Study 8

Egg Survival (Fall 2012)

Public Draft
2013 Monitoring and Analysis Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM

September 2012

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1. Statement of Need

The Restoration Goal of the San Joaquin River Restoration Program includes the return of viable, long-term and sustainable populations of naturally-producing spring and fall-run Chinook salmon. To realize restoration of the Lower San Joaquin River salmon populations, successful completion of the freshwater portion of the lifecycle must occur. A proposed component of this goal is the importation of salmon embryos from an appropriate source and incubation of those embryos within the lower river to successful emergence. For this to occur, the gravel environment must not only meet the requirements of spawning females, it must allow for successful incubation and emergence. While it has been hypothesized that an appropriate spawning and incubation matrix is available, the last salmon to successfully spawn in the lower river was over 5 decades ago (McBain and Trush 2002). Therefore, the suitability of the available habitat must be fully evaluated. Specific variables that contribute to suitability for incubation and emergence include hyporheic temperature, permeability, dissolved oxygen and the sediment size composition and sedimentation rate that contribute to the values of those variables.

This study addresses several limiting factors (i.e., sedimentation, streamflow, temperature, gravel quality and quantity, dissolved oxygen) to the "Healthy Fry Production" life stage (via egg survival) of Chinook salmon (FMWG 2009a); and provides the necessary information on existing conditions to inform the reintroduction of salmon by 2012 by identifying factors that may contribute significant mortality to introduced salmonids.

2. Background

Incubating salmon eggs require appropriate conditions (temperature, spawning gravel size distribution, water quality including DO and pH, etc) to survive and hatch successfully. Field studies indicate there may be a significant amount of sand and other fine sediments in the areas otherwise perceived to be adequate spawning habitats (DWR – Grain Size Analysis). The infiltration of these materials into the redd, in addition to poor water-quality conditions (in the hyporheic environment) may result in decreased survival of eggs and prevent the SJRRP from meeting the targets identified in the Fish Management Plan (FMWG 2009a).

Spawning gravel and water quality assessments are considered important components in the San Joaquin River Restoration Program. This program covers a large extent of the San Joaquin River from Friant Dam to the mouth of the Merced River and involves fish passage improvements and flow rehabilitation. Recently, restoration flows to the San Joaquin River have been implemented as a first step towards developing a Chinook salmon (*Oncorhynchus tshawystcha*) fishery (FMWG, 2010). During spawning activity and redd construction, Chinook eggs are buried in the substrate, at depths from ca. 30 cm (e.g., DeVries 1997) to 45 cm (Geist 2000). This relatively deep substrate region is often in the zone of surface water and groundwater interaction, typically referred to as the hyporheic zone. Hyporheic conditions within the redd may differ markedly from those found at the surface (e.g., Soulsby, et al. 2001). Hyporheic conditions may vary widely for different redds because of variation in channel morphology, groundwater connectivity, and substrate permeability (Arntzen, et al. 2006).

Intragravel DO criteria concentrations set for the protection of salmonids (EPA 1986) include mean values of 6.5 mg/L and 1-day minimum of 5.0 mg/L ambient DO. Other literature, however, does not support these criteria. Ingendahl (2001) identified a critical DO limit for successful emergence of 7.0 mg/L, while Maret, et al. (1993) found that intragravel DO concentrations above 8.0 mg/L generally increased survival of eggs and larvae in the redd environment. Davis (1975) indicated that 9.74 mg/L is ideal for mature eggs and salmonid larvae and suggested that an average member of the species (at this life stage) will start to exhibit oxygen distress when DO falls to 8.09 mg/L. Malcolm, et al. (2003) found that salmonid embryo-to-hatch mortality rates were near zero at mean DO concentrations of about 11.7 mg/L. Chapman (1988), in a review of the literature, concluded that any decrease in DO below saturation probably reduces survival to emergence or post-emergent survival. Lowest DO’s typically occur early in the life history during August/September when water temperatures are relatively warm. In the SJR this period is when it is expected that the spring run of Chinook salmon would be spawning. Davis (1975) suggests that there is less demand for DO early in the incubation stages. If this is true, levels that drop even as low as 1.14 mg/L may do little harm (Davis 1975), if only early eggs are exposed to these concentrations. Other researchers, however, indicated that pre-eyed eggs may be especially sensitive to low DO because of their dependence on diffusion for oxygen (Wickett 1954, Reiser and White 1990). Brown and Hallock (2009) reviewed DO water quality standards of Pacific Northwest (PNW) government agencies. The review included western states, tribes, and the Canadian province of British Columbia and found that 1-Day minimum criteria ranged from 5 to 8 mg/L. This variance in values reflects the near absence of studies dealing with this critical issue.

Recent spot checks of DO using hyporheic pot samplers in the San Joaquin indicate that DO may be very low (ca. 2 mg/L) at some locations and that there may be diurnal variation in these values. In-stream photosynthesis causes highest DO to occur in the late afternoon, with lowest readings often recorded just before daybreak. In some parts of the San Joaquin, it appears that dense periphyton growth may play a role in these DO shifts. Intragravel DO monitoring to date has only occurred during daylight hours and it is important to consider DO concentrations at different times that may impact early life-stage salmonids. The other important consideration is the absence of clarity on the impacts of low DO’s on the egg stage of salmonids. The present proposal addresses San Joaquin intragravel continuous DO monitoring and spatial characteristics, periphyton biomass, and salmonid egg survival.

Fall 2011 Friant Dam flows were approximately 100 cfs for a prolonged period due to scheduled downstream maintenance at Mendota Dam. These low flows may have resulted in conditions that would not be typically encountered by spawning salmonids.

Temperature appears to be an impediment to egg survival in the San Joaquin River. Results of fall 2011 monitoring challenged existing assumptions about timing and location of spawning below Friant Dam, and the influence of flow rate on surface-groundwater interaction. Flows of approximately 350 cfs maintained DO in a suitable range for salmonid spawning and incubation. Hyporheic DO declined during the fall pulse in mid-October and later in the season when flows were less than 350 cfs.

3. Anticipated Outcomes

The objective of this study will be to determine egg survival under current spawning conditions in the Restoration Area. Additionally, this work would indicate the relationship between egg survival and several environmental parameters in the restoration area (e.g., particle size, hyporheic water quality, distance downstream from Friant Dam, etc.). Additionally, it will provide the Program with critical information on the suitability of spawning habitat for egg survival in the Restoration Area. Finally, this information will also help the FMWG make decisions on how to best manage and/or recommend restoration actions in the perceived spawning areas in the Restoration Area.

This study provides continuous DO, temperature, and conductivity data during different flow rates, as well as estimates of fine sediment infiltration, and associated egg survival. This information allows for potential links between flow rate, DO, temperature, and fine sediment in the hyporheic zone, with egg survival which may be useful for determining optimal flow releases to provide optimal conditions for incubating Chinook salmon eggs. This information would be taken into account during the Interim Flows scheduling process, and in determining sites for priority habitat restoration actions.

4. Methods

a. Egg Survival

USFWS, DFG and DWR will construct several artificial redds using fall-run chinook salmon eggs (October/November 2012) to document the impacts of conditions on the survival of those eggs. While fall run spawn later than spring run, there is overlap with the timing and we will pursue early spawning Feather River fall run to improve the temporal aspects of the study. Spring run Chinook eggs cannot be utilized by the program prior to the approval of the Section 10 permit for take of spring run Chinook salmon. Methods will follow Merz et al (2004).

We will continue to investigate the effect of longitudinal gradient, surface water parameters, hyporheic water quality, substrate composition, permeability, and fine sediment accumulation on egg survival, and will construct artificial redds at five riffles from Friant Dam downstream to the Skaggs Bridge where suitable spawning habitat exists.

Embryo survival will be compared with physical habitat characteristics and evaluated against modeled predictions of survival based on particle size (Tappel and Bjornn 1983), substrate permeability (Tagart 1976; McCuddin 1977), and water quality parameters (Merz et al 2004).

b. Water Quality

Reclamation will install continuous dissolved oxygen/temperature, and conductivity monitoring equipment along with an airstone and tubing (for discrete sample withdrawal) at approximately 6 intragravel locations (ca. 30 cm depth) per site (5 riffle sites, 30 sensor locations total). At each riffle site, one surface water DO/temp and conductivity sensor will be installed.

It is expected that equipment will be installed during the mid-September. Site visits and monitoring would occur September 2012 – January 2013 when equipment would be removed for analyses.

c. Hydraulics

Water surface elevation and channel cross-section data will be collected over the range of flows available during the study period upstream and downstream of riffles where hyporheic water quality monitoring equipment are installed. These data will be used in analyses of site-specific groundwater interaction changing with flows.

5. Schedule

Fall-run eggs will be placed in Oct./Nov of 2012.

Water quality, sedimentation, and hydraulics monitoring will occur mid-September 2012-January 2013.

6. Budget

a. Equipment

New equipment for fall 2012:

Conductivity sensors: 30 x $600/each= $18,000

DO sensors: 18 x $1100/each= $19,800

b. Staff time

USFWS budget: Funding for this effort was requested through the 2012 MAP. This study plan simply represents an update to actions that will occur in 2012.

7. Deliverables: Draft and Final Reports to the Annual Technical Report. Data collected will be evaluated along with 2011 data to determine if relationships observed in 2011 are consistent with 2012 results.

8. Point of Contact/Agency and responsibilities:

Michelle Workman, PI, USFWS; secure fall-run egg source, egg transport, placement, and survival evaluation, report preparation

Mark Nelson, PI, Reclamation: placement and analysis of intergravel DO, temperature and conductivity sensors and analysis of groundwater/surface water interactions, report preparation

Matt Bigelow, PI, DFG: coordination of field crews, site access, report preparation

Matt Meyers, PI, DWR: analysis of fine sediment accumulation, grain size analysis, permeability, report preparation

8. References

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