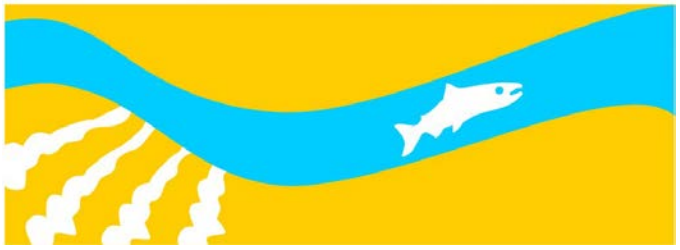
Study 12

Fall-Run Captive Rearing Study

Public Draft
2014 Monitoring and Analysis Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM



September 2013

August 5, 2013
California Department of Fish and Game
STUDY WORKPLAN
DETAIL CHECK LIST

MAP Study Title: Fall-run Captive Rearing

Principal Investigator(s): Paul Adelizi

Contact Info. Of Principal Investigator(s):

Paul Adelizi
1234 E. Shaw Ave.
Fresno, CA 93710
paul.adelizi@wildlife.ca.gov

Proposed Staff:

Jamie McGrath-Castro
Mike Grill
Thomas Gromis
Doug Aubushon
Brian Mahardja

County(ies) affected by Study: Fresno

I. Study Management

A. Study Description

1. Background

The San Joaquin River Restoration Program (Program) is developing a conservation hatchery that is anticipated to provide much of the founding population for salmon restoration. The San Joaquin Salmon Conservation and Research Facility (Conservation Facility) is scheduled to be operational in February 2016. During facility planning and construction, a modest Interim Facility and the Fall-run Captive Rearing Study have been developed to refine techniques and protocols for rearing Chinook salmon through adulthood, and to help meet reintroduction timelines during full-scale facility development.

The first year of the study focused on installing and testing fish culture equipment; developing and testing transportation, handling, and rearing methods; and monitoring and modulating fish growth rates. Five hundred and fifty fertilized Chinook salmon eggs were collected during the 2010 fall spawn at Merced River Fish Facility. Eyed eggs were transferred to Silverado Fisheries Base (Yountville, CA) for hatching, holding, and fish health assessment. In March 2011, fish were transferred to the Interim Facility (Friant,

CA), PIT tagged for tracking individual growth data, and tissue sampled for genetic analysis by the UC Davis Genomic Variation Lab (Davis, CA).

During year two of the study, the salmon continued to be reared and monitored. At age-one (November 2011), approximately 15% of the males matured early. The target age of maturation is at three or four years. Gonad development was then confirmed by ultrasound, and semen was expressed from each precocious male, tested for motility and cryopreserved. Sexes were segregated to allow targeted feeding regimes for each sex. A strict feed regime was instituted in an effort to modulate growth rates and thereby attempt to control future male precocity. Females, which are less prone to precocity, were fed a standard full ration, while males were fed at half ration. Additionally, half of the fish from the study (approximately 200) were released to the San Joaquin River and monitored as part of the Program's Juvenile Survival and Migration Study.

During year three of the study, early maturation was again observed, occurring in 11% of age-two females (11/96 females) and 79% of age-two males (85/108 males). One female died prior to spawning, and nine surviving mature "jills" were paired with nine jacks and mated. A spawning matrix was developed using genetic relatedness data provided by the UC Davis Genomic Variation Lab to assure mating of least related individuals. Gamete development was monitored using ultrasonography. One jill was used as a control and paired with a 3-year-old male that was trapped in the wild as part of the Program's Trap and Haul Study. Two other 3-year-old male and female wild pairs were also spawned and used as controls.

Spawning occurred November 14-21, 2012. This corresponded to the peak of spawning at the Merced River Fish Facility and the peak of redd construction observed on the Merced River (Unpublished CDFW data). This indicates that spawn timing was not significantly altered by captive rearing.

Early maturation and captive rearing limited the size of fish at the time of spawning compared to typical wild adults. Growth rates of male fish had been intentionally slowed in effort to reduce levels of precocity. Therefore, males were considerably smaller than two-year-old wild counterparts. Female growth rates were not restricted, yet they were also smaller than wild counterparts, averaging approximately 1.5 lbs at time of spawning. The smaller size of captive reared salmon is common in similar programs. The body size of female salmon is correlated with fecundity. As anticipated, fecundity was low, averaging 1066 eggs per female (N=10), and egg size was small, averaging 185 eggs/fluid oz (Table 1). Comparatively, fecundity from the two female wild controls averaged 6,406 eggs with an egg size averaging 85 eggs/fluid oz.

Fertility and early survival of eggs from age-two females fish was relatively high. Egg survival to the eyed stage averaged 87% for study fish and approximately 90% for the two female wild salmon. However, survival was significantly lower for the study fish during hatch and through swim-up. Many sac fry from age-two females died while emerging from shells, resulting in a 28 percent survival to swim-up. The lower survival of eggs from study fish was possibly due to the small egg size and low nutritional status of the fry. Reduced survival of eggs from two-year-old female Chinook has also been

reported from wild Chinook returning to the Merced River Fish Facility, albeit less severe than observed in this study.

Table 1. Spawning Data from the 2012/13 Fall-run Captive Rearing Study

Age-two captive reared female fall-run Chinook salmon (N=10)

• Average fecundity	1,066
• Average number of eggs per liquid oz	185
• Average survival to eyed egg stage	87%
• Average survival from eyed stage to swim-up	28%

Age-three fall-run Chinook salmon rescued from San Joaquin River (N=2)

• Average fecundity	6,406
• Average number of eggs per oz from SJR trapped females	86
• Average survival to eyed egg stage	90.5%
• Estimated average survival from eyed stage to swim-up (using Deep Matrix Incubator)	95%

2. Study purpose

a. Study Goal: The purpose of the proposed study is to investigate conservation hatchery practices during early stages of fish rearing.

b. Study Objectives: There are three main objectives of the study:

1. Spawn 2010 Chinook fall-run broodstock to test and practice procedures that will be used for spring-run Chinook.

2. Investigate conservation hatchery approaches for egg incubation by testing deep matrix hatching jars.

3. Investigate conservation hatchery approaches to juvenile rearing by incorporating habitat enrichment to the early rearing environment.

c. Study Milestones

1. August/September 2013

a. Procure equipment and supplies for project

b. Install Vertical Tray Incubators at Interim Facility

c. Design and Construct Deep Matrix Hatching Jars

2. October 2013

a. Minimize or stop feeding of Adult broodstock

b. Ultrasound adult broodstock on a weekly basis

c. Develop mating matrix for 2010 fall-run Chinook

d. Disc Tag adults that are ready or near ready for spawning

3. November 2013

a. Spawn adult broodstock and place eggs in incubators

4. December/January 2013/2014

a. Hatch eggs and place swim up fry in rearing tanks with and without environmental enrichment

5. Spring 2014

a. Report findings

3. Management implications of the study

If results of the study are positive, results would be incorporated into the hatchery practices at SCARF.

B. Study Organization and Responsibilities

Paul Adelizi – Lead
Brian Mahardja – Mating Matrix Development

C. Study Design

Spawning 2010 Brood Year Adults
In the fall of 2013, it is anticipated that most of the 2010 brood year fall-run Chinook will be ready to spawn (total inventory of 106 fish). Using the pairwise genetics relatedness

data prepared by the UC Davis Genomic Variation Lab, a mating matrix will be developed in effort to maximize the genetic diversity during spawning. Each female will be spawned with up to four males. Because of the high loss of male fish to precocity in previous years, male semen may be harvested and used from adult Chinook from Merced River Hatchery or from the Program's Trap and Haul study. Most of the fertilized eggs from each paired mating will be incubated in traditional vertical tray incubators, with the exception of eggs from four females that will be incubated in experimental deep matrix hatching jars described below.

Experimental Egg Incubators

The goal of conservation hatcheries is to minimize hatchery induced selection and promote wild behavior in hatchery fish. Quinn (2005) reported that fry incubated in hatcheries are often smaller than wild fry, suggesting that this was due to energy expended by sac fry while attempting to position themselves upright in flat bottom hatchery trays. Crevasses in gravel allow sac fry to rest upright and thus expend less energy. Also, Salvanes et al (2013) found that exposing fish to enriched conditions upregulated the forebrain expression of NeuroD1 mRNA and improved learning ability assessed in a spatial task, and Kihslinger and Nevitt (2005) found that variations in early rearing environment resulted in increased cerebrellar volume.

CDFW has conducted preliminary investigations using deep matrix style incubators (ARED) for the past two years. The incubators consisted of aluminum boxes (4.5 ft^3) that contain a gravel substrate and are designed to up well water through the gravel. A slotted aluminum screen is placed on the surface of the gravel and eyed eggs are place on the screen. This allows dead eggs to be removed during incubation to avoid fouling. Upon hatch, the sac fry swim through slotted screen and swim down into the gravel to incubate until emergence. The outflow each unit has a screen which can be remove to allow volitional or controlled release of emerging fry.

In the fall of 2012, two female Chinook salmon from the Program's Trap and Haul studies were spawned and the eggs were place into two large deep matrix incubators (Figures 1 and 2). The incubators were plumbed to allow emerging fry to swim into a 3-ft diameter counting tank for daily enumeration. A total of 11,600 eyed eggs were placed in two incubators. Each day, fish in the counting tanks were enumerated and place into 3-ft diameter rearing tank or into aluminum cages in the San Joaquin River. Figure 3 shows the number and timing off fish emerging from each clutch of eggs.

Cylindrical hatching jars are commonly used at salmon hatcheries worldwide. Hatching jars provide the same upwelling water flow used in the deep matrix incubator but have an upright tubular design and are commonly made from PVC pipe or clear acrylic tubing of various sizes. Hatching jars are known for their ability to accommodate large numbers of eggs in a small area and are typically considered to reduce labor during incubation.

In this study, eight experimental hatching jars will be constructed using 8-in PVC pipe. Jars will be filled with ¾-in gravel to provide media for sac fry development which differs from tradition jars which are void of media. Four female Chinook salmon will be spawned for the study. Eggs from each female will be fertilized from a single male and

the eggs will be divided into four equal groups. Duplicate groups of eggs from each female will be incubated in the both deep matrix hatching jars and in standard vertical egg trays, resulting in a total of eight deep matrix hatching jars and eight vertical tray incubators. Dead eggs will be removed from each incubator daily, and temperature and oxygen will be recorded. Fish will be sampled for weight and length during emergence. Some fish may be sacrificed to identify anatomical differences from each treatment.

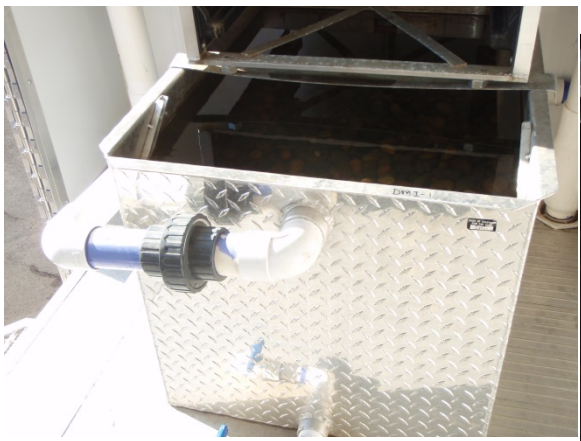


Figure 1. Deep Matrix Incubator

Figure 2. Inside view of Deep Matrix Incubator gravel and emerging fry.

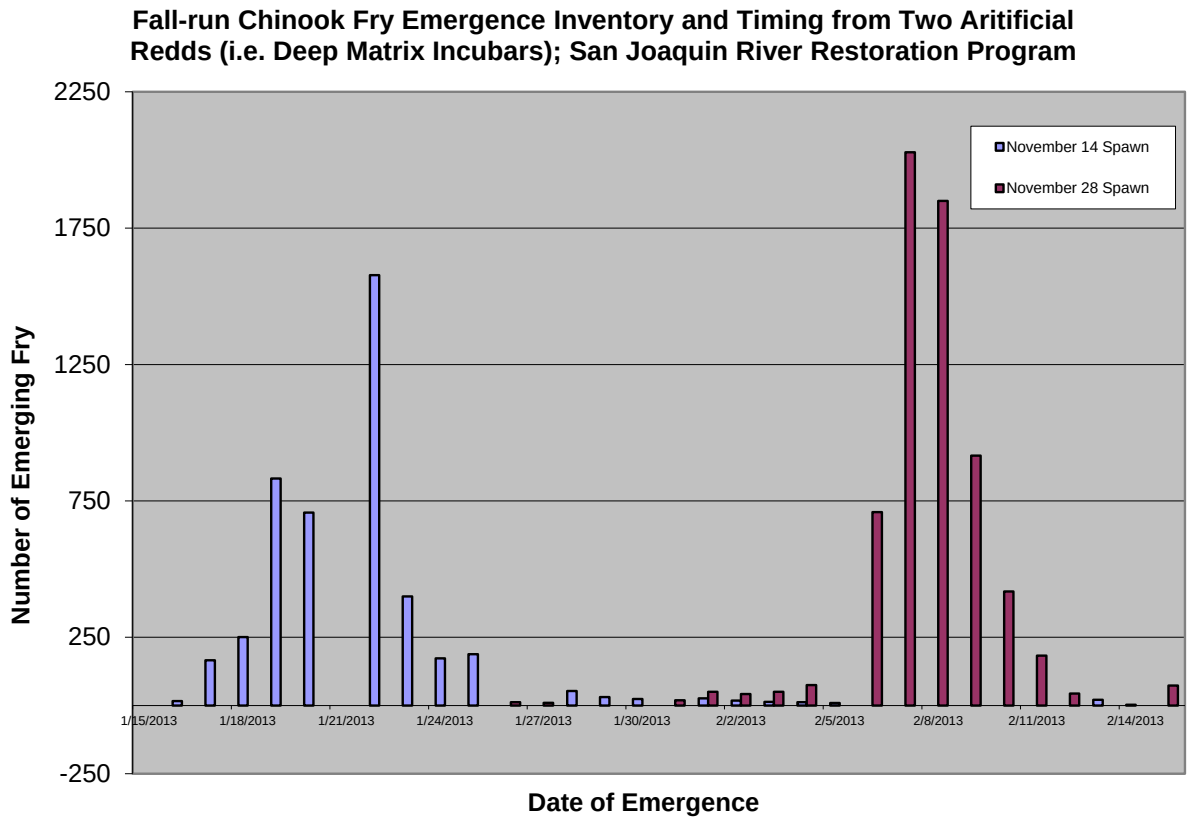


Figure 3. Emergence timing from Deep Matrix Incubators

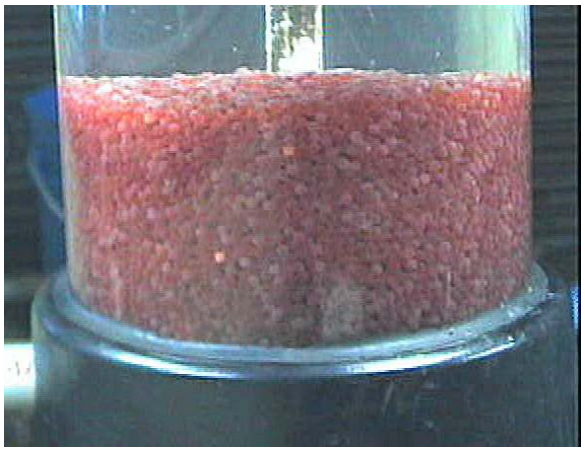


Figure 4. Eggs incubating in standard McDonald style hatching jar.

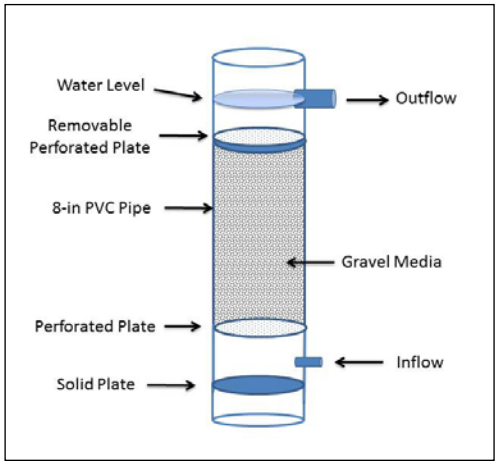


Figure 5. Design of proposed experimental hatching jar.

Habitat Enrichment of Rearing Environment

Many studies with a variety of animals have shown the benefit of providing a complex rearing environment to promote cognitive ability (Salvanes et al 2013). In addition to providing complexity to the incubation environment, adding complexity to the rearing environment will also be investigated. This preliminary study will investigate the use of an artificial substrate "Aquamats". The study will examine options for securing and

placement of substrate, how the substrate affects tank maintenance, methods for cleaning substrate, and how juveniles interact with the substrate.

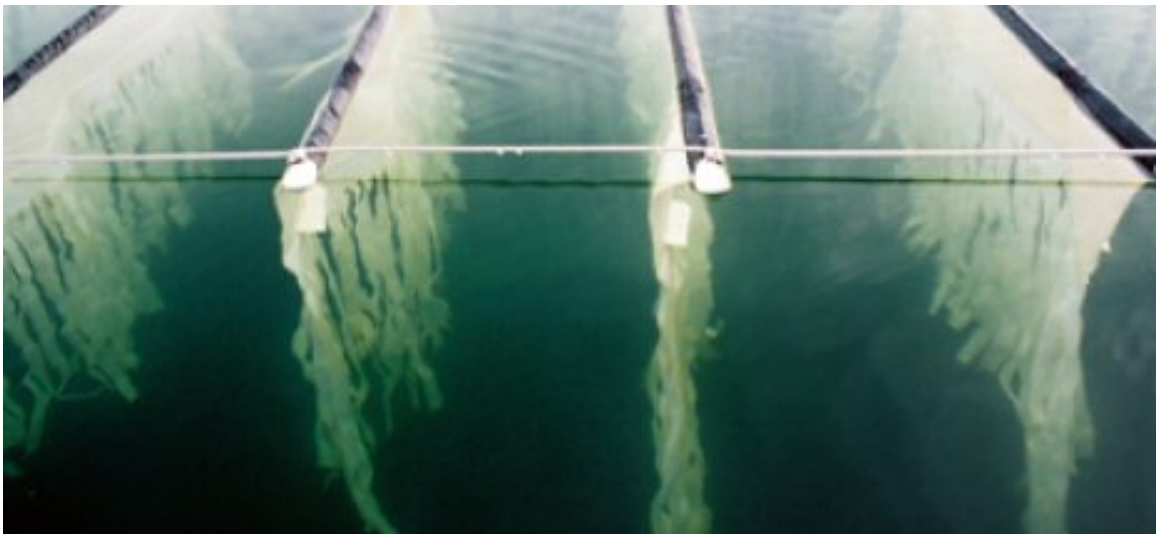


Figure 6. Image of Aquamats suspended in pond.

D.

D. Study Resource Needs

1. Budget

Estimated cost of materials - $2,500

2. Personnel needs – none

E. Compliance Considerations

1. Release of study fish to SJR is covered under existing CEQA permits

F. F. Invasive Species:

N/A

References:

Kihslinger, Rebecca L. and Gabrielle A. Nevitt. 2005. Early rearing environment impacts cerebellar growth in juvenile salmon. The Journal of Experimental Biology 209, 504-509.

Salvanes AGV, Moberg O, Ebbesson LOE, Nilsen TO, Jensen KH, Braithwaite VA. 2013. Environmental enrichment promotes neural plasticity and cognitive ability in fish. Proceedings of the Royal Society B 280: 20131331. http://dx.doi.org/10.1098/rspb.2013.1331

Quinn, Thomas P. The behavior and ecology of Pacific salmon and trout. 1st ed. University of Washington Press, Seattle, WA, P. 163.