

X. FOCUSED STUDY: BATTLE CREEK SALMONID LIFE HISTORY

X.A. Background

The Battle Creek Salmon and Steelhead Restoration Project (Restoration Project) and accompanying Adaptive Management Plan (AMP) includes the restoration of Battle Creek to assist in the recovery of four distinct runs of Chinook salmon and steelhead rainbow trout. The four runs of Chinook salmon include Winter-run, Spring-run, Fall-run and late-fall-run. Winter-run Chinook, Spring-run Chinook, and steelhead have been identified as the priority species for recovery because they are listed under the State and/or Federal endangered species act (CESA and ESA respectively) as either endangered (winter-run Chinook) or threatened (spring-run Chinook and steelhead). Fall-run and late fall-run are also runs included in the restoration goals for Battle Creek. They are listed as candidate species by ESA.

Each of the runs of Chinook salmon have unique life history characteristics for different phases of their life cycle. Winter-run Chinook salmon enter the San Francisco Bay from November through June. Their migration past Red Bluff Diversion Dam (RBDD) at River mile 242 begins in mid- December and continues into early August. The majority of the run passes RBDD between January and May, with the peak in mid-March (Hallock and Fisher 1985)

Winter-run typically spawn in their third year of life (Hallock and Fisher 1985), though a small percent return as two year olds and four year olds. Winter-run Chinook salmon typically spawn from late April through mid-August with the peak occurring in May and June. Prior to the construction of Shasta Dam, winter-run Chinook salmon spawned in the headwaters of the McCloud, Pit, and Little Sacramento Rivers (Yoshiyama et. al. 1998). Fry emergence occurs from mid-June through mid-October. Historical reports of naturally reproduced winter-run Chinook in Battle Creek of juvenile winter-run size salmon (Rutter 1903).

The residence time of juveniles in streams is less than a year (5-10 months) followed by an intermediate time in the estuary (Moyle 2002). Emigration past RBDD may begin in late July, generally peaks in September, and can continue until mid-March in drier years (Vogel and Marine 1991). Peak emigration through the San Francisco, San Joaquin Delta generally occurs from January through April, but the range of emigration may extend from September up to June (U.S. Fish and Wildlife Service 1994).

It is estimated adult Sacramento River spring-run Chinook salmon leave the ocean to start their upstream migration in late January to early February based on the time they start entering their natal tributary streams (CDFG 1998). The spring-run are not sexually mature when they enter the fresh water, but will mature during the spring and summer while in their natal streams (Marcotte 1984). Adults enter their natal tributary streams from mid-February through July with upstream migration peaking in May.

Currently, spring-run Chinook spawning occurs between mid-August and October. According to Harvey (1995) spring-run Chinook salmon in Deer Creek spawn first at higher elevations and cooler water temperatures and spawn progressively later as the elevation

decreases and the temperature increases. It is expected the same type of activity would occur on Battle Creek. Currently spring-run Chinook salmon are limited in distribution to lower elevations in Battle Creek and their spawning activity occurs between mid-September and mid-October (Brown 2002). It is believed after restoration of Battle Creek, Spring-run Chinook salmon will be able to ascend to higher elevation in the watershed and spawning will occur earlier due to cooler water temperatures. Spawning further up in the watershed will also facilitate increased spatial and temporal separation from fall-run Chinook salmon.

Fall-run Chinook salmon are currently and historically the most abundant run of Chinook salmon in the Central Valley (Moyle 2002). They enter the River and migrate to their preferred tributary streams from July through September. They enter fresh water sexually mature and spawn from early October through December with peak spawning occurring in October and November. Since fall-run Chinook salmon are sexually mature when they start there upstream migration, they tend to spawn at elevations lower than 1,000 feet above sea level.

Juveniles emerge from the gravel and emigrate from January through June. The majority of fall-run Chinook salmon immigrate the first year, but a few may over summer in their natal stream if summer temperatures remain non-lethal. This strategy has allowed them to use large rivers and tributary streams that are too warm in the summer to support other runs of salmon.

Late fall-run Chinook salmon typically arrive in Battle Creek November through April with peak migration occurring in January generally as four and five year olds. Spawning typically occurs January through April with the peak in February and March. The juveniles emergence in April through June and will stay in the stream for seven to thirteen months (Yoshiyama et al 1998). Many of the juveniles may emigrate quickly from Battle Creek and complete rearing in the Sacramento River.

There is considerable overlap in the adult migration timing within Battle Creek, which complicates spawning escapement estimates. Genetic analysis is required to distinguish the four Chinook runs. The WHICHRUN analysis can distinguish winter from other Chinook on an individual basis. Previously WHICHRUN genetic analysis was provided under a contract which has expired with the Bodega Marine Laboratory which no longer performs this type of work. Additional funding and a new laboratory would be required to continue the genetic analysis. Genetic techniques capable of differentiating all Chinook runs on an individual basis have been developed by Dr. Michael Banks under a contract with the California Department of Water Resources.

The CALFED Science Panel report on the "Compatibility of Coleman National Fish Hatchery Operations and Restoration of Anadromous Salmonids in Battle Creek" made recommendations for genetic studies, including: "We therefore recommend an immediate (genetic) study to determine the reliability of separating unmarked spring and fall Chinook salmon at CNFH on the basis of visual methods" (pg. 8). "Spring Chinook salmon that spawn late in the run may be prone to hybridize with fall Chinook salmon that spawn early. We expect that the probability of hybridization will diminish over generations as the populations adapt genetically to the "new" conditions. During the interim, however, actions to avoid hybridization may be necessary. The obvious action is to reduce the numbers of fish that overlap in spawning time the consequent loss of the genetic integrity (due to hybridization) could be disastrous" (pg.

27), and “Because it seems impossible to block all fall and late-fall Chinook salmon, we also recommend intense genetic monitoring to detect any hybridization as early as possible” (pg. 28).

X.B. Battle Creek Setting

Battle Creek enters the Sacramento River near the town of Cottonwood approximately 25 river miles downstream of Keswick Dam. The importance of Battle Creek for its many resources was recognized as early as the late 1800’s. Spawning salmon were recorded in the Creek in 1897, and the first hatchery reared salmon were released into Battle Creek in 1898 (CFC 1900). Constant high flow also made Battle Creek a prime stream for hydroelectric development. Because of the multitude of human activities during the last 100 years, Battle Creek’s diverse anadromous fish population has significantly declined. The demonstrated persistence of the various anadromous species inhabiting Battle Creek is a key factor in concluding wild populations could again flourish if habitat improvements are made to better support the various fish life stages. Recovery of an assemblage of several listed species in Battle Creek would contribute significantly to reversal of the decline of these populations as a whole.

Battle Creek offers an extraordinary restoration opportunity because of its geology, hydrology, and habitat suitability for several anadromous species in a restored stream environment. The geology of the Battle Creek watershed, located at the southern end of the Cascades, is primarily volcanic in nature. This type of terrain provides deeply incised, shaded, cool stream corridors and its ruggedness limits the extent of human activities that typically occur around more readily accessible streams. Although substantial quantities of water have been diverted for hydroelectric production since the early 1900s; other activities that could have had potentially detrimental impacts on the stream and surrounding riparian environment have been effectively precluded by the nature of the terrain.

Battle Creek also has great potential for restoration because of the volcanic nature of the drainage. Seasonal precipitation does not rapidly run off the watershed as with streams situated farther south in the Sierra Nevada. Instead, a large portion of the annual precipitation percolates through the underlying volcanic strata and emerges throughout the watercourse as cold springs that ensure a relatively high and stable base flow throughout the year. The naturally regulated stable base flow and cold water temperature offer drought resistance rarely found in the present range of anadromous fish. Because of this hydrology Battle Creek offers natural habitat conditions conducive to the recovery of species no longer able to access all of their ancestral streams.

X.C. Study approach

Many of the criteria used to measure success of Battle Creek restoration rely on assessments of adult and juvenile populations of each of the targeted species and runs. Some of the uncertainties identified in the AMP include whether populations of targeted salmonids will respond favorably to the increased habitat created by the restoration efforts, and the ability to accurately quantify juveniles of each run of Chinook salmon. Current and proposed ongoing downstream migrant rotary screw trapping studies will help in answering overall juvenile abundance uncertainties. However, current studies use length at date data from Fisher (1992) for

assigning a run designation based on measurements from fall-run Chinook salmon raised in artificial channels at the Tehama-Colusa fish facility which is no longer in operation. There is uncertainty whether these criteria can be used for different runs of salmon reared in the Sacramento River tributaries such as Battle Creek.

To address these uncertainties we propose the following studies:

X.C.1. Collect tissue samples for juvenile salmonids for genetic analysis and length at date evaluation.

Hypothesis: Using the date adults of each run of salmon spawn, the known temperature of Battle Creek, the time juveniles emerge, and current genetic analysis techniques, an accurate length at date determination can be made for each run of juvenile salmonid in the creek.

Monitoring Goal: The goal of this study is to collect information to accurately determine the run of individual juvenile Chinook salmon based on size at date criteria. This will be accomplished by collecting a non-lethal tissue sample from juvenile Chinook salmon captured in a rotary screw trap currently operated by the USFWS upstream of CNFH and sent to a qualified genetics lab for evaluation. This tissue sample will likely consist of a small fin clip commensurate to current genetic tissue collecting techniques. The date of capture, length of each Chinook salmon, and tissue sample number will be recorded. This information will be compared to adult spawn timing, stream temperatures, and genetic analysis as they are determined for each sample. Current genetic analyses techniques are accurate for determining presence and absence of winter-run genotypes. This will be valuable in distinguishing the two primary target species which are spring-run and Winter-run Chinook salmon.

Fall-run and late fall-run Chinook salmon will likely be detained from the project area until viable populations of the other two runs have been established. The current technology for genetic determination is progressing rapidly and some researchers believe they can distinguish between runs of Chinook salmon with varying degrees of accuracy at this time. When these runs are reintroduced the genetic sampling protocol may need to be reevaluated.

The desired product will be a usable technique for determining Battle Creek juvenile Chinook salmon run based on size criteria. This technique can also be compared to current studies being conducted on other Sacramento River tributaries like Clear Creek, Deer Creek, and Mill Creek.

X.C.2. Collect juvenile salmonids near spawning areas.

Hypothesis: Juvenile salmonids collected by non-harmful techniques near spawning areas could help determine emergence timing and therefore run designation.

Monitoring goal: The goal of this study is to collect juvenile salmonids near known spawning areas to determine the date the fish emerged from nearby redds. This will be accomplished using small beach seines or electrofishing equipment. The date of emergence can be estimated from known spawn timing and water temperature data. During the time period emergence is likely to occur, a team of two researchers will seine or electrofish areas of low

water velocity near known redd sites and attempt to collect juvenile fish. Fish collected will be identified to species, measured to the nearest millimeter, have tissue removed (optional), and be released to the creek. Any collection of tissue samples will follow the previously mentioned protocol.

X.C.3.Distinguishing Runs of Chinook at Adult Life Stage

The first step of genetic analysis of Battle Creek Chinook would be to characterize the baseline of the existing samples collected from 1996 to present of fish from all runs. While 200 samples of each run would be desirable, at least 100 samples would be required. This baseline would then be used to assign runs to Chinook sampled in the future at the barrier weir and from snorkel survey carcasses. The baseline would also be used to assign runs to Chinook juveniles sampled by rotary screw trap or potentially by seining, to develop the run specific designation criteria. The genetic techniques could also be directly applied by sub sampling juveniles collected by screw trapping.

Goal 1) to develop methods to distinguish 4 runs of salmon during the adult life stage to improve escapement estimates, juvenile production estimate and fishery management.

Objectives: A) develop genetic baseline from previously-collected samples of adult Chinook.

B) apply genetic techniques to samples from barrier weir to produce escapement estimates.

C) use genetic techniques to evaluate ability of visual techniques to separate spring and fall Chinook.

D) apply genetic techniques to juveniles to evaluate ability of temperature unit analysis to create a run specific designation criteria.

E) apply genetic techniques directly to juvenile samples to correct past and future juvenile production estimates.

X.C.4.Total Cost

The total cost for all elements of this life history study is \$373,081.

X.C.5.Possible Adaptive Responses

There is uncertainty whether we can distinguish between runs of Chinook salmon using date at length criteria coupled with genetic analysis. As we learn more of the capabilities of genetic analysis, we can refine our sampling collection techniques to increase the reliability of this tool.

X.C.6. References

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