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CHINOOK SALMON SPAWNING HABITAT QUALITY EVALUATION STUDIES

SHASTA RIVER AND SOUTH FORK TRINITY RIVER BASINS

1994

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ABSTRACT

Chinook salmon (*Oncorhynchus tshawytscha*) spawning habitat quality was evaluated in two Klamath River tributaries, Shasta River and South Fork Trinity River (SFTR), in 1994. Sediment samples were collected using a McNeil sampler and wet sieved through a series of Tyler screens (12.5 mm, 4.75 mm, 2.36 mm, 1.0 mm, and 0.85 mm); fines (≤0.85 mm) were determined after a 10 min. settling period in Imhoff cones. Thirteen stations, located in the mainstem Shasta River between river km (RK) 0.8 and 59.1, were sampled. Eleven mainstem SFTR stations, located between RK 0.2 and 118, were sampled; two other stations were sampled that were located in tributaries to the SFTR. From a review of the literature, fines in spawning habitat in excess of 15-20% can reduce salmonid egg survival by preventing oxygen absorption and removal of metabolic waste. Small gravel/sand (variously defined in the literature as <6.4 mm or between 1.0-3.35 mm) can entomb sac fry: if sediment particles <6.4 mm comprised 10-30% of spawning gravel, or if 1.0-3.35 mm particles exceed 10-20% of spawning gravel, emergence rates declined rapidly. Results indicate that fines are present in quantities deleterious to egg survival in the Shasta River: sample mean percent fines ranged between 20.8-55.0%. In the SFTR, small gravel/sand (all sediment particles ≤4.75 mm) ranged between 38.7-52.5%; at those levels, decreased sac fry emergence rates would result. This study found that levels of fines and other small sediment particles are higher than those measured historically in both river basins. Reduction of egg survival or sac fry emergence rates due to sedimentation in spawning gravels is likely leading to reduced juvenile production from the Shasta and South Fork Trinity Rivers.

INTRODUCTION

The Shasta River (Siskiyou County) and South Fork Trinity River (SFTR) basins (Humboldt and Trinity counties) are major tributaries in the Klamath River basin (Figure 1). Both watersheds support anadromous Pacific salmon (*Oncorhynchus* sp.) and steelhead (*O. mykiss*) populations. Runs of fall-run chinook salmon (*O. tshawytscha*) into the Shasta River, once numbering as high as 81,844 fish in 1931, had declined to 586 fish in 1992. Steelhead counts in the Shasta River exhibit similar declines: 8,525 fish were counted in 1932 (Snyder 1933), while 233 fish were counted in 1978 (unpublished data). Spring- and fall-run chinook salmon escapements 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 runs numbering in the hundreds: 232 and 324 spring-run chinook salmon entered the SFTR in 1991 and 1992, respectively (Dean 1994, Dean 1995). Fall-run chinook salmon escapement into SFTR was 345 fall-run chinook salmon in 1990 (Jong and Mills 1993). 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, Wilson and Collins 1994).

Several factors have been identified which contribute 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-appropriations 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 of these 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 (food) production could be reduced (Reiser and Bjornn 1979).

The effects of sedimentation, specifically the effects of excessive amounts of small sediment sizes on salmon and steelhead spawning gravel has 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 as cited by Reiser and Bjornn 1979, Reiser and Bjornn 1979, Tappel and Bjornn 1983). High percentages of fines (<0.833 mm) in spawning gravel reduces water movement through the gravelbed by filling intergravel spaces, while fines overlaying spawning habitat can prevent water from entering the subgravel environment. Wickett (1958) related egg survival with permeability: survival increased with permeability. McNeil and Ahnell (1964) report that permeability was low when gravel is comprised of 15% fines. Incubating eggs suffer increased mortality from smothering or a build-up of metabolic wastes as a result of excessive fines. An inverse relationship exists between fines content and egg survival rates. Cloern (1976) demonstrated that if percent fines (<0.85 mm) exceed 15%, coho salmon (*O. kisutch*) egg hatching rates rapidly decreases. Tagart (1976) reports that coho salmon egg survival to emergence decreases when fines exceed 20%. Koski (1966) reports that gravel comprised of 35% or more fines resulted in 0% coho salmon egg survival to emergence.

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 amount of sediment ≤3.3 mm. Hall and Lantz (1969) and Phillips et al. (1975) demonstrated that if 1-3 mm dia. sediments comprised 10-20% of the sample, steelhead and coho salmon fry emergence was reduced. Also, chinook and steelhead fry emergence is reduced if 20-25% of sediment is comprised of <6.4 mm dia. material (Bjornn 1969, McCuddin 1977 as cited by Reiser and Bjornn 1979).

The purpose of this study was to evaluate chinook salmon spawning gravel quality in the Shasta River and SFTR basins. Descriptions of physical habitat in both basins are important to decision makers. These data serve as a baseline from which to identify areas requiring habitat improvement, evaluate the effectiveness of habitat improvement projects, give biologists an indication of the relative health of the stream, and enhances the ability of the California Department of Fish and Game (CDFG) to modify land management practices to prevent habitat degradation. Coordinated Resource Management Programs (CRMP) have been established in both watersheds, and are attempting to protect and promote the recovery of their anadromous salmonid fishery resources. Several management options exist (e.g., land acquisition, fencing, spawning gravel augmentation, gravel retention structures, ripping). However, the CRMP's limited budget requires that their activities be ranked. It is hoped that data from studies such as this will assist their efforts. Furthermore, several species or subspecies of anadromous salmonids in California and along the Pacific coast are either categorized as subjects of special concern or in extreme cases, threatened, or endangered. Habitat quality evaluations, such as these, would be valuable during the status review process, and during the development and implementation of any recovery plan.

STUDY AREA

Shasta River

The Shasta River basin (Figure 2) is located in northern California and enters the Klamath River 284 river km from the Pacific Ocean. The river drains an area of about 1,554 km2. It originates on the north slope of Mt. Eddy and flows 81 river km to it's mouth. River valley configuration varies considerably: small headwater streams drain onto the Shasta Valley and meander northward before dropping through a steep gradient, V-shaped canyon to the Klamath River. For purposes of discussion, the Shasta River (between the mouth and Dwinnell Dam) was divided into three reaches based on channel morphology (Table 1). Dwinnell Dam impounds Lake Shastina to provide water storage for irrigation and recreational use; it was completed in 1926 and is located at RK 64.5. The majority of the watershed is privately owned; small parcels owned by the federal government are scattered throughout the basin. The major land use is agriculture.

While general descriptions of spawning habitat distribution in the Shasta River are available, little spawning habitat quality data is available. Wales (1951) reported that: i) excellent spawning habitat was located in the lower 9.6 river km (canyon section), ii) good spawning areas existed in the 1.6 river km upstream of the canyon section, iii) Dwinnell Dam reduced available spawning habitat by 22%; the gravel near Edgewood was deemed excellent, iv) salmon and steelhead spawn in Big Springs Creek, and v) considerable, suitable spawning habitat was located below Yreka-Montague Road (RK 20.3) (the extent of this spawning habitat was not described). Coots (1957) mapped two principal king salmon spawning areas; a lower spawning area extended from the mouth to approx. RK 16.1, and an upper area primarily including Big Springs Creek and portions of the Shasta River adjacent to the confluence. Coots (1962) also noted spawning activity in the Shasta River from the vicinity of Grenada (RK 45) to the mouth of Parks Creek (RK 55.5), and in Big Springs Creek. Spawning activity was noted, from aerial redd counts, between the mouth of the Shasta River and Dwinnell Dam, and in Big Springs Creek in the late 1970s (Rogers 1978, Rogers 1979); detailed locations of redds was not discussed. However, in 1975 and 1983, no spawning was observed in the Shasta River from confluence with Big Springs Creek to Dwinnell Dam; spawning was observed in the Shasta River between the mouth of the Shasta River to the confluence with Big Springs Creek, and in Big Springs Creek (Rogers 1975, Rogers 1983). West et al. (1990) surveyed the Shasta River from the Klamath River to the confluence with Oregon Slough (RK 18.7) in 1988; they report that this section is heavily used for spawning.

More recently, CDFG's Klamath River Project and Region 1 personnel conducted chinook salmon spawner surveys in the Shasta River in 1993 and 1994. The purpose of those surveys was to recover tags to estimate adult escapement and to map spawning distribution. Surveys were conducted weekly during the fall-run chinook salmon spawning season between Grenada Irrigation District (GID) property (approx. RK 48) and the Klamath River (Figure 2). The heaviest chinook salmon spawning occurred in the lower 14 river km of the Shasta River; spawning activity was observed as high as RK 53.8 (Louie Road bridge), just 0.2 river km upstream of the confluence with Big Springs Creek (B. Chesney, California Department of Fish and Game, pers. comm.). In 1995, chinook salmon spawning activity was observed during late October and early November in the Shasta River near RK 60, and in the lower 8 river km of Parks Creek (B. Chesney, California Department of Fish and Game, pers. comm.).

The only spawning habitat quality evaluation conducted prior to this study was

1980 DWR data

conducted in the lower section of the Shasta River, between river km (RK) 1.4 and 11.7, by California Department of Water Resources (CDWR) personnel in 1980 (Scott and Buer 1981). They used a core sampler to collect a 35.5 cm dia. x 20.3 cm deep sample at ten stations located between RK 1.4 and RK 11.7. The quality of the gravel they sampled varied widely. Overall mean percent sediment finer than 4.75 mm was 21.0%, which approaches quantities associated with reduced fry emergence (20-25%) for <6.4 mm reported by Bjornn (1969). Percent sediment <4.75 mm met or exceeded 20% at 4 of 10 stations, and 18% at 7 of 10 stations, measuring as high as 43.5%. The smaller sized sieves used in 1980 do not match what typically is used to measure fines (0.85 mm): the closest sieve sizes to 0.85 mm were 1.18 and 0.6 mm, making direct comparisons difficult. However, those data do indicate that sediment bracketing the 0.85 mm size class are generally low. The overall means for sediment <1.18 and <0.6 mm were 9.4% and 6.2%, respectively.

West et al. (1990) visually evaluated quality of 9 habitat types in the Shasta River between the mouth and Oregon Slough (Figure 2). Five of 9 habitat types evaluated contained significant amounts of spawning habitat. Spawning habitat contained fines ranging from 14-52%; percent fines exceeded 15% in 4 of the 5 habitat types.

South Fork Trinity River

The SFTR basin (Figure 3) is located in northern California about 70 km west of Redding and 90 km east of Eureka. The SFTR can be broken into three sections, roughly based on valley configuration: the upper and lower sections are narrow, steep-sided V-shaped valleys and the middle section (Hyampom Valley) is a wide U-shaped valley. For the purposes of discussion, the SFTR is divided into three reaches (Table 1). The watershed encompasses 2,640 km2. 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 km2 and enters near the town of Hyampom at RK 48.4. The watershed is sparsely populated; land management practices have included timber harvest, 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 3). Fall-run chinook salmon generally utilize 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). 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) in 1992 (Dean 1995). In 1985, spawned coho salmon carcasses have been recovered in mainstem SFTR at RK 3.2, while unspawned carcasses have been recovered at RK 44.7 (Jong and Mills 1993). Spawning steelhead have been 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 indicates that spawning habitat in the SFTR basin contains quantities of small sediment particles that are detrimental to salmonid egg hatching and emergence rates. CDWR personnel described sediment size distribution between the mouth and Forest Glen (Buer and Senter 1982) (Figure 3). Bulk sampling was limited to five locations in Hyampom Valley; 50% of samples was comprised of finer than 13.0-27.5 mm particles, and 16% of samples was comprised of finer than 1.7-2.9 mm particles. Sediment particles ≤1.0 mm comprised 1% of samples. Fines deposition was assessed in the mainstem SFTR and tributaries. Cans containing clean gravel (known particle size composition) were buried prior to winter storms; they were retrieved after one or more storm events. Gravel quality before and after the storm was used to predict percent egg survival. Mean predicted egg survival rate (all stations combined) before the cans were buried was 87.3% (range 70-95+%); post storm event mean egg survival rate declined to 63.3% (range 26-90%).

U.S. Forest Service (USFS) personnel have collected sediment samples from several tributaries and mainstem SFTR. Barnes (In press) evaluated potential spawning habitat quality in Grouse Creek in 1988 and 1989: mean percent fines was 16.7%, and ranged from 13.2-21.5% (combined data for all stations and years). 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. Gravel quality in 13 tributaries and for 2 mainstem SFTR in stations (located in the upper SFTR basin) was evaluated in 1989 (USFS 1990). Fines (≤0.85 mm) content in tributary stations ranged between 2.03% and 11.81%, while fines at two mainstem SFTR stations were 2.39% and 3.32%. Particles ≤3.35 mm ranged between 11.36% and 37.41% at 20 of 21 stations; one station contained 7.98%. Gravel quality was measured at 40 stations located between river km (RK) 74 and RK 103 in the mainstem SFTR near Forest Glen in 1990 (USFS 1991). Fines ranged between 0.82-14.83%. Particles ≤3.35 mm ranged between 11.6-35.3% at 37 of 40 stations. Proportions of larger sediment sizes (e.g. >6.4 mm) in samples were not reported in either USFS (1990) or USFS (1991).

CDFG personnel spot checked spawning habitat quality the SFTR at four stations in 1992 and at one station in 1993 (unpubl. data) (Figure 3, 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% (all years and stations). According to the literature, fines were present in quantities at 4 of 5 stations sampled that are detrimental to egg hatching rates; particles ≤4.75 mm were present in quantities at all stations that are detrimental to sac fry emergence rates.

METHODS AND MATERIALS

Personnel of CDFG Inland Fisheries Division's Natural Stocks Assessment Project (NSAP) surveyed portions of the Shasta River and SFTR during the 1993 fall-run chinook salmon spawning season to locate and map redds. Distance and compass bearing measurements from the individual redd to fixed points on shore were recorded to allow samplers to locate that redd the following

year. Only a portion of those watersheds that is available to anadromous salmonids was surveyed because of budget constraints;

also, landowners who control key access points and properties were reluctant to grant access. Portions of the Shasta River, between the mouth to the GID property (approx. RK 48), were surveyed by CDFG personnel in 1993. Redds were mapped between the mouth to RK 20. During the late summer and fall months of 1994, NSAP personnel returned to the Shasta River and collected sediment samples from 11 redds located between river km (RK) 0.8 and 14.8 (Figure 2, Table 3). Two additional stations were sampled at RK 56.6 and 59.1 when landowner access was granted to property that was not surveyed in 1993. Sediment samples were also collected from 10 redd locations (stations) located between river km (RK) 0.1 and 92.2 in the SFTR (Figure 3, Table 3). Two additional stations were established in unsurveyed sections of SFTR and East Fork of the SFTR based on descriptions, provided by CDFG personnel, of spawning habitat either used in previous years or currently in use. One station was sampled at the mouth of Hayfork Creek; this station could be sampled periodically to give biologists a picture of the relative health (in terms of gravel quality) of this tributary.

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 (6 in.) Methc

deep x 15.2 cm (6 in.) dia. sample. Because most of the redds mapped in the Shasta River were still visible, samples were collected from the gravel covering the egg pit; none of the redds in the SFTR were visible. Five replicate samples were collected from each redd. Samples were either immediately partitioned through 12.5, 4.75, 2.36, 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 $\leq$0.85 mm dia. was determined after a 10 minute settling period in Imhoff cones.

Samples from potential spawning habitat (locations where redds were not mapped the previous year, but either are accessible to salmonids, or was used in prior years) were collected from the riffle crest within the thalweg. The number of replicates, and sample processing was the same as described above.

River km (RK) data for the Shasta River were available from two sources: Scott and Buer (1981), and Pacific Southwest Inter-agency Committee (1973). Discrepancies were found between those publications; all RK data used in this report are consistent with the former publication. RK data for the SFTR were obtained from U.S. Geological Survey topographic quadrangles.

In this report, all sediment particles that pass through a 4.75 mm sieve (sum of the particles retained by 2.36, 1.0, 0.85 mm sieves and fines) will be referred to as small sediment (finer than 4.75 mm), and those passing through a 0.85 mm sieve will be referred to as fines ($\leq$0.85 mm).

RESULTS AND DISCUSSION

Shasta River

< 0.85 mm

Sample mean percent fines ranged from 20.8-55.0% at all stations sampled in the Shasta River in 1994 (Table 4, Figure 4). Most researchers agree that salmon and steelhead spawning gravel are detrimentally impacted if they are comprised of 15% or higher fines (Koski 1966, Hall and Lantz 1969, Phillips et al. 1975, Cloern 1976). The level of fines measured during this study at all stations exceed 15%; at these levels, egg mortality due to smothering would be expected to occur at the stations sampled in the Shasta River in 1994.

Mean percent fines appear to vary by reach: the highest (36.3%) was measured in the Middle Reach, followed by 34.8% fines in the Lower Reach, and 31.9% fines in the Upper Reach (Table 4). Unfortunately, percent fines measured in this study (≤0.85 mm) are not directly comparable with data reported by Scott and Buer (1981). Their closest sieve size to 0.85 mm was 1.18 or 0.6 mm. Also, the 10 stations bulk sampled in 1980 are located in the Lower Reach. It is obvious that fines measured in 1994 in the Lower Reach are higher than levels of either ≤1.18 or ≤0.6 mm measured in 1980 (Table 4). Average levels of fines measured in 1994 are 3.7x and 5.6x higher than the ≤1.18 and ≤0.6 mm 1980 Lower Reach percent levels, respectively. Although, visual estimates of percent fines in Shasta River spawning habitat surveyed by West et al. (1990) in 1988 are not directly comparable to percent fines measured in this study. Their estimates and these results agree that fines are present in excessive quantities. These data and observations indicate that spawning habitat quality has degraded since 1980.

Research has indicated that mixtures of small gravel/sand (<6.4 mm) can entomb chinook salmon and steelhead sac fry,

preventing emergence (Bjornn 1969, McCuddin 1977 as cited by Reiser and Bjornn 1979, Tappel and Bjornn 1983). In general, percent emergence ranges from 88-95% in gravel mixtures containing no small sediment. As the percent of small sediment increases to about 20-25%, percent emergence declined rapidly. Due to equipment limitations, this data analysis was restricted to small sediment finer than 4.75 mm. In 1994, mean percent small sediment was 52.6%, and ranged from 40.1 to 64.8% (Table 4, Figure 4). These data indicate that at the stations sampled in the Shasta River in 1994, levels of small sediment exceeds levels that have been documented to hinder fry emergence rates (20-25%). In 1980, Scott and Buer (1981) found small sediment (finer than 4.75 mm) exceeding the 20-25% levels associated with excessive hindrance of fry emergence (Bjornn 1969, McCuddin 1977 as cited by Reiser and Bjornn 1979) in only 4 of 10 stations from the Lower Reach of the Shasta River. In 1994, measured mean levels of small sediment (52.6%) were 2.5x higher that those observed in 1980 (21%), a clear indication that spawning habitat quality has degraded since 1980 (Table 4).

Mean percent small sediment appears to vary by reach; the highest (57.6%) was measured in the Middle Reach, followed by 52.6% small sediment in the Upper Reach, and 50.7% small sediment in the Lower Reach (Table 4).

South Fork Trinity River

Sample mean percent fines ranged from 13.3-23.5% at all stations sampled in the South Fork Trinity River in 1994 (Table 4, Figure 5). Percent fines did not appear to be related to location in the SFTR basin. The level of fines measured at 9 of 13 stations this study exceed 15%. At these levels, egg mortality would be expected to occur in the South Fork Trinity River, and result in reducing juvenile salmonid production. Percent fines at the other four stations approached 15%, and ranged from 13.3-14.6%.

Percent fines in this study are not directly comparable between this study and data collected in 1981 by CDWR: CDWR reported 1.0 mm as the smallest particle size (Buer and Senter 1982). However, 0.85 mm and 1.0 mm particle sizes are closely alike and for purposes of discussion, those sizes will be treated as the same. CDWR's bulk sample results (Hyampom Valley) indicate that particles ≤1.0 mm comprise 5% of samples. Fines measured in 1994 are between 2.7-4.7x higher than results reported by CDWR.

Fines measured by USFS in the SFTR basin were variable. Barnes (In press) reported that in 1988 and 1989 in Grouse Creek, percent fines ranged from 13.2-21.5%. This is nearly identical to those (13.3-23.5%) measured during this study. However, in 1989 fines measured in 13 tributaries (range 2.03-11.81%) and at 2 mainstem stations (range 2.39-3.32%) were lower than levels (range 13.3-23.5%) measured at all mainstem stations in 1994 (USFS 1990). In 1990, fines measured at 39 of 40 mainstem SFTR sampling stations (range 0.82-10.02%) were lower than levels measured in 1994. Fines content at one station (14.8%) was comparable to levels measured in 1994 (USFS 1991). The higher fines content in the mainstem SFTR in 1994 is an indication that sedimentation has increased in recent years.

Levels of fines measured by CDFG at 4 of 5 stations sampled during 1992 and 1993 (Table 2) are consistent with those measured in 1994 (Table 4). At those 4 stations, fines ranged from 17.5-27.5%, while in 1994, fines ranged from 13.3-23.5%. Egg mortality due to smothering would be expected at those stations.

Sample mean percent particles finer than 4.75 mm ranged from 38.7-52.5% at all stations sampled in the South Fork Trinity River in 1994 (Table 4). These data indicate that sac fry emergence is hindered at all stations sampled in the South Fork Trinity River in 1994, and is consistent with findings presented by CDWR (Buer and Senter 1982) and Barnes (In press).

It is clear that small sediment particles (finer than 4.75 mm) make up a large proportion of the chinook salmon and potential spawning habitats sampled, and that these smaller materials are present in quantities associated with excessive salmon and steelhead egg mortalities and decreased emergence rates. Such reductions are likely to lead to reduction of juvenile salmonid production from the Shasta and South Fork Trinity River basins. Based on the limited data collected, the quality of the salmonid spawning habitat at the locations sampled is poor; furthermore, levels of small and fine sediment measured in the Shasta River in 1994 has increased over levels measured in 1980, indicating that sedimentation of salmon spawning habitat has increased. These data indicates that sedimentation is one of the factors limiting juvenile salmonid production in the Shasta and South Fork Trinity Rivers. Future salmon and steelhead population restoration efforts through habitat manipulation should include reducing spawning habitat sedimentation as an objective.

RECOMMENDATIONS

1. A comprehensive sedimentation study should be planned and implemented to provide fishery and land managers with a full picture of conditions, in not only the Shasta and South Fork Trinity Rivers, but in the entire Klamath River basin. The purpose of this study would be to measure the effects of sedimentation on salmonid rearing habitat, aquatic invertebrate production and spawning habitat quality. This study should examine the interactions between sedimentation, flow regimes, livestock, development, and other land management activities with the fishery resource. Fishery and land managers would then be in a better position to determine the effects of sedimentation on juvenile salmonid production. Specific management recommendations to reduce the effects of sedimentation could then be formulated and implemented.

2. The use of different equipment or techniques by this study and other field and laboratory studies reviewed above makes data comparisons and trend analysis difficult. Future quantitative spawning habitat quality sampling should, as a minimum, use a series of sieves that includes 6.4 mm, 3.35 mm, 1.0 mm, 0.85 mm. This should allow for direct comparisons with data presented in the literature.

3. Annual, comprehensive stream surveys should be conducted to identify areas contributing excessive sediment, and their causes. Once these areas are located, remedial measures should be planned and implemented. Sediment sampling could be used to identify the degree and extent of sedimentation. This information can then be used to set priorities for restoration efforts. Sediment sampling should be included in any habitat manipulations to monitor it's effectiveness. Another benefit of stream surveys is that fishery managers would be to identify and locate migration impediments and barriers (e.g., critical riffles due to low flows, diversion dams, debris jams, culverts, and clogged fishways). Any passage problems located could then be alleviated.

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Caption for Figure 1.

CHINOOK SALMON SPAWNING HABITAT QUALITY EVALUATION STUDIES,

SHASTA RIVER AND SOUTH FORK TRINITY RIVER BASINS, 1994

Howard W. (Bill) Jong

Figure 1. Map of the Klamath River basin in northern California

depicting the location of tributaries and major landmarks.

Caption for Figure 2.

CHINOOK SALMON SPAWNING HABITAT QUALITY EVALUATION STUDIES,

SHASTA RIVER AND SOUTH FORK TRINITY RIVER BASINS, 1994

Howard W. (Bill) Jong

Figure 2. Map of the Shasta River basin (Siskiyou County) depicting the location of major landmarks and chinook salmon spawning habitat quality evaluation study sampling stations, 1994.

Caption for Figure 3.

CHINOOK SALMON SPAWNING HABITAT QUALITY EVALUATION STUDIES,

SHASTA RIVER AND SOUTH FORK TRINITY RIVER BASINS, 1994

Howard W. (Bill) Jong

Figure 3. Map of the South Fork Trinity River basin (Humboldt and Trinity counties) depicting the location of major landmarks and chinook salmon spawning habitat quality evaluation study sampling stations, 1992 through 1994.

Caption for Figure 4.

CHINOOK SALMON SPAWNING HABITAT QUALITY EVALUATION STUDIES,

SHASTA RIVER AND SOUTH FORK TRINITY RIVER BASINS, 1994

Howard W. (Bill) Jong

Figure 4. Mean percent composition of chinook salmon spawning habitat sampled in the Shasta River, 1994.

Caption for Figure 5.

CHINOOK SALMON SPAWNING HABITAT QUALITY EVALUATION STUDIES,

SHASTA RIVER AND SOUTH FORK TRINITY RIVER BASINS, 1994

Howard W. (Bill) Jong

Figure 5. Mean percent composition of chinook salmon spawning habitat (Stations 1-10) and potential spawning habitat (Stations 11-13) sampled in the South Fork Trinity River, 1994.

NOTE: THE TABLES IN THE DOCUMENT ARE STILL UNDER CONSTRUCTION. THEY ARE NOT YET FORMATTED FOR WEB VIEWING.

TABLE 1. Reach descriptions, Shasta River and South Fork Trinity River chinook salmon spawning habitat evaluation study, 1994.

Extent

Reach (RK) Reach characteristics

SHASTA RIVER

Lower 0 to 12.6 Mouth to Anderson Grade bridge: V-shaped canyon, steep gradient

Middle to 53.6 Anderson Grade bridge to confluence with Big Springs Creek: wide valley floor, channel meanders, low gradient

Upper to 64.5 Confluence with Big Springs Creek to Dwinnell Dam: numerous riffles, moderate gradient

SOUTH FORK TRINITY RIVER

Lower 0 to 40 Mouth to lower end of Hyampom Valley: V-shaped valley, steep gradient

Middle to 50 Hyampom Valley: wide valley, channel meanders, low gradient

Upper to headwaters Upper end of Hyampom Valley to headwaters: V-shaped valley, steep gradient

TABLE 2. Salmon spawning habitat quality measured by California Department of Fish and Game personnel in the South Fork Trinity River, 1992 and 1993.

Year	RK	Location	Percent finer than 4.75 mm	Percent finer than 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. Sampling station numbers, locations, and descriptions, Shasta River and South Fork Trinity River (SFTR) chinook salmon and potential spawning habitat evaluation study, 1994.

Station	RK	Station description 1/
SHASTA RIVER		
Lower Reach		
1-A	0.8	100 m downstream USGS gaging station, redd #1
1-B	0.8	100 m downstream USGS gaging station, redd #2
1-C	0.8	100 m downstream USGS gaging station, redd #3
2	4.3	Side channel, Tire Flat Improvement Site, 0.6 river km below Pioneer Bridge
3-A	9.0	Salmon Heaven Improvement Site, mid section, gravel retained by rock weir, redd #1 and 2
3-B	9.0	Salmon Heaven Improvement Site, mid section, gravel retained by rock weir, redd #3 and 4
4	9.2	Salmon Heaven Improvement Site, upper section, gravel retained by rock weir, redd #3 and 4
5	9.2	Side channel, Salmon Heaven Improvement Site, upper section
Middle Reach		

6 13.6 50 m below Interstate Highway 5 bridge

7 13.9 150 m above Interstate Highway 5 bridge

8 14.8 1.1 river km above Interstate Highway 5 bridge

Upper Reach

9 56.6 Hole in the Ground Ranch, 2.2 river km above mouth of Parks Creek

10 59.1 Hole in the Ground Ranch, 5.5 river km below Dwinnell Dam

SOUTH FORK TRINITY RIVER

Lower Reach

1 0.2 100 m downstream of Highway 299 bridge

2 0.24 50 m upstream of Highway 299 bridge

3 1.3 Sandy Bar

4 1.4 Sandy Bar boat launch

Station RK Station description 1/

SOUTH FORK TRINITY RIVER

Lower Reach

5 23.2 0.6 RK upstream of Surprise Creek

Middle Reach

6 42.6 USGS gaging station, lower Hyampom Valley

7 49.1 100 m upstream of Curved Bridge, upper Hyampom Valley

Upper Reach

8 68.4 Road ford at McClellan Place (River Spirit Community)

9 89.5 250 m downstream of Highway 3 bridge near Forest Glen

10 92.2 0.5 RK upstream of confluence with Rattlesnake Creek

Potential Chinook Salmon Spawning Habitat		
11	118.0	SFTR, 300 m downstream of confluence with East Fork of the SFTR
12	5.2	East Fork of the SFTR, approx. 250 m upstream of USFS Road 30 bridge
13	0.1	Hayfork Creek, approx. 20 m downstream of Garret Road bridge

1/ Unless otherwise specified, samples were collected from the main channel of the Shasta River or SFTR

TABLE 4. Chinook salmon and potential spawning habitat quality measured in the Shasta River and South Fork Trinity River, 1994. (Small sediment = all sediment particles passing through a 4.75 mm sieve, Fines = all sediment particles passing through a 0.85 mm sieve)

Station 1/	RK	Small sediment (<4.75 mm)	Fines (<0.85 mm)
SHASTA RIVER			
Lower Reach			
1-A	0.8	56.6	31.6
1-B	0.8	57.3	36.6
1-C	0.8	50.1	29.8
2	4.3	48.6	48.2
3-A	9.0	40.1	32.9
3-B	9.0	62.9	55.0
4	9.2	43.1	20.8
5	9.2	47.2	23.6
Mean		50.7	34.8

Std dev 7.7 11.7

Middle Reach

6 13.6 62.4 39.3

7 13.9 64.8 39.8

8 14.8 45.5 29.8

Mean 57.6 36.3

Std dev 10.5 5.6

Upper Reach

9 56.6 54.4 41.5

10 59.1 50.8 22.3

Mean 52.6 31.9

Std dev 2.6 13.6

(Continued on next page)

TABLE 4 (continued). Chinook salmon and potential spawning habitat quality measured in the Shasta River and South Fork Trinity River, 1994. (Small sediment = all sediment particles passing through a 4.75 mm sieve, Fines = all sediment particles passing through a 0.85 mm sieve)

Small

sediment Fines

Station RK (<4.75 mm) (<0.85 mm)

SOUTH FORK TRINITY RIVER

Lower Reach

1 0.2 44.6 18.7

2 0.24 43.9 14.6

3 1.3 47.8 15.6

4 1.4 38.7 13.7

5 23.2 43.5 13.3

Mean 43.7 15.2

Std dev 3.3 2.2

Middle Reach

6 42.6 41.2 18.5

7 49.1 44.4 18.0

Mean 42.8 18.2

Std dev 2.3 0.4

Upper Reach

8 68.4 42.7 17.5

9 89.5 46.3 17.6

10 92.2 50.0 20.7

Mean 46.3 18.6

Std dev 3.7 1.8

TABLE 4 (continued). Chinook salmon and potential spawning habitat quality measured in the Shasta River and South Fork Trinity River, 1994. (Small sediment = all sediment particles passing through a 4.75 mm sieve, Fines = all sediment particles passing through a 0.85 mm sieve)

Small

sediment Fines

Station RK (<4.75 mm) (<0.85 mm)

SOUTH FORK TRINITY RIVER

Potential Spawning Habitat

11 118.0 42.7 18.9

12 2/ 5.2 37.9 14.1

13 3/ 0.1 52.5 23.5

1/ Unless otherwise specified, samples were collected from the main channel of the Shasta River or SFTR

2/ East Fork of the SFTR

3/ Hayfork Creek