1999 Ten Mile River
Sediment Monitoring Report

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Introduction

McNeil sediment sampling, as applied in the TMRW, measures the particle size distribution of streambed gravels in areas likely to be used as spawning beds by coho salmon and steelhead trout. As the proportion of fine particles increases, the ability of salmonid eggs to develop and survive to become emergent fry diminishes (Tappel and Bjomn 1983). It is therefore a useful way to assess instream sediment conditions relative to the reproductive biology of salmonid species. This method does not measure the instream sediment bedload, sediment delivery or removal rates, or the effects of sedimentation on other habitat variables such as pool frequency and depth. Bums (1970) and others have used this method to measure the impact of logging disturbances on salmonid habitat. The application of the McNeil protocol in the TMRW is intended as a monitoring tool and, unlike the Bums study, does not have treatment and control components. Therefore, the method focuses on instream conditions and does not explicitly investigate the sources of sediment input. The degree to which timber harvest activities are responsible for the observed conditions is beyond the scope of this report.

Methods

Collection Methods

Methods for McNeil sampling follow those recommended by Valentine (1995, *in* Taylor, Ed. 1996), and the Timber-Fish-Wildlife Ambient Monitoring Program Manual (Schuett-Hames *et al*. 1994). There were 23 instream substrate-sampling stations in the TMRW (Appendix A): eight in NFT, six in CFT, and nine in SFT. Sampling occurred during the low flow of late summer and early fall subsequent to fry emergence and prior to adult spawning. Sample dates were kept as consistent as possible from year to year to reduce sampling bias.

All samples were collected with a modified McNeil sampler (modified with a Koski plunger to avoid loss of core material) with a core measuring 15.5 centimeters (cm) in diameter, 13.5 cm in length and capable of holding 2547 cubic centimeters (cc) of material. All samples were processed in-situ and wet-sieved (volumetric method) rather than dry-sieved (gravimetric method). The volumetric method is advantageous because it is less time intensive and requires less equipment than the gravimetric method. Wet sieving does produce error since water is increasingly retained with decreasing sieve size allowing greater volumetric displacement of smaller sediments. Correction factors (Shirazi and Seim 1979) will account for this type error but they frequently are not used nor did Valentine suggest them (1995, in Taylor, Ed 1996). Correction factors were not calculated for the 1993 through 1999 monitoring efforts. Furthermore, all known historical sediment sampling was done using the volumetric method without correction factors.

Samples were taken from the pool/riffle juncture and not necessarily extracted from known salmonid redds. Pool/riffle junctures, or riffle crests are often the first area in the stream selected by anadromous fishes for spawning (Tripp and Poulin 1986). Winnowing of fine sediments when salmonids excavate redds results in a substantial decrease in this fine material (Kondolf *etal.* 1993, Everest *et al.* 1987). Conditions in the actual redds should be no worse than the samples, so actual survival would likely be as good or better than indicated. Winnowing is difficult to model and not estimated in this study. Also, our sampling occurred during the late summer and early fall low flows, the time when fines are most concentrated in potential spawning substrates. For these reasons, we consider samples taken from the riffle crests indicate a worse case scenario of the true sediments found in the spawning substrate (Valentine 1995, *in* Taylor, Ed. 1996).

Two riffles were sampled at each station, with four cores taken at each riffle, for a total of eight cores per station. Individual core samples were averaged, geometric mean and fredle index were then calculated.

To classify the overall particle-size distribution of the sample, based on a geometric progression, the following 30.5 cm diameter sieves were used: 63.0 mm, 31.5 mm, 16.0 mm, 8.0 mm, 4.0 mm, 2.0 mm, 1.0 mm, and 0.85 mm as recommended by Shirazi *et al.* (1981). Instream characteristics noted during collection were stream gradient and stream flow.

As recommended by Valentine (1995, *in* Taylor, Ed. 1996), measurements were taken along the second medial axis of the three largest rocks collected per individual core. If the largest particles were greater than 1\3 -1\4 the diameter of the sampling core, a larger sampler was suggested (Valentine 1995, *in* Taylor, Ed. 1996). These measurements were taken for all core samples at all locations.

Sample locations remained constant from year to year (with the exception ofNFT2 and NFT10 which were not sampled until 1995), however, the same riffle crests were not necessarily sampled each year. Winter flows often moved these riffle crests or eliminated them completely; in such cases, the nearest suitable location was sampled.

<u>Metrics and Thresholds</u>

Assessment of the McNeil sampling results requires definitions of the metrics used and consideration of value ranges (thresholds) considered acceptable to the life cycle requirements of the species and to the entities charged with their conservation. For the purposes of this report, the proportion of smallest measured particle size sampled is referred to as % fines and is defined as those particles less than or equal to 0.85mm in diameter (Valentine 1995, *in* Taylor, Ed. 1996). Similar definitions have been developed based on observed relationships between particle size and salmonid embryo survival (Waters 1995, Tagart 1976, Koski 1966). Bums (1970) used 0.8mm to define fines in his report.

Threshold values are typically used with McNeil data to determine whether conditions are acceptable or not. As with other thresholds, there is disagreement as to the appropriate value, and no single value is universally accepted. CTM, (formerly The Timber Company), has used 20% fines as its internal threshold. This value is associated with increased failure of eggs and larval development in some studies (Lisle and Eads 1991, Tagart 1976, Koski 1966). The Bums (1970) study sampled gravels using the McNeil method in several local watersheds (Little North Fork Noyo River, North Fork Caspar Creek, and South Fork Caspar Creek) prior to any logging of second growth timber. A composite average of those results yields a value of 19.4%. This has been proposed as a possible threshold for local watersheds because it is likely to represent background conditions and is based on data from watersheds with similar characteristics (Surfleet *et al.* unpubl.) The following discussion ofTMRW results will refer to the 19.4% threshold when evaluating sediment conditions.

Other metrics commonly used to evaluate McNeil sediment sampling results include the Fredle index and geometric mean. The Fredle index correlates particle size distribution with survival to emergence of salmonid fry (Lotspeich and Everest 1981). Survival to emergence has also been correlated with geometric mean (Platts *et al.* 1979). This information is presented in Appendix B, but is not addressed beyond that.

A less conventional metric, referred to here as trend analysis, is actually an extension of the % fine metric. Trend analysis, as presented here, is simply a least squares linear regression line applied to the % fme results for the seven years of data. A critical r -value of ±0.75 was used to determine the linearity of the data points. Although sites with lesser r - values could still be subjectively evaluated, sites exceeding ±0.75 could be said to have a definite linear trend. The slope of the least squares line is also presented. This is used to evaluate the rate of change in % fines. This method was applied to each of the 23 sites.

Trend analysis was also applied to sub-basin weighted averages. The three sub-basins are the North Fork of the TMRW (NFT), the Clark Fork of the TMRW (CFT), and the South Fork of the TMRW (SFT). Weighted averages for each sub-basin were calculated by extrapolating the % fine values to the entire extent of Class 1 stream. First, streams were divided into channel types based on stream habitat typing data (Ambrose *et al.* 1996). Percent fine values for each site were then multiplied by the proportion of stream length with similar channel type. Channel types were often lumped in tributaries due to insufficient sampling to accommodate the variety of channel types. In those cases the whole tributary was assigned the results of the nearest sampling site with similar characteristics (i.e. the nearest tributary with data). The intent of the weighted average was to give each sample site more accurate representation when aggregating the data. For example, results from a sample site in a small tributary may represent a smaller proportion of the basin than a sample taken on the mainstem and should therefore not be given equal weight when averaging.

Results

Twenty-one index sites were established in 1993. In 1995 two sites were added (NFT2 and NFT10). Since that time, 23 index sites have been sampled annually (Table 1). The % fines values have ranged from a high of 31.0% at NFT7 in 1993 to a low of 8.8% at CFT2 in 1998. The overall average for all sites and all years is 17.8%.

Table 1. Sampling Schedule.

1998	1999	Area Code	Site Name
1-Sep	8-Sep	CFT1	CFT AT REYNOLD'S GULCH
8-Oct	25-Oct	CFT2	CFT AT LITTLE BEAR HAVEN CREEK
1-Sep	8-Sep	CFT3	LOWER BEAR HAVEN CREEK
7-Oct	8-Sep	CFT4	LOWER CFT
15-Sep	10-Sep	CFT5	BOOTH GULCH
8-Oct	4-Oct	CFT6	LITTLE BEAR HAVEN CREEK
30-Sep	23-Sep	NFT1	NFT AT PATSY CREEK
21-Sep	20-Sep	NFT2	BALD HELL CREEK
17-Sep	13-Sep	NFT5	NFTAT CAMP 5
15-Sep	9-Sep	NFT6	LOWER LITTLE NFT
14-Sep	29-Sep	NFT7	BUCKHORN CREEK
18-Sep	16-Sep	NFT9	NFT AT GULCH 9
30-Sep	23-Sep	NFT10	PATSY CREEK
4-Sep	14-Sep	SFT1	LOWER SMITH CREEK
4-Sep	14-Sep	SFT2	LOWER CAMPBELL CREEK
4-Sep	14-Sep	SFT3	SFT AT BROWER'S GULCH
2-Sep	15-Sep	SFT4	CHURCHMAN CREEK
2-Sep	29-Sep	SFT5	SFT AT BUCK MATHEWS GULCH
10-Sep	2-Sep	SFT6	SFTAT CAMP 28
28-Sep	17-Sep	SFT8	UPPER REDWOOD CREEK
23-Oct	19-Oct	SFT9	UPPER SFT
2-Sep	15-Sep	SFT13	SFT AT CHURCHMAN CREEK
6-Oct	30-Sep	TEN1	MILL CREEK

Site specific results for the years'1998 and 1999 including % fines, geometric mean and survival to emergence estimates are included in Appendix B. This information for previous years is included in earlier reports (Ambrose and Hines 1998, Ambrose and Hines 1997, Ambrose *et al.* 1996).

Time series trends for all are included in Appendix C. These include slope and correlation coefficients plotted on % fine results over the seven years of data collection. Seven of the 23 sites (30%) show significant linear relationships with the critical r-value

S ±0.75 (CFT4, CFT6, NFT2, NFT6, NFT10, SFT1, and SFT13). Three additional sites (NFT5, NFT9, and SFT2) appear very linear, but fail to exceed the critical r-value because their slopes approach zero (Brase and Brase 1995). If these are considered to have linear trends, then the total number of sites with this condition becomes 10, or 43% of 23. Of the 10 sites, all are stable or decreasing with the exception of SFT1, which is increasing.

Variation between years for the remaining thirteen sites is too great to conclude a linear trend. However, regression lines for these data may still be useful in providing a subjective assessment of trends as long as the viewer understands that conclusions cannot be definitive. Sites suggesting an increase in % fines include, CFT1, CFT3, CFT5, and SFT6. Areas suggesting a decrease in % fines include, NFT7, SFT3, and SFT4.

Time series results aggregated at the sub-basin level (Table 2 and Appendix D) show strong linear trends, however the slope for CFT and SFT approach zero and, for that reason fail to meet the critical r-value (Brase and Brase 1995). However, the linear relationship between years is an indication of stability within their respective basins. The NFT sub-basin differs from the others in that it shows a distinct downward trend (r = -0.79). Results of a straight averaging of all sites at the sub-basin level are included in Table 2. It is useful to compare these averages with the sub-basin estimates in order to understand the impact the sub-basin weighted averaging estimate had on the results. The % fine values dropped slightly for CFT and NFT and rose slightly for SFT. The relationship of values between years, however, is exactly the same with both methods. This is consistent with the calculations, which assigned the same proportion of stream length to a given site for each year, resulting in no net changes between years.

Table 1. % Fine averages for sub-basins within the TMRW.

Weighted	Average:						
	1993	1994	1995	1996	1997	1998	1999
CFT	15.6	18.4	18.4	16.8	16.2	16.6	18.0
NFT	19.1	20.6	21.3	17.5	17.7	17.9	15.8
SFT	17.4	16.5	17.0	17.7	17.0	18.2	14.9
Straight	Average:						
	1993	1994	1995	1996	1997	1998	1999
CFT	16.7	18.3	19.1	17.4	17.6	16.8	18.5
NFT	19.8	20.5	22.3	19.1	18.3	18.7	16.8
SFT	17.0	16.5	17.0	17.3	16.5	17.6	14.6

Summaries of pertinent stream habitat typing variables are contained in Appendix E. This table is intended to enhance understanding of sediment conditions in the system in lieu of more comprehensive sediment monitoring results. A detailed treatment of the stream habitat typing results is contained in an earlier report (Ambrose *et al.* 1996). Distinctions between mainstem reaches versus tributary reaches are apparent with most of the variables. Mainstem reaches tended to have greater percentages of pool and primary pool habitat. Although no reach exceeded 50% pool habitat by length, more than 50% of that pool habitat consisted of primary pools in the mainstem reaches (NFT = 84%, CFT = 52%, and SFT = 77%). Reaches containing 50% or more primary pools are considered to have adequate pool habitat (Flosi and Reynolds 1994). Only three reaches

(Churchman, Campbell, and Smith Creeks) had greater than 20% of the pools formed by large woody debris. Among other things, this may indicate a lack of sediment metering mechanisms in the system.

The percent of riffle crests with high embeddedness ratings exceeded 30% in all reaches except for Bald Hill Creek (19%). Interestingly, these results did not correlate well with the % fines values from the McNeil sediment sampling. Mainstem reaches had greater percentage of high embeddedness than most of the tributary reaches (NFT = 97%, CFT = 55%, and SFT = 74%).

Gravel dominance in low gradient riffles was prevalent in most reaches. However, tributaries tended to have lower ratings. These areas tend to be higher gradient and therefore are more likely to transport gravels to lower gradient reaches.

Discussion

Basin Level Conditions

The 1999 weighted average % fines for the North Fork Ten Mile River was 15.8% (Table 2). This value is well below both the Bums and CTM thresholds. The r - value is significant (-0.76) and the slope is negative (-0.67) (Appendix D). This indicates a linear decrease in average percent fines over the last seven years. By this measure, the North Fork Ten Mile River has attained, or at least is heading toward, desired conditions. However, other indicators (Appendix E) suggest it is an aggraded system (low in pool habitat and high embeddedness). The fact of the matter is that existing data is not adequate to quantitatively assess the overall condition of the basin. But, some educated hypothesizing may be useful here. The old-growth timber in NFT was harvested more recently than the other forks and was subjected to tractor logging more so than the others (Ambrose *et al.* 1996). Assuming the bulk of sediment delivery was associated with this early disturbance, one might expect to pick up a recovery trend for NFT and not the others. That is, if the other forks were disturbed earlier, we may have missed the downward trend and be measuring a post-disturbance stabilization for CFT and SFT.

The 1999 weighted average % fmes for the dark Fork Ten Mile River was 18.0%. This was the highest of the three sub-basin averages. It is below both the CTM and Bums thresholds. But, it also has the poorest ratings of any of the three forks in key habitat variables. The slope of the least squares line in the trend analysis is near zero (0.04) and, despite the low r - value (0.08) it demonstrates a pattern of relative stability. The condition of this sub-basin is arguable, depending on the threshold one uses. However, it does not appear to be changing one way or the other.

The 1999 weighted average % fines for the South Fork Ten Mile River was 14.9%. The slope is near zero, but with a slight downward trend (-0.15). Although lacking in overall pool habitat, it has the highest LWD rating of any of the forks. These conditions are good, especially when considered in the context of the extensive activity that has occurred there in the last ten years.

The overall conditions suggest a moderately high sediment load and a lack of metering mechanisms (low LWD ratings). Tributaries, in general appear to function as transport reaches and the mainstems as depositional reaches. Percent pool and primary pool ratings in mainstems suggest that scouring and redistribution of gravels has occurred. The bulk of the sediment load has likely been in the system for many years.

Site Specific Conditions

Within the NFT, % fines are still high in the upper portion of the basin (Patsy Creek and the upper mainstem). But, all of the monitored tributaries are trending down and the mainstems are remaining stable. As with all of the three sub-basins, tributaries tend to be low in pool habitat, have fewer primary pools, and be lower in LWD ratings. Gulch 23 was not sediment sampled but the habitat ratings were exceptionally poor. Other than that, there were no specific areas of concern.

Within the CFT, Bear Haven Creek rated fairly well in key habitat variables, and is one of the last tributaries to support juvenile coho salmon, but it showed a pattern of increasing fine sediment. Booth Gulch and the upper mainstem although variable, also appear to be increasing. Little Bear Haven Creek was among the best of the tributaries in terms of % fines and key habitat variables.

Smith Creek, in SFT, is the only tributary in the entire TMRW to show in increase in % fines with a significant linear progression. Although the absolute value of% fines is moderate, and the pool and LWD habitat values were good, the source of introduced fines should be identified in this tributary, as it is also one of the few to support coho salmon. Campbell Creek had somewhat high levels of fines but appears stable. Redwood Creek and Churchman Creek were moderate to low and did not show signs of increasing fines. Comparison of the % fine trends between upper SFT (SFT9) and SFT at Camp 28 (SFT6) show an increase at the downstream station indicating some change in condition between the two locations.

Recommendations

Areas in good or improving condition should be acknowledged and management should be given consideration for increased flexibility in those areas. Also, as previously stated, this monitoring study does not explicitly study the causes of sedimentation. It is therefore unknown to what degree, if any, the existing conditions deviate from those that would occur in the absence of modem land use activities. It should therefore not be assumed that areas with high fines and/or increasing trends, are outside the range of natural background conditions. However, areas with potential for improvement should be surveyed for sources of sediment input. If appropriate and practical, as determined by management, the sources should then be repaired to the extent possible.

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