Session 1: Adult Chinook salmon: Fall and Spring-run Reintroduction

Adult Fall-run Chinook salmon Trap and Haul, San Joaquin River, California

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A primary goal of the San Joaquin River Restoration Program (Program) is to reintroduce a self-sustaining population of Chinook salmon (*Oncorhynchus tshawytscha*) to the San Joaquin River. Fall-run Chinook salmon passing the Hills Ferry Barrier, near the confluence of the San Joaquin River and Merced River were captured and translocated from furthermost downstream end of the Restoration Area (Reach 5) to the uppermost section (Reach 1), circumventing non-navigable obstacles that currently block migration routes, to study behavior and spawning site preference prior to reintroduction. Bureau of Reclamation and California Department of Fish and Wildlife biologists performed trap and haul efforts to capture and move 119, 367, and 510 Chinook salmon from 2012–2014, respectively. Salmon were captured using fyke nets in the mainstem San Joaquin River, Mud and Salt Slough, and near the confluence of the San Joaquin River with the Eastside Bypass, and using dip nets at the terminal end of irrigation canals. Once captured, length, gender, reproductive stage, photographs, and a tissue sample for genetic analysis were collected. Individuals were then transported upriver from Hills Ferry Barrier (Approx. river mile 119) to Camp Pashayan (Approx. river mile 243) for release. Salmon were marked with external tags denoting gender and an individual fish number for ease of identification in the water column, and to reference specific individuals during post-spawning carcass surveys. A portion of female salmon were additionally tagged and tracked using intragastrically implanted acoustic transmitters. Acoustic transmitter data were used to further determine spawning locations, as well as to derive how fish moved throughout the system under a variety of environmental factors. While the majority of fish were released back into the San Joaquin River, some fish were retained for artificial spawning and incubation purposes, as a means to supplement a variety of juvenile outmigration studies. Salmon released into Reach 1, naturally produced more than 70 spawning redds in 2013 and 2014.

Acoustic telemetry of adult fall-run Chinook salmon (Oncorhynchus tshawytscha) migration, San Joaquin River, California

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Since 2012, the San Joaquin River Restoration Program (SJRRP) has been trapping adult fall-run Chinook salmon (Oncorhynchus tshawytscha) in Reach 5 and adjacent sloughs and transporting them to spawning habitat in Reach 1 of the Restoration Area. Portions of the captured fish were intragastrically implanted with Vemco© V13 coded transmitters in 2012 (n=34), 2013 (n=52), and 2014 (n=108). While both males and females were tagged in 2012, only females were tagged in 2013 and 2014. These tagged fish were tracked actively using a Vemco VR100 hydrophone and passively using approximately 20 stationary Vemco© VR2 69Hz acoustic receivers in Reach 1 between the SR 99 Bridge (RM 242.2) and Friant Dam (RM 267). Data from these tagged fish are used to understand survival post-transport, migration speed and distance, habitat utilization, and behavior. Data suggest that early arriving salmon exhibit an active searching pattern during their upstream migration from the release site, whereas the later arriving salmon tend to utilize a more opportunistic behavior for spawning site selection.

Spawning behavior and habitat selection of Chinook salmon (Oncorhynchus tshawytscha) within the San Joaquin River, California

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Recent studies have found that salmonid spawning habitat selection is related to fish size of the female spawner. Current scientific literature suggests that this, along with the tendency of salmon to return to their natal stream to spawn, may support genetic diversity and population resilience through reproductive isolation by limiting the successful spawning to a particular size of fish. Therefore, observations of the spawning behavior and habitat selection of female Chinook salmon (*Onchorynchus tshawytscha*) as related to fish size is beneficial in evaluating present conditions within San Joaquin River in determining future population success of a reintroduced species. Using acoustic telemetry, individual females from the 2013 and 2014 fall-run trap-and-transport efforts on the San Joaquin River were linked to the specific redds they created. This linkage allows for each female's spawning behavior to be independently observed and analyzed based on the characteristics (e.g., size, date and location of capture/release, age, stream of origin, genetic signature) of that female. When combined with data from other studies (e.g., trap and transport, redd and carcass surveys, stationary acoustic receivers), it is possible to determine, for each individual female, the time from release to spawning, the distance traveled between release to the selected spawning site, and the approximate time spent to construct, spawn in, and guard their redd. Additionally, linking individual females of a known size to specific redds allows detailed exploration of the relationship between fish size and habitat preference, such as substrate composition (e.g., D16, D50, D84 particle sizes), threshold particle size (i.e., largest particle moved during redd construction), redd size, and hydraulic conditions (i.e., flow and depth). These attributes provide insight to spawning behavior and habitat selected and its physical limitations to spawning success as a function of fish size. This work could inform what type of spawning habitat variability is required, if future spawning habitat improvement actions are performed, to ensure that a reintroduced population maintains a variation in fish size and genetics through time.

Fish Passage Evaluation

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An important goal of the San Joaquin River Restoration Program (SJRRP) is to restore a self-sustaining Chinook salmon fishery in the San Joaquin River. In order to meet this goal, the SJRRP will release flows and perform structure modification to provide unimpeded fish passage at known barriers. The Department of Water Resources has been conducting fish passage evaluations to meet this goal by identifying structural barriers to adult Chinook salmon within the Restoration Area. The result of the evaluations will be used to develop alternatives to improve fish passage on the river and flood bypasses to allow for unimpeded fish passage. A Fish Passage Evaluation Plan was developed in 2010 with the Fisheries Management Workgroup. The objectives of the plan include:

1. Identification of potential structural barriers that may fish passage in the Restoration Area;
2. Evaluation of passage impairment of potential barriers using common passage criteria (i.e., depth, velocity, and discharge) under a variety of flow conditions;
3. Development of a prioritized list of structural barriers;
4. Provide a preferred alternative for fish passage improvements at priority fish passage barriers.

The plan is divided into three tasks: Task 1 included the identification and limited data collection of potential fish passage barriers and the identification of fundamental passage criteria to allow an initial evaluation of potential barriers, Task 2 included data collection and hydraulic evaluation of the potential fish passage barriers that were identified for further study in Task 1, and Task 3 (which is currently being completed) will include development of conceptual designs to improve or modify the structures that were deemed a fish passage impediment during either Tasks 1 or 2. DWR has completed Task 1 and Task 2 (Objectives 1 & 2). The focus of this presentation will be the results from these first two tasks. The presentation will include a summary of the data that was collected, the fish passage criteria and how it was applied, and a list of the structural barriers with an allowable passage range for adult Chinook salmon.

SalSim for SJRRP

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AD Consultants developed an online version of SalSim for the California Department of Fish and Wildlife and the State Water Resources Control Board as a flow management tool for Chinook salmon in the Stanislaus, Tuolumne, and Merced rivers. It is currently being used for the San Joaquin River/Southern Delta Water Quality Control Planning - Phase I and Federal Energy Regulatory Commission hydropower relicensing.

The objective of this project is to modify SalSim to include spring-run and fall-run salmon production and user-defined salmon production parameters for the San Joaquin River Restoration Area.

SalSim is a total life-history population simulation model for fall-run Chinook salmon originating from the San Joaquin River and its salmon bearing tributaries. SalSim covers all fall-run Chinook salmon life history habitats including the upper San Joaquin River basin (Inland), the Sacramento-San Joaquin River Delta (Delta), and the Pacific Ocean (Ocean).

SalSim estimates fall-run Chinook salmon production (egg survival; juvenile growth, survival and movement; and adult escapement and spawning) relative to flow management (magnitude and timing), water temperatures (in reservoirs and rivers), density dependence, stream morphology (flow velocity and floodplain inundation), hatchery management (in rivers and Delta), irrigation diversions, Head of Old River Barrier operations, predation (in rivers and Delta), Delta exports, ocean conditions and ocean harvest efforts, along with other environmental factors. It also takes into account in and out of SJR basin adult straying.

The existing SalSim model employs approximately 450 parameters in the computation process. These parameters were calibrated using fall-run data in the basin, including adult carcass studies, otolith life history analyses, CWT smolt survival studies, rotary screw studies, adult harvest, and adult straying studies.

The existing model has a limited representation of the Restoration Area, it does not include spring-run salmon, and it does not have user-defined parameters. Furthermore, it does not have the capabilities to evaluate how various Friant restoration actions would influence fish production, such as installation of fish barriers, segregating fall-run spawners from spring-run spawners, hatchery fish planting and flow routing.

AD Consultants is currently (FY 2015) developing an offline version of SalSim with enhanced features specifically geared for the SJRRP:

1) SJRRP SalSim will be a user-friendly desktop version of the SalSim simulation engine that fully represents conditions in the Restoration Area and models spring-run and fall-run salmon.
2) GUI feature that would facilitate modification of select parameters governing juvenile biology (growth, movement, survival, etc.), and examination of the resulting fish population at discrete points within the restoration area.
3) A spreadsheet-based (and easy to use) operations/temperature model (Ops model) to quickly simulate various reservoir release strategies as input by SalSim.

There are several additional modifications that would further enhance the SJRRP SalSim model:

1) Incorporate new functions and define parameters to better reflect salmon biology in the Restoration Area.
2) Recode the Ops model as an integral part of SalSim.
3) Automate Riverware and HEC-5Q functions within SalSim.

Spring-running Salmon in the Stanislaus and Tuolumne Rivers and Overview of Spring-run Recovery
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Currently Central Valley spring-run Chinook salmon (spring-run) are listed as threatened under the Endangered Species Act (ESA). The listing in 1999 only included populations in the Sacramento River basin as it was presumed, that the entire run of spring-run Chinook salmon was extirpated from the San Joaquin River basin. Historically, spring-run of the San Joaquin River has been described as "one of the largest Chinook salmon runs anywhere on the Pacific Coast" and numbering "possibly in the range of 200,000-500,000 spawners annually" (CDFG 1990). Analyzing the historic data and information specifically on the Tuolumne and Stanislaus rivers, there is high probability based on records coupled with current data that naturally (fish that naturally spawned in river systems and whose parents did as well) occurring spring-run Chinook are present in small numbers. NMFS is currently in the process of conducting the next 5 year status review for its ESA listed salmonids. This presentation will cover how the 5 year status review will address this current information and the SJRRP spring-run experimental population, and the overall outlook for spring-run Chinook salmon recovery.

Citation

California Department of Fish and Game (CDFG). 1990. Status and management of spring-run Chinook salmon. Report by the Inland Fisheries Division to the California Fish and Game Commission, Sacramento. May 1990. 33 pp.

Genetic considerations in donor stock selection for SJRRP broodstock
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The San Joaquin River Restoration Project is reintroducing Central Valley Spring-run Chinook salmon to a river where they were extirpated decades ago. Program plans include use of a new conservation hatchery facility and multiple reintroduction strategies to reestablish a viable salmon population in the southern Central Valley. Although likely once the most abundant salmon stock in the Central Valley of California, Spring-run salmon are now primarily relegated to two relictual populations in the northern Sacramento River basin, Butte Creek and Mill/Deer Creeks, a third population in the Feather River and several other Central Valley tributaries with small numbers of spring-running phenotype fish. Given the difficulty of this endeavor, a thorough analysis of the remaining spring run stocks in the ESU is necessary to determine which stocks will be used and whether efforts will be made to maintain them separately or not. We used analyses of existing population genetic data sets, including one with a large number of single nucleotide polymorphism loci, to evaluate the three primary Spring-run Chinook salmon stocks as possible sources of fish for reintroduction. In addition, we evaluated the origin and stock affiliation of many of the small populations of spring-running fish in other tributaries, both to evaluate them as potential sources and also to better understand the process of recolonization. Two of these populations, which have increased substantially in size over the last decade, Battle and Clear Creeks, were found to have been recolonized by fish from two of the major Spring-run stocks. Ongoing evaluation of the patterns of mate choice and reproduction in these populations will inform the San Joaquin River Spring-run salmon reintroduction.