FISHERY RESEARCH

CAPTIVE REARING PROGRAM FOR SALMON RIVER CHINOOK SALMON

PROJECT PROGRESS REPORT
January 1, 2010—December 31, 2010

Prepared by:

Eric J. Stark, Senior Fisheries Research Biologist
David P. Richardson, Senior Fisheries Technician

IDFG Report Number 11-03
January 2011

CAPTIVE REARING PROGRAM FOR SALMON RIVER CHINOOK SALMON

Project Progress Report

2010 Annual Report

By

Eric J. Stark
David P. Richardson

Idaho Department of Fish and Game
600 South Walnut Street
P.O. Box 25
Boise, ID 83707

To

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97283-3621

Project Number 2007-403-00
Contract Number 44419

IDFG Report Number 11-03
January 2011

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Page

LIST OF APPENDICES

Page

ABSTRACT

During 2010, the Idaho Department of Fish and Game (IDFG) continued to monitor the reproductive performance of mature captive-reared Chinook salmon *Oncorhynchus tshawytscha* released to spawn in natal streams. Eyed eggs were collected from the East Fork Salmon River (EFSR) and the West Fork Yankee Fork Salmon River (WFYF) to establish study groups for an emergence survival study initiated in 2007. Captive rearing groups were not collected in 2009; brood year 2005 (BY05) represented the final brood cohorts collected for full-term captive rearing studies in the EFSR and WFYF. During 2010, no captive Chinook remained in freshwater rearing at Eagle Fish Hatchery (FH). The last remaining brood year (BY05) was rearing to maturity in salt water at the Manchester Research Station, Manchester, Washington (Manchester) during 2010. Maturing fish transfers from Manchester to Idaho for release to natal waters included 14 individuals from the WFYF and five from the EFSR. All maturing captive-reared Chinook salmon were released in 2010. Mature adults were released to evaluate reproductive performance of captive releases-reared. One redd was constructed by a volitionally spawning captive-reared Chinook salmon female in the WFYF and one constructed upstream of the adult trap in the EFSR. Tissue samples from Chinook salmon adults were collected at the EFSR adult trap again in 2010 to assess production levels from volitional spawning events resulting from program releases conducted in 2005-2007. Genetic material from these adults will be analyzed with samples taken from all program adults and natural carcasses collected within the study area. This information will be used in future parentage analyses. In 2010, we successfully genotyped 779 tissue samples from Chinook salmon adults captured at the EFSR adult trap from 2004-2009. From these samples, a total of 141 adults assigned to a parent-pair with zero or one locus mismatches by parentage analysis. Only seven of these adults were assigned to captive-reared Chinook. However, we would not have expected much production from captive-reared fish released in 1999-2003, because very few fish were released or the ones that were released had very poor post-release survival. The exception was the 2002 captive-reared release, which produced 33 redds, yet did not produce a single adult return (progeny). Captive-reared adults spawned in captivity and their eggs placed in egg boxes in the EFSR in 2004 produced four returning adults (progeny) in 2008. This production is near our expectations based on modeled survival and production of adult returns. Captive-reared adult releases in 2006 also produced three progeny that returned as adults in 2009. However, captive-reared brood years 2005 and 2006 would not all be expected to return by 2009, and more progeny could assign to these releases in 2010 and 2011 returns.

Authors:

Eric J. Stark
Senior Fisheries Research Biologist

David P. Richardson
Senior Fisheries Technician

INTRODUCTION

In 1992, Snake River Chinook salmon were listed as threatened under the Endangered Species Act (ESA; National Marine Fisheries Service [NMFS] 1992). Many sources of mortality have contributed to the decline in natural/wild Snake River Chinook salmon over several decades. However, until smolt-to-adult survival increases, our challenge is to preserve the existing metapopulation structure (by preventing local or demographic extinctions) of these stocks to ensure they remain extant to benefit from future recovery actions. This project is developing technology that may be used in the recovery of the listed Snake River spring/summer Chinook salmon evolutionarily significant unit (ESU), which consists of 31 subpopulations (i.e. breeding units or stocks); (McClure et al. 2003). Preserving the metapopulation structure of this ESU is consistent with the various Snake River Salmon Recovery Plans (NMFS 1995; Schmitten et al. 1997; McClure et al. 2003), and supports the Northwest Power and Conservation Council's (NPCC) goal of maintaining biological diversity while doubling salmon and steelhead runs (NPCC 1994).

Idaho and Oregon state, tribal, and federal fish managers met during 1993 and 1994 to discuss captive culture research and implementation in the Snake River basin. The outcome of those meetings was to initiate two programs: 1) the Oregon Department of Fish and Wildlife (ODFW) would initiate a captive broodstock program using selected Grande Ronde River Chinook salmon populations, and 2) the Idaho Department of Fish and Game (IDFG) would initiate captive rearing research using selected Salmon River Chinook salmon populations. Captive fish culture techniques begin by bringing naturally produced juveniles (eggs, parr, or smolts) into captivity and rearing them to sexual maturity in a hatchery. At this point, the two programs use different techniques. The F_1 generation in a captive rearing program (IDFG) is returned to their natal streams and allowed to spawn naturally. Alternately, the F_1 generation from a captive broodstock program (ODFW) is spawned in the hatchery, where the resulting F_2 progeny are held until release. The F_2 generation is then released to its natal stream to emigrate volitionally while a subset remains in captivity for the next generation. The primary focus of these programs is to evaluate the effectiveness of the two forms of captive culture to meet population conservation objectives. Implicit within each research project is the objective to develop and test appropriate facilities and fish culture protocols specific to the captive culture of Chinook salmon for conservation management of depressed populations.

Little scientific information regarding captive culture techniques for Pacific salmonids was available at the inception of these programs, but a substantial amount of new literature was published in the ensuing years. The Chinook Salmon Captive Propagation Technical Oversight Committee (CSCPTOC) was formed to convey this new information between the various state, federal, and tribal entities involved in the captive culture of Chinook salmon. The CSCPTOC meets quarterly, which allows an adaptive management approach to all phases of the program and provides a forum of peer review and discussion for all activities and culture protocols associated with this program. Flagg and Mahnken (1995) provided an initial literature review of captive rearing and captive broodstock technology, which provided the knowledge base upon which the program was designed. Using this work, the IDFG captive rearing program for Salmon River Chinook salmon was initiated to further develop this technology by monitoring and evaluating captive-reared fish during rearing and post-release spawning phases. Since the program's inception, studies documenting the spawning behavior of captive-reared Chinook salmon (Berejikian et al. 2001b), coho salmon *O. kisutch* (Berejikian et al. 1997), and Atlantic salmon *Salmo salar* (Fleming et al. 1996) have been published. Other studies have also compared the competitive behavior of male captive-reared and natural coho salmon during spawning (Berejikian et al. 2001a), and the competitive differences between newly emerged fry produced by captive-reared and natural coho salmon (Berejikian et al. 1999). Finally, Hendry et al. (2000) reported on the reproductive development of sockeye salmon *O. nerka* reared in captivity.

The IDFG captive rearing program was developed as a way to increase the number of naturally spawning adults and maintain metapopulation structure in selected populations at high risk of extinction while avoiding the impacts of multigenerational hatchery culture described in Reisenbichler and Rubin (1999). The strategy of captive rearing is to prevent cohort collapse in the target populations by returning captive-reared adults to natural spawning areas to augment depressed natural escapement (or replace it in years when no natural escapement occurs). This maintains the continuum of generation-to-generation smolt production and provides the opportunity for population maintenance or increase, should environmental conditions prove favorable for that cohort. However, the success of the captive rearing approach to produce adults with the desired morphological, physiological, and behavioral attributes to spawn successfully in the wild remains somewhat elusive (Fleming and Gross 1992, 1993; Joyce et al. 1993; Flagg and Mahnken 1995).

The IDFG captive rearing program was initiated in 1995 with the collection of brood year (BY) 1994 Chinook salmon parr from three study streams. Since then, naturally spawned Chinook salmon progeny from BY95-BY05 have been reared in captivity to continue the project. Hassemer et al. (1999, 2001), Venditti et al. (2002, 2003a, 2003b, 2005), Baker et al. (2006a, 2006b, 2007), Stark et al. (2008, 2009), and Stark and Gable (2010) summarize project activities from inception through 2010. The streams selected for inclusion in the captive rearing program include the Lemhi River (LEM), the East Fork Salmon River (EFSR), and the West Fork Yankee Fork Salmon River (WFYF). Project activities were completed on the LEM in 2003 with the release of mature BY99 adult fish, enabling increased monitoring intensity on the EFSR and WFYF to the present day (Figure 1).

All three study streams were selected because of their water temperature and water quality. Water temperatures are ideal for juvenile Chinook salmon rearing in all three streams, while water quality ranges from sufficient to ideal. Stream habitat quality ranges from relatively pristine to areas of riparian degradation caused by sedimentation, grazing, mining, logging, road building, and irrigation diversion. The EFSR drains a relatively sterile watershed of granitic parent material associated with the Idaho batholith. The lower 30 km of the EFSR runs through ranch and grazing property developed during the last century, but the upper reaches reflect near pristine conditions with little historical disturbance.

The goal of the captive rearing program is to evaluate the potential of captive rearing technology for the conservation of Snake River spring/summer Chinook salmon. There are two primary project objectives needed to accomplish this goal: 1) develop and implement culture practices and facility modifications necessary to rear Chinook salmon to maturity in captivity having morphological, physiological, and behavioral characteristics similar to natural fish; and 2) evaluate the spawning behavior and success of captive-reared individuals under hatchery and natural conditions. These objectives divide the program into two functional units (fish culture and field evaluations), but the success of the program is dependent on the synchronous development of both. This report documents activities performed in both aspects of the evaluation from January 1, 2010 through December 31, 2010. This project was coordinated with the Northwest Power and Conservation Council's Fish and Wildlife Program (NPCC 2000), identified as project 2007-40-300. Funding was provided through the Bonneville Power Administration under contract 44419.

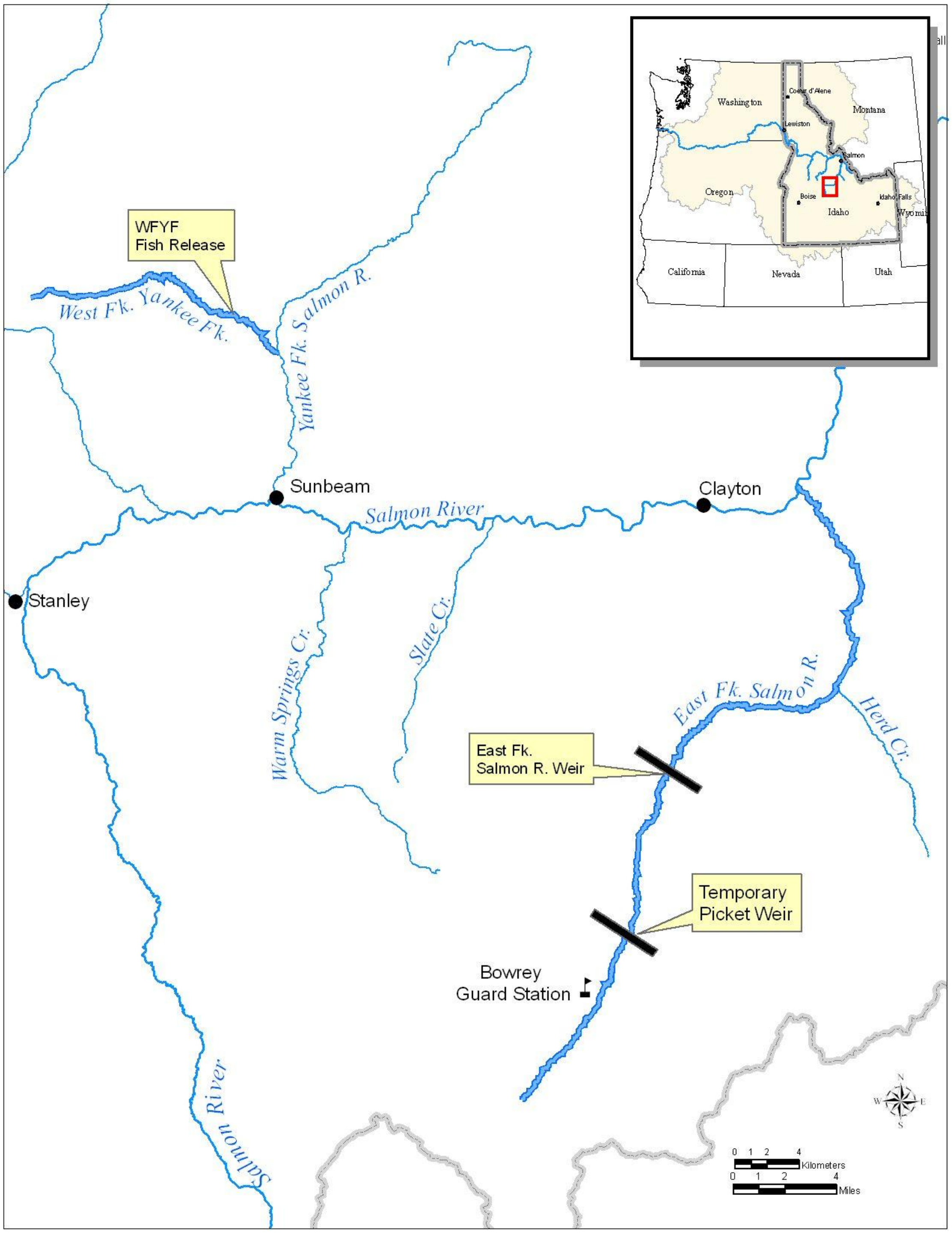

Figure 1. Location of study streams included in the Idaho Department of Fish and Game Captive Rearing Program for Salmon River Chinook salmon.

FACILITIES

The IDFG Eagle Fish Hatchery (Eagle FH) in Eagle, Idaho is the primary Idaho site for the captive culture of program fish. Eagle FH was utilized for egg incubation, ponding, and juvenile/parr periods of the rearing cycle then were transferred seawater at the smolt-stage. Seawater rearing is provided for all study animals following smoltification at the National Oceanic & Atmospheric Administration (NOAA) Manchester Research Station in Manchester, Washington (Manchester). This facility is located on Puget Sound near Seattle, Washington, and is supplied with approximately 5,000 L/min of seawater that ranges in temperature between 7°C and 14°C annually and averages 29% salinity. Raw seawater is passed through sand and cartridge filters to remove particles >5 μm, sanitized with ultraviolet light, and degassed prior to entering fish rearing tanks. Effluent from the rearing tanks is treated with ozone prior to being returned to Puget Sound (Frost et al. 2002). Fish are segregated by brood year and stream origin throughout all rearing phases. At maturation, fish are transferred from seawater back to freshwater at Eagle FH or Sawtooth Fish Hatchery (Sawtooth FH) EFSR adult trap facility holding ponds, before being released into their natal waters. Detailed facility specifications are referenced in previous project annual reports (Hassemer et al. 1999, 2001; Venditti et al. 2002, 2003a, 2003b, 2005; Baker et al. 2006a, 2006b, 2007; Stark et al. 2008, 2009; and Stark and Gable, 2010).

METHODS

No captive culture remained in freshwater (juveniles) during 2010. The last remaining brood year (BY05) was transported to Manchester for saltwater rearing in 2007. Freshwater culture methods at Eagle FH; and juvenile rearing, marking, and transportation methods are summarized in Baker et al. (2008). Only one brood year remained in rearing in saltwater at Manchester during 2010 (BY05).

Adult Rearing, Marking, and Transportation

Maturing Chinook salmon at Manchester were transported to Idaho (Eagle FH and/or stream of origin) to complete the freshwater phase of their maturation and for spawning performance evaluation. Maturation state was determined for all individuals at Manchester by ultrasound examination using an Aloka SSD-500V ultrasound unit with an Aloka Electronic Linear Probe UST-556L-7.5 (Aloka Co., Ltd., Tokyo, Japan).

Maturing Chinook salmon destined for release for natural spawning were fitted with spaghetti tags prior to release. Spaghetti tags were color-coded to identify the brood year to which the fish belonged. Fish were anesthetized in buffered MS-222, weighed to the nearest 1.0 g, and measured to the nearest 1 mm FL. Water temperature in the anesthetic baths was determined by the tank temperature to which the fish were being exposed. Spaghetti tags were attached by passing a stainless steel needle through the musculature of the dorsal surface just ventral to the midline of the dorsal fin. The two ends of the spaghetti tag were then tied in a knot to secure. After marking, all fish were allowed to recover in coolers of temperature-appropriate water before being returned to the holding tanks.

Adults were transported using similar equipment and techniques as described above, and loading volumes did not exceed 89 g/L. Maturing fish from multiple brood years were pooled by stock for transport to Idaho, although stocks that may have posed a health risk to other program fish were transported in separate vehicles. Tanks were loaded with approximately ¼ seawater and ¾ freshwater (by volume) to begin freshwater acclimation during transport.

Adults destined for return to natal waters were transferred from truck tanks to streamside release sites.

When required, the captive rearing program has utilized various disinfectants, antibiotics, vaccinations, and antifungal treatments to control pathogens. The dosage, purpose of use, and method of application, when used, are summarized in Stark and Gable (2010). Tissue samples were collected from dead program fish during necropsies to monitor for the presence of common bacterial and viral pathogens. Bacterial or viral pathogens were isolated to identify parasite etiology using American Fisheries Society Bluebook procedures (Thoesen 1994). All examinations were conducted under the direction of the program fish pathologist. Genetic samples were also collected from these fish in the event that they may be needed in future mitochondrial DNA and/or nuclear DNA evaluations for Chinook salmon populations held in the program. After necropsy, carcasses that were not vital to further analysis were disposed of as per language contained in the ESA Section 10 permit for the program.

Tissues from maturing Chinook salmon transferred to the State of Idaho from Manchester were screened for *Piscirickettsia salmonis*, and additional ovarian fluid was "blind passed" in a separate test for the North American strain of viral hemorrhagic septicemia. These pathogens do not occur in Idaho, but have been identified in fish reared at a seawater net pen location close to the Manchester site in prior years.

Brood Year Growth and Survival

Each program year, individual brood cohorts are terminated with respect to remaining live individuals of a certain age component (typically after year 5 of culture). In order to track the contribution of individual cohorts through time, measures such as growth, mortality by age, and maturation by age were summarized for completed brood groups. Fish weights collected during routine sampling at both Eagle FH and Manchester were plotted over time, and both individual fish weight and group means were calculated. Finally, we determined the total number of brood year program fish from each study stream that reached sexual maturity and computed the percentage that matured at age-2, -3, -4, and -5. In this report, the growth and survival of BY05 Chinook salmon is summarized. However, this brood year was raised entirely at Manchester (no freshwater rearing after smoltification) precluding a comparison between fish raised at Eagle FH and Manchester.

Volitional Spawning

During 2010, unlike previous years, installation of a temporary weir in the EFSR was not utilized to keep captive-reared fish confined upstream of the weir. Instead, they were released below the historic study area and allowed to disperse and spawn amongst natural/wild fish. Thus, assessment of captive-reared Chinook salmon spawning success was performed alongside natural Chinook spawning observations. Study sections were divided into multiple reaches of varying length to permit systematic observations of Chinook salmon spawning. Thermographs were used to document the thermal histories of redds created by captive-reared individuals. Thermal records provided a means to accurately determine when redds should be sampled and ultimately to determine fertilization rates and survival to the eyed egg stage of development. No temporary weir was constructed on the WFYF during this reporting period, allowing released captive fish in the WFYF to migrate unrestricted throughout the drainage.

Maturing captive-reared Chinook salmon were transported by truck to a streamside site in preparation for release into the study section. Water temperatures in each of the two study streams deviated from each other, thus the water temperature in the transport tank represented a compromise temperature appropriate for the transport of both study groups. Fish were transferred to insulated coolers streamside, and carted to specific release sites on each study stream.

Monitoring of Chinook spawning activity began approximately 24 h after captive-reared fish were released. Each field crew was assigned three to four stream reaches to monitor each day. Depending upon crew availability, the entire study section was monitored a minimum of three times per week. Technicians walked slowly upstream surveying for Chinook salmon with the aid of polarized sunglasses. When adult fish were located, technicians remained motionless and viewed each fish for a minimum of five minutes looking for spawning behaviors. During this time, the technician recorded the number of fish observed, fish origins (natural origin or captive-reared based on the presence of a spaghetti tag), and the gender of each fish when possible. For each female Chinook observed, its location was recorded on a handheld global positioning system receiver and the location marked with flagging. The observer noted the gender, origin (natural or captive), and spawn activities observed for each fish on the flagging. Not all spawn activities were recorded as in previous years (Stark and Gable 2010), but were used as guidance for determining the likelihood of spawning and redd completion to occur. For each spaghetti-tagged study fish, the identification color was also recorded. For each female Chinook observed, a unique redd number was recorded along with the date and the observer initials. When multiple female Chinook were observed simultaneously, their activity and location information were recorded separately and each assigned their own redd number and GPS waypoint.

Emergence Survival

In this study, we adapted techniques described by Rubin (1995) to estimate eyed egg to emergence survival of progeny from captive-reared and natural Chinook salmon that spawned naturally in the EFSR. Our objective was to test the hypothesis that eyed egg to fry survival for captive-origin and natural origin Chinook salmon is equal. This hypothesis was tested by estimating survival from eyed egg to emergence for both captive-reared and natural fish that volitionally spawned within our study areas. Field investigations for this study began during the fall of 2006 and were completed in the spring of 2010, and here we present only results from 2009-2010. Naturally spawned eyed eggs collected between September 29 and November 17, 2009 (BY09) included eggs from 13 redds constructed by captive-reared female adult Chinook salmon and 15 redds constructed by natural returning fish (Stark and Gable 2010).

During 2009, we counted a total of 18 and 114 redds from captive-reared and natural origin spawners respectively in the EFSR. Redds chosen to be sampled for the emergence survival study were selected based upon several factors recorded during our redd surveys; including timeline, completeness, structure, and accessibility. The completeness and timeline factors rated our confidence in knowing that the redd was completed and when it was completed, respectively. Knowing when it was completed helped us estimate when eggs would reach the eyed stage and thus when to pump the redd. The structure factor was a subjective grading of the quality or stage of development of classic redd characteristics including trenching, a pit, and especially a definitive egg pillow. The last factor was how easily accessible the redd was with regard to hiking in the redd pump gear. We gave each of these factors a score from one to five, then averaged the score of all four factors to determine a rating for pumping the redd to sample eggs.

Eyed eggs for this study were collected using hydraulic sampling methods described in Venditti et al. (2005) and Baker et al. (2008). This system consists of two main components. The first is a gasoline-powered pump attached to a 3.8 cm diameter aluminum probe using flexible tubing. Holes drilled near the top of the probe infuse air into the water stream through venturi action. The second component is the collection net frame, which consists of a “D” shaped aluminum frame with expanded plastic mesh along its curved portion and netting around the bottom and sides of its straight portion. When the pump is operating, water and air are forced through the probe, which is worked into the substrate within the net frame. The air/water mixture lifts eggs out of the substrate, where they are swept downstream into the net. The expanded plastic screen confines eggs lifted out near the periphery and directs them into the net. In order to minimize disturbance to the redd, sampling is initiated downstream of estimated nest pocket locations and progresses upstream. This prevents fine materials lifted out of the substrate from settling back into the redd and possibly smothering the remaining eggs. Care is also taken to keep personnel below or to the side of the net frame to minimize redd disturbance.

Actual egg numbers collected per redd varied, but attempts were made to collect between 40 and 50 eggs per redd. From these collections, 40 live eggs were then placed into an egg capsule which was placed back in the redd. If more than 40 live eggs were collected at sampling, surplus eggs were placed in an extra egg capsule and buried in the same redd (different location). This extra capsule could then be retrieved as a means of determining emergence timing for the redd, thereby ensuring against premature retrieval and subsequent loss of the treatment capsule results.

Egg transport tubes made of rigid plastic mesh, currently used at Eagle FH (Venditti et al. 2005; Baker et al. 2006a, were modified and used as the egg capsules for eggs placed back into the redd. Egg capsules were approximately 30 cm x 8 cm with mesh holes measuring 1 mm x 2 mm. A plastic-coated steel cable (extraction cord) was secured to the bottom of the capsule and extended through the middle of the capsule, with a 0.5 m “tail” protruding out the top of the capsule to facilitate future removal (Figure 2).

Hydraulic sampling gear previously used for eyed egg collections for captive rearing was modified to allow eyed eggs to be inserted back into their natal redd after being enumerated and carefully placed into an egg capsule. The only modification made to equipment already being used in this program was the addition of an aluminum sleeve that fits snuggly around the outside of the existing probe while the sampling gear is in use. Aluminum washers between the probe and the sleeve form a seal that blocks rocks or debris from becoming lodged between the probe and sleeve.

When an egg pocket was encountered while sampling a redd, the pump was shut off and the probe kept in place while eggs were collected. Egg capsules were filled with gravel collected from the receiving redd, thus representative of the substrate sizes sought by naturally spawning fish. Eyed eggs were then distributed throughout the capsule and around the gravel to minimize egg-to-egg contact. The environment inside each egg capsule was made as similar to the natural conditions as possible. Eggs were not exposed to metal inside the capsule and only stainless steel was used for securing the extraction cord to the outside of each capsule. The probe, still in the gravel at the depth of the egg pocket, was then pulled out of the sleeve and the egg capsule dropped into the empty sleeve and pushed to the bottom. The sleeve was then lifted out of the gravel leaving the egg capsule in the same location from which the eggs were extracted. This method eliminates the additional step of using a spike and tube described by Dumas and Marty (2006).

Figure 2. Egg capsules used for emergence survival study.

Embryo development was then monitored through water temperatures. Surviving fry in egg capsules were sampled after depletion of yolk reserves, determined by tracking accumulated thermal units and using historic emergence timing estimates for similar stocks of Chinook salmon. When estimated emergence timing was reached, the capsules were extracted from the gravel and hatched fish were enumerated. This method was thought to provide a reliable estimate of survival to emergence because a known number of eggs were placed into each capsule, and a known number of fry were collected when a capsule was extracted. Egg capsules from BY09 egg collections were retrieved between April 1 and April 28, 2010, based upon accumulated Celsius Temperature Units (CTUs). Fry hatched in retrieved egg capsules were released into the stream after enumeration.

For statistical comparison, captive-reared fish and natural fish were compared and each redd was treated as a sample unit. Eyed egg to emergence survival was averaged from all redds created by captive-reared fish and natural fish, respectively. Mean egg survival of captive-reared and natural Chinook was compared, and observed differences were determined to be statistically significant if the 95% confidence intervals of their means did not overlap.

EFSR Trapping - Adult Returns

In 2010, the Sawtooth FH satellite facility on the EFSR (EFSR adult trap) was operated to collect genetic samples from returning natural Chinook salmon. The facility is located near Big Boulder Creek, approximately 29 river kilometers upstream from the confluence with the main Salmon River. During high flows, the trap was checked regularly between 0700 and 2000 (every 2-3 hours) to assure proper settings and operation. The trap box was raised each morning and fish were individually netted. Chinook salmon were placed in a separate holding tank for further data collection. All other fishes were identified by species, measured to FL, genetic samples collected on salmonids, and released upstream of the trap.

Procedures for examining trapped Chinook salmon included placing fish in an anesthetic bath containing MS-222 (50 mg/L) buffered with sodium bicarbonate. After each Chinook salmon was adequately sedated, it was checked for any visible marks, scanned for a coded wire tag, gender was determined, and FL to nearest 0.1 cm recorded. If the Chinook salmon was not a recapture, it received a numbered jaw tag (installed around the lower-left mandible), and a genetic sample was taken from the caudal fin with the aid of a hole punch, and preserved in 95% ethanol. The hole punch and any forceps used to remove the sample were subsequently swabbed with isopropyl alcohol between specimens to reduce the possibility of DNA cross-contamination. The genetic sample location on the caudal fin was subsequently treated with Iodophor and sealed with n-butyl cyanoacrylate (veterinary tissue adhesive) in an effort to minimize the possibility of infection. The fish was then placed into a freshwater recovery bath until ready for release upstream of the trap.

Total Chinook salmon numbers were reported to the IDFG trapping database daily via internet. To determine if the trap was altering the movements of migrating adult Chinook salmon, the area downstream of the trap was monitored by snorkeling periodically from July through September, and all observed fish were enumerated by species. Snorkeling efforts were concentrated in the river channel from the pool immediately below the trap to approximately 250 m downstream to the confluence with Big Boulder Creek.

Parentage Genetic Analyses

This project will utilize genetic tagging technology to determine the contribution of naturally spawning captive-reared adult Chinook in the EFSR to natural/wild adult returns to the EFSR adult trap facility. Genetic markers were chosen because they do not require any time, effort, or expense to apply tags to the fish since fish are "tagged with genetic markers inherited from their parents" (ISRP/ISAB 2009-1). All that is needed is a small piece of fin. In addition, genetic markers should have no particular effects on survival or behavior. Lastly, they have the advantage of much higher tagging rates and are less invasive.

Parentage genetic analysis will be used to assign offspring (returning adults) to their parents (natural spawners or captive-reared spawners); (ISRP/ISAB 2009-1, pg. 69). Natural/wild returning adult Chinook (parents) have been captured at the EFSR adult trap since 2004 and tissues collected from each fish. In addition, tissues have also been collected from all mature adult captive-reared Chinook released to spawn naturally (parents) in the EFSR above the trap. Lastly, natural/wild returning adult Chinook (offspring/progeny) will continue to be captured at the EFSR adult trap through 2014 and tissues collected from each fish.

Fin clips from adult Chinook salmon collected from the EFSR adult weir and from spawned-out adults will be genetically analyzed to determine if they were the progeny of captive-reared parents previously released to spawn naturally in the EFSR. Genetic material from these adults will be analyzed with samples from all captive-reared adults released to spawn, all previous years' natural adult returns, and all carcasses recovered from the study area. These samples will be used in parental analyses through the use of microsatellite markers (parental exclusion analysis: Estoup et al. 1998; Bernatchez and Duchesne 2000; Eldridge et al. 2002). These data will allow us to determine the reproductive success of captive-reared adults and quantify contribution to the Upper Salmon River spring/summer Chinook MPG.

DNA will be extracted from fin tissue samples using Nexttec extraction kits (Nexttec, Leverkusen, Germany) following the manufacturer's instructions (fish tissue protocol; version 4.0). Samples will be genotyped with a suite of microsatellite loci standardized among GAPS labs (Seeb et al. 2007). All genotyping will be quality controlled by utilizing positive (known genotype) and negative (without DNA) controls in each run. Repetitive genotyping of ~12% of randomly selected individuals will be completed to ensure reliability of genotyping results and for QA/QC measures.

Parentage (and thus age) of adults will be determined through assignment procedures back to the parental genotype database using either an exclusionary or maximum likelihood analysis (with a zero or one mismatch cut-off) using the software program CERVUS 3.0 (www.fieldgenetics.com; Kalinowski et al. 2007). This latest version of CERVUS has updated likelihood equations that increase the success of paternity assignment while accommodating genotyping error (Kalinowski et al. 2007). Individuals that assign to at least one parent will be summarized by cohort year and age and the number of fish returning from each brood year can be used to collectively determine reproductive success. For each brood year, starting in 2004, the number of captive-reared and released adults that successfully reproduced and the variance in reproductive success of released adults will be summarized.

RESULTS AND DISCUSSION

Adult Rearing, Marking, and Transportation

On June 15, 2010, spaghetti tags were attached to EFSR and WFYF captive-reared Chinook salmon identified as maturing at Manchester. These mature adults consisted of only one brood year (BY05) for both the WFYF and EFSR stocks (Appendix A). A total of 25 WFYF and six EFSR Chinook salmon were tagged during this event (Table 1). Post-tagging mortality occurred in two fish (WFYF).

On June 22, 2010 we transferred 28 captive-reared Chinook salmon from Manchester to the EFSR adult trap holding pond (22 WFYF and 6 EFSR); (Table 1). No mortalities were observed during transport of the WFYF and EFSR stocks in 2010. On July 13, 2010, these fish were transported from the holding pond and released to the EFSR and WFYF, respectively, for volitional spawning. One EFSR and eight WFYF stock mortalities were observed, during holding at the satellite holding pond prior to release. Therefore, 14 Chinook salmon were released into the WFYF and five into the EFSR for volitional spawning. Radio transmitters were not utilized in either stock of captive-reared Chinook salmon released in 2010.

Table 1. Number of captive-reared Chinook salmon tagged and released into their natal waters (West Fork Yankee Fork Salmon River = WFYF and East Fork Salmon River = EFSR). Tagging mortalities, mean fork length (FL), and mean weight of adults are summarized by stock, brood year (BY), and sex. No transfer mortalities were observed in 2010.

Stock / Release Location	BY	Sex	Tagged: Number Tagged	Tagged: Tagging Mortalities	Released: Number Released	Released: Mean FL (mm)	Released: Mean Wt. (g)
EFSR	2005	Female	6	0	5	555	2,634
EFSR	2005	Male	0	0	0	n/a	n/a
		Total EFSR[a]	**6**	**0**	**5**	**555**	**2,634**
WFYF	2005	Female	18	2	12	481	1,774
WFYF	2005	Male	3	0	1	576	1,484
WFYF	2005	Unknown	3	0	1	n/a	521
		Total WFYF[b]	**24**	**2**	**14**		**1,539**
		TOTAL ALL	**30**	**2**	**19**		

[a] One EFSR BY05 female and captive Chinook mortality occurred while holding at the EFSR adult trap ponds.

[b] Eight WFYF BY05 captive Chinook mortalities occurred while holding fish at the EFSR adult trap ponds (4 females, 2 males, 2 unknown).

Brood Year Growth and Survival

Brood year 2005 captive-reared Chinook salmon were transferred as smolts to Manchester on May 1, 2007. General sources of mortality in this cohort were similar to those observed previously (Hassemer et al. 2001; Venditti et al. 2002, 2003a, 2003b, 2005), although losses to BKD were lower than early brood years (Venditti et al. 2003b). Primary sources of mortality in this group included mortality of immature fish during hatchery rearing, unproductive mature adults (includes mature hatchery mortality and mature culls), and productive mature adults (precocial culls at Manchester or released for volitional spawning). Of the 302 BY05 EFSR eyed eggs collected, 242 fish (80.1%) survived to maturity (productive mature adult); 55 fish (18.2%) either died as immature fish (n = 35), unproductive mature fish (n = 15), or of unknown maturity (n = 5). An additional five BY05 EFSR fish were unaccounted or missing (1.7%). Of the 304 BY05 WFYF eyed eggs collected, 261 fish (85.8%) survived to maturity (productive mature adult), 27 fish (8.9%) died as immature fish, six as unproductive mature fish (2.0%), and four died at an unknown stage of maturity (1.3%; Figure 3). An additional six BY05 WFYF fish were unaccounted or missing (2.0%).

Of the 242 fish that matured in the EFSR cohort, 82 fish (33.9%) matured as age-2 (precocial) adults, 39 fish (16.1%) matured as age-3 fish, 115 fish (47.5%) matured as age-4 fish, and six fish (2.5%) matured as age-5 fish. Of the 55 fish that died during culture of the EFSR cohort, zero fish (0.0%) died as age-1, 16 fish (29.1%) died as age-2, 22 fish (40.0%) died as age-3, 13 fish (23.6%) died as age-4, and four fish (7.3%) died as age-5 fish (Figure 3).

Of the 261 fish that matured in the WFYF cohort, 61 fish (23.4%) matured as age-2 (precocial) adults, 80 fish (30.7%) matured as age-3 fish, 101 fish (38.7%) matured as age-4, and 19 fish (7.3%) matured as age-5 fish. Of the 37 fish that died in culture from the WFYF cohort, zero fish (0.0%) died as age-1, four fish (10.8%) died as age-2, 11 fish (29.7%) died as age-3, 12 fish (32.4%) died as age-4, and 10 fish (27.0%) died as age-5 fish (Figure 3).

A total of 503 fish reached maturity from a total of 606 eyed eggs collected (EFSR & WFYF combined, including unproductive mature fish). The precocity rate (age-2 maturation) for both stocks of BY05 fish combined averaged 40.4% (EFSR-51.2%, WFYF-29.6%), compared to brood years 97-04 average rate of 33.5% (Hassemer et al. 2001; Venditti et al. 2002, 2003a, 2003b, 2005). The average maturation rate (productive mature adult) combined for both stocks of BY05 fish (83.0%) was greater than the average of the previous five brood years (BY99-04 = 59.6%). Compared to brood years 1997-2004 mean weight at maturity, BY05 age-3 and age-5 weighed less but age-4 fish weighed more (Figure 4). The mean length at maturity of BY05 fish was shorter than the brood years 1997-2004 average lengths for age-3 and age-5 fish, but BY05 age-4 fish were longer than previous brood years (Figure 5).

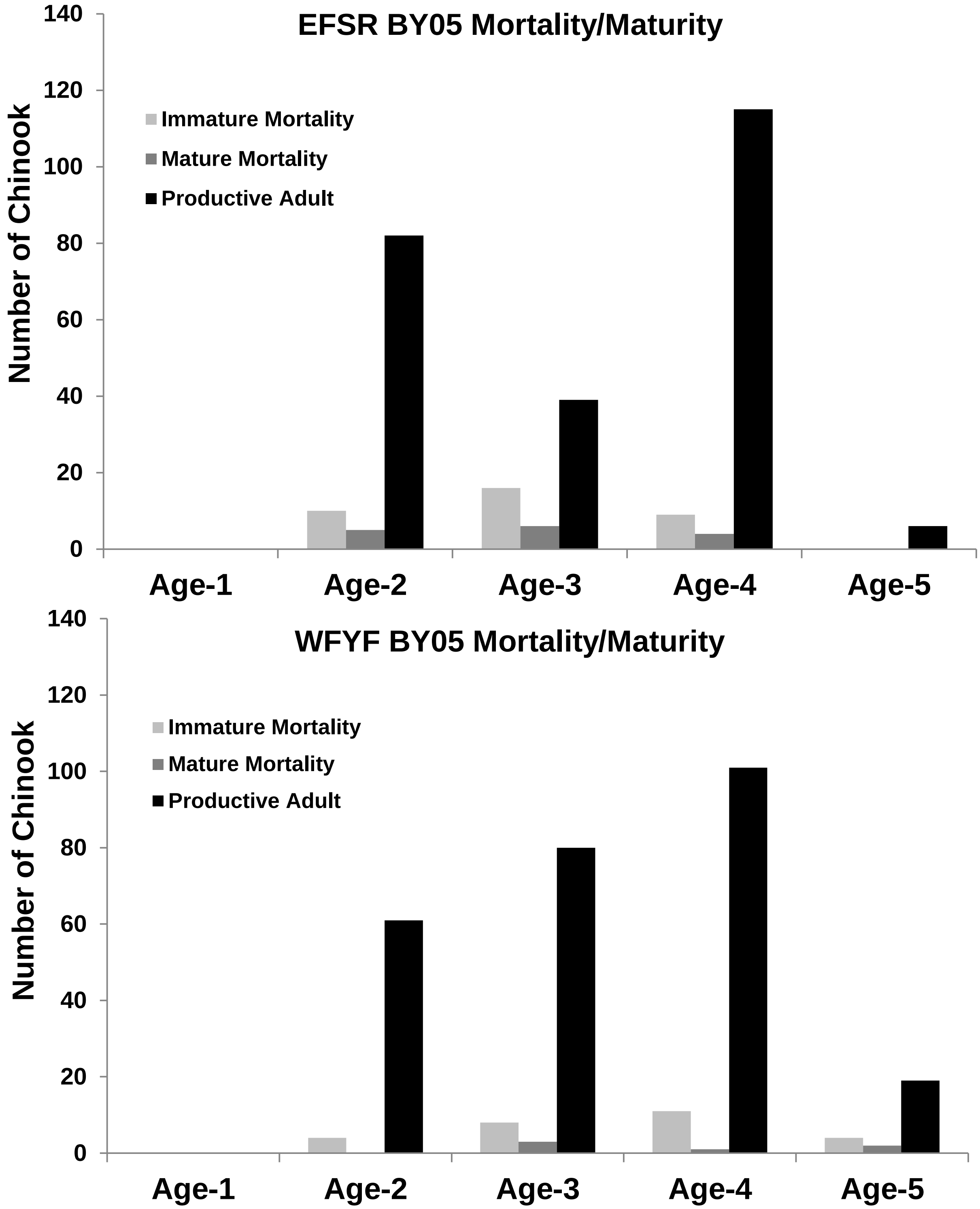

Figure 3. Mortality by age and age at maturation for East Fork Salmon River (EFSR) and West Fork Yankee Fork (WFYF) captive-reared brood year 2005 (BY05) stocks. Immature Mortality = fish that died prior to reaching sexual maturity; Mature Mortality = fish that reached sexual maturity but did not spawn; Productive Adult = fish that reached sexual maturity and were released to spawn.

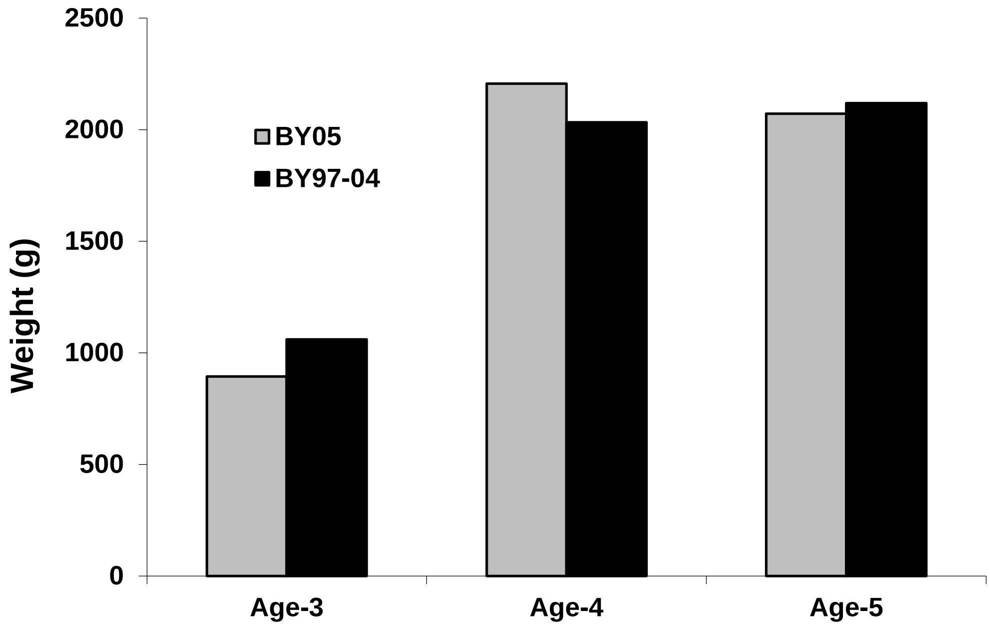

Figure 4. Weight at maturity by age for captive-reared Chinook salmon from brood year 2005 (BY05) and the average of BY98-BY04. No data is available for BY97 age-3, BY00 age-5, or BY01 age-5 fish.

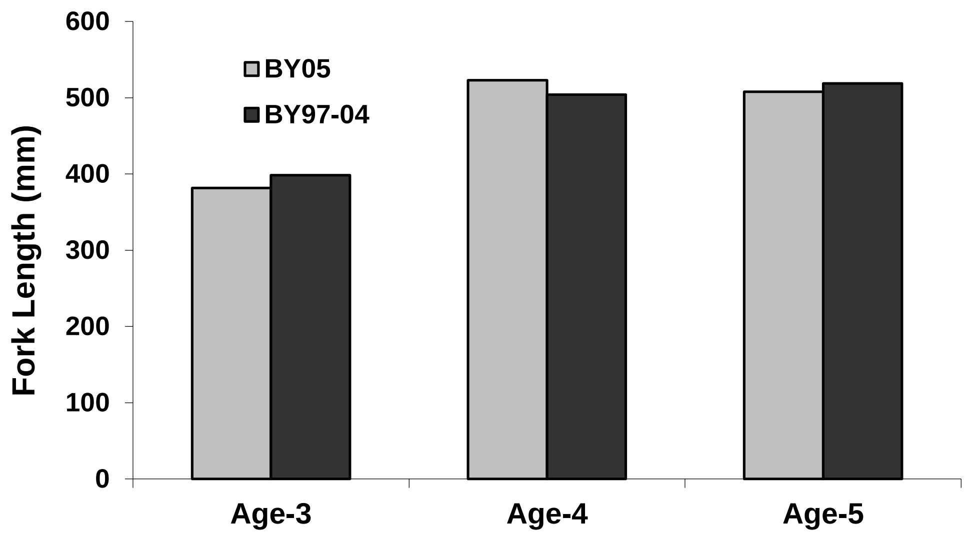

Figure 5. Length at maturity by age for captive-reared Chinook salmon from brood year 2005 (BY05) and the average of BY98-BY04. No data is available for BY97 age-3, BY00 age-5, or BY01 age-5 fish.

Volitional Spawning

Maturing adults were released into their natal streams for natural spawning and spawning observation studies on July 13, 2010 (Appendix B). Fish destined for both the EFSR and the WFYF were held at the EFSR adult trap holding ponds June 22–July 12 then subsequently released the following day. No transportation mortalities occurred in either the WFYF or EFSR stocks. However, nine mortalities occurred while fish were held in the holding ponds. All released fish appeared to be in good condition.

Radio tagging of captive-reared adults in previous years revealed consistent findings, including prolonged holding in one or two pools, and both downstream and upstream migration. Thus, radio tagging and subsequent tracking were not deemed necessary in 2010.

One redd constructed by captive-reared adults was identified within the WFYF on September 7, 2010. No additional redds were observed in the Yankee Fork downstream of the WF confluence. The number of redds per captive female (0.08) was lower than the 2004-2009 weighted mean (0.16; Table 2). Between August 17 and September 7, 2010, seven redds constructed by natural adult Chinook salmon were identified in the WFYF by ground observers compared to the previous five-year average of five (Appendix C). Annual Chinook salmon aerial redd counts conducted by IDFG Region 7 staff in WFYF trend sites were not conducted in 2010 (Table 3).

One redd constructed by captive-reared adults was identified upstream of the EFSR adult trap on September 15, 2010. The number of redds per captive female (0.20) was much less than the previous five-year weighted mean of 0.35 (Table 2). A temporary blocking weir was not installed in 2010, to confine captive spawning to a specific upstream area, and it is unclear whether this had any influence on female redd construction. Between August 4 and September 15, 2010, IDFG crews counted 60 redds constructed by natural adults upstream of the EF adult trap, and an additional 119 were located within 6 km downstream of the trap (Appendix C). Shoshone-Bannock Tribe Fisheries crews counted 110 redds constructed by natural adults from the mouth of the EFSR upstream to 6 km downstream of the EF adult trap. Annual Chinook salmon aerial redd counts were not conducted by IDFG Region 7 staff in EFSR trend sites (NS-1a and NS-1b) in 2010 (Table 3).

Table 2. Number of captive-reared female Chinook salmon released and redds produced by these fish (2004-2010) in the West Fork Yankee Fork Salmon River (WFYF), Yankee Fork Salmon River (YFSR), and East Fork Salmon River (EFSR). Captive redds were enumerated via ground counts.

Study stream	Year	Females release	Captive redds	Redds per captive female
WFYF	2004	59	11	0.19
WFYF	2005	10	2	0.20
WFYF	2006	48	8	0.17
WFYF	2007	113	7	0.06
WFYF	2008	99	13	0.13
WFYF YFSR	2009 2009	98	28[b]	0.29
WFYF	2010	12	1	0.08
EFSR	2004	4	1	0.25
EFSR	2005	25	8	0.32
EFSR	2006	73	13	0.18
EFSR	2007	124	63	0.51
EFSR	2008	112	55	0.49
EFSR	2009	112	19	0.17
EFSR	2010	5	1	0.20

[a] No fish survived to spawn post release in 2003 due to unknown causes (Venditti et al. 2005)

[b] Includes 12 redds located in the YFSR, downstream of the WFYF confluence.

Table 3. Number of redds observed from aerial counts (2000-2009) and ground counts (2010) on the West Fork Yankee Fork Salmon River (WFYF) and East Fork Salmon River (EFSR). Aerial counts were not conducted in 2010.

Stream	Section Description	Number of Redds 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
WFYF	WFYF mouth to Lightning Cr [1]	4	10	10	18	5	1	0	7	1	1	7
	Lightning Cr to Cabin Cr [2]	0	3	1	7	0	0	0	0	0	0	0
	Total	**4**	**13**	**11**	**25**	**5**	**1**	**0**	**7**	**1**	**1**	**7**
EFSR	Mouth of East Fork to Herd Cr (NS-2a) [3]	12	17	56	15	38	12	7	3	34	13	110
	Herd Cr to 3.5 mi downstream of EF Trap (NS-2b) [4]	20	59	79	60	37	18	19	31	40	24	
	3.5 mi downstream of EF Trap to EF Weir (NS-1a) [5]	18	48	100	93	55	32		21	50	13	119
	EF Weir to Bowrey Guard Station (NS-1b) [6]	9	12	44	59	24	16	2	25	27	9	60
	Total	**59**	**136**	**279**	**227**	**154**	**78**	**28**	**80**	**151**	**59**	**289**

Section Start Waypoint - Section End Waypoint (WGS-84 datum; Zone 11):

[1]681207mE 4913151mN - 675543mE 4917302mN
[2]675543mE 4917302mN - 672961mE 4918255mN
[3]713337mE 4905174mN - 715846mE 4892489mN
[4]715846mE 4892489mN - 709618mE 4891548mN
[5]709618mE 4891548mN - 705656mE 4887911mN
[6]705656mE 4887911mN - 700640mE 4872303mN

Discharge (flow) of the EFSR during 2010 was above average during most of the year (Figure 6). Discharge was noticeably higher from mid-June through early July. Similar to the 2009 water year, low discharge during spring and high discharge during early summer was likely the result of a wet yet cold late spring. This delayed runoff likely resulted in cooler than average (previous six years) August and September stream temperatures (Figure 7). Discharge data are not available on the WFYF, so we were not able to examine the relationship between discharge and stream temperatures there.

During 2010, water temperatures during August and September in the EFSR were cooler than the average of the previous six years (10.2°C), while those in the WFYF were slightly warmer than the six-year average (9.5°C; Figure 7). Water temperatures during August and September averaged 8.5°C in the EFSR (minimum 6.5°C / maximum 10.7°C) and 9.7°C in the WFYF (minimum 6.9°C / maximum 12.8°C).

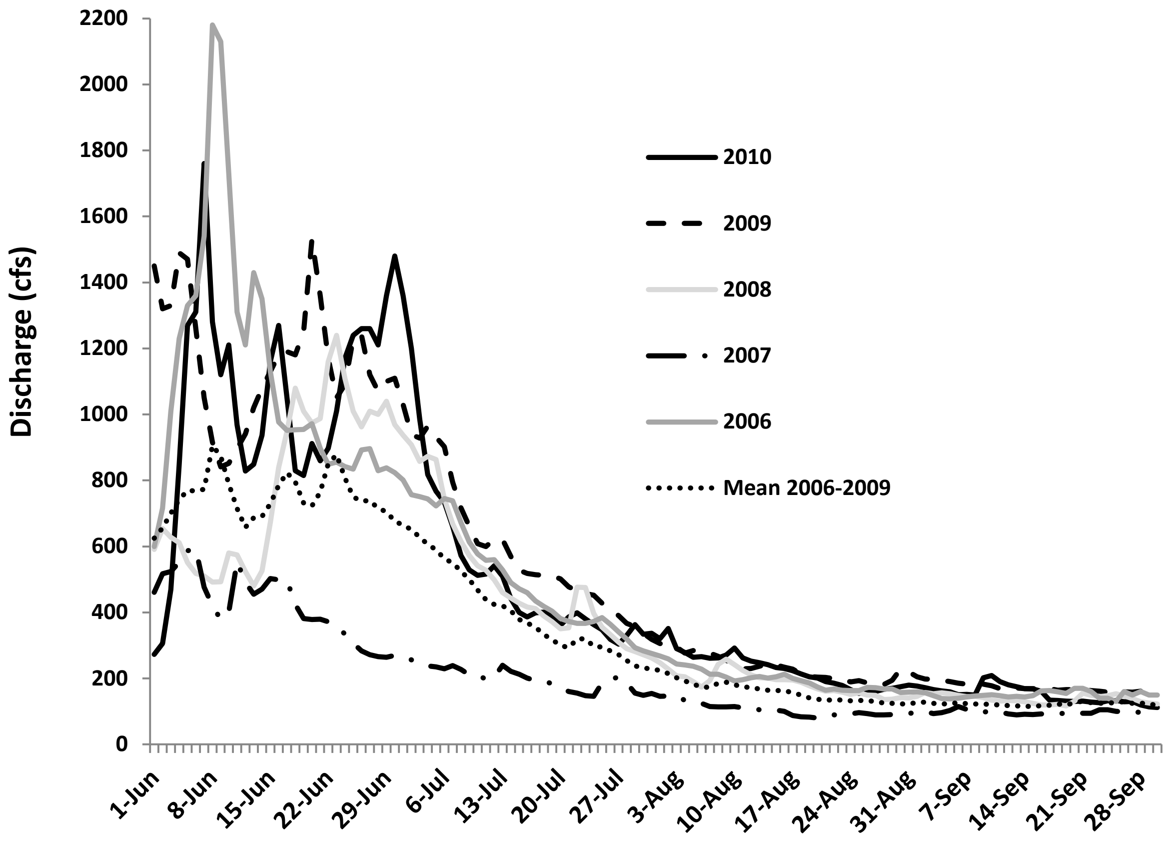

Figure 6. Discharge of the East Fork Salmon River (EFSR), June 1–September 30, 2010.

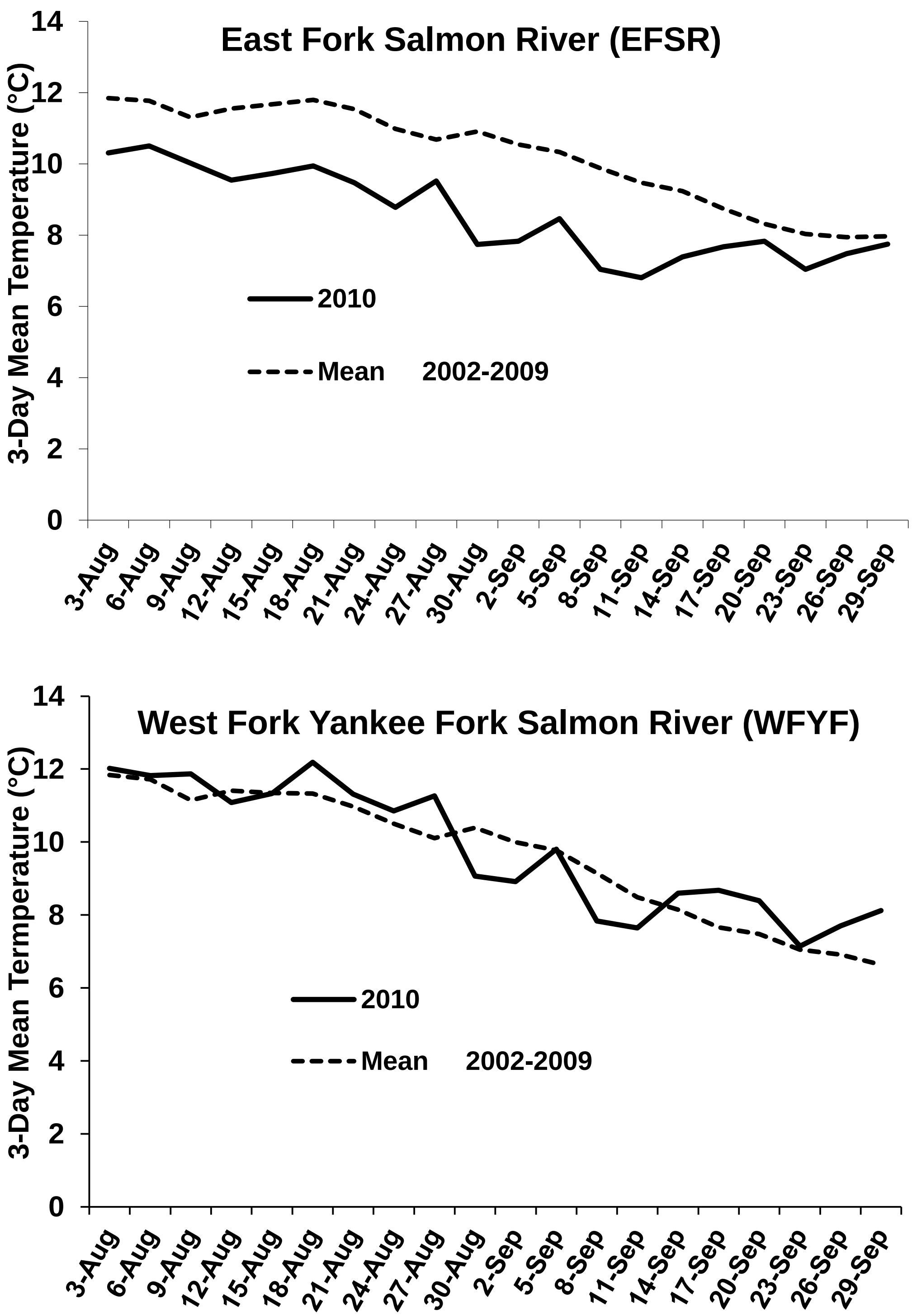

Figure 7. Three-day moving average temperatures in 2010 for the East Fork Salmon River (EFSR) and the West Fork Yankee Fork (WFYF) compared to the mean for 2002-2009.

Emergence Survival

Naturally spawned eyed eggs collected between September 29 and November 17, 2009 (BY09) included eggs from 13 redds constructed by captive-reared female adult Chinook salmon and 15 redds constructed by natural returning fish (Stark and Gable 2010). During 2010, no eggs were collected for broodstock captive culture nor collected as research subjects for any further emergence survival studies. At the end of this reporting period, no study groups remained either in hatchery incubators or in study redds.

From the 480 BY09 natural origin eyed eggs initially placed into capsules that were able to be sampled, 446 live fry were enumerated and released back into the stream (Table 4). Survival (±95% CI) ranged from 80.0% to 100% and averaged 92.9% (±0.03%); (Figure 8). Of the initial 441 captive-reared eyed eggs placed into capsules that were able to be sampled, 319 live fry were recovered and released. Survival ranged from 0.0% to 97.6% for all captive redds and averaged 72.3% (±0.18%).

Natural origin progeny demonstrated higher survival to emergence than captive-reared progeny from BY09 studies. However, the difference in survival was statistically indistinguishable based on overlapping 95% confidence intervals (Figure 8).

Primary sources of mortality in BY09 eggs from both groups appear to be from predatory invertebrates that move into the capsules or from siltation events caused by localized disturbances. One complication that arose was difficulty locating capsules again in the spring after altered flows from ice buildup or downed trees. A total of five capsules could not be located and were not subsequently recovered (redds 8, 10, 15, 21, and 25), which include 3 capsules from natural redds and 2 capsules from captive redds (Table 4). Another limitation to this method (egg capsule) is it does not account for post-hatch mortality that may occur as fry emigrate out of the natural gravel environment.

Table 4. Egg-to-fry survival of brood year 2009 (BY09) eyed eggs collected in the East Fork Salmon River (EFSR). Eyed eggs were collected during October and November 2009, counted into egg capsules, and returned to the redd. Capsules were then retrieved and live fry enumerated and released in April 2010.

Redd Number	Origin	Date Redd Completed	Eyed Eggs in Capsule	Date Retrieved	Dead (eggs, parts, fry)	Live Fry	Egg to Fry Survival
1	N	8/12/09	40	4/1/2010	3	32	80.0%
2	N	8/12/09	40	4/1/2010	0	36	90.0%
3	N	8/16/09	40	4/1/2010	0	37	92.5%
4	N	8/17/09	40	4/1/2010	1	38	95.0%
5	N	8/13/09	40	4/1/2010	0	37	92.5%
6	N	8/18/09	40	4/7/2010	0	36	90.0%
7	N	8/18/09	40	4/7/2010	0	40	100.0%
8	N	8/18/09	40	4/7/2010	NA	NA	NA
9	N/C[a]	8/18/09	40	4/7/2010	0	36	90.0%
10	N	8/18/09	40	4/7/2010	NA	NA	NA
11	N	8/20/09	40	4/14/2010	0	36	90.0%
12	N	8/20/09	40	4/14/2010	0	40	100.0%
13	N	8/25/09	40	4/14/2010	0	40	100.0%
14	N	8/24/09	40	4/14/2010	0	38	95.0%
15	N	8/26/09	40	4/14/2010	NA	NA	NA
16	C	8/29/09	40	4/14/2010	0	35	87.5%
17	C	9/6/09	40	4/14/2010	0	31	77.5%
18	C	9/3/09	41	4/22/2010	0	40	97.6%
19	C	9/3/09	40	4/22/2010	2	30	75.0%
20	C	9/4/09	40	4/22/2010	1	39	97.5%
21	C	9/7/09	40	4/28/2010	NA	NA	NA
22	C/N[b]	9/7/09	40	4/28/2010	0	33	82.5%
23	C	9/10/09	40	4/22/2010	0	34	85.0%
24	C	9/12/09	40	4/28/2010	0	31	77.5%
25	C	9/12/09	40	4/28/2010	NA	NA	NA
26	C	9/12/09	40	4/28/2010	0	13	32.5%
27	C	9/16/09	40	4/28/2010	4	33	82.5%
28	C	9/18/09	40	4/28/2010	28	0	0.0%

[a] Redd with a natural female and captive-reared male spawners.
[b] Redd with a captive-reared female and natural male spawners.
NA Egg capsules that were lost due to winter ice movements, and therefore survival could not be enumerated.

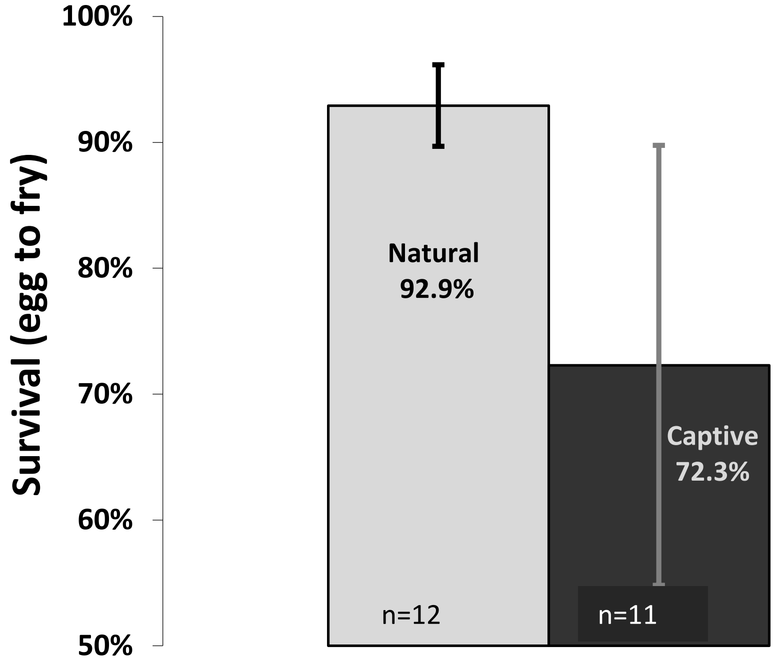

Figure 8. Comparison of egg-to-fry survival from brood year 2009 (BY09) eyed egg collections from redds produced from natural versus captive-reared Chinook salmon in the East Fork Salmon River (EFSR). Error bars represent the 95% CI of the mean, and n is the sample size.

<u>EFSR Trapping - Adult Returns</u>

During operation of the trap facility from June 11 through September 21, two hundred seventy-five adult Chinook salmon (72 females, 163 males, 40 jacks) were captured and released upstream (Table 5). Fin clips were collected from 320 adult Chinook for genetic analyses; 275 from Chinook captured in the adult trap (NS-1b), and 45 samples from post-spawn carcasses downstream of the trap (NS-1a); (Appendix C). One adipose-clipped Chinook salmon (hatchery origin) was trapped and subsequently relocated back to the main-stem Salmon River. Additional species trapped and passed upstream included bull trout *Salvelinus confluentus*, westslope cutthroat trout *O. clarkii lewisi*, rainbow trout *O. mykiss*, and mountain whitefish *Prosopium williamsoni* (Table 6).

Snorkeling surveys were conducted periodically in the pool immediately downstream of the trap to the confluence of Big Boulder Creek. No adult Chinook salmon were observed holding within the reach during the 2010 trapping season. Based on these observations, the trap did not appear to inhibit Chinook salmon from migrating upstream. Additional species observed during snorkeling included bull trout, rainbow trout, cutthroat trout, and mountain whitefish.

Table 5. Disposition of natural origin adult Chinook salmon captured and passed upstream at the East Fork Salmon River (EFSR) adult trap facility during 2010.

	Gender			
	Females	**Males**	**Jacks**	**Total**
June	2	3	0	5
July	36	74	13	123
August	34	81	22	137
Sept	0	5	5	10
Total	**72**	**163**	**40**	**275**
	Age			
Age (length) [a]	**3 (≤64 cm)**	**4 (64-82 cm)**	**5 (>82 cm)**	**Total**
Females	n/a	65	7	72
Males	n/a	148	15	163
Jacks	40	n/a	n/a	40
Total	**40**	**213**	**22**	**275**
	Recaptures			
Age (length)	**3 (≤64 cm)**	**4 (64-82 cm)**	**5 (>82 cm)**	**Total**
Females	n/a	0	0	0
Males	n/a	29	3	32
Jacks	2	n/a	n/a	2
Total [b]	**2**	**29**	**3**	**34**

[a] Fish were assigned ages based upon a previously established age-at-length relationship from natural origin EFSR Chinook salmon scale aging.
[b] Not including multiple recaptures of the same fish.

Table 6. Summary of additional fish captured and passed upstream at the East Fork Salmon River adult trap during 2010.

Species	**No. Captured**[a]
Bull trout	208
Westslope cutthroat trout	3
Rainbow trout	5
Mountain whitefish	217
Catostomus spp.	0
Steelhead (adult)	1
Sockeye salmon[b]	2

[a] Includes trapping mortality.
[b] Captured Sockeye salmon were live transported to Eagle Fish Hatchery for holding.

Parentage Genetic Analyses

In 2010, we successfully genotyped 779 fin tissue samples from a total of 782 (99.6%) Chinook salmon adults captured at the EFSR adult trap from 2004 through 2009 (Table 7). Of the successfully genotyped samples, only 141 assigned to a parent pair (of either natural or captive parents) with 95% confidence zero or one locus mismatches.

Table 7. Chinook salmon captured at the East Fork Salmon River adult trap during 2004-2009, then successfully genotyped and assigned to parents in 2010.

Adult Natural Returns	2004	2005	2006	2007	2008	2009	Total
Number Trapped	152	63	80	89	207	191	782
Successfully Genotyped	152	63	80	89	204	191	779
Tagging Rate	100.0%	100.0%	100.0%	100.0%	98.6%	100.0%	99.6%
2 Parents[a]	0	0	0	9	64	68	141
Other[b]	1	0	1	5	54	64	125
No Assignment	151	63	79	75	86	59	513
Assignment Rate	1%	0%	1%	16%	58%	69%	34%

[a] 95% confident, 0 or 1 mismatch parentage assignments.
[b] Single parent assignments or indiscernible samples that assigned but violated age class.

The parentage assignment rate for 2004-2009 (both single and parent-pair assignments) ranged from 0% to 69%. But, the assignment rate has increased in recent years' adult returns (progeny) from 16% in 2007, 58% in 2008, and most recently 69% in 2009. The overall average assignment rate is clearly brought down by the low assignment rate in 2004-2006, where very few (2 of 295, 0.7%) adult returns (progeny) assigned to any parents either captive or natural. This low assignment rate is not unexpected though, since the EFSR adult trap was not operated until 2004. Thus, we would not have expected any 2004-2006 adult returns to assign to natural adults, since we would not have any genetic samples from any of their parents (brood years 1999-2003).

Of the 141 adults which assigned to a parent-pair with zero locus mismatches, most of these adults (n = 125, 89%) were produced from natural parents. A total of seven returning adults assigned to captive-reared Chinook during 2004-2009 (11%); (Table 8). Four 2008 returning adults assigned to captive x captive crosses from captive-reared fish spawned in captivity in 2004 and eggs placed into egg-boxes. Two 2009 adults assigned to captive x captive crosses from captive-reared adults released to spawn volitionally in 2006. And one 2009 adult return assigned to a captive x natural cross from naturally spawning fish in 2006 (Table 8).

The majority of all parent-pair assignments (n = 87, 62%) were produced from fish that either spawned naturally (n = 83 wild adults) or were spawned in captivity (n = 4 captive-reared adults) in 2004. An additional 44 fish were progeny of wild adults in 2005, and ten 2006 adult spawners (three captive-reared, seven wild); (Table 9).

Table 8. Parentage assignments of adult Chinook captured in the East Fork Salmon River adult trap, 2004-2009. Assignments are 2-parents with 95% confidence, and 0 or 1 mismatches summarized by parent source crosses and age.

	PROGENY ASSIGNMENTS												
	Captive x Captive				Captive x Natural				Natural x Natural				
Adult Return Year (RY)	**Age 3**	**Age 4**	**Age 5**	**Total**	**Age 3**	**Age 4**	**Age 5**	**Total**	**Age 3**	**Age 4**	**Age 5**	**Total**	**TOTAL ALL**
2004				0				0				0	0
2005				0				0				0	0
2006				0				0				0	0
2007				0				0	9			9	9
2008		4		4				0	6	54		60	64
2009	2			2	1			1	7	38	20	65	68

Table 9. Captive-reared (C) and natural/wild (N) Chinook production in the East Fork Salmon River upstream of the adult trap and subsequent progeny (adult returns) assigned to those spawn years. All progeny assignments were to two parents at 95% confidence with zero or one mismatch. Not all fish from spawn years 2005 and 2006 have returned as of January 1, 2010.

	Females		Redds		Redds/Female		Progeny		Recruits/Redd		Recruits/Female	
Spawn Year	**C**	**N[b]**	**C**	**N**	**C**	**N**	**C**	**N**	**C**	**N**	**C**	**N**
1999	6	-	1	4	0.2	-	-	-	-	-	-	-
2000	0	-	0	9	0.0	-	-	-	-	-	-	-
2001	0	-	0	12	0.0	-	-	-	-	-	-	-
2002	37	-	33	44	0.9	-	-	-	-	-	-	-
2003	35[a]	-	-	59	-	-	-	-	-	-	-	-
2004	4	45	1	21	0.3	0.1	4[c]	83	4.0	4.0	1.0	1.8
2005	28	21	11	17	0.4	0.8	0	44	0.0	2.6	0.0	2.1
2006	71	21	12	16	0.2	0.8	3	7	0.3	0.4	0.0	0.3
Total 2004-2006	**103**	**87**	**24**	**54**	**0.9**	**1.7**	**7**	**134**	**4.3**	**7.0**	**1.1**	**4.3**
Mean 2004-2006	**34**	**29**	**8**	**18**	**0.3**	**0.6**	**3**	**45**	**1.4**	**2.3**	**0.4**	**1.4**

[a] *No captive-reared fish survived to spawn post release in 2003 due to unknown causes (Venditti et al. 2005).*
[b] *The EFSR adult trap was not operated from 1998-2003, thus the number of female natural returns are not available in these years.*
[c] *All four progeny assigned to spawn year 2004 were from adult captive-reared fish spawned in captivity and their eggs placed in egg boxes in the EFSR that fall (not from a captive-reared adult release).*

During this reporting period, very few returning adults assigned back to captive-reared parents. Only three adult returns were assigned to captive-reared chinook released to spawn volitionally in the EFSR, all from a single adult release in 2006, two captive x captive parent pairs, one captive x natural parent pair. All the remaining two-parent assignments were from adult returns in 2008 that assigned to 2004 captive-reared adults spawned in captivity and their eggs subsequently placed into egg boxes in the EFSR. We would not have expected captive-reared releases in 2000, 2001, and 2003 to have produced any progeny returning as adults since no females were released (2000 and 2001), or no adults released survived post-spawn (2003). We did however; expect to detect considerable production from the 2002 captive-reared release of 37 females, which produced 33 redds. And, it is not clear why these captive-reared adults did not produce progeny that returned as adults. Lastly, four captive-reared females were released in 2004 that produced only one redd. But, as described above, all parentage assignments back to 2004 brood year were solely from captive-reared adults spawned in captivity and their eggs place in egg boxes in the EFSR, not from adults released to spawn volitionally.

Not all fish have returned from spawn year (brood year) 2005 and 2006 captive-reared releases; therefore, complete evaluation of reproductive success (returned progeny) was not possible as of 2010. Age-5 progeny from SY05 will return in 2010, and SY06 in 2011, which may contribute additional captive-reared production. Adult captive-reared chinook released in 2007-2009 have not yet been genotyped, but we would not expect them to have produced any progeny that could have returned as adults through 2009.

Considering these low assignment rates and low reproductive success, we compared these results with what we might have expected given the number of adult females released and the number of redds they produced and contrasted these estimates with wild fish projections (Table 10). First, we utilized mean fecundity of females to estimate the number of eggs natural/wild returns and captive-reared releases would produce. We used the mean fecundity of female Chinook from 1985-1993 egg takes from the Sawtooth Fish Hatchery, when EFSR wild females were spawned and incorporated into their hatchery broodstock, to estimate natural fecundities (Rogers 1988, 1989, 1990; Alsager 1993a, 1993b; Chapman and Coonts 1993, 1994; Snider and Coonts 1998; Snider and Schilling 1998). The mean fecundity of captive-reared females used in our calculations was from females spawned in captivity in 2002-2004 (Venditti 2003b, 2005; Baker et al. 2006b). We then multiplied their fecundity by the mean spawn to eyed egg survival rates from emergence survival studies in 2007-2009 (Stark and Gable 2010, Stark et al. 2008, 2009) to estimate the number of eyed eggs that would be expected. Next, we used an optimistic, hypothetical mean eyed egg to smolt survival rate of 5% for both wild and captive-reared fish to estimate the number of smolts. Then, we applied an optimistic smolt to adult survival rate (SAR) of 2%, again for both groups, to estimate their adult return (Table 10). Lastly, we utilized EFSR wild adult assigned phenotypic ages (Stark and Gable 2010) to determine the expected age structure of returning adults (Table 11).

Comparison of projected reproductive success (progeny assigned) of wild and captive-reared versus actual progeny assignments, year-to-date, reveals wild fish returned at levels close to our projections (67%) while captive-reared fish did not. No progeny assigned to adult releases from captive-reared brood years that are complete (1999-2004); (Table 11); however, we expected very few fish to return from these releases. We would have expected 28 BY02 fish to have returned and none were interrogated. We would also have expected 9 BY05 fish to have returned and none have been interrogated. The eyed egg to smolt (5%) and smolt-to-adult (2%) survival rates used in our projections were high (optimistic), but they were high for both groups (natural and captive). More BY06 jacks returned than expected which could indicate a strong year class for captive-reared fish. More progeny could assign to these brood years during the 2010 and 2011 return years. Again, four fish in the 2008 adult return did assign to 2004 captive-reared fish spawned in captivity, and eyed eggs placed in egg boxes in the EFSR.

These results to-date provide a complex, and often confounded understanding of reproductive success of natural and captive-reared Chinook salmon in the EFSR. However, results do establish reproductive success of captive-reared Chinook salmon released to spawn as adults. Despite detecting few adult returns produced from captive-reared adults thus far, our best probability of detection remains via adult returns in 2011-2012, because captive-reared releases in 2007 and 2008 demonstrated very good spawning success (Appendix D). Lastly, field efforts will include continued capture and genetic sampling of adult returns at the EFSR adult trap, but also concentrated effort in obtaining fresh genetic samples from carcasses recovered below the trap.

Table 10. Projected natural and captive-reared Chinook salmon production from spawn years 1999-2006 in the East Fork Salmon River. The EFSR adult trap was not operated from 1998-2003, thus the number of female natural returns are not available in these years.

Spawn Year	Females[a]	Redds	Redds/ Female	Eggs/ Female[b]	Egg Production	Spawn to Eyed egg Survival[c]	Eyed egg Production	Eyed egg to Smolt Survival[d]	Smolts	Smolt to Adult Survival[d]	Adult Return
Natural/Wild Chinook											
1999	-	-	-	5,589	-	90.6%	-	5.0%	-	2.0%	-
2000	-	-	-	5,589	-	90.6%	-	5.0%	-	2.0%	-
2001	-	-	-	5,589	-	90.6%	-	5.0%	-	2.0%	-
2002	-	-	-	5,589	-	90.6%	-	5.0%	-	2.0%	-
2003	-	-	-	5,589	-	90.6%	-	5.0%	-	2.0%	-
2004	45	21	0.47	5,589	117,369	90.6%	106,336	5.0%	5,317	2.0%	106
2005	21	17	0.81	5,589	95,013	90.6%	86,082	5.0%	4,304	2.0%	86
2006	21	16	0.78	5,589	92,024	90.6%	83,373	5.0%	4,169	2.0%	83
MEAN	**29**	**18**	**0.69**	**5,589**	**101,469**	**90.6%**	**91,930**	**5.0%**	**4,597**	**2.0%**	**92**
TOTAL	**87**	**54**									**276**
Captive-reared Chinook											
Spawn Year	**Females[e]**	**Redds**	**Redds/ Female**	**Eggs/ Female[f]**	**Egg Production**	**Spawn to Eyed egg Survival[c]**	**Eyed egg Production**	**Eyed egg to Smolt Survival[d]**	**Smolts**	**Smolt to Adult Survival[d]**	**Adult Return**
1999	6	1	0.17	1,214	1,214	70.5%	855	5.0%	43	2.0%	1
2000	0	0	0.00	1,214	0	70.5%	0	5.0%	0	2.0%	0
2001	0	0	0.00	1,214	0	70.5%	0	5.0%	0	2.0%	0
2002	37	33	0.89	1,214	40,062	70.5%	28,224	5.0%	1,411	2.0%	28
2003	35	-	-	1,214	-	70.5%	-	5.0%	-	2.0%	-
2004	4	1	0.25	1,214	1,214	70.5%	855	5.0%	43	2.0%	1
2005	28	11	0.39	1,214	13,354	70.5%	9,408	5.0%	470	2.0%	9
2006	71	12	0.17	1,214	14,568	70.5%	10,263	5.0%	513	2.0%	10
MEAN	**23**	**0.3**	0.01	**1,214**	**10,059**	**70.5%**	**7,086**	**5.0%**	**354**	**2.0%**	**7**
TOTAL	**181**	**58**									**50**

[a] Mean fecundity of EFSR wild females spawned at Sawtooth Fish Hatchery (1985-1993).
[b] Mean spawn to eyed egg survival rate estimated from emergence survival experiments (2007-2009).
[c] Optimistic mean survival rates from the literature.
[d] No captive-reared fish survived to spawn post release in 2003 due to unknown causes (Venditti et al. 2005).
[e] Mean fecundity of captive-reared females, spawned in captivity in 2004 (Baker et al. 2006b).

Table 11. Comparison of projected versus actual progeny two-parent assignments of natural and captive-reared Chinook salmon from brood years 1999-2006 in the East Fork Salmon River.

Natural/Wild Chinook

Brood Year	Parents: Females[a]	Redds	Redds per Female	Projected Adult Returns (Progeny): 2002	2003	2004	2005	2006	2007	2008	2009	Total	Progeny Assigned[b]: No.	% of Projected
2004	45	21	0.47						15	71	20	106	83	78%
2005	21	17	0.81							12	57	69	44	64%
2006	21	16	0.78								12	12	7	58%
MEAN	**29**	**18**	**0.69**									**92**	**45**	
TOTAL	**87**	**54**		-	-	-	-	-	**15**	**83**	**90**	**276**	**134**	**49%**
Progeny Assigned									**9**	**60**	**65**			
Percent of Projected									**58%**	**72%**	**73%**			

Captive-reared Chinook

Brood Year	Parents: Females	Redds[c]	Redds per Female	Projected Adult Returns (Progeny): 2002	2003	2004	2005	2006	2007	2008	2009	Total	Progeny Assigned[b]: No.	% of Projected
1999	6	1	0.17	0	1	0						1	0	0%
2000	0	0	0		0	0	0					0	0	
2001	0	0	0			0	0	0				0	0	
2002	37	33	0.89				4	19	5			28	0	0%
2003	35	-	-					-	-	-		-	0	
2004[d]	4	1	0.25						0	1	0	1	0	0%
2005	28	11	0.39							1	6	7	0	0%
2006	71	12	0.17								1	1	3	300%
MEAN	**23**	**8**	**0.27**									**7**	**0**	
TOTAL	**181**	**58**		**0**	**1**	**0**	**4**	**19**	**5**	**2**	**8**	**49**	**3**	**6%**
Progeny Assigned									**0**	**0**	**3**			
Percent of Projected									**0%**	**0%**	**39%**			

[a] The EFSR adult trap was not operated from 1998-2003, thus adult return projections were not possible in these years.
[b] Brood years 2005 and 2006 are incomplete as of December 31, 2009. Thus more progeny could be assigned in subsequent years.
[c] No captive-reared fish survived to spawn post release in 2003 due to unknown causes (Venditti et al. 2005).
[d] Four 2008 adult returns assigned to captive-reared Chinook, but from adults spawned in captivity in 2004.

LITERATURE CITED

Alsager, R. D. 1993a. Sawtooth Fish Hatchery and East Fork Satellite 1988 Chinook Salmon Brood Year Report and 1989 Steelhead Brood Year Report.

Alsager, R. D. 1993b. Sawtooth Fish Hatchery and East Fork Satellite 1989 Chinook Salmon Brood Year Report and 1990 Steelhead Brood Year Report.

Baker, D. B., J. Heindel, D. Vidergar, J. Gable, K. Plaster, J. Redding, and P. Kline. 2006a. Captive rearing program for Salmon River Chinook salmon, 2005. Project Progress Report to the Bonneville Power Administration, Contract Number 00004002. Portland, Oregon.

Baker, D. B., J. Heindel, D. Vidergar, J. Gable, J. Redding, and P. Kline. 2006b. Captive rearing program for Salmon River Chinook salmon, 2004. Project Progress Report to the Bonneville Power Administration, Contract Number 00004002. Portland, Oregon.

Baker, D. B., J. Heindel, D. Vidergar, E. Stark, J. Gable, K. Plaster, and P. Kline. 2007. Captive rearing program for Salmon River Chinook salmon, 2006. Project Progress Report to the Bonneville Power Administration, Contract Number 00024657. Portland, Oregon.

Berejikian, B. A., E. P. Tezak, S. L. Schroder, C. M. Knudsen, and J. J. Hard. 1997. Reproductive behavioral interactions between wild and captively reared coho salmon (*Oncorhynchus kisutch)*. ICES Journal of Marine Science 54:1040-1050.

Berejikian, B. A., E. P. Tezak, S. L. Schroder, T. A. Flagg, and C. M. Knudsen. 1999. Competitive differences between newly emerged offspring of captive-reared and wild coho salmon. Transactions of the American Fisheries Society 128:832-839.

Berejikian, B. A., E. P. Tezak, L. Park, E. LaHood, S. L. Schroder, and E. Beall. 2001a. Male competition and breeding success in captively reared and wild coho salmon (*Oncorhynchus kisutch)*. Canadian Journal of Fisheries and Aquatic Sciences 58:804-810.

Berejikian, B. A., E. P. Tezak, and S. L. Schroder. 2001b. Reproductive behavior and breeding success of captively reared Chinook salmon. North American Journal of Fisheries Management 21:255-260.

Bernatchez, L., and P. Duchesne. 2000. Individual-based genotype analysis in studies of parentage and population assignment: how many loci, how many alleles? Canadian Journal of Fisheries and Aquatic Sciences 57:1-12.

Chapman, J., and P. Coonts. 1993. Sawtooth Fish Hatchery 1990 Chinook Salmon Brood Year Report and 1991 Steelhead Brood Year Report.

Chapman, J., and P. Coonts. 1994. Sawtooth Fish Hatchery and East Fork Satellite 1991 Chinook Salmon Brood Year Report and 1992 Steelhead Brood Year Report.

Dumas, J., and S. Marty. 2006. A new method to evaluate egg-to-fry survival in salmonids, trials with Atlantic salmon. Journal of Fish Biology 68:284-304.

Eldridge, W. H., M. D. Bacigalupi, I. R. Adelman, L. M. Miller, and A. R. Kapuscinski. 2002. Determination of relative survival of two stocked walleye populations and resident natural-origin fish by microsatellite DNA parentage assignment. Canadian Journal of Fisheries and Aquatic Sciences 59:282-290.

Estoup, A., K. Gharbi, M. SanCristobal, C Chevalet, P. Haffray, and R. Guyomard. 1998. Parentage assignment using microsatellites in turbot (*Scophthalmus maximus*) and rainbow trout (*Oncorhynchus mykiss*) hatchery populations. Canadian Journal of Fisheries and Aquatic Sciences 55:715-725.

Flagg, T. A., and C. V. W. Mahnken. 1995. An assessment of the status of captive broodstock technology for Pacific Salmon. Final report to the Bonneville Power Administration, Project No. 93-56, Contract No. DE-AI79-93BP55064. Portland, Oregon.

Fleming, I. A., and M. R. Gross. 1992. Reproductive behavior of hatchery and wild coho salmon (*Oncorhynchus kisutch*): does it differ? Aquaculture 103:101-121.

Fleming, I. A., and M. R. Gross. 1993. Breeding success of hatchery and wild coho salmon (*Oncorhynchus kisutch*) in competition. Ecological Applications 3(2):230-245.

Fleming, I. A., B. Jonsson, M. R. Gross, and A. Lamberg. 1996. An experimental study of the reproductive behaviour and success of farmed and wild Atlantic salmon (*Salmo salar*). Journal of Applied Ecology 33:893-905.

Frost, D. A., W. C. McAuley, D. J. Maynard, and T. A. Flagg. 2002. Redfish Lake sockeye salmon captive broodstock rearing and research. Project Progress Report to the Bonneville Power Administration, Contract 00004464. Portland, Oregon.

Hassemer, P. F., P. Kline, J. Heindel, and K. Plaster. 1999. Captive rearing initiative for Salmon River Chinook salmon, 1998. Project Progress Report to the Bonneville Power Administration, Contracts 97-BI-97538 and 98-BI-63416, Portland, Oregon.

Hassemer, P. F., P. Kline, J. Heindel, K. Plaster, and D. A. Venditti. 2001. Captive rearing initiative for Salmon River Chinook salmon, 1999. Project Progress Report to the Bonneville Power Administration, Contracts 97-BI-97538 and 98-BI-63416, Portland, Oregon.

Hendry, A. P., A. H. Dittman, and R. W. Hardy. 2000. Proximate composition, reproductive development, and a test for trade-offs in captive sockeye salmon. Transactions of the American Fisheries Society 129:1082-1095.

ISRP/ISAB (Independent Scientific Review Panel and Independent Scientific Advisory Board). 2009-1. Tagging Report: A comprehensive review of Columbia River Basin tagging technologies and programs. (http://www.nwcouncil.org/library/isab/isrpisab2009-1.pdf).

Joyce, J. E., R. M. Martin, and F. P. Thrower. 1993. Successful maturation of captive chinook salmon broodstock. Progressive Fish-Culturist 55:191-194.

Kalinowski, S. T., M. L. Taper, and T. C. Marshall. 2007. Revising how the computer program CERVUS accommodates genotyping error increases success in paternity assignment. Molecular Ecology 16: 1099-1006.

McClure, M., and 11 co-authors. 2003. Independent Populations of Chinook, steelhead, and sockeye for listed evolutionarily significant units within the interior Columbia River basin (Discussion Draft). Interior Columbia Basin Technical Recovery Team.

NMFS (National Marine Fisheries Service). 1992. Threatened status for Snake River spring/summer chinook salmon, threatened status for Snake River fall chinook salmon. Final Rule. Federal Register 57:78 (April 22, 1992):14563-14663.

NMFS (National Marine Fisheries Service). 1995. Proposed Recovery Plan for Snake River Salmon. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. NMFS Protected Resources Division. Portland, Oregon.

NPCC (Northwest Power and Conservation Council). 1994. Columbia River Basin Fish and Wildlife Program. Portland, Oregon.

NPCC (Northwest Power and Conservation Council). 2000. Columbia River Basin Fish and Wildlife Program. Portland, Oregon.

Reisenbichler, R. R., and S. P. Rubin. 1999. Genetic changes from artificial propagation of Pacific salmon affect the productivity and viability of supplemented populations. ICES Journal of Marine Science 56:459-466.

Rogers, T. L. 1988. Sawtooth Fish Hatchery and East Fork Satellite 1985 Chinook Salmon Brood Year Report and 1986 Steelhead Brood Year Report.

Rogers, T. L. 1989. Sawtooth Fish Hatchery and East Fork Satellite 1986 Chinook Salmon Brood Year Report and 1987 Steelhead Brood Year Report.

Rogers, T. L. 1990. Sawtooth Fish Hatchery and East Fork Satellite 1987 Chinook Salmon Brood Year Report and 1988 Steelhead Brood Year Report.

Rubin, J. F. 1995. Estimating the success of natural spawning of salmonids in streams. Journal of Fish Biology 46:603-622.

Schmitten, R., W. Stelle, and M. Brentwood. 1997. Draft Snake River Salmon Recovery Plan. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Seeb, L. W., A. Antonovich, M. A. Banks, T. D. Beacham, M. R. Bellinger, S. M. Blankenship, M. Campbell, N. A. Decovich, J. C. Garza, C. M. Guthrie III, T. A. Lundrigan, P. Moran, S. R. Narum, J. J. Stephenson, K. J. Supernault, D. J. Teel, W. D. Templin, J. K. Wenburg, S. F. Young, and C. T. Smith. 2007. Development of a standardized DNA database for Chinook salmon. Fisheries 32:540–552.

Snider, B. R. and P. Coonts 1998. Sawtooth Fish Hatchery and East Fork Satellite 1992 Chinook Salmon Brood Year Report and 1993 Steelhead Brood Year Report.

Snider, B. R. and K. Schilling 1998. Sawtooth Fish Hatchery and East Fork Satellite 1993 Chinook Salmon Brood Year Report and 1994 Steelhead Brood Year Report.

Stark, E. J., D. Baker, J. Gable, and J. Heindel. 2008. Captive rearing program for Salmon River Chinook salmon, 2007. Project Progress Report to the Bonneville Power Administration, Contract Number 00029463. Portland, Oregon.

Stark, E. J., J. Gable, D. Baker, and J. Heindel. 2009. Captive rearing program for Salmon River Chinook salmon, 2008. Project Progress Report to the Bonneville Power Administration, Contract Number 00035399. Portland, Oregon.

Stark, E. J., and J. Gable. 2010. Captive rearing program for Salmon River Chinook salmon, 2009. Project Progress Report to the Bonneville Power Administration, Contract Number 00039364. Portland, Oregon.

Thoesen, J. C. (editor). 1994. Blue book, version 1. Suggested procedures for the detection and identification of certain finfish and shellfish pathogens. Fish Health Section, American Fisheries Society. Bethesda, Maryland.

Venditti, D. A., C. Willard, C. Looney, P. Kline, and P. Hassemer. 2002. Captive rearing program for Salmon River Chinook salmon, 2000. Project Progress Report to the Bonneville Power Administration, Contract Number 00000167-00001, Portland, Oregon.

Venditti, D. A., C. Willard, T. Giambra, D. Baker, and P. Kline. 2003a. Captive rearing program for Salmon River chinook salmon, 2001. Project Progress Report to the Bonneville Power Administration, Contract Number 00004002. Portland, Oregon.

Venditti, D. A., C. Willard, C. James, D. Baker, and P. Kline. 2003b. Captive rearing program for Salmon River Chinook salmon, 2002. Project Progress Report to the Bonneville Power Administration, Contract Number 00004002. Portland, Oregon.

Venditti, D. A., D. Baker, J. Heindel, C. James, and P. Kline. 2005. Captive rearing program for Salmon River Chinook salmon, 2003. Project Progress Report to the Bonneville Power Administration, Contract Number 00004002. Portland, Oregon.

APPENDICES

Appendix A. Summary of fish transfers conducted by the Chinook Salmon Captive Rearing Project during 2010. MAN = Manchester Research Station, WFYF = West Fork Yankee Fork River, POND = Sawtooth Hatchery - East Fork Salmon River satellite holding pond, EFSR = East Fork Salmon River, Brood Year = BY, NE = natural egg.

Stream-Source	BY	MAN to POND	Transfer Date	POND to EFSR	Transfer Date	POND to WFYF	Transfer Date
WFYF-NE	2005	22	22-Jun			14	13-Jul
EFSR-NE	2005	6	22-Jun	5	13-Jul		

Appendix B. Tag and identification summary for captive-reared Chinook salmon released for volitional spawning in the West Fork Yankee Fork Salmon River (WFYF) and the East Fork Salmon River (EFSR) in 2010. Fish were spaghetti-tagged for visual identification (Fluorescent = FL). A portable ultrasound unit was used on maturing fish reared at the Manchester Research Station to determine sex, and classified as female or male.

Pit Tag Number	Stock	BY	Sex	Tag Color
3D9.1BF259109B	WFYF	2005	Female	White
3D9.1BF2584760	WFYF	2005	Unknown	White
3D9.1BF258D348	WFYF	2005	Female	White
3D9.1BF2584703	WFYF	2005	Female	White
3D9.1BF2591C94	WFYF	2005	Female	White
3D9.1BF2590E40	WFYF	2005	Female	White
3D9.1BF258CB7B	WFYF	2005	Female	White
3D9.1BF2587730	WFYF	2005	Male	Yellow
3D9.1BF2584983	WFYF	2005	Female	White
3D9.1BF258CBA4	WFYF	2005	Female	White
3D9.1BF2585E7A	WFYF	2005	Female	White
3D9.1BF258F728	WFYF	2005	Female	White
3D9.1BF2584800	WFYF	2005	Female	White
3D9.1BF25841BC	WFYF	2005	Female	White
3D9.1BF258C9C5	WFYF	2005	Female	White
3D9.1BF2590FCE	EFSR	2005	Female	Orange
3D9.1BF2591ED7	EFSR	2005	Female	Orange
3D9.1BF258FB97	EFSR	2005	Female	Orange
3D9.1BF25849FB	EFSR	2005	Female	Orange
3D9.1BF2594837	EFSR	2005	Female	Orange

Appendix C. Summary of Chinook salmon redds observed during ground counts in the West Fork Yankee Fork Salmon River (WFYF), Yankee Fork Salmon River (YFSR), and the East Fork Salmon River (EFSR) during 2010. Origin of redds observed were natural (N), both female and male; captive-reared (C), both female and male; captive female and natural male (C/N); or natural female and captive male (N/C). Locations are GPS waypoints (WGS-84 datum).

Stream	Redd Name	Origin	Date Observed	Location Easting	Northing	Zone	Section Name	SGR Trend Transect
EFSR	KBK01EF	N	8/4/10	705525	4887587	11	N1	NS-1b
EFSR	KBK02EF	N	8/5/10	703164	4878111	11	N7	NS-1b
EFSR	KBK03EF	N	8/12/10	703341	4880757	11	N5	NS-1b
EFSR	ECP01EF	N	8/12/10	703496	4883139	11	N4	NS-1b
EFSR	KBK04EF	N	8/13/10	705728	4888209	11	N01	NS-1a
EFSR	KBK05EF	N	8/13/10	705914	4888255	11	N01	NS-1a
EFSR	KBK06EF	N	8/13/10	706091	4888353	11	N01	NS-1a
EFSR	KBK07EF	N	8/13/10	706383	4889423	11	N01	NS-1a
EFSR	KBK08EF	N	8/13/10	706399	4889410	11	N01	NS-1a
EFSR	KBK09EF	N	8/13/10	706519	4889494	11	N01	NS-1a
EFSR	KBK10EF	N	8/14/10	704716	4885899	11	N2	NS-1b
EFSR	KBK11EF	N	8/14/10	704730	4885458	11	N2	NS-1b
EFSR	KBK12EF	N	8/14/10	703510	4883279	11	N4	NS-1b
EFSR	DPR01EF	N	8/15/10	703350	4880353	11	N6	NS-1b
EFSR	DPR02EF	N	8/15/10	703411	4880100	11	N6	NS-1b
EFSR	DPR03EF	N	8/15/10	703483	487677	11	N6	NS-1b
EFSR	DPR04EF	N	8/16/10	705269	4887125	11	N1	NS-1b
EFSR	DPR05EF	N	8/17/10	704055	4884057	11	N3	NS-1b
EFSR	DPR06EF	N	8/17/10	703894	4884058	11	N3	NS-1b
EFSR	DPR07EF	N	8/17/10	703942	4883942	11	N3	NS-1b
EFSR	DPR08EF	N	8/17/10	703504	4883238	11	N4	NS-1b
EFSR	DPR09EF	N	8/17/10	703475	4882862	11	N4	NS-1b
EFSR	DPR10EF	N	8/17/10	703475	4882872	11	N4	NS-1b
EFSR	ECP02EF	N	8/18/10	703461	4880998	11	N5	NS-1b
EFSR	ECP03EF	N	8/18/10	703328	4880597	11	N5	NS-1b
EFSR	ECP04EF	N	8/18/10	703328	4880597	11	N5	NS-1b
EFSR	KBK13EF	N	8/19/10	706672	4889570	11	N01	NS-1a
EFSR	KBK14EF	N	8/19/10	706689	4889568	11	N01	NS-1a
EFSR	KBK15EF	N	8/19/10	706728	4889664	11	N01	NS-1a
EFSR	KBK16EF	N	8/19/10	707252	4890015	11	N01	NS-1a
EFSR	KBK17EF	N	8/19/10	707421	4890191	11	N01	NS-1a
EFSR	KBK18EF	N	8/19/10	707486	4890423	11	N01	NS-1a
EFSR	KBK19EF	N	8/19/10	707488	4890439	11	N01	NS-1a
EFSR	KBK20EF	N	8/19/10	707639	4890414	11	N01	NS-1a
EFSR	KBK21EF	N	8/19/10	707786	4890476	11	N01	NS-1a
EFSR	KBK22EF	N	8/19/10	707836	4890661	11	N01	NS-1a
EFSR	KBK23EF	N	8/19/10	707839	4890669	11	N01	NS-1a
EFSR	KBK24EF	N	8/19/10	707906	4890736	11	N01	NS-1a
EFSR	KBK25EF	N	8/19/10	707917	4890747	11	N01	NS-1a
EFSR	KBK26EF	N	8/19/10	707438	4890299	11	N01	NS-1a
EFSR	ECP05EF	N	8/19/10	705586	4887696	11	N1	NS-1b
EFSR	ECP06EF	N	8/19/10	705607	4887683	11	N1	NS-1b

Appendix C. Continued.

Stream	Redd Name	Origin	Date Observed	Location Easting	Location Northing	Location Zone	Section Name	SGR Trend Transect
EFSR	ECP07EF	N	8/19/10	705607	4887683	11	N1	NS-1b
EFSR	ECP08EF	N	8/19/10	705536	4887591	11	N1	NS-1b
EFSR	ECP09EF	N	8/19/10	705469	4887522	11	N1	NS-1b
EFSR	ECP10EF	N	8/19/10	705001	4886802	11	N1	NS-1b
EFSR	ECP11EF	N	8/20/10	704631	4884808	11	N2	NS-1b
EFSR	ECP12EF	N	8/20/10	704153	4884209	11	N3	NS-1b
EFSR	ECP13EF	N	8/20/10	704083	4884052	11	N4	NS-1b
EFSR	ECP14EF	N	8/20/10	704048	4884088	11	N4	NS-1b
EFSR	ECP15EF	N	8/20/10	703953	4884074	11	N4	NS-1b
EFSR	ECP16EF	N	8/21/10	703843	4883877	11	N4	NS-1b
EFSR	DPR11EF	N	8/22/10	709326	4891513	11	N01	NS-1a
EFSR	DPR12EF	N	8/22/10	709137	4891480	11	N01	NS-1a
EFSR	DPR13EF	N	8/22/10	709137	4891481	11	N01	NS-1a
EFSR	DPR14EF	N	8/22/10	708844	4891429	11	N01	NS-1a
EFSR	DPR15EF	N	8/22/10	708567	4891393	11	N01	NS-1a
EFSR	DPR16EF	N	8/22/10	708086	4890959	11	N01	NS-1a
EFSR	DPR17EF	N	8/22/10	707383	4890235	11	N01	NS-1a
EFSR	DPR18EF	N	8/22/10	707395	4890205	11	N01	NS-1a
EFSR	DPR19EF	N	8/22/10	707135	4889907	11	N01	NS-1a
EFSR	DPR20EF	N	8/22/10	707135	4889906	11	N01	NS-1a
EFSR	DPR21EF	N	8/22/10	707092	4889949	11	N01	NS-1a
EFSR	DPR22EF	N	8/22/10	706938	4889788	11	N01	NS-1a
EFSR	DPR23EF	N	8/22/10	706737	4883753	11	N01	NS-1a
EFSR	DPR24EF	N	8/22/10	706593	4889592	11	N01	NS-1a
EFSR	DPR25EF	N	8/22/10	706576	4889610	11	N01	NS-1a
EFSR	DPR26EF	N	8/22/10	706504	4889582	11	N01	NS-1a
EFSR	DPR27EF	N	8/22/10	706477	4889563	11	N01	NS-1a
EFSR	DPR28EF	N	8/22/10	706538	4889427	11	N01	NS-1a
EFSR	DPR29EF	N	8/22/10	706538	4889427	11	N01	NS-1a
EFSR	DPR30EF	N	8/22/10	706389	4889420	11	N01	NS-1a
EFSR	DPR31EF	N	8/22/10	706340	4889392	11	N01	NS-1a
EFSR	DPR32EF	N	8/22/10	706343	4889368	11	N01	NS-1a
EFSR	DPR33EF	N	8/22/10	706364	4889261	11	N01	NS-1a
EFSR	DPR34EF	N	8/22/10	706323	4889110	11	N01	NS-1a
EFSR	DPR35EF	N	8/22/10	706350	4889098	11	N01	NS-1a
EFSR	DPR36EF	N	8/22/10	706301	4889071	11	N01	NS-1a
EFSR	DPR37EF	N	8/22/10	706279	4889065	11	N01	NS-1a
EFSR	DPR38EF	N	8/22/10	706221	4889058	11	N01	NS-1a
EFSR	DPR39EF	N	8/22/10	706194	4889042	11	N01	NS-1a
EFSR	DPR40EF	N	8/22/10	706145	4889024	11	N01	NS-1a
EFSR	DPR41EF	N	8/22/10	706163	4888844	11	N01	NS-1a
EFSR	DPR42EF	N	8/22/10	706040	4888661	11	N01	NS-1a
EFSR	DPR43EF	N	8/22/10	706080	4888602	11	N01	NS-1a
EFSR	DPR44EF	N	8/22/10	706098	4888520	11	N01	NS-1a
EFSR	DPR45EF	N	8/22/10	706029	4888285	11	N01	NS-1a
EFSR	DPR46EF	N	8/22/10	705840	4888273	11	N01	NS-1a
EFSR	DPR47EF	N	8/22/10	705816	4888269	11	N01	NS-1a
EFSR	DPR48EF	N	8/22/10	705881	4888274	11	N01	NS-1a

Appendix C. Continued.

Stream	Redd Name	Origin	Date Observed	Location Easting	Location Northing	Location Zone	Section Name	SGR Trend Transect
EFSR	DPR49EF	N	8/22/10	705759	4888257	11	N01	NS-1a
EFSR	DPR50EF	N	8/22/10	705759	4888257	11	N01	NS-1a
EFSR	DPR51EF	N	8/22/10	705713	4888193	11	N01	NS-1a
EFSR	DPR52EF	N	8/22/10	705734	4888172	11	N01	NS-1a
EFSR	DPR53EF	N	8/22/10	705710	4888123	11	N01	NS-1a
EFSR	DPR54EF	N	8/22/10	705703	4888903	11	N01	NS-1a
EFSR	DPR55EF	N	8/22/10	705697	4888071	11	N01	NS-1a
EFSR	DPR56EF	N	8/22/10	705686	4887951	11	N01	NS-1a
EFSR	EJS01EF	N	8/24/10	705434	4887479	11	N1	NS-1b
EFSR	EJS02EF	N	8/24/10	705421	4887451	11	N1	NS-1b
EFSR	EJS03EF	N	8/24/10	705325	4887237	11	N1	NS-1b
EFSR	EJS04EF	N	8/24/10	705315	4887204	11	N1	NS-1b
EFSR	EJS05EF	N	8/24/10	705174	4887073	11	N1	NS-1b
EFSR	EJS06EF	N	8/24/10	704996	4886811	11	N1	NS-1b
EFSR	EJS07EF	N	8/24/10	704779	4885660	11	N2	NS-1b
EFSR	EJS08EF	N	8/24/10	704792	4885473	11	N2	NS-1b
EFSR	EJS09EF	N	8/24/10	704710	4885394	11	N2	NS-1b
EFSR	EJS10EF	N	8/24/10	704641	4885107	11	N2	NS-1b
EFSR	DPR57EF	N	8/24/10	704614	4884934	11	N3	NS-1b
EFSR	DPR58EF	N	8/24/10	704020	4884742	11	N3	NS-1b
EFSR	DPR59EF	N	8/24/10	704183	4884217	11	N3	NS-1b
EFSR	DPR60EF	N	8/24/10	703907	4883893	11	N3	NS-1b
EFSR	EJS11EF	N	8/25/10	708289	4891096	11	N01	NS-1a
EFSR	EJS12EF	N	8/25/10	708232	4891068	11	N01	NS-1a
EFSR	EJS13EF	N	8/25/10	707218	4891060	11	N01	NS-1a
EFSR	EJS14EF	N	8/25/10	707926	4890752	11	N01	NS-1a
EFSR	EJS15EF	N	8/25/10	707847	4890712	11	N01	NS-1a
EFSR	EJS16EF	N	8/25/10	707739	4890390	11	N01	NS-1a
EFSR	EJS17EF	N	8/25/10	707668	4890405	11	N01	NS-1a
EFSR	EJS18EF	N	8/25/10	707489	4890431	11	N01	NS-1a
EFSR	EJS19EF	N	8/25/10	707413	4890192	11	N01	NS-1a
EFSR	EJS20EF	N	8/25/10	706932	4889857	11	N01	NS-1a
EFSR	EJS21EF	N	8/25/10	706734	4889731	11	N01	NS-1a
EFSR	EJS22EF	N	8/25/10	706731	4889575	11	N01	NS-1a
EFSR	EJS23EF	N	8/25/10	706623	4889588	11	N01	NS-1a
EFSR	EJS24EF	N	8/25/10	706622	4889602	11	N01	NS-1a
EFSR	EJS25EF	N	8/25/10	706589	4889599	11	N01	NS-1a
EFSR	EJS26EF	N	8/25/10	706501	4889548	11	N01	NS-1a
EFSR	EJS27EF	N	8/25/10	706536	4889510	11	N01	NS-1a
EFSR	EJS28EF	N	8/25/10	706479	4889432	11	N01	NS-1a
EFSR	EJS29EF	N	8/25/10	706461	4889424	11	N01	NS-1a
EFSR	EJS30EF	N	8/25/10	706410	4889427	11	N01	NS-1a
EFSR	KBK27EF	N	8/26/10	706030	4888300	11	N01	NS-1a
EFSR	KBK28EF	N	8/26/10	706075	4888343	11	N01	NS-1a
EFSR	KBK29EF	N	8/26/10	706117	4888382	11	N01	NS-1a
EFSR	KBK30EF	N	8/26/10	706107	4888514	11	N01	NS-1a
EFSR	KBK31EF	N	8/26/10	706045	4888651	11	N01	NS-1a
EFSR	KBK32EF	N	8/26/10	706340	4889169	11	N01	NS-1a

Appendix C. Continued.

Stream	Redd Name	Origin	Date Observed	Location Easting	Location Northing	Location Zone	Section Name	SGR Trend Transect
EFSR	KBK33EF	N	8/27/10	708342	4891193	11	N02	NS-1a
EFSR	KBK34EF	N	8/27/10	708359	4891269	11	N02	NS-1a
EFSR	KBK35EF	N	8/27/10	708397	4891299	11	N02	NS-1a
EFSR	KBK36EF	N	8/27/10	708460	4891329	11	N02	NS-1a
EFSR	KBK37EF	N	8/27/10	708644	4891370	11	N02	NS-1a
EFSR	KBK38EF	N	8/27/10	708865	4891422	11	N02	NS-1a
EFSR	KBK39EF	N	8/27/10	709199	4891481	11	N02	NS-1a
EFSR	KBK40EF	N	8/27/10	709366	4891534	11	N02	NS-1a
EFSR	KBK41EF	N	8/27/10	709656	4891537	11	N02	NS-1a
EFSR	DPR61EF	N	8/30/10	705589	4887684	11	N1	NS-1b
EFSR	DPR62EF	N	8/30/10	705570	4887618	11	N1	NS-1b
EFSR	DPR63EF	N	8/30/10	704713	4885886	11	N2	NS-1b
EFSR	DPR64EF	N	8/30/10	704728	4885472	11	N2	NS-1b
EFSR	DPR65EF	N	8/31/10	708211	4891059	11	N01	NS-1a
EFSR	DPR66EF	N	8/31/10	707918	4890748	11	N01	NS-1a
EFSR	DPR67EF	N	8/31/10	707369	4890142	11	N01	NS-1a
EFSR	DPR68EF	N	8/31/10	706523	4889490	11	N01	NS-1a
EFSR	DPR69EF	N	8/31/10	706542	4889429	11	N01	NS-1a
EFSR	DPR70EF	N	8/31/10	706340	4889371	11	N01	NS-1a
EFSR	DPR71EF	N	8/31/10	706072	4888627	11	N01	NS-1a
EFSR	DPR72EF	N	8/31/10	706032	4888298	11	N01	NS-1a
EFSR	DPR73EF	N	8/31/10	705913	4888253	11	N01	NS-1a
EFSR	DPR74EF	N	8/31/10	705898	4888263	11	N01	NS-1a
EFSR	DPR75EF	N	8/31/10	705711	4888165	11	N01	NS-1a
EFSR	KBK42EF	N	9/1/10	707791	4890564	11	N02	NS-1a
EFSR	DPR76EF	N	9/2/10	705606	4887712	11	N1	NS-1b
EFSR	DPR77EF	N	9/2/10	705241	4887070	11	N1	NS-1b
EFSR	DPR79EF	N	9/2/10	704716	4885439	11	N2	NS-1b
EFSR	KBK43EF	N	9/2/10	706078	4888603	11	N1	NS-1b
EFSR	KBK44EF	N	9/2/10	706052	4888286	11	N01	NS-1a
EFSR	KBK45EF	N	9/2/10	705726	4888244	11	N01	NS-1a
EFSR	KBK46EF	N	9/2/10	705722	4888145	11	N01	NS-1a
EFSR	DPR80EF	N	9/5/10	709146	4891501	11	N02	NS-1a
EFSR	DPR81EF	N	9/7/10	703497	4883230	11	N4	NS-1b
EFSR	KBK47EF	N	9/8/10	706029	4888660	11	N02	NS-1a
EFSR	KBK48EF	N	9/8/10	706318	4889379	11	N02	NS-1a
EFSR	DPR82EF	N	9/8/10	703486	4882815	11	N4	NS-1b
EFSR	DPR83EF	N	9/8/10	703481	4882860	11	N4	NS-1b
EFSR	DPR84EF	N	9/8/10	703526	4882798	11	N4	NS-1b
EFSR	DPR85EF	N	9/10/10	704996	4886804	11	N1	NS-1b
EFSR	KBK49EF	N	9/15/10	704774	4885688	11	N2	NS-1b
EFSR	KBK50EF	C	9/15/10	704633	4885106	11	N2	NS-1b

Appendix C. Continued.

Stream	Redd Name	Origin	Date Observed	Location Easting	Location Northing	Location Zone	Section Name	SGR Trend Transect
WFYF	ECP01WF	N	8/17/10	682004	4908544	11	1	NS-8
WFYF	KBK01WF	N	8/18/10	676638	4916208	11	1	NS-8
WFYF	KBK02WF	N	8/18/10	676332	4916433	11	1	NS-8
WFYF	KBK03WF	N	8/18/10	675716	4916893	11	1	NS-8
WFYF	KBK04WF	N	8/18/10	675750	4917019	11	1	NS-8
WFYF	EJS01WF	N	8/23/10	679021	4915468	11	1	NS-8
WFYF	KBK04WF	N	8/25/10	680953	4913427	11	1	NS-8
WFYF	KBK06WF	C	9/7/10	676695	4916160	11	1	NS-8

Appendix D. Number of females, redds, and redds per female of both captive-reared (C) and natural/wild (N) Chinook in the East Fork Salmon River upstream of the adult trap; and subsequent progeny (adult returns) assigned to those spawn years.

Spawn Year[a,b]	Females		Redds		Redds/Female		Progeny[d]		Recruits/Redd		Recruits/Female	
	C	N	C	N[c]	C	N	C	N	C	N	C	N
2004	4	45	1	21	0.25	0.47	4	83	4.00	4.00	1.00	1.84
2005	28	21	11	17	0.44	0.81	1	44	0.09	2.59	0.04	2.10
2006	71	21	12	16	0.21	0.78	3	7	0.25	0.44	0.04	0.33
2007	124	27	63	24	0.51	0.89						
2008	111	64	55	45	0.50	0.70						
2009	113	60	10	49	0.18	0.82						
2010	5	72	1	60	0.20	0.83						
Total (mean)	**452**	**265**	**152**	**211**	**0.34**	**0.80**	**8**	**134**	**1.43**	**2.34**	**0.36**	**1.42**

[a] Spawn years 2005 and 2006 are incomplete (i.e. not all possible progeny have returned yet).

[b] Captive-reared 2007-2010 releases have not yet been genotyped, and therefore not yet included in the parentage analysis.

[c] Does not include redds counted below the EFSR adult trap (2009-66, 2010-119).

[d] All progeny assignments are parent pair assignments, 95% Confident, 0 or 1 Mismatch.

Prepared by:

Eric J. Stark
Senior Fisheries Research Biologist

David P. Richardson
Senior Fisheries Technician

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Daniel J. Schill
Fisheries Research Manager

Edward B. Schriever, Chief
Bureau of Fisheries