methods; the Dec. 1999 samples will be analyzed using the same methods.

The latitude and longitude of the constructed “redds” were estimated using a hand-held gps unit. The gps unit is estimated to have an error in horizontal accuracy that rarely exceeds 100 m (Magellan Systems, 1997). Based on repeated measurements of benchmarked sites over two years, we found that gps coordinates of specific sites appear to vary by up to about 0.07 minutes, or about 90 m. We used gps coordinates, field bench marks, and sketch maps to construct the "redds" in 1999 in the same locations as in 1998, to the extent possible. In cases where inter-annual channel change (e.g. the loss of a pool tailout) had made a location fail to meet the location criteria (e.g., typical spawning habitats as in Bjornn and Reiser (1991)), the site was moved to the most proximate location meeting the site criteria. Other methods related to the monitoring of overwinter sedimentation remained the same as in prior years.

In April 1999, the containers of cleaned gravels placed in the substrate in 1998 were collected. Sediment accumulations and the particle size of accumulated sediment within the containers of cleaned gravels were determined using standard particle size methods. The larger volume of the samples significantly increased the analysis time beyond the amount initially estimated. Currently, sample analysis together with quality assurance and control (QA/QC) has only been completed for the samples collected in Granite Creek and the Grande Ronde River in April 1999. The containers placed in the substrate in Sept. 1999 will be collected in April 2000. Salmon survival from egg to fry will be estimated from the fine sediment and overwinter sedimentation data via the methods of Stowell et al. (1983), the data of Scully and Petrosky (1991), and the data of Reiser and White (1988) and will be reported in a forthcoming report.

The results of the monitoring of overwinter sedimentation and surface fines will be investigated using regression analysis and a *t*-distribution to test the hypothesis that surface fines and the magnitude of overwinter sedimentation are related in a statistically significant fashion. This potential relationship will be investigated for two reasons: 1) it can be performed without any additional collection effort; and 2) to investigate whether monitoring of surface fines can be a useful surrogate for monitoring of bulk bed composition to estimate the effects of fine sediment on salmon survival. Bulk sampling of substrate is time-consuming (Grost et al., 1991). In contrast, surface fines within a reach can be measured using the grid method in approximately 25 minutes using five randomly spaced measurement points across three transects within a reach. Further, in order to estimate effects on redds during incubation via bulk sampling of substrate, repeated sampling and subsequent analysis is required (Lisle and Eads, 1991). Therefore, if there is a valid relationship between surface fines and intrusion levels in some streams, measuring surface fines alone may be adequate to assess relative trends in habitat condition and salmon survival at a fraction of the expense and effort related to repeated bulk substrate sampling.
While the method for determining the particle sizes in samples of overwinter sedimentation is unchanged, we are analyzing all samples of overwinter sedimentation and bulk substrate for the percent composition in four particle size classes, rather than just the percent by weight < 6.35 mm in diameter, as in previous years. The four size classes are: 1) diameter >6.35 mm; 2) diameter <6.35 mm; 3) diameter <2.0 mm; 4) diameter <0.85 mm. These size fractions are being analyzed to provide greater detail on sedimentation and to use the data of Reiser and White (1988) to estimate the survival of salmon from egg-to-fry, as well as the methods of Stowell et al (1983) and the data of Scully and Petrosky (1991).

Surface fines in the study reaches were monitored concurrent with excavation and construction of artificial redds and placement of sample containers in Sept. 1998 and 1999. In each stream reach monitored, the grid method was used at 10 transects across riffles at locations upstream of the sites for monitoring overwinter sedimentation. At each transect, five measurements were taken at equidistant points across the channel width. Surface fines at each transect were visually estimated by two independent observers prior to measurement by a third observer. To improve the accuracy of the grid counts, a below-water viewer was used for counting grid intersections. The latitude and longitude of transects where surface fines were measured, were recorded using a gps unit. All other methods for visually estimating and measuring surface fines via the grid method were as in previous years.

In Sept. 1999, we also used the pebble count method of Wolman (1954) to assess particle sizes at the surface of the channel substrate, concurrent with placement of sample containers in artifically-constructed "redds" and visual estimation and measurement of surface fines via the grid method. Pebble counts are often used to estimate the amount of surface fine sediment (e.g., Bauer and Burton, 1993; Clifton et al., 1999). The pebble counts were used to generate an additional measurement of the amount of surface fine sediment < 6.35 mm (Bauer and Burton, 1993) for comparison with the results of visual estimates and grid measurements. Pebble counts were taken at 4 transects in the Grande Ronde River where surface fine sediment was measured via the grid method and visually estimated. In the other three stream reaches monitored, pebble counts were taken at three transects where surface fine sediment was measured and estimated. The locations of the transects where pebble counts, grid measurements, and visual estimates of surface fines were made are shown in Table 4.

Bulk samples of substrate were collected in each stream concurrent with the placement of containers of cleaned gravels in artificial redds and monitoring of surface fine sediment. The bulk samples were collected to provide an indication of particle size distributions at depth, prior to the incubation period. Tables 1 and 2 include the locations where bulk samples were collected. The bulk samples were collected using the shovel method (Grost et al., 1991). Sampling bulk substrate by shovel in small streams, such as the ones we monitored (3-20 m wide), can be as accurate as other methods, but far less difficult and time-consuming (Grost et al., 1991). The bulk samples were analyzed using standard particle size methods.

The results of surface fine measurements and visual estimates were analyzed via linear regression and *t*-distribution to perform a one-tailed test of the hypothesis that they are related in a statistically significant fashion. Confidence intervals generated at given probability levels were used to test whether it appears that the surface fine sediment goals of CRITFC (1994) and NMFS (1995) are met, based on the measurements of surface fines in the monitored streams via the grid method. Both of these tests were made treating transect means of measured surface fines as a single sample. The same methods were used to test whether the sample means for surface fine sediment in the four rivers were different in a statistically significant manner.

With one exception, all the statistical and regression analyses results reported in this report were derived using the statistical, regression, and mathematical functions and tools in Excel. We found that in one case, this software generated obviously incorrect results (e.g., a negative R^2 value in the linear regression of pebble count with visual estimates of surface fine sediment with the Y-intercept of the linear regression line forced through 0). For this case, the regression results were generated via SYSSTAT. We spot-checked other statistical and regression results generated from Excel functions with those from SYSSTAT and other spreadsheet software, and they were in agreement, and appear to be without error. In the future, the veracity of these results will be completely cross-checked with other computerized statistical packages.

Variability within and among sample sites will also be analyzed in the future using standard statistical methods. Initial estimates of variability will be used to estimate the number of samples needed in future investigations to generate a given level of statistical significance at given probabilities of "type I and II" errors using standard statistical methods (Benjamin and Cornell, 1970).   Trend analysis will be analyzed via standard regression methods.

On the administrative end, a biological assessment (BA) of the project's effects was prepared for use in project consultation with NMFS under the Endangered Species Act (ESA) in 1998.   The BA was prepared using the same format and approach as the Catherine Creek Biological Assessment (La Grande Ranger District, 1994a) and the Upper Grande River Biological Assessment (La Grande Ranger District, 1994b). The project BA tiered to La Grande Ranger District (1994a; b) and described potential project effects within the context of project actions, information on the study streams, and scientific literature related to possible effects. The project BA was submitted to BPA and NMFS in August 1998.

RESULTS AND DISCUSSION

Visual estimates and grid measurements of surface fine sediment: '98-99

The results of the grid measurements and visual estimates of surface fines in Sept. 1998 are shown in Tables 3 and 4 and in Figures 2, 3, and 4. Based on these results, we again found that visual estimates of the amount of the substrate surface occupied by fine sediment were relatively accurate and showed no consistent bias. For the 1998 data, the slope of the linear regression line through points of visually estimated versus measured surface fine sediment (%) by the grid method was 0.99 and the relationship was statistically significant ($p < 0.01$), using a *t*-distribution to test for whether the regression slope is positive. Table 5 and Figure 2 show the relationship of the measured and visually estimated percent surface fine data collected in 1998. Relative to the results of the 1995 data, the absolute standard error was higher at 6.3% and the R^2 (0.73) was considerably lower, indicating that visual estimates were not as accurate. Table 5 provides a comparison of the results of the analyses of measured and estimated surface fines in 1995 (Rhodes and Purser, 1998) and from Sept. 1998 and 1999. It is possible that visual estimates may not have been as accurate as in previous years due to the lack of calibration by trained observers. In 1995, the trained observers had consistently practiced and calibrated visual estimates for several years. In 1998, the observers had practiced and calibrated visual estimates to a much more limited degree over the previous two years. Other potential explanation are that the accuracy of measurements of surface fine sediment were improved by the use of the below-water viewer and/or that greater sample numbers better reflected variability in surface fine sediment conditions.

Figure 2. Measured and visually estimated surface fines in the four study streams, Sept. 1998 and linear regression line through data (n = 40). Vertical lines show standard error of Y estimate.

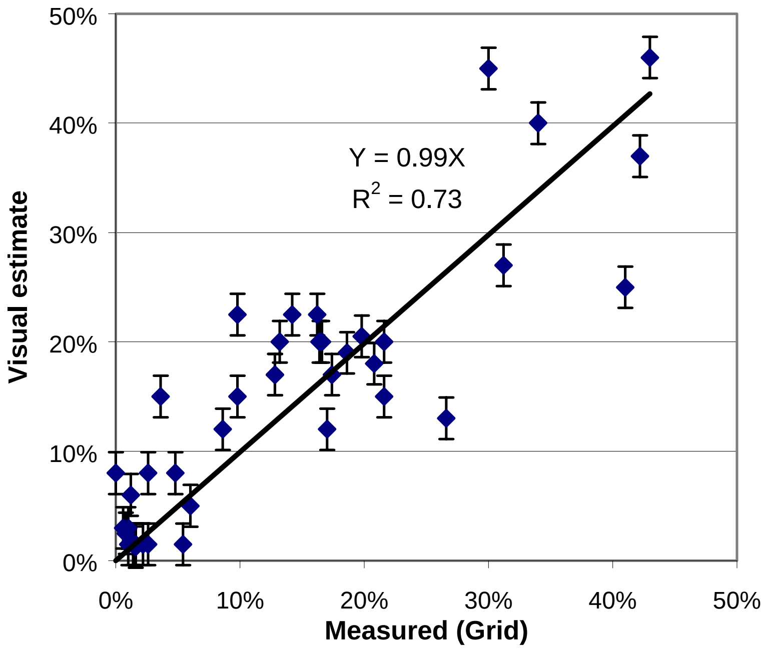


Figure 3. Measured and visually estimated surface fine sediment in the four study streams, Sept. 1999 and regression line through data (n = 40). Vertical lines through the data show standard error of Y estimate.

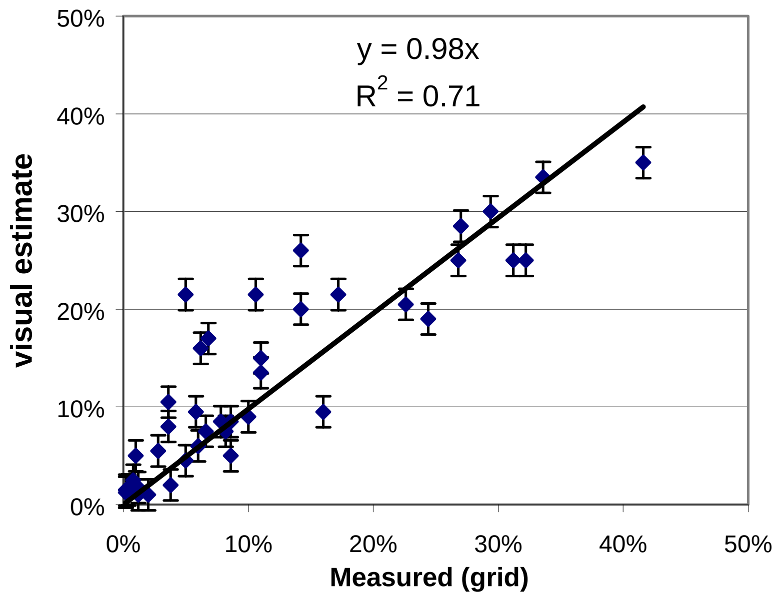


Figure 4. Measured and visually estimated surface fine sediment in the four study streams, Sept. 1998 and 1999 and regression line (n = 80) through combined data.

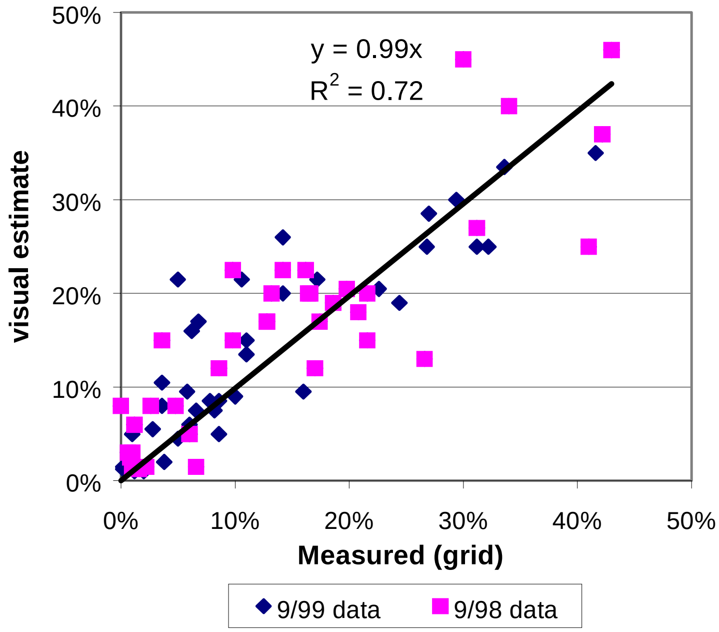


Table 5. Comparison of results of regression analysis of measured (grid method) and visually estimated percent surface fine sediment in Sept. 1995 (Rhodes and Purser, 1998), 1998, and 1999 at all surface fine transects in all four study streams. Measured percent surface fine sediment was treated as the independent variable in the analyses in both years. See also Figures 2, 3, and 4.

Attributes of analysis results	Year data collected			
	1995	1998	1999	'98-99 (combined)
Number of samples	14	40	40	80
Slope and relationship statistically significant?	Yes, $p < 0.01$	Yes, $p < 0.01$	Yes, $p < 0.01$	Yes, $p < 0.01$
R^2 value from linear regression analysis	0.92	0.73	0.71	0.72
Slope of regression line	1.0	0.99	0.98	0.99
Y-intercept	0.0	0.0	0.0	0.0
Std. error of Y estimate	5.0%	6.3%	5.4%	5.8%

Table 6. Summary statistics and results of the measured percent surface data collected by the grid method in Sept. 1998 by stream. A surface fine sediment level of < 20% is the substrate goal set in both CRITFC (1995) and NMFS (1995). For all four monitored streams, n = 10.

Stream	Mean	Std. dev.	CI at p = 0.10	Mean < 20% (p = 0.10)	Mean > 20% (p = 0.10)
Grande Ronde	25.4%	11.6%	6.0%	Possibly. No, at p = 0.15	Possibly. Yes, at p = 0.15
Catherine Cr.	1.8%	1.4%	0.7%	Yes	No
NFJDR	16.8%	7.6%	4.0%	Possibly. Yes, at p = 0.15	Possibly No at p = 0.15
Granite Cr.	11.1%	12.2%	6.3%	Yes	No

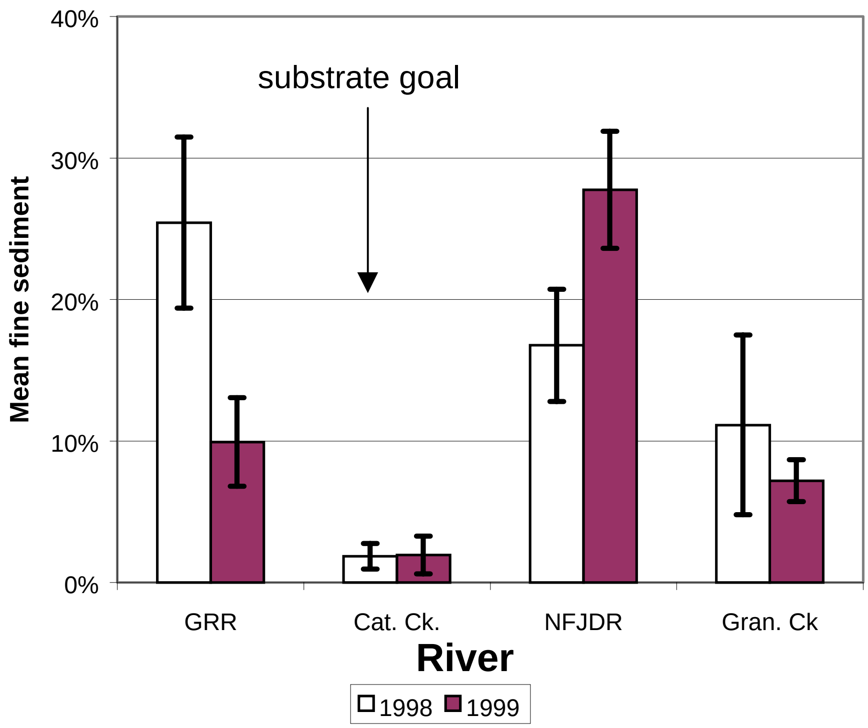
Table 7. Summary statistics and results of the measured percent surface data collected by the grid method in Sept. 1999 by stream. A surface fine sediment level of < 20% is the substrate goal set in both CRITFC (1995) and NMFS (1995). For all four monitored streams, n = 10.

Stream	Mean	Std. dev.	CI at p = 0.10	Mean < 20% (p = 0.10)	Mean > 20% (p = 0.10)
Grande Ronde	9.94%	6.02%	3.13%	Yes	No
Catherine Cr.	1.94%	2.57%	1.34%	Yes	No
NFJDR	27.76%	7.94%	4.13%	No	Yes
Granite Cr.	7.20%	2.86%	1.49%	Yes	No

The results of the surface fine sediment measurements from the grid method in 1998 (Table 6 and Figure 5) indicate that the mean fine sediment levels in the monitored reaches of the Grande River are higher than the <20% surface fine sediment goal set in CRITFC (1995) and NMFS (1995). However, at $p = 0.10$, the calculated confidence interval (CI) around the mean overlaps with the <20% surface fine sediment goal. Therefore, the hypothesis that mean fine sediment levels in the Grande Ronde are higher than 20% is not statistically significant at $p = 0.10$, using transect means as independent sample points. However, at $p = 0.15$, the hypothesis that surface sediment levels in the Grande Ronde River are > 20% can be accepted as true. Other results for the other sampled reaches in 1998 are shown in Table 6.

The results of the surface fine sediment measurements from the grid method in 1999 (Table 7 and Figure 5) indicate that the mean fine sediment levels in the monitored reaches of the NFJDR are higher than the <20% surface fine sediment goal ($p < 0.10$). Based on the grid measurements (Table 7) in 1999, the other three monitored stream reaches appear to meet the <20% surface fine sediment goal ($p < 0.10$).

Figure 5. Mean surface fine sediment (% < 6.35 mm) as measured by the grid method in monitored reaches in Sept. 1998 and 1999. Vertical lines through data show total size of confidence interval about the mean at p = 0.10.



There is a statistically significant difference in mean surface fine levels among some of the study streams in both 1998 and 1999 and between the years for some of the streams, as illustrated in Figure 5. In 1998, mean surface fine sediment levels in the Grande Ronde were higher than in Catherine and Granite Creeks; this difference was statistically significant ($p < 0.10$). Catherine Creek had lower levels of mean surface fines than the NFJDR and Granite Creek in Sept. 1998; these differences were statistically significant at $p < 0.10$. In Sept. 1998, the differences in mean surface fine sediment levels in the NFJDR and Grande Ronde River were not statistically significant at $p < 0.10$. Similarly, the differences between mean surface fine sediment levels in the NFJDR and Granite Creek were not statistically significant at $p < 0.10$ in Sept. 1998.

In Sept. 1999, mean surface fines were higher in the NFJDR than in all three other study streams; these differences were statistically significant ($p < 0.10$). Catherine Creek had lower levels of mean surface fines than the other three streams in Sept. 1999; these differences were also statistically significant at $p < 0.10$. In Sept. 1999, the differences between mean surface fine sediment levels in the Grande Ronde River and Granite Creek were not statistically significant at $p < 0.10$.

The differences in mean surface fine sediment between years was statistically significant ($p < 0.10$) in the Grande Ronde and the NFJDR, but not in Catherine and Granite Creeks (Figure 5). In the Grande Ronde substrate conditions improved, while they deteriorated in NFJDR in the study reaches from 1998-1999. Obviously, there is too little data at this point to assess whether the trend is statistically significant.

<u>Comparisons of Different Methods of Characterizing Surface Fines</u>

The complete results of the pebble count measurements are displayed in Appendix A in Figures A-1 to A-13. The results of the pebble counts method, grid method, and visual method for characterizing surface fines are shown in Table 8 for all surface fine sediment transects in all study streams where all three methods were used. The results of regression analysis of the relationship among the methods for determining the amount of surface fine sediment are shown in Table 9. The regression analyses were made using both regression-derived intercepts and an intercept of zero to analyze bias in the methods. Figures 6 and 7 display the relationship of pebble count results to those of the grid method and visual estimates.

Table 8. Results of three methods for characterizing the amount (%) of surface fine sediment in channel substrate with diameter < 6.35 mm. In the table, GR = Grande Ronde; C = Catherine Cr.; N = NFJDR; GT = Granite Cr.; SF = surface transect with numbers corresponding to the transects and locations in Table 4.

Surface fine transect identifier	Surface fine sediment (% < 6.35)		
	Mean measured (grid)	Visual estimate	Pebble count
GRSF2	11.0%	13.5%	21.3%
GRSF4	14.2%	26.0%	20.3%
GRSF5	5.0%	21.5%	22.4%
GRSF8	8.6%	8.5%	12.2%
CSF3	1.2%	1.8%	3.0%
CSF9	0.4%	1.5%	2.0%
CSF10	2.0%	1.0%	6.1%
NSF4	14.2%	20.0%	13.1%
NSF8	29.4%	30.0%	21.1%
NSF10	24.4%	19.0%	22.1%
GTSF5	10.0%	9.0%	16.0%
GTSF7	11.0%	15.0%	20.3%
GTSF8	10.6%	21.5%	24.3%

Based on the regression results, it appears that the visual estimates are more accurate than pebble count methods for estimating surface fines as measured by the grid method. The slope of the regression line for pebble counts vs. grid method results with a regression-derived intercept is significantly less than 1.0. This indicates that pebble counts tend to overestimate surface fines in locations where surface fines are low and underestimate surface fines where they are high, as measured by the grid method. Additional evidence of this bias is that the regression line through these points has an intercept of 9.3% (Table 9 and Figure 6). The R^2 for this regression is the lowest for any of the regression results from the analysis of the relationships among the three methods (Table 9). Forcing the regression line for pebble counts vs. grid method data through the origin results in a slope that is closer to 1.0, but increases the standard error to the highest value derived from any of the regression analyses summarized in Table 9. Although this regression results in the highest R^2 value of any of the analyses summarized in Table 9, this value is an artifice of forcing the regression line through the origin, and consequently closer to a single outlying point, rather than an indication of a relatively tight fit through the data (e.g. when the data from NSF 8 in Table 8 are omitted, the R^2 value is 0.14 for the regression analysis of pebble count vs. grid method data with a Y-intercept of zero).

Table 9. Results of regression analysis of 1999 surface sediment data collected by visual, grid, and pebble count methods at 13 transects (n=13) in the four study streams. See Table 4 for locations of transects where all three methods were used. Asterisk (*) denotes regression data generated from SYSTAT. All analyzed relationships are statistically significant at $p < 0.01$.

Dates	Y-Value	X-Value	R^2	Slope	Y-Intercept	Std. Error
1999	Pebble Count*	Mean Grid	0.79	1.13	0.0%	8.3%
1999	Pebble Count	Mean Grid	0.42	0.59	9.3%	6.2%
1999	Visual Estimate	Mean Grid	0.50	1.16	0.0%	6.8%
1999	Visual Estimate	Mean Grid	0.60	0.87	5.0%	6.3%
1999	Visual Estimate	Pebble Count	0.69	0.94	0.0%	5.4%
1999	Visual Estimate	Pebble Count	0.69	1.03	-1.7%	5.5%

Although the regression analysis indicates that visually estimated surface fines are not a completely accurate measure of surface fines as measured by the grid method, the visual estimates appear to be more accurate and less biased than pebble counts at the transects where all three methods were used. For instance, the 0.87 slope of the regression line for visually estimated vs. grid method data with a regression-derived intercept is closer to 1.0 than the 0.59 slope of line derived from a similar analysis of pebble counts vs. grid method data. Similarly, the regression-derived intercept of 5.0% for the regression line for visual estimates vs. grid method data is far closer to the zero, which is ideal, than the intercept of 9.3% derived from similar regression analysis of pebble counts and grid method data, indicating that visual estimates are a less biased estimator of surface fines as measured by the grid than pebble counts. With regression-derived Y-intercepts, visual estimates also result in a higher R^2 (0.60) for the regression with grid method data than pebble counts ($R^2 = 0.42$); the magnitude of the standard errors are similar (Table 9). With the regression line forced through the origin, the regression analyses result in a lower standard error (6.8%) for visual estimates vs. the grid method than pebble counts vs. the grid method (std. error = 8.3%). However, these same analyses indicate that visual estimates vs. the grid method have a lower R^2 value (0.50) and a regression line slope (1.16) that is farther from 1.0 than the regression line through the pebble count vs. grid method data with the intercept forced through the origin (Table 9). In aggregate, these regression analysis results indicate that the visual estimates are a more accurate estimator of surface fines as measured by the grid method than pebble counts.

Visual estimates and pebble count data for surface fines are more strongly correlated with each other than to the grid method data. Regression analysis indicates that with comparable Y-intercepts, the visual estimates vs. pebble count data has higher R^2 values, slopes closer to 1.0, lower standard errors, and a Y-intercept closer to zero, than data from either visual estimates or pebble counts vs. grid method data (Table 9).

All of the regression analyses summarized in Table 9 indicate that the slope of the regression lines are statistically significant at $p < 0.01$. Therefore, the null hypothesis (the slope of the regression line through the data = 0) can be rejected for all analyzed relationships among the data from the three methods.

Figure 6. Percent surface fines at 13 transects in study streams as estimated from pebble counts and measured by the grid method in Sept. 1999 and regression line through data. Vertical bars scaled to standard error of Y estimate.

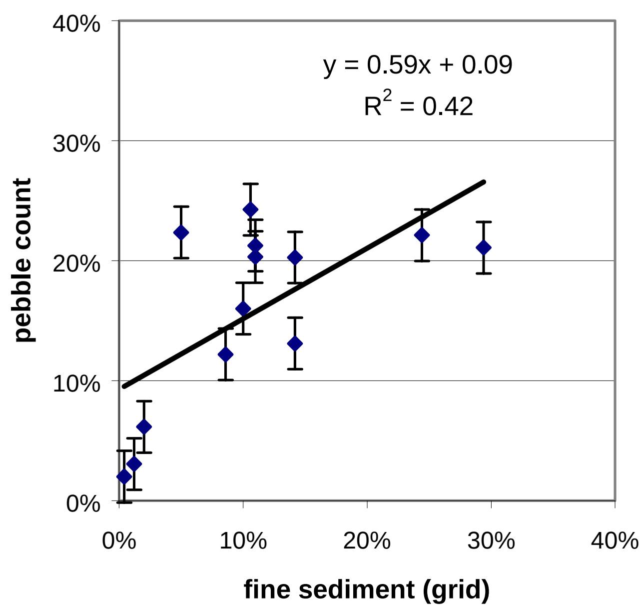
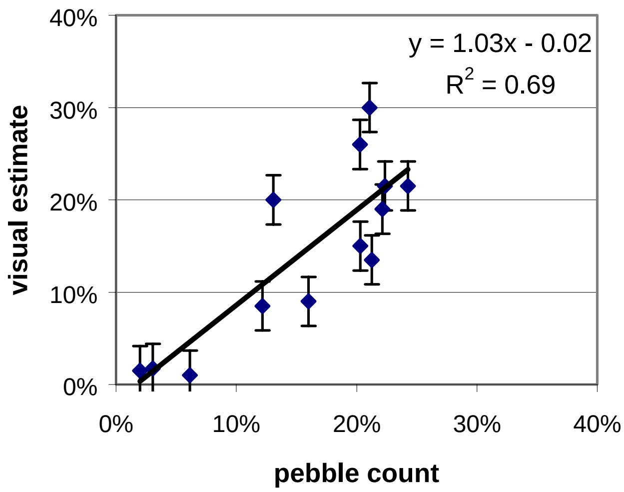


Figure 7. Percent surface fine sediment at the same 13 transects shown in Figure 6 in study streams as estimated via pebble counts and visual method in Sept. 1999 and regression line through the data. Vertical lines through data scaled to standard error of Y estimate.



We have assumed that the grid method is the most accurate measure of surface fine sediment levels for several reasons. First, it is based on measurement rather than visual estimates. Second, unlike pebble counts, it explicitly measures fine sediments < 6.35 mm at the surface of the substrate. In contrast, the amount of fine sediment at the surface as estimated by pebble counts, is based on interpolation, rather than direct measurement, which can reduce accuracy (Nelson et al., 1996; 1997). Third, it is well-documented that pebble counts tend to underestimate the amount of surface fine sediment for several reasons, including that it is difficult to sample finer particles between the interstices of larger particles (Bauer and Burton, 1993; Nelson et al. 1996). Fourth, accuracy typically increases with sample number. The grid method, as employed in this study, uses 500 sample points at a transect while the pebble count method typically uses only 100. However, the sample points in the grid method are clustered rather than widely distributed across a transect and may be affected by heterogeneity at the sampling scale, which may affect accuracy.

While the literature indicates that pebble counts tend to underestimate surface fine sediment, our results do not indicate this, uniformly. Based on our data, it appears that with respect to grid measurements, pebble counts tend to overestimate surface fine sediment at low values and underestimate at high values, albeit with considerable scatter. However, this indicates that pebble counts may be the most insensitive of the three methods for detecting shifts in fine sediment levels over time, which is a clearly undesirable trait in a monitoring technique.

The time required to evaluate surface fines varies considerably among the three methods. The field time required for measurement of surface fines at a transect via the grid method requires 10-20 minutes, while visual estimates by trained observers requires about 5 minutes, and pebble counts require 40-60 minutes depending on channel and stream conditions. The time needed for data entry and analysis also vary. For a single transect, visual estimates require no appreciable office time, while grid method data requires about 5 minutes and the pebble count data takes about 15 minutes to enter and evaluate, once spreadsheet algorithms for interpolation are in place.

Logistical considerations also vary among the methods. Visual estimates and the grid method require relatively high water clarity. The visual estimates also require relatively low surface turbulence. Both the grid method and pebble counts require traversing streams, which is unsafe at higher flows.

The methods also vary in potential outputs. Unlike the other two methods, the pebble count method can be used at the transect scale to estimate the median and geometric mean particle size of surface substrate, as well as the size of substrate at varying levels of the cumulative frequency distribution. Such information can used in evaluations of bed stability and channel sediment transport (Reid and Dunne, 1996). The pebble count can also be used to develop summary statistics on particle sizes, although it can not be used to develop variance estimates for smaller fractions, such as surface fine sediment. Notably, fine sediment fractions clearly have the greatest effect on salmonid survival (Rhodes et al., 1994) and are the size fraction most sensitive to land management effects (Young et al., 1991).

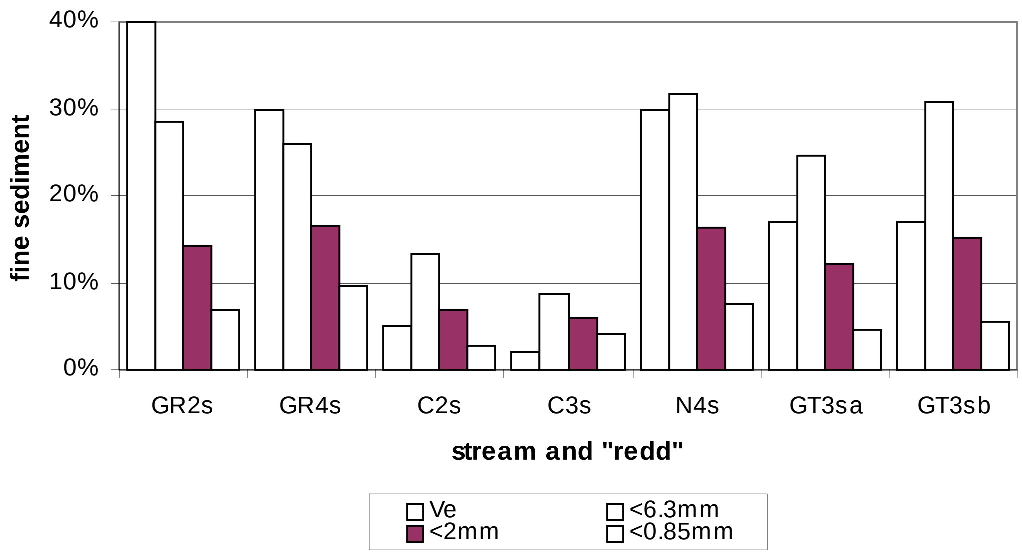
At the transect scale, the grid method data can be analyzed for estimates of central tendency and variance for surface fines, but not for other size fractions. It also provides an indication of how fine sediment levels vary across the channel at a transect, which the other two methods do not. Data from visual estimates cannot be used to generate estimates of central tendency or variance at the transect scale. Multiple observations by multiple observers can be used to examine observer bias and variation in estimation, but this does not provide an estimate of natural variation in surface fine sediment levels across the channel at the transect scale. However, visual estimates can be made at multiple transects within reaches or streams to allowing analysis of the central tendency and mean at the reach or stream scale. Further, visual estimates are integrative across a channel and may avoid errors associated with the point and clustered point sampling in pebble counts and the grid method.

Due to the pebble count method's apparent relative insensitivity to shifts in particle diameter over time and space, lower relative accuracy, and relatively high time requirements for collection and analysis, it appears to be the least desirable tool for monitoring surface fine sediments of the three used, based on our study results. Visual estimates by trained observers correlate well with data generated by both other methods and require nominal time investments. Where extensive measurements are needed in limited time and at limited expense, visual estimates of surface fines can be used where statistical variation at the transect scale is not the primary concern. However, we emphasize that if some degree of accuracy is to result from visual estimates, it must be done by trained observers with frequent calibration with measurements, as other experienced stream surveyors have repeatedly noted (C. Huntington, Principal Biologist, Clearwater BioStudies, Inc., pers. comm.) Where statistical analysis at the transect scale and accuracy are more important than logistical expediency, the grid method appears to be the preferred approach based on our data, especially since it does not require much greater field and analysis time than the visual estimates.

1998 Bulk Substrate Sampling and Mid-Winter Sedimentation Results

The results of the bulk substrate sampling in Sept. 1998 and the collection of containers of cleaned gravels in constructed "redds" in Dec. 1998 are shown in Table A-1 and Figures 8, 9, and 10. The amount of fine sediment by weight in bulk substrate samples from Sept. 1998 were generally higher than the levels of surface fine sediment as measured by the grid method or visually estimated (Table A-1 and Figure 4). This result corroborated field notes from Catherine Creek, NFJDR, and Granite Creek, where it was observed that fine sediment levels at depth were higher than at the surface (Table A-2). Such gradation in sediment sizes with depth is common in streams where the supply of fine sediment does not exceed the capacity of a stream to transport fine sediment (Richards, 1982). In the Grande Ronde River, surface fine sediment levels exceeded the amount of fine sediments by weight at depth, possibly indicating a surfeit of fine sediment supply with respect to transport capacity.

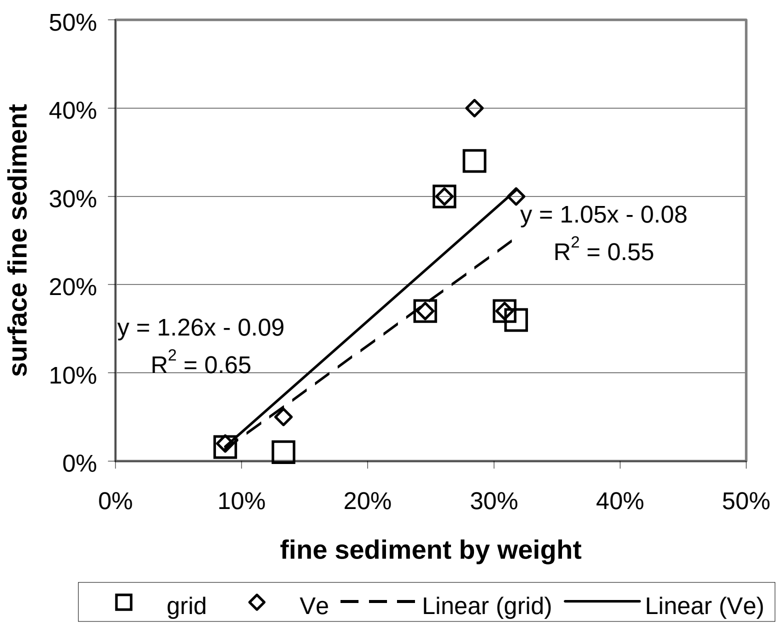
Figure 8. Visually estimated surface fine sediment levels and fine sediment by weight in bulk substrate samples collected at constructed "redds" in the four study streams in Sept. 1998. GR = Grande Ronde; C = Catherine Cr.; N = NFJDR; GT = Granite Creek. Numbers refer to enumerated "redds" (Table 1); "s" denotes samples collected by shovel; Ve = visual estimate of percent surface fine sediment at the location of the bulk sample. The three size fractions are all percent by weight.



Surface fine sediment levels measured both by the grid method and visually estimated were related, in a statistically significant fashion ($p < 0.01$), to the amount of fine sediment by weight with a diameter < 6.35 mm in the bulk samples collected by shovel. Visually estimated surface fine sediment exhibited greater correlation with the amount of fine sediment by weight < 6.35 mm in the bulk samples, than surface fines measured by the grid (Figure 9). However, this relationship is based on very few bulk samples collected in very few places in the four streams. The amount of fine sediment at depth typically exhibits considerable spatial variation (Everest et al., 1987). Increasing the sample number at a specific location probably would have increased the variance and scatter, although the two samples collected near "redd" GT3 in Granite Creek exhibited relatively little variation in the magnitude of the three size fractions (Table A-1 and Figure 9).

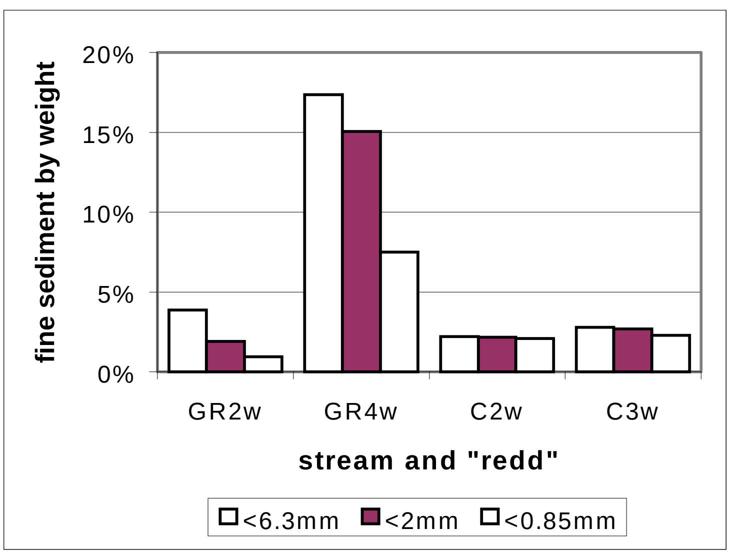
If there is a relationship between surface fine sediment and the amount of fine sediment at depth, it is likely to vary among streams (Nelson et al., 1996). The analysis in Figure 9 lumps all the data into a single population, which may not be merited. Nonetheless, Figure 9 provides an illustration of the results of concurrent monitoring of fine sediment at the surface and at depth in the study streams. We will continue to analyze these potential relationships in the future, as more data is collected.

Figure 9. Visually estimated and measured (grid) surface fine sediment and percent fine sediment by weight (< 6.35 mm) at locations where bulk substrate samples were collected by shovel in study streams in Sept. 1999 and regression lines through data. Measured surface fine sediment data is from site most proximate to bulk sample collection point.



The results of the mid-winter monitoring of sedimentation in containers of cleaned gravels in constructed "redds" indicates that sedimentation occurs early in the incubation period for spring chinook salmon eggs (Figure 10). In at least one case, the sedimentation is significant. In "redd" 4 in the upper Grande Ronde River (Figure 10), the container collected in Dec. 1998 had ~17% fine sediments by weight for the fraction < 6.35mm. This was as high as any of the samples collected later in April 1999 (Table A-2), indicating that the sample was already at capacity for fine sediments in the container, as field notes also indicated (Table A-1). Although fine sediment accumulation from Sept.-Dec. 1998 was variable between the two reaches and at the two sites in the Grande Ronde (Figure 10), it is clear that measurable overwinter sedimentation is occurring during this period. It also appears, based on the limited sample numbers, that the amount of overwinter sedimentation for the < 6.35mm fraction was higher from Sept.-Dec. 1998 in the Grande Ronde than in Catherine Creek (Figure 10). This may be related to the amount of mobile fine sediment at the substrate surface which can be transported and re-deposited, even at low stream discharge levels (Leopold, 1992; Booth and Jackson, 1997). The mean surface fine sediment measured via the grid method was 25.4% in the Grande Ronde River study reach and 1.8% in Catherine Creek. However, the limited sample numbers make it impossible to analyze the statistical significance and the apparent result may be due solely to the small sample size.

Figure 10. Percent by weight fine sediment for three size fractions in constructed redds in containers of cleaned gravels collected in Dec. 1998. GR = Grande Ronde; C = Catherine Creek; numbers refer "redds" as in Table 1; "w" denotes sample collected in winter. In Sept. 1998, mean measured surface fine sediment was at 25.4% in the Grande Ronde and 1.8% in Catherine Creek.



In Catherine Creek, sedimentation in containers in Dec. 1998 was almost solely comprised of fine sediment < 0.85 mm (Table A-1 and Figure 10). The fine sediments in the Grande Ronde samples a were more evenly distributed among the three size classes, but were primarily comprised of sediment < 2.0 mm (Table A-1 and Figure 10). Collection notes indicated no bridging or surface sealing by fine sediment in the upper layers of the samples in Dec. 1998. Other researchers have found that bridging or surface sealing from fine sediment occurs during the salmonid incubation period in northern California (Lisle, 1989) and Idaho (King et al., 1992; Maret et al., 1993).

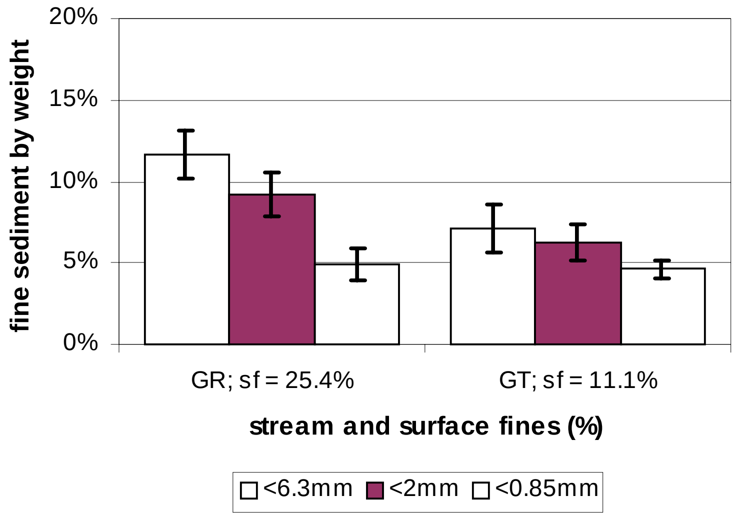
Overwinter sedimentation Sept. 1998-April 1999

The partial results of overwinter sedimentation in the four study streams indicate that overwinter sedimentation occurred consistently in all sites in the Grande Ronde and in all sites where samples were recovered in Granite Creek. Table A-2 displays the complete results for all recovered samples in these two streams, including notes from field collection. Figure 11 shows the mean values for the two streams for each of the three size fractions analyzed. In Granite Creek, we were unable to recover samples at two constructed redd sites. Both areas exhibited significant signs of channel change due to the high spring runoff caused by a deep snowpack with a relatively long return period. One of the sites where samples could not be recovered exhibited evidence of significant deposition, probably burying the samples deeply; the other site showed evidence of substantial scour, probably washing out the sample containers (Table A-2).

Although the results are only partial over the study area, the preliminary data indicate that mean overwinter sedimentation of fine sediment is higher in the Grande Ronde than in Granite Creek for some size fractions. Using a two-tailed test and the *t*-distribution, it can be accepted that the mean fraction by weight of Grande Ronde samples < 6.35 mm is greater than in Granite Creek with $p < 0.01$. Similarly, using the same distribution and test, it can be accepted that the Grande Ronde had a higher mean magnitude of sedimentation of particles < 2 mm than in Granite Creek at $p < 0.05$. For the fraction by weight of particle sizes < 0.85mm, the null hypothesis (means are the same) cannot be rejected at $p < 0.05$. Using a two-tailed *F*-test, the null hypotheses (variances are equal) cannot be rejected at $p < 0.10$ for the three size fractions analyzed. Therefore, the Grande Ronde samples had greater mean levels of sedimentation than Granite Creek for two of the three size fractions analyzed (see also Figure 11). This may be related to the amount of mobile fine sediment at the substrate surface which can be transported and re-distributed, even at low stream discharge levels (Leopold, 1992; Booth and Jackson, 1997). The mean surface fine sediment measured via the grid method in Sept. 1998 was 25.4% in the Grande Ronde River study reach and 11.4% in Granite Creek. While the differences in fine sediment accumulation are statistically significant, the relation to surface fine sediment levels is not, due to the paucity of data points. As we finalize the analysis of the 1998 overwinter samples, we will complete the analysis of the potential relationship of surface fine sediment to the magnitude of overwinter sedimentation.

Other researchers have found bridging or surface sealing of substrate by deposited fine sediments during salmonid incubation periods in streams in northern California (Lisle, 1989) and Idaho (King et al., 1992; Maret et al., 1993). However, we found no evidence of bridging or surface sealing in the overwintering containers collected in April 1999 in the Grande Ronde and Catherine and Granite Creeks. (See collection notes in Table A-2). Although samples in the NFJDR did not clearly exhibit bridging or surface sealing, fine sediment in the collected containers exhibited a clear gradation in particle size with depth. Fine sediment in the bottom of the NFJDR containers was obviously finer than the fine sediment at the surface of the containers, as recorded in the collection notes (Table A-2).

Figure 11. Mean percent fine sediment by weight for three size fractions of fine sediment in the Grande Ronde River (n = 10) and Granite Creek (n = 6) in samples collected April 1999. GR = Grande Ronde; GT = Granite Creek; "sf" = mean grid measured surface fine sediment in the streams in Sept. 1999. Vertical bars show magnitude of 90% confidence interval.



Any one or combination of the following phenomena could have caused the gradation in fine sediment size with depth in the NFJDR samples. First, fine sediment size fractions may be sequentially mobilized by flows of differing magnitude. Lower initial flows may transport silts and clays and deposit them at the base of the containers of cleaned gravels and higher flows later may transport sands with subsequent deposition above the finer deposited sediment. Second, differential settling of particle sizes within the containers may be occurring after initial deposition, causing a "sieving effect." Third, differential scour may be occurring in the upper layers of the containers, winnowing out the finest size fractions. Fourth, partial bridging may be occurring once larger sizes of fine sediment are deposited in the cleaned gravels under a sequential particle size transport regime.

<u>Other Results</u>

Consultation with NMFS on the projects potential effects on spring chinook salmon and their habitats was completed in Sept. 1998. NMFS concluded that the project was not likely to adversely affect the salmon or their habitats.

The summary of the findings from monitoring from 1992-1995 has now been published in a peer-reviewed conference proceeding (Rhodes and Purser, 1998). Results from (Rhodes and Purser, 1998) include the following. Fine sediment accumulation was highly variable, but occurred consistently, indicating that fine sediment is transported invariably during the winter incubation period for spring chinook salmon. The magnitude of sedimentation was related to surface fine sediment in a statistically significant fashion when data from all streams in all years were analyzed ($p < 0.01$); this was not the case in a single year among streams nor in the upper Grande Ronde River among all sampling years. Sedimentation was the highest in the upper Grande Ronde River where surface fine sediment levels were highest. The winnowing of fine sediment from redds by salmon is a transient condition in the monitored streams, especially where surface sediment is high. The magnitude of overwinter sedimentation collected in containers in constructed redds in the upper Grande Ronde River, was not related, in a statistically significant fashion, to stream discharge. In the upper Grande Ronde River, it appears that stream discharge or the availability of mobile fine sediment does not limit the magnitude of sedimentation during the incubation period. This may be because surface fine sediment levels are high and stream discharge regularly occurs at magnitudes that are adequate to transport fine sediment. It appears that overwinter sedimentation is reducing salmon survival-to-emergence in the study area and especially in the upper Grande Ronde River. Surface fine sediment appears to provide a statistically significant index of the susceptibility of redds to overwinter sedimentation in streams.

CONCLUSIONS

Analysis of data from 1998 and 1999 collected throughout the project area indicate that visual estimates of surface fine sediments by trained observers provide a rapid, but fairly accurate means of estimating surface fine sediment levels. Visual estimates show no significant bias when compared to measurements of surface fines via the grid method. In situations where accuracy and a greater degree of flexibility to perform statistical analysis is of more concern than time and effort, measurements via the grid method have distinct advantages.

As others have noted (Nelson et al., 1996; 1997), the estimates of surface fine sediment by pebble counts appear to have less accuracy than other methods, such as visual estimates or grid measurements. Our data analysis indicates that pebble counts are relatively insensitive to detecting differences in surface fine sediment levels among sites or over time. Pebble counts also require significantly more time and effort to collect data in the field and analyze in the office than the other two methods. The insensitivity of the method together with the time and effort requirements make pebble counts a poor choice for monitoring fine sediment conditions in substrate. For these reasons, we recommend that other methods for monitoring fine sediment should be used instead of the pebble counts, as others have recommended in evaluating the utility of various methods of monitoring fine sediment conditions in substrate (Nelson et al., 1996; 1997). This is especially important since fine sediments have consistently been shown to be the size fraction most deleterious to salmonid survival (Rhodes et al., 1994) and most affected by land management (Young et al., 1991). Notably, the pebble count method was not originally developed as a tool for monitoring fine sediments, but rather for characterizing the size of coarse bed, as the title of Wolman's (1954) paper attests.

Based on the analysis of 1998 data, it is uncertain that the substrate goals (surface fine sediment $< 20\%$) of CRITFC (1995) and NMFS (1995) were met in the Grande Ronde and John Day in the monitored reaches, using a statistical significance level of $p < 0.10$. At a lower level of statistical significance, ($p < 0.15$), the hypotheses can be accepted that the fine sediment substrate goal was met in the sampled reaches of the NFJDR and not met in sampled areas of the Grande Ronde River in 1998. In 1999, at $p < 0.10$ it can be accepted that the $< 20\%$ surface fine sediment substrate goal was met in the Grande Ronde River and not met in the NFJDR in monitored reaches. From 1998 to 1999 the decrease in surface fine sediment in the Grande Ronde River and increase in the NFJDR were statistically significant ($p < 0.10$). At this same level of statistical significance, it can be accepted that the substrate goals were met in the monitored reaches of Catherine and Granite Creeks in 1998 and 1999. There were no statistically significant changes in surface fine sediment levels in Catherine and Granite Creeks from 1998 to 1999.

Mean fine sediment levels in Catherine Creek were the lowest among the four study streams in 1998 and 1999; the differences between these levels in Catherine Creek and the other three study streams were statistically significant ($p < 0.1$). In 1998, mean surface fines levels in the Grande Ronde were higher than in Granite Creek, in a statistical manner ($p < 0.1$), but not in the NFJDR. Differences between mean surface fine sediment levels in the NFJDR and Granite Creek were not statistically significant at $p < 0.10$ in Sept. 1998.

In Sept. 1999, mean surface fines were higher in the NFJDR than in all three other study streams; these differences were statistically significant ($p < 0.10$). In Sept. 1999, the differences between mean surface fine sediment levels in the Grande Ronde River and Granite Creek were not statistically significant at $p < 0.10$.

Bulk samples of substrate in 1998 by shovel indicate that fine sediment levels at depth by weight were generally higher than the amount of surface fine sediment, as is typical in many streams. However, the initial results indicate that surface fine sediment levels, both measured and estimated, are related to fine sediment conditions at depth in a statistically significant fashion. This statistically significant relationship may be an artifice of small sample numbers and/or inappropriately lumping the samples from all four study streams into a single population for statistical analysis.

Samples collected in Dec. 1998 indicate that significant sedimentation occurs early in the incubation period in the Grande Ronde River and Catherine Creek. Although small sample numbers preclude a statistical assessment, the magnitude of overwinter sedimentation from Sept.-Dec. 1998 increased with increasing levels of surface fine sediment. The highest amount of sedimentation by fine sediment during this period occurred in the Grande Ronde where mean surface fine sediment measured by the grid method was 25.4%, in comparison to 1.8% mean surface fine sediment in Catherine Creek.

Samples collected in April 1999 indicate that overwinter sedimentation consistently occurs in clean gravels in environments mimicking salmon redds in the Grande Ronde River and Granite Creek. The mean amount of overwinter sedimentation in the Grande Ronde River was higher than in Granite Creek and this difference was statistically significant ($p <0.10$) for two of the three size fractions analyzed. Although limited sample numbers preclude statistical assessment, overwinter sedimentation in 1998-1999 was greatest in the Grande Ronde where mean surface fine sediment (25.4%) was higher, in a statistically significant manner ($p < 0.10$), than in Granite Creek (11.4%). These results are consistent with those previously documented by Rhodes and Purser (1998) in the study streams from 1992-1995.

Consistent with statistical considerations and the results of most studies, increased sample numbers would have improved the resolution of the results. Although we will attempt to increase the number of sampling points for surface fine sediment levels in the forthcoming year, this attempt will have to be tempered by budgetary considerations. Collection of pebble count data together with the increased expense of analyzing larger volumes of overwinter sediment samples have seriously stressed the annual project budget. We may not be able to increase sampling effort in <u>any</u> aspect of the project without significantly increasing the annual budget. In the near future, we will use the results of the project to date to provide estimates of the increases in budget required to increase sampling efforts.

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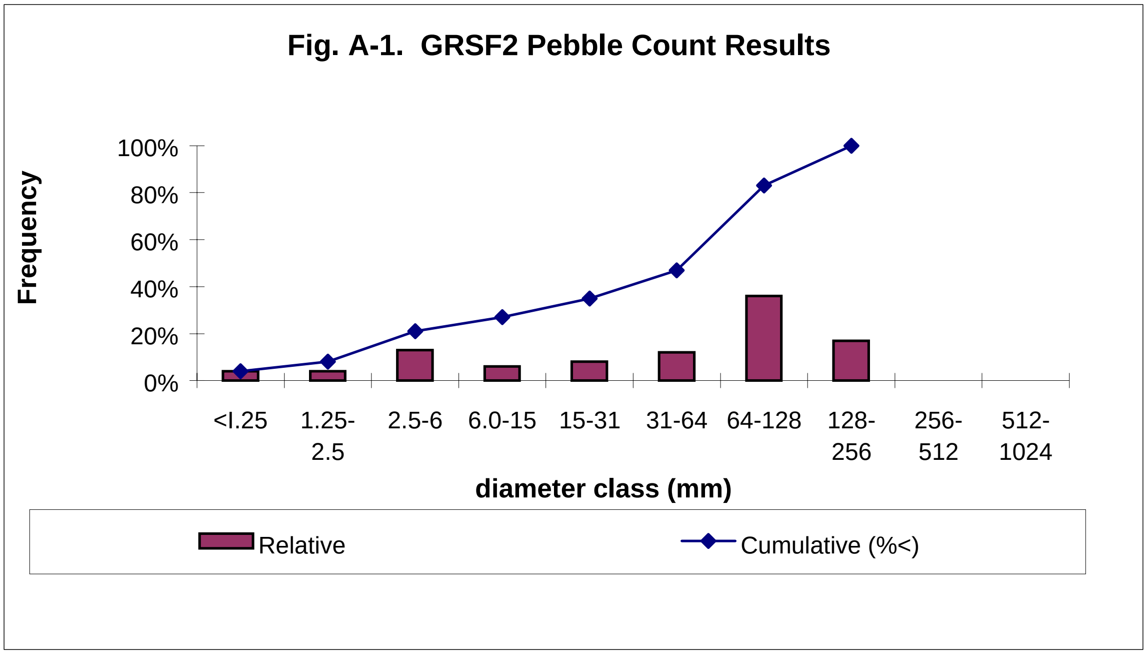
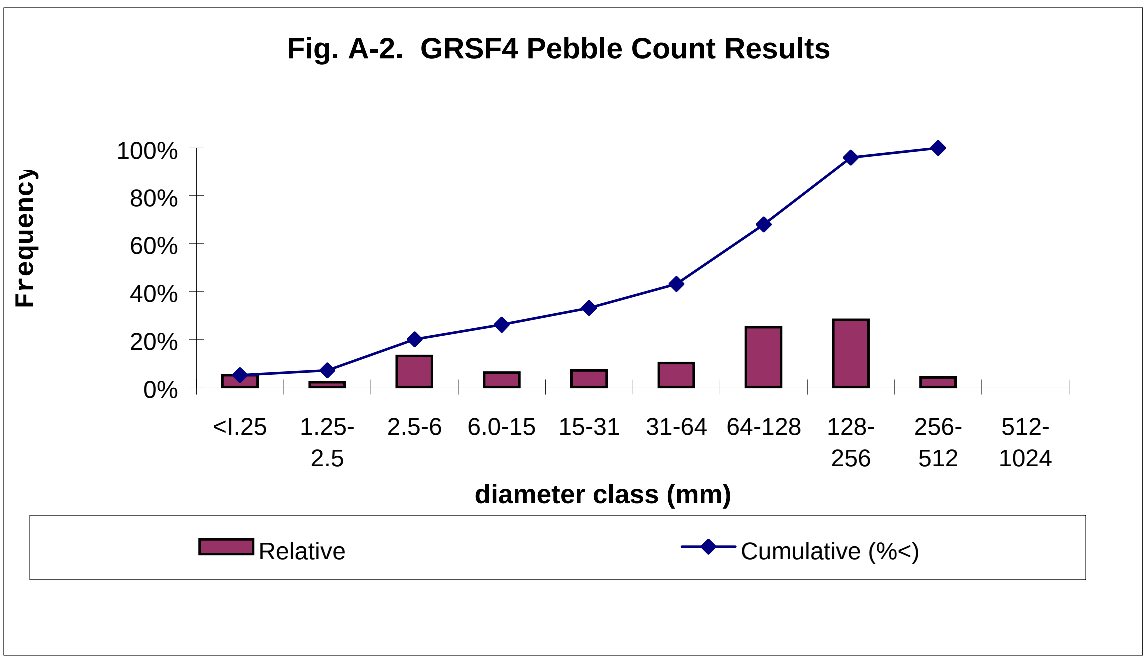
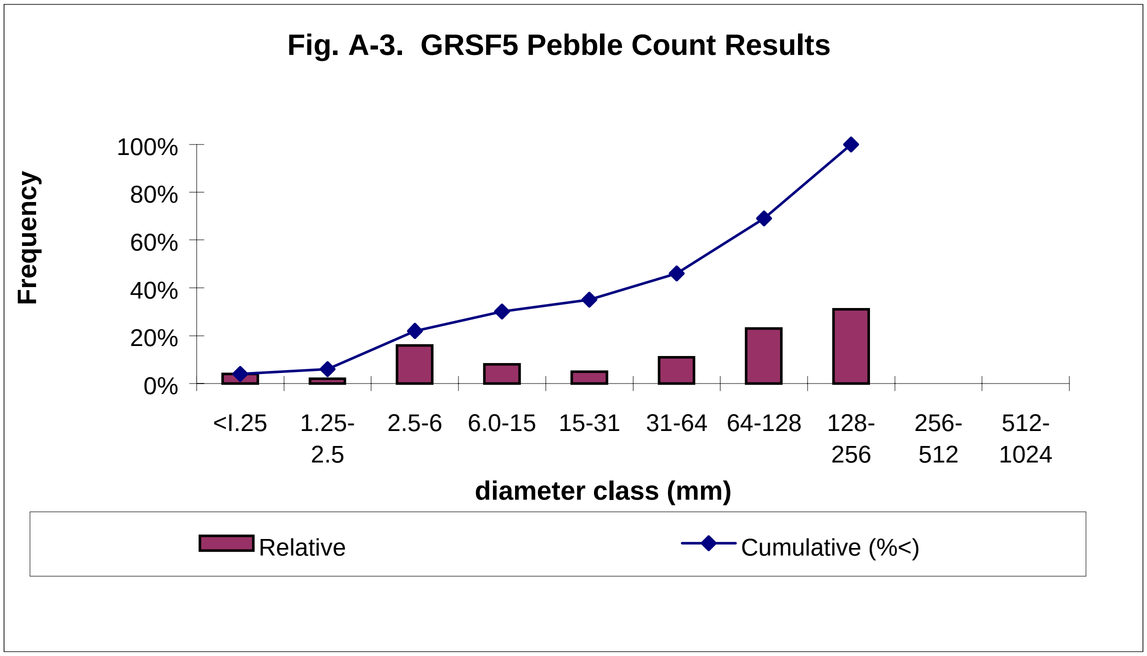
Appendix A

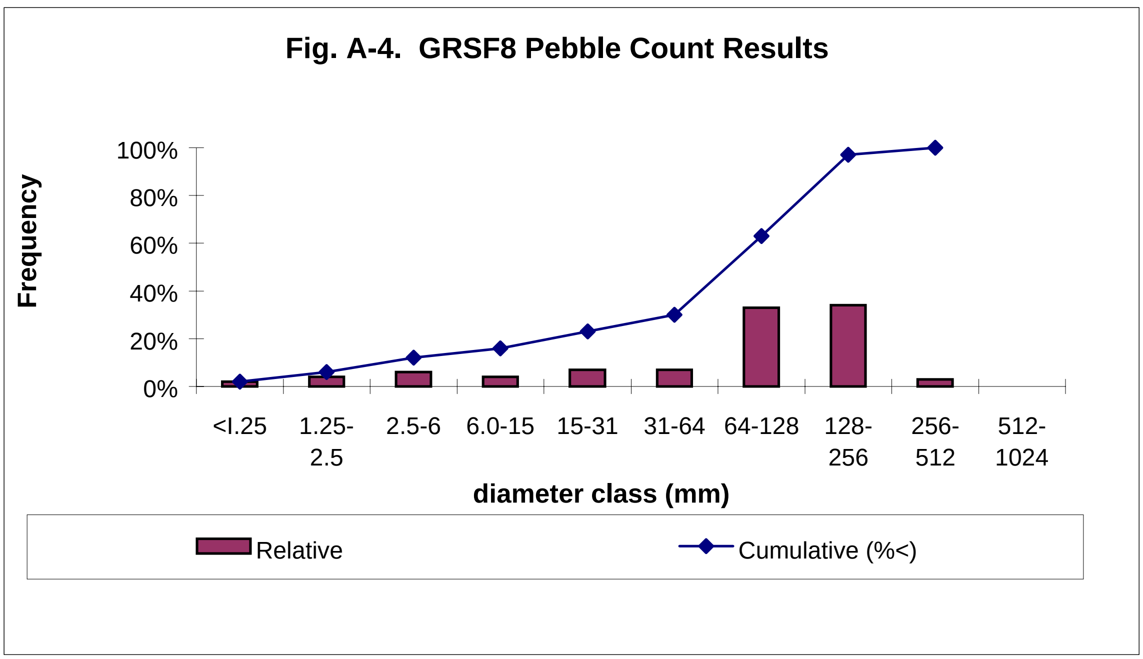
Data from 1999 Pebble Counts, 1998 Bulk Substrate Samples, 1998 Midwinter Sedimentation Samples, and 1998-1999 Overwinter Sedimentation Samples



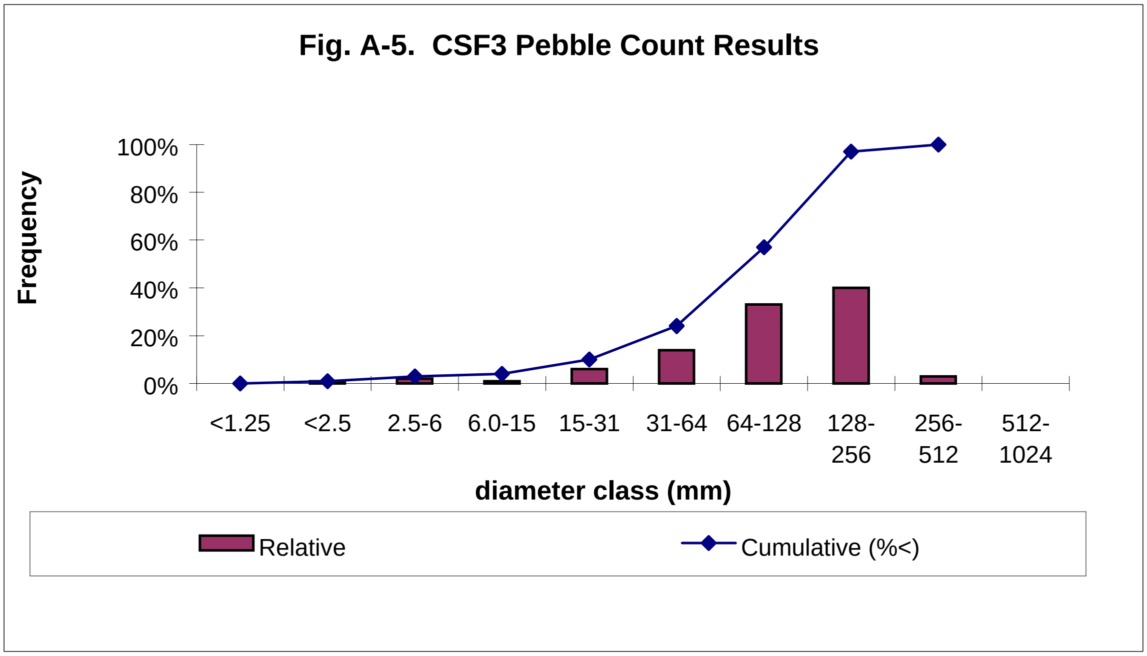


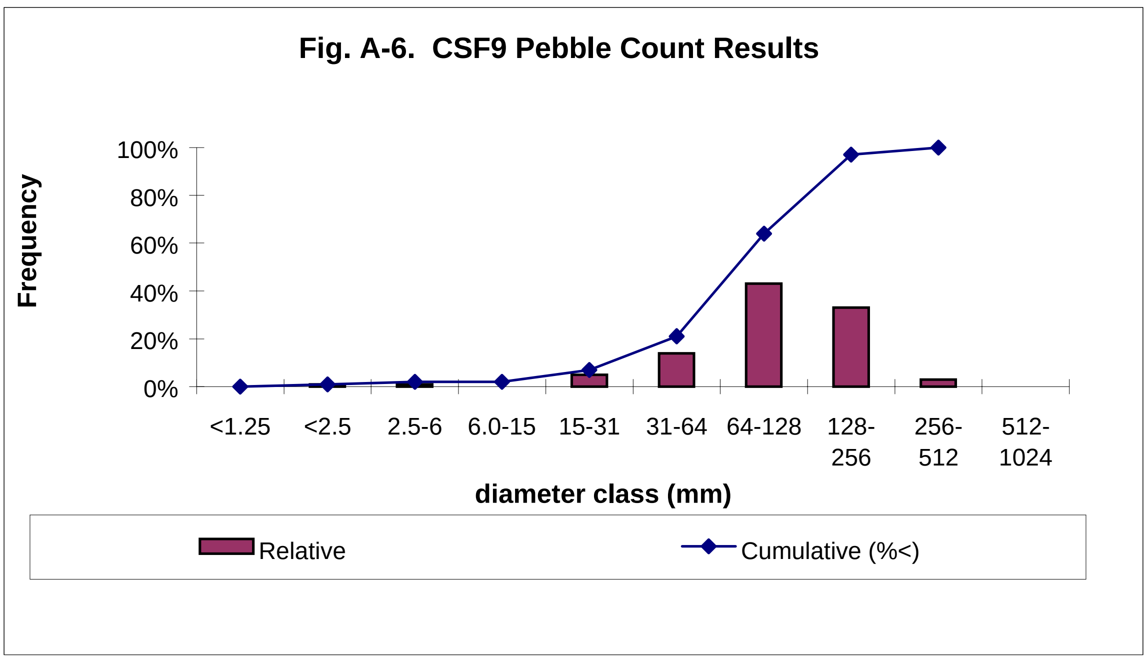
Figures A-1 to A-2. Results of individual pebble counts (n=100) in study streams, collected at transects where surface fine levels were also measured via the grid method (Bauer and Burton, 1993) and visually estimated, Sept. 1999. GR = Grande Ronde; C = Catherine Ck.; N = NFJDR; GT = Granite Creek; SF = Surface fine sediment transect number. The locations of all referenced transects are in Table 4.



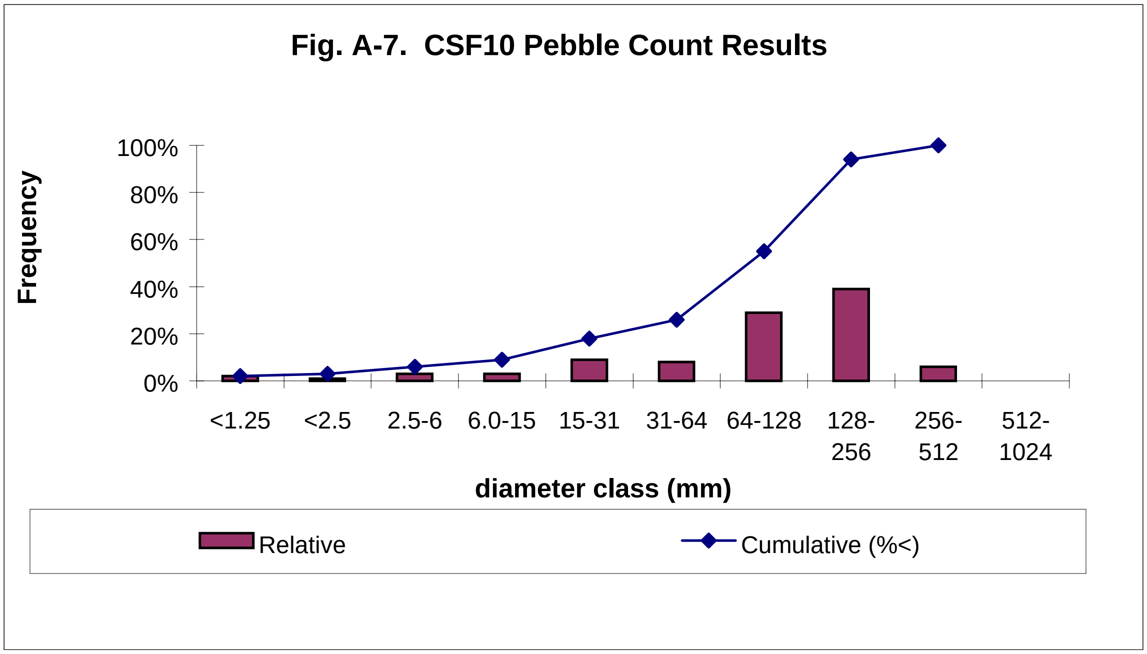


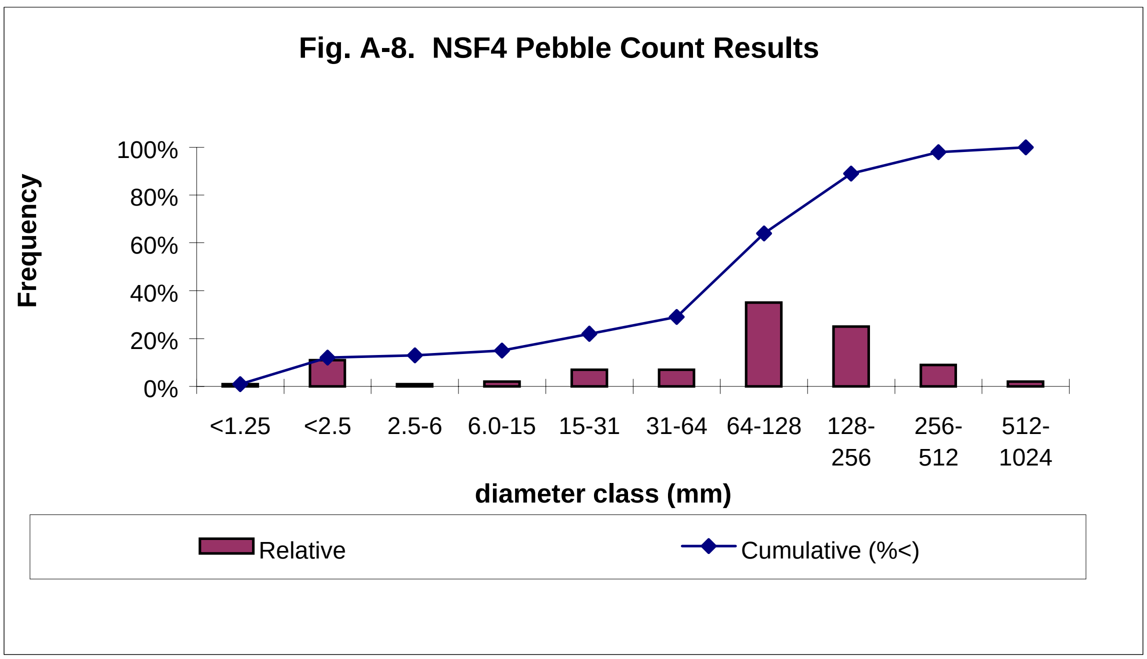
Figures A-3 to A-4. Results of individual pebble counts (n=100) in study streams, collected at transects where surface fine levels were also measured via the grid method (Bauer and Burton, 1993) and visually estimated, Sept. 1999. GR = Grande Ronde; C = Catherine Ck.; N = NFJDR; GT = Granite Creek; SF = Surface fine sediment transect number. The locations of all referenced transects are in Table 4.



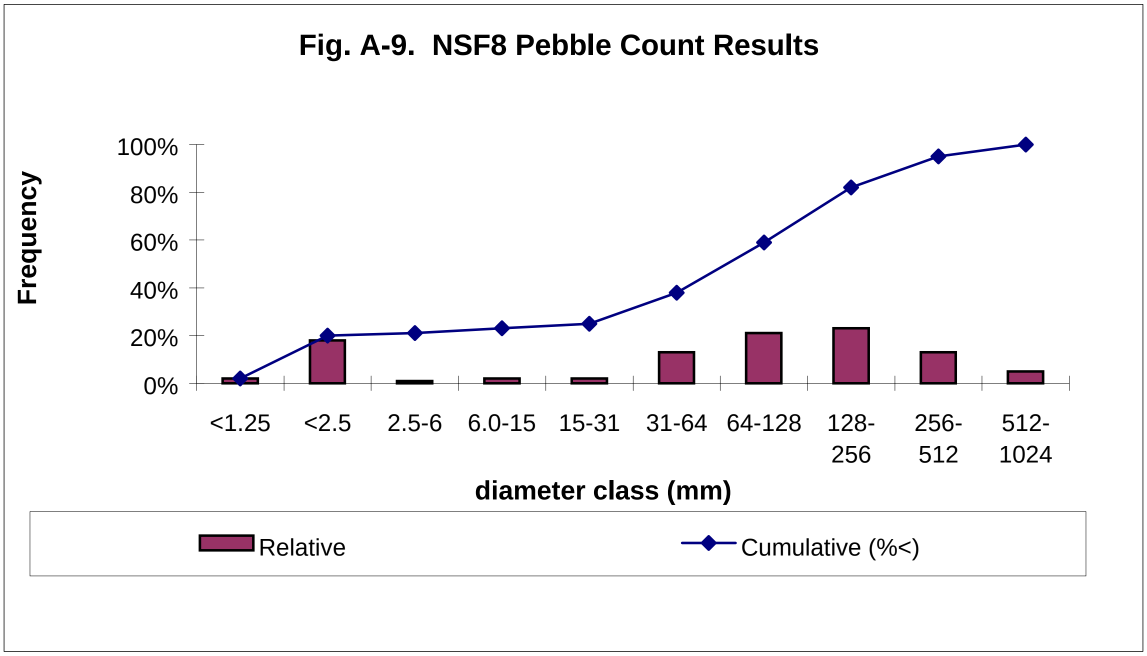


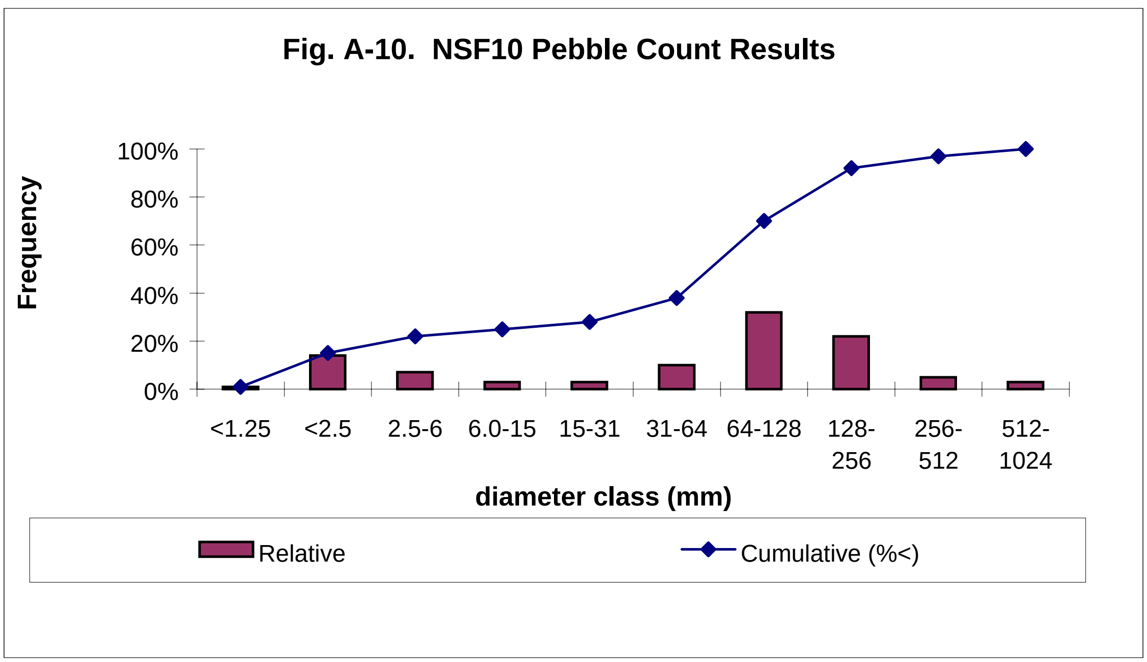
Figures A-5 to A-6. Results of individual pebble counts (n=100) in study streams, collected at transects where surface fine levels were also measured via the grid method (Bauer and Burton, 1993) and visually estimated, Sept. 1999. GR = Grande Ronde; C = Catherine Ck.; N = NFJDR; GT = Granite Creek; SF = Surface fine sediment transect number. The locations of all referenced transects are in Table 4.



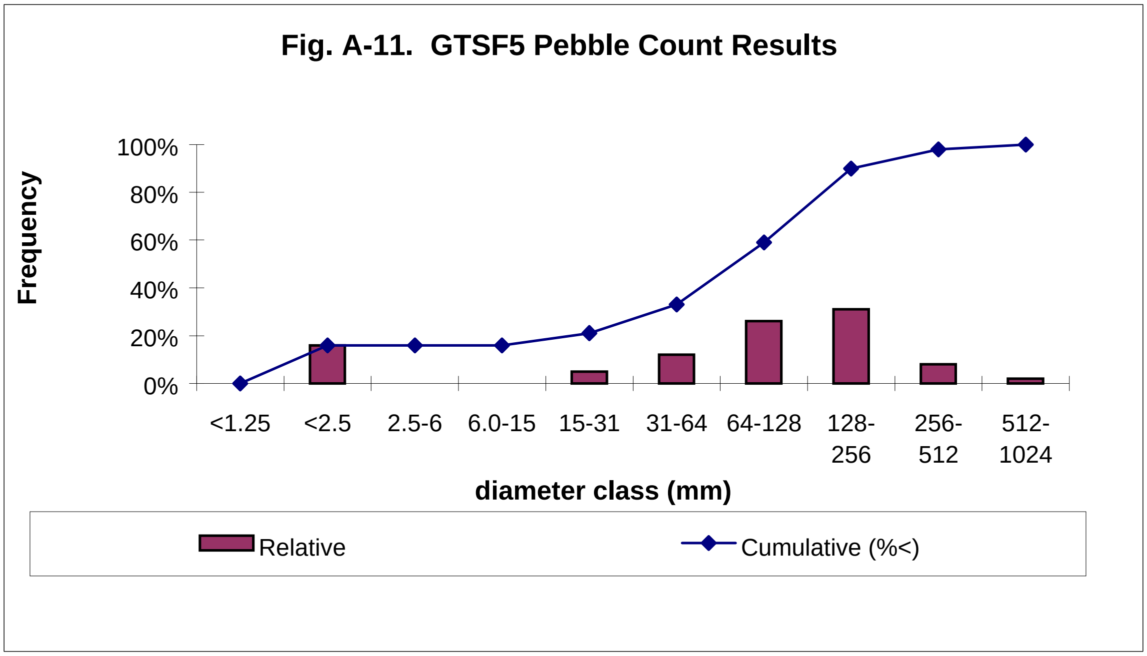


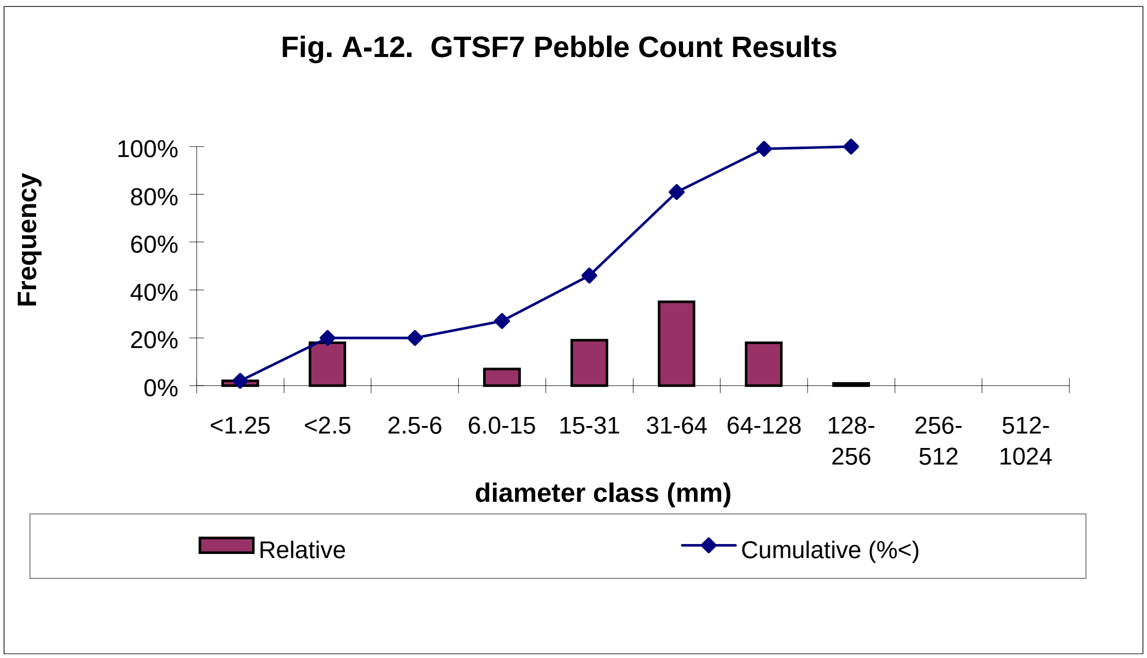
Figures A-7 to A-8. Results of individual pebble counts (n=100) in study streams, collected at transects where surface fine levels were also measured via the grid method (Bauer and Burton, 1993) and visually estimated, Sept. 1999. GR = Grande Ronde; C = Catherine Ck.; N = NFJDR; GT = Granite Creek; SF = Surface fine sediment transect number. The locations of all referenced transects are in Table 4.





Figures A-9 to A-11. Results of individual pebble counts (n=100) in study streams, collected at transects where surface fine levels were also measured via the grid method (Bauer and Burton, 1993) and visually estimated, Sept. 1999. GR = Grande Ronde; C = Catherine Ck.; N = NFJDR; GT = Granite Creek; SF = Surface fine sediment transect number. The locations of all referenced transects are in Table 4.





Figures A-11 to A-12. Results of individual pebble counts (n=100) in study streams, collected at transects where surface fine levels were also measured via the grid method (Bauer and Burton, 1993) and visually estimated, Sept. 1999. GR = Grande Ronde; C = Catherine Ck.; N = NFJDR; GT = Granite Creek; SF = Surface fine sediment transect number. The locations of all referenced transects are in Table 4.

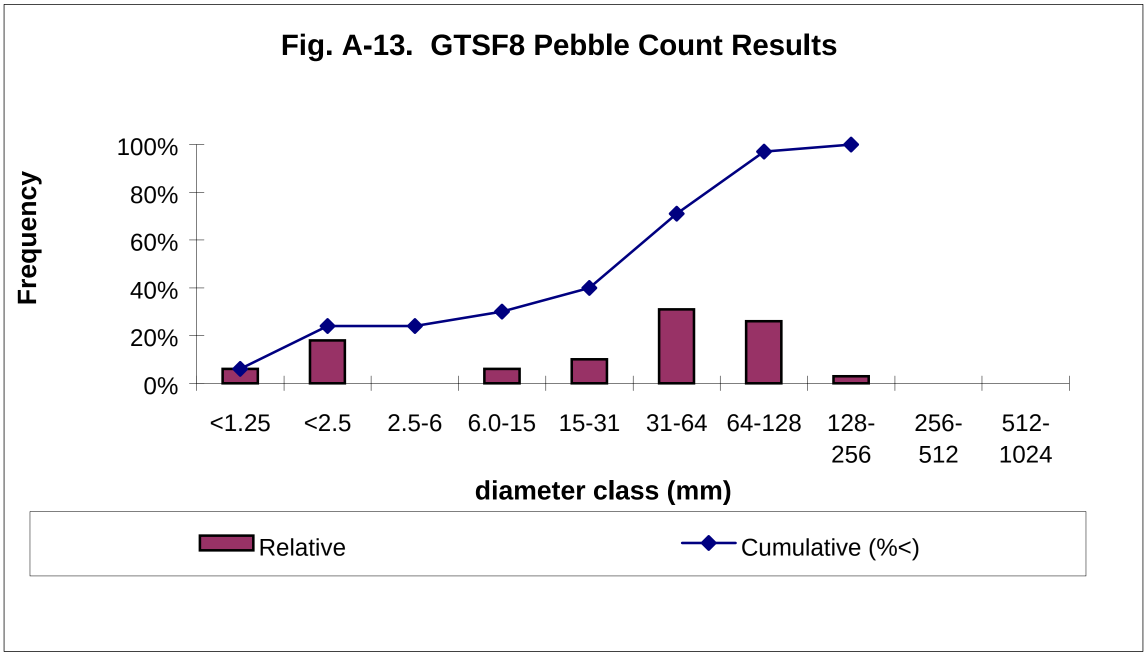


Figure A-13. Results of individual pebble counts (n=100) in study streams, collected at transects where surface fine levels were also measured via the grid method (Bauer and Burton, 1993) and visually estimated, Sept. 1999. GR = Grande Ronde; C = Catherine Ck.; N = NFJDR; GT = Granite Creek; SF = Surface fine sediment transect number. The locations of all referenced transects are in Table 4.

Table A-1. Collection notes and percent by weight of fine sediment fractions in bulk samples collected by shovel and sample containers collected midwinter. Sample ID codes are as follows: GR = Grande Ronde; C = Catherine Creek; N = NFJDR; GT = Granite Creek; numbers reference "redd numbers" where saples were collected (see Table 2); s = collection by shovel; w = containers of cleaned gravels in "redds" collected in Dec. 1998.

collection date	sample ID	< 6.3 mm	mean < 6.3 mm	< 2mm	mean < 2mm	<0.85 mm	mean <0.85 mm	Visually estimated (Ve) surface fines at collection time	Collection notes	mean surface fines for stream (n=10) in 9/98 (grid method)
(mo/d/yr)		(%)	(%)	(%)	(%)	(%)	(%)	(%)		(%)
09/05/98	GR2s	28.5%	27.3%	14.2%	15.4%	7.0%	8.3%	40.0%		25.44%
09/05/98	GR4s	26.1%		16.5%		9.6%		30.0%		
09/05/98	C2s	13.3%	11.0%	6.8%	6.4%	2.7%	3.5%	5.0%	Fine sediment levels higher at depth than at surface (armored)	1.82%
09/05/98	C3s	8.7%		5.9%		4.2%		2.0%	Fine sediment levels higher at depth than at surface (armored)	
09/05/98	N4s	31.8%		16.3%		7.7%		30.0%		16.76%
09/05/98	GT3sa	24.6%	27.7%	12.3%	13.8%	4.7%	5.1%	17.0%	Fine sediment levels higher at depth than at surface (armored)	11.14%
09/05/98	GT3sb	30.8%		15.2%		5.6%		17.0%	Fine sediment levels higher at depth than at surface (armored)	
12/05/98	GR2w	3.9%	10.6%	1.9%	8.5%	1.0%	4.2%	18.0%	Signs of fine sediment fill: duned/drifted sands, buckets not filled to capacity, fine sediment mainly sand, no bridging, filling from bottom up. Log sill upstream may be trapping fines in transport. Surface fines measured by grid as in 9/98 (n=5)=19.8%.	25.44%
12/05/98	GR4w	17.4%		15.1%		7.5%		30.0%	Duned/drifted sands, all buckets filled to capacity, fine sediment mainly sand, no bridging. Surface fines measured by grid as in 9/98 (n=5)=28.6%. GR1-5 all show infilling, but GT4 the most.	
12/05/98	C2w	2.2%	2.5%	2.2%	2.4%	2.1%	2.2%	3.0%	No signs of scour/fill, buckets not filled to capacity, fine sediment mainly silt, no bridging, filling from bottom up.	1.82%
12/05/98	C3w	2.8%		2.7%		2.3%		3.0%	No signs of scour/fill, buckets not filled to capacity, fine sediment mainly silt, no bridging, filling from bottom up.	

Table A-2. Collection notes and percent by weight of fine sediment fractions in sample overwintering sample containers collected in April 1998. Sample ID codes are as follows: GR = Grande Ronde; C = Catherine Creek; N = NFJDR; GT = Granite Creek; numbers reference "redd numbers" where samples were collected (see Table 2).

collection date	sample ID	< 6.3mm				< 2 mm				< 0.85 mm				Visually estimated (Ve) surface fines 4/99	Collection notes	mean surface fines for stream (n=10) in 9/98 (grid method)
		individual containers	mean for stream	90% CI	std. dev	individual containers	mean for stream	90% CI	std. dev	individual containers	mean for stream	90% CI	std. dev			
(mo/d/yr)		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		(%)
04/12/99	GR1a	12.0%				9.3%				3.0%				27%	No major signs scour or deposition at site. Fines to capacity in bucket, no bridging.	
04/12/99	GR1b	8.8%				6.8%				2.3%						
04/12/99	GR2a	10.2%				9.0%				4.7%				50%	In pool 5m upstream, Ve=70-80%. Duned/drifted fines at site. Fines to capacity in buckets, no bridging in 2a. Bridging in 2b.	
04/12/99	GR2b	12.0%				10.6%				4.9%						
04/12/99	GR3a	12.0%	11.6%	1.5%	2.9%	10.0%	9.2%	1.3%	2.5%	5.8%	4.9%	1.0%	1.9%	35%	No major signs of scour/fill, fines to capacity in bucket, no bridging.	25.44%
04/12/99	GR3b	13.1%				10.8%				6.0%						
04/12/99	GR4a	13.4%				10.4%				6.8%				40%	Duned/drifted fines, also on N. bank outside of channel. Fines to capacity in bucket, no bridging.	
04/12/99	GR4b	17.6%				13.7%				8.5%						
04/12/99	GR5a	7.1%				5.3%				3.5%				45%	Duned/drifted fines, also on N. bank outside of channel. Fines to capacity in bucket, no bridging.	
04/12/99	GR5b	10.2%				6.1%				3.5%						
04/13/99	GT1a	8.9%				6.9%				3.7%				15%	Minor signs of variable scour/fill. Fines not to capacity in bucket, but at highest levels of GT samples, no bridging.	
04/13/99	GT1b	10.5%				9.1%				5.3%						
04/13/99	GT2a&b	nd				nd				nd				15%	Major signs of scour/fill, bed reworked, buckets not found, probably due to scour	
04/13/99	GT3a	6.9%	7.1%	1.4%	2.2%	5.6%	6.3%	1.1%	1.7%	4.3%	4.6%	0.6%	0.8%	15%	Signs of variable scour/fill. Fines not to capacity in bucket, fines mainly silt, no bridging.	11.14%
04/13/99	GT3b	5.2%				4.6%				3.8%						
04/13/99	GT4a&b	nd				nd				nd				15%	Major signs of scour/fill, bed reworked, buckets not found, probably due to fill.	
04/13/99	GT5a	5.0%				5.0%				4.7%				15%	Signs of variable scour/fill. Fines not to capacity in bucket, fines mainly silt, no bridging.	
04/13/99	GT5b	6.3%				6.2%				5.9%						