Study 27

Scour and Deposition Effect on Incubation Habitat

Final
2015 Monitoring and Analysis Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM

January 2015

1.0 Scour and Deposition Effect on Incubation Habitat

Theme(s):

- Flow management
- Spawning and incubation

Related Question(s):

- SI-001a: Is spawning habitat quality in Reach 1A sufficient to support adequate egg survival and healthy emergent fry for both spring- and fall-run Chinook salmon?

- SI-001b: Is substrate permeability in Reach 1 sufficient for acceptable natural egg survival rates?

- SI-001c: Will fine sediment accumulation during incubation impair egg survival and/or alevin emergence in fall-run and spring-run Chinook salmon redds?

- SI-004: How do cumulative stresses (e.g., temperature, water quality, fine sediment, etc.) affect egg viability?

- SI-005: Will releasing pulse flows to attract fall-run Chinook salmon increase sand accumulation in spring-run redds?

- SI-006b: What are the mortality rates for newly emerged fry in Reach 1? Do current spawning habitat conditions (e.g., sand accumulation rates) result in "weak fry" that would have higher mortality than healthy fry?

- SI-008: If new spawning habitat is created, or existing spawning habitat rehabilitated, will future sand (fine bedload) quickly infiltrate spawning habitat and reduce the quality (longevity) of spawning habitat? How frequently would gravel improvements be needed?

- SI-009a: Is existing sand storage contributing to the infiltration into gravels in Reach 1, thereby negatively affecting the health and survival of fry?

- SI-009b: Will future Restoration Flows alter the fine sediment budget in Reach 1? Will this increase or reduce sand storage and fine sediment infiltration into redds?

- SI-009c: Does sedimentation negatively impact spawning in Reach 1? If so, are there strategies available to reduce its impacts (e.g., sedimentation basins, sediment removal, watershed rehabilitation)?

1.1 Statement of Need

The San Joaquin River Restoration Program (SJRRP) Restoration Goal is to "restore and maintain fish populations in good condition in the main stem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally-reproducing and self-sustaining populations of salmon and other fish." The SJRRP Fisheries Management Plan (SJRRP 2009) identifies spawning and incubation as a life stage to be supported for successful completion of the salmon life cycle. The SJRRP Spawning and Incubation Group agreed on a process for ensuring adequate spawning habitat is available to support fish populations, and a central effort in that process involves identifying the quality and quantity of spawning habitat. Several uncertainties exist as to the suitability for successful spawning in the existing stream bed within Reach 1A, which include adequate (1) hyporheic and surface water exchange, (2) flow depth and velocity, (3) sediment attributes, and (4) hyporheic water quality. The channel area that currently contain and is expected to maintain each of these attributes in high quality should be used to quantify the amount of suitable spawning habitat. Most of these attributes and their contribution to spawning and incubation habitat quality are dependent on the absence of fine sediment on the bed or within the redd. Though the spawning salmon may cleanse the gravels and cobbles of fines as she cuts into the bed, fine sediment can accumulate afterwards if it is transported by subsequent flows.

1.2 Background

After the completion of Friant Dam in the 1940s the reduced instream flow that ensued downstream resulted in a coarsened bed texture as finer grains were typically the only grains capable of being eroded. However, in addition to bed erosion, other processes such as erosion of stored bank deposits and floodplains, and fine sediment contributions during tributary flow events have, to some extent, maintained a supply of mobile sand in Reach 1A. It is generally accepted that the proportion of fine sediment (e.g. sand and finer) is inversely related to egg survival.

Multiple studies are currently underway or have been completed (including this study) to help identify the quality of the hyporheic environment as it relates to successful spawning, incubation, and fry emergence (see SJRRP 2013). These include efforts to evaluate water quality within the hyporheic zone (DO, water temperature, fine sediment accumulation), egg survival, spawning habitat use by trapped-and-hauled fall-run Chinook, bed material size and mobility, scour and deposition, and channel morphology changes associated with alteration to the flow regime. Recently, the USBR has proposed quantifying the spawnable area based on a layered approach of the above compilation of characteristics (see USBR 2013).

In 2009, DWR began a study designed to evaluate bed mobility within Reach 1A at two riffles approximately midway between Friant Dam and Highway 41. The result of this study is a measured and validated critical shear stress (preliminary Shield's numbers of 0.020 ± 0.003 at Riffle 38 and 40) for incipient entrainment of coarse bed material (i.e., gravel and cobble). With this primary input parameter for sediment transport formulae, the sediment transport rate for specified discharges can be predicted and, aided by a two dimensional (2D) hydraulic model, the area of mobilization will be delineated and quantified. Relevant to this study, this information will help inform the SJRRP as to the areas where scour may be an issue.

Between 2008 and 2011, Tetra Tech (2011) assessed sand storage and sources within Reach 1A. The amount of sand within the channel and the location of other sources are useful for understanding which areas are more susceptible to its deposition. Sand transported on the bed surface is much more likely to deposit between larger particles where it is sheltered from the force exerted by the flowing water. Such transport and resulting deposition can clog gravel interstices, reducing hyporheic ventilation. Several sand source areas were noted by Tetra Tech (2011), including eroding banks, bluffs, floodplain, and side channels. However, flows capable of accessing and eroding these storage sites are not known, and therefore, the change in sand storage and the rate of contribution to the channel from these sources are also presently unknown. Therefore, potential spawning beds downstream of these sand sources may be prone to sand deposition.

In 2011, DWR began *this* spawning gravel sand accumulation study in collaboration with the USFWS's egg survival study. Initial results indicate variable egg survival that correlates well with sand accumulation. Sand transport was observed to vary across the five study sites, which were evenly spaced between Friant Dam and Highway 41. The upstream-most site (at RM 266.7) experienced the least sediment transport and deposition, while these attributes generally increased with distance downstream. The greatest transport and deposition occurred at the fourth site downstream (RM 258.6). Transport and deposition of sand decreased at the fifth site (RM 255.5) relative to the fourth site. These results suggest local sources supplying sand, a translating sand pulse, and/or differential sand storage within the channel and are supported by sand mapping efforts by Tetra Tech (2011) and bed sample results collected by DWR (SJRRP 2012). Furthermore, results of *this* study demonstrate that the amount of sand being transported and deposited within the artificial redds is sufficient to inhibit egg survival.

In 2012, the USGS began monitoring the contribution of sediment provided by two intermittent tributaries within upper Reach 1A called Cottonwood Creek and Little Dry Creek. Though little, if any, coarse sediment is likely being supplied by these ephemeral streams, it is possible that they are providing sand-sized sediment to the main-stem San Joaquin River. Future monitoring results will provide information to quantify their contribution.

1.3 Anticipated Outcomes

This study is intended to investigate the effect of discharge on incubation habitat quality over the life span of a redd. The outcomes will include:

- Hydraulic conditions that encourage fine sediment deposition into the gravel framework of artificially constructed redds;
- Rate of fine sediment accumulation within a redd with respect to flow level; and
- Determination of whether expected Restoration Flow levels are capable of scouring the redd framework gravels; and
- Change in permeability within the redd with time as a function of fine sediment accumulation.
- Relationships between fine sediment accumulation and bed permeability with egg survival.

Collaboration with U.S. Fish and Wildlife (USFWS), and California Department of Fish and Game will combine studies to additionally measure dissolved oxygen and temperature in the redd interstices, as well as including salmon eggs for quantifying survivorship over time.

1.4 Methods

Type of Study: Field studies.

Reach: Upper Reach 1A at five sites evenly spaced between Highway 41 bridge and Friant Dam.

Study Sites: Five sites were selected where the amount and influence of fine sediment infiltration into redds will be measured. Each site was located immediately upstream of a riffle crest where flow velocities at base flow conditions were greater than 3 feet per second and flow depths were greater than 1.5 feet. These sites were chosen to span the anticipated higher quality spawning habitat in upper Reach 1A and evaluate for a gradient in fine sediment accumulation relative to sediment sources and/or distance downstream. To establish this monitoring program we artificially constructed redds and installed scour chains. Tasks performed to characterize site conditions will include bed material size analysis, hyporheic flow monitoring, scour chain monitoring, flow profile surveys, and bed load transport monitoring.

Sand Accumulation: Pairs of redds were constructed with the intention of sampling each over time. Artificial redds were constructed by raking and shoveling into the bed to a depth of 1 foot below the bed surface. Upon reaching redd bottom a collapsed sediment retrieval bag was inserted at the redd's bottom. The sediment bags were then buried in bed material that was cleaned of sediment finer than 6.5mm. Cables attached to the bag that stretched to the bed surface allowed its retrieval along with that of the overlying redd framework particles and accumulated fines. The first bag was retrieved typically halfway through the incubation period; and the second was pulled after the incubation period was over. These two samples were intended to capture a trend of increasing fines with time and flow levels. Each sample was sieved using sieves approximately scaled to ½ phi intervals. Mass retained in each sieve was weighed and recorded.

Hyporheic Flow and Water Quality Monitoring: Additionally, at least three perforated pipes were inserted into each redd for subsequent permeability and DO measurements from within the redd (see Lisle and Eads, 1991). Each pipe targeted the 12 inch depth below the bed surface. The pipes allowed these measurements with minimal disturbance of subsequently deposited fine sediment. Collaborators from the USFWS, and California's Department of Fish and Game performed temperature and DO measurement activities as part of companion studies.

Scour Chain Monitoring: Scour chains were installed in the vicinity of the artificial redds with the intention of measuring the total scour depth. Each chain was fitted with a duck bill anchor to avoid chain loss due to erosional forces. Each chain was driven into the stream bed with hand tools to a depth of approximately 3 ft. The number of remaining links exposed on the bed surface was noted and the link closest to the bed's surface was marked with a hog ring. No other marking was used so as to avoid potential hampering.

Flow Profile Surveys: The flow depth and velocity was monitored above each redd during the course of each monitoring study. As flow levels change we measured the depth and velocity at characteristic levels for each monitored period. Either an acoustic Doppler current profiler (ADCP) or acoustic Doppler velocimeter (ADV) was used to measure the flow velocity. The flow velocity was compared to accumulated sand and bedload transport samples for the purpose of determining their relationships.

Bed Load Transport Monitoring: Bed load transport was measured in the vicinity of each redd over the course of each monitored period. A hand held bedload sampler with a 3 inch square opening and 0.125 mm mesh bag was used to collect bed load samples at wade-able flows. As flow levels changed efforts were made to collect samples at characteristic flow levels for each monitored period. The transport rates were compared to accumulated sand samples for the purpose of determining the trap efficiency of clean gravels at each site.

1.5 Deliverables and Schedule

The field component of this study began in November 2011 and ended in 2012. To date, field data and interim results have been presented in the previous Annual Technical Reports. A final technical memorandum will present trends in egg survivorship and health of fry in relation to changes in location, permeability, bed load transport, and fine sediment accumulation. The final memorandum, which will require inter-agency cooperation, is anticipated by December 2014 dependent upon schedule compatibility.

1.6 Budget

The total cost estimate is $30,000 for 2015.

Table 1-1. Proposed 2015 Budget

Task	Cost
Reporting	$30,000
Total	$30,000

1.7 Point of Contact / Agency Principal Investigator

Matthew A. Meyers / California Department of Water Resources
(559) 230-3329
mmeyers@water.ca.gov

1.8 References

Lisle, T.E., and R.E Eads. 1991. Methods to measure sedimentation of spawning gravels. U.S. Forest Service. Research Note PSW-411. 7 pp.

SJRRP Fisheries Management Work Group (FMWG). 2009. Conceptual models of stressors and limiting factors for San Joaquin River Chinook salmon. 178 pp. June.

SJRRP (2012), Appendix D Sediment, in 2011 Final Annual Technical Report.

SJRRP (2013), Monitoring and Analysis Plan Final, November 2012. Section 3.6 Spawning and Incubation.

Tetra Tech. 2011. Draft Evaluation of Sand Supply, Storage, and Transport in Reach 1A and 1B. In Preparation.

USBR (2013), San Joaquin River Spawning Gravel Suitability Study, San Joaquin River Restoration Project, Draft Version 3/15/13.