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EVALUATION OF SALMON AND STEELHEAD SPAWNING HABITAT QUALITY IN THE SOUTH FORK TRINITY RIVER BASIN, 1997

by

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ABSTRACT

Sediment sampling was used to evaluate chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) spawning habitat quality in the South Fork Trinity River (SFTR) basin. Sediment samples were collected using a McNeil-type sampler and wet sieved through a series of Tyler screens (25.00 mm, 12.50 mm, 6.30 mm, 3.35 mm, 1.00 mm, and 0.85 mm). Fines (particles < 0.85 mm) were determined after a 10-minute settling period in Imhoff cones. Thirteen stations were sampled in the SFTR basin: five stations were located in mainstem SFTR between rk 2.1 and 118.5, 2 stations each were located in EF of the SFTR, Grouse Creek, and Madden Creek, and one station each was located in Eltapom and Hayfork Creeks. Sample means for fines (particles < 0.85 mm) for SFTR stations ranged between 14.4 and 19.4%; tributary station sample mean fines ranged between 3.4 and 19.4%. Decreased egg survival would be expected at 4 of 5 mainstem SFTR stations and at one station in EF of SFTR and Grouse Creek where fines content exceed 15%. Small gravel/sand content measured at all stations were high, and exceed levels associated with reduced sac fry emergence rates. Reduction of egg survival or sac fry emergence due to sedimentation in spawning gravels could lead to reduced juvenile production from the South Fork Trinity River.

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INTRODUCTION

The South Fork Trinity River (SFTR) basin (Humboldt and Trinity counties) is a major tributary to the Klamath River basin (Figure 1). The watershed supports anadromous Pacific salmon (*Oncorhynchus* spp.) and steelhead (*O. mykiss*) populations. Spring- and fall-run chinook salmon escapement into SFTR in 1964 were estimated at 11,604 and 3,337 fish, respectively (LaFaunce 1967). Recent annual chinook salmon escapements into SFTR have declined to as low as 232 and 324 spring-run chinook salmon in 1991 and 1992, respectively (Dean 1994, 1995). Fall-run chinook salmon escapement into SFTR was 345 fish in 1990 (Jong and Mills 1993). Preliminary counts for 1996 show a slight increase in spring-run chinook to 1,097, and 1,835 for the fall-run chinook (B. Jong, CDFG). Historic SFTR steelhead escapement estimates are not available; however, during the 1990-91 and 1991-92 seasons 2,326 and 3,741 steelhead entered SFTR, respectively (Wilson and Collins 1992, 1994).

Several factors have contributed to the decline of the anadromous fishery resource in the Klamath River basin (CH2M-Hill 1985). They include low flows, high summer water temperatures, unscreened water diversions, degraded spawning gravels, over-appropriation of water, commercial and sport harvest, poor water quality, loss of riparian vegetation, dam-caused loss of gravel recruitment, alteration of flow regimes, overgrazing, poor ocean conditions, urbanization, road construction, disease, mining, predation, and other land management practices. Some factors have the potential to affect stream habitat quality by accelerating erosion. The resulting sedimentation can reduce the ability of a stream to produce fish in several ways. For example, i) salmon spawning habitat can be clogged or buried, reducing salmon egg survival, ii) juvenile rearing habitat could become filled, reducing the stream's carrying capacity, and iii) aquatic invertebrate production could be reduced (Reiser and Bjornn 1979).

The effects of excessive amounts of small sediment sizes on salmon and steelhead spawning gravel have been studied by several investigators (Wickett 1958, Cordone and Kelley 1961, McNeil and Ahnell 1964, Cooper 1965, Koski 1966, Bjornn 1969, Hall and Lantz 1969, Phillips et al. 1975, Cloern 1976, Tagart 1976, McCuddin 1977[1], Reiser and Bjornn 1979, Tappel and Bjornn 1983). They found that high percentages of fines <0.83 mm in spawning gravel reduces water movement through the gravel bed by filling intergravel spaces, while fines overlaying spawning habitat can prevent water from entering the subgravel environment. Wickett (1958) found egg survival increased with gravel permeability. Permeability was found to be low when gravel is comprised of 15% fines (McNeil and Ahnell 1964). Incubating eggs suffer increased mortality from smothering or a build-up of metabolic wastes as a

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[1]As cited by Reiser and Bjornn (1979).

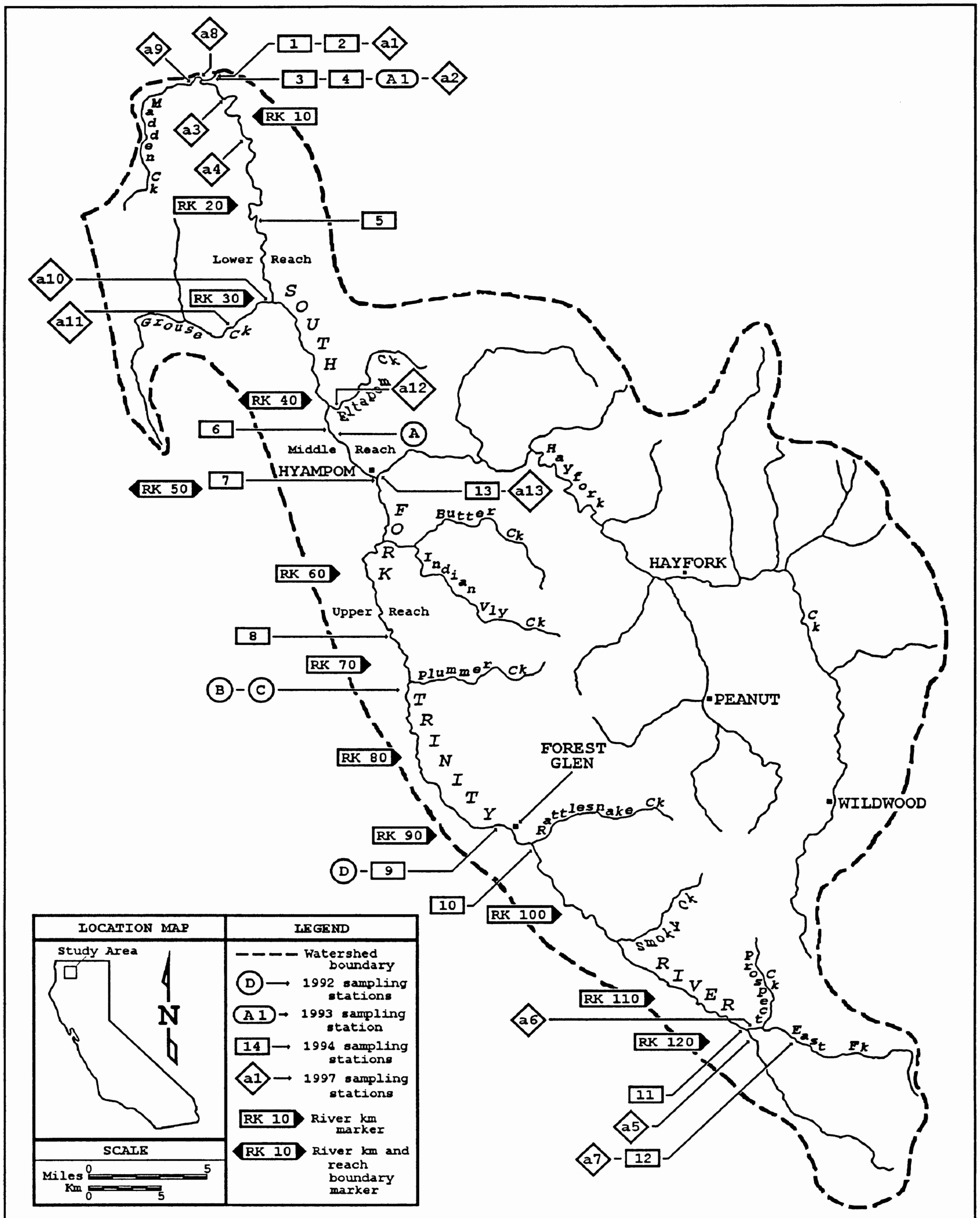

Figure 1. Map of the South Fork Trinity River basin depicting the location of major landmarks and salmon and steelhead spawning habitat quality evaluation sampling stations, 1997.

result of excessive fines. An inverse relationship exists between fines content and egg survival. Cloern (1976) demonstrated for coho salmon (*O. kisutch*) that when fines (particles <0.85 mm) exceeded 15%, the proportion of eggs that hatch sharply decreased. Egg-to-emergence survival for coho salmon decreased when fines exceed 20% (Tagart 1976). Gravel comprised of 35% or more fines resulted in 0% egg-to-emergence survival for coho salmon (Koski 1966).

Sediment sizes larger than fines have also been shown to adversely affect sac fry emergence. Koski (1966) reported that emergence was inversely related to the proportion of sediment ≤3.3 mm in size. Hall and Lantz (1969) and Phillips et al. (1975) demonstrated that when 1-3 mm diameter sediments comprised 10-20% of the sample, steelhead and coho salmon fry emergence was reduced. Also, chinook and steelhead fry emergence is reduced when 20-25% of sediment is comprised of particles <6.4 mm in diameter material (Bjornn 1969, McCuddin 1977[2]) (Figure 2).

This study evaluated chinook salmon spawning gravel quality in the SFTR basin in 1997.

STUDY AREA

The SFTR basin (Figure 1) is located in northern California about 70 km west of Redding and 90 km east of Eureka. The SFTR can be segregated into three reaches (Table 1). The upper and lower reaches are narrow, steep-sided V-shaped valleys and the middle reach (Hyampom Valley) is a wide U-shaped valley. The watershed encompasses 2,640 km^2. The river originates in the Yolla Bolla Mountains at an elevation of 2,397 m and flows about 145 km to its confluence with the main stem Trinity River. The mouth of the SFTR is 120.5 river km from the Pacific Ocean. The major tributary to the SFTR is Hayfork Creek which drains an area of 982 km^2 and enters near the town of Hyampom at RK 48.4. The watershed is sparsely populated; land management practices have included timber harvest, urban development, agriculture, and mining.

Anadromous salmonids spawn in the mainstem SFTR between the mouth and the confluence with East Fork of the SFTR, and in numerous tributaries located between those two points (Figure 1). Fall-run chinook salmon generally use the mainstem SFTR from the mouth to the upper reaches of Hyampom Gorge near RK 50 and the lower 4-5.5 river km of Hayfork Creek (LaFaunce 1967, Jong and Mills 1993). In 1992, spring-run chinook salmon held and spawned in the SFTR between Grouse Creek (RK 30.2) and the confluence with East Fork of the SFTR (RK 118.3)(Dean 1995). In 1985, spawned

[2]As cited by Reiser and Bjornn (1979).

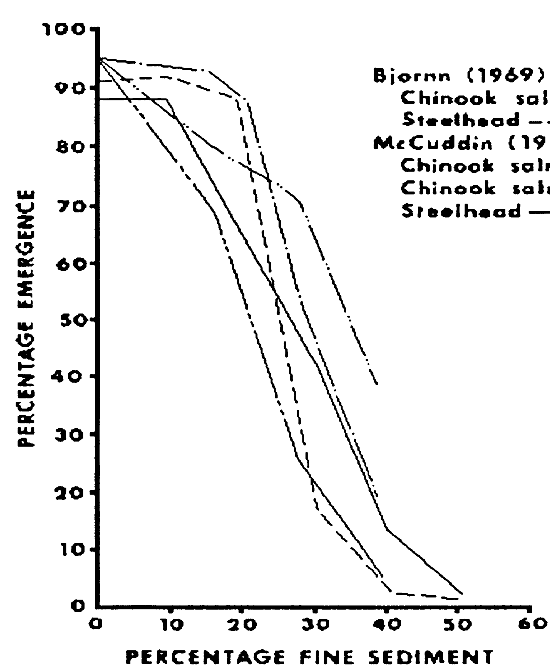

FIGURE 2. Percent emergence of fry from newly fertilized eggs in gravel-sand mixtures. Fine sediment was granitic sand with particles less than 6.4 mm. (from Reiser and Bjornn 1979)

coho salmon carcasses were recovered in mainstem SFTR at RK 3.2, while unspawned carcasses were recovered at RK 44.7 (Jong and Mills 1993). Spawning steelhead were observed in numerous tributaries in the Hyampom Valley, Hayfork Creek drainage, and East Fork of the SFTR (Wilson and Mills 1992, Hanson and Collins 1995).

Limited historical data indicated that spawning habitat in the SFTR basin contained quantities of small sediment particles that are detrimental to salmonid egg hatching and fry emergence. Buer and Senter(1982) described sediment size distribution between the mouth and Forest Glen (Figure 1). Bulk sampling was limited to five locations in Hyampom Valley; 50% of the samples were comprised of particles finer than 13.0-27.5 mm, and 16% of samples were comprised of particles finer than 1.7-2.9 mm. Sediment particles ≤1.0 mm comprised 1% of samples. Fines deposition was assessed in the mainstem SFTR and tributaries. Cans containing clean gravel of known particle size composition

TABLE 1. Reach name, description, characteristic, and extent for chinook salmon spawning habitat in the South Fork Trinity River, 1997.

Reach name	Extent river kilometers	Reach description and characteristics
Lower	0 to 40	Mouth to lower end of Hyampom Valley: V-shaped valley, steep gradient
Middle	41 to 50	Hyampom Valley: wide valley, channel meanders, low gradient
Upper	51 to headwaters	Upper end of Hyampom Valley to headwaters: V-shaped valley, steep gradient

were buried prior to winter storms; they were retrieved after one or more storms. Gravel quality before and after the storm was used to predict egg survival. Mean predicted egg survival for all stations combined before the cans were buried was 87.3% (range 70-95%); post storm, the mean egg survival declined to 63.3% (range 26-90%).

U.S. Forest Service (USFS) personnel collected sediment samples from several tributaries and mainstem SFTR. Potential spawning habitat quality was evaluated in Grouse Creek in 1988 and 1989: mean percent fines was 16.7% (range 13.2-21.5%) for combined data for all stations and years[3] (USFS data were reported as percent composition based on dry weight; the data discussed here are converted to wet weight for direct comparison). Particles ≤6.3 mm comprised from 26.7-47.5% of samples. He concluded that the level of fines in potential spawning habitat was unlikely to cause steelhead egg mortality, while the level of particles ≤6.3 mm could result in 0-55% survival to emergence. In 1989, gravel quality was evaluated in 13 tributaries and in the upper main stem of SFTR (USFS 1990). Fines (particles ≤0.85 mm) for tributary stations ranged between 2.0% and 11.8%, while fines at two mainstem SFTR stations were 2.4% and 3.3%. Particles ≤3.35 mm ranged between 11.4% and 37.4% at 20 of 21 stations; one station contained 8.0%. Gravel quality was measured at 40 stations located between RK 74 and RK 103 in the mainstem SFTR near Forest Glen in 1990 (USFS 1991). Fines ranged between 0.8-14.8%. Particles ≤3.35 mm ranged between 11.6-35.3% at 37 of 40

[3] J. Barnes. Six Rivers National Forest, Eureka, California, manuscript, 15 p.

stations. Proportions of larger sediment sizes >6.40 mm were not reported by USFS (1990,1991).

Department personnel spot checked spawning habitat quality the SFTR at four stations in 1992 and at one station in 1993 (unpubl. data) (Figure 1, Table 2). Percent fines ranged from 10.4-27.5%; fines exceeded 15% at 4 of 5 stations. Particles ≤4.75 mm ranged from 31.0-62.1% for all years and stations. Fines were present in quantities detrimental to egg hatching at 4 of 5 stations. Particles ≤4.75 mm were present at all stations in quantities that are detrimental to sac fry emergence.

Jong (1997) evaluated chinook salmon spawning habitat in the SFTR in 1994, using a McNeil-type sampler. Measured quantities of fine and small sediments exceeded levels found to be detrimental to egg survival and fry emergence rates. Mean percent composition of small sediment (< 4.75 mm) for the lower, middle and upper reaches were 43.7, 42.8, and 46.3%, respectively. Mean percent fines for the lower, middle and upper reaches were 15.2, 18.2, and 18.6%, respectively.

METHODS AND MATERIALS

All sampling stations were chosen by visual inspection at a riffle crest within the thalweg in areas that were accessible to spawning salmon or harbored spawning salmon in prior years. Unlike previous investigations, (Jong 1997) exact redd locations were not mapped the previous year for follow up sediment sampling. At each station, the potential spawning habitat was partitioned into 2 ft x 2 ft cells using a grid system. The cells to be sampled were chosen by random number generation. Five replicate samples were collected from all stations.

Four stations sampled in 1994 were selected for sampling in 1997 to provide a basis for comparison (Figure 1, Table 3). Nine

TABLE 2. Salmon spawning habitat quality as measured by percent particle size less than 4.75 mm and 0.85 mm in the South Fork Trinity River, 1992 and 1993.

Year	River kilometer	Location	Percent smaller than 4.75 mm	0.85 mm
1992	43.4	Hyampom Valley	31.0	10.4
1992	71.6	near Plummer Ck	62.1	26.0
1992	71.9	near Plummer Ck	49.1	27.5
1992	89.5	Forest Glen	41.8	20.5
1993	1.3	Sandy Bar	41.6	17.5

TABLE 3. Name, river kilometer index, and location of salmon and steelhead potential spawning habitat quality evaluation sampling stations in the South Fork Trinity River (SFTR) basin, 1997.

Station name	River km	Station description
		SOUTH FORK TRINITY RIVER
Lower Reach		
a1	2.1	Sandy Bar. Equivalent to Station 3, sampled in 1994 by Jong (1997).
a2	2.2	Sandy Bar, boat launch. Equivalent to Station 4, sampled by Jong (1997).
a3	5.3	SFTR, approx. 50 m above large landslide.
a4	8.7	SFTR, approx. 20 m below foot bridge.
Upper Reach		
a5	118.5	SFTR, 500 m upstream of confluence with East Fork of the SFTR. Equivalent to Station 11, sampled in 1994 by Jong (1997).
		SFTR TRIBUTARIES
a6	0.1	East Fork of the SFTR
a7	5.2	East Fork of the SFTR, approx. 250 m upstream of USFS Road 30 bridge.
a8	0.1	Madden Creek, 20 m up from confluence with South Fork Trinity River.
a9	0.9	Madden Creek, pool tail out just below USFS bridge
a10	1.2	Grouse Creek, approx. 200 m below Devastation Slide.
a11	4.8	Grouse Creek, 200 m above USFS Sims Mt. Rd. Bridge
a12	0.4	Eltapom Creek, approx. 250 m from mouth in side channel.
a13	0.1	Hayfork Creek, approx. 20 m downstream of Garret Rd. Bridge. Equivalent to Station 13, sampled in 1994 by Jong (1997).

additional stations, located in the mainstem SFTR and in tributaries, were selected to describe habitat conditions in areas of historic use.

RK data for the SFTR and tributaries were obtained from U.S. Geological Survey topographic quadrangles.

Sediment samples were collected and analyzed by a method similar to that outlined by McNeil and Ahnell (1964) using a McNeil-type sampler. This sampler collects a 15.2 cm deep x 15.2 cm diameter sample. Five replicate samples were collected from each redd site. Samples were either immediately partitioned through 25.0 12.5, 6.3, 3.35, 1.0, and 0.85 mm sieves, or placed in sealed buckets for partitioning at a later date. Sediment retained by each sieve was quantified by volumetric displacement. The volume of any material <0.85 mm diameter was determined after a 10-minute settling period in Imhoff cones.

In this report, spawning habitat quality was evaluated based on three categories: i) percent fines (particles < 0.85 mm), ii) sand-sized sediment (particles retained by 1.0 mm sieve), and iii) small sediment particles < 6.3 mm, that is the sum of particles retained by 3.35, 1.0, and 0.85 mm sieves, and fines.

RESULTS AND DISCUSSION

Mainstem SFTR Conditions

Station sample means for percent fines measured at five mainstem SFTR stations in 1997 ranged from 14.4 to 19.4% (Table 4, Figure 3). Fines exceeding 15% have been associated with egg mortality due to smothering (Koski 1966, Hall and Lantz 1969, Phillips et al. 1975, Cloern 1976). Fines exceeding 15% were measured at four of five mainstem SFTR stations in 1997. All mainstem SFTR stations showed a slight increase in fines in 1997 compared with 1994 (Table 5).

Sand-sized sediment (retained by 1.0 mm sieve) ranged from 2.1 to 35.3% (Figure 3). Hall and Lantz (1969) and Phillips et al. (1975) demonstrated that when 1-3 mm diameter sediments comprised 10-20% of the sample, steelhead and coho salmon fry emergence was reduced. Sand-sized sediment was measured at or above those levels associated with decreased salmonid sac fry emergence at three of five stations.

Small sediment levels (particles < 6.3 mm) ranged from 21.4 to 73.0% in 1997 (Table 4). Chinook salmon and steelhead sac fry emergence rates decline rapidly as the percent of small sediment increases to about 20-25% (Figure 2) (Bjornn 1969, McCuddin

TABLE 4. Salmon and steelhead potential spawning habitat quality measured in the South Fork Trinity River (SFTR) basin, 1997.

Station	River km	Particles smaller than 6.30 mm	3.35 mm	0.85 mm
		SOUTH FORK TRINITY RIVER		
a1	2.1	41.2	30.2	17.8
a2	2.2	21.4	18.4	15.6
a3	5.3	33.3	24.4	14.4
a4	8.7	73.0	55.8	15.9
a5	118.5	45.6	33.8	19.4
		SFTR TRIBUTARIES		
a6 EF of SFTR	0.1	40.1	29.0	11.9
a7 EF of SFTR	5.2	50.2	39.8	18.5
a8 Madden Ck	0.1	27.4	16.4	3.4
a9 Madden Ck	0.9	52.9	42.5	19.4
a10 Grouse Ck	1.2	50.3	41.4	12.6
a11 Grouse Ck	4.8	27.9	21.4	18.4
a12 Eltapom Ck	0.4	26.0	20.5	14.2
a13 Hayfork Ck	0.1	41.3	36.1	13.1

1/ Sum of all sediment particles passing through a 6.3 mm sieve.
2/ Sum of all sediment particles passing through a 3.35 mm sieve.

1977[4]). Small sediment measured at all stations sampled in 1997 meet or exceed levels associated with entombing eggs and fry, and decreased sac fry emergence rates.

Station a5 (sampled in 1997) can be compared to Station 33 sampled by USFS in 1989 (USFS 1990): fines were 3.32% and 19.4% in 1989 and 1997, respectively (Table 4). USFS reported percent mean station sediment particles finer than 3.35 mm was 20.4%; in 1997, particles finer than 3.35 mm was 33.8%. These data suggest

[4]As cited by Reiser and Bjornn (1979).

that potential salmon and steelhead spawning habitat conditions have worsened over the last decade.

Tributary Conditions

Station sample means for percent fines measured in tributaries were variable (Table 4). Two sampling stations were located in three of five tributaries (EF of SFTR, Madden Creek and Grouse Creek); in all three streams, fines content in the lower station was lower than at the upper station. Furthermore, fines content in the lower stations were below levels associated with higher egg mortality rates, while levels in the upper stations exceeded 15%. Fines at the mouth of Hayfork Creek decreased from 23.5% in 1994 to 13.1% in 1997 (Tables 4 and 5).

The two stations sampled in 1997 in Grouse Creek directly compare with the lower two stations sampled by USFS in Grouse Creek in 1988 and 1989[5] (Tables 4 and 6). These data suggest that indicators of spawning habitat quality are variable through time. Small sediment (finer than 6.3 mm) and sand-sized particles (finer than 3.35 mm) are present in quantities associated with reductions in sac fry emergence in all years and at both stations. Fines exceed levels associated with egg mortality at the lower station in 1988, and at the upper station in 1997.

TABLE 5. Comparison of fines (particles < 0.85 mm) content at four stations sampled in 1994 that were sampled in 1997, South Fork Trinity River basin.

River km	Station mean percent fines for years 1994	1997
SOUTH FORK TRINITY RIVER		
2.1	15.6	17.8
2.2	13.7	15.6
118.5	18.9	19.4
HAYFORK CREEK		
0.1	23.5	13.1

[5] J. Barnes. Six Rivers National Forest, Eureka, California, manuscript, 15 p.

TABLE 6. Comparison of potential salmon and steelhead spawning habitat quality in Grouse Creek at two stations sampled in 1988 and 1989 by the U.S. Forest Service (USFS, and in 1997 by the California Department of Fish and Game (CDFG).

		Particles smaller than								
	Station	6.3 mm			3.35 mm			0.85 mm		
RK	USFS/CDFG	1988	1989	1997	1988	1989	1997	1988	1989	1997
1.2	1/a10	44.1	38.5	50.3	32.1	22.1	41.4	16.5	9.5	12.6
4.8	2/a11	37.4	40.3	27.9	27.2	32.9	21.4	10.8	13.4	18.4

CONCLUSION

It is clear that small sediment particles (particles < 6.3 mm), and fines make up a large proportion of the potential salmon and steelhead spawning habitat sampled, and that these smaller materials are present in quantities associated with excessive salmon and steelhead egg mortality and decreased sac fry emergence. Such levels are likely to lead to reduction of juvenile salmonid production from the South Fork Trinity River basin. The quality of the salmonid spawning habitat at the locations sampled in the SFTR in 1997 was poor.

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