Study 30

San Joaquin River Spawning Habitat Assessment – Incubation Environment

Public Draft
2014 Monitoring and Analysis Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM

September 2013

San Joaquin River Spawning Habitat Assessment – Incubation Environment

Scope of Work

Spawning & Incubation Group Study Workplan

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Introduction

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 identifies spawning and incubation as a life stage to be supported for successful completion of the salmon life cycle.

SJRRP's current understanding of the system is that sufficient availability and quality of spawning habitat within Reach 1 of the San Joaquin River is imperative to sustaining a population of Chinook salmon. For the purposes of this workplan spawning habitat is defined as habitat that will produce the desired outcome from spawning, with the desired outcome being a large proportion of the fertilized eggs will survive and add to the out-migrating cohort. This includes the allowance of the successful completion of spawning, redd construction, egg incubation, and fry emergence. Successful salmon spawning survival-to-emergence is often dependent upon the physical habitat quality of the incubation environment, as determined by limits to gravel size and the presence and accumulation of fine sediment, which directly affect gravel permeability, intragravel flow (i.e., apparent velocity, and vertical hydraulic gradient (VHG)), and hyporheic water quality parameters (e.g., DO, temperature, etc.) at the egg incubation pocket (Kondolf et al., 2008).

As per the report of Restoration Objectives for the San Joaquin River prepared by Stillwater Sciences in 2003, Stillwater's restoration objective designed to support successful salmon egg incubation and fry emergence was to "maintain average gravel permeability rates of approximately 2,000 cm/hr (or higher) in spawning areas to support at least 30% survival-to-emergence rates." This restoration objective is based on the highly significant relationship of gravel permeability rates to survival-to-emergence ratios of Tagart (1976) and McCuddin (1977), which were applied to the average of two potential spawning riffles in the uppermost areas of Reach 1 that resulted in ratios of 43% and 17%. Stillwater incorporated this averaged 30% survival-to-emergence ratio into salmon population modeling and determined that even modest reductions in survival-to-emergence can have serious consequences for the salmon population. With a survival-to-emergence ratio reduced to 15%, neither fall-run nor spring-run salmon populations will be self-sustaining. Three other potential spawning riffle sites were sampled downstream resulting in survival-to-emergence ratios of 20%, 21% and 12%, respectively.

Recent results from several studies confirm that fine sediment (transport and deposition) increases downstream, and also suggest local sources of supply sand, a translating sand pulse, and/or differential sand storage with the channel (SJRRP, 2012; Tetra Tech, 2012a, 2012b; USBR, in press). As sand is transported and subsequently deposited, this fine sediment accumulation clogs gravel interstitial spaces thereby reducing gravel permeability, intragravel flow, and therefore reducing hyporheic water quality parameters. The amount of sand being transported and deposited in the San Joaquin River is sufficient to inhibit egg survival.

Based on the results that fine sediment accumulation of sand increases downstream and can inhibit egg survival on the San Joaquin River, and Stillwater (2003) gravel permeability rates are all well below the restoration objective except for the most upstream site, significant uncertainties persist as to the suitability of the existing streambed incubation environment for successful salmon spawning survival-to-emergence habitat within Reach 1A.

(1) What are the magnitudes, variability, and extent of gravel permeability and intragravel flow in the existing streambed incubation environment of the San Joaquin River?

    - Does the existing streambed allow for suitable levels of gravel permeability (i.e., 2,000 cm/hr or greater) in the incubation environment of naturally created redds that maintain and support a critical threshold (30% or greater survival-to-emergence ratio) for a self-sustaining salmon population?

(2) What are the existing conditions of gravel permeability and intragravel flow within the incubation environment of natural redds that were created as a resulted from the fall 2012 and in the future fall 2013 trap-and-haul adult Chinook salmon transport study?

    - What are the magnitudes, variability, and extent of gravel permeability of the potential spawning areas proximal to the fall 2012 and fall 2013 natural redds?

Insight provided by answering these questions will provide options for enhancing spawning area quantity and quality. Comparison of gravel permeability and intragravel flow criteria within the scientific literature will allow us to develop reasonable expectations for spawning survival-to-emergence success with and without management actions (e.g., ripping, gravel augmentation, gravel cleaning, etc.), thereby allowing prediction of net benefit gained for an incurred cost.

Therefore, the work Reclamation proposes within this scope of work seeks to answer these critical uncertainties of the incubation environment within Reach 1. Assessing and mapping salmon incubation habitat quality and quantity by measuring gravel permeability, intragravel flow, fine sediment bedload, and percent of fines in bed material will provide necessary insight to whether naturally created redds meet the restoration objective of 30% or greater survival-to-emergence, and what are the factors inhibiting suitable incubation environment quality and quantity (e.g., accumulation of fine-sediment). Gravel permeability, and intragravel flow studies have demonstrated to be an accurate (highly significant) and cost-effective predictor of Chinook salmon (*Oncorhynchus tshawytscha*) egg incubation and emergence success (Barnard and McBain, 1994; McBain and Trush, 2001; Stillwater, 2007, etc). In addition, there are many permeability and intragravel flow studies throughout the Central Valley to evaluate and compare the salmon incubation environment with that of the San Joaquin River.

Purpose

The work Reclamation proposes within this scope seeks to answer critical uncertainties (see above Introduction questions) related to the incubation environment within Reach 1. These uncertainties of the salmon incubation environment quality and quantity will be investigated by directly measuring gravel permeability, intragravel flow, fine sediment bedload, and percent of fines in bed material at naturally created Chinook salmon redds and their surrounding areas of potential spawning habitat. Insight provided by answering the critical uncertainties in determining whether or not the incubation environment meets the restoration objective of 30% or greater survival-to-emergence, will provide options for enhancing spawning through emergence area quantity and quality. Comparison of gravel permeability and intragravel flow criteria with the scientific literature will allow us to develop reasonable expectations for spawning survival-to-emergence success with and without management actions (e.g., ripping, gravel augmentation, gravel cleaning, etc.), thereby allowing prediction of net benefit gained for an incurred cost.

Goals

The Spawning & Incubation Group identified task elements of investigating gravel permeability, intragravel flow, hyporheic water quality parameters, sediment (i.e., fine sediment accumulation and percent fines in bed material) at and near natural redds as essential for delineating suitable spawning habitat on the San Joaquin River. The goal of this study is to determine the survival-to-emergence success for natural redds in Reach 1 by using the highly significant relationships of gravel permeability and intragravel flow to predict survival-to-emergence ratios derived from Tagart (1976), McCuddin (1977), and Stillwater (2007), as well as determine factors (e.g., accumulation of fine sediment and percent fines in bed material) that may limit self-sustaining salmon populations by resulting in a survival-to-emergence less than the restoration objective of 30%. Incubation habitat quality parameter maps resulting from this study will be used in providing quantitative measures as first-order data layers that are critical to SJRRP's immediate need of quantifying potential spawning habitat (see Spawning and Incubation Group's Process Document, in press).

Objectives

The Reach 1 salmon incubation environment quality and quantity will be investigated by directly measuring gravel permeability, intragravel flow, fine sediment bedload, and percent of fines in bed material at natural redds and their surrounding areas of potential spawning habitat to:

(1) Predict survival-to-emergence from indices for the natural redds mapped in fall 2012 by measuring gravel permeability at the mean egg pocket depth, and sampling redd bed material before fall 2013 spawning occurs.

(2) Determine fine sediment transport and accumulation at the natural redds mapped in fall 2013 by measuring fine sediment bedload transport at the leading and tailing faces of the redd.

(3) Predict survival-to-emergence from indices for natural redds mapped in fall 2013 by measuring gravel permeability, intragravel flow, and sampling redd bed material at the mean egg pocket depth post-emergence of fry.

(4) Determine the magnitude of fine sediment accumulation in natural redds by collecting and comparing the percent fines in bed material samples from fall 2012 and fall 2013 redds.

(5) Establish currently unknown baseline data by delineating the magnitudes, variability, and extent of post-disturbance gravel permeability for potential spawning gravel areas near the mapped fall 2012 and 2013 natural redds in relation to the restoration objective (i.e., 2,000 cm/hr or greater permeability). Establishing initial conditions will allow for detecting trends/relationships and changes that occur within a site, or between sites (e.g., comparing data measured as similar geomorphic features), and establish a baseline for monitoring these attributes through time.

(6) Develop incubation habitat quality parameter maps from gravel permeability and intragravel flow data for use in providing quantitative measures in the layered habitat suitability index (HSI) approach to quantifying existing spawning through emergence habitat. These first-order data layers are critical to SJRRP's immediate need of quantifying potential spawning through emergence habitat (see Spawning and Incubation Group's Process Document, in press).

Study Design

Fall 2012 Mapped Natural Redds

In order to capture critical data from the approximately fourteen mapped fall 2012 natural redd locations before it's lost by possible disturbance from fall 2013 salmon spawning and redd creation, gravel permeability, VHG, and bed material data will be collected.

<u>Post-emergence</u>

- Gravel permeability will be measured at the mean egg pocket depth by advancing a temporary stainless steel standpipe piezometer and using an electric vacuum pump to extract a flux (volume/time) from the standpipe that can converted to gravel permeability (Barnard and McBain, 1994; McBain and Trush, 2001; Stillwater, 2003, 2007; and Terhune, 1958).

- VHG data will be collected by measuring the difference in water levels from the top of the standpipe, the depth-to-water both inside and outside the standpipe.

    - If the VHG is too small to measure manually without confidence, VHG will not be measured in the mapped fall 2012 redds. Rather VHG will be measured in the mapped fall 2013 (post-emergence) with continuous pressure/temperature sensors.

- Redd bed material will be collected subsequent to measuring gravel permeability and VHG to assess salmon preferred sediment gradations, as well as the percent fines within the redd.

Fall 2013 Mapped Natural Redds

The incubation environment investigation is partially contingent on the success of the fall 2013 trap-and-haul study (see 2014 MAP) that transports tagged adult Chinook salmon up to Reach 1 for spawning. Once natural redds are detected, their coordinate location will be recorded with GPS.

<u>Pre-emergence</u>

- Fine sediment bedload transport will be measured, prior to the estimated emergence, at the leading and tailing faces of the redd.

<u>Post-emergence</u>

- Gravel permeability will be measured similar to the fall 2012 mapped natural redds, and shortly after emergence has occurred.

- Intragravel flow data (i.e., apparent velocity and VHG) will be measured at the mean egg pocket depth using continuous pressure/temperature sensors placed inside a temporary piezometer at the middle of the perforated band, and one attached to the outside of the temporary piezometer at the stream bed surface elevation. Each natural redd will contain a temporary piezometers with sensors for a minimum of 72 hours.

    - Apparent velocity will be measured by differences in diel temperature at the egg pocket depth relative to the streambed surface and time lags between minimum and maximums.

    - VHG will be measured by recorded by the differences in hydraulic pressures at mean egg pocket depth relative to the bed surface. This pressure difference will provide continuous VHG data (similar to differences in measured water levels) from inside and outside the standpipe, but at a finer resolution.

- Redd bed material will be collected to assess salmon preferred sediment gradations, as well as the percent fines within the redd.

Data Processing & Analysis

- Survival-to-emergence ratios from the fall 2012 and 2013 mapped natural redd locations will be derived from the highly significant relationships with gravel permeability from the indices of Tagart (1976) and McCuddin (1977), as well as relationships determined recently by Stillwater (2007) in an artificial redd study on the nearby Tuolumne River, Central California.

    - Survival-to-emergence ratios determine by Stillwater (2007) resulted in lower than expected than predicted ratios from that of Tagart (1976) and McCuddin (1977). This may be an outcome of artificial redd construction or a factor to the conditions in the Tuolumne.

  - How do survival-to-emergence ratios compare from 2012 and 2013 mapped natural redds?
    - Gravel permeability measured from 2012 and 2013 natural redds collected within the same spawning areas allow comparisons in data that may differ from accumulation of fine sediment over time.

- Survival-to-emergence ratios from the fall 2012 and 2013 mapped natural redd locations will be derived from the highly significant relationships with apparent velocity as identified by Stillwater (2007) in an artificial redd study on the nearby Tuolumne River, Central California.
  - This intragravel flow is influenced by the magnitude of the downwelling VHG if gravel permeability is held constant. In contrast, a changing gravel permeability (i.e., from accumulation of fine sediment) will affect apparent velocity if VHG is held constant as generally observed on the San Joaquin River due to long regulated release flow bench periods.

- Survival-to-emergence ratios from the fall 2012 and 2013 mapped natural redd locations will be derived from the highly significant relationships with natural redd bed material gradation data from the index of Tappel and Bjornn (1983).
  - How do the survival-to-emergence ratios compare from 2012 and 2013 mapped natural redds?
    - Bed material samples from 2012 and 2013 natural redds collected within the same spawning areas will allow comparison of percent fines and accumulation of fine sediment over time.
    - Fall 2012 redds will have been accumulating fine sediment for approximately 11 months during relatively low regulated flow releases before bed material sampling occurs. The difference of the 2012 redds to the 2013 redds, which will have been constructed for approximately only 3 months before sampling occurs, may provide insight to the relatively continuous rate in linear accumulation of fine sediment onto the natural redd.
    - The bedload samples collected at the 2013 redds will provide an independent measurement in refining the rates of fine sediment accumulation onto natural redds in Reach 1.

- Refinement of survival-to-emergence relationship to gravel permeability, intragravel flow, and bed gradation data.
  - How does the San Joaquin River differ from relationship of survival-to-emergence and the incubation environment of other Central California rivers, and the indices derived from Tagart (1976), McCuddin (1977), Stillwater (2007), and Tappel and Bjornn (1983)?

- Based on the successful emergence trapping of natural redds as in the proposed USFWS' Fall 2013 Egg Survival and Emergence Study (see 2014 MAP), adjacent and/or nearby natural redds, if any, that are not capped and not excavated post-emergence will allow for the measurement of gravel permeability, intragravel flow, and bed material collection. These data and their proximal location from the trapped redd emergence counts from the USFWS proposed study, will permit refining survival-to-emergence relationships specific to the San Joaquin River relative to the incubation habitat quality parameters measured.

- Develop incubation habitat quality parameter maps from gravel permeability, intragravel flow, and bed material data for use in providing quantitative measures in the layered habitat suitability index (HSI) approach to quantifying existing spawning habitat.
    - These first-order data layers are critical to SJRRP's immediate need of quantifying potential spawning habitat (see Spawning & Incubation Group's Process Document, in press).

Deliverables

Deliverables for this effort will consist of a preliminary Technical Memorandum (TM) and final TM as well as ATR updates documenting methods utilized to complete the aforementioned tasks. In addition, a geodatabase compiling GIS layers (vector and raster) of raw and interpolated distributions for each incubation habitat quality parameter will be provided for quantitative measures in the layered habitat suitability index (HSI) approach to quantifying existing spawning habitat. These layers include, but are not limited to the: (1) gravel permeability, (2) vertical apparent velocity,(3) vertical conductivity, (4) vertical/horizontal hydraulic conductivity anisotropy ratios, (5)redd bed material data of redds, and (6) survival-to-emergence derived from incubation quality parameters.

Schedule

Implementation of field work will begin mid to late September 2013 and end in winter 2014. Initial scope of data analysis will begin in late fall to early winter 2013 and will be completed in spring 2014. A draft TM and GIS geodatabase will be provided for comments in May 2014, with final deliverables completed no later than June 30, 2014.

Budget

1. <u>Equipment – EXISTING (expected cost = **$0.00**)</u>
    a. McBain Modified Electric Vacuum Pump (CA DWR)
    b. Slide Hammer (USBR)
    c. GPS/Compass (USBR)
    d. 14' Aluminum Jon Boat/Trailer/Oars/PFD (USBR/SJRRP/TSC)

   e. Vehicle w/ tow-hitch (USBR)
   f. Temporary standpipe piezometers for deploying continuous sensors (USBR/CA DWR)
   g. Pressure/Temperature sensors for measuring intragravel flow (USBR)
   h. Helley-Smith hand-held bedload sampler (CA DWR)
   i. Course and fine material sieves for bed material sample processing (CA DWR)
   j. Water level meter (USBR/CA DWR)

2. Equipment – NEW (expected cost = **$280.00**)
   a. Modified Terhune Standpipe
      i. One (1) Schedule 40 stainless steel, I.D. 2.54 cm w/ drive point. ($150)
      ii. Steel drill bits (to drill perforation holes) ($30)
      iii. Folding wooden measuring tape ($25)
   b. Helley-Smith hand-held sampler baseplate (fabricated by USBR = $75)
3. Staff Time –TSC daily rate ($488) (expected cost (maximum) = **$37,576.00**)
   a. USBR/SJRRP lead staff (55 days x $488/day = ≤ $26,840)
      i. Gravel permeability (≤ 10 days)
      ii. Intragravel flow (≤ 6 days)
      iii. Bed material sampling (≤ 12 days)
      iv. Bed material processing (≤ 12 days)
      v. Data processing & Analysis/Deliverables (≤ 15 days)
   b. Staff Assistant (USBR/CA DWR/CA DFW) (≤ 22 days x $488/day = $10,736)
      i. Gravel permeability (≤ 10 days)
      ii. Bed material sampling (≤ 12 days)
4. Travel/Hotel/Meals & Incidentals (expected cost = **$0.00**)

Proposed Study Budget, Total = Maximum of $37,856.

Point of Contact/Agency & Responsibilities

Andy J. Shriver (USBR): Principal Investigator, Project planning, field deployment and data collection, data processing & analysis, and reporting. (ashriver@usbr.gov/253.720.5585)

Erica Meyers (CA DFW): Co-PI, Assisting in the implementation of study.

Matthew Meyers, P.G. (CA DWR): Co-PI, Assisting in the implementation of study.

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