FISHERY RESEARCH

CAPTIVE REARING PROGRAM FOR SALMON RIVER CHINOOK SALMON

PROJECT PROGRESS REPORT
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Project Progress Report

2005 Annual Report

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

List of Figures, continued.

Page

LIST OF APPENDICES

ABSTRACT

During 2005, 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 = 327) and the West Fork Yankee Fork Salmon River (WFYF; N = 336) to establish brood year 2005 culture cohorts. The eyed eggs were incubated and reared at the Eagle Fish Hatchery, Eagle, Idaho (Eagle FH). Juveniles representing brood year 2003 (BY03) were passive integrated transponder and elastomer tagged and vaccinated against *Vibrio* spp. and bacterial kidney disease (causative agent *Renibacterium salmoninarum*) prior to being transferred to the National Oceanic & Atmospheric Administration (NOAA) Fisheries, Manchester Research Station, Manchester, Washington (Manchester) for seawater rearing through maturity. Smolt transfers included 296 individuals from the WFYF and 302 from the EFSR. Maturing fish transfers from Manchester to Eagle FH included 122 individuals from the WFYF and 228 from the EFSR. This was the fifth 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. Unlike previous years, all returning adults were placed on the same chilled water temperature regimen that allocated all available chilled water evenly to all holding tanks. All maturing captive-reared Chinook salmon were released in 2005. No maturing adults were spawned at Eagle FH for gamete evaluations, precluding the availability of eggs for in-stream incubators. Mature adults were released into study sections of the WFYF (n = 116) and EFSR (n = 216) to evaluate reproductive performance of captive-reared adults as well as behavioral interactions of captive x captive and captive x natural adults. Eight captive-reared Chinook salmon females volitionally spawned in the WFYF and two in the EFSR. Prespawn behavior differed from that of natural origin Chinook salmon but was consistent with the behavior of previously observed captive-reared Chinook salmon allowed to volitionally spawn. Juvenile Chinook salmon were collected from the EFSR (N = 100) and the WFYF (N = 91) to assess production levels from volitional spawning events and eyed egg plants resulting from program releases conducted in the EFSR during 2004. 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 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 hatchery programs would not negatively affect the productivity or genetic viability of target or other populations and natural populations would remain self-sustaining even with hydropower projects in place. In reality, smolt-to-adult survival in wild 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 the 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 artificial 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; National Marine Fisheries Service [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. This project is developing technology that may be used in the recovery of the listed Snake River spring/summer Chinook salmon evolutionarily significant unit (ESU), which consists of 31 subpopulations (i.e. breeding units or stocks; McClure et al. 2003). Preserving the metapopulation structure of this ESU is consistent with the various Snake River Salmon Recovery Plans (NMFS 1995; Schmitten et al. 1997; McClure et al. 2003), and supports the Northwest Power and Conservation Council's (NPCC) goal of maintaining biological diversity while doubling salmon and steelhead runs (NPCC 1994).

Idaho and Oregon state, tribal, and federal fish managers met during 1993 and 1994 to discuss captive culture research and implementation in the Snake River basin. The outcome of those meetings was 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 begin 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 diverge. The F_1 generation in a captive rearing

program are 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 wild coho salmon during spawning (Berejikian et al. 2001a) and the competitive differences between newly emerged fry produced by captive-reared and wild coho salmon (Berejikian et al. 1999). Finally, Hendry et al. (2000) report 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 BY94 Chinook salmon parr from three study streams. Since then, naturally spawned Chinook salmon progeny from BY95-BY05 have been represented in captivity to continue the project. Hassemer et al. (1999, 2001) and Venditti et al. (2002, 2003a, 2003b, 2005) summarize project activities from inception through 2004. The streams selected for inclusion in the captive rearing program include the Lemhi River (LEM), the East Fork Salmon River (EFSR), and the West Fork Yankee Fork Salmon River (WFYF); the 2005 study area is depicted in Figure 1. Project activities were completed on the LEM in 2003 with the release of mature BY99 adult fish, enabling increased

monitoring intensity on the EFSR and WFYF to present day. 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 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 wild 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, 2005 through December 31, 2005. This project is coordinated with the Northwest Power and Conservation Council's Fish and Wildlife Program (NPCC 2000) and is identified as project 199700100. Funding is provided through the Bonneville Power Administration under contract 00004002 and 00067094.

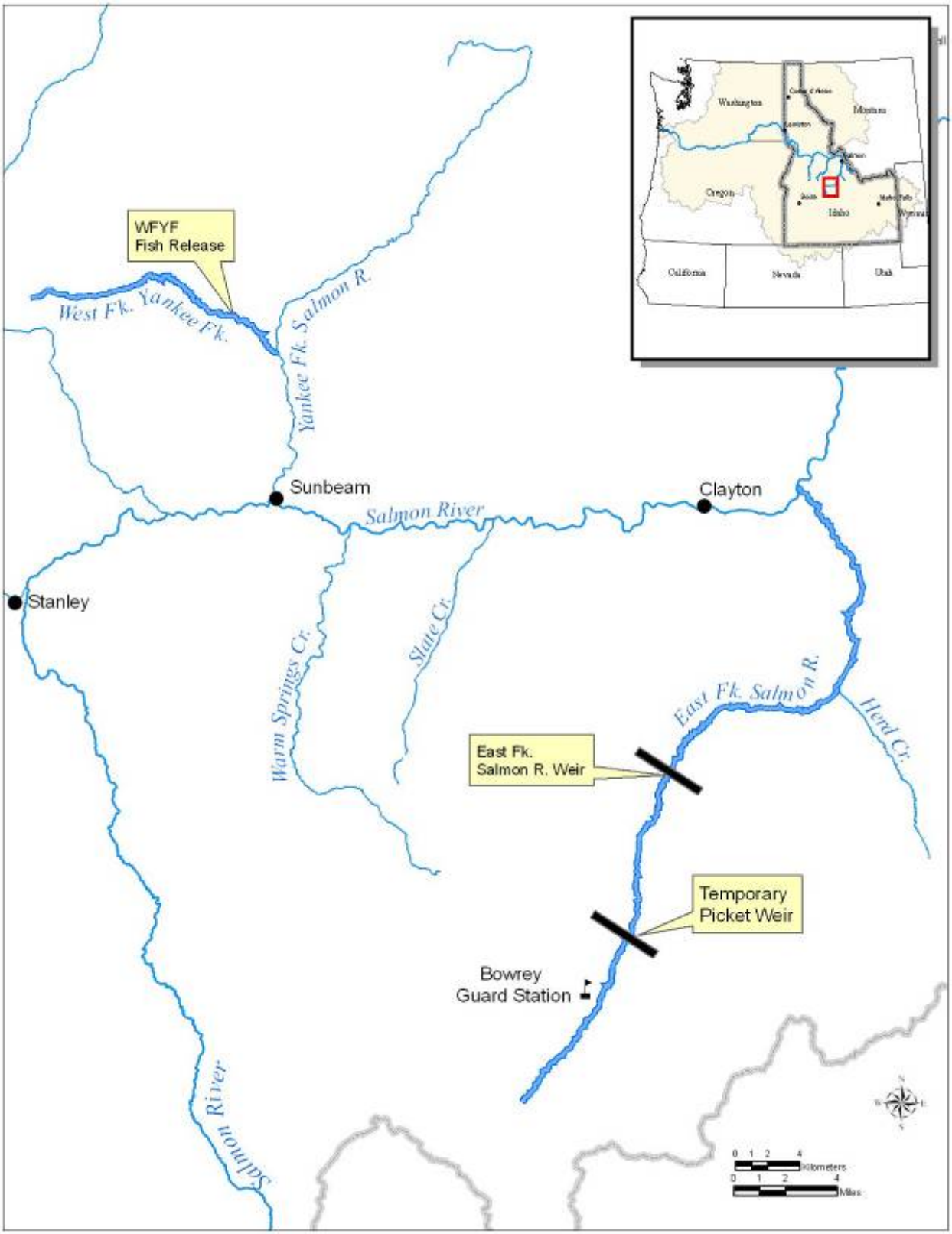


Figure 1. Location of study streams included in the Idaho Department of Fish and Game Captive Rearing Program for Salmon River Chinook salmon.

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 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 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 of 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 the various life stages and sizes of Chinook salmon maintained on station. Plastic incubators and fiberglass tanks ranging in size from 0.7–3.0 m in diameter are used to culture Chinook salmon from eggs to maturity. Fertilized eggs are held in incubators until swim-up, 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) separated 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 a minimum of 1.5 exchanges per hour, with shade covering (70%) and jump screens 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 National Oceanic & Atmospheric Administration (NOAA) Manchester Research Station in Manchester, Washington (Manchester). This facility is located on Puget Sound near Seattle, Washington, and is supplied with approximately 5,000 L/min of 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 were both traditional and 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, British Columbia, Canada). Ration and water temperature were manipulated to simulate the ration and temperature profiles that would be experienced in the natural environment to modulate growth and reduce precocial male development. This feeding regimen was developed collaboratively with NOAA Fisheries Project Number 96-067-00.

Eyed Egg Collection, Incubation, and Transport

To establish individual brood year captive cohorts, eyed eggs 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 a 3.8 cm diameter aluminum probe 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).

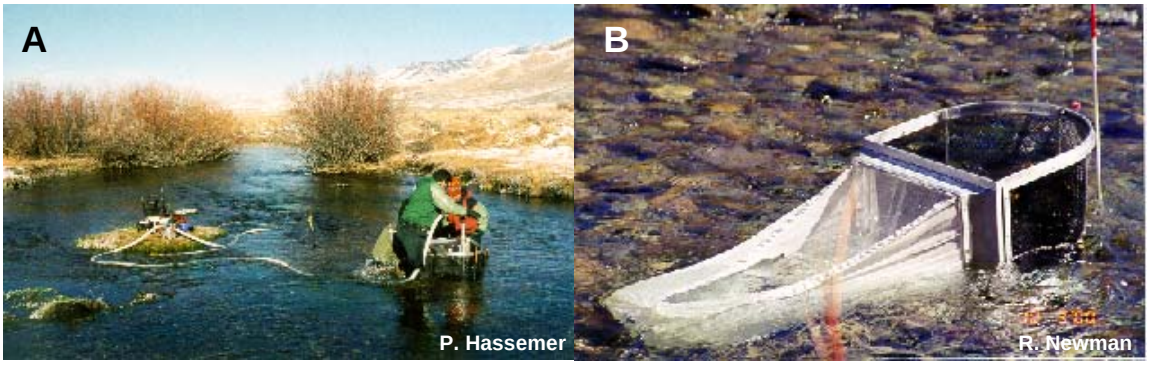


Figure 2. Hydraulic sampling gear including (A) the pump and probe, and (B) the collection net used to collect eyed eggs from naturally spawned redds.

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. Information on when the redd was first observed and the spawning state of fish seen associated with the redd (e.g., courting, digging, trenching, etc.) was 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 accumulating 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 the stream and redd from which they were collected. 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 began feeding (Heindel et al. 2005). A constant flow (1.2 L/min) of chilled water (approximately 7°C-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).

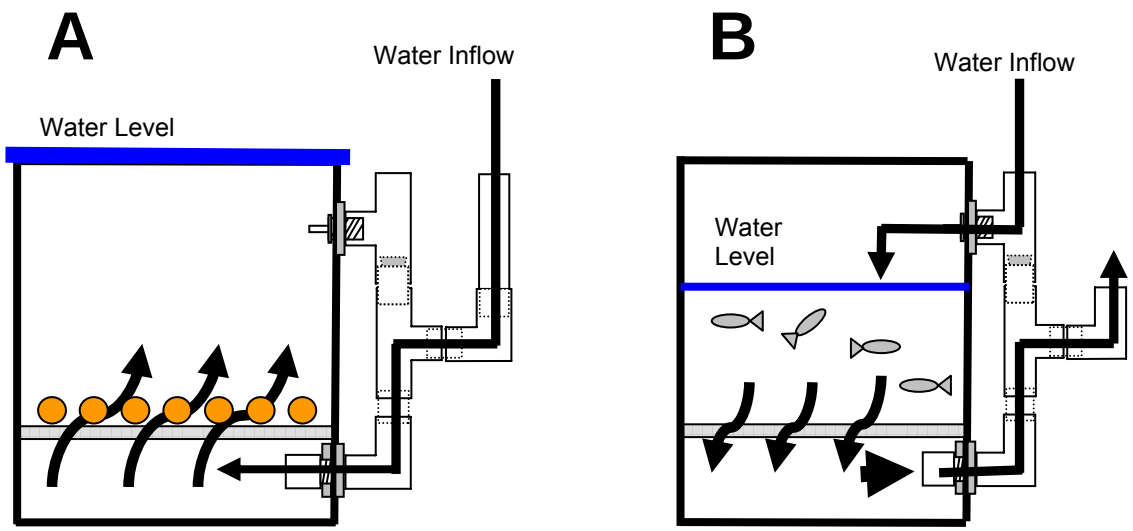


Figure 3. Schematic diagram of reversible flow incubators used to incubate eggs and rear newly emerged fry. A) Upwelling configuration for egg incubation, and B) downwelling configuration for fry rearing.

Juvenile Rearing, Marking, and Transportation

Swim-up fry were fed for one week while 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/d, until they reached a mean weight of 1.0 g. Growth projections were developed at this time, and feeding rates were reduced to four times/d. Ambient and chilled water was added to the tanks to maintain a temperature of approximately 8.5°C and a turnover rate of approximately 1.5 turnovers/h. Fry were fed a commercial diet (Bio-Oregon Starter #2) at approximately 2% of their body weight/d. As fish grew, ration and pellet sizes were increased 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.

Age-1 juvenile Chinook salmon were marked during two separate events at Eagle. 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 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 WFYF received orange marks (the EFSR group was not marked in 2005). 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 freshwater 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 backup 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, if necessary, transport water was tempered to within 2.0°C of the receiving water 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 0.25% saltwater and 0.75% 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 forming a loop at the end with needle-nose pliers. 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*.

From 2001 through 2004, maturing Chinook salmon stocks were separated into three groups and held at two temperatures during their freshwater maturation at Eagle FH. Maturing adults transferred from Manchester to Eagle FH were divided 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 treatment 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 used to construct 95% confidence intervals (CI) around the means (Scheaffer et al. 1990). Fish were also assigned to size groups within brood years and treatment 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 the 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 were 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 freshwater compared to earlier groups. During 2005, all returning mature Chinook salmon were placed on a similar chilled water regimen as described above.

Monitoring Programs

Hatchery Spawning and Gamete Evaluation

Generally, a small number of maturing fish from each treatment group (one 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 treatment group became ripe, hatchery spawning allowed the comparison of egg quality (survival to the eyed stage) between the temperature 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 treatment 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 (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 accumulated 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. When produced, eyed eggs from all hatchery crosses were provided to biologists with the Shoshone-Bannock Tribes for transfer to in-stream 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 treatment groups. The spawn date for each female was the number of days after the first female is 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 are administered orally in Bio-Diet soft-moist feed obtained from Bio-Oregon (Warrenton, Oregon) to produce a dose of 100 mg/kg of body weight for up to 28 d. When oral administration is not feasible, as with maturing adults, an intraperitoneal injection of erythromycin is given to fish at a dose of 20 mg/kg of body weight. In addition, fingerlings are fed oxytetracycline as needed to control outbreaks of pathogenic *myxobacteria*, *aeromonad*, and *pseudomonad* bacterial infections.

2) Vaccinations: age-1 Chinook salmon are vaccinated prior to transfer to seawater 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, and 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. 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. 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 were recently identified in fish reared at a seawater net pen location close 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 year 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, the growth and survival of BY00 Chinook salmon is summarized; however, this brood year was raised entirely at Manchester, precluding a comparison between fish raised 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 by truck or helicopter to a construction site and assembled at the downstream end of a given study 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 created by captive-reared individuals to provide a means to accurately determine when redds should be sampled to determine fertilization rates and survival to the eyed egg stage of development. During this reporting period, only the EFSR received a fish weir. Fish released into the WFYF were allowed to migrate unrestricted throughout the drainage.

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 at various sites with the aid of a helicopter (distant or inaccessible release sites) or transferred on foot. Fish transported by helicopter were transferred in insulated coolers filled with water from the transport tank. The coolers were secured inside specially constructed steel frames for transport under the helicopter during the approximately 2 km flight to the release site. Fish transported and released on foot were transferred either in water-filled coolers or in specially constructed, water-filled slings that were then carried to the release site. During this reporting period, fish were only transported and released on foot from the transport tank.

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; 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 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 a disk-tagged study fish, the identification color combination and/or number of the tag was recorded. If the number was identified or a natural Chinook salmon was observed, its location was recorded on a global positioning system 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, the person 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 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 dip nets (Bonneau et al. 1995) and anglers using hook and line techniques throughout the study section. 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, parr were transferred to tubs located on the shore filled with fresh stream water, lightly anesthetized with MS-222, and measured to the nearest 1.0 mm FL. 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. Parr were then released back into the stream, after recovering in a tub of freshwater, near their point of collection. 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 in-stream incubator production (eggs produced from hatchery spawning and planted in the previous year) from 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 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. After each Chinook salmon was adequately sedated, it was checked for any visible marks, 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 iodophor 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. All information was recorded on data sheets, and total Chinook salmon numbers were reported to Sawtooth Fish Hatchery daily via telephone.

To determine if the weir was altering the movements of migrating adult Chinook salmon, the area downstream of the weir was monitored by snorkeling periodically 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, 2005. During this reporting period, 10 rearing groups were in culture at the IDFG Eagle FH. These rearing groups represent stocks 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). During this reporting period, only NE fish were being raised in the program.

Brood Year 2001 Culture Groups

At the beginning of the reporting period, all BY01 captive groups were in saltwater culture at Manchester. Thirteen WFYF-NE (10 female, zero male, three unknown) and 33 EFSR-NE (28 female, zero male, five unknown) adults were transferred from Manchester to Eagle FH in 2005 to complete maturation in freshwater. Ten WFYF-NE females and three unknowns (immatures) were released into the WFYF for volitional spawning. Twenty-four EFSR-NE females and four unknowns (immatures) were released into the EFSR for volitional spawning. In addition, one EFSR-NE maturing female died due to handling, and four females died prior to release with undetermined, noninfectious mortality as cause of death (Tables 2 and 3).

Table 2. Summary of losses and magnitude of mortality for five West Fork Yankee Fork (WFYF) captive-reared Chinook salmon culture groups reared at Idaho Department of Fish and Game facilities in 2005. Culture groups are designated by brood year; all groups were sourced by natural egg collections.

	Culture Groups				
	BY01	**BY02**	**BY03**	**BY04**	**BY05**
Starting Inventory (January 1, 2005)	0	0	296	268	336[a]
Eyed egg to Fry					
Undetermined[b]	n/a	n/a	n/a	n/a	29
Mechanical Loss					
Handling	0	2	0	0	na
Jump-out	0	0	0	0	na
Transportation	0	0	0	0	na
Noninfectious					
Lymphosarcoma	0	0	0	0	na
Nephroblastoma	0	0	0	0	na
Other[c]	0	3	1	4	na
Infectious					
Bacterial	0	0	0	0	na
Viral	0	0	0	0	na
Other	0	0	0	0	na
Hatchery Spawning					
Male Spawners	0	0	0	0	na
Female Spawners	0	0	0	0	na
Cryopreservation	0	0	0	0	na
Relocation					
Transferred In	13	54	55	0	na
Transferred Out	0	0	296	0	na
Planted/Released	13	49	54	0	na
Ending Inventory (December 31, 2005)	0	0	0	264	307

[a] Initial eyed egg collection—winter 2005.
[b] Typical egg to fry mortality includes nonhatching eggs, abnormal fry, and swim-up loss.
[c] 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 five East Fork Salmon River (EFSR) captive-reared Chinook salmon culture groups reared at Idaho Department of Fish and Game facilities in 2005. Culture groups are designated by brood year; all groups were sourced by natural egg collections.

	Culture Groups				
	BY01	**BY02**	**BY03**	**BY04**	**BY05**
Starting Inventory (January 1, 2005)	0	0	304	430	327[a]
Eyed egg to Fry					
Undetermined[b]	n/a	n/a	n/a	n/a	22
Mechanical Loss					
Handling	1	0	0	0	na
Jump-out	0	0	0	0	na
Transportation	0	1	0	0	na
Noninfectious					
Lymphosarcoma	0	0	0	0	na
Nephroblastoma	0	0	0	0	na
Other[c]	4	5	3	4	na
Infectious					
Bacterial	0	0	0	0	na
Viral	0	0	0	0	na
Other	0	0	0	0	na
Hatchery Spawning					
Male Spawners	0	0	0	0	na
Female Spawners	0	0	0	0	na
Cryopreservation	0	0	0	0	na
Relocation					
Transferred In	33	125	70	0	na
Transferred Out	0	0	302	0	na
Planted/Released	28	119	69	0	na
Ending Inventory (December 31, 2005)	0	0	0	426	305

[a] Initial eyed egg collection—winter 2005.
[b] Typical egg to fry mortality includes nonhatching eggs, abnormal fry, and swim-up loss.
[c] Includes mortality due to maturation; culling associated with cultural anomalies; and all undetermined, noninfectious mortality.

Brood Year 2002 Culture Groups

At the beginning of the reporting period, all BY02 captive groups were in seawater culture at Manchester. A total of 54 WFYF-NE (zero female, 52 male, two unknown) and 125 EFSR-NE (zero female, 106 male, 19 unknown) adults were transferred from Manchester to Eagle FH in 2005 to complete maturation in freshwater. Forty-eight WFYF-NE males and one unknown (immature) were released into the WFYF for volitional spawning. In addition, two BY02 WFYF-NE Chinook salmon died in culture due to handling and three BY02 WFYF-NE adults died at Eagle FH with the cause of death listed as undetermined, noninfectious mortality. One hundred EFSR-NE males and 19 unknowns (immatures) were released into the EFSR for volitional spawning. In addition, one EFSR-NE maturing male died in transport, and five males died prior to release with undetermined, noninfectious mortality as cause of death (Tables 2 and 3).

Brood Year 2003 Culture Groups

At the beginning of the reporting period, 296 WFYF-NE and 304 EFSR-NE juveniles were in culture at Eagle FH. In May of 2005, all smolts (296 WFYF-NE and 302 EFSR-NE) were transferred to Manchester to complete maturation in seawater. A total of 55 WFYF-NE and 70 EFSR-NE precocial males were transferred from Manchester to Eagle FH in July 2005 to complete maturation in freshwater. Fifty-four WFYF-NE males were released into the WFYF for volitional spawning and one BY03 WFYF-NE Chinook salmon died in culture at Eagle FH prior to release. Sixty-nine EFSR-NE males were released into the EFSR for volitional spawning. In addition, one EFSR-NE maturing male died prior to release (Tables 2 and 3).

Brood Year 2004 Culture Groups

At the beginning of the reporting period, 268 WFYF-NE and 430 EFSR-NE juveniles were in culture at Eagle FH. Ending inventory for BY04 groups at Eagle FH totaled 264 and 426, WFYF-NE and EFSR-NE juveniles, respectively (Tables 2 and 3).

Brood Year 2005 Culture Groups

Eyed egg collections for BY05 cohorts were conducted in September and October of 2005 in both the WFYF and EFSR study areas. A total of 336 WFYF-NE and 327 EFSR-NE eyed eggs were collected from redds of wild/natural Chinook salmon in 2005. At the end of the reporting period, 307 WFYF-NE and 305 EFSR-NE eyed eggs/developing fry were in culture at Eagle FH (Tables 2 and 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 BY05. Collections totaled 327 eyed eggs from the EFSR (five redds) and 336 from the WFYF (three redds, Table 4). Percent survival to ponding was 93.0% for the EFSR eggs and 91.7% for the WFYF eggs. Estimated CTUs to hatch ranged from 532.0 to 567.0 for the EFSR eggs and 489.0 to 535.0 for the WFYF eggs.

Table 4. Summary of eyed egg collections in the East Fork Salmon River (EFSR) and West Fork Yankee Fork (WFYF) to establish brood year 2005 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	Total
9/28/05	EFSR	73	82	62	57	53	327
Total	**EFSR**						**327**
CTUs		335	369	369	380	314	
9/19/05	WFYF	105	131	—	—	—	236
10/19/05	WFYF	—	—	100	—	—	100
Total	**WFYF**						**336**
CTUs		297	343	318	—	—	

Juvenile Rearing, Marking, and Transportation

Juvenile Chinook salmon from BY03 culture groups destined for transfer to Manchester for seawater rearing received intraperitoneal injections to provide a measure of protection from two common pathogens. Both vaccines were administered on March 16, 2005. Juveniles from the WFYF averaged 136.5 mm FL and 30.4 g (N = 296, range 112–170 mm FL and 15.5–56.0 g), and those from the EFSR averaged 134.3 mm FL and 29.2 g (N = 303, range 112–159 mm FL and 18.8–48.5 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 prior years (Venditti et al. 2002, 2003a, 2003b, 2005).

Brood year 2003 juvenile Chinook salmon were transferred from Eagle FH to Manchester as smolts on May 3, 2005. Smolts transferred between facilities included 302 fish from the EFSR-NE group and 296 fish from the WFYF-NE group. All BY03 precocial smolts (WFYF = 55 and EFSR = 70) were returned to Eagle FH on July 21, 2005 to be released to natal streams.

Two culture groups of juvenile Chinook salmon representing BY04 (N = 691) were PIT tagged on December 14, 2005. Two hundred sixty-four WFYF and 427 EFSR fish were PIT tagged at that time. Fish from the WFYF averaged 106.1 mm FL and 14.2 g (range 73–127 mm FL, 4.3–24.7) while EFSR fish averaged 109.6 mm FL and 15.2 g (range 75–138 mm FL, 5.5–32.5 g).

Adult Rearing, Marking, and Transportation

Adult Chinook salmon from the WFYF and EFSR stocks determined to be maturing at Manchester were transferred to Eagle FH on three occasions in 2005. Adults from the first sort transported on May 4 included fish from BY01 and BY02. Two hundred fourteen maturing adults were transferred at that time including 64 from the WFYF and 150 from the EFSR (Appendix A). Adults that were determined to be maturing during a second sort were transferred on June 8 and contained three WFYF individuals (BY02) and eight EFSR individuals (BY02). The final

transfer of maturing Chinook occurred on July 21 and included 70 BY03 EFSR and 55 BY03 WFYF precocial males.

On August 4 and 5, Petersen Disk tags were attached to BY01 and BY02 EFSR groups, and jaw tags were attached to the lower left mandible of BY03 EFSR and all WFYF Chinook salmon (BY02, BY03) groups destined for release to their natal streams. Petersen Disk and jaw tags used for the WFYF and EFSR groups were applied using standard tagging procedures. These tags facilitated the identification of postspawn adults in the WFYF system and aided in the pre- and postspawn monitoring of captive fish in the EFSR study section. During this same handling event, radio transmitters were inserted into the stomachs of seven (four males and three females) and seven (three males and four females) maturing captive-reared Chinook salmon to be released into the WFYF and EFSR, respectively (Appendix B). A total of 117 WFYF Chinook were marked during this event including 13 BY01, 50 BY02, and 54 BY03 adults (Table 5). East Fork Salmon River stock totaled 219 marked adults including 29 BY01, 120 BY02, and 70 BY03 adults (Table 5). Post-tagging mortality occurred in four fish between marking and release, which included one fish from the WFYF stock and three fish from the EFSR stock.

Table 5. Mean weight and length of captive-reared Chinook salmon marked for release in 2005. All fish were released into their natal waters (West Fork Yankee Fork River = WFYF; East Fork Salmon River = EFSR).

Stock	Brood Year	# released	Mean weight (g)	Mean length (mm)
EFSR	01	29	915	414.9
EFSR	02	120	767.2	375.3
EFSR	03	70	181.5	223.4
WFYF	01	13	861.9	403.8
WFYF	02	49	1063.7	403.5
WFYF	03	54	165.3	219.6

Chilled Water Experiment

Based on results from previous years (2001–2004), water temperature manipulations were continued during this reporting period in an attempt to address the asynchronous spawn timing of captive-reared and natural Chinook salmon (Hassemer et al. 1999, 2001; Venditti et al. 2002, 2003a, 2003b, 2005). Unlike previous years, all returning adults in 2005 were placed on the same chilled water temperature regimen that allocated all available chilled water evenly to all holding tanks; daily average from May 4 through August 3, 2005 was 11.4°C (10.2°C–13.0°C). Two additional 3-meter tanks were plumbed to receive chilled water in 2005. Prior to release, all adults were marked in a way that allowed observers to identify (post mortem) specific individuals and stock.

Monitoring Programs

Hatchery Spawning and Gamete Evaluation

No captive-reared Chinook salmon were held for hatchery spawning or gamete evaluations in 2005.

Fish Health Monitoring

Vaccines for both BKD and *Vibrio* spp. were administered on March 16, 2005.

In 2005, nine laboratory accessions (representing nine 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

Monitoring for *Renibacterium salmoninarum*, the causative agent of BKD in salmonids, has been routinely conducted in captive-reared Chinook salmon since the inception of the program in 1995. In 2005, fish sampled for *R. salmoninarum* included seven prespawn adults (three BY01 EFSR, one BY02 EFSR, three BY02 WFYF) and two pretransfer juveniles (BY04 EFSR). Results were negative for detection of *R. salmoninarum* in all samples using enzyme-linked immunosorbent assay (ELISA) and direct fluorescent antibody testing (DFAT) techniques.

Viral Pathogens

In 2005, the Eagle Fish Health Lab processed nine laboratory accessions (nine 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 Chinook cultured in freshwater at Eagle FH.

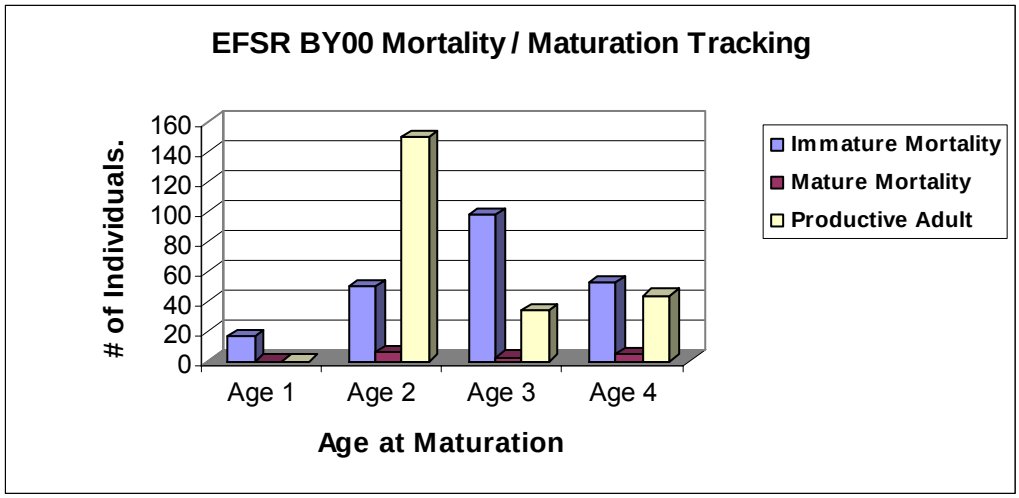
Parasitic Pathogens

Principal parasitic fish health concerns include the presence of *Myxobolus cerebralis*—the causative agent of salmonid whirling disease, and the gill parasite *Salmincola californiensis*. All WFYF and EFSR Chinook salmon examined for *M. cerebralis* and *S. californiensis* in 2005 tested negative for the presence of these parasites. The absence of these pathogens in recent years reflects 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 2000

Brood year 2000 captive-reared Chinook salmon were all reared at the Manchester facility; this is different from past years when brood year cohorts were split between freshwater rearing at Eagle FH and seawater rearing at the Manchester facility.

General sources of mortality in this cohort were similar to those observed previously (Hassemer et al. 2001; Venditti et al. 2002, 2003a, 2003b, 2005), although losses to BKD were lower than for some previous brood years (Venditti et al. 2003b). Primary sources of mortality in this brood year were summarized for both immature and mature losses. Immature mortality was largely attributed to undetermined hatchery causes (59.3%), undetermined diseases (14.9%), and culls (6.2%), whereas mature mortality was largely attributed to natural spawning (26.3%), precocial spawning (26.3%), and precocial culls (16.8%). Mortality occurred in 45 percent of the EFSR stock at age-2 followed by age-3 (29%), age-4 (22%), and age-1 (4%; Figure 4). Mortality occurred in 50 percent of the WFYF stock at age-2 followed by age-4 (38%), age-3 (9%), and age-1 (3%; Figure 4).



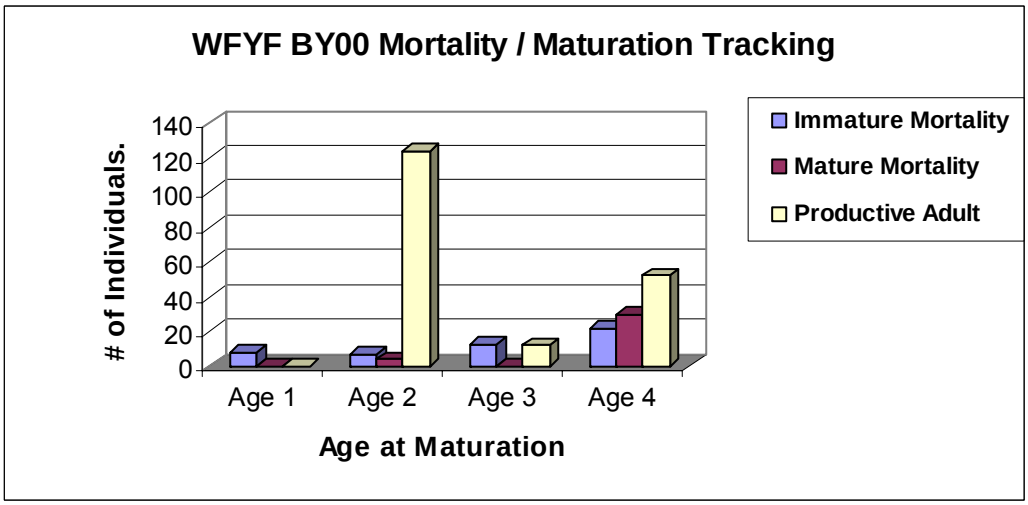


Figure 4. Mortality by age and age at maturation for East Fork Salmon River and West Fork Yankee Fork captive-reared brood year 2000 stocks. Immature Mortality = fish that died prior to reaching sexual maturity; Mature Mortality = fish that reached sexual maturity but did not spawn; Productive Adults = fish that reached sexual maturity and spawned.

Brood year 2000 captive-reared Chinook salmon from the WFYF and EFSR matured at a similar overall rate to previous cohorts. There was a unique collection of 250 eggs from a natural redd in the Yankee Fork Salmon River (YFSR) in BY00. Yankee Fork Salmon River fish were released as smolts in 2001 and had an eye-to-smolt survival of 87.6%. In the WFYF stock, 232 (76.3%) of the 304 original egg collection brought into the program matured, and of these, 131 males (56.5%) matured at age-2; 8 females (3.4%) and 4 males (1.75%) matured at age-3; 57 females (24.6%), 3 males (1.3%), and 2 fish of unknown sex at release (1.0%) matured at age-4; and no fish from this brood year matured at age-5. In the EFSR stock, 242 (48.1%) of the 503 original egg collection brought into the program matured, and of these, 156 males (64.0%) matured at age-2, 37 males (15.9%) and no females matured at age-3, 49 females (20.2%) and no males matured at age-4, and no fish from this brood year matured at age-5. Precocity rates (age-2 and age-3 maturation), averaged 47.0% in the WFYF stock and 38.4% in the EFSR stock for BY00, compared to brood years 97-99 rates of 27.7 and 25.9%, respectively (Hassemer et al. 2001; Venditti et al. 2002, 2003a, 2003b, 2005). Maturation in BY00 (58.7%) was less than the average of the previous three brood years (60.9%). Length and weight at maturity in BY00 was within the range of previous brood years except that fish that matured at age-3 were significantly longer (ANOVA, P-value >.001; α=0.05) than those of previous brood years and were heavy compared to previous brood years (Figures 5 and 6). Greater precocity in BY00 may be a result of the larger weight and length at maturity for BY00 relative to brood years 97-99.

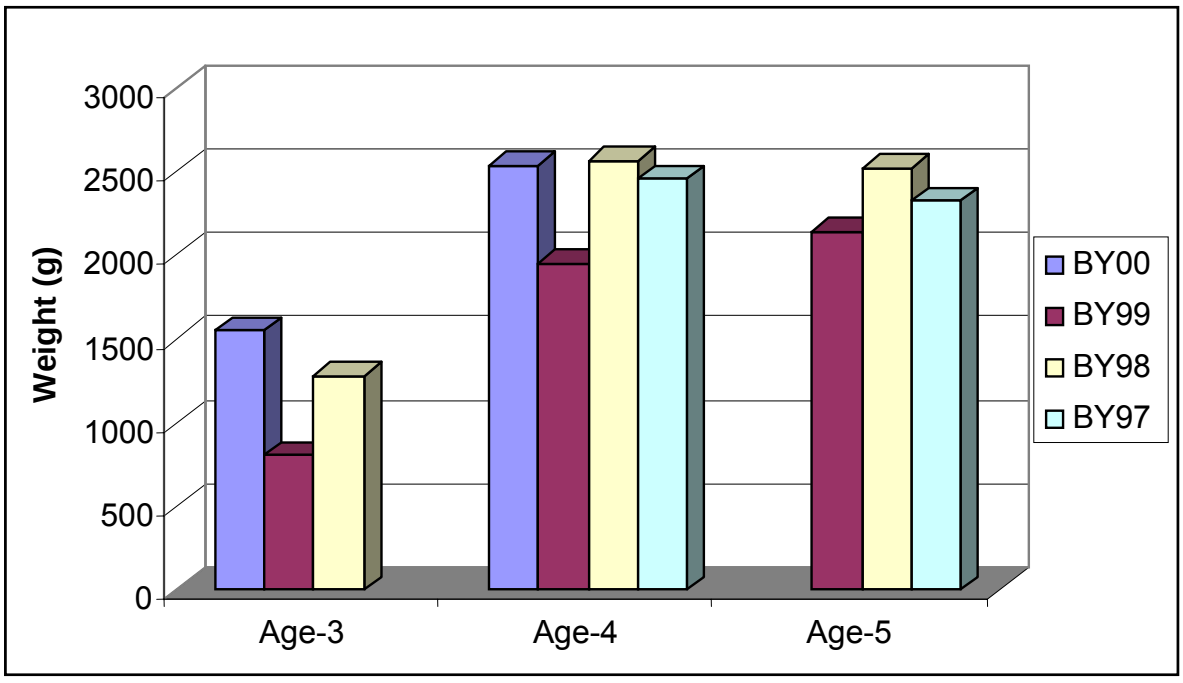


Figure 5. Weight at maturity by age for captive-reared Chinook salmon from BY97-BY00. No data is available for BY97 age-3 fish and BY00 age-5 fish.

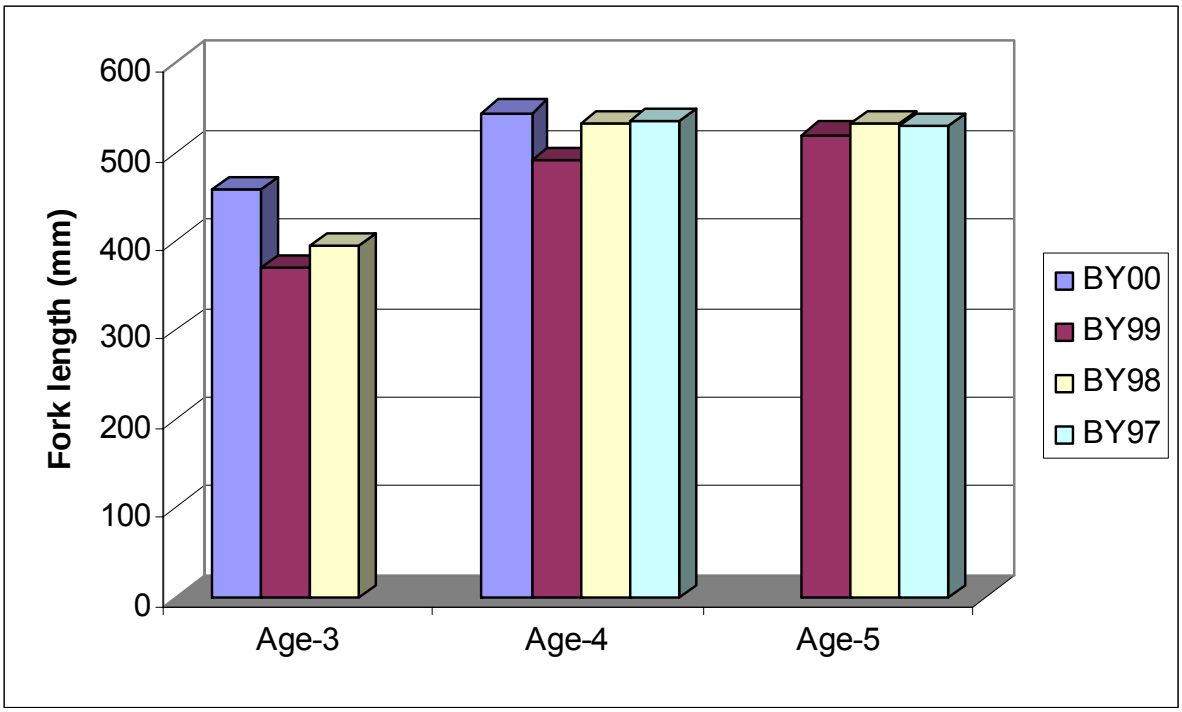


Figure 6. Length at maturity by age for captive-reared Chinook salmon from BY97-BY00. No data is available for BY97 age-3 fish or BY00 age-5 fish.

Volitional Spawning

In 2005, maturing adults were released into their natal streams for natural spawning and spawning observation studies on August 8 and 9 in the EFSR and WFYF, respectively (Appendix B, Table 6). 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 from the WFYF stock were released in the WFYF system approximately 4 rkm upstream of the confluence with the YFSR and had access to the entire length of the river. Adults released in the EFSR were released 2 rkm upstream of a temporary picket weir that was installed approximately 14 rkm upstream of the Sawtooth Fish Hatchery satellite weir on the main EFSR (Figure 1) and were confined to the area above the picket weir.

Table 6. Summary of captive-reared Chinook salmon releases in the East Fork Salmon River (EFSR) and West Fork Yankee Fork (WFYF) for spawning evaluation studies in 2005.

Date	Stream	BY01	BY02	BY03	Total
August 8	**EFSR**	**28**	**119**	**69**	**216**
August 9	**WFYF**	**13**	**49**	**54**	**116**

Behavior and habitat associations of captive-reared Chinook salmon observed in the study streams were similar to observations recorded in previous years directly following release; however, spawning behavior and habitat associations were only quantified for fish on the EFSR in 2005. Initially, study fish were observed to be generally associated with pools, large woody debris, or runs (Figure 7). Holding was the dominant behavior observed during August and September accounting for approximately 43% of all observations, whereas moving was the second most dominant behavior with 21%, followed by milling with 16% (Figure 8). These behaviors were also the dominant associations observed from August to September in study years 2001—2003 (Venditti et al. 2003a, 2003b, 2005). Such behavior and habitat associations are in accord with prespawn Atlantic salmon (Bardonnet and Baglinière 2000) and coho salmon (Berejikian et al. 1997); this behavioral adaptation of selecting habitats with low water velocity and complex structures may benefit them by helping to conserve depleted energy reserves for future spawning activities (Torgersen et al. 1999) or by providing refuge from predators. Behavior of captive-reared Chinook salmon differed from that of natural origin Chinook salmon observed in the same areas from 2001—2005. General behaviors of natural origin Chinook salmon were dominated by milling (20%), courting (19%), and redd holding (18%), whereas behaviors of captive-reared Chinook salmon were dominated by holding (43%), moving (21%), and milling (16%).

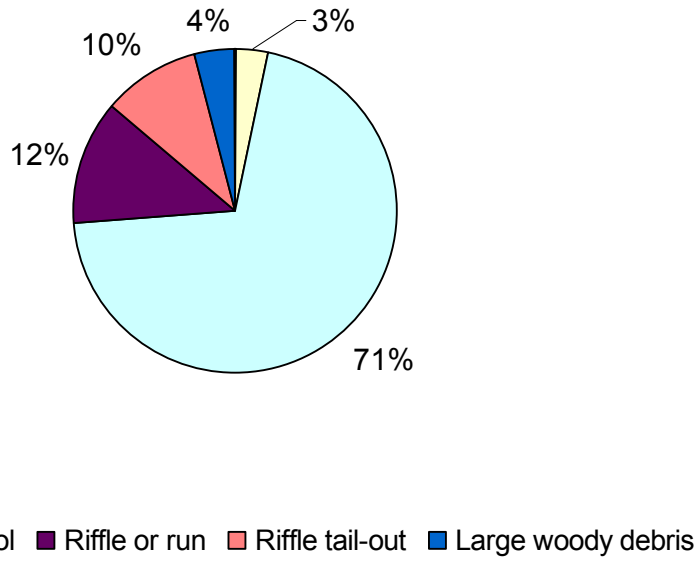


Figure 7. Habitat associations of captive-reared Chinook salmon released into the East Fork Salmon River in the summer of 2005. Data were collected during standardized observation intervals of 5 min.

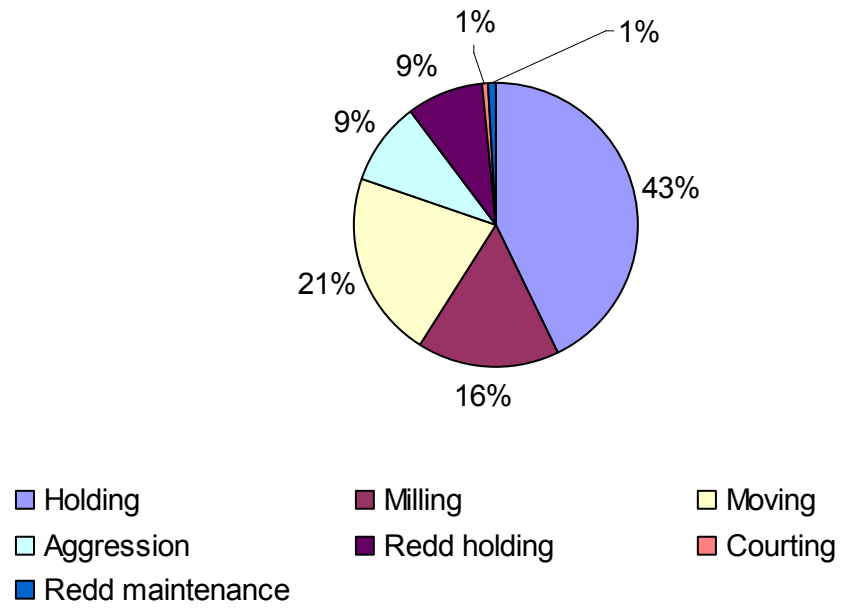


Figure 8. General behaviors of captive-reared Chinook salmon released into the East Fork of the Salmon River in the summer of 2005. Data were collected during standardized observation intervals of 5 min.

Radio tags were implanted in seven of the 116 adults (three females, four males) released into the WFYF for natural spawning. Radio-tagged fish were tracked one to two times weekly from August 9 through September 19, 2005. One day after release, one fish was found dead and two others migrated downstream out of the WFYF and did not return. The remaining four fish did not travel more than 4 rkm downstream or 2 rkm upstream from their release site. Radio-tagged fish from the WFYF were not observed in spawning events during 2005 field observations.

Between August 28 and September 8, 2005, two redds constructed by captive-reared adults were identified within the WFYF study area. Captive-reared Chinook salmon redds per released female (1:0.18) in 2005 was less than in previous years (1:0.37; 2001, 2002, 2004; Venditti et al. 2005). Between August 14 and September 2, 2005, five redds constructed by natural adult Chinook salmon were identified in the WFYF compared to the previous four-year average of 13.

Radio tags were implanted in seven of the 216 adults (four females, three males) released into the EFSR for natural spawning. Fish were released approximately 2 rkm upstream of the temporary picket (blocking) weir on August 8. Radio-tagged fish in the EFSR were tracked one to three times weekly from August 8 through September 30, 2005. Radio-tagged fish failed to travel more than 2 rkm downstream or 1.5 rkm upstream from their release site. No direct spawning events were observed in EFSR radio-tagged fish during the 2005 field season.

Between September 1 and September 16, 2005, eight redds constructed by captive-reared adults were identified within the EFSR study area; no natural Chinook salmon redds

were observed. Captive-reared Chinook salmon redds per released fish (1:0.27) was greater than the previous three-year average (1:0.10). Annual natural Chinook salmon redd counts conducted by the IDFG in EFSR trend sites identified 66 redds in 2005, compared to the previous four-year average of 167.

Water temperatures during August and September in both the EFSR and the WFYF did not substantially deviate from the previous four years (Figure 9). Only the minimum water temperature in the EFSR differed from the previous three-year average for both the EFSR and the WFYF.

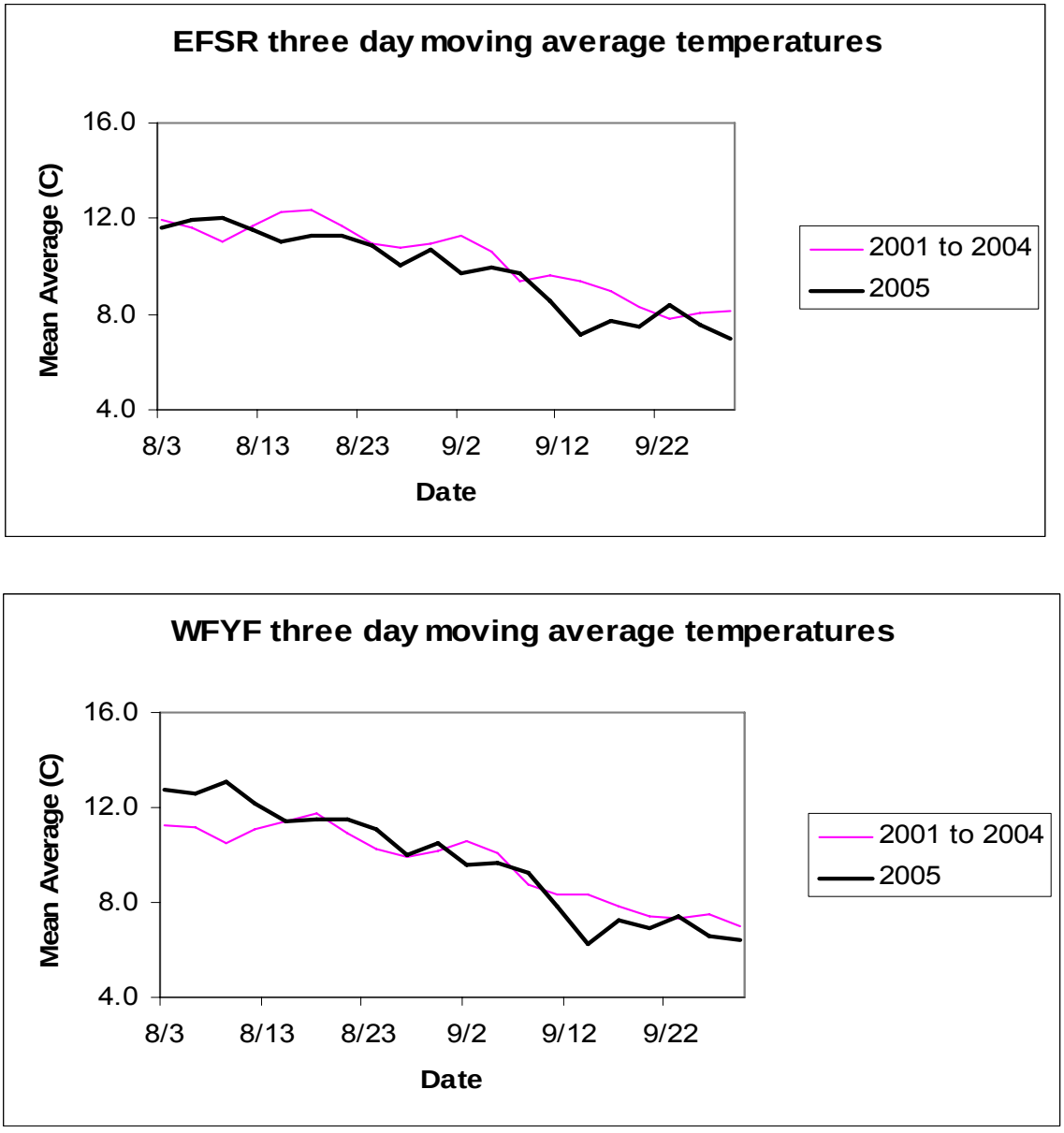


Figure 9. Average 2005 three-day moving average temperatures for the West Fork Yankee Fork (WFYF) and the East Fork Salmon River (EFSR) compared to the 2001-2004 average.

Production Estimation

Chinook salmon parr were collected in both the EFSR and the WFYF in 2005 to obtain fin clips for genetic analysis to determine if they were the product of program releases made in calendar year 2004. One hundred Chinook salmon parr were collected from the EFSR during August and September and 91 from the WFYF from July to November in 2005. Genetic samples were collected from all captured parr, and no mortalities occurred during sampling. Samples collected in 2005 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

In 2005, the Sawtooth Fish Hatchery satellite weir on the EFSR was operated to collect genetic samples from returning natural Chinook salmon, as well as to monitor the movement of Chinook salmon and other resident species. The facility is located approximately 29 rkm upstream from the confluence with the main Salmon River, near Big Boulder Creek. During operation of the site from June 7 through September 5, 2005, sixty-three adult Chinook salmon (21 females, 31 males, 11 jacks) were trapped at the facility (Table 7). None of the 63 Chinook salmon trapped in 2005 were adipose fin-clipped or coded-wire tagged, indicating Chinook salmon of wild/natural origin. Additional species trapped included bull trout *Salvelinus confluentus*, westslope cutthroat trout *O. clarkii lewisi*, rainbow trout *O. mykiss*, mountain whitefish *Prosopium williamsoni*, and *Catostomus* spp. (Table 8).

In an effort to assess whether the Sawtooth Fish Hatchery satellite weir was altering the movements of migrating adult Chinook salmon, the area downstream was periodically monitored by snorkeling July 14 to August 16, 2005. 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. Over the entire monitoring period, only four Chinook salmon adults were observed holding in the pool immediately below the weir. These observations were made on August 16, and the next day all four fish were trapped upstream at the weir. 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, mountain whitefish, and various *Catostomus* spp.

Table 7. Natural origin adult Chinook salmon distributions trapped at the East Fork Salmon River weir facility during 2005.

	Gender			
	Females	**Males**	**Jacks**	**Total**
June	1	0	0	1
July	12	9	5	26
August	8	22	6	36
Total	**21**	**31**	**11**	**63**
	Age			
Age (length)	**3 (≤65 cm)**	**4 (65-82 cm)**	**5 (>82 cm)**	**Total**
Females	0	8	13	21
Males	n/a	26	5	31
Jacks	11	n/a	n/a	11
Total	**11**	**34**	**18**	**63**
	Recapture rates			
Age (length)	**3 (≤65 cm)**	**4 (65-82 cm)**	**5 (>82 cm)**	**Total**
Females	0	0	0	0
Males	n/a	2	0	2
Jacks	3	n/a	n/a	3
Total	**3**	**2**	**0**	**5**

Table 8. Summary of additional fish trapped at the East Fork Salmon River (EFSR) weir during 2005.

Species	**Trapped**	**Recaptured**	**Unknown Recap**[a]	**Genetics taken**
Bull trout	205	30	2	198
Westslope cutthroat trout	5	0	0	4
Rainbow trout	1	0	0	0
Mountain whitefish	194	6	12[b]	60

[a] Some fish found with highly eroded upper caudal fin lobes or data not recorded.
[b] Not all mountain whitefish were marked allowing detection of recaptures.

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APPENDICES

Appendix A. Summary of fish transfers conducted by the Chinook Salmon Captive Rearing Project during 2005. MAN–Manchester Research Station, WFYF-West Fork Yankee Fork River, EFSR-East Fork Salmon River, 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-NE	01			13	5/4, 6/8	13	8/9		
WFYF-NE	02			54	5/4, 6/8	49	8/9		
WFYF-NE	03	296	5/3	55	7/21	54	8/9		
EFSR-NE	01			33	5/4, 6/8			28	8/8
EFSR-NE	02			125	5/4, 6/8			119	8/8
EFSR-NE	03	302	5/3	70	7/21			69	8/8

Appendix B. 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). All WFYF adults and the BY03 EFSR precocials received jaw tags for visual identification, while EFSR adults received Peterson disc tags. 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 before release.

PIT Code	BY	Sex	Radio #	Number	Stock	Rearing
3D9.1BF1BDD9F4	2002	M		154	WFYF	MAN
3D9.1BF11BBCA9	2001	F		155	WFYF	MAN
3D9.1BF11BB83C	2001	U		156	WFYF	MAN
3D9.1BF1BDD950	2002	M		157	WFYF	MAN
3D9.1BF1BB4E57	2002	M		158	WFYF	MAN
3D9.1BF1BD8CBD	2002	M		159	WFYF	MAN
3D9.1BF1BC141A	2002	M	150.175	160	WFYF	MAN
3D9.1BF123C3EF	2001	F		161	WFYF	MAN
3D9.1BF1BC03A2	2002	M		162	WFYF	MAN
3D9.1BF1BDDAE6	2002	M		163	WFYF	MAN
3D9.1BF1BD9B52	2002	M		164	WFYF	MAN
3D9.1BF1BDD2CB	2002	F		165	WFYF	MAN
3D9.1BF11F0007	2001	F		168	WFYF	MAN
3D9.1BF1BBB2B0	2002	M		169	WFYF	MAN
3D9.1BF1BBFA9F	2002	M		170	WFYF	MAN
3D9.1BF1BDD4C0	2002	M		171	WFYF	MAN
3D9.1BF1BB921B	2002	M		172	WFYF	MAN
3D9.1BF1BBB795	2002	M	150.075	173	WFYF	MAN
3D9.1BF1BCF4FF	2002	M		174	WFYF	MAN
3D9.1BF1BEE616	2002	M		175	WFYF	MAN
3D9.1BF1BD7631	2002	M		176	WFYF	MAN
3D9.1BF11A2D9B	2001	F		177	WFYF	MAN
3D9.1BF11BC4E7	2001	F	151.184	178	WFYF	MAN
3D9.1BF1BC138E	2002	M	150.158	179	WFYF	MAN
3D9.1BF1BC7F53	2002	M		180	WFYF	MAN
3D9.1BF1BD9C6B	2002	M		181	WFYF	MAN
3D9.1BF1BB9803	2002	M		182	WFYF	MAN
3D9.1BF1BDD73E	2002	M		183	WFYF	MAN
3D9.1BF1BDA1BC	2002	M		184	WFYF	MAN
3D9.1BF123C455	2001	U		185	WFYF	MAN
3D9.1BF1BC1C15	2002	M		186	WFYF	MAN
3D9.1BF1BCECCB	2002	M		187	WFYF	MAN
3D9.1BF1BEF197	2002	M		188	WFYF	MAN
3D9.1BF123BB06	2001	F	151.064	189	WFYF	MAN
3D9.1BF1BBFB73	2002	M		190	WFYF	MAN
3D9.1BF11EFE27	2001	F		191	WFYF	MAN
3D9.1BF1BD8421	2002	M		192	WFYF	MAN
3D9.1BF1BC04A8	2002	M		193	WFYF	MAN
3D9.1BF11BC120	2001	U		194	WFYF	MAN
3D9.1BF1BBB2CC	2002	M		195	WFYF	MAN
3D9.1BF1BBAC07	2002	M		196	WFYF	MAN
3D9.1BF123BFEB	2001	F	151.103	197	WFYF	MAN
3D9.1BF12566F3	2001	F		198	WFYF	MAN
3D9.1BF1BC0179	2002	M		199	WFYF	MAN
3D9.1BF1BBAAD1	2002	M		370	WFYF	MAN

Appendix B. Continued.

PIT Code	BY	Sex	Radio #	Number	Stock	Rearing
3D9.1BF1BC1FD5	2002	M		371	WFYF	MAN
3D9.1BF1BC8737	2002	M		372	WFYF	MAN
3D9.1BF1BD6823	2002	M		373	WFYF	MAN
3D9.1BF1BEDF27	2002	M		374	WFYF	MAN
3D9.1BF1BDD453	2002	M		375	WFYF	MAN
3D9.1BF1BD8C7F	2002	M		376	WFYF	MAN
3D9.1BF1BDF03B	2002	M	150.135	377	WFYF	MAN
3D9.1BF1BBA238	2002	M		378	WFYF	MAN
3D9.1BF1BCAFF4	2002	M		379	WFYF	MAN
3D9.1BF1BCEC45	2002	M		380	WFYF	MAN
3D9.1BF1BC1F9C	2002	M		381	WFYF	MAN
3D9.1BF1BEEE9B	2002	M		382	WFYF	MAN
3D9.1BF1BBFF11	2002	M		383	WFYF	MAN
3D9.1BF1BEEE3D	2002	M		384	WFYF	MAN
3D9.1BF11BC13A	2001	F		385	WFYF	MAN
3D9.1BF1BBBDF9	2002	M		386	WFYF	MAN
3D9.1BF1BD9E8E	2002	M		387	WFYF	MAN
3D9.1BF1A78024	2003	M		388	WFYF	MAN
3D9.1BF1F88D42	2003	M		389	WFYF	MAN
3D9.1BF1F83D13	2003	M		390	WFYF	MAN
3D9.1BF1F8915C	2003	M		391	WFYF	MAN
3D9.1BF1F7CAA5	2003	M		392	WFYF	MAN
3D9.1BF1F7777C	2003	M		393	WFYF	MAN
3D9.1BF1A736BA	2003	M		394	WFYF	MAN
3D9.1BF1F7C718	2003	M		395	WFYF	MAN
3D9.1BF1F8542D	2003	M		396	WFYF	MAN
3D9.1BF1F7F80F	2003	M		397	WFYF	MAN
3D9.1BF1A7629F	2003	M		398	WFYF	MAN
3D9.1BF11B43C0	2003	M		399	WFYF	MAN
3D9.1BF1A75251	2003	M		475	WFYF	MAN
3D9.1BF1F80996	2003	M		476	WFYF	MAN
3D9.1BF1F88989	2003	M		477	WFYF	MAN
3D9.1BF1A22162	2003	M		478	WFYF	MAN
3D9.1BF11B7658	2003	M		479	WFYF	MAN
3D9.1BF1F71457	2003	M		480	WFYF	MAN
3D9.1BF11B426A	2003	M		481	WFYF	MAN
3D9.1BF1F7DBF1	2003	M		482	WFYF	MAN
3D9.1BF11B419A	2003	M		483	WFYF	MAN
3D9.1BF11B47EE	2003	M		484	WFYF	MAN
3D9.1BF11B4902	2003	M		485	WFYF	MAN
3D9.1BF1F7BB29	2003	M		486	WFYF	MAN
3D9.1BF1F7DE88	2003	M		487	WFYF	MAN
3D9.1BF11B5503	2003	M		488	WFYF	MAN
3D9.1BF11B44D3	2003	M		489	WFYF	MAN
3D9.1BF11B43D5	2003	M		490	WFYF	MAN
3D9.1BF1A1D693	2003	M		491	WFYF	MAN
3D9.1BF1F85B04	2003	M		492	WFYF	MAN
3D9.1BF1F78F02	2003	M		493	WFYF	MAN
3D9.1BF1A773C9	2003	M		494	WFYF	MAN
3D9.1BF11B4F8F	2003	M		495	WFYF	MAN
3D9.1BF1F7F07A	2003	M		496	WFYF	MAN
3D9.1BF1F80269	2003	M		497	WFYF	MAN
3D9.1BF1F85E0F	2003	M		498	WFYF	MAN
3D9.1BF1F7152B	2003	M		499	WFYF	MAN

Appendix B. Continued.

PIT Code	BY	Sex	Radio #	Number	Stock	Rearing
3D9.1BF1A1D787	2003	M		500	WFYF	MAN
3D9.1BF1A7265A	2003	M		299	WFYF	MAN
3D9.1BF1F7CB8A	2003	M		298	WFYF	MAN
3D9.1BF1A1E9F4	2003	M		297	WFYF	MAN
3D9.1BF1F7BFC4	2003	M		296	WFYF	MAN
3D9.1BF1F7F0DF	2003	M		295	WFYF	MAN
3D9.1BF11B74CB	2003	M		294	WFYF	MAN
3D9.1BF1F85EB8	2003	M		293	WFYF	MAN
3D9.1BF1F7D2D5	2003	M		292	WFYF	MAN
3D9.1BF11B44D9	2003	M		291	WFYF	MAN
3D9.1BF1A7604A	2003	M		290	WFYF	MAN
3D9.1BF1F7E676	2003	M		289	WFYF	MAN
3D9.1BF1F85857	2003	M		288	WFYF	MAN
3D9.1BF1A76675	2003	M		287	WFYF	MAN
3D9.1BF1F8E1D3	2003	M		286	WFYF	MAN
3D9.1BF1F74B7F	2003	M		285	WFYF	MAN
3D9.1BF1A254DB	2003	M		284	WFYF	MAN
3D9.1BF1F71E3A	2003	M		300	EFSR	MAN
3D9.1BF1F85598	2003	M		301	EFSR	MAN
3D9.1BF1F88FBB	2003	M		302	EFSR	MAN
3D9.1BF1F884BD	2003	M		303	EFSR	MAN
3D9.1BF1F8901C	2003	M		304	EFSR	MAN
3D9.1BF1F7C264	2003	M		305	EFSR	MAN
3D9.1BF1F86C61	2003	M		306	EFSR	MAN
3D9.1BF1A7A6C2	2003	M		308	EFSR	MAN
3D9.1BF1F7CA17	2003	M		309	EFSR	MAN
3D9.1BF1A7649E	2003	M		310	EFSR	MAN
3D9.1BF1F81BC2	2003	M		311	EFSR	MAN
3D9.1BF1F87AAE	2003	M		312	EFSR	MAN
3D9.1BF1F7F1D8	2003	M		313	EFSR	MAN
3D9.1BF1A75B2D	2003	M		314	EFSR	MAN
3D9.1BF1F7E40E	2003	M		315	EFSR	MAN
3D9.1BF1F7F1A1	2003	M		316	EFSR	MAN
3D9.1BF1F7C533	2003	M		317	EFSR	MAN
3D9.1BF1F77D8D	2003	M		318	EFSR	MAN
3D9.1BF1F7BEBE	2003	M		319	EFSR	MAN
3D9.1BF1A7A0CE	2003	M		320	EFSR	MAN
3D9.1BF1A1E1C1	2003	M		321	EFSR	MAN
3D9.1BF1F77269	2003	M		322	EFSR	MAN
3D9.1BF1F7CA9F	2003	M		323	EFSR	MAN
3D9.1BF1F72794	2003	M		324	EFSR	MAN
3D9.1BF1A729F8	2003	M		325	EFSR	MAN
3D9.1BF1F7E263	2003	M		326	EFSR	MAN
3D9.1BF1A23DAE	2003	M		327	EFSR	MAN
3D9.1BF1F892AD	2003	M		328	EFSR	MAN
3D9.1BF1F7FEFF	2003	M		329	EFSR	MAN
3D9.1BF1F7EAD2	2003	M		330	EFSR	MAN
3D9.1BF1A77DFD	2003	M		331	EFSR	MAN
3D9.1BF1F7CE6A	2003	M		332	EFSR	MAN
3D9.1BF1F85E27	2003	M		333	EFSR	MAN
3D9.1BF1F7EFAC	2003	M		334	EFSR	MAN
3D9.1BF1A762B1	2003	M		335	EFSR	MAN
3D9.1BF1F7EC56	2003	M		336	EFSR	MAN
3D9.1BF1F82272	2003	M		337	EFSR	MAN

Appendix B. Continued.

PIT Code	BY	Sex	Radio #	Number	Stock	Rearing
3D9.1BF1A1CD3B	2003	M		338	EFSR	MAN
3D9.1BF1F7CBF9	2003	M		339	EFSR	MAN
3D9.1BF1F86D78	2003	M		340	EFSR	MAN
3D9.1BF1F87DBC	2003	M		341	EFSR	MAN
3D9.1BF1A1D46D	2003	M		342	EFSR	MAN
3D9.1BF1F807CA	2003	M		343	EFSR	MAN
3D9.1BF1F7CC5B	2003	M		344	EFSR	MAN
3D9.1BF1F7FF10	2003	M		345	EFSR	MAN
3D9.1BF1F7E975	2003	M		346	EFSR	MAN
3D9.1BF1F7E711	2003	M		347	EFSR	MAN
3D9.1BF1A729F2	2003	M		348	EFSR	MAN
3D9.1BF1F8119C	2003	M		349	EFSR	MAN
3D9.1BF1A25264	2003	M		350	EFSR	MAN
3D9.1BF1F83592	2003	M		351	EFSR	MAN
3D9.1BF1F86A53	2003	M		352	EFSR	MAN
3D9.1BF1F7A7A3	2003	M		353	EFSR	MAN
3D9.1BF1A1ED7A	2003	M		354	EFSR	MAN
3D9.1BF1F7B6EC	2003	M		355	EFSR	MAN
3D9.1BF1F7E447	2003	M		356	EFSR	MAN
3D9.1BF1F7DBCD	2003	M		357	EFSR	MAN
3D9.1BF1F7F121	2003	M		358	EFSR	MAN
3D9.1BF1F72C31	2003	M		359	EFSR	MAN
3D9.1BF1A2350F	2003	M		360	EFSR	MAN
3D9.1BF1F7E6A5	2003	M		361	EFSR	MAN
3D9.1BF1F7E8DD	2003	M		362	EFSR	MAN
3D9.1BF1F81BC7	2003	M		363	EFSR	MAN
3D9.1BF1F753BA	2003	M		364	EFSR	MAN
3D9.1BF1F7CDEC	2003	M		365	EFSR	MAN
3D9.1BF1F80E25	2003	M		366	EFSR	MAN
3D9.1BF1A2251C	2003	M		367	EFSR	MAN
3D9.1BF1A73BA6	2003	M		368	EFSR	MAN
3D9.1BF1A786BB	2003	M		369	EFSR	MAN
3D9.1BF1BC0175	2002	M		0/W 53	EFSR	MAN
3D9.1BF1BD8C30	2002	M		G/W 11	EFSR	MAN
3D9.1BF1BB4E58	2002	M		G/W 12	EFSR	MAN
3D9.1BF1BB9C4A	2002	M		G/W 13	EFSR	MAN
3D9.1BF1BD9EA3	2002	M		G/W 14	EFSR	MAN
3D9.1BF1BCEF78	2002	M		G/W 15	EFSR	MAN
3D9.1BF1BBBFA7	2002	M		G/W 16	EFSR	MAN
3D9.1BF1BBCF8C	2002	M		G/W 17	EFSR	MAN
3D9.1BF1BD6F4D	2002	M		G/W 19	EFSR	MAN
3D9.1BF1BD8962	2002	M	150.194	G/W 20	EFSR	MAN
3D9.1BF1BD6FAB	2002	M		G/W 21	EFSR	MAN
3D9.1BF1BC81F2	2002	M		G/W 22	EFSR	MAN
3D9.1BF1BEE211	2002	M		G/W 23	EFSR	MAN
3D9.1BF1BBC694	2002	M		G/W 24	EFSR	MAN
3D9.1BF1BB9755	2002	M		G/W 25	EFSR	MAN
3D9.1BF1BBAC6E	2002	M		G/W 26	EFSR	MAN
3D9.1BF1BEE45E	2002	M		G/W 27	EFSR	MAN
3D9.1BF1BCBA83	2002	M		G/W 30	EFSR	MAN
3D9.1BF1BCED0E	2002	M		G/W 50	EFSR	MAN
3D9.1BF1BEF69D	2002	U		G/W 51	EFSR	MAN
3D9.1BF1BCEC62	2002	U		G/W 52	EFSR	MAN
3D9.1BF1BCBE99	2002	M		G/W 54	EFSR	MAN

Appendix B. Continued.

PIT Code	BY	Sex	Radio #	Number	Stock	Rearing
3D9.1BF1BCF7E9	2002	M		G/W 55	EFSR	MAN
3D9.1BF1BDD2BF	2002	M		G/W 56	EFSR	MAN
3D9.1BF1BDDFA2	2002	M		G/W 58	EFSR	MAN
3D9.1BF1BBD4F4	2002	M		G/W 61	EFSR	MAN
3D9.1BF1BEE8AE	2002	M		G/W 62	EFSR	MAN
3D9.1BF1BD8C9D	2002	M		G/W 63	EFSR	MAN
3D9.1BF1BDE071	2002	U		G/W 67	EFSR	MAN
3D9.1BF1BB93D2	2002	M		G/W 69	EFSR	MAN
3D9.1BF1BB1FF8	2002	M		G/W 70	EFSR	MAN
3D9.1BF1BC1C11	2002	M		G/W 73	EFSR	MAN
3D9.1BF1BD803D	2002	M		G/W 75	EFSR	MAN
3D9.1BF1BBE1EC	2002	M		G/W 76	EFSR	MAN
3D9.1BF1BC00A0	2002	M		G/W 77	EFSR	MAN
3D9.1BF1BBCA90	2002	U		G/W 79	EFSR	MAN
3D9.1BF1BCFB84	2002	M		G/W 80	EFSR	MAN
3D9.1BF1BC1B6D	2002	U		G/W 81	EFSR	MAN
3D9.1BF1BC0E3F	2002	M		G/W 82	EFSR	MAN
3D9.1BF1BD6F4E	2002	M		G/W 83	EFSR	MAN
3D9.1BF1BD8C8A	2002	U		G/W 85	EFSR	MAN
3D9.1BF1BBD978	2002	M		G/W 86	EFSR	MAN
3D9.1BF1BD8344	2002	M		G/W 90	EFSR	MAN
3D9.1BF1BEEEA2	2002	M		G/W 91	EFSR	MAN
3D9.1BF1BD901D	2002	M		G/W 92	EFSR	MAN
3D9.1BF1BDE226	2002	M		G/W 93	EFSR	MAN
3D9.1BF1BDD4BF	2002	M		G/W 97	EFSR	MAN
3D9.1BF1BDD2AC	2002	M		G/W 99	EFSR	MAN
3D9.1BF1BBAAB8	2002	M		O/W 00	EFSR	MAN
3D9.1BF1BC193C	2002	M		O/W 01	EFSR	MAN
3D9.1BF1BBF69E	2002	M		O/W 02	EFSR	MAN
3D9.1BF1BD6C25	2002	U		O/W 03	EFSR	MAN
3D9.1BF1BBF6AC	2002	M		O/W 05	EFSR	MAN
3D9.1BF1BEE93B	2002	M		O/W 06	EFSR	MAN
3D9.1BF1BB969A	2002	M		O/W 07	EFSR	MAN
3D9.1BF1BD7D44	2002	M		O/W 09	EFSR	MAN
3D9.1BF1BDE792	2002	M		O/W 11	EFSR	MAN
3D9.1BF1BC18C5	2002	M		O/W 13	EFSR	MAN
3D9.1BF1BC0D57	2002	M		O/W 14	EFSR	MAN
NO READ	2002	M		O/W 15	EFSR	MAN
3D9.1BF1BE00CE	2002	M		O/W 16	EFSR	MAN
3D9.1BF1BCD685	2002	M		O/W 19	EFSR	MAN
3D9.1BF1BEE674	2002	U		O/W 20	EFSR	MAN
3D9.1BF1BEEF0F	2002	M		O/W 21	EFSR	MAN
3D9.1BF1BCB499	2002	M		O/W 22	EFSR	MAN
3D9.1BF1BCBC02	2002	M		O/W 23	EFSR	MAN
3D9.1BF1BBCD8F	2002	M		O/W 24	EFSR	MAN
3D9.1BF1BC038A	2002	M		O/W 25	EFSR	MAN
3D9.1BF1BC7888	2002	M		O/W 26	EFSR	MAN
3D9.1BF1BDE446	2002	M		O/W 27	EFSR	MAN
3D9.1BF1BD93CC	2002	M		O/W 29	EFSR	MAN
3D9.1BF1BD837C	2002	M		O/W 30	EFSR	MAN
3D9.1BF1BD9F7A	2002	M		O/W 31	EFSR	MAN
3D9.1BF1BCF19A	2002	M		O/W 32	EFSR	MAN
3D9.1BF1BBF303	2002	M		O/W 33	EFSR	MAN
3D9.1BF1BDE90E	2002	M		O/W 34	EFSR	MAN

Appendix B. Continued.

PIT Code	BY	Sex	Radio #	Number	Stock	Rearing
3D9.1BF1BCEC48	2002	M		O/W 35	EFSR	MAN
3D9.1BF1BBF30D	2002	M		O/W 36	EFSR	MAN
3D9.1BF1BBBCCB	2002	M		O/W 37	EFSR	MAN
3D9.1BF1BDE8F9	2002	M		O/W 39	EFSR	MAN
3D9.1BF1BC8981	2002	U		O/W 41	EFSR	MAN
3D9.1BF1BBF801	2002	M		O/W 43	EFSR	MAN
3D9.1BF1BBCC5C	2002	M		O/W 44	EFSR	MAN
3D9.1BF1BBA6F6	2002	M		O/W 45	EFSR	MAN
3D9.1BF1BBFAAC	2002	M		O/W 48	EFSR	MAN
3D9.1BF1BD773A	2002	M		O/W 51	EFSR	MAN
3D9.1BF1BBE1BD	2002	M		O/W 52	EFSR	MAN
3D9.1BF1BC1905	2002	M		O/W 54	EFSR	MAN
3D9.1BF1BD6C6F	2002	U		O/W 55	EFSR	MAN
3D9.1BF1BBF590	2002	M		O/W 56	EFSR	MAN
3D9.1BF1BBF6C5	2002	U		O/W 57	EFSR	MAN
3D9.1BF1BCBA34	2002	M		O/W 59	EFSR	MAN
3D9.1BF1BD754E	2002	M		O/W 62	EFSR	MAN
3D9.1BF1BDDA30	2002	F		R/W 04	EFSR	MAN
3D9.1BF1BDD570	2002	M		R/W 12	EFSR	MAN
3D9.1BF1BBFB23	2002	F		R/W 17	EFSR	MAN
3D9.1BF1BCAA4B	2002	F		R/W 50	EFSR	MAN
3D9.1BF1BC12EF	2002	M		R/W 60	EFSR	MAN
3D9.1BF1BBFED5	2002	M		R/W 61	EFSR	MAN
3D9.1BF1BDE079	2002	M		R/W 64	EFSR	MAN
3D9.1BF1BC7B74	2002	M		R/W 65	EFSR	MAN
3D9.1BF1BE0609	2002	M		R/W 67	EFSR	MAN
3D9.1BF1BD8D2C	2002	M		R/W 70	EFSR	MAN
3D9.1BF1BCFB17	2002	M		R/W 71	EFSR	MAN
3D9.1BF1BEEA4B	2002	M		R/W 72	EFSR	MAN
3D9.1BF1BB4F8E	2002	M	150.116	R/W 73	EFSR	MAN
3D9.1BF1BC1C62	2002	U		R/W 75	EFSR	MAN
3D9.1BF1BC0F22	2002	M	150.035	R/W 76	EFSR	MAN
3D9.1BF1BC8648	2002	M		R/W 80	EFSR	MAN
3D9.1BF1BBCA96	2002	M		R/W 81	EFSR	MAN
3D9.1BF1BB9BA9	2002	U		R/W 82	EFSR	MAN
3D9.1BF1BCF540	2002	M		R/W 83	EFSR	MAN
3D9.1BF1BB4F33	2002	M		R/W 84	EFSR	MAN
3D9.1BF1BBDA2D	2002	M		R/W 85	EFSR	MAN
3D9.1BF1BDE968	2002	U		R/W 91	EFSR	MAN
3D9.1BF1BC1FA6	2002	M		R/W 93	EFSR	MAN
3D9.1BF1BD9CAA	2002	M		R/W 94	EFSR	MAN
3D9.1BF1BD7D67	2002	M		R/W 95	EFSR	MAN
3D9.1BF1BCAA63	2002	U		R/W 97	EFSR	MAN
3D9.1BF11B6E91	2001	F		Y/W	EFSR	MAN
3D9.1BF123B741	2001	F		Y/W 01	EFSR	MAN
3D9.1BF11BC12D	2001	F	151.244	Y/W 02	EFSR	MAN
3D9.1BF11B6049	2001	F	150.056	Y/W 03	EFSR	MAN
3D9.1BF11BF05A	2001	F		Y/W 04	EFSR	MAN
3D9.1BF123BAA0	2001	F	150.014	Y/W 05	EFSR	MAN
3D9.1BF11B446C	2001	F		Y/W 07	EFSR	MAN
3D9.1BF11BBD3A	2001	F	150.096	Y/W 11	EFSR	MAN
3D9.1BF123B8AF	2001	F		Y/W 12	EFSR	MAN
3D9.1BF11BCEEA	2001	F		Y/W 12	EFSR	MAN
3D9.1BF123C3AA	2001	F		Y/W 13	EFSR	MAN

Appendix B. Continued.

PIT Code	BY	Sex	Radio #	Number	Stock	Rearing
3D9.1BF11B63F1	2001	F		Y/W 15	EFSR	MAN
3D9.1BF11BB382	2001	U		Y/W 17	EFSR	MAN
3D9.1BF11BC222	2001	F		Y/W 22	EFSR	MAN
3D9.1BF11A303B	2001	F		Y/W 23	EFSR	MAN
3D9.1BF11B5345	2001	U		Y/W 24	EFSR	MAN
3D9.1BF11BBA5F	2001	F		Y/W 25	EFSR	MAN
3D9.1BF11F0A0D	2001	F		Y/W 27	EFSR	MAN
3D9.1BF11A2543	2001	F		Y/W 31	EFSR	MAN
3D9.1BF11B5BDD	2001	F		Y/W 32	EFSR	MAN
3D9.1BF11B47B2	2001	F		Y/W 33	EFSR	MAN
3D9.1BF11F1D95	2001	F		Y/W 34	EFSR	MAN
3D9.1BF11B4416	2001	F		Y/W 35	EFSR	MAN
3D9.1BF11B63AB	2001	F		Y/W 37	EFSR	MAN
3D9.1BF11A2582	2001	F		Y/W 41	EFSR	MAN
3D9.1BF123B126	2001	F		Y/W 42	EFSR	MAN
3D9.1BF11BC50B	2001	U		Y/W 43	EFSR	MAN
3D9.1BF11B76C6	2001	F		Y/W 44	EFSR	MAN

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