FISHERY RESEARCH

CAPTIVE REARING PROGRAM FOR SALMON RIVER CHINOOK SALMON

PROJECT PROGRESS REPORT
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Project Progress Report

2004 Annual Report

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ABSTRACT

During 2004, the Idaho Department of Fish and Game continued to develop techniques to rear Chinook salmon *Oncorhynchus tshawytscha* to sexual maturity in captivity and to monitor their reproductive performance under natural conditions. Eyed eggs were hydraulically collected from redds in the East Fork Salmon River (EFSR; N = 444) and the West Fork Yankee Fork Salmon River (WFYF; N = 279) to establish brood year 2004 culture cohorts. The eyed eggs were incubated and reared at the Eagle Fish Hatchery, Eagle, Idaho (Eagle FH). Juveniles collected in 2002 were marked with passive integrated transponder and elastomer tags and vaccinated against *Vibrio* spp. and bacterial kidney disease (causative agent *Renibacterium salmoninarum*) prior to being transferred to the NOAA Fisheries, Manchester Research Station, Manchester, Washington (Manchester) for saltwater rearing through maturity. Smolt transfers included 272 individuals from the WFYF and 320 from the EFSR. Maturing fish transfers from Manchester to Eagle FH included 103 individuals from the WFYF and 112 from the EFSR. This was the fourth year maturing adults were held on chilled water at Eagle FH to test if water temperature manipulations could advance spawn timing and improve egg quality. Adults from the EFSR and WFYF were divided into chilled (≈°7°C-12°C) and ambient (≈ 13.5°C) temperature groups while at Eagle FH. Thirty-nine mature females from the EFSR (22 chilled; treatment and 17 ambient; control) were spawned with 48 EFSR males at the Eagle FH in 2004. Egg survival to the eyed stage was 46.5% (±36.7%, range 0.0%-93.2%) for test females and 59.67% (±37.6%, range 0.0%-98.6%) for control females, this difference was not significant. Overall egg survival to the eyed stage averaged 51.8% for both groups combined. Personnel from the Shoshone-Bannock Tribes placed 24,503 eyed eggs from these crosses into instream incubators. Mature adults were released into study sections of the WFYF (N = 70) and EFSR (N = 4) to evaluate reproductive performance of captive adults as well as behavioral interactions of captive x captive and captive x natural adults. Juvenile Chinook salmon were collected from the EFSR (N = 405) to assess production from volitional spawning events and eyed egg plants in the EFSR during 2003. Genetic material from these juveniles will be analyzed with samples from all program adults and natural carcasses collected within the study area; this information will be used in future parental exclusion analyses.

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INTRODUCTION

Idaho Department of Fish and Game's (IDFG) long-term management objective for Chinook salmon *Oncorhynchus tshawytscha* is to maintain Snake River salmon populations at levels that will provide sustainable harvest (IDFG 2001). Restoring currently depressed populations to historic levels is a prerequisite to this condition. Artificial propagation of spring and summer Chinook salmon in the Salmon River basin, through the Lower Snake River Compensation Plan (LSRCP) and Idaho Power Company hatcheries, was initiated to compensate for lost production and productivity caused by the construction and operation of private and federal hydroelectric facilities in the Snake River basin. The mitigation approach was to trap, spawn, and rear a portion of the historically productive local broodstock to produce a large number of smolts (Bowles 1993). When Chinook salmon trapping began in 1981 as part of the LSRCP, it was assumed that enough Chinook salmon adults would return to provide for harvest and continued hatchery production needs. It was also assumed that hatchery programs would not negatively affect the productivity or genetic viability of target or other populations and that natural populations would remain self-sustaining even with hydropower projects in place. In reality, smolt-to-adult survival in natural Snake River Chinook salmon declined abruptly with completion of the federal hydroelectric system by the mid-1970s (Petrosky and Schaller 1994; Petrosky et al. 1999), and numbers of naturally produced salmon declined at various rates throughout the Snake River basin. It now appears survival rate estimates used in the hatchery mitigation program models were substantially overestimated, which has led to hatchery programs that have not consistently mitigated for reductions in Chinook salmon production and productivity. Spring/summer Chinook salmon returns have been insufficient to meet hatchery and natural smolt and adult production goals, much less provide a consistent harvestable surplus of adults (Hassemer 1998).

Development of the Snake River hydrosystem has substantially influenced the decline of local spring/summer Chinook salmon stocks by reducing productivity and survival (Raymond 1979; Schaller et al. 1999) and has contributed to the listing of Snake River Chinook salmon under the Endangered Species Act (ESA; NMFS 1992). A recovery strategy incorporating natural-river function is most likely to increase the smolt-to-adult return rate and provide for recovery of these populations (Marmorek et al. 1998). 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. The Chinook salmon captive-rearing 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 goal of maintaining biological diversity while doubling salmon and steelhead runs (NPCC 1994).

Idaho and Oregon state, tribal, and federal fish managers met in 1993 and 1994 to discuss captive culture research and implementation in the Snake River basin. The outcome of those meetings was an agreement that the Oregon Department of Fish and Wildlife would initiate a captive broodstock program using selected Grande Ronde River Chinook salmon populations, and the IDFG would initiate captive rearing research using selected Salmon River Chinook salmon populations. Both captive culture techniques began by bringing naturally produced juveniles (eggs, parr, or smolts) into captivity and rearing them in a hatchery to sexual maturity. At this point, the two techniques diverged. The F_1 generation in a captive rearing

program is returned to their natal streams and allowed to spawn naturally. The F_1 generation from a captive broodstock program is spawned in the hatchery, where the resulting F_2 progeny are held until smoltification. The F_2 generation is then released as smolts to their natal streams to emigrate volitionally. 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 has been 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 approximately every two months, 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 the development of 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 speculative (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 through BY04 have been represented in captivity to continue the project. Hassemer et al. (1999, 2001) and Venditti et al. (2002, 2003a, b, 2005) summarize project activities from inception through 2003. The streams initially selected for inclusion in the captive rearing program included the Lemhi River (LEM), the East Fork Salmon River (EFSR), and the West Fork Yankee Fork Salmon River (WFYF); the 2004 study area is depicted in Figure 1. Project activities were completed on the LEM with the release of mature

BY99 adult fish. Water temperatures are ideal for juvenile Chinook salmon rearing in all three streams while water quality ranges from sufficient to ideal. Habitat quality ranges from relatively pristine to areas of riparian degradation caused by sedimentation, grazing, mining, logging, road building, and irrigation diversion. The LEM drains productive basaltic parent material resulting in rapid fish growth. The lower section of this river flows through private land developed extensively for agriculture and grazing and typically reflects C channel conditions (Rosgen 1985). 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 from logging, mining, or agriculture. Stream habitat in the EFSR typically reflects B and C conditions (Rosgen 1985). The WFYF, which drains a sterile watershed similar to the EFSR, remains primarily roadless and has remained nonimpacted by land use practices for nearly half a century. Stream habitat typically reflects B and C conditions (Rosgen 1985).

The goal of the captive rearing program is to evaluate the potential usefulness of the captive rearing concept as applied to the conservation of Snake River spring/summer Chinook salmon. We have identified two primary project objectives needed to realize this goal. These are to: 1) develop and implement culture practices and facility modifications necessary to rear Chinook salmon to adulthood 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 including 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, 2004 through December 31, 2004. This project is coordinated with the Northwest Power and Conservation Council's Fish and Wildlife Program (NPPC 2000) and is identified as project 199700100. Funding is provided through the Bonneville Power Administration under contract 00004002.

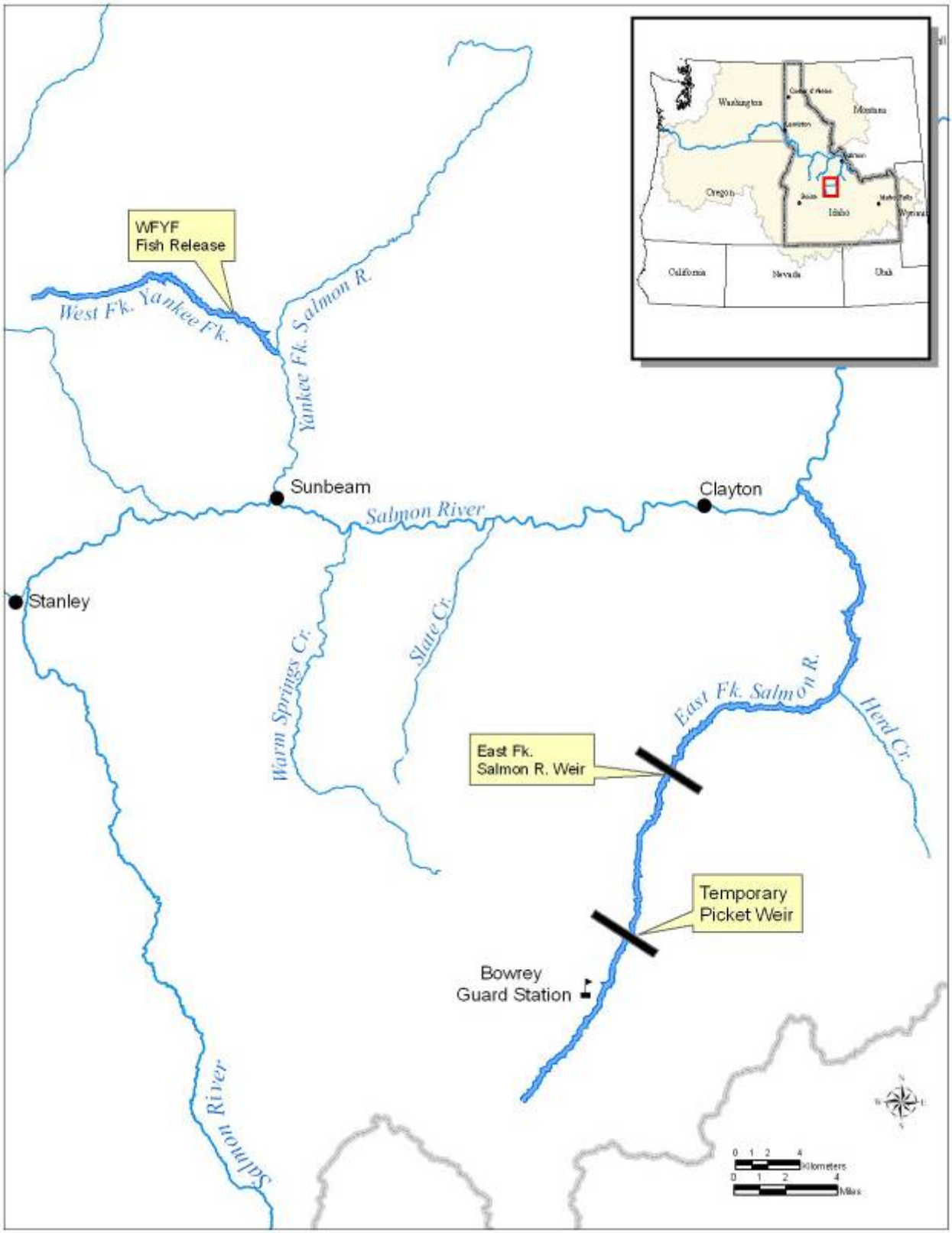


Figure 1. Location of study streams included in the Idaho Department of Fish and Game Captive Rearing Program for Salmon River Chinook Salmon.

FACILITIES

Eagle Fish Hatchery

The IDFG Eagle Fish Hatchery, Eagle, Idaho (Eagle FH) is the primary Idaho site for the captive culture of program fish. The hatchery is supplied with pathogen-free artesian water from three wells, and the artesian flow is augmented with three separate pump and motor systems. Ambient water temperature and total dissolved gas average 13.5°C and 100% after degassing, respectively. Water chilling capability was added in 1994 and expanded in 2001 for use during various stages of the captive rearing process. Water temperature is maintained between 7.0°C and 9.0°C during the egg incubation period of the rearing cycle. From ponding through the transfer of smolts to saltwater, water temperature is maintained between 8.0°C and 10.0°C. Chilled water is also used in holding tanks for maturing, adult Chinook salmon prior to in-hatchery spawning or release for natural spawning. Backup and system redundancy is maintained for degassing, pumping, and power generation. Nine water level alarms are linked through an emergency service operator. Additional security is provided by limiting public access and by the presence of three on-site residences occupied by IDFG hatchery personnel.

Tanks of various sizes and configurations are maintained at Eagle FH to accommodate various life stages and sizes of Chinook salmon maintained on station. Plastic incubators and fiberglass tanks ranging in size from 0.7–6.0 m in diameter are used to culture Chinook salmon from eggs to maturity. Fertilized eggs are held in incubators until swim-up and then transferred to 0.7 m semisquare tanks (0.09 m^3) and then to 1.0 m diameter semisquare tanks (0.30 m^3), where they remain until they reach approximately 10 g. Fish are then moved to 2.0 m semisquare tanks (1.42 m^3) where they remain until transfer to saltwater at smoltification. At maturation, fish are transferred from saltwater back to freshwater at Eagle FH. Maturing fish are held in 3.0 m circular tanks (6.50 m^3) by stream origin until they are released into their natal waters or spawned in the hatchery to monitor specific reproductive success variables.

Flow to all tanks at Eagle FH is maintained at no less than 1.5 exchanges per hour, and shade covering (70%) and jump screens are used where appropriate. Tank discharge standpipes are assembled in two sections ("half-pipe" principle) to prevent tank dewatering when removed for tank cleaning.

Manchester Research Station

Saltwater rearing is provided for all study animals post smoltification at the NOAA Fisheries 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 saltwater that ranges in temperature between 7°C and 14°C annually and averages 29‰ salinity. Raw saltwater is passed through sand and cartridge filters to remove particles >5 μ, 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).

METHODS

Fish Culture

Fish husbandry practices employed at Eagle FH ranged from traditional to experimental. Fish health issues were handled using only approved therapeutants, and standard fish culture practices were employed whenever possible (for an overview of standard methods see Leitritz and Lewis 1976; Piper et al. 1982; Erdahl 1994; Bromage and Roberts 1995; McDaniel et al. 1994; Pennell and Barton 1996). However, due to the experimental nature of the work conducted at Eagle FH, some aspects of the incubation, rearing, and feeding protocols differ from those used at production hatcheries. Eggs were hatched in specially designed incubators (Heindel et al. 2005) that can allow siblings from individual spawn crosses or redds to be maintained separately until the juveniles are tagged with passive integrated transponder (PIT) tags (Prentice et al. 1990) to permit future familial identification. Rearing tank size, density, and food ration varied with fish age, and were managed to promote optimum growth and the attainment of program objectives. Juveniles were periodically anesthetized, weighed to the nearest 0.1 g, and measured to the nearest 1 mm fork length (FL) to track growth and to ensure that projected weights tracked closely with actual weights.

Fish were fed standard commercial diets produced by Bio-Oregon (Warrenton, Oregon) and Skretting (Vancouver, BC, Canada). Ration and water temperature were manipulated to simulate the ration and temperature regimes that would be experienced in the natural environment to modulate growth and reduce precocial male development. This feeding regime was developed collaboratively with NOAA Fisheries Project Number 96-067-00.

Eyed egg Collection, Incubation, and Transport

Eyed eggs to establish individual brood year captive cohorts were collected from redds spawned by natural Chinook salmon in study streams using hydraulic sampling methods described by McNeil (1964). The hydraulic sampling system consisted of two main components. The first was a gas-powered pump attached to an aluminum probe (3.8 cm diameter) via flexible tubing (Figure 2A). Holes drilled near the top of the probe infused air into the water stream through venturi action. The second component was the collection net frame that consisted 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 (Figure 2B). During operation, water was forced through the probe, which was worked into the substrate. The air/water mix lifted eggs out of the substrate, where they were swept downstream into the net. The expanded plastic screen confined eggs lifted out near the periphery and channeled them into the net. In order to minimize disturbance to the redd, sampling was generally initiated slightly downstream of estimated nest pocket locations and progressed upstream. This procedure prevented the fine materials lifted out of the substrate from settling back into the redd and possibly smothering the eggs. Care was also taken to keep personnel behind or to the side of the net frame to minimize redd trampling, which has been shown to kill eggs and pre-emergent fry in trout redds (Roberts and White 1992).

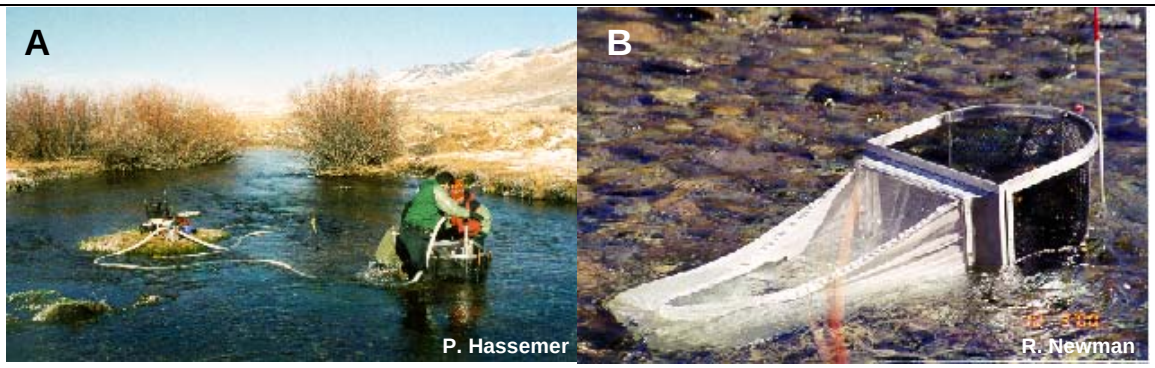


Figure 2. Hydraulic sampling gear including (A) the pump and probe, and (B) the collection net used to collect eyed eggs from naturally spawned redds.

To facilitate eyed egg collections, redd locations were marked, construction and completion dates determined, and stream temperatures monitored with recording thermographs. Program personnel walked portions of the study streams every 3–5 d to identify new redds and estimate completion dates of previously located redds. Redd locations were marked by placing flagging on shoreline vegetation near their position. The date the redd was first observed and the spawning state of fish seen associated with the redd (e.g., courting, digging, trenching, etc.) were recorded on the flagging. Thermographs deployed in the study streams recorded water temperature every 2 h, and daily average water temperature was computed to track the number of Celsius temperature units (CTUs) received by the developing embryos in each stream. Eyed eggs were collected after receiving 300-400 CTUs, a developmental period where eye pigmentation in developing embryos was readily identifiable and egg structures were capable of withstanding collection.

Eyed eggs were transferred from collection locations to Eagle FH using the following standardized protocols. Eyed eggs were packed at a conservative density in perforated shipping tubes, capped, and labeled to identify them to stream and redd. Tubes were wrapped in paper towels saturated with river water and packed in small, insulated coolers. Ice chips were added to maintain proper temperature and a moist environment during transport. Eggs were taken to Eagle FH as soon as possible after collection, and were generally on site 4–6 h after extraction from the gravel.

Once at Eagle FH, familial groups of eyed eggs were disinfected in 100 mg/L iodophor for 10 min. and transferred to separate incubators (14 cm diameter x 19 cm height, 2.5 L total operating volume) where they remained until the resulting fry were ready to begin feeding (Heindel et al. 2005). A constant flow (1.2 L/min) of chilled water (approximately 7°-9°C) was maintained throughout incubation and was provided as upwelling from below the eggs (Figure 3A). Incubators were checked daily, and dead eggs removed. After hatching, water flow was reversed to downwelling (Figure 3B).

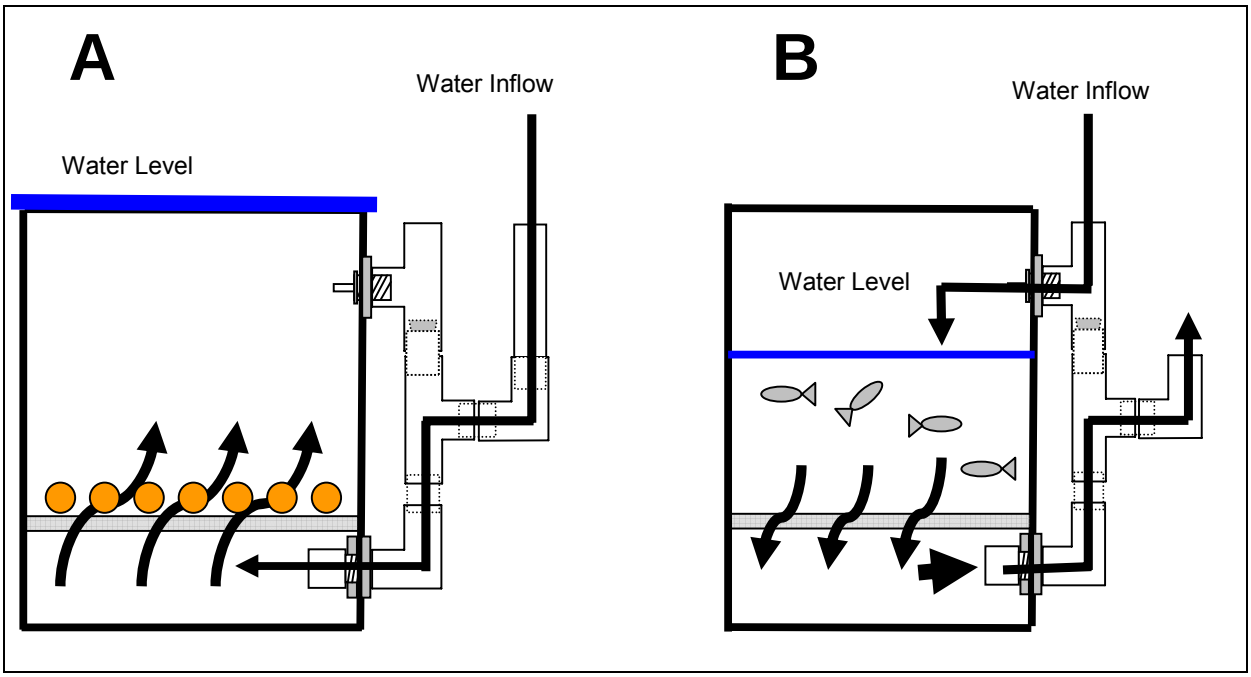


Figure 3. Schematic diagram of reversible flow incubators used to incubate eggs and rear newly emerged fry. A) Upwelling configuration for egg incubation, and B) downwelling configuration for fry rearing.

Juvenile Rearing, Marking, and Transportation

Swim-up fry were fed for one week in their incubators prior to ponding to 0.7 m semisquare tanks, and individual family groups were maintained separately until PIT tagging. Fry were fed hourly during daylight hours, approximately eight times per day, until they reached approximately 1 g. Growth projections were developed at this time and feeding rates were reduced to four times / d. Tanks received a mixture of ambient and chilled water that maintained a temperature of approximately 8.5°C and ensured approximately 1.5 turnovers per hour. Fry were fed a commercial diet (Bio-Oregon Starter #2) at approximately 2% body weight / d. As fish grew, ration and pellet sizes were adjusted accordingly. Sample counts were conducted as needed to ensure actual growth closely tracked the projected growth rate, but fish were handled as infrequently as possible.

Juvenile Chinook salmon were marked during two separate events to aid in tracking fish in the program. The first involved injecting a PIT tag into the peritoneal cavity of age-1 juveniles. Fish were anesthetized in MS-222 (tricaine methanesulfonate; buffered to neutrality with sodium bicarbonate), weighed to the nearest 0.1 g, and measured to the nearest 1 mm FL. A modified 12-gauge hypodermic needle was used to inject the PIT tag into the body cavity slightly anterior to the pelvic girdle and just off the ventral midline. The PIT tag gave each individual a unique identity within the program that was used to track each fish through the remainder of its life. The second marking involved age-1 juveniles and was conducted shortly before they were transported to Manchester. Fish were again anesthetized in buffered MS-222, weighed to the nearest 0.1 g, measured to the nearest 1 mm FL, and a color-coded elastomer tag was injected

into the clear tissue immediately posterior to the eye (Olsen and Vøllestad 2001; Close and Jones 2002), based on its stream of origin. Fish from the EFSR and WFYF received green and orange marks, respectively. The fish also received intraperitoneal injections of Renogen® (Aqua Health, Ltd., Charlottetown, Prince Edward Island, Canada) *Arthrobacter* spp. to vaccinate against bacterial kidney disease (BKD) and Vibrogen® (Aqua Health, Ltd.) to vaccinate against *Vibrio* spp. After each marking event, fish were allowed to recover in coolers of fresh water before being returned to the general population.

All age-1 juvenile Chinook salmon were transported to Manchester as smolts for saltwater rearing. Smolts were transported between facilities in truck-mounted, insulated tanks (950 L capacity) with alarm and back-up oxygen systems and "fresh flow" mechanical water movement units on board. Loading volumes did not exceed 89 g/L (0.75 lb/gal). Prior to offloading, transport water was tempered to within 2.0°C of the receiving water, if necessary, and fish were moved, by stock, to 6.0 m circular tanks filled with full strength freshwater for saltwater acclimation. Once in the circular tanks, full strength saltwater was introduced into the tanks until the freshwater was completely replaced (approximately 12 h, C. McAuley, NOAA Fisheries, personal communication).

Adult Rearing, Transportation, and Marking

Maturing Chinook salmon at Manchester were transported to Eagle FH 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. A second maturation sort was also conducted at Manchester several weeks after the initial sort to identify any maturing fish not detected in the earlier ultrasound examination. 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 Eagle FH, although stocks that may have posed a health risk to other program fish were transported in separate vehicles. Tanks were loaded with ¼ saltwater and ¾ freshwater to begin freshwater acclimation during transport. Once at Eagle FH, fish were immediately placed in 3.0 m circular tanks filled with full strength freshwater.

Maturing Chinook salmon destined for release for natural spawning were fitted with either disc tags, Floy tags, or jaw tags prior to release. Disc tags were color-coded to identify the temperature treatment (see below) and brood year to which the fish belonged. Additionally, each disc tag had a unique number embossed upon it to identify the individual. 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 temperature treatment the fish were being exposed to (see below). Disc tags were attached to the fish by passing a stainless steel pin through a hole in the center of the tag and passing the pin through the musculature of the dorsal surface just ventral to the midline of the dorsal fin. Then, a corresponding tag (same color code and number) was slipped onto the pin on the opposite side of the fish. The tag was secured by trimming the pin to length and a loop was formed at the end with needle-nose pliers. Floy tags or jaw tags were used occasionally instead of disk tags to mark mature captive-reared fish released for volitional spawning or to mark natural adults trapped at the Sawtooth Fish Hatchery (SFH) satellite weir on the EFSR prior to releasing them upstream. When used, Floy tags were inserted into the left side of the dorsal musculature in a similar location as disc tags, but did not protrude to the opposite side. Additionally, individually-numbered jaw tags, when used, were clamped on the lower left mandible of adults destined for

release. Fish receiving Floy tags and jaw tags were anesthetized using the same protocol as outlined for disc tagging procedures. After marking, all fish were allowed to recover in coolers of temperature appropriate water before being returned to the holding tanks.

Chilled Water Experiments

A common thread linking previous releases of captive-reared Chinook salmon had been the asynchrony in spawn timing when compared to earlier spawning, naturally produced counterparts (Hassemer et al. 1999, 2001; Venditti et al. 2002, 2003a, 2003b, 2005). In order to address this limitation, additional water chilling capacity was added at Eagle FH in 2001 to assess if water temperature manipulations between the time maturing adults were returned to freshwater and release could be used to advance their spawn timing. While we could find no instances where this has been tested on Chinook salmon, there is a substantial amount of literature describing the effect of temperature on the timing of ovulation in other salmonid species. Elevated holding temperature prior to spawning has been shown to retard the onset of ovulation in rainbow trout *O. mykiss* (Pankhurst et al. 1996; Pankhurst and Thomas 1998; Davies and Bromage 2002), pink salmon *O. gorbuscha* (Beacham and Murray 1988), Atlantic salmon (Taranger and Hansen 1993), and Arctic charr *Salvelinus alpinus* (Gillet 1991; Jobling et al. 1995). However, Henderson (1963) did not observe this relationship in eastern brook trout *S. fontinalis*.

Maturing Chinook salmon stocks were separated into three groups for holding at two temperatures during their freshwater maturation at Eagle FH. Fish determined to be maturing during the first maturation sort at Manchester were separated into control and treatment groups. Control fish were maintained on ambient well water averaging approximately 13.5°C. In contrast with previous years when treatment fish were held on chilled water at one constant low temperature, treatment fish held on chilled water (averaging ≈ 8.5°C) now experienced water temperature changes designed to simulate those experienced by naturally migrating Chinook salmon passing up the Columbia and Snake rivers to spawning streams in the Salmon River drainage. Care was taken to ensure that the entire size range of fish present was represented in both experimental groups. Mean group weight in each experimental group was calculated for each stock and brood year. Means (within brood year) were compared by computing an estimate of the sample variance (adjusted with the finite population correction factor) and standard deviation around the means (Scheaffer et al. 1990). Fish were also assigned to size groups within brood years and experimental groups to determine if water temperature had a differential effect on spawn timing relative to body size. Fish weighing less than the group average (within brood year) were randomly assigned to either the treatment or control group and were classified as “small.” Those weighing more than the group mean (within brood year) were also randomly divided between experimental groups and designated as “large.” The mean weight for each group was also reported. Mean weight differences between small and large classes of fish, in the various pairings, were not compared statistically because by definition the largest fish in the “small” group was smaller than the smallest fish in the “large” group. A third group of fish consisted of those determined to be maturing in the second maturation sort at Manchester (designated “late-arrivals”). After transfer to Eagle FH, these fish were held on ambient temperature water and not included in temperature experiments due to the different amount of time spent in fresh water compared to earlier groups.

Monitoring Programs

Hatchery Spawning and Gamete Evaluation

Generally, a small number of maturing fish from each stock were retained annually at Eagle FH and spawned in the hatchery where eggs remained through the eyed stage of development. In addition to the date fish from each experimental group became ripe, hatchery spawning allowed the comparison of egg quality (survival to the eyed stage) between the temperature experimental groups. This is important since elevated water temperature prior to ovulation has been shown to reduce egg survival in salmonids (Pankhurst et al. 1996; Taranger and Hansen 1993; Gillet 1991). When one or more females were determined to be in spawning condition, milt was preharvested from males with the same experimental history. Ripe females were stripped of their eggs, and total fecundity was estimated by calculating average egg weight from a subsample of approximately 50 eggs and dividing the total egg weight by average egg weight. Eggs from each female were divided into one to three sublots of approximately equal size depending on the number of eggs produced. Each sublot was fertilized with milt from a unique male, and placed in separate incubators (see Figure 3). Male use was subsequently equalized as each male spawned with approximately three females. The creation of multiple subfamilies increased the representation of parental genetic diversity in progeny groups, and the factorial-mating design helped offset risks associated with individual sublot failure. Incubators were checked daily and opaque eggs or those with fungal growth were removed. When developing embryos received approximately 325–350 CTUs, the eggs were shocked and those that became opaque were removed. Survival to the eyed stage was computed as the number of green eggs minus the number of dead or unfertilized eggs removed divided by the number of green eggs produced. Eyed eggs produced from all hatchery crosses were provided to biologists with the Shoshone-Bannock Tribes for transfer to instream hatch-boxes within the appropriate study system.

The effect of water temperature treatment on spawn timing and gamete quality was evaluated by comparing mean spawn date and mean embryo survival to the eyed stage of development in both experimental groups. The spawn date for each female was the number of days after the first female was spawned (day one). Based on these values the mean spawn date in both groups was computed, the variance of the means estimated and adjusted with the finite population correction factor (Equation 1) for each group, and the bound on the error of estimation (Equation 2) was used to construct an approximate 95% CI around the means (Equation 3; Scheaffer et al. 1990). Statistical significance was assumed when the resulting intervals did not overlap. Embryo survival to eye-up was compared similarly. Survival was recorded for all egg-lots and a mean computed for females in both groups; the variance of the means was estimated (adjusted with the finite population correction factor) and used to construct approximate 95% CI around the means (Scheaffer et al. 1990). Significance was assumed when the intervals did not overlap.

$$\hat{V}(\bar{y}) = \frac{s^2}{n}\left(\frac{N-n}{N}\right)$$

Equation 1. *where*

$$s^2 = \frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}$$

Equation 2. $$B = 2\sqrt{\hat{V}(\bar{y})} = 2\sqrt{\frac{s^2}{n}\left(\frac{N-n}{N}\right)}$$

Equation 3. $$\bar{y} \pm B$$

Fish Health Monitoring

When required, the captive rearing program has utilized various disinfectants, antibiotics, vaccinations, and antifungal treatments to control pathogens. When used, the dosage, purpose of use, and method of application were as follows:

1) Antibiotic therapies: Prophylactic erythromycin treatments were administered orally in Bio-Diet soft-moist feed obtained from Bio-Oregon to produce a dose of 100 mg/kg of body-weight for up to 28 d. When oral administration was not feasible, as was the case with maturing adults, an intraperitoneal injection of erythromycin was given to fish at a dose of 20 mg/kg of body weight. In addition, fingerlings were fed oxytetracycline as needed to control outbreaks of pathogenic myxobacteria, aeromonad, and pseudomonad bacterial infections.

2) Vaccinations: age-1 Chinook salmon were vaccinated prior to shipment to saltwater with intraperitoneal injections of Vibrogen (Aqua Health, Ltd., Charlottetown, Prince Edward Island, Canada) to vaccinate against *Vibrio* spp. and Renogen (Aqua Health Ltd.) to vaccinate against *Renibacterium salmoninarum* (causative agent of BKD).

3) Egg disinfection: newly fertilized eggs were water hardened in 100 mg/L solution of iodophor for 20 minutes to inactivate viral and/or bacterial pathogens on the egg surface and in the perivitelline space. In addition, eyed eggs transferred to Eagle FH from field collections were disinfected in a 100 mg/L iodophor solution for ten minutes prior to incubator transfer.

Fish health was monitored daily by observing feeding response, external condition, and behavior of fish in each tank as initial indicators of developing problems. In particular, fish culturists looked for signs of lethargy, spiral swimming, side swimming, jumping, flashing, unusual respiratory activity, body surface abnormalities, or unusual coloration. Presence of any of these behaviors or conditions was immediately reported to the program fish pathologist. When a treatable pathogen was either detected or suspected, the program fish pathologist prescribed appropriate prophylactic and therapeutic drugs to control the problem. Dead fish were routinely analyzed for common bacterial and viral pathogens (e.g., BKD, infectious hematopoietic necrosis virus, etc.). Select carcasses were appropriately preserved for pathology, genetic, and other analyses. 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.

Tissue samples were collected from dead program fish during necropsies to monitor for the presence of common bacterial and viral pathogens. American Fisheries Society “Bluebook” procedures were employed to isolate bacterial or viral pathogens and to identify parasite etiology (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.

Spawning adults were analyzed for common bacterial and viral pathogens such as BKD, infectious hematopoietic necrosis virus, and viral hemorrhagic septicemia. Tissue samples were collected from the kidney, spleen, and pyloric caeca of each fish, and ovarian fluid samples were collected from each female and analyzed at the Eagle Fish Health Laboratory. In addition, 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 in close proximity to the Manchester site. Results of fish health analyses on spawned fish were used by IDFG and the CSCPTOC to determine the disposition of eggs and subsequent juveniles.

Growth and Survival of Completed Brood Years

Each program year, individual brood cohorts are terminated with respect to remaining live individuals of a certain age component (typically after age-5 of culture). In order to track the contribution of individual cohorts through time, measures such as growth, sources and magnitudes of mortality, and maturation rates were evaluated 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 presented graphically. Major sources of mortality were compiled including disease, tagging, mechanical (e.g., equipment) failure, and maturation. Mortality at Eagle FH and Manchester were combined into a single analysis. 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, we summarize and compare growth and survival of BY99 Chinook salmon reared at Eagle FH and Manchester.

Volitional Spawning

Fish weirs were utilized in study streams receiving mature Chinook salmon from the captive-rearing program to assess spawning behavior and success in a natural environment. The components of a blocking weir were transported (truck or helicopter) to a construction site and assembled at the downstream end of a given section to ensure that project fish remained in the study area above the weir. Trap boxes built into the weir allowed natural Chinook salmon and other species to pass in either direction; however, study fish attempting to move out of the study area were returned to the stream above the weir. Generally, study sections were divided into multiple reaches of varying length to permit systematic observations of Chinook salmon spawning above the weir. Thermographs were used to document the thermal histories of redds spawned by captive-reared individuals and provided a means to accurately determine when redds could be sampled to determine fertilization rates and survival to the eyed egg stage of development.

Following weir construction, maturing captive-reared Chinook salmon were transported by truck from Eagle FH to a streamside site in preparation for release into the study section. Water temperature in the transport tank varied with respect to the stream temperature into which they were released and represented a compromise temperature appropriate for the transport of both study groups. Fish were then released to various sites with the aid of a helicopter (distant or inaccessible release sites) or transferred on foot. Fish transported by

helicopter were transferred to insulated coolers filled with water from the transport tank. The coolers were secured inside specially constructed steel frames for transport under the helicopter. Fish transported and released on foot were transferred either to water-filled coolers or to specially constructed, water-filled slings that were then carried to the release site.

Behavioral data collection began approximately 24 h after fish were released. Field observers were assigned stream reaches within a study section and the entire study section was monitored daily. Observers walked slowly upstream watching for Chinook salmon and when a fish was detected, the time was recorded and its habitat associations and behavior activities (Table 1) were observed and documented for 5 min. During this time, the observer also used binoculars and polarized sunglasses to determine if it was a natural or a study fish based on the presence or absence of a disc or Floy tag. If it was confirmed as a tagged study fish, the color combination and/or number of the tag was recorded. If the tag number or a natural Chinook salmon was observed, its location was recorded on a global positioning system (GPS) receiver. When multiple fish were observed simultaneously, their activity, habitat, and location information were recorded separately.

When spawning related behaviors were observed during the first 5 min of observation, additional time was spent recording the frequency of these behaviors to estimate how close the pair was to spawning. If, based on these frequencies, the observer believed that spawning would occur within 1-2 h, they remained with that pair and recorded their behaviors until 30 min after spawning. Behavioral observations were recorded in 10 min blocks during this time to facilitate comparisons of courting, aggression, and digging frequencies as spawning approached.

Table 1. Habitat and behavior variables recorded during observations of captive-reared Chinook salmon.

Habitat	**Definition**
Overhead vegetation	Associated with riparian vegetation overhanging the stream
Aquatic vegetation	Associated with aquatic vegetation
Cut bank	Under an overhanging bank
Pool	In a pool with no other structure
Riffle or run	In a riffle or run with no other structure
Riffle tail-out	In the tail-out section of a riffle with no other structure
Large woody debris	Within one body length of log(s)
General Behavior	**Definition**
Holding	Remaining in one position
Milling	Movement not resulting in displacement
Moving (A)	Movement in an upstream direction
Moving (B)	Movement in a downstream direction
Aggression	Aggression between Chinook salmon of undetermined sex
Redd Holding	Maintaining position on or near a redd
Courting	Active male and receptive female
Spawn	Observed release of eggs and milt
Male Behavior	**Definition**
Quiver	Dart toward female ending with body vibrations
Crossover	Movement to opposite side, head passing over peduncle
Aggression (A)	Male on male aggression
Aggression (B)	Male on female aggression
Aggression (C)	Male on other species aggression
Following	Female present, no redd
Satellite	Holding away or downstream of a courting pair
Female Behavior	**Definition**
Aggression (A)	Female on female aggression
Aggression (B)	Female on male aggression
Aggression (C)	Female on other species aggression
Test dig	2–6 body flexures, not concentrated
Nest dig	5–8 body flexures in a concentrated area
Cover dig	8–12 body flexures along redd perimeter

Production Estimation

Chinook salmon parr were collected in previously supplemented study streams to obtain fin clips for genetic analysis to determine if they were the product of program parents. Parr were collected by snorkelers using aquarium dipnets (Bonneau et al. 1995) and anglers using hook and line techniques throughout the study section, although particular emphasis was given to areas near known spawning locations of captive-reared adults or egg-box incubators from supplementation efforts in the previous year. Once captured, the parr were transferred to tubs located on the shore filled with fresh stream water and lightly anesthetized with MS-222. A small portion of the anal fin was removed and preserved in 95% ethanol. Scissors used to remove fin tissues were swabbed with isopropyl alcohol between specimens to reduce the possibility of DNA cross-contamination. The fish were also measured to the nearest 1 mm FL before being

placed into a tub of fresh stream water to recover. Parr were released back into the stream near their point of collection once sampling was completed at that site. Genetic material from these juveniles will be analyzed with samples from all program adults and natural carcasses recovered from the study area; this information will be used in future parental exclusion analyses. Microsatellite markers will be utilized to conduct parentage analysis (parental exclusion analysis; Colbourne et al. 1996; Talbot et al. 1996; Estoup et al. 1998; Bernatchez and Duchesne 2000; Eldridge et al. 2002) to determine the reproductive success of captive-reared adults (released for volitional spawning in the previous year) as well as instream incubator production (eggs produced from hatchery spawning and planted in the previous year) in terms of F_1 progeny (parr collections).

East Fork Salmon River Weir Operations

The Sawtooth Fish Hatchery satellite weir was operated to collect genetic samples from returning natural Chinook salmon, as well as to monitor the movement of captive-reared Chinook salmon and resident species. The facility is located near Big Boulder Creek, approximately 29 river kilometers (rkm) upstream from the confluence with the main Salmon River. The facility was checked regularly between 0700 and 2000 (every 2-3 hours) to assure proper trap settings and operation. The trap was emptied daily 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, FL recorded, genetic samples collected on salmonids, and released upstream of the weir. Additionally, bull trout were checked for radio transmitters implanted by Regional IDFG personnel.

Procedures for examining trapped Chinook salmon included placing fish in an anesthetic bath containing MS-222 (50 mg/L) buffered with sodium bicarbonate. Once a Chinook salmon was adequately sedated, it was checked for any visible marks and scanned for coded-wire tags, gender was determined, and FL 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 aid of a hole punch. The genetic sample location on the caudal fin was subsequently treated with argentine and sealed with ethyl cyanoacrylate ("super glue") in an effort to minimize the possibility of infection. The fish was then placed into a recovery bath until ready for release upstream of the weir.

To assess whether the weir was altering the movements of migrating adult Chinook salmon, the area downstream of the weir was monitored by snorkeling three times per week from July through mid-September, and all observed fish were enumerated by species. Snorkeling efforts were concentrated in the river channel from the pool immediately below the weir to approximately 250 m downstream to the confluence with Big Boulder Creek.

RESULTS AND DISCUSSION

Brood Year Report Outline

The following information reflects culture history for the reporting period January 1 through December 31, 2004. During this reporting period, 13 rearing groups were in culture at the Eagle FH from the WFYF and EFSR. Summaries of losses, transfers, and releases while in culture are presented in Tables 2 and 3. The following acronyms are used in the following section of the report to describe culture groups: NP refers to "natural parr" or fish collected from

natal streams as natural parr; SN refers to “safety net” or fish generated from hatchery spawning events; and NE refers to “natural egg” or fish generated from the collection of eyed eggs from redds constructed by natural adults. The year of development of specific culture groups may appear abbreviated (e.g., BY00 refers to brood year 2000).

Brood Year 1998 Culture Groups

At the beginning of the reporting period, only one BY98 captive-reared Chinook salmon remained in saltwater culture at Manchester awaiting age-6 maturation. The lone adult, a WFYF-NP female, returned to Eagle FH for freshwater holding in 2004. Prior to volitional spawn releases, this female was determined to be immature and was later culled. After initiation of a standard fish health necropsy examination, this female was diagnosed with clinical levels of BKD. Calendar year 2004 marked the final year of culture for BY98 collection groups at both facilities (Table 2).

Brood Year 1999 Culture Groups

At the beginning of the reporting period, all BY99 groups were in saltwater culture at Manchester. In 2004, a total of 14 WFYF-SN (12 females, 2 males) and two EFSR-SN (2 females) maturing adults were transferred to Eagle FH to complete maturation in freshwater. Ten WFYF-SN adults (8 females, 2 males) were released into the WFYF for volitional spawning and one EFSR-SN adult (female) was utilized in hatchery spawn crosses at Eagle FH. At the end of the reporting period, zero BY99 WFYF-SN and zero BY99 EFSR-SN adults remained in culture at Eagle FH (Tables 2 & 3).

Brood Year 2000 Culture Groups

At the beginning of the reporting period, all BY00 captive groups were in saltwater culture at Manchester. In 2004, a total of 79 WFYF-NE (77 females, 1 male, 1 hermaphrodite) and 54 EFSR-NE (53 females, 1 male) adults were transferred to Eagle FH to complete maturation in freshwater. Fifty-two WFYF-NE maturing adults (51 females, 1 male) were released into the WFYF for volitional spawning. Twenty-seven (26 females, 1 hermaphrodite) maturing WFYF-NE adults died in culture at Eagle FH with mortality linked to clinical levels of BKD. Four EFSR-NE females were released into the EFSR for volitional spawning, and 36 females were utilized in hatchery spawn crosses. Additionally, 15 EFSR-NE adults (14 females, 1 male) died in freshwater culture at Eagle FH associated with undetermined, noninfectious mortality as cause of death. At the end of this reporting period, zero BY00 WFYF-NE and zero BY00 EFSR-NE adults remained in culture at Eagle FH (Tables 2 & 3).

Table 2. Summary of losses and magnitude of mortality for seven West Fork Yankee Fork captive-reared Chinook salmon culture groups reared at Eagle Fish Hatchery in 2004. Culture groups are designated by brood year (BY) and by the method the group was sourced (NP = natural parr, SN = safety net, and NE = natural egg).

	Culture Groups						
	BY98 NP	**BY99 SN**	**BY00 NE**	**BY01 NE**	**BY02 NE**	**BY03 NE**	**BY04 NE**
Starting Inventory (January 1, 2004)	0	0	0	0	272	303[a]	279[b]
Eyed egg to Fry							
Undetermined[c]	n/a	n/a	n/a	n/a	n/a	n/a	11
Mechanical Loss							
Handling	0	0	0	0	0	0	0
Jump-out	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0
Noninfectious							
Lymphosarcoma	0	0	0	0	0	0	0
Nephroblastoma	0	0	0	0	0	0	0
Other[d]	0	4	0	1	0	7	0
Infectious							
Bacterial	1	0	27	0	0	0	0
Viral	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0
Hatchery Spawning							
Male Spawners	0	0	0	0	0	0	0
Female Spawners	0	0	0	0	0	0	0
Cryopreservation	0	0	0	0	0	0	0
Relocation							
Transferred In	1	14	79	9	0	0	0
Transferred Out	0	0	0	0	272	0	0
Planted/Released	0	10	52	8	0	0	0
Ending Inventory (December 31, 2004)	0	0	0	0	0	296	268

[a] Inventory adjustment after PIT tagging was completed in December.
[b] Initial eyed egg collection–winter 2004.
[c] Typical egg to fry mortality includes nonhatching eggs, abnormal fry, and swim-up loss.
[d] Includes mortality due to maturation; culling associated with cultural anomalies; and all undetermined, noninfectious mortality.

Table 3. Summary of losses and magnitude of mortality for six East Fork Salmon River captive-reared Chinook salmon culture groups reared at Eagle Fish Hatchery in 2004. Culture groups are designated by brood year (BY) and by the method the group was sourced (NP = natural parr, SN = safety net, and NE = natural egg).

	Culture Groups					
	BY99 SN	**BY00 NE**	**BY01 NE**	**BY02 NE**	**BY03 NE**	**BY04 NE**
Starting Inventory (January 1, 2004)	0	0	0	320	307[a]	444[b]
Eyed egg to Fry						
Undetermined[c]	n/a	n/a	n/a	n/a	n/a	14
Mechanical Loss						
Handling	0	0	0	0	0	0
Jump-out	0	0	0	0	0	0
Transportation	0	0	0	0	0	0
Noninfectious						
Lymphosarcoma	0	0	0	0	0	0
Nephroblastoma	0	0	0	0	0	0
Other[d]	1	15	3	2	3	0
Infectious						
Bacterial	0	0	0	0	0	0
Viral	0	0	0	0	0	0
Other	0	0	0	0	0	0
Hatchery Spawning						
Male Spawners	0	0	7	41	0	0
Female Spawners	1	36	2	0	0	0
Cryopreservation	0	0	0	0	0	0
Relocation						
Transferred In	2	55	12	43	0	0
Transferred Out	0	0	0	320	0	0
Planted/Released	0	4	0	0	0	0
Ending Inventory (December 31, 2004)	0	0	0	0	304	430

[a] Inventory adjustment after PIT tagging in December.
[b] Initial eyed egg collection—winter 2004.
[c] Typical egg-to-fry mortality includes nonhatching eggs, abnormal fry, and swim-up loss.
[d] Includes mortality due to maturation, culling associated with cultural anomalies, and all undetermined, noninfectious mortality.

Brood Year 2001 Culture Groups

At the beginning of the reporting period, all BY01 captive groups were in saltwater culture at Manchester. Nine WFYF-NE (1 female, 8 males) and 12 EFSR-NE (3 females, 9 males) adults were transferred from Manchester to Eagle FH in 2004 to complete maturation in freshwater. Eight WFYF-NE males were released into the WFYF for volitional spawning and one female died in culture at Eagle FH with clinical levels of BKD found at necropsy. Seven EFSR-NE males and two females were utilized in hatchery spawn crosses in 2004. In addition, one EFSR-NE maturing female that failed to ovulate was later culled, and two males died prior to spawning from undetermined causes (Tables 2 & 3).

Brood Year 2002 Culture Groups

At the beginning of the reporting period, 272 WFYF-NE and 320 EFSR-NE presmolt juveniles were in culture at Eagle FH. In May of 2004, all BY02 juveniles (272 WFYF-NE, 320 EFSR-NE) were transferred to Manchester for the seawater rearing phase of culture. Forty-three EFSR-NE precocial males were returned to Eagle FH in July of 2004 to contribute to calendar year 2004 in-hatchery EFSR spawn crosses. Forty-one precocial males were utilized in EFSR spawn crosses at Eagle FH, and the remaining two males were culled due to a lack of milt production. No WFYF-NE precocial males were returned to Eagle FH in 2004. At the end of this reporting period, zero BY02 captives remained in freshwater culture at Eagle FH (Tables 2 & 3).

Brood Year 2003 Culture Groups

At the beginning of the reporting period, 303 WFYF-NE and 307 EFSR-NE juveniles were in culture at Eagle FH. Ending inventory for BY03 groups at Eagle FH totaled 296 and 304, WFYF-NE and EFSR-NE juveniles, respectively (Tables 2 & 3).

Brood Year 2004 Culture Groups

Eyed egg collections for BY04 cohorts were conducted in September and October of 2004 in both the WFYF and EFSR. A total of 279 WFYF-NE and 444 EFSR-NE eyed eggs were collected from redds of naturally spawned, natural Chinook salmon in 2004. At the end of the reporting period, 268 WFYF-NE and 430 EFSR-NE eyed eggs/developing fry were in culture at Eagle FH (Tables 2 & 3).

Eyed Egg Collection, Transport, and Incubation

Naturally spawned, eyed eggs were collected from the EFSR and the WFYF to establish captive culture groups representing BY04. Collections totaled 444 eyed eggs from the EFSR and 279 from the WFYF (Table 4). Survival to ponding was 96.8% for the EFSR eggs and 96.1% for the WFYF eggs. Estimated CTUs to hatch ranged from 457.3 to 532.8 for the EFSR eggs and 463.8 to 610.8 for the WFYF eggs.

Table 4. Summary of eyed egg collections in the East Fork Salmon River (EFSR) and the West Fork Yankee Fork (WFYF) to establish BY04 culture groups for the Chinook Salmon Captive Rearing Program. Celsius Temperature Units (CTUs) are reported for the time of collection.

Date	Stream	Redd 1	Redd 2	Redd 3	Redd 4	Redd 5	Redd 6	Redd 7	Redd 8	Total
9/28/04	EFSR	56	49	53	8	—	—	—	—	166
10/5/04	EFSR	—	—	—	—	47	111	55	65	278
Total	**EFSR**									**444**
CTUs		308	339	308	327	303	303	323	314	
9/16/04	WFYF	111	—	—	—	—	—	—	—	111
10/6/03	WFYF	—	168	—	—	—	—	—	—	168
Total	**WFYF**									**279**
CTUs		318	312							

Juvenile Rearing, Marking, and Transportation

Juvenile Chinook salmon from BY02 culture groups destined for transfer to Manchester for saltwater rearing received intraperitoneal injections to provide a measure of protection from two common pathogens. Both vaccines were administered on March 23, 2004. Juveniles from the WFYF averaged 141.3 mm FL and 35.5 g (N = 272 range 93–175 mm FL and 11–67 g), and those from the EFSR averaged 132.1 mm FL and 29.6 g (N = 320 range 92–201 mm FL and 9.5–105.5 g). Improved feed rationing and the availability of chilled water at Eagle FH during incubation and early rearing resulted in smolts of a more appropriate size (compared to their natural counterparts) than those produced in 2002 and 2003 (Venditti et al. 2003b, 2005).

Brood year 2002 juvenile Chinook salmon were transferred from Eagle FH to Manchester as smolts on May 5, 2004. Smolts transferred between facilities included 320 fish from the EFSR-NE group and 272 fish from the WFYF-NE group (Appendix B). All BY02 EFSR precocial (N = 43) males were returned to Eagle FH on July 2 for use in 2004 spawn crosses. Precocial males from the BY02 WFYF group were culled at Manchester.

Two culture groups of juvenile Chinook salmon representing BY03 (N = 600) were PIT tagged on December 15, 2004. A total of 296 WFYF and 304 EFSR fish were PIT tagged at that time. Fish from the WFYF averaged 108 mm FL and 15.7 g (range 84–135 mm FL, 7.0–31.0) while EFSR fish averaged 108 mm FL and 16.1 g (range 88–126 mm FL, 8.3–26.8 g).

Adult Rearing, Marking, and Transportation

Adult Chinook salmon from the WFYF and EFSR determined to be maturing at Manchester were transferred to Eagle FH on three occasions in 2004. Adults from the first sort were transported on May 6, 2004 and included fish from BY98, BY99, BY00, and BY01. One hundred fifty-seven maturing adults were transferred at that time and included 91 from the WFYF and 66 from the EFSR (Appendix B). Adults that were determined to be maturing during a second sort were transferred on June 2 and contained 12 WFYF individuals (three BY99 and

nine BY00) and three EFSR individuals (two BY00 and one BY01). The third maturing Chinook salmon transfer included 43 EFSR BY02 precocials, which were incorporated into the spawning design (Appendix B).

On August 3, 2004, jaw tags were attached to the lower left mandible of WFYF Chinook salmon destined for release to their natal stream. Jaw tags were not utilized for the four EFSR adults released in 2004. These tags facilitated the identification of postspawn adults in the WFYF study section. Radio transmitters (Advanced Telemetry Systems, Isanti, Minnesota) were also inserted into the stomachs of ten and four maturing females to be released into the WFYF and EFSR, respectively, during this handling event (Appendix C). Seventy-eight fish (74 WFYF, 4 EFSR) were marked in the one-day event. Ten BY99 adults averaging 2,049 g and 733 mm FL (range 435–3,402 g, 543–1,331 mm FL), 56 BY00 adults averaging 2,369 g and 599 mm FL (range 397–5,392 g, 422–1,330 mm FL), and 8 BY01 adults averaging 695 g and 349 mm FL (range 374–865 g) were jaw tagged from the WFYF. Four EFSR BY00 adults averaging 3,454 g and 595 mm FL (range 2,706–4,644 g, 557–660 mm FL) received radio transmitters.

Chilled Water Experiment

Water temperature manipulations were continued during this reporting period. Two size classes of maturing adults from BY99, BY00, and BY01 WFYF and EFSR stocks were exposed to either chilled or ambient temperature regimes at Eagle FH in an attempt to advance spawn timing in captive-reared Chinook salmon and improve gamete quality (Appendix A). Water temperature in treatment (chilled) tanks averaged 8.7°C (range 6.8°C–13.7°C, SD = 1.36) and the temperature in control (ambient temperature well water) tanks averaged 13.5°C (12.8°C–14.2°C, SD = 0.18, Figure 4). Both treatment and control groups represented the entire size range of fish present in the experiment and contained approximately equal numbers of fish (Figure 5). A portion of adults from the EFSR group was retained in the hatchery to compare the maturation dates and gamete quality of treatment and control groups in the hatchery environment. Prior to release, the remaining fish from the EFSR and all mature adults from the WFYF were marked as described above to allow observers to identify the individual fish, experimental group, and brood year of each fish (post mortem).

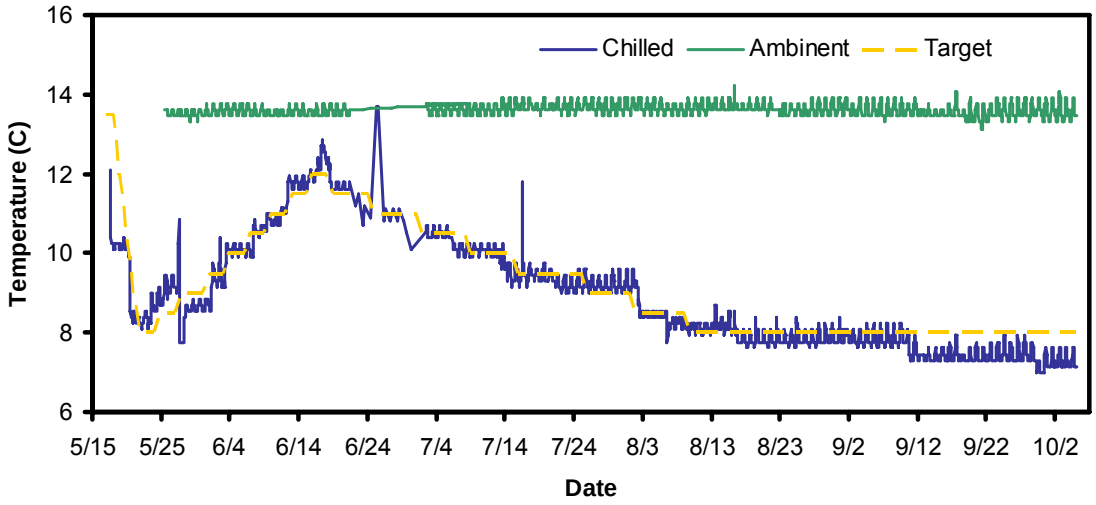


Figure 4. Chilled and ambient tank water temperatures experienced by maturing captive-reared Chinook salmon at the Eagle Fish Hatchery during their final freshwater maturation, May–October 2004.

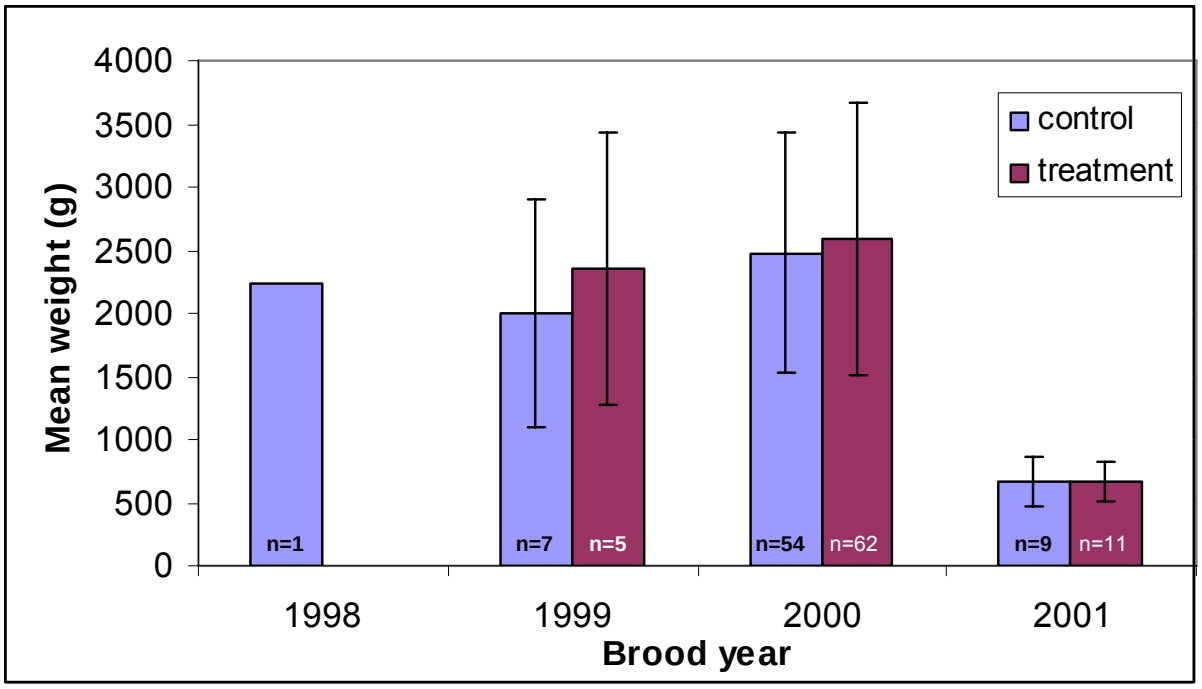


Figure 5. Mean weight of captive-reared Chinook salmon held on ambient (C) and chilled (T) water at the Eagle Fish Hatchery during 2004. Sample size of each experimental group is expressed inside the respective bar. Vertical bars represent one standard deviation around the mean weight for each experimental group. There were no Brood Year 1998 fish included in the treatment group.

Monitoring Programs

Hatchery Spawning and Gamete Evaluation

Maturing program fish from the EFSR were spawned at Eagle FH to assess the effect of water temperature on maturation timing and gamete quality. A total of 39 females and 48 males were used in these crosses (Appendix A). By September 22 (approximately halfway through spawning), 15 of 22 females (68%) in the treatment group had spawned compared to 6 of 17 females (35%) in the control group (Figure 6). The average spawn date (determined by the ordinal date based on the first female to ripen in either group) for females in the treatment group (15.2 ±3.72 d) was similar to that of females in the control group (14.7 ±2.7 d; Figure 7); indicating that chilled water did not provide a benefit to moving spawn timing forward.

Survival to the eyed stage was variable in both temperature treatment groups, but this difference was not significant (Treatment: mean = 46.5 ± 36.7%, range 0.0%-93.2%; Control: mean = 59.7 ± 37.6%, range 0.0%-98.6%, Appendix A). Mean survival to the eyed stage averaged 51.8% for both treatment groups combined.

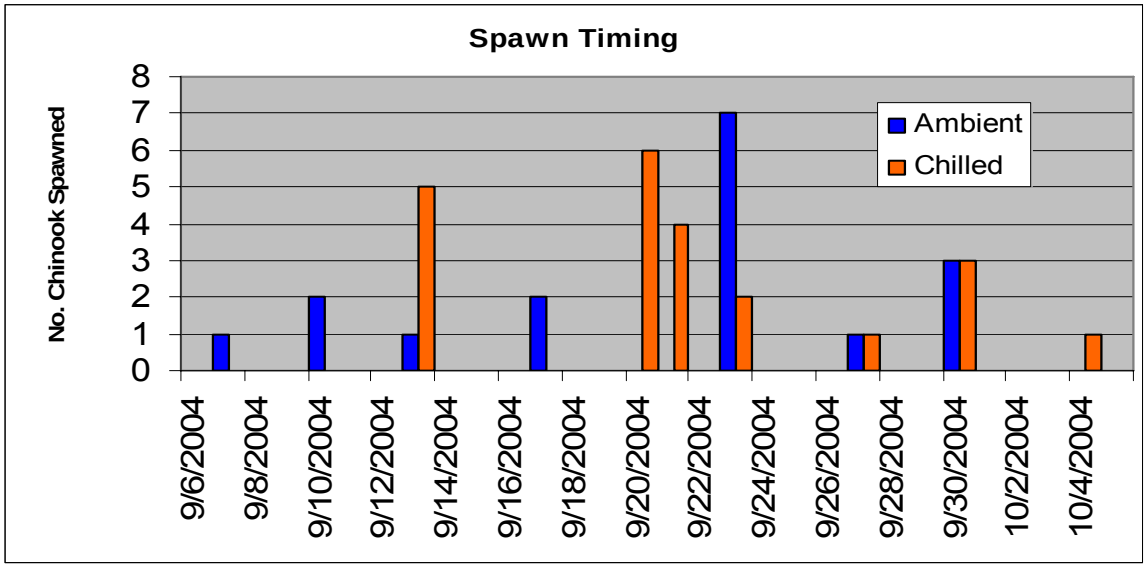


Figure 6. Distribution of 2004 spawning dates for female captive-reared Chinook salmon exposed to two water temperature regimes during their final freshwater maturation at the Eagle Fish Hatchery.

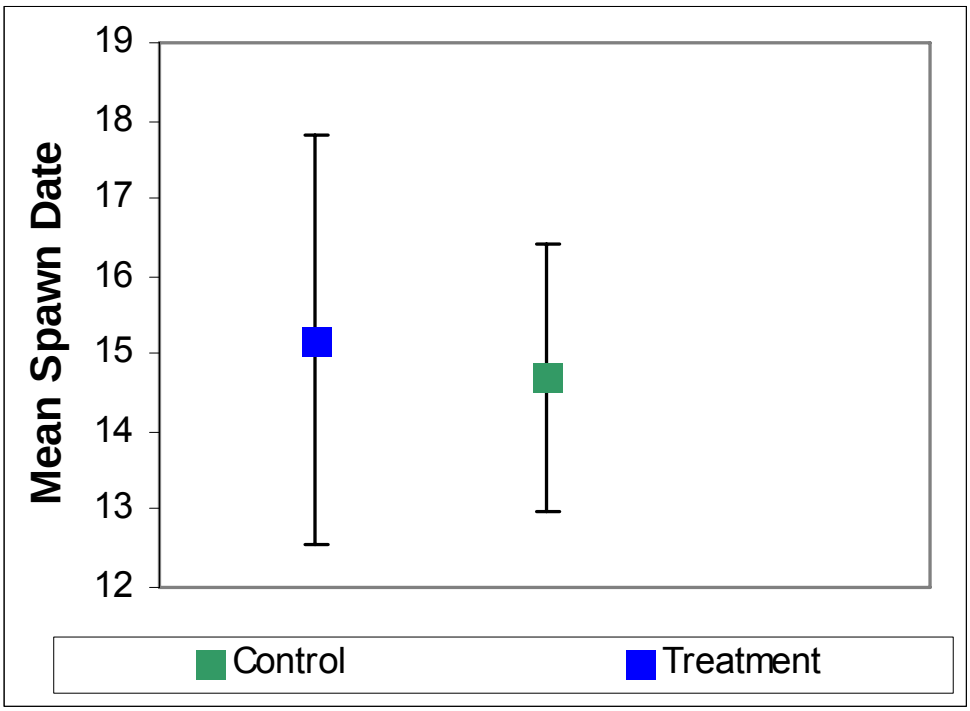


Figure 7. Mean spawn date (± 95% CI) in two groups of captive-reared Chinook salmon spawned in 2004. Spawn date was determined by the ordinal date based on the first female to become ripe in either group. The treatment group was held on a chilled water regime that simulated natural in-river temperatures. The control group was held on a stable regime of ambient water at the Eagle Fish Hatchery (≈ 13.5°C).

Due to the low numbers of maturing, adult males in each group (three treatment, five control), 43 precocial BY02 EFSR males were returned to Eagle FH from Manchester. Brood year 2002 males were not included in the study design but were distributed between both control and treatment tanks. Sixteen of the 43 BY02 males were running milt by September 7, 2004. On September 10, 2004, fourteen BY02 males were implanted with gonadotropin releasing hormone analogs (GnRHa) to accelerate spermiation (seven fish received 25 µg GnRHa; seven fish received 50 µg GnRHa).

Calendar year 2004, in-hatchery EFSR spawning encompassed ten different spawn dates from September 7 through October 4. Thirty-nine females (1 BY99 EFSR-SN, 36 BY00 EFSR-NE, 2 BY01 EFSR-NE) were spawned in 2004 yielding 47,331 green eggs. Mean survival to the eyed-stage of development was 51.8% and resulted in 24,503 eyed eggs that were transferred to Shoshone-Bannock Tribe (SBT) biologists for placement in instream incubation boxes. Three transfers containing approximately 1,733 eyed eggs, 18,077 eyed eggs, and 4,693 eyed eggs were made on October 5, 19, and 26, 2004, respectively. After receiving the eyed eggs, SBT biologists placed them in the EFSR based on the recommendations of IDFG Regional Fisheries staff. Tribal cooperators were responsible for placing the incubators in the streambed, monitoring the eggs during incubation, and estimating hatch and emergence rates.

Fish Health Monitoring

Vaccines for both BKD and Vibrio spps. were administered on March 23, 2004.

In 2004, 25 laboratory accessions (representing 95 fish) were generated at the Eagle Fish Health Laboratory for captive-reared Chinook salmon. Cause of mortality and magnitude of loss for Chinook salmon maintained at Eagle FH during this reporting period are presented in Tables 2 and 3.

Bacterial Pathogens

In 2004, prespawn BY00 WFYF adults reared at Manchester experienced chronic mortality associated with BKD prior to freshwater transfer. A total of 79 BY00 WFYF adults were returned to Eagle FH freshwater rearing prior to release. Of the 79 adults transferred, 27 fish died with mortality attributed to clinical levels of BKD. Fish health necropsies performed on the first six fish resulted in elevated enzyme-linked immunosorbent assay (ELISA) optical density (OD) values, as well as positive detection via direct fluorescent antibody testing (DFAT).

Viral Pathogens

In 2004, the Eagle Fish Health Lab processed 25 laboratory accessions (95 fish) that included virology screening for the major salmonid viral pathogens. Consistent with sampling conducted in all prior years, no viral pathogens were detected in captive-reared Chinook salmon adults cultured at Manchester or Eagle FH in 2004.

Parasitic Pathogens

Principle parasitic fish health concerns include the presence of *Myxobolus cerebralis*, the causative agent of salmonid whirling disease, and gill parasite *Salmincola californiensis*. All WFYF and EFSR Chinook salmon adults examined for *M. cerebralis* and *S. californiensis* in 2004 tested negative for the presence of these parasites. The absence of these parasites in recent years is likely a result of the programmatic shift from juvenile to eyed egg broodstock collections and the resultant successful elimination of these fish health concerns.

Growth and Survival of Brood Year 1999

Growth rate comparisons of BY99 captive-reared Chinook salmon indicated, similar to past years, that those from Manchester attained a larger size than those reared at Eagle FH (Venditti et al. 2003a, 2003b, 2005). Comparisons were not made beyond 2001 because comparable numbers of fish were not reared at Eagle FH. Sample weights collected from fish at Eagle FH in August of 2001 show that program fish reared at Eagle FH averaged 200.3 g, while program fish reared at Manchester averaged 291.8 g. Chinook salmon reared at Manchester once again exhibited very little growth during their fifth year of life, which is consistent with previous observations (Venditti et al. 2002, 2003a, 2003b, 2005) and were generally smaller than many of those measured at age-4.

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 much lower than for some previous brood years (Venditti et al. 2003b). Primary sources of mortality in this group included unexplained mortality while in the rearing tanks, maturation, and spawning (Figure 8). Mortality tracking includes a 'No record' category that includes any fish for which a more precise cause of mortality cannot be attributed as well as fish that cannot be accounted for. The 'No record' group has ranged between 1.9 to 5.6% of the total mortality during the past four years; the rise in 2004 may be attributed to a change in personnel and the detail at which mortality tracking was summarized at the time this report was written.

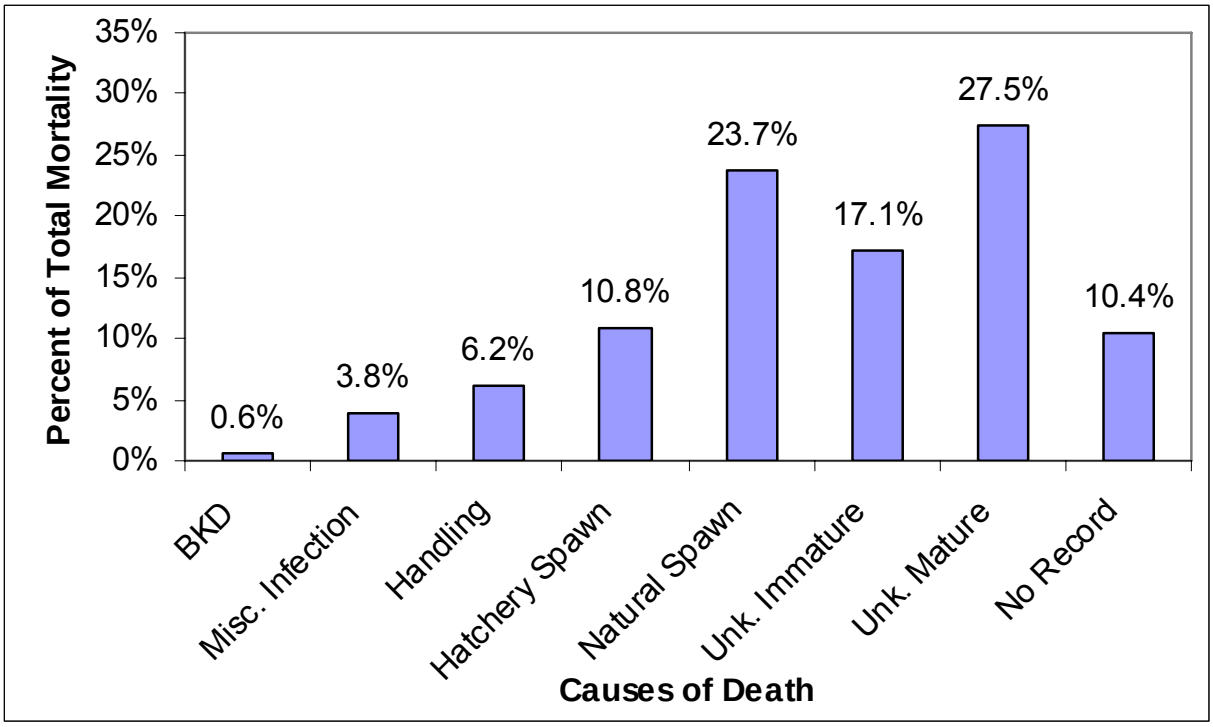


Figure 8. Primary sources of mortality in BY99 captive-reared Chinook salmon at Eagle FH and Manchester Research Station. Abbreviations: BKD= bacterial kidney disease, Unk. = Unknown.

Brood year 1999 captive-reared Chinook salmon from the WFYF, EFSR, and LEM matured at a similar overall rate to previous cohorts. Overall, 148 of 242 fish (61.2%) from the WFYF brought into the program matured, and of these, 10 males (6.8%) matured at age-2, 68 males (45.9%) matured at age-3, 43 females (29.1%) and 17 males (11.3%) matured at age-4, while nine females (6.1%) and one (0.7%) unknown sex at release matured at age-5. Precocity was lower than observed in earlier cohorts from the WFYF (Hassemer et al. 2001, Venditti et al. 2002). In the LEM stock, 125 of 210 (59.5%) BY99 program fish matured. Precocial maturation in this group was 55 males (44.0%), while 35 males (28.0%) matured at age-3; four males (3.2%), 28 females (22.4%) and three (2.4%) unknown sex at release matured at age-4. No fish from this brood year matured at age-5 or were released in 2004. In the EFSR, 86 out of 178 (48.3%) BY99 fish matured. Of these, 21 males (24.4%) matured as precocials. Nineteen males

(22.1%), three females (3.5%), and one unknown sex at release (1.2%) matured at age-3. Nine males (10.5%), 29 females (33.7%), and two unknown sex at release (2.3%) matured at age-4, while two females (2.3%) matured at age-5. Maturation in BY99 (57.0%) was similar to that experienced by BY98 (56.3%) but less than that of BY97 (69.5%; Venditti et al. 2002, 2003a, 2003b, 2005). However, BY99 fish matured at a smaller weight (Figure 9) and length (Figure 10) relative to BY97 and BY98 adults. When both the WFYF and EFSR stocks are combined, there is no significant difference between brood years for either length or weight at maturity; however when the two stocks are examined separately, BY99 WFYF was statistically smaller (in both length and weight) than either BY98 or BY97.

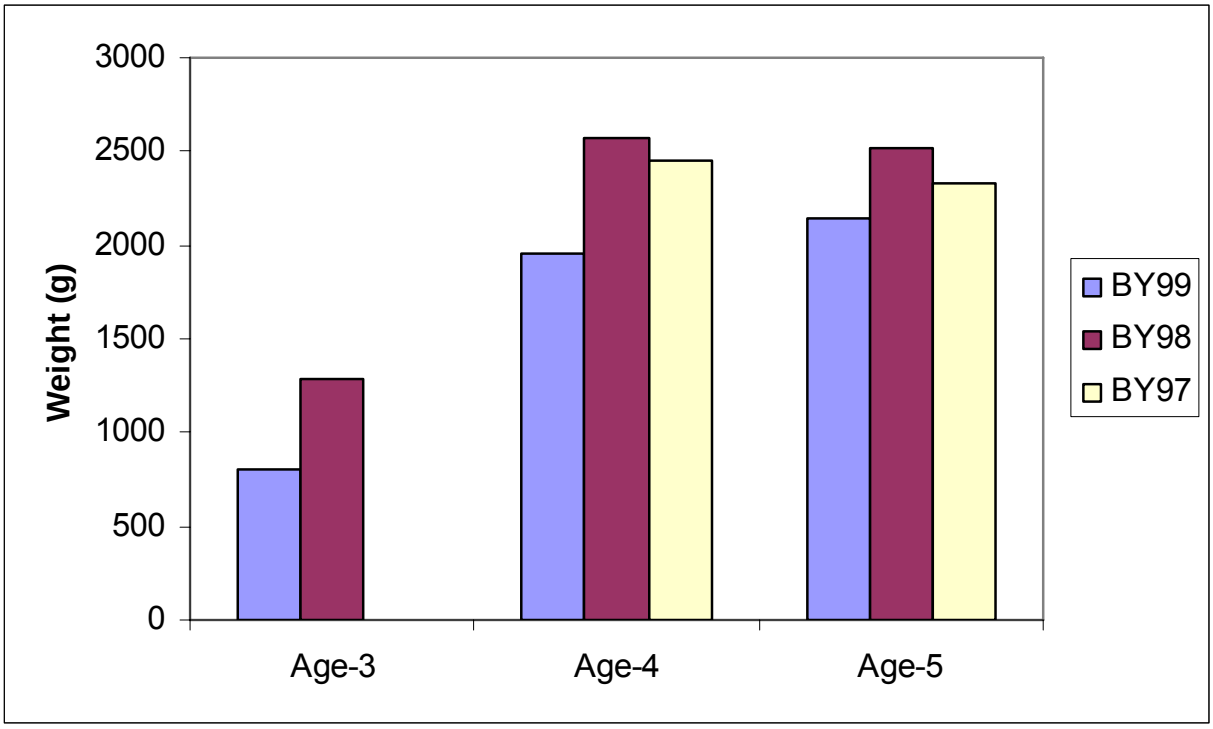


Figure 9. Mean weight at maturity by age for West Fork Yankee Fork and East Fork Salmon River captive-reared Chinook salmon from BY97-BY99. No data is available for BY97 age-3 fish.

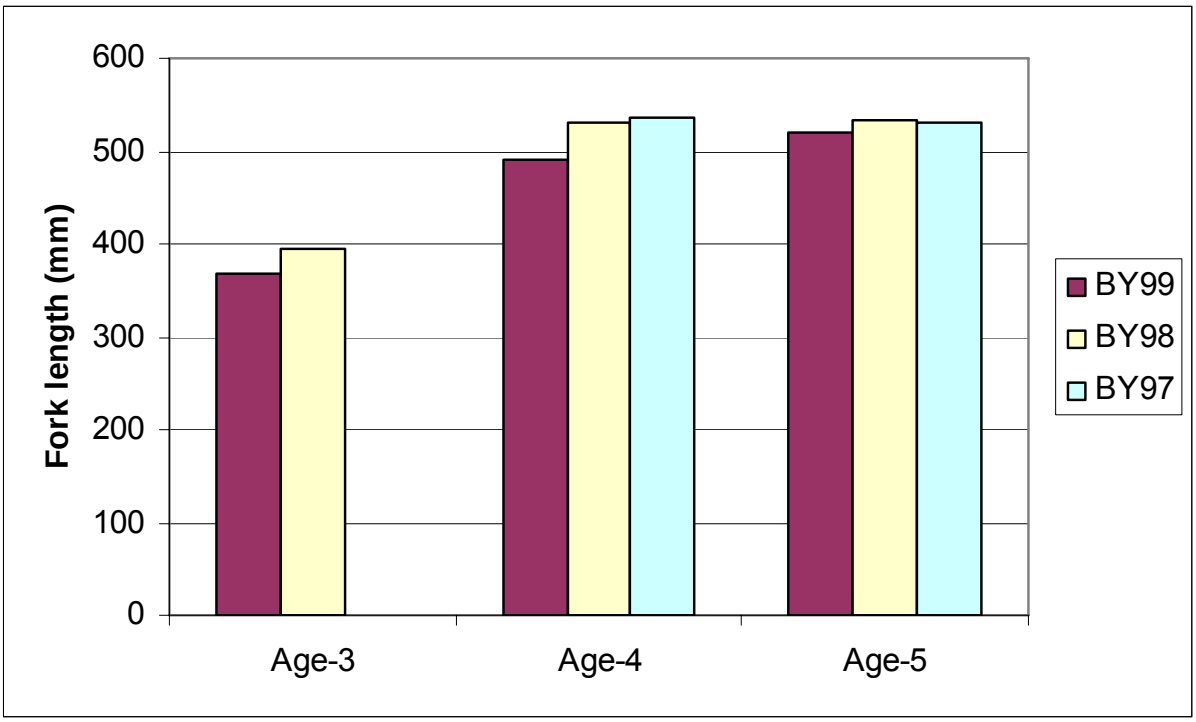


Figure 10. Mean length at maturity by age for West Fork Yankee Fork and East Fork Salmon River captive-reared Chinook salmon from BY97-BY99. No data is available for BY97 age-3 fish.

Volitional Spawning

Maturing adults were released into their natal streams for natural spawning and spawning observation studies on August 12, 13, (WFYF) and 19 (EFSR) in 2004 (Appendix B, Table 5). Unlike previous years, a blocking weir was not constructed on the WFYF precluding the need for a helicopter to transport adult fish or equipment. Adults released to the WFYF approximately 4 km upstream of the confluence with the Yankee Fork Salmon River (YFSR) had access to the entire length of the river, while those released in the EFSR were confined to the area above a temporary weir, approximately 14 km upstream of the SFH satellite weir.

Table 5. Summary of fish releases in the East Fork Salmon River (EFSR) and the West Fork Yankee Fork River (WFYF) for spawning evaluation studies in 2004.

Date	Stream	BY99	BY00	BY01	Total
	EFSR	—	4	—	
August 19	**EFSR**				**4**
	WFYF	10	52	8	
August 12 & 13	**WFYF**				**70**

Although specific behaviors and habitat preferences were not recorded in 2004, observed fish did display a progression of habitat associations and behavior consistent with progressing maturation and the onset of spawning (Berejikian et al. 2001b; Venditti et al. 2005). Captive-reared fish observed after release were spatially distributed but generally stayed within 5 km of their release site.

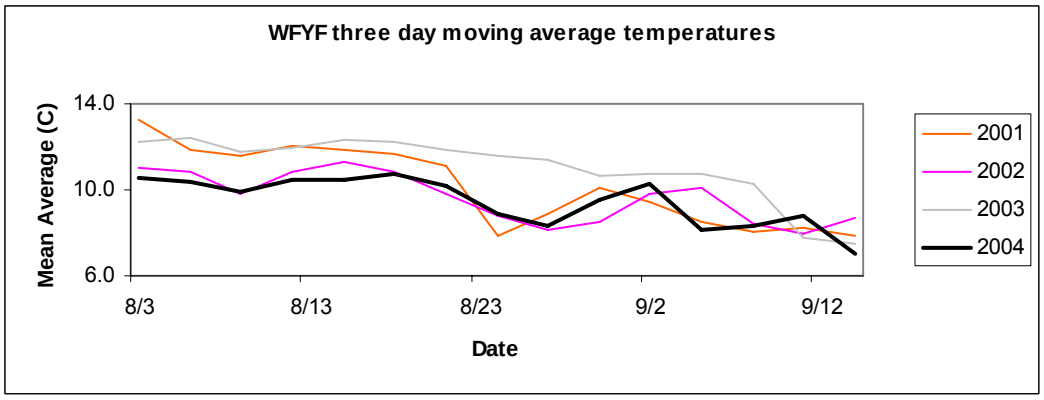
Radio tags were implanted in 10 adults released into the WFYF for natural spawning. Two radio-tagged fish left the WFYF (the carcass of one was recovered in the YFSR and found to have spawned), two tags were never located after the first week, and six tagged fish were suspected to have been consumed by predators although their carcasses never recovered.

Between August 26 and September 1, 12 redds constructed by captive-reared adults were identified within the WFYF study area (eleven in the WFYF and one in the main YFSR near the mouth of the WFYF). The uppermost redd (captive-reared) was located approximately 4 km upstream of the release site. Captive-reared Chinook salmon redds per released female (1:0.20) was less than in either 2002 (1:0.54) or 2001 (1:0.39); no captive-reared fish survived to spawn in 2003 (Venditti et al. 2005). Trend counts for natural Chinook salmon redds also showed a decline in 2004. Four redds constructed by natural Chinook salmon were observed between August 13 and August 31 in the WFYF, compared to the previous three year average of 18 (www.streamnet.org).

Radio tags were implanted in all four adults released into the EFSR for natural spawning. Fish were released approximately 2 km upstream of the temporary blocking weir on August 19. Two of the four fish were recovered as carcasses during field observations, neither of which appeared to have spawned volitionally. The two remaining females were suspected to have been consumed by predators and never recovered, although one was known to have spawned prior to her disappearance.

On September 17, one redd constructed by a captive-reared female was identified within the EFSR study area; a second female was observed test digging but the redd was never completed. Captive-reared Chinook salmon redds per released fish (1: 0.25) was greater than in 2003 (1: 0.06) and 2002 (1:0). Trend counts for natural Chinook salmon redds showed a decline in 2004. Natural Chinook salmon redd surveys conducted by the IDFG in the EFSR identified 116 redds in 2004, compared to the previous three year average of 185(www.streamnet.org).

Water temperatures (3 d moving average) during August and September in both the EFSR and the WFYF did not substantially deviate from the previous three years (Figure 11). However, the mean average, maximum, and minimum water temperatures in 2004 were slightly cooler than the previous three-year average for both the EFSR and the WFYF.



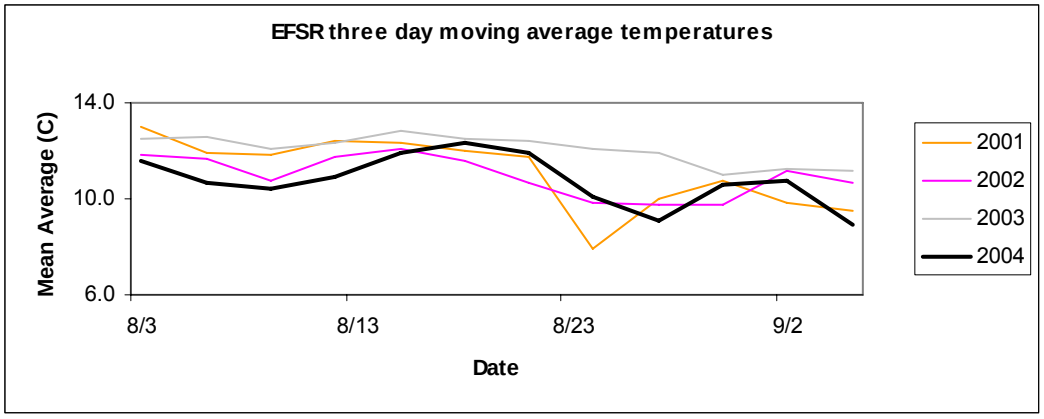


Figure 11. Average three-day moving average temperatures for the West Fork Yankee Fork and the East Fork Salmon rivers 2001-2004.

Production Estimation

On October 6, 2004, eggs were collected from five of the 11 redds spawned by captive-reared Chinook salmon in the WFYF. Estimated survival to the eyed stage of development for sampled eggs ranged from zero to 87% and averaged 18.4%, compared to previous year averages of 65% (2002) and 58% (2001). Other studies have estimated survival to eyed egg development by naturally spawned captive-reared fish to be as high as 97% (Berejikian and Tezak 2005) and naturally spawned natural fish to range between 90 and 97% (Healey 1991). Survival to the eyed stage of development is only estimated for sampled redds because the eggs collected only represent an individual nest or a portion of the eggs within the redd, and egg survival presumably varies between nests and within a redd. Comparatively, eyed egg survival in the hatchery from this same brood year was 51.8%. No eggs were sampled from redds on the EFSR, because only one captive-reared Chinook salmon redd was identified and a decision was made not to disturb those eggs.

Chinook salmon parr were collected in the EFSR in 2004 to obtain fin clips for genetic analysis to determine if they were the product of program releases made in calendar year 2003.

A total of 405 Chinook salmon parr were collected from the EFSR in August and September of 2004. Genetic samples were collected from all captured parr, and no mortalities occurred during sampling. Samples collected in 2004 will be used for future parental exclusion analysis (Colbourne et al. 1996; Talbot et al. 1996; Estoup et al. 1998; Bernatchez and Duchesne 2000; Eldridge et al. 2002) to determine relative production of program releases. Genetic analysis is currently ongoing and will be reported as results become available.

East Fork Salmon River Weir Operations

During operation of the site from May 11 through September 10, 2004, a total of 152 adult Chinook salmon (46 females, 70 males, 15 jacks, 21 undetermined) were trapped at the facility (Table 6). Five of the 152 Chinook salmon adults trapped in 2004 were adipose fin clipped (1 female, 1 male, 2 jacks, 1 unknown sex), indicating a hatchery origin fish, and a sixth fish (female) was marked with a radio transmitter from the University of Idaho. Additional species trapped included bull trout *Salvelinus confluentus*, westslope cutthroat trout *O. clarkii lewisi*, rainbow trout *O. mykiss*, mountain whitefish *Prosopium williamsoni*, as well as one sockeye salmon *O. nerka* trapped on August 20, 2004 (Table 7).

In an effort to assess whether the weir was altering the movements of migrating adult Chinook salmon, the area downstream was periodically monitored by snorkeling. Snorkeling efforts were concentrated in the river channel from the pool immediately below the weir to approximately 250 m downstream to the confluence with Big Boulder Creek. Only one Chinook salmon, a male in poor condition, was observed milling in the pool below the weir and the remains of one carcass was found on a gravel bar approximately 100 m downstream (both on August 31). Based on these observations the weir did not appear to inhibit Chinook salmon from migrating upstream. Additional species observed included bull trout, rainbow trout, cutthroat trout, and mountain whitefish.

Table 6. Adult Chinook salmon distributions trapped at the Sawtooth Fish Hatchery satellite weir during 2004.

Gender:					
	Females	**Males**	**Jacks**	**Unknown Sex**	**Total**
June	13	10	1	21	**45**
July	6	15	3	0	**24**
August	23	39	10	0	**72**
September	4	6	1	0	**11**
Total	**46**	**70**	**15**	**21**	**152**
Age:					
Age (length)	**3 (< 64 cm)**	**4 (64-82 cm)**	**5 (> 82 cm)**	**Total**	
Females	0	30	16	**46**	
Males	n/a	46	24	**70**	
Jacks	15	n/a	n/a	**15**	
Unknown	0	14	7	**21**	
Total	**15**	**90**	**47**	**152**	
Recapture rates:					
Age (length)	**3 (< 64 cm)**	**4 (64-82 cm)**	**5 (> 82 cm)**	**Total**	
Females	0	2	0	**2**	
Males	n/a	10	0	**10**	
Jacks	4	n/a	n/a	**4**	
Unknown	0	1	0	**1**	
Total	**4**	**13**	**0**	**17**	

Table 7. Summary of additional species trapped at the Sawtooth Fish Hatchery satellite weir during 2004.

Species	**Trapped**	**Recaptured**	**Unknown Recap[a]**	**Genetics taken**
bull trout	169	19	4	166
westslope cutthroat trout	5	0	0	4
Rainbow trout	3[b]	0	0	1
mountain whitefish	161	2	11[c]	61
sockeye salmon	1	0	0	1

[a] Some fish found with highly eroded upper caudal fin lobes, or data not recorded.
[b] Including one possible Cutthroat-Rainbow hybrid.
[c] Not all mountain whitefish caudal fin marked.

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APPENDICES

Appendix A. Summary of spawning activities involving captive-reared, East Fork Salmon River Chinook salmon at the Eagle Fish Hatchery in 2004. Maturing fish were separated into two groups; one held on chilled water (treatment), one on ambient water (control) to determine the effect of temperature on maturation timing. The number that could be maintained on chilled water determined the number of fish in the two groups. Fish beyond this number were maintained on ambient water but were treated as a separate group for analysis. Males and females from BY99, BY00, BY01, and BY02 matured in 2004. Overall egg survival for individual females was computed using the geometric mean survival to the eyed stage of development in individual subfamilies produced by that female.

Spawn date	Female origin	Female BY	Temp. group	Female weight	Female fecundity	Male origin	Male BY	Temp. group	Green eggs	Eyed eggs	Subfamily survival	Mean survival
9/7	NOAA	1999	Ambient	1,027	139	NOAA	2001	Ambient	139	0	.000	.000
9/10	NOAA	2000	Ambient	962	414	NOAA	2001	Ambient	414	19	.046	.046
9/10	NOAA	2000	Ambient	1,064	353	NOAA	2002	Non-study	143	137	.958	.952
						NOAA	2001	Ambient	210	199	.947	
9/13	NOAA	2000	Chilled	3,250	2,204	NOAA	2001	Chilled	613	53	.086	.065
						NOAA	2001	Chilled	1591	90	.057	
9/13	NOAA	2000	Chilled	1,728	1,070	NOAA	2001	Chilled	571	411	.720	.681
						NOAA	2001	Chilled	499	318	.637	
9/13	NOAA	2000	Chilled	929	151	NOAA	2001	Chilled	151	0	.000	.000
9/13	NOAA	2001	Chilled	830	943	NOAA	2002	Non-study	443	1	.002	.134
						NOAA	2002	Non-study	491	125	.255	
9/13	NOAA	2000	Chilled	2,278	1,784	NOAA	2002	Non-study	877	0	.000	.007
						NOAA	2002	Non-study	907	12	.013	
9/13	NOAA	2000	Ambient	1,064	422	NOAA	2002	Non-study	422	368	.872	.872
9/17	NOAA	2000	Ambient	2,366	2,016	NOAA	2002	Non-study	700	631	.901	.907
						NOAA	2002	Non-study	619	556	.898	
						NOAA	2002	Non-study	697	642	.921	
9/17	NOAA	2000	Ambient	1,855	1,418	NOAA	2002	Non-study	713	526	.738	.809
						NOAA	2002	Non-study	705	621	.881	
9/20	NOAA	2000	Chilled	1,276	352	NOAA	2001	Chilled	352	52	.148	.148
9/20	NOAA	2000	Chilled	1,466	883	NOAA	2002	Non-study	430	2	.005	.220
						NOAA	2002	Non-study	453	192	.424	
9/20	NOAA	2000	Chilled	1,680	1,036	NOAA	2001	Chilled	532	393	.739	.750
						NOAA	2002	Non-study	504	384	.762	
9/20	NOAA	2000	Chilled	1,921	1,144	NOAA	2002	Non-study	467	243	.520	.552
						NOAA	2002	Non-study	678	388	.572	
9/20	NOAA	2000	Chilled	1,911	1,841	NOAA	2001	Chilled	900	358	.398	.433
						NOAA	2002	Non-study	941	439	.466	
9/20	NOAA	2000	Chilled	2,457	2,152	NOAA	2001	Chilled	741	622	.839	.836
						NOAA	2001	Chilled	730	607	.831	
						NOAA	2002	Non-study	681	570	.837	
9/21	NOAA	2000	Chilled	3,013	2,197	NOAA	2002	Non-study	773	40	.052	.045
						NOAA	2002	Non-study	714	29	.041	
						NOAA	2002	Non-study	710	30	.042	
9/21	NOAA	2000	Chilled	1,814	1,160	NOAA	2002	Non-study	590	550	.932	.923
						NOAA	2002	Non-study	570	521	.914	
9/21	NOAA	2000	Chilled	2,106	1,306	NOAA	2002	Non-study	645	584	.905	.913
						NOAA	2002	Non-study	661	608	.920	
9/21	NOAA	2000	Chilled	3,355	2,074	NOAA	2002	Non-study	691	561	.812	.802
						NOAA	2002	Non-study	698	560	.802	
						NOAA	2002	Non-study	685	542	.791	
9/23	NOAA	2000	Chilled	2,610	1,591	NOAA	2002	Non-study	778	126	.162	.140
						NOAA	2002	Non-study	813	97	.119	
9/23	NOAA	2000	Chilled	2,060	1,631	NOAA	2002	Non-study	832	723	.869	.853
						NOAA	2002	Non-study	797	668	.838	
9/23	NOAA	2000	Ambient	1,681	1,434	NOAA	2001	Ambient	719	640	.890	.895
							2002	Non-study	715	644	.901	
9/23	NOAA	2000	Ambient	1,844	1,350	NOAA	2001	Ambient	687	381	.555	.714
							2002	Non-study	663	583	.879	
9/23	NOAA	2000	Ambient	1,769	768	NOAA	2001	Ambient	376	256	.681	.336
							2002	Non-study	392	2	.005	
9/23	NOAA	2000	Ambient	1,310	636	NOAA	2001	Ambient	316	152	.481	.480
							2002	Non-study	320	153	.478	

Appendix A. Continued.

Spawn date	Female origin	Female BY	Temp. group	Female weight	Female fecundity	Male origin	Male BY	Temp. group	Green eggs	Eyed eggs	Subfamily survival	Mean survival
9/23	NOAA	2000	Ambient	2,113	1,499	NOAA	2002	Non-study	756	690	.913	.888
							2002	Non-study	743	641	.863	
9/23	NOAA	2000	Ambient	2,236	1,864	NOAA	2002	Non-study	942	57	.060	.059
							2002	Non-study	922	53	.057	
9/23	NOAA	2000	Ambient	1,669	1,039	NOAA	2002	Non-study	520	495	.952	.924
							2002	Non-study	519	465	.896	
9/27	NOAA	2000	Chilled	2,294	1,857	NOAA	2002	Non-study	960	873	.909	.473
							2002	Non-study	897	6	.007	
9/27	NOAA	2000	Ambient	2,904	2,003	NOAA	2002	Non-study	677	182	.269	.092
							2002	Non-study	655	1	.002	
							2002	Non-study	671	1	.002	
9/30	NOAA	2000	Chilled	1,643	624	NOAA	2002	Non-study	308	14	.045	.032
							2002	Non-study	316	6	.019	
9/30	NOAA	2000	Chilled	1,455	612	NOAA	2002	Non-study	306	233	.761	.737
							2002	Non-study	306	218	.712	
9/30	NOAA	2001	Chilled	532	510	NOAA	2002	Non-study	250	2	.008	.004
							2002	Non-study	260	0	.000	
9/30	NOAA	2000	Ambient	1,488	881	NOAA	2001	Ambient	449	435	.969	.977
							2002	Non-study	432	426	.986	
9/30	NOAA	2000	Ambient	2,186	1,282	NOAA	2001	Ambient	647	477	.737	.770
							2002	Non-study	635	510	.803	
9/30	NOAA	2000	Ambient	1,745	1,369	NOAA	2001	Ambient	695	321	.462	.238
							2002	Non-study	674	5	.007	
10/04	NOAA	2000	Chilled	1,760	1,332	NOAA	2002	Non-study	665	497	.747	.740

Appendix B. Summary of fish transfers conducted by the Chinook Salmon Captive Rearing Project during 2004. MAN – Manchester Research Station, EAG – Eagle Fish Hatchery. NP, NE, and SN refer to natural parr, natural egg, and safety net groups, respectively.

Source Stream	BY	EAG to MAN	Transfer Date	MAN to EAG	Transfer Date	EAG to WFYF	Transfer Date	EAG to EFSR	Transfer Date
WFYF-NP	98			1	5/6				
WFYF-SN	99			14	5/6,6/2	10	8/12,8/13		
WFYF-NE	00			79	5/6,6/2	52	8/12,8/13		
WFYF-NE	01			9	5/6	8	8/12,8/13		
WFYF-NE	02	272	5/5						
EFSR-SN	99			2	5/6				
EFSR-NE	00			55	5/6,6/2			4	8/19
EFSR-NE	01			12	5/6,6/2				
EFSR-NE	02	320	5/5	43	7/2				

Appendix C. Tag and identification summary for captive-reared Chinook salmon released for volitional spawning in the West Fork Yankee Fork (WFYF) and the East Fork Salmon River (EFSR). Fish were jaw tagged (WFYF only) for visual identification. A portable ultrasound unit was used on maturing fish reared at the Manchester Research Station (MAN) to determine sex, and classified as undetermined – U, female – F, or male – M. Ultrasound was used a second time when fish were jaw tagged at Eagle Fish Hatchery (FH) before release. Treatment groups in the WFYF and EFSR refers to the temperature experienced during freshwater maturation at Eagle FH. Test fish (T) were held on chilled water, (~8.0–12.0°C); control fish (C) were held on ambient water (~13.5°C); and late arrivals (LA), those fish transferred to freshwater about six weeks later than the others, were held on ambient water. Fish heavier then the group mean for their stock and brood year (BY) were classified as large (L), while those lighter were considered small (S). Fish from the EFSR-LA and WFYF-LA were not included in the temperature study.

PIT Code	BY	Sex	Radio #	Number	Stock	Size	Treatment	Rearing
3D9.1BF0EC3986	1999	F		400	WFYF	L	T	MAN
3D9.1BF11AED35	2000	F	151.204	401	WFYF	L	T	MAN
3D9.1BF11AE9C7	2000	F		402	WFYF	S	T	MAN
3D9.1BF11ADEE5	2000	F		403	WFYF	S	T	MAN
3D9.1BF11AE9D3	2000	F	151.085	404	WFYF	L	T	MAN
3D9.1BF11ADBF5	2000	F		405	WFYF	S	T	MAN
3D9.1BF11AB1CA	2000	F	151.124	406	WFYF	L	T	MAN
3D9.1BF11ADC00	2000	F		407	WFYF	L	T	MAN
3D9.1BF11EB13D	2000	F		408	WFYF	S	T	MAN
3D9.1BF11BD54E	2001	M?		409	WFYF	L	T	MAN
3D9.1BF11E9384	2000	F		410	WFYF	S	T	MAN
3D9.1BF11AFE49	2000	F	150.044	411	WFYF	L	T	MAN
3D9.1BF11AE59F	2000	F		412	WFYF	S	T	MAN
3D9.1BF11BAF3F	2001	F		413	WFYF	L	T	MAN
3D9.1BF11AC4EB	2000	F		414	WFYF	S	T	MAN
3D9.1BF11F0B41	2001	M		415	WFYF	L	T	MAN
3D9.1BF11AA8B1	2000	F		416	WFYF	S	T	MAN
3D9.1BF11AE37B	2000	F		417	WFYF	L	T	MAN
3D9.1BF0EC3EF2	1999	F		418	WFYF	L	T	MAN
3D9.1BF0DEF813	1999	F		419	WFYF	L	T	MAN
3D9.1BF11A258D	2001	M		420	WFYF	S	T	MAN
3D9.1BF11AF381	2000	F		421	WFYF	S	T	MAN
3D9.1BF0DF9AB9	1999	F		422	WFYF	S	T	MAN
3D9.1BF11AE870	2000	F		423	WFYF	S	T	MAN
3D9.1BF11AE892	2000	F	150.004	424	WFYF	L	T	MAN
3D9.1BF11ADED3	2000	F		425	WFYF	L	C	MAN
3D9.1BF11AFB16	2000	F		426	WFYF	L	C	MAN
3D9.1BF11AF99B	2000	F		427	WFYF	L	C	MAN
3D9.1BF11AE8A3	2000	F		428	WFYF	L	C	MAN
3D9.1BF11AA844	2000	F		430	WFYF	L	C	MAN
3D9.1BF11AFA8F	2000	F		431	WFYF	S	C	MAN
3D9.1BF11AE338	2000	F	150.064	432	WFYF	S	C	MAN
3D9.1BF11AB9CC	2000	F		433	WFYF		C	MAN
3D9.1BF11AE63B	2000	F		434	WFYF	S	C	MAN
3D9.1BF11AFE40	2000	F		435	WFYF	S	C	MAN
3D9.1BF11ADA9F	2000	F		436	WFYF	S	C	MAN
3D9.1BF11AEA48	2000	F	150.103	437	WFYF	S	C	MAN

Appendix C. Continued.

PIT Code	BY	Sex	Radio #	Number	Stock	Size	Treatment	Rearing
3D9.1BF11ABDF9	2000	F		438	WFYF	S	C	MAN
3D9.1BF11BBDAE	2001	M		439	WFYF	S	C	MAN
3D9.1BF11AE01D	2000	F		440	WFYF	S	C	MAN
3D9.1BF11EBC46	2001	U		441	WFYF	S	C	MAN
3D9.1BF11ACDA8	2000	F		442	WFYF	S	C	MAN
3D9.1BF11AC3A2	2000	F		443	WFYF	S	C	MAN
3D9.1BF11ACD99	2000	F		444	WFYF	L	C	MAN
3D9.1BF11B9AAB	2000	F		445	WFYF	L	C	MAN
3D9.1BF11AED96	2000	F		446	WFYF	S	C	MAN
3D9.1BF11ED638	2001	M		447	WFYF	L	C	MAN
3D9.1BF11ADCCF	2000	F		448	WFYF	S	C	MAN
NO TAG B3 #01	2000	F	151.145	449	WFYF		C	MAN
3D9.1BF11AE222	2000	F		450	WFYF	S	C	MAN
3D9.1BF11AEC00	2000	F	151.064	451	WFYF	L	C	MAN
3D9.1BF11AE93D	2000	F		452	WFYF	S	C	MAN
3D9.1BF11E9327	2000	F		454	WFYF	S	C	MAN
3D9.1BF11F1A25	2001	M		455	WFYF	S	C	MAN
3D9.1BF11AE270	2000	F		456	WFYF	S	C	MAN
3D9.1BF0EC3E11	1999	F		457	WFYF	L	C	MAN
3D9.1BF0EC5BDC	1999	F		458	WFYF	L	C	MAN
3D9.1BF11AC1BD	2000	F		459	WFYF	S	C	MAN
3D9.1BF11AE865	2000	F	151.045	460	WFYF	L	C	MAN
3D9.1BF0EC495D	1999	F		461	WFYF	S	C	MAN
3D9.1BF11AE247	2000	F		462	WFYF	S	C	MAN
3D9.1BF11AF110	2000	F?		463	WFYF		LA	MAN
3D9.1BF0DEFC00	1999	M		464	WFYF		LA	MAN
3D9.1BF0EC5F94	1999	M		465	WFYF		LA	MAN
3D9.1BF11AE9BC	2000	M		466	WFYF		LA	MAN
3D9.1BF11AEBDC	2000	U		467	WFYF		LA	MAN
3D9.1BF0EC40CC	1999	F		468	WFYF		LA	MAN
3D9.1BF11BA638	2000	F		469	WFYF		LA	MAN
3D9.1BF11AE48F	2000	F		471	WFYF		LA	MAN
3D9.1BF11EB9B6	2000	F		472	WFYF		LA	MAN
3D9.1BF11AE368	2000	F	151.244		EFSR		C	MAN
3D9.1BF11B066F	2000	F	150.004		EFSR		C	MAN
3D9.1BF11B837A	2000	F	151.163		EFSR		T	MAN
3D9.1BF11C1125	2000	F	151.023		EFSR		T	MAN

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