Status and Monitoring of Natural and Supplemented Chinook Salmon in Johnson Creek, Idaho

Annual Progress Report: 2006 to 2007

Picture taken by Mary Edwards

**STATUS AND MONITORING OF NATURAL AND
SUPPLEMENTED CHINOOK SALMON IN JOHNSON CREEK,
IDAHO**

Annual Report

Period Covered: 2006 to 2007

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ABSTRACT

The Nez Perce Tribe Johnson Creek Artificial Propagation Enhancement Project (JCAPE) has conducted juvenile and adult monitoring and evaluation studies for its 10th consecutive year. Completion of adult and juvenile Chinook salmon studies were conducted for the purpose of evaluating a small-scale production initiative designed to increase the survival of a weak but recoverable spawning aggregate of summer Chinook salmon *Oncorhynchus tshawytscha*. The JCAPE program evaluates the life cycle of natural origin (NOR) and hatchery origin (HOR) supplementation fish to quantify the key performance measures: abundance, survival-productivity, distribution, genetics, life history, habitat, and in-hatchery metrics.

Operation of a picket style weir and intensive multiple spawning ground surveys were completed to monitor adult Chinook salmon and a rotary screw trap was used to monitor migrating juvenile Chinook salmon in Johnson Creek.

In 2007, spawning ground surveys were conducted on all available spawning habitat in Johnson Creek and one of its tributaries. A total of 63 redds were observed in the index reach and 11 redds for all other reaches for a combined count of 74 redds. Utilization of carcass recovery surveys and adult captures at an adult picket weir yielded a total estimated adult escapement to Johnson Creek of 438 Chinook salmon. Upon deducting fish removed for broodstock (n=52), weir mortality/ known strays (n=12), and pre-spawning mortality (n=15), an estimated 359 summer Chinook salmon were available to spawn.

Estimated total migration of brood year 2005 NOR juvenile Chinook salmon at the rotary screw trap was calculated for three seasons (summer, fall, and spring). The total estimated migration was 34,194 fish; 26,671 of the NOR migrants left in the summer (July 1 to August 31, 2005) as fry/parr, 5,852 left in the fall (September 1 to November 21, 2005) as presmolt, and only 1,671 NOR fish left in the spring (March 1 to June 30, 2006) as smolt. In addition, there were 120,415 HOR supplementation smolts released into Johnson Creek during the week of March 12, 2007.

Life stage-specific juvenile survival from Johnson Creek to Lower Granite and McNary dams was calculated for brood year 2005 NOR and HOR supplementation juvenile Chinook salmon. Survival of NOR parr Chinook salmon migrating from Johnson Creek to Lower Granite and McNary dams was 28.2% and 16.2%. Survival of NOR presmolt Chinook salmon migrating from Johnson Creek to Lower Granite and McNary dams was 28.2% and 22.3%. Survival of NOR smolt Chinook salmon migrating from Johnson Creek to Lower Granite and McNary dams was 44.7% and 32.9%. Survival of HOR smolt Chinook salmon migrating from Johnson Creek to Lower Granite and McNary dams was 31.9% and 26.2%.

Multi-year analysis on smolt to adult return rate's (SAR's) and progeny to parent ratio's (P:P's) were calculated for NOR and HOR supplementation Brood Year 2002 Chinook

salmon. SAR's were calculated from Johnson Creek to Johnson Creek (JC to JC), Lower Granite Dam to Lower Granite (LGD to LGD), and Lower Granite Dam to Johnson Creek (LGD to JC); for NOR fish SAR's were 0.16%, 1.16% and 1.12%, while HOR supplementation SAR's from JC to JC, LGD to LGD and LGD to JC were 0.04%, 0.19% and 0.13%. P:P's for all returning NOR and HOR supplemented adults were under replacement levels at 0.13 and 0.65, respectively. Recruit per spawner estimates (R/S) for Brood Year 2005 adult Chinook salmon were also calculated for NOR and HOR supplemented Chinook salmon at JC and LGD. R/S estimates for NOR and HOR supplemented fish at JC were 231 and 1,745, while R/S estimates at LGD were 67 and 557.

Management recommendations address 1) effectiveness of data collection methods, 2) sufficiency of data quality (statistical power) to enable management recommendations, 3) removal of uncertainty and subsequent cessation of M&E activities, and 4) sufficiency of findings for program modifications prior to five-year review.

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GLOSSARY OF TERMS

Adult - Refers to Chinook salmon that resided two to four years in the ocean.

Anadromous Fish – Fish that spawn in freshwater, rear for various durations in freshwater, migrate to the ocean, become sexually mature in the ocean and return to freshwater.

Artificial Spawning – The fertilization of eggs and sperm done under artificial methods.

Artificial Supplementation – Hatchery programs that are used to enhance natural reproduction in the natural environment.

Broodstock – Group of fish that are used to provide eggs and sperm to produce a hatchery stock for supplementation purposes.

Brood Year (BY) – Refers to the year when adults producing progeny returned to spawn.

Fry – Life stage of fish between the egg and parr stages. For salmon this typically refers to fish less than 50 millimeters long. In the context of this report, fry represent an actively migrating BY05 summer Chinook progeny that is trapped in the Johnson Creek rotary screw trap between March 1 and June 30, 2006.

Hatchery Origin (HOR) – Refers to juvenile, jack, or adult Chinook salmon that were reared in a hatchery as juveniles.

HOR strays – Refers to jack or adult Chinook salmon that were reared at a hatchery as juveniles from systems other than Johnson Creek and strayed into Johnson Creek as adults. These fish are typically identified by the absence of fins (adipose, ventral).

HOR supplementation – Refers to juvenile, jack or adult Chinook salmon that were produced from NOR adults collected in Johnson Creek and artificially spawned.

Jack – Refers to Chinook salmon that resided in the ocean for only one year, rather than two years, as is typical for the species. Jacks are predominately male.

Juvenile – The early stage in the life cycle of anadromous fish when they rear in freshwater and migrate downstream to the ocean.

Migrant to Adult Return rate (MAR) – Defined as the number of adults from a given brood year that return to a defined point (e.g., Johnson Creek, Lower Granite Dam) divided by the number of juvenile migrants of all life stages (e.g., parr, presmolt, smolt) that left the same point 1-3 years prior, integrated over all return years (see also smolt to adult return rate - SAR).

Migration Year (MY) - Refers to the year that juvenile, jack or adult Chinook salmon migrate through the Federal Columbia River Power System (FCRPS).

Natural Origin (NOR) – Refers to juvenile, jack, or adult Chinook salmon that result from in-stream adult spawning, rather than artificial propagation (see Hatchery Origin).

Natural Spawning – The fertilization of eggs and sperm done under natural conditions. A female digs and deposits eggs into a redd which is fertilized by a male.

Progeny per Parent ratio – The Progeny per Parent ratio refers to the replacement rate of a specific adult cohort. It is defined as the ratio of return of adults to parent adults.

Parr – Refers to a juvenile Chinook salmon lifestage which follows the fry and precedes the presmolt/smolt. Parr are typically characterized by distinct series of bars on their sides (parr marks), and measure from approximately 50 to 70 mm fork length. In the context of this report, parr represent an actively migrating BY05 summer Chinook progeny that is trapped in the Johnson Creek rotary screw trap between July 1 and August 31, 2006.

Presmolt - Refers to a juvenile Chinook salmon lifestage which follows the parr and precedes the smolt. Presmolt do not show typical smolt characteristics (e.g., silvery color and the tendency to easily lose their scales) yet lack the characteristic parr marks. In the context of this report, presmolt represent an actively migrating BY05 summer Chinook salmon progeny that is trapped in the Johnson Creek rotary screw trap between September 1 and November 21, 2006.

Pre-spawning Mortality - Females are considered a pre-spawning mortality if <25% of their gametes have been expelled; pre-spawn males are defined as male mortalities found prior to the onset of the first completed redd.

Recruit per Spawner estimate - Recruit per Spawner estimate refers to the adult productivity of a specific cohort. It is defined as the number of juvenile fish resulting from the preceding adult life stage.

Redd - nest made in gravel, consisting of a depression dug by a fish for egg deposition (and then filled) and associated gravel mounds.

Smolt – Refers to a juvenile Chinook salmon lifestage which follows the presmolt and precedes the yearling. Smolt exhibit a silvery color which is a function of physiological changes to adapt its body from a freshwater to a saltwater environment. In the context of this report, smolt represent an actively migrating BY05 summer Chinook salmon progeny that is trapped in the Johnson Creek rotary screw trap between March 1 and June 30, 2007 during its second spring residence in freshwater.

Smolt to Adult Return rate (SAR) – The smolt-to-adult return rate is a measure of the number of adults from a given brood year that return to a defined point (e.g., Johnson Creek, Lower Granite Dam) divided by the number of smolts that left the same point 1-3 years prior, integrated over all return years (see also migrant to adult return rate - MAR).

Spawner (Spawner Abundance) – Estimated number of total spawners on the spawning ground. Calculated as the number of fish that return to an adult monitoring site, minus broodstock removals, weir mortalities, and harvest if any. Also subtracts the number of female prespawning mortalities and expands for redds located below weirs.

Supplementation - The use of artificial propagation to maintain or increase (supplement) natural production while maintaining the long-term fitness of the target population, and keeping the ecological and genetic impacts to non-target populations within specified biological limits (RASP 1992). Natural origin populations are supplemented through the release of juvenile hatchery origin Chinook salmon into targeted streams with the purpose of allowing the returning adults to spawn naturally, thereby increasing natural production.

Yearling – Refers to a juvenile Chinook lifestage which follows the smolt. Yearlings are typically larger than 90 mm and tend to exhibit male sexual maturity; however, not all are sexually mature. In the context of this report, yearling represent an actively migrating BY05 summer Chinook progeny that is trapped in the Johnson Creek rotary screw trap between June 30 and November 22, 2007 during its second summer residence in freshwater.

GLOSSARY OF ACRONYMS

BPA	Bonneville Power Administration
BY	Brood Year
CBFWA	Columbia Basin Fish and Wildlife Authority
CFS	Cubic feet per second
CJS	Cormack Jolly Seber
CRITFC	Columbia River Intertribal Fisheries Commission
CWT	Coded Wire Tag
DEQ	Department of Environmental Quality
EFSFSR	East Fork South Fork Salmon River
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
FKL	Fork Length
FPP	Fish per pound
FPR	Fish per redd
GPS	Global positioning system
HOR	Hatchery-origin
ICTRT	Interior Columbia Technical Recovery Team
IDFG	Idaho Department of Fish and Game
JCAPE	Johnson Creek Artificial Propagation Enhancement
LGD	Lower Granite Dam
LSRCP	Lower Snake River Compensation Plan
M&E	Monitoring and Evaluation
MCN	McNary Dam
MEH	Mid-eye hypural
MPG	Major population group
MS-222	Tricaine Methanesulfonate
MY	Migratory year
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOR	Natural-origin
NPCC	Northwest Power and Conservation Council
NPT	Nez Perce Tribe
PIT	Passive Integrated Transponder
PTAGIS	PIT tag Information System
RKM	River kilometer
RMIS	Regional Mark Information System
SFSR	South Fork Salmon River
SURPH	Survival Under Proportional Hazards
USFS	United States Forest Service
USGS	United States Geological Survey
VIE	Visual Implant Elastomer
YOY	Young of the year

CHAPTER 1: BACKGROUND OF THE JOHNSON CREEK ARTIFICIAL PROPAGATION ENHANCEMENT PROJECT

INTRODUCTION

Population Status

Historical summer Chinook salmon *Oncorhynchus tshawytscha* production in central Idaho's South Fork Salmon River (SFSR; Figure 1) watershed likely exceeded that of other summer-run watersheds in the Columbia Basin (Mallet 1974), and is estimated to have accounted for as much as 60 to 70% of Idaho's total adult summer Chinook salmon returns (IDFG 1992). Strong adult returns to the SFSR persisted until the late 1950's; with escapement estimates ranging from 10,000 to 15,000 fish (Mallet 1974). Chinook salmon production in the SFSR has declined thereafter; reduced spawner numbers combined with adverse human manipulation of habitat have resulted in decreased spawning abundance and population fragmentation. Declining trends of natural escapement to the SFSR basin have paralleled those of other Snake River stocks with adult seeding levels amounting to less than 15% of historic values (NPCC 2005). Due to low adult returns, Snake River spring/summer Chinook salmon were listed under the Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS) as threatened in 1992.

Johnson Creek represents one of 32 ESA-listed spring/summer Chinook salmon populations in the Snake River Evolutionally Significant Unit (ICTRT 2005). The Interior Columbia Technical Recovery Team (ICTRT) identifies four unique populations of spring/summer Chinook salmon that occur within the South Fork Salmon River Major Population Group (MPG); the Little Salmon (SRLSR), the South Fork Salmon River mainstem (SFMAI), the Secesh (SFSEC), and the East Fork South Fork Salmon River (SFEFS). Johnson Creek is the primary spawning aggregate within the East Fork South Fork Salmon River (Figure 1). Together, these four populations make up a geographically and genetically cohesive unit, or MPG (ICTRT 2005). The ICTRT provides a summary of the respective Chinook salmon populations that comprise the South Fork Salmon River MPG.

Reductions in the size of the SFEFS population have been most notable over the last fifty years. Escapement levels in Johnson Creek have declined from a high of 486 redds in 1960 to a low of five (5) redds observed in 1995 (Elms-Cockrum 1997; Apperson 1998; Kucera and Blenden 1998). Recent escapement levels of natural origin (NOR) summer Chinook salmon (1998-2007) have ranged from a high of 1,558 in 2001 to an estimated low of 77 fish in 1999 (assuming a nine-year mean 3.2 above-weir fish per redd average and 24 redds in 1999), and have typically been below ICTRT's minimum abundance threshold of 1,000 NOR spawners (Figure 2). Adult return objectives that were established in the Salmon Subbasin Plan (NPCC 2005) were not specific to Johnson Creek, but exceed 36,400 NOR summer Chinook for the entire subbasin, an escapement level which has also yet to be attained.

South Fork Salmon River Subbasin

Figure 1. South Fork Salmon River subbasin including the South Fork Salmon River mainstem (SFMAI), Secesh River (SFSEC drainage), East Fork South Fork Salmon River, and Johnson Creek (SFEFS drainage).

Figure 2. Estimated annual natural-origin (NOR) adult summer Chinook salmon spawner abundance to Johnson Creek compared to the East Fork South Fork Salmon River/Johnson Creek MPG quasi-extinction threshold and population viability (delisting) threshold (ICTRT 2005).

Project History

The Johnson Creek Artificial Propagation Enhancement (JCAPE) program was instituted by the Nez Perce Tribe (NPT) in response to successive years of critically low abundance of the Johnson Creek population. On March 23, 1998, the Columbia River Inter-Tribal Fisheries Commission (CRITFC) applied for a section 10 (a) (1) (A) permit to artificially propagate summer Chinook in Johnson Creek (Lothrop 1998). On April 17, 1998, the Bonneville Power Administration (BPA) requested that CRITFC's section 10 permit application be used to initiate their section 7 consultation (Beraud 1998). The NMFS concurred with BPA's request on May 7, 1998 (Smith 1998).

Since these initial phases, the project has received a high priority ranking through Columbia Basin Fish and Wildlife Authority (CBFWA) and has been reviewed and recommended through the *U.S. v Oregon* Production Advisory Committee process. The NMFS has deemed the project as critical to recovery of ESA-listed salmon (Stelle 1996, 1999). Additionally, this program has undergone intense scrutiny and review through the NMFS ESA Section 10 Permit Application

process and an Independent Scientific Review through the NPCC 3-Step Process. In December, 2005, the JCAPE program completed the three-step review process required by the NPCC that was intended to address elements and conditions placed on the project over the previous six years as part of project selection process.

The monitoring and evaluation component, which was initiated in 1998, complements the operations and maintenance (production) component of the JCAPE project by assessing progress towards achievement of programmatic management objectives. The Johnson Creek Monitoring and Evaluation Plan (Vogel et al. 2005), which was first drafted in 2000, represents the guidance document under which the M&E program operates. The M&E Plan incorporates regionally accepted performance measures to inform the specific goals and objectives that guide the program.

Chinook salmon have a complex life cycle where juvenile fish emigrate out of the stream over multiple life stages and return as adults over multiple years, therefore, this report incorporates evaluation over multiple life stages and broodyears. Adult Chinook salmon data covered in this report consists of fish returning to Johnson Creek in the summer/fall of 2007 (Chapter 2). Chapter 3 presents results of the data collected from March 1, 2006 to November 26, 2007 for brood year (BY) 2005 natural-origin (NOR) and hatchery-origin (HOR) supplementation juvenile Chinook salmon. In Chapter 4 we cover multi-year analysis survival/productivity measures (smolt to adult return rates, migrant to adult return rates and progeny to parent ratios) for brood year 2002 adults and (recruit per spawner estimates) for BY05 adults. A review of temperature and flow conditions affecting habitat and migration patterns is provided in Chapter 5. Management recommendations are provided in Chapter 6.

GOALS AND OBJECTIVES

JCAPE Project Goals

The goal of the Johnson Creek Artificial Propagation Enhancement project is to reduce the demographic risk of extirpation of the ESA listed Johnson Creek summer Chinook salmon and begin its recovery through supplementation. A secondary goal is to maintain genetic diversity of the artificially propagated summer Chinook salmon population and the natural population. The intent is to increase adult returns through increased juvenile survival. This project is separated into two distinct projects; the Operations and Maintenance and the Monitoring and Evaluation portions. The Operations and Maintenance project publishes adult run and brood year reports annually, which are available electronically at Bonneville Power Administration's Environment Fish and Wildlife website (<http://www.efw.bpa.gov>). This annual progress report is for the Monitoring and Evaluation portion of the project only.

M&E Program Objectives

The JCAPE Monitoring and Evaluation (M&E) program assesses the life stage specific status and performance of the existing Chinook salmon population in Johnson Creek. In concert with evaluating the natural component of the summer Chinook salmon in Johnson Creek, this program also monitors and evaluates the supplementation program.

The monitoring and evaluation program's structure is presented in Vogel et al. (2005). A total of seven, programmatic management objectives serve as the primary strata (listed below). Associated monitoring and evaluation objectives (listed below) are stratified under the respective programmatic management objectives.

MANAGEMENT OBJECTIVE 1:

MAINTAIN AND ENHANCE NATURAL PRODUCTION IN THE JOHNSON CREEK SUMMER CHINOOK SALMON POPULATION.

Monitoring and Evaluation Objective 1a: Determine and compare productivity of NOR and HOR supplementation Chinook salmon.

Monitoring and Evaluation Objective 1b (unfunded): Conduct genetic parentage analysis to determine and compare relative reproductive success of NOR and HOR supplementation Chinook salmon.

Monitoring and Evaluation Objective 1c: Determine and compare the spawning distribution of NOR and HOR supplementation Chinook salmon in Johnson Creek.

Monitoring and Evaluation Objective 1d: Determine and compare life-stage specific survival rates for NOR and HOR supplementation Chinook salmon in Johnson Creek.

MANAGEMENT OBJECTIVE 2:

MAINTAIN LIFE HISTORY CHARACTERISTICS IN THE JOHNSON CREEK SUMMER CHINOOK SALMON POPULATION.

Monitoring and Evaluation Objective 2a. Determine adult life history characteristics of NOR Chinook salmon compared to HOR supplementation Chinook salmon in Johnson Creek.

Monitoring and Evaluation Objective 2b. Determine juvenile life history characteristics of NOR Chinook salmon compared to HOR supplementation Chinook salmon in Johnson Creek.

MANAGEMENT OBJECTIVE 3:

OPERATE THE HATCHERY PROGRAM SO THAT GENETIC DIVERSITY OF HOR SUPPLEMENTATION CHINOOK SALMON MIMIC NOR CHINOOK SALMON.

Monitoring and Evaluation Objective 3a. Determine and compare genetic characteristics of NOR and HOR supplementation Chinook salmon in Johnson Creek.

MANAGEMENT OBJECTIVE 4:

KEEP IMPACTS OF THE SUPPLEMENTATION PROGRAM ON NON-TARGET CHINOOK SALMON POPULATIONS WITHIN ACCEPTABLE LIMITS.

Monitoring and Evaluation Objective 4a. Determine the proportion of HOR supplementation Chinook salmon from Johnson Creek that stray into Lake Creek, Secesh River, and the South Fork Salmon River and spawn naturally.

Monitoring and Evaluation Objective 4b. Determine if the operation of the adult trap/weir has any impacts to resident and/or anadromous fish populations in Johnson Creek.

MANAGEMENT OBJECTIVE 5:

OPERATE THE HATCHERY PROGRAM TO ACHIEVE OPTIMAL PRODUCTION EFFECTIVENESS WHILE MEETING PRIORITY MANAGEMENT OBJECTIVES FOR NATURAL PRODUCTION ENHANCEMENT AND DIVERSITY.

Monitoring and Evaluation Objective 5a. Compare management plan objectives and actions with program outcomes to determine plan feasibility and effectiveness.

Monitoring and Evaluation Objective 5b. Determine disease agents or pathogen presence and prevalence in the HOR supplementation population and compare with the NOR population presence and prevalence.

MANAGEMENT OBJECTIVE 6:

UNDERSTAND THE CURRENT STATUS AND TRENDS OF NOR CHINOOK SALMON POPULATIONS AND THEIR HABITATS IN JOHNSON CREEK.

Monitoring and Evaluation Objective 6a. Describe status and trends in adult abundance and productivity for all summer Chinook salmon populations in the South Fork Salmon River watershed.

Monitoring and Evaluation Objective 6b. Monitor spawning distribution in the South Fork Salmon River Subbasin summer Chinook salmon populations.

Monitoring and Evaluation Objective 6c (unfunded). Determine status and trends of Chinook salmon habitat in the South Fork Salmon River Subbasin.

Monitoring and Evaluation Objective 6d. Determine status and trends of temperature and flow in Johnson Creek.

Monitoring and Evaluation Objective 6e. Contribute data to basin-wide effort to determine relationships between in-basin and out-of-basin habitat conditions and population productivity and abundance.

MANAGEMENT OBJECTIVE 7:

COORDINATE MONITORING AND EVALUATION ACTIVITIES AND COMMUNICATE PROGRAM FINDINGS TO RESOURCE MANAGERS.

Monitoring and Evaluation Objective 7a. Provide accurate data summaries in a continual and timely manner.

Monitoring and Evaluation Objective 7b. Communicate study plans and results in a timely fashion locally and regionally.

Monitoring and Evaluation Objective 7c. Support a scientifically sound adaptive management process of JCAPE with M&E program findings.

Monitoring and Evaluation Objective 7d. Coordinate needed and existing activities within agencies and between all managers.

DESCRIPTION OF PROJECT AREA

Johnson Creek is located in the central part of Idaho within the Boise National Forest (Figure 3). It originates near Deadwood Summit at an elevation of 2,322 meters and traverses in a northeasterly direction where it enters the East Fork South Fork Salmon River near Yellow Pine, Idaho at an elevation of 1,417 meters. Johnson Creek is approximately 51 kilometers in length with the entire watershed encompassing 552 square kilometers (USGS 2007). The major tributaries to Johnson Creek are Riordan, Trapper, Burntlog, Ditch, Halfway, Rustican, Sheep, Lunch, Landmark, Rock, and Boulder creeks.

The landscape was formed by glacial and fluvial processes and is characterized by alpine ridges and cirques in the higher elevations and U-shaped valleys with broad bottoms in the lower elevations. The geological characteristics of Idaho Batholith make the nutrient levels within the watershed low. Water quality in terms of water chemistry is considered to be near or close to pristine. However, the steep slopes and fragile soils within the watershed tend to make the landscape prone to erosion (USFS 1995).

Roads are the foremost cause of soil erosion in the Johnson Creek drainage. They have contributed up to 90% of the management induced sediment. Road erosion is the greatest in lower Johnson Creek within the Burntlog/Halfway subwatershed. Landslides occur naturally and input sediment, substrate, and large woody debris; however, the frequency and magnitude of landslide events have greatly increased due to the construction of roads. Landslide prone acreage within the Johnson Creek drainage consists of 10 percent of the landscape. Fire has induced between one and 14 percent of the total induced erosion. Timber harvesting activities have yielded between one and four percent of the total induced erosion (USFS 1995).

Mean annual precipitation ranges from 70 cm at Yellow Pine to 148 cm at Deadwood Summit. The average annual precipitation for the drainage is 81cm (USFS 1995). Stream discharge is lowest in November/December and peaks in May/June. The lowest recorded stream discharge was 0.59 m³/s on November 30, 1954, November 20, 1979, and November 18, 1988, and the highest recorded stream discharge was 176.41 m³/s on June 17, 1974. From 1928 to 2007, average annual stream discharge was 9.63 m³/s (USGS 2008).

The drainage supports species of anadromous and resident fish in both lake and stream habitats. Anadromous and resident fish populations consist of summer Chinook salmon, summer steelhead *O. mykiss*, rainbow trout *O. mykiss*, cutthroat trout *O. clarki*, bull trout *Salvelinus confluentus*, brook trout *S. fontinalis*, mountain whitefish *Prosopium williamsoni*, longnose dace *Rhinichthys cataractae*, and sculpin *Cottus spp.*.

The majority of the Chinook salmon spawning habitat in Johnson Creek is located between Deadhorse Rapids (RKM 9.75) and the confluence of Moose Creek (RKM 15.2) (Figure 3). However, in 1985 four migration barriers from Burnt Log Creek to Trout Creek were removed by the Idaho Department of Fish and Game (IDFG; Petrosky and Holubetz, 1985). This enabled the passage of Chinook salmon during low and moderate flows and increased spawning and rearing habitat by 395,000 m² (IDFG 1990). Today, spawning to a lesser extent occurs from Landmark upstream to Whiskey Creek.

Figure 3. Johnson Creek watershed including juvenile trap, weir location and extensive spawning ground locations.

CHAPTER 2: ADULT STATUS EVALUATION OF JOHNSON CREEK CHINOOK
SALMON FOR THE 2007 MIGRATION YEAR

INTRODUCTION

This chapter includes an assessment of adult Chinook salmon returning to Johnson Creek from July to September, 2007. The status of 2007 Johnson Creek adults involves evaluations of abundance, survival/productivity, distribution, and life history characteristics. Performance measures used to inform these evaluations are shown in Table 1, as are the corresponding monitoring and evaluation objectives.

Table 1. Johnson Creek adult summer Chinook salmon performance measures and corresponding Monitoring and Evaluation Objectives for natural-origin (NOR) and hatchery-origin (HOR) supplementation Chinook salmon.

Performance Measure		Objectives
Abundance	Index of Spawner Abundance - redd counts	1a, 1d
	Adult Abundance to tributary	1a, 1b, 1d, 6a
	Fish per Redd Estimate	1a, 1d
	Spawner Abundance	1a, 1d
	Hatchery Ratio	1a, 1d
	Run Prediction	1d, 5a
Survival - Productivity	Pre-spawn Mortality (female 0-25%)	1a, 1d
Distribution	Adult Spawner Spatial Distribution	1c 6b
	Disease Frequency	5b
Life History	Age Class Structure	1a, 1d
	Age-at-Return	1a, 1d, 2a
	Size-at-Return	2a 2b
	Percent Females	1a, 1b, 1d, 2a
	Fecundity by Age	1b
	Adult Run-timing	2a
	Spawn-timing	1b

METHODS

Adult Monitoring – Field Operations

Data collection methods used to monitor and evaluate adult summer Chinook salmon abundance, survival-productivity, distribution, and life history characteristics in Johnson Creek include trap/weir operation and multiple pass spawning ground/carcass surveys.

Trap/weir operation

Operation of a temporary bi-directional picket style weir, located 8.2 kilometers upstream of the confluence of Johnson Creek and the East Fork South Fork Salmon River (N 44.901166° W 115.488842°), was used for the collection of broodstock for the supplementation program (Figure 3). The trap box and weir, which consisted of an angled guide fence and in-stream trap box (Figure 4), was checked daily during its period of operation for fish and/or loose and bent pickets. The weir was operated from mid June (as soon as flow allows) through late September, or seven days after the last fish was captured. Adult Chinook salmon captured at Johnson Creek were either: 1) released upstream for natural spawning; 2) selected as broodstock and transported approximately 56 kilometers to the Lower Snake River Compensation Plan (LSRCP) South Fork Salmon River (SFSR) satellite adult facility operated by the Idaho Department Fish and Game (IDFG); 3) released downstream if captured in the downstream trap box; or 4) euthanized and placed into Johnson Creek for nutrient enhancement or given to Nez Perce Tribal Members for distribution (stray adipose fin-clipped fish only). A brief description of weir protocols is listed below. Hill and Gebhards (2007) provide a complete description of adult trapping methods and protocols.

Figure 4. Adult picket weir, upstream and downstream trap box, holding and workup area located on Johnson Creek used for capturing adult Chinook salmon.

All captured fish were anesthetized with Tricaine Methanesulfonate (MS-222) and examined for length (fork and mid-eye to hypural), sex, marks (radio tags, passive integrated transponder tags, coded wire tags, visual implant elastomer), and origin type. Genetic samples were collected from the caudal fin using a paper punch. Fish captured at the adult weir were marked with a uniquely numbered opercle disk tag. The total numbers of Chinook salmon returning to the adult trap and their disposition (released upstream to spawn naturally or collected for broodstock) were recorded daily and summarized in weekly reports.

Spawning Ground Surveys

Multiple-pass pre-spawning mortality, spawning ground (a.k.a. *redd*), and carcass surveys were conducted in Johnson Creek and one of its tributaries (Burnt Log Creek; Figure 3). The surveys were conducted to provide researchers an *index of spawner abundance*, among other information. Surveys, which initiated in July and concluded mid-September, were conducted weekly on seven discrete sections of Johnson Creek and one section of Burnt Log Creek (Table 2). July surveys focused on obtaining estimates of *pre-spawn mortality*; females were considered a *pre-spawning mortality* if <25% of their gametes had been expelled, males were defined as pre-spawn mortalities if found as carcasses prior to the onset of the first completed redd. Procedures for spawning ground surveys were based on standardized protocol developed by the NPT Department of Fisheries Resources Management (unpublished) and are similar to those used by Hassemer (1993).

Personnel initiated spawning ground surveys at mid-day to ensure adequate light conditions, and proceeded up the stream channel on opposing sides. Chinook salmon redds were enumerated and marked (on stream bank) with flagging and with a Global Positioning System (GPS) unit, so that the number of new redds could be determined with each additional survey. Marks on flagging included redd number (chronologically-based), observer's initials, agency initials, and date observed. Conservative counts were made in areas with multiple redds. Redds were directly enumerated and summarized as a total number per stream with no estimate of variation. Number of redds were evaluated temporally and/or spatially (supports index area time series data).

Live fish were counted during surveys. All recovered carcasses were checked for marks, scanned for presence of passive integrated transponder (PIT) tags and the snout scanned for presence of coded wire tags (CWT). Fork and mid-eye hypural (MEH) lengths were taken to the nearest 0.5 centimeter on all carcasses. Scales and dorsal fin rays (dorsal fin samples have been used from 1999-2005) were removed from each carcass and placed in labeled envelopes for ageing analysis (e.g., Kiefer et al. 2004). Scales were removed from a preferred area located two to three rows above the lateral line on a diagonal scale column running from the posterior base of the dorsal fin to the anterior base of the anal fin (Schwartzberg 1987; Nicholas and Van Dyke 1982; Kiefer et al. 2002). Fish were incised to verify sex and determine percent spawned (0, 25, 50, 75, 100). Snouts from carcasses detected with CWT's were removed for analysis. Prior to the carcass being returned to the stream, tails were cut off to prevent duplicate sampling.

Table 2. Sections walked in Johnson Creek and Burnt Log Creek (tributary to Johnson Creek); included are the section lengths, number of projected passes, and GPS coordinates (World Geodetic System (WGS) 84) of start/end points.

Stream	Section	Transect Length	# of Passes	GPS start Location	GPS end location
Johnson	Section 1- Confluence of Johnson Creek and East Fork South Fork Salmon River to NPT screw trap	6.28 km	10	N 44.962469° W 115.502462°	N 44.91763° W 115.483355°
Johnson	Section 2 - NPT screw trap to NPT adult weir	1.91 km	10	N 44.91763° W 115.483355°	N 44.901166° W 115.488842°
Johnson	Section 3 - NPT adult weir to top of Deadhorse rapids	1.56 km	10	N 44.901166° W 115.488842°	N 44.891977° W 115.49791°
Johnson	Section 4 – Top of Deadhorse rapids to mouth of Moose Creek	5.45 km	10	N 44.891977° W 115.49791°	N 44.852551° W 115.509123°
Johnson	Section 5 - Mouth of Moose Creek to mouth of Burnt Log Creek	6.36 km	10	N 44.852551° W 115.509123°	N 44.802991° W 115.518556°
Johnson	Section 6 - Old Burnt Log trail crossing to Landmark bridge	6.50 km	3	N 44.69737° W 115.545397°	N 44.652499° to W 115.54237°
Johnson	Section 7 - Landmark bridge to Swamp Creek	10.05 km	3	N 44.652499° to W 115.54237°	N 44.597181° to W 115.524275°
Burnt Log	Section 1 - Mouth of Burnt Log Creek to 1.1 km above mouth of Buck Creek	2.8 km	10	N 44.802991° W 115.518556°	N 44.780333° to W 115.520741°
Total Surveyed Length		40.91 km			

Adult Monitoring - Performance Measures

Abundance

Index of Spawner Abundance – Redd Counts

(Refer to Spawning Ground Surveys discussion above)

Total Adult Escapement Matrix

Calculations of adult abundance to tributary, as well as other adult monitoring performance measures (e.g., those that use adult abundance values or subsets of abundance in their derivation), were based on information provided in a total adult escapement matrix. The matrix was stratified by origin, age, and sex of Chinook salmon that were either trapped at the weir, or were estimated through mark-recovery or redd

count expansions. Proportional assignment of biological data (e.g., origin, age, sex, or length) obtained from fish that were handled ('input data') provided the basis for determinations made on fish that lacked the biological information ('estimated data'), thus providing the information needed to account for all fish that were estimated to have returned to the tributary. Methods of derivation and assumptions used in the matrix are presented below.

Input Data:

Biological data obtained from fish trapped at the weir were used to establish origin, length, and sex of a base population that were either 1) taken for broodstock, 2) euthanized at the weir, or 3) or released above the weir to spawn. The proportion of the base population that were spawned at the hatchery, collected as mortalities at the weir (including euthanized HOR strays), or recaptured from spawning ground surveys, provided carcasses from which age determinations could be made (origin, sex, and length were known). Aging methods, which included visual implant elastomer (VIE), coded wire tags (CWT), passive integrated transponder (PIT) tags, or age-fin analysis, combined with biological data obtained at the weir, were used to establish length at age relationships. Hatchery fish (HOR supplemented or HOR strays) were then separated from natural-origin fish and each group stratified into an array of five-centimeter fork length bins. Origin-specific proportions of the total number of fish occurring in each length bin were then calculated for each respective age category to form a matrix from which fish length at age assignments for fish lacking biological data could be made.

Assumptions associated with the input data included 1) the sex of a fish was validated upon dissection of the carcass; corrections on sex misidentification from the weir were changed on a 1:1 basis; 2) opercle tags were all recorded correctly; 3) the origin of a fish was based on best known validation techniques (i.e., recovery of CWT from a carcass that scanned negative at the weir was changed to CWT positive); corrections on origin misidentification were changed on a 1:1 basis.

Estimated Data:

Those fish in the total abundance estimate that lacked information pertaining to origin, age, or sex included fish above the weir that were estimated through the mark-recapture formula (see below), and/or fish below the weir that were estimated through fish per redd counts (see below). We used the origin, age, and sex of above-weir, unmarked carcasses to define origin, age, and sex of the expanded component of the total abundance estimate (refer to Appendix Table 1 for clarification). To verify if unmarked carcasses were truly representative of the expanded component, we first compared the origin and sex of carcasses collected above the weir to origin and sex of fish collected at the weir (2-way ANOVA, $\alpha=0.05$). We then compared the origin and sex of above-weir unmarked carcasses to above-weir marked carcasses (χ^2 goodness-of-fit test $\alpha=0.05$). A similarity between biological characteristics of fish captured at the weir and captured as carcasses suggests either capture method could be used to describe the expanded component; however a difference between unmarked and marked carcasses suggests the unmarked component would best describe the expanded component.

Adult Abundance to tributary

This performance measure accounts for the total adults returning (TAR) to Johnson Creek each year and is calculated by summing up three distinct segments; total adults above the weir (AAW), plus adults removed at the weir (ARW), plus total adults below the weir (ABW):

$$TAR = AAW + ARW + ABW$$

Adults Above the Weir

Adults above the weir was calculated by marking adult fish at the weir/trap and then ‘recapturing’ the marks as carcasses during extensive spawning ground/carcass surveys. Numbered opercle disk tags were applied to Johnson Creek Chinook salmon to enable enumeration of fish released above the trap.

Opercular-tagged and non-tagged carcasses recovered above the weir during spawning ground and supplemental carcass surveys were tallied (assuming equal distribution and probability of recovery). We used the adjusted Petersen estimator (Chapman 1951), a commonly used mark-recapture formula (Cousens et al. 1982), to approximate an unbiased escapement estimate of adults above the weir (AAW). Carcass data (which included adults and age 3 jacks) was applied to the following terms:

$$\hat{AAW}_{M/R} = \frac{(M+1)(C+1)}{(R+1)} - 1$$

Where M is the number of marked (opercular-tagged) adults released above the weir (excludes any marked fish that are recaptured in the downstream trap box and remain downstream of the weir), C is the total number of carcass recoveries (marked and unmarked) above the weir, and R is the number of marked (opercular-tagged, or lost opercular-tag with identifying staple marks) carcasses found above the weir. All carcass recoveries that were unidentifiable for marks were removed from analysis. The variance for this estimate was calculated as:

$$Var_{\hat{AAW}} = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}$$

Adults Removed at the Weir

Adults removed at the weir include all fish removed for broodstock, weir mortalities, and all strays euthanized.

Adults Below the Weir

Adults below the weir is a derived value; to correctly characterize the composition of fish below the weir, we use information taken from the composition of fish arriving at the weir and composition of fish spawning above the weir.

For fish below the weir, origin, age, and sex determinations were made by 1) developing proportions of the origin, age, and sex of fish comprising the abundance to tributary estimate, which excluded below-weir locations; 2) enumerating unmarked carcasses collected at various locations below the weir and assigning them to the appropriate origin, age (age was determined through ageing techniques or through length at age assignment), and sex categories; 3) multiplying the corrected female per redd ratio upstream of the weir (see description below) by the male:female ratio above the weir to obtain a corrected fish:red ratio and then multiplying the corrected fish:red ratio by the number of redds below the weir to obtain the below-weir escapement estimate; 4) multiplying values obtained from step three by corresponding values obtained in step one to obtain origin, age, and sex assignments for estimated below-weir fish; 5) totaling values obtained in step two and step four (refer to Appendix Table 2 for clarification).

Fish per Redd Estimate

An initial fish per redd (FPR) estimate was derived by dividing above-weir total escapement by the number of redds observed above the weir. Because of the larger sample size of fish trapped at the weir, we used the above-weir FPR estimate to define the below-weir estimate, and ultimately the below-weir escapement estimate.

Assignment of the above-weir FPR ratio to derive a below-weir escapement estimate was based on the premise that the above-weir female:red and male:red ratios were characteristic of below-weir ratios. We knew this assumption to be false since broodstock and stray removal artificially altered the original composition of males and females captured at the weir. It was therefore necessary to adjust for the changes in above-weir sex ratios that resulted from removal of fish at the weir in order to accurately define below-weir escapement estimates.

In order to obtain an ‘adjusted’ above-weir fish per redd ratio we first calculated female:red and male:red estimates. We obtained an adjusted female:red estimate by dividing the total (included fish derived by the adjusted Peterson estimator) number of females above the weir by the number of above-weir redds. The male:red estimate was calculated by multiplying the female:red estimate by the original (pre-removal) male:female sex ratio. The sum of the female:red and male:red ratios yielded the ‘adjusted’ fish:red ratio.

Multiplying the ‘adjusted’ fish per redd ratio by the number of redds below the weir yielded an estimated below-weir escapement estimate. Calculation of the entire stream FPR was done by taking the total fish available to spawn divided by the total number of redds.

Calculations of fish per redd estimates upstream of the weir included corrections for sex and/or origin misidentifications made at the weir. Fish sex was validated upon examination of internal anatomy of any uniquely identifiable carcass collected from fish released above the weir and/or from fish retained for broodstock. Origin was validated

through the examination of marks and/or the presence/absence of fins. If a fish was determined to be misidentified at the weir, the reported data was changed (1:1 change) to reflect the actual sex and/or origin of the individual.

Spawner Abundance

Spawner abundance was defined as the number of adults (jacks included) present in a tributary that were available at the time of spawning. This measure included the Total Adults Returning (*TAR* explained above) and accounted for reductions in population size due to fish removed at the weir for broodstock, fish that were euthanized at the weir (e.g., strays), pre-spawn mortalities, and/or weir mortalities.

Hatchery Ratio

Hatchery fraction was calculated using two variants of parents; estimated total escapement, and estimated total spawner abundance. For both variants, the origin structure of fish captured at the adult trap and released upstream of the weir was used to determine the above-weir proportion of each origin type. Origin structure of fish captured at the adult trap was also used to estimate below-weir population composition. The total number of fish captured at the weir was divided by each contributing origin total (numbers of NOR, HOR supplementation, and HOR strays captured at the weir) to calculate respective proportions. These proportions were subsequently multiplied by the below-weir abundance estimate (corrected FPR estimate upstream of weir * number of redds below weir) to define contributions of fish, by origin, to the total below weir estimate. The hatchery fraction of the total escapement was then calculated by taking the point estimate of the total escapement (*refer to methods of calculation above*) and dividing it by the total number of fish determined to be of hatchery-origin (includes HOR supplemented and stray fish above and below the weir).

The hatchery fraction of spawner abundance was calculated the same as total escapement yet excluded fish removed for broodstock, weir mortality, pre-spawning mortality, and known strays. Calculations for the two measures did not include fish that were subsequently recaptured in the downstream trap box, released downstream, and remained downstream of the weir.

Run Prediction

Adult run predictions were calculated using two different methodologies; pre-season (prior to the migration of fish) and in-season (when fish are migrating upstream). The pre-season estimate was calculated using run-reconstruction information from the last five brood years (cohorts). The average age class structure (determined by fork length breakouts for NOR fish and CWT and VIE marks for HOR fish) by origin type of adults returning to Johnson Creek was used to estimate the run size for future generations of fish. The estimated number of age 4 and 5 year old fish was calculated by using the number of adults that most closely approximates the 5 year average age class structure. The three year old component of the run prediction also used migrant to adult ratios and juvenile abundance estimates. The three year old component was calculated by

multiplying the juvenile abundance estimate (or known release number for hatchery-origin fish) by the migrant to adult ratio and by the average five-year proportion of adults returning as age three.

The in-season adult run predictions were based, in part, on juvenile migrant abundance estimates. For a given year, we calculated expected adult runs by utilizing representative PIT tags (barged or bypassed in the same ratio as unmarked fish) across life stages and independent for each origin type in conjunction with the average Johnson Creek adult run timing at Bonneville and the average Johnson Creek adult survival from Bonneville to Johnson Creek (averages of the four-years of PIT tag data that precede the year in question). The proportion of PIT tagged adults returning to Bonneville (by origin type and lifestage) was multiplied by the actual or estimated juvenile migration number (by origin type and lifestage) and then multiplied by the average run timing and average survival proportions of adults returning to Johnson Creek.

Survival-Productivity

Pre-spawn mortality

As described above, pre-spawn mortality was characterized as the percentage of female spawners recovered as carcasses during spawning ground surveys that were zero to 25% percent spawned. This percentage can be expanded to an estimated abundance of pre-spawn mortality (PSM) by multiplying the percentage by the estimated adult escapement. Stream surveys in core areas that fish hold prior to the spawning period were walked every week starting in July. Accurate determination of pre-spawn status of males was not possible due to sperm regeneration, therefore, male carcasses found prior to the completion of the first redd were the only ones that could be considered PSM.

Distribution

Adult spawner spatial distribution

Chinook salmon redd distribution was used as an index of adult spawner spatial distribution. Standard spawning ground survey methods were used to compare redd distribution between pre- and post-supplementation periods in Johnson Creek. We used redd locations to determine how spawning adults were dispersing throughout the available spawning habitat. Redds were counted during foot surveys in spawning areas from early August to mid-September. Surveys were conducted in known spawning areas covered by the traditional spawning ground survey transects. Redd locations were marked using global positioning satellite (GPS) units and plotted on maps.

Determinations and comparisons of the spawning distribution of NOR and HOR supplementation Chinook salmon in Johnson Creek were also made by using GPS technology to mark and compare specific (within section) locations of carcasses. Origin-specific carcass locations of jacks, adult males, and females recovered above the weir were stratified by one kilometer analysis units and compared using a χ^2 goodness-of-fit test. The χ^2 test allowed us to calculate the expected frequency of carcasses in each

analysis unit by applying the equal portion (uniform) of the total carcass sample size to each unit. The goodness-of-fit test allowed us to test the following hypothesis:

H₀: There is no difference in distribution of carcasses by origin between hatchery fish and naturally produced fish spatially in Johnson Creek

H_a: There is a significant difference in distribution of carcasses by origin between hatchery fish and naturally produced fish spatially in Johnson Creek

We considered the fact that inclusion of males in the sample may not be an accurate representation of spawner distribution due to the fact that males tend to roam post-spawn, however the exclusion of males resulted in a significantly reduced sample size (using the one-kilometer analysis units) and precluded our ability to conduct statistically robust tests for differences. We also considered combining carcasses recovered below the weir with those collected above the weir, but determined that the removal of fish at the weir for broodstock purposes alters the composition of the above-weir carcass population, and would in turn artificially alter what is expected to be recovered below the weir. It is also known that the majority of spawning occurs above the weir in the index area (around 92% on average), which further emphasizes the need to consider the possibility of a non-uniform distribution of spawners (and carcasses) throughout available spawning habitat. We thus conducted above and below weir evaluations of spawner spatial distribution independently.

Disease frequency

Each year, the IDFG Eagle Fish Health Lab in Eagle, ID samples Johnson Creek adult female Chinook salmon used as broodstock to test for bacterial kidney disease (BKD), infectious hematopoietic necrosis (IHN), infectious pancreatic necrosis (IPN), whirling disease (WHD), and North American viral hemorrhagic septicemia (NAVHS).

Life History

Age Class Structure/Age at Return

Annual age class structure was characterized by proportionally distributing ocean age returns into five centimeter fork length bins. Methods for determining individual fish age for HOR supplemented fish included; known age assignment via CWT, PIT tags, and VIE tags. Unknown ages for HOR strays was based on proportional length at age data obtained from CWT recoveries at the LSRCF SFSR Satellite Facility trap during 2007 (data downloaded from the Regional Mark Information System (RMIS)). Age determination for NOR fish used known age PIT tag information and dorsal fin ray indices obtained from carcass surveys. Dorsal fin rays were collected from carcasses and aged by IDFG using techniques described by Copeland et al. (2007). Undetermined ages of NOR and HOR supplemented fish were determined by applying the length at age proportional distribution of aged fish. Fork lengths obtained from fish measured at the weir were used in the analysis when ever possible in order to prevent bias resulting from differences in measurements of fish obtained during carcass surveys.

Size at Return

Adult size-at-return is primarily a function of ocean growth and duration of ocean residence; length is a beneficial descriptor for comparing relative growth experienced by fish during ocean rearing. Fork and mid-eye hypural lengths of NOR and HOR fish were obtained from carcasses and measurements from fish interrogated at the weir.

Percent Females

Similar to hatchery fraction, this performance measure was calculated using two parental variants; estimated percentage of females in the total escapement, and estimated percentage of females in the total spawner abundance. Calculations for percent females for both measures used one of three data sources, 1) weir data, 2) total known-origin carcass recoveries, and 3) weir data and unmarked carcasses above and below the weir.

The percentage of females in the total estimated escapement includes abundance estimates (refer to methods discussed above) of total males and females, by origin, that were estimated to have returned to Johnson Creek (e.g. fish captured at weir that were released upstream and remained upstream, broodstock spawned, broodstock mortalities, fish euthanized at the weir, weir mortalities, estimated unmarked fish above the weir, fish captured at the downstream trap-box at the weir that were released downstream and remained downstream, and unmarked fish below the weir). The total numbers of females of each origin type were divided into the total number of fish (origin-specific) to derive origin-specific percentage of females in the total estimated escapement. Total females returning to Johnson Creek (regardless of origin) were divided by the total escapement estimate to arrive at an overall percentage of total females.

The percentage of females estimated to be in the total spawner abundance relied upon the same derivations as total estimated escapement, yet excluded fish taken for broodstock, fish that were euthanized at the weir (e.g., strays), pre-spawn mortalities, and/or weir mortalities.

Fecundity by Age

Fecundity by age was determined using dorsal fin ray aging technology (analyzed by IDFG) and PIT tag technology. Average fecundity for NOR fish was determined by utilizing the NOR fish taken for hatchery broodstock. Green eggs per female were enumerated using an egg counter. Fork length data per female was collected to determine relationships between fecundities.

Adult Run-Timing

Adult run-timing, as described by adult passage at LGD, relied upon detection of population-specific adults via PIT tags. It required a sufficient number of PIT tag detections to achieve significant detections upon return. If adequate detections were achieved, the Julian date for the 10%, 50%, and 90% passages was calculated.

Run-timing of adults to Johnson Creek was determined by summarizing daily adult enumeration by week in relation to season-wide abundance in frequency distribution of the weir. Julian dates of the 10%, 50%, and 90% passage dates to Johnson Creek were generated directly from cumulative capture data.

Spawn-Timing

Spawn timing of NOR and HOR supplementation Johnson Creek fish was determined through weekly multiple pass spawning ground surveys. Spawn timing of NOR fish that were collected at the trap/weir and transported to the LSRCP SFSR satellite facility was determined by sorting fish twice weekly for spawn readiness (a.k.a. 'ripeness'). Comparisons of spawn times between fish retained for broodstock and dates when carcasses were collected in Johnson Creek provided a tool to determine the possibility of divergence between an artificial versus natural state of spawning.

RESULTS & DISCUSSION

Adult Monitoring – Field Operations

On June 13, 2007, personnel from the JCAPE M&E project assisted JCAPE O&M personnel with the installation of the picket weir and trap. The weir was made fish tight on the 14th and began operation in late afternoon of that day. The timing of trap/weir installation and its onset of operation occurred when flows were low enough to enable personnel to work safely across the entire channel. The first adult Chinook salmon was trapped on June 20 and the last fish on September 11. The weir was removed from the river on September 12 and 13. Overall, 380 Chinook salmon were trapped in Johnson Creek in 2007. Problems encountered during weir operation were primarily associated with wildfire activity, which affected day-to-day logistics, and influenced sampling frequency.

Pre-spawning mortality surveys started in early July and continued through mid-September. It is likely that some unspawned carcasses weren't (or never are) detected by survey efforts due to effects from predation and/or poor efficiency at locating jacks (refer to pre-spawning mortality section for further discussion).

Observations of live fish were first made July 9 in Section 4. The first completed redd was documented August 11 in Burnt Log Creek. Spawning ground and carcass surveys concluded September 18.

Adult Monitoring – Performance Measures

Abundance

Index of Spawner Abundance – redd counts

A total of 74 new redds were observed in the Johnson Creek drainage between August 11 and September 11 (Table 3). Similar to previous years, the majority of redds observed throughout the mainstem occurred in Section 4; 63 of the 72 mainstem redds were enumerated in Section 4, comprising 88% of the total. One redd was observed in Section 1 (1%), seven redds in Section 2 (10%), and one redd in Section 5 (1%) which accounted for all other observations made in the mainstem. The only section within which live fish were observed and no redds documented was Section 3. In Burnt Log Creek, a total of two redds were observed between July 14 and September 8 (Table 4).

In Johnson Creek a total of 121 (118 known-origin) carcasses were collected out of Sections 2, 3, 4, and 5 (Table 3). Seventy-three of the 121 carcasses were collected during routine redd surveys while 48 were collected during surveys specifically designed to only collect carcasses (a.k.a. supplemental surveys). Four hundred and thirty two (432) live fish were observed over the survey period in all but two sections. In Burnt Log Creek one live fish was observed and no carcasses were collected.

Table 3. Multiple pass spawning ground and carcass surveys conducted by Nez Perce Tribe employees in Johnson Creek in 2007. Numbers in parenthesis indicate the number of additional carcasses that were collected prior to the date shown.

Section/Transect	Date	# New redds	# New Redds in Progress	Live fish	Carcasses
Section 1/ Mouth to Screw Trap (6.28 km)	9-Jul	0	0	0	0
	16-Jul	0	0	3	0
	23-Jul	0	0	0	0
	30-Jul	0	0	0	0
	5-Aug	0	0	1	0
	12-Aug	0	0	0	0
	21-Aug	0	0	1	0
	27-Aug	1	0	1	0
	5-Sep	0	0	0	0
	10-Sep	0	0	0	0
Subtotal		1	0	6	0
Section 2/ Screw Trap to Adult Weir (1.91 km)	10-Jul	0	0	0	0
	17-Jul	0	0	0	0
	24-Jul	0	0	0	0
	31-Jul	0	0	0	0
	6-Aug	0	0	2	0
	14-Aug	0	0	5	2
	20-Aug	0	0	3	0
	27-Aug	1	4	14	0
	6-Sep	6	0	1	0 (6)
	11-Sep	0	0	0	0 (1)
	18-Sep	0	0	0	0
Subtotal		7	0	25	2 (7)
Section 3/ Adult Weir to Deadhorse Rapids (1.56 km)	11-Jul	0	0	0	0
	19-Jul	0	0	0	0
	26-Jul	0	0	0	0
	2-Aug	0	0	0	0
	9-Aug	0	0	0	0
	16-Aug	0	0	0	0
	30-Aug	0	0	0	0
	6-Sep	0	0	1	4 (4)
Subtotal		0	0	1	4 (4)
Section 4/ Deadhorse rapids to Moose Cr. (Index Area) (5.45 km)	9-Jul	0	0	4	0
	17-Jul	0	0	1	0
	23-Jul	0	0	3	2
	30-Jul	0	0	3	0
	6-Aug	0	0	3	1
	13-Aug	5	0	21	0
	20-Aug	9	2	102	0
	26-Aug	23	6	170	9
	5-Sep	23	1	41	48 (25)
	11-Sep	3	0	1	4 (12)
Subtotal		63	9	345	64 (37)

Section/Transect	Date	# New redds	# New Redds in Progress	Live fish	Carcasses
Section 5/ Moose Cr. to Burnt log Cr. (6.36 km)	13-Jul	0	0	10	1
	20-Jul	0	0	0	0
	27-Jul	0	0	10	0
	10-Aug	0	0	18	0
	17-Aug	0	0	1	0
	24-Aug	0	0	13	0
	31-Aug	0	1	3	0
	7-Sep	1	0	0	2
	17-Sep	0	0	0	0
Subtotal		1	1	55	3
Section 6/ Old Burnt Log Trail Crossing to Landmark Bridge (6.50 km)	21-Aug	0	0	0	0
	6-Sep	0	0	0	0
Subtotal		0	0	0	0
Section 7/ Landmark Bridge to Swamp Cr. (10.05 km)	21-Aug	0	0	0	0
	6-Sep	0	0	0	0
Subtotal		0	0	0	0
TOTAL		72	10	432	73 (48)

Table 4. Multiple pass spawning ground and carcass surveys conducted by the Nez Perce Tribe (NPT) employees in Burnt Log Creek (tributary to Johnson Creek) in 2007.

Section/Transect	Date	# New redds	# New Redds in Progress	Live fish	Carcasses
Section 1a/ Mouth to 2 km upstream of Buck Creek (3.32 km)	14-Jul	0	0	0	0
	21-Jul	0	0	0	0
	28-Jul	0	0	0	0
	4-Aug	0	0	0	0
	11-Aug	2	0	0	0
	20-Aug	0	0	1	0
	30-Aug	0	0	0	0
	8-Sep	0	0	0	0
TOTAL		2	0	1	0

Total Adult Escapement Matrix

Table 5 provides the basis for calculations of abundance at different locations in Johnson Creek. The matrix is stratified by estimates of origin, age, and sex of adults that returned and those estimated to have returned to Johnson Creek.

Table 5. Total adult escapement matrix. Refer to Appendix Table 1 and Appendix Table 2 for additional definition of unmarked carcasses collected above and below the weir (respectively).

Location	Origin	NOR								HOR supplemented						HOR stray						Total
	Age	3		4		5		6		3		4		5		3		4		5		
	Sex	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	
Captured at weir, released and remained upstream		0	33	2	38	18	10	1	0	0	141	25	43	2	2	0	0	0	0	0	0	315
Broodstock spawned		0	1	8	17	15	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	48
Broodstock mortalities		0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Euthanized at weir		0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7	0	4	0	0	12
Weir mortalities		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Estimated unmarked fish above weir		0	0	3	3	12	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	21
Captured at weir and remained downstream of weir		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Estimated fish between mouth and screw trap		0	0	0	1	1	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	5
Estimated fish between screw trap and adult weir		0	2	1	3	10	1	0	0	0	9	3	3	0	0	0	0	0	0	0	0	32
Total Escapement		0	37	15	62	59	16	3	0	0	156	28	47	2	2	0	7	0	4	0	0	438
Total Escapement Above Weir		0	33	5	41	30	10	1	0	0	144	25	43	2	2	0	0	0	0	0	0	336
Total Escapement Above Screw Trap		0	35	6	44	40	11	1	0	0	154	28	46	2	2	0	0	0	0	0	0	369
Total Fish captured at Adult Weir		0	35	11	55	36	15	3	0	0	142	25	43	2	2	0	7	0	4	0	0	380
Total Fish collected for Broodstock		0	2	9	17	17	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	52

Adult Abundance to Tributary

In 2007, there were seven unmarked adult carcasses recovered above the weir indicating the lack of a census. Based on an estimated above-weir escapement of 336 (± 14), plus a below-weir escapement estimate of 38, and the addition of 52 Chinook taken for broodstock and 12 Chinook euthanized at the weir, the total estimated escapement to Johnson Creek for the 2007 migration year was 438 summer Chinook salmon (Table 6). Breakouts by origin for total escapement included an estimated 206 NOR fish, 221 HOR supplementation fish, and 11 HOR strays (refer to Table 5).

Table 6. Estimates of total escapement to Johnson Creek in 2007.

Estimated Escapement Above Weir ($\pm 95\%CI$)	Estimated Escapement Below Weir	Fish Removed for Broodstock	Euthanized Fish at the Weir	Total Estimated Escapement to Johnson Creek
336 (14)	38	52	12	438

Spawner Abundance

Upon subtracting fish taken for broodstock and accounting for strays (fish euthanized at the weir) and pre-spawning mortality, the total estimated spawner abundance was 359 adults (Table 7). Breakouts by origin for total spawners included an estimated 133 NOR fish, 226 HOR supplementation fish, and 0 strays (refer to Table 5). Weir efficiency over the entire adult run was 93.75%.

Table 7. Estimates of spawner abundance in Johnson Creek, 2007 (values in brackets indicate deductions).

Total Estimated Escapement to Johnson Creek	Fish Removed for Broodstock	Euthanized Fish at the Weir	Prespawning Mortality	Total Estimated Spawner Abundance
438	[52]	[12]	[15]	359

Expansion Estimate

In order to assign sex and origin to the unmarked component of the total escapement estimate, we first determined whether the sex and origin of carcasses ($n=103$) were proportionate to the sex and origin of fish collected at the weir and released to spawn ($n=315$). Comparisons, which were conducted using a 2-way ANOVA, indicated that proportionately, the sex and origin of Chinook collected as carcasses did not differ significantly from sex and origin of fish trapped at the weir (Table 8).

Table 8. Comparison of origin and sex of adult Chinook salmon captured at the adult weir and as carcasses. Tests for differences in proportions were conducted using a 2-way ANOVA ($\alpha=0.05$).

Source of Variation	Degrees of Freedom	Sum of Squares	Mean of Squares	F-Statistic	P-value
Origin	1	0.0460	0.0460	0.2460	0.6200
Sex	1	0.0176	0.0176	0.0940	0.7590
Origin x Sex	1	0.0002	0.0002	0.0010	0.9750
Residual	414	77.5200	0.1870		
Total	417	77.6200	0.1860		

After verifying that carcasses were indicative of the sex and origin of the naturally spawning population, we tested to see whether there were differences between sex and origin of marked and unmarked carcasses. Using a χ^2 goodness-of-fit test ($\alpha=0.05$), we determined that the origin and sex of marked carcasses differed significantly from sex and origin of unmarked carcasses (Table 9). These differences meant that the origin and sex of unmarked carcasses should be used instead of the marked carcasses to proportionately characterize the expanded component of the total escapement estimate.

Table 9. Comparison of origin and sex of adult Chinook salmon captured above the weir as marked and unmarked carcasses. Tests for differences were conducted using a χ^2 goodness-of-fit test ($\alpha=0.05$).

Carcass Type	Origin		χ^2 P value	Sex		χ^2 P value
	HOR	NOR		Male	Female	
Marked	63	40	0.001	88	15	0.042
Unmarked	1	6		2	5	

The above-weir expanded component of the total escapement estimate was comprised of a total of 21 fish; seven of which were unmarked carcasses and fourteen that were expansion fish (refer to Appendix Table 1 for origin, age, and sex breakdown). It was estimated that there were a total of 18 NOR fish and 3 HOR supplementation fish; 3 Chinook salmon were estimated to be NOR male and 15 to be female. The HOR component was comprised of three males.

Based on the eight redds between the mouth and the weir, and on a corrected fish-per-redd ratio of 4.7, we estimated there to be a total of 38 adults below the weir in 2007. The origin composition of this total included an estimated 19 NOR adults and 19 HOR adults (included one HOR male that escaped below the weir and failed to return above the weir). Sex composition of the NOR component was estimated to include seven males and 12 females. Sex composition of the HOR component was estimated to include 16 males and three females (refer to Appendix Table 2 for origin, age, and sex breakdown).

As discussed previously, calculations of origin and sex composition below the weir were based on two methods: 1) origin and sex of carcasses collected below the weir ($n=9$), and 2) proportional distribution of the origin and sex of fish comprising the above-weir estimate of total escapement ($n=400$; HOR fraction = 57%). Seven of the nine carcasses collected below the weir were NOR females, while the remaining two fish were comprised of one HOR supplementation female, and one NOR male. Origin and sex of the remaining 29 fish were determined using above-weir proportions (12 NOR and 17 HOR). Upon adding one HOR male that escaped below the weir and failed to return above the weir, there were a total of 19 NOR fish and 19 HOR fish.

Fish per Redd

As discussed previously, it was necessary to develop an ‘adjusted’ fish-per-redd estimate in order to account for effects of broodstock and stray removal on the above-weir sex composition. As such, the female:redd estimate (0.95) was multiplied by the original male:female sex ratio (3.94) to calculate the male:redd estimate (3.76). The male:redd estimate and female:redd estimate were then summed to yield the adjusted fish:redd ratio of 4.71.

Multiplying the ‘adjusted’ fish per redd ratio of 4.71 by the number of redds below the weir ($n=8$) yielded an estimated below-weir escapement of 38 fish. Calculation of the entire stream FPR was done by taking the total fish available to spawn (374; 336 above weir + 38 below weir) divided by the total number of redds (74; 66 above weir + 8 below weir), resulting in a 5.05 FPR (Table 10; see also Table 5 and Appendix Tables 1-2 for additional clarification regarding sex and origin breakdown).

Table 10. Johnson Creek redd counts, estimated number of adult returns, and fish per redd estimates for the sections: above the weir, below weir; and for entire stream in 2006.

	Redds ¹	Escapement Estimate ²	Fish Per Redd
Above Weir	66	336	5.09
Below Weir	8	38	4.71
Entire Stream	74	374	5.05

¹ Redds counted include all counts on Johnson Creek and tributaries above the Johnson Creek adult weir.

² Total escapement above the Johnson Creek adult weir excludes fish removed for broodstock, weir mortality, and known strays.

Spawner Abundance

Upon deducting fish removed for broodstock ($n=52$), weir mortality/ known strays ($n=12$), and pre-spawning mortality ($n=15$), an estimated 359 summer Chinook salmon were available to spawn naturally.

Hatchery Ratio

An estimated 56 percent ($n=246$) of the total escapement ($n=438$) of adults to Johnson Creek was made up of hatchery-origin Chinook salmon (includes HOR strays). Hatchery-origin Chinook salmon comprised an estimated 63 percent ($n=225$) of the total spawner abundance ($n=359$) in Johnson Creek, and accounted for an estimated 64 percent ($n=207$) of all spawners located above the weir ($n=322$). The higher percentage of hatchery-origin fish that contributed to the spawning aggregate is a function of the reduction of 64 fish from the total escapement point estimate. Reductions include the removal of 52 NOR adults for broodstock, and 12 euthanized strays (includes 1 mistakenly euthanized NOR fish).

Run Prediction

Adult run predictions for NOR and HOR supplementation Johnson Creek Chinook salmon, are provided in Table 11. Predictions for both origin types were underestimated with HOR supplementation predictions representing the greatest percentage of error. Run predictions for 2008 are shown in Table 12. Discounting the percentage error associated with our predictions, it is likely that escapement in 2008 will be higher than recent years.

Table 11. Actual and predicted escapement of NOR and HOR supplementation adult Chinook salmon returning to the Johnson Creek weir in 2007.

Age	NOR (Actual)	NOR (Predicted)	HOR Supplemented (Actual)	HOR Supplemented (Predicted)
3	35	1	144	28
4	73	51	68	45
5	62	19	4	12
6	3	0	0	0
Total	173	71	216	85
Percent Error	Under estimated 143.7%		Under estimated 154.1%	

Table 12. Predicted escapement of NOR and HOR supplementation adult Chinook salmon returning to the Johnson Creek weir in 2008.

Age	NOR	HOR Supplemented	Total
3	27	202	229
4	347	238	585
5	72	10	82
Total	446	450	896

Survival-Productivity

Pre-spawn mortality

Crews conducted weekly walks of the seven sections of Johnson Creek from July 1 through September 15 and documented a total of four Chinook salmon pre-spawn mortalities; two of the four were males that had died prior to the onset of spawning, while the other two Chinook salmon were females that were zero to 25% percent spawned (Table 13). One unknown sex pre-spawn carcass was also found prior to the first completed redd.

It is likely that the overall estimate of pre-spawn mortality is biased low and should be somewhere between 4.2% (males) and 7.1% (females). The estimate of 4.2% overall pre-spawn mortality is conservative due to our inability to account for effects of predation on carcasses or due to our inability to make determinations of spawning success (or lack thereof) of males that reached the spawning grounds but died before spawning. It is known that predators, such as various species of raptors or bear, remove adult carcasses from the spawning ground prior to the fish being enumerated. Partially consumed carcasses or opercle disc tags observed in scat, as well as visual accounts of predators removing carcasses from the stream support this statement.

As stated in the methods section, because of their ability to regenerate sperm, males were only considered a pre-spawn mortality if they were found as carcasses prior to the onset of spawning. For 2007, this meant that the only males that could be accurately defined as a pre-spawn mortality were those collected as carcasses between July 1 and August 11. The total number of pre-spawn males collected over this 41-day period was thus representative of the 73-day sampling period (July 1 through September 11) thereby biasing the estimate low due to the omission of 32 days worth of potentially unrealized carcass collection. Conversely, females were eligible for consideration as a pre-spawn mortality throughout the entire staging and spawning season, which in turn makes them a better indicator of overall pre-spawn mortality.

Table 13. Number of adult female and male Chinook salmon prespawn mortalities that were recovered above and below the weir during 2007. Estimates are from Johnson Creek HOR supplementation, HOR stray, NOR and unknown origin carcass surveys. Carcasses that were not able to be determined for percent spawn are not included.

Sex	Percent of pre-spawn carcasses				
	HOR	HOR Stray	NOR	Unknown	Overall
Female	(1/9) 11.1%	N/A	(1/19) 5.3%	N/A	(2/28) 7.1%
Male	(0/58) 0.0%	N/A	(1/31) 3.6%	(1/1) 100%	(2/90) 2.2%
Unknown	N/A	N/A	N/A	(1/1) 100%	(1/1) 100%
Overall	(1/67) 1.5%	N/A	(2/50) 4.0%	(2/2) 100%	(5/119) 4.2%

Distribution

Adult spawner spatial distribution

The JCAPE project marked all adult 74 Chinook salmon redds with GPS coordinates in 2007 (Figure 5 and Appendix Figure 1 - Appendix Figure 5). Redds were constructed in Sections 1, 2, 4, and 5 and in Burnt Log Creek; redds were absent in Sections 3, 6, and 7.

Figure 5. Overall spawning distribution of adult summer Chinook salmon in surveyed sections of Johnson Creek, 2007.

Results from comparisons of HOR supplementation and NOR carcass distribution above the weir are presented in Table 14. Overall, there was not a significant difference ($P=0.4268$) in the distribution of adult carcasses collected above the weir. A chi-square evaluation of differences between HOR supplementation and NOR carcasses below the weir was not possible due to an inadequate sample size. There was, however, a predominance of NOR females (seven of the nine carcasses collected were NOR female) collected in the RKM 8 analysis unit. The location of RKM 8 relative to defined survey sections in Johnson Creek occurs in Section 2, just below the adult weir. Typically it is in this area that the majority of below-weir redds are found, and is almost predominately comprised of NOR spawners (defined by annual carcass recoveries). We suspect that the late-arriving group of NOR Chinook salmon in 2007 (see arrival timing section below) were ready to spawn upon entering Johnson Creek, and did so in the RKM 8 analysis unit. Upon spawning, the males moved upstream to later be collected as carcasses in upriver analysis units while the females remained near their redds to later be collected in RKM 8.

Table 14. Chi-square goodness of fit test for HOR supplementation and NOR adult summer Chinook salmon carcass distribution above the weir in Johnson Creek, 2007.

Analysis Unit (RKM)	HOR Supplementation		NOR		χ^2	P-value
	Observed	Expected	Observed	Expected		
9	6	4.8	2	3.2	0.72	0.9982
10	2	2.4	2	1.6	0.18	1.0000
11	6	7.2	6	4.8	0.54	0.9993
12	22	24.2	18	15.8	0.48	0.9995
13	4	5.4	5	3.6	0.96	0.9954
14	10	7.8	3	5.2	1.49	0.9827
15	10	9.7	6	6.3	0.03	1.0000
16	4	2.4	0	1.6	2.63	0.9170
Total	64	64	42	42	7.02	0.4268

Disease frequency

Two of the 25 females sampled in 2007 tested positive for BKD, both had low optical densities (greater than 0.1 and less than 0.25) enzyme-linked immunosorbent assay (ELISA) BKD values (R. Hill Nez Perce Tribe unpublished). All other tests were negative for the other pathogens in which tests were conducted.

Life History

Age Class Structure

Age at Return

Table 15 shows estimates of age class structure for all 438 Chinook salmon that escaped to Johnson Creek in 2007. As discussed previously, we relied upon proportional distributions of known age assignments and fin ray indices to determine ages for non-aged NOR, HOR supplementation, and HOR stray Chinook salmon. The use of proportional age assignments in our calculations of age class structure resulted in fractions, making it necessary to round estimates to the nearest integer, which invariably does not allow for direct comparisons to age at return data.

Table 15. Age class structure of natural origin (NOR), hatchery origin (HOR) supplementation and hatchery origin stray Chinook salmon that escaped to Johnson Creek in 2007.

Origin	Age 3 (BY04)	Age 4 (BY03)	Age 5 (BY02)	Age 6 (BY01)	N
NOR	37	77	75	3	192
HOR supplementation	156	75	4	0	235
HOR stray	7	4	0	0	11
Total	200	156	79	3	438

The number of HOR supplementation age-three fish (jacks) that returned to Johnson Creek in 2007 was proportionately higher than any other age class of returning adult. There were more than four times as many HOR supplementation jacks returning to Johnson Creek in 2007 than age-three NOR adults. The 2007 return year marked the second year in a row that age-six NOR Chinook salmon were present in the spawning aggregate.

Size at Return

Length frequency analyses for HOR supplementation Chinook salmon were stratified by age at return data, which relied upon PIT tags, VIE marks, and/or CWT tags that were collected in 2007. All lengths used were based on measurements taken at the weir. There were 137 age-three fish (One salt; BY04), 63 age-four fish (Two salt; BY03), and four age-five fish (Three salt; BY02), for a total of 204 usable samples (Figure 6).

Length frequency analyses for NOR adult Chinook salmon that returned to the Johnson Creek weir were also stratified by age at return data (Figure 7). Dorsal fin rays that were collected during carcass surveys were used to age a total of 105 NOR Chinook salmon. Twelve of the NOR fish were aged using PIT tags. There were 19 age-three fish, 40 age-four fish, 43 age-five fish, and 3 age-six fish.

As shown in Figure 6, there was minimal overlap in fork lengths per given age of HOR supplementation adults that returned to Johnson Creek. All but one HOR adult that was

aged as a three-year old measured between 43-63 cm (n=138). Similarly, all but one HOR adult that was aged as a four-year old measured between 68-87 cm (n=64). Three of the four age five fish measured between 93-105 cm.

Figure 7 illustrates a clear division in fork lengths of NOR Chinook salmon that returned as three and four-year olds; all nineteen fish that were aged as three-year olds measured between 48-56 cm. There was an overlap in fork lengths for fish that were aged as four- and five-year olds; 40 of the 57 fish that had fork lengths measuring between 65 and 87 cm were aged as four-year olds whereas, 15 of the 57 fish in the 65-87 cm length category were age-five. There was a lack of division in fork lengths for five and six-year old Chinook salmon.

Figure 6. Size at return of hatchery-origin supplementation adult Chinook salmon captured at the Johnson Creek adult weir and recovered as carcasses in 2007.

Comparisons of size at return for HOR supplementation and NOR adults were conducted using a Student's *t*-test (Table 16). Of the known-age and/or fin-ray aged fish, age three HOR supplementation adults returned at a significantly larger size ($P < 0.001$) than their NOR counterparts. The mean size at return for age four HOR supplementation adults was also significantly ($P < 0.04$) higher than size at return of age four NOR adults. There was not a significant difference in size at return of age five adults; however, the small sample size likely influenced the power of the test performed at an alpha equal to 0.05.

Figure 7. Size at return of natural-origin adult Chinook salmon captured at the Johnson Creek adult weir and recovered as carcasses in 2007.

Table 16. Comparison of size at return for 2007 HOR supplementation and NOR adults captured at the weir and recovered as carcasses (Student's *t*-test ($\alpha = 0.05$))

	Age 3			Age 4			Age 5		
	Mean FKL (cm)	<i>N</i>	<i>P</i> -value	Mean FKL (cm)	<i>N</i>	<i>P</i> -value	Mean FKL (cm)	<i>N</i>	<i>P</i> -value
HOR	53.6	137	<0.001	77.5	63	0.04	93.0	4	0.41
NOR	50.3	19		75.4	40		90.1	43	

Percent Females

Data used to define the percentage of Johnson Creek females in 2007 are presented in Table 7. The total percentage of females that were captured at the weir was 20.2% (77 out of 380 fish trapped at the weir were female). Comparisons of origin for all females captured at the weir show that 65% were NOR (50 out of 77 fish). Twenty-eight of the 52 fish removed for broodstock were NOR females (53.9%).

Table 17. Percentage of females that returned to Johnson Creek in 2007. Values shown reflect ‘corrected’ totals which are based on sex and origin adjustments, downstream captures that remained below the weir, and fish trucked from the SFSR satellite facility and released into Johnson Creek.

Disposition	Sex	NOR	NOR % Females	HOR	HOR % Females	Stray	Stray % Females	Total	Total % Females
Captured at weir	Males	105		187		11		303	
	Females	50	32.3	27	13.0	0	0.0	77	20.2
	Total	155		214		11		380	
Released above weir	Males	81		186		0		267	
	Females	21	20.6	27	13.0	0	0.0	48	15.2
	Total	102		213		0		315	
Broodstock	Males	24		0		0		24	
	Females	28	53.9	0	0	0	0.0	28	53.9
	Total	52		0		0		52	
Carcasses Recovered Below Weir	Males	0		0		0		0	
	Females	7	100.0	1	100.0	0	0.0	8	100.0
	Total	7		1		0		8	

Table 18 shows the percentage of females (by origin) that were estimated to have contributed to the total escapement to Johnson Creek in 2007 and the percentage that were estimated to have contributed to the spawning population. The percentage of NOR females contributing to the total escapement to Johnson Creek (40.1%) was more than three times that of HOR supplementation female spawners (12.8%). Upon the removal of 24 NOR males and 28 NOR females for broodstock needs, the percentage of females available for spawning decreased to 34.6%, which still exceeded the percentage of HOR supplementation females (12.6%) that were available to spawn by 2.7 times. The comparatively low percentage of HOR supplementation female spawners is a function of skewed sex ratios; there were 6.8 HOR supplementation males per 1 HOR female spawner versus 1.9 NOR males per 1 NOR female spawner. And, as discussed previously, the dominant component of HOR supplementation males were those ≤ 63 cm.

Fecundity by Age

Adult Chinook salmon fecundity of NOR fish spawned for broodstock is shown in Table 19. The average fecundity of all NOR females spawned was 4,576 with an average fork length of 87 centimeters. The average fecundity of age-four NOR female Chinook salmon was 3,907 eggs with an average fork length of 79 centimeters. Mean fecundity of age-five NOR Chinook salmon was 4,786 with an average fork length of 90 centimeters. Two of the females taken for broodstock were aged as six year olds, with an average fecundity of 5,681 and mean fork length of 94.5 centimeters. There was a positive relationship between individual fork length and fecundity of 2007 females ($R^2=0.63$).

Table 18. Percentage of females that returned to Johnson Creek in 2007 (by disposition and origin) as defined by two parental variants; total escapement and total number available to spawn. Estimates include fish below the weir.

	Sex	NOR	NOR % Females	HOR	HOR % Females	Stray	Stray % Females	Total	Total % Females
Total	Males	115		205		11		331	
Estimated	Females	77	40.1	30	12.8	0	0.0	107	24.4
Escapement	Total	192		235		11		438	
Total	Males	87		197		0		284	
Available	Females	46	34.6	29	12.8	0	0.0	75	20.9
To Spawn	Total	133		226		0		359	

¹ Excludes two Johnson Creek hatchery-origin (HOR) supplementation fish that were captured in the South Fork Salmon river adult facility and were trucked and released into Johnson Creek.

Table 19. Fecundity, fork length and age of natural-origin (NOR) adult Chinook salmon females captured at the Johnson Creek adult weir, 2007.

Age ₁	Fecundity	Fork Length
4	3,051	75
	3,316	77
	4,389	79
	3,549	79
	3,808	79
	3,953	79
	4,688	80
	4,498	85
	Average	79
5	4,766	83
	3,608	84
	3,699	87
	5,317	87
	4,203	87
	3,716	87
	3,335	88
	5,535	89
	5,351	90
	5,082	90
	4,786	91
	5,340	91
	5,200	93
	5,651	96
	6,194	101
	Average	90
6	5,190	92
	6,171	97
	Average	94.5
Overall Average		87

¹ – Age was determined using dorsal fin ray aging and/or PIT tag technology.

Adult Run-Timing

Arrival timing of Johnson Creek adults to Bonneville, McNary, Ice Harbor and Lower Granite dams are shown in Figure 8. Passage time for PIT tagged adults, from Bonneville to Lower Granite, was 69 days; June 1 – August 5 denote the 0 and 100% cumulative detection dates at BON and LGR (respectively). Because of the small sample sizes of returning PIT tagged adults (all origin types were combined); 1) it was not possible to calculate 10%, 50%, and 90% arrival times, and 2) arrival times of PIT tagged fish should only be considered to be an indicator of arrival times of non-PIT tagged fish.

Run timing of adult Chinook salmon captured at the Johnson Creek weir is shown in Figure 9. Similar to previous years, the run timing of returning adults was defined by two discrete periods in 2007. There was an ‘early’ component that arrived between June 20 and July 18, and a ‘late’ component, which arrived between July 19 and September 1. The 10, 50 and 90 percent arrival timing dates for fish captured at the Johnson Creek weir were June 27, July 18, and August 25, respectively.

Median arrival timing to the weir (Figure 10) occurred approximately 24 days earlier for HOR supplementation adults (by 7/16/07 50% of all HOR adults had been captured) than for NOR adults (by 8/8/07 50% of all NOR adults had been captured), which may have contributed to differences in spatial spawner distribution below the weir. Run timing completion, however, was similar for both origin types.

Figure 8. Arrival timing of Johnson Creek adult Chinook PIT tagged salmon at Bonneville, McNary, Ice Harbor, Lower Granite dams in 2007.

Figure 9. Run timing of natural-origin (NOR), hatchery-origin (HOR) supplementation and HOR stray adult Chinook salmon (combined) captured at the Johnson Creek adult weir in 2006.

Figure 10. Run timing of natural-origin and hatchery-origin supplementation adult Chinook salmon captured at the Johnson Creek adult weir in 2007.

Accurate representation of run timing is important for comparisons of life history characteristics and has bearing on broodstock management. The bi-modal run timing presented for 2007 and previous years (e.g., Rabe et al. 2006, Rabe and Nelson 2007) may be a function of weir location rather than when the run actually enters the system. Based on observations made during pre-spawning mortality surveys, adults will stage in the lower 8.2 kilometers of habitat prior to their detection at the weir. One hypothesis is that fish move into Johnson Creek as an aggregate in late-June or early July with some fish staging in the lower third of the system for two to three weeks, and then move up to spawn in July and late August. Provided we are able to find a suitable location, the weir may be relocated closer to the confluence in June of 2008.

Movement of the weir closer to the mouth would enable the JCAPE M&E program to test their adult arrival hypothesis and would provide a better representation of run timing. Relocation of the weir closer to the mouth would also improve our estimates of sex ratios (e.g., current below-weir estimates of sex ratios are wholly based on those obtained above the weir) and representation of the genetic makeup of returning adults.

Spawn-Timing

Spawning was first documented in Burnt Log Creek on August 11, 2007 (Table 20). Spawning peaked during the week of September 3rd, and concluded during the week of September 10th. In-hatchery spawn timing follows a pre-set schedule, occurring twice a week, and is based on female ripeness (Table 21).

Table 20. Spawn timing of naturally spawned Chinook salmon in Johnson Creek and Burnt Log Creek. Includes the number of redds, live fish and carcasses observed in all sections.

Week	# Redds	# Live Fish	# Carcasses
Aug 06 - 12	2	21	1
Aug 13 - 19	5	22	0
Aug 20 - 26	9	116	9
Aug 27 – Sep 02	25	188	0
Sep 03 - 09	30	43	89
Sep 10 - 16	3	1	17

Table 21. Spawn timing of artificially spawned Chinook salmon from Johnson Creek.

Date	Females Spawned
Aug 17	5
Aug 21	6
Aug 24	4
Aug 28	8
Aug 31	2

CHAPTER 3: LIFE HISTORY EVALUATION OF JOHNSON CREEK BROOD
YEAR 2005 JUVENILE CHINOOK SALMON

INTRODUCTION

This chapter covers data collected for BY05 natural-origin (NOR) and hatchery-origin (HOR) supplementation juvenile Chinook salmon from March 1, 2006 to November 26, 2007. Performance measures used to inform these evaluations are shown in Table 22, as are the corresponding monitoring and evaluation objectives.

Table 22. Johnson Creek juvenile summer Chinook salmon performance measures and corresponding Monitoring and Evaluation Objectives for natural-origin (NOR) and hatchery-origin (HOR) supplementation Chinook salmon.

Performance Measure		Objectives
Abundance	Juvenile Abundance at tributary	1d
	Hatchery Production Abundance	1a
	Juvenile Abundance at Lower Granite Dam (Smolt Equivalents)	1a, 1d
Survival - Productivity	Juvenile Survival to Lower Granite & McNary Dams	1d, 1e
	In-hatchery Life Stage Survival	5a
Distribution	Disease Frequency	5b
Life History	Age-at-Migration	2 b
	Size-at-Migration	2b
	Condition of Juveniles at migration	2b
	Juvenile Migration Timing	2b

METHODS

Juvenile Monitoring – Field Operations

The primary data collection methods used to monitor and evaluate juvenile summer Chinook salmon abundance, survival-productivity, distribution, and life history characteristics are through the migrant trap and marking program. This occurs both in the hatchery and in the field via a rotary drum screw trap.

Marking and Tagging Juvenile HOR supplementation Chinook salmon

Juvenile monitoring of HOR supplementation Chinook salmon was facilitated through marks administered in the LSRCP McCall hatchery. All HOR supplementation fish received a CWT and VIE mark during juvenile rearing; the CWT was administered in June (10 months prior to their release) and the VIE tag in November (four months before they were released). Around 10 percent of all juveniles also received a PIT tag in January, approximately two months prior to their direct release in mid-March.

Idaho Department of Fish and Game personnel applied all CWT's. Tags were implanted using an automated tagging system developed by Northwest Marine Technology Inc (NMT). Procedures for operation of the tagging system were followed by IDFG personnel and are available online through the NMT website (NMT 2007).

Nez Perce Tribe personnel applied VIE tags using methods outlined in NMT (2006). Fluorescent tags were injected into the eyelid adipose tissue of anesthetized juvenile Chinook salmon via handheld air injection units provided by NMT. The elastomer was injected just below the dermis parallel to the skin in a dorsal-ventral orientation. Fish were released into a raceway for observation immediately following tagging procedures and were later checked for tag retention.

All PIT tags were implanted using methods similar to those described by Prentice et al. (1990a, 1990b) and the CBFWA PIT Tag Steering Committee (1999). The HOR fish were taken off feed 24 h prior to treatment. Tagging was done manually using a modified 10cc syringe hand injector unit that consisted of a steel rod, compression spring, push rod and 12-gauge hypodermic needle. Tagging needles and PIT tags were disinfected before each use by soaking them for 10 minutes in 70% ethyl alcohol, and subsequently dried for 10 minutes. The needles, which were pre-loaded with PIT tags, were inserted into the fish so that the beveled tip completely penetrated beneath the surface of the skin at a point on the midline of the ventral surface posterior to the pectoral fins. Fish were measured to the nearest millimeter (fork lengths), weighed to the nearest gram using an electronic scale, and placed in a flow-through recovery vat.

Before the March smolt release, fish were sampled to estimate CWT and VIE tag retention. The PIT tag retention was determined from tags recovered in raceways after tagging. The number of PIT tagged fish was adjusted to account for in-hatchery

mortalities and lost/rejected tags. The PIT tag release files were then updated before submitting them to the PIT Tag Information System (PTAGIS). The mortality of fish with marks or tags was also recorded throughout the rearing process so that numbers reportedly released were as accurate as possible.

Marking and Tagging NOR Chinook salmon

Operation of a rotary drum screw trap throughout the migratory year was the method used to capture, measure, and mark/tag NOR juvenile Chinook salmon. The trap, which was manufactured by E.G. Solutions Inc., Corvallis, OR, was located 6.2 kilometers above the confluence of Johnson Creek at river kilometer (RKM) 522.303.215.060.024 (N44.91764, W115.48336) and the East Fork South Fork Salmon River (Figure 3). The screw trap was attached to a cable suspension system anchored by gabion baskets, which allowed side to side and upstream/downstream movement of the trap. This setup permitted the trap to be fished in the optimum position during most flow conditions. The trap consisted of a trapping cone (1.5 m diameter) supported by a metal A-frame, live box, two six-meter by one-meter pontoons, and a clean-out drum (Figure 11).

Although we attempted to fish the trap continuously, there were times when the trap could not be operated due to low flow or freezing conditions, excessive flow/debris, or mechanical breakdowns. We assume there was very little downstream migration past our traps during December and January. Attempts to adjust population estimates for non-operation periods factor in amount of downtime and required extrapolation, although we typically limited unneeded extrapolation to control for associated bias. For this reason, our estimates represent a minimum number of migrants.

Figure 11. Rotary screw trap located on Johnson Creek used for capturing migrating juvenile Chinook salmon.

The live box of the screw trap was checked every morning (several times throughout each night and day during high water, storms, or ice-up events). Piscivorous fish and large numbers of incidentally captured fish were removed from the live box and scanned for PIT tags. Mortality due to trapping was noted and recorded.

Processing procedures were similar to those used by Ashe et al. (1995) and Prentice et al. (1990b). On a daily basis, juvenile summer Chinook salmon captured in the trap were removed, placed in 18.9-liter plastic holding buckets, and transported (40 meters) to a data processing area. Fish were then transferred to flow-through work-up vats where they were held prior to being moved to an aerated work-up tub.

All fish were interrogated for PIT tags using a Destron® loop-style detector and reader, examined for PIT tag scars, marks, and overall physical condition. Fish were measured to the nearest millimeter and weighted to the nearest gram. Fish were anaesthetized in a plastic tub filled with 6 liters of water, 15 milliliters of standard stock solution (15 grams/liter) of MS-222, and buffered with 15 milliliters standard stock solution (30 grams/liter) of sodium bicarbonate to decrease stress and mortality (e.g., McCann et al. 1994). We also used Stress Coat® (1 part Stress Coat® per 1 part distilled water) in work up tubs, on measurement boards and scale tubs in an effort to replace the natural protective slime coating that may have been compromised by handling or measurement-related stress.

Upon anesthetization, unmarked or non-tagged NOR Johnson Creek summer Chinook salmon were identified for tagging (PIT tagging protocols follow those described previously) or marking. Earlier in the field season, a large portion of the young of the year (YOY) juveniles collected in the screw traps were too small to be PIT-tagged (e.g., CBFWA 1999). In order to represent the entire population, we uniquely marked a sub-sample of all fish for trap efficiency estimates with a mark that could be applied to any size fish that were captured.

Three times a week, a sub-sample of the total trap catch was selected for staining with Bismark-Brown dye, a mark that has proven effective in the identification of fish with fork lengths as low as 30 mm (Lockhart et al. unpublished data). Fish were held in dye (0.4g/16 L solution) for 1 h. Battery powered aerators were used to maintain oxygen saturation in the dye solution and the temperature was monitored constantly. To evaluate possible delayed mortality and to reduce predation, stained fish were held in live boxes until dusk and were released at the same time and at the same site as PIT tagged fish.

Freshly marked or tagged fish were placed into an 'upstream' live box, while recaptures or incidental catches were placed into a 'downstream' live box. Larger or piscivorous specimens were placed into a separate live box to reduce the potential of predation. The live boxes were large, drilled-out plastic shipping boxes with lids, which provided containment, protection, and acclimation of the fish back to the riverine environment. Marked fish spent no less than 12 h in the live boxes and were released at dusk. These

protocols helped ensure complete recovery from anesthetic, minimized risk of predation, and promoted reintegration and mixing with other NOR fish during peak movement periods. Following their release, boxes were checked for mortalities and shed PIT tags.

Marked or tagged fish that were placed into the ‘upstream’ live box were used to derive estimates of trap efficiency through their subsequent recapture at the screw trap. The ‘upstream’ fish were released approximately 800 m upstream of the trap or at least two riffles and a pool upstream of the trap. All other fish were held in separate live boxes and released 183 m downstream of the trap. Trap efficiency was determined by releasing a known number of marked or tagged fish above the trap and enumerating recaptures. Trap efficiency was calculated as follows (Murphy et al. Unpublished):

$$\hat{E} = \frac{m + 1}{r + 1}$$

$\hat{E}$ = trap efficiency estimate
 m = number of marked fish
 r = number of recaptured fish

Juvenile Monitoring - Performance Measures

Abundance

Juvenile Abundance at tributary

For the purpose of this monitoring, we assumed that all juvenile summer Chinook salmon captured in the trap were downstream “migrants”. The term “migratory year” (MY) referred to the earliest calendar year juveniles were expected to migrate to the ocean. The term “brood year” (BY) referred to the calendar year eggs were fertilized. Life stages were based on age, biological development, and seasonal trapping dates (Table 23).

Juvenile migrant abundance at Johnson Creek was estimated for four life-stage-specific juvenile migrants (fry, parr, presmolt, smolt) leaving the tributary. Estimation of the abundance of juveniles migrating by life stage is achieved via mark/recapture of fish captured at the rotary screw trap during the course of the year. Abundance estimates on yearling or precocial Chinook salmon captured in the trap during the summer and fall of 2006 were not conducted due to low capture rates affecting our ability to obtain robust trapping efficiency estimates.

To calculate brood year-specific migration estimates from rotary screw trap operations we utilized a Gauss program developed by the University of Idaho (Steinhorst 2000). Gauss (Aptech Systems, Maple Valley, Washington) is a structured programming language where the basic variables are matrices rather than scalars. We divided the trap seasons into periods, typically 7 to 10 days in length. Period lengths were selected to minimize environmental variation within each period, which presumably translates to a relative decrease in variation of trap efficiencies within a given period. Fish were marked and released upstream of the trap. The recaptured portion of the marked fish provided an initial calculated p_1 and the number of unmarked fish provided an initial N . This information was inserted into the Gauss program which iteratively maximized the log

likelihood, $\ln L(N, p_I)$ until the estimate did not change significantly (stabilization). Since the estimators did not have a finite expectation, the Bailey (1951) modified estimator ($N_{\text{simple } h}^B = c_h X(m_h+1)/(r_h+1)$) was used to determine N (Steinhorst 2000). The maximum likelihood estimates of N and the corresponding confidence intervals required minimal assumptions: 1) fish are captured independently with probability p and 2) marked fish mix with unmarked migrating fish. Our release sites were selected to maximize the probability of mixing between marked fish and the general population.

Table 23. Definition of BY05 juvenile summer Chinook salmon life stages and associated trapping dates applied at the Johnson Creek rotary screw trap.

Life Stage	Definition	Trapping Season
Young of the Year (YOY; fry)	Newly emerged progeny from adults that spawned in 2005 (BY05), captured from trap installation through June 30, 2006,	1 st Spring
Parr	Actively migrating BY05 progeny that are entering their first summer in fresh water, captured July 1 through August 31, 2006.	1 st Summer
Presmolts	Actively migrating BY05 progeny that do not show typical smolt characteristics (e.g., silvery color and the tendency to easily lose their scales), captured September 1 through fall trap removal.	1 st Fall
Smolts	Actively migrating BY05 progeny that exhibit the typical silvery color of a smolt, are greater than one year old, and are captured between January 1 and June 30, 2007.	2 nd Spring
Yearlings	Fish in their 2nd summer or fall, or 3rd spring.	Varies
Precocial yearlings	Yearlings that release milt when handled.	Varies
Type 1 yearlings	Fish that are tagged at the tributary (screwtrap) as parr, presmolts (2006), or smolts (2007) but are not detected at LGD until 2008.	Varies
Type 2 yearlings	Yearlings that are tagged at the tributary (screwtrap) during the summer, fall (2007), or spring of 2008.	Varies

Hatchery production abundance

Hatchery production abundance estimates were based on counts made in the hatchery. Initial abundance estimates were based on female fecundity, which typically averages between 4,200 – 4,400 eggs per female. Abundance estimates were refined at eye-up, when all eggs were run through a counter. Fish were subtracted from this estimate following subsequent mortality. Another inventory occurred when fish received a CWT mark, during which all hatchery-origin fish were counted. Subsequent counts occurred when the hatchery population received VIE tags. The VIE tagging process served as an additional check to the accuracy of the CWT counts.

Juvenile Abundance at Lower Granite Dam (Smolt Equivalents)

Brood Year 2005 juvenile abundance (a.k.a. 'smolt equivalents') at LGD, which resulted from juvenile migrant trapping and PIT tagging in Johnson Creek, was derived by

estimating the proportion of the total juvenile abundance estimate at the tributary comprised of each juvenile life stage (fry, parr, presmolt, smolt) that survive to LGD. It was calculated by multiplying the life stage specific abundance estimates (with standard error) by the life stage specific survival estimates to LGD (with standard error). The standard error around the smolt equivalent estimate was calculated using the following formula; where X = life stage specific juvenile abundance estimate and Y = life stage specific juvenile survival estimate:

$$Var(X \cdot Y) = E(X)^2 \cdot SE(Y)^2 + E(Y)^2 \cdot SE(X)^2 + SE(X)^2 \cdot SE(Y)^2$$

$$SE_{(X \cdot Y)} = \sqrt{Var(X \cdot Y)}$$

An exception to this calculation was for the fry life history stage. Because no fish were PIT tagged in the fry group we could not calculate a life stage-specific survival estimate to LGD. Therefore it was necessary to combine abundance estimates for fry and parr (with associated standard error) and assume that the fry survival estimate was similar or equal to the parr survival estimate to LGD. The group variance and standard error for fry (X) and parr (Y) was calculated using the following formula:

$$Var(X + Y) = SE(X)^2 + SE(Y)^2$$

$$SE_{(X+Y)} = \sqrt{Var(X + Y)}$$

Survival-Productivity

Juvenile Survival to Lower Granite and McNary Dams

Juvenile survival to LGD and MCN, was estimated using PIT tag technology which allowed fish to be individually marked and subsequently observed without being sacrificed. Multiple detections of PIT-tagged fish at the Snake and Columbia River dams was used to estimate migration timing for each tag group. There were four tag groups of BY05 juvenile Chinook salmon for which we estimated migration timing and survival to LGD and McNary (MCN) during the 2007 migration year: (1) NOR parr, (2) NOR presmolts, (3) NOR smolts and (4) HOR supplementation smolts. Survival and run timing to Lower Granite and McNary Dams was not calculated for BY05 yearling Chinook salmon. Annual minimum tagging goals were established for Johnson Creek given the variability in survival rates and detection probabilities. The Sample Size Program 3.1 (Lady et al. 2003) was used to estimate minimum samples sizes per life stage. Typically a minimum of 500 to 1,500 fish are needed per lifestage to obtain survival point estimates to LGD with 95% CI of $\pm 5\%$.

For each tag group we estimated survival to LGD using the PitPro (v.4.8) program, developed by the University of Washington (Westhagen and Skalski 2006). The program enabled us to process raw data from the Pacific States Marine Fisheries Commission (PSMFC) PIT-tag information system (PTAGIS) database (PSMFC 2007) into usable

capture history data for survival analysis, which included the separation of actively migrating fish from those that were potentially transported, potentially handled, or died during migration.

The PitPro program utilized two data files to create capture histories: tagging data, and interrogation data. Capture history data were compared against one of three outcomes: transported; returned to river; or censored. Censored or transported fish were removed from capture history files upon any recapture or mortality event; otherwise, all observations up to the point of censor or transportation were included.

We used Cormack-Jolly-Seber (CJS) survival probabilities from the Survival Under Proportional Hazards (SURPH) 2.2b, a component of PIT Pro, to calculate the probability of survival to LGD for fish in each tag group (Lady et al. 2002). This method takes into account the probability of detection when calculating the probability of survival. We use SURPH2.2b information to compare performances among and between the different life stages of tagged juvenile salmon. Please refer to Appendix D for a discussion of efficiency estimates and separation by code technology.

In-hatchery life stage survival

In-hatchery survival was calculated during early life history stages of hatchery-origin juvenile Chinook salmon. Individual female's eggs were transported from the LSRCP SFSR satellite facility to the LSRCP McCall Fish Hatchery in separate egg bags. Each female's eggs were incubated separately in an eight-tray vertical stack incubator. Enumeration of individual female's live and dead eggs occurred when the eggs were picked. These numbers created the inventory with subsequent mortality subtracted. This inventory could be changed to the physical count of fish obtained during CWT or VIE tagging.

Distribution

Disease Frequency

Johnson Creek juvenile HOR supplementation fish were inspected by the Eagle Fish Health Lab on a quarterly basis for *Renibacterium salmoninarum* (the causative agent of bacterial kidney disease (BKD)), viral replication agents, parasites, and bacterial pathogens. The pre-liberation sample consisted of 20 randomly collected fish and examined for *R. salmoninarum*, *Myxobolus cerebralis* (the causative agent of whirling disease), and viral replicating agents. An organosomatic index (Goede and Houghton 1987) was also performed on these fish. The pre-liberation sample was performed within 45 days of release.

Life History Characteristics

Age at Migration

Age-at-migration was characterized by the proportional distribution of freshwater age at smolting (tributary specific spring emigrants). Initial assignment of brood year for

individual fish was determined by length frequency distributions. Monitoring of delayed migration of juvenile Chinook salmon that spent a second year in fresh water downstream of the screw trap was determined from PIT tag detections at the Snake and Columbia River hydro-project PIT tag interrogation and trap sites. Age-at-migration for hatchery-origin fish is a standard program description of age at release with validation and potential adjustment for delayed PIT tag detection at LGD. Standard aspects of PTAGIS data query apply.

Size-at-Migration and Condition of Juveniles at Migration

Size-at-migration is quantified for each life stage as described above (Table 23). Fork length (mm) and weight (g) are representatively collected weekly from at least 100 migrating natural juveniles captured in migration traps. Mean fork length and variance for all samples within a lifestage-specific migration period are generated. *Condition of juveniles at migration* (condition factor) by life stage of juveniles is also generated using the formula:

$$K = (w/l^3)(10^4)$$

where K is the condition factor, w is the weight in grams (g), and l is the length in millimeters (Everhart and Youngs 1992).

Because of daily variation in the numbers of fish trapped and their associated weights and lengths, it was necessary to use weighted averages in summarizations of periodic (i.e. monthly or bi-monthly) data. Summaries of size (length and weight) and condition factor at migration incorporate the formula:

$$\bar{x} = \frac{\sum_{i=1}^n w_i x_i}{\sum_{i=1}^n w_i}$$

Size-at-migration for hatchery production was generated from pre-release sampling of 500 juveniles. A fish-per-pound (FPP) estimate was obtained from the HOR samples and used as a gauge of weight. Comparisons of size and condition at migration between HOR and NOR juveniles were coarse due to the lack of individual measurements of HOR fish, the fact that hatchery length measurements use total length rather than fork length (screw trap measurements), and because NOR smolt generally were not trapped at the same time that HOR smolts were direct released into Johnson Creek.

Juvenile Migration Timing

Capture histories and relative proportions of PIT tagged, Johnson Creek juveniles were used in conjunction with seasonal population estimates (refer to *Juvenile Abundance to Tributary* methods section) to describe *juvenile migration timing*. As described previously, total migrants at Johnson Creek included fry, parr, presmolt, and smolt life stages, each of which were based on age, biological development, and seasonal trapping

dates. Weekly population estimates are presented either as proportional or cumulative distributions over time relative to the total escapement. Run timing of BY05 NOR juveniles captured at the juvenile trap and that of PIT-tagged HOR supplementation and NOR juveniles detected at LGD are presented.

In an effort to improve the accuracy of migration timing for parr life stages, the cumulative percentage of PIT-tag detections at Lower Granite Dam (by origin) were weighted by relative abundance estimates. By weighting respective life stages based on abundance rather than presence/absence of tags, it was possible to improve the representation of parr life stages, which, based on abundance estimates, often comprise a greater percentage of Johnson Creek's juvenile migrants but aren't accounted for due to their lack of PIT tags (e.g., Rabe et al. 2006). For this analysis, our seasonal population estimates for the parr life stage included fish captured from March 31 through June 30, 2006 (fry) in addition to those captured July 1 through August 31, 2006 (parr). Daily weighted correction factors were calculated by dividing the total number of detections (by life stage) by the total population estimate (by life stage) and multiplying the quotient by the given number of detections on that day. The product was added cumulatively to obtain median, 0, 10%, 50%, and 90% detection dates. Weighting was applied to NOR juveniles independent to the NOR x HOR aggregate.

RESULTS & DISCUSSION

Juvenile Monitoring – Field Operations

Hatchery Marking and Tagging

All BY06 juveniles reared received CWT and VIE tags, while 12,060 were also PIT tagged (and released; Table 24). Mark retention in 2007 for both CWT and VIE marks applied exceeded 98% and virtually all HOR supplementation fish retained at least one of the marks (Table 25). The PIT tag related mortality in 2007 was negligible. In the future, we recommend that the number of PIT tags applied to HOR supplementation fish be reduced due the potential effects PIT tags may be having on recruitment, growth and survival (e.g., Knudsen et al. in press). Additional studies examining PIT tag retention are recommended.

Table 24. Brood year 2005 juvenile release numbers, their associated fish per pound (fpp), marks received, and release dates.

Brood Year	# Smolts Released	Smolt Size at Release (fpp)	CWT Code	VIE Color/Side	# PIT Tagged	Release Dates
2005	120,415	120.1 (26.9)	612725 (74.4%) 612726 (25.6%)	Orange/Left Eye	12,060	3/12- 3/14/2007

Table 25. Coded wire, visual elastomer and PIT tag marking retention for BY05 juvenile hatchery-origin Chinook salmon.

Total Number of Fish Checked	Percent of both CWT and VIE tags Retained	Percent of CWT Tags Retained	Percent of VIE Tags Retained	Percent of at Least One Tag Retained	Percent of PIT Tags Lost/Rejected	Percent of PIT tags Mortalities
12,158	98.00	98.54	99.44	99.98	0.05	0.00

Screw Trap Operation

The rotary screw trap was installed on March 1, 2006. The trap remained operational until March 13, 2006, at which point it was pulled due to the direct release of BY04 HOR supplementation smolts into Johnson Creek. Reinstallation occurred 4 days later on March 17, 2006 and resumed normal operations until high water precluded trapping operations on May 14, 2006. The trap was down for 16 days and was reinstalled on May 30, 2006, at which time it ran continuously the rest of the 2006-trapping season until freeze-up on November 22, 2006. The 2007 trapping season commenced with the installation of the rotary screw trap on March 1. The trap was fished continuously until the release of BY05 hatchery smolt on March 12. Reinstallation occurred five days later on March 17, 2007. The cone was raised on May 1 due to high water, but was

subsequently lowered the next day. Trapping operations continued throughout the remainder of the spring runoff period, with the exception of two brief periods (May 10 and 13) during which debris prohibited cone rotation. The cone remained operational until freeze-up conditions prompted removal of the trap on November 26, 2007.

Juvenile Monitoring – Performance Measures

Abundance

Juvenile Abundance at Johnson Creek

Juvenile migration estimates for BY05 hatchery (HOR) supplementation and natural-origin (NOR) Chinook salmon in Johnson Creek are presented in Table 26. There was an estimated 34,194 NOR migrants from BY05 compared to 120,415 HOR supplementation smolts (released March 12-15). We estimated that more than three-quarters (78%) of all NOR juvenile migrants that left Johnson Creek were from the fry/parr lifestage.

Abundance estimates for yearling Chinook salmon were not obtained due to low numbers of captures. Please refer to Appendix Table 3 for a daily capture summary of BY05 juvenile Chinook salmon and Appendix Table 4 for a daily summary of incidental species captured in 2006-2007.

Similar to previous years, fry/parr represent the dominant lifestage of juveniles migrating from Johnson Creek and have the highest associated standard error around their abundance estimates. This uncertainty is due to a combination of factors influencing weekly trap efficiency, which is lowest during the period of early trap operation and coincident with the time that most fry/parr are migrating from the system. Trap efficiency estimates for fish between 39 mm and 59 mm rely upon the use of the Bismark Brown stain for mark/recapture. The duration of the stain is typically three to four days, after which the mark becomes less visible.

Table 26. Juvenile migration estimates for BY05 hatchery (HOR) supplementation and natural-origin (NOR) Chinook salmon in Johnson Creek. Estimates are reported with 95% confidence intervals and standard errors. Estimates are from operation of screwtrap March-November.

Lifestage	Population Estimate/Release	95% C.I.	S.E.
NOR fry/parr	26,671	17,119 to 46,860	7,754.3
NOR presmolt	5,852	5,227 to 6,804	441.3
NOR smolt	1,671	1,275 to 2,181	221.8
Total natural	34,194	24,538 to 52,328	7,872.6
HOR smolt	120,415		

As discussed in Rabe and Nelson (2007) the application of the 8.5 mm PIT tag represents an option for tagging smaller sized (e.g., <65 mm) juveniles so as to obtain improved estimates of abundance and survival for a proportionately significant component of the

population. Starting on June 26 and ending July 1, we applied a total of eight 8.5 mm tags to BY06 Chinook in 2007.

Hatchery Production Abundance

A total of 120,415 brood year 2005 HOR supplementation Chinook salmon smolts reared by the JCAPE project were direct released into Johnson Creek at Moose Creek (RKM 15) starting March 12 and ending March 15 of 2007. Average annual releases have been 91,186 fish. In 2003, 2005, 2006, and 2007 we completed the adult returns from the brood years 1998, 2000, 2001, and 2002 smolt releases.

Juvenile Abundance at Lower Granite Dam (Smolt equivalents)

Estimates for BY05 NOR and HOR supplementation Chinook salmon at LGD are shown in Table 27.

Table 27. Estimated number of juvenile fish at Lower Granite Dam for BY05 natural-origin and hatchery-origin supplementation Chinook salmon.

Lifestage	Estimated number of fish at LGD	Standard Error
Natural origin	9,929	2,456
Hatchery origin	38,436	2,830

Survival-Productivity

Juvenile Survival to Lower Granite and McNary Dams

Juvenile survival and capture probability estimates for BY05 migrants from Johnson Creek to LGD and MCD (respectively) are shown in Table 28. Estimated survival of NOR smolt from Johnson Creek to LGD (0.4471) was the highest of all NOR life history strategies and exceeded that of HOR supplementation smolt by about thirteen percent (13%). Survival of NOR smolt and HOR supplementation smolt to McNary dam was estimated at 0.3286 and 0.2623 respectively. Survival estimates of NOR fry and yearling Chinook salmon lifestage were not calculated due to the low numbers of fish PIT tagged from each group.

Table 28. Lifestage specific survival and capture estimates to Lower Granite Dam and McNary Dam for BY05 natural and hatchery-origin supplementation juvenile Chinook salmon.

Lifestage	LGD		MCD	
	Survival (S.E.)	Capture Probability (S.E.)	Survival (S.E.)	Capture Probability (S.E.)
NOR parr	0.2824 (0.0394)	0.2878 (0.0527)	0.1622 (0.0227)	0.5476 (0.0768)
NOR presmolt	0.2819 (0.0164)	0.3300 (0.0256)	0.2230 (0.0179)	0.4472 (0.0392)
NOR smolt	0.4471 (0.0459)	0.3289 (0.0469)	0.3286 (0.0493)	0.4444 (0.0741)
HOR smolt	0.3192 (0.0235)	0.2143 (0.0169)	0.2623 (0.0143)	0.3498 (0.0170)

In-hatchery life stage survival

Life history-specific survival for BY04 hatchery-reared, Johnson Creek juvenile supplementation Chinook salmon is provided in Table 29. Based on comparisons of lifestage to lifestage survival, parr to smolt survival is highest (99.6%) while green egg to eyed egg is lowest (88.2%).

Table 29. Lifestage specific survival of BY05 juvenile hatchery-origin (HOR) supplementation Chinook salmon.

Lifestage	Survival (%)
Green egg to eyed egg	88.2%
Eyed egg to parr	95.6%
Parr to smolt	99.6%
Egg to Smolt	84.2

Distribution

Disease Frequency

Idaho Department of Fish and Game personnel conducted Organosomatic evaluations on 20 BY05 juvenile summer Chinook salmon at the LSRCP McCall hatchery on February 28, 2007. Tests on the HOR supplementation fish included assays of hematocrit (the proportion of blood consisting of packed red blood cells) serum protein (volume of dissolved proteins in plasma), and organs (i.e., eyes, gills, pseudobranchs, thymus, spleen, gut, kidney, liver, bile). All tests conducted indicated the HOR supplementation juveniles were free of disease and had normal organ condition and function.

Life History

Age-at-migration

Size-at-migration

Condition of Juveniles at migration

Length and fish per pound data for BY05 HOR supplementation juvenile Chinook salmon reared at the McCall fish hatchery are provided in Table 30. Discounting emergence or early life history stages, the months of February, March, and April (2006) represent periods when the hatchery-reared juveniles attained the greatest growth increases (based on relative changes in fish per pound measures), versus November (2006) and March (2007), which represented periods of least growth. Based on daily weighted average fish-per-pound (FPP) and fork length measurements, naturally-reared Chinook salmon captured at the Johnson Creek screwtrap attained the greatest growth during the months of July and August and grew the least in April (Table 31).

Direct temporal comparisons of size (length and weight) between HOR supplementation and NOR BY05 juveniles were difficult due to differences in measuring schedules at the screw trap versus the hatchery. Hatchery personnel conduct FPP counts at the end of each month to estimate total number of fish, and/or total length (mm) per fish.

Conversely, JCAPE screw trap operations sample and measure fish daily over the course of the month, which results in a difference in average fish length per given month; the average length of hatchery fish will be larger than the NOR fish since HOR fish were measured upon the conclusion of a month-long growing cycle while NOR fish were measured continuously over the month-long growing cycle. In the future, we plan to conduct bi-monthly sampling events at the hatchery in an effort to improve consistency between size comparisons of HOR supplementation and NOR juveniles.

Table 30. Length and fish per pound for BY05 hatchery-origin (HOR) juvenile supplementation Chinook salmon reared at the McCall fish hatchery.

Year	Month	Number of fish	Total Length (mm)	Fish Per Pound
2005	December	11,562	35	1,300
2006	January	90,421	37	1,125
	February	122,235	39	928
	March	121,891	43	695
	April	121,633	50	455
	May	121,093	59	261
	June	120,830	74	135
	July	120,916 ¹	86	86
	August	120,784	100	53
	September	120,698	108	40
	October	120,643	117	32
	November	120,599	116	33
	December	120,596	118	31
2007	January	120,572	121	29
	February	120,539	123	27
	March ²	120,415	120	27

1 – Inventory adjustment up 344 fish due to count at CWT tagging.

2 – Inventory at smolt planting

Table 31. Weighted daily average fork length, condition factor and fish per pound for BY05 natural-origin juvenile Chinook salmon captured at the Johnson Creek rotary screw trap.

Year	Month	Number of samples	Weighted Daily Average		
			Fork Length (mm)	Condition Factor	Fish/lb
2006	April	1	33	0.83	1,515
	May	2	42	1.05	606
	June	182	42	0.70	875
	July	382	53	0.92	341

Year	Month	Number of samples	Weighted Daily Average		
			Fork Length (mm)	Condition Factor	Fish/lb
2007	August	553	64	0.98	174
	September	779	74	0.97	112
	October	1,241	79	0.99	91
	November	356	82	0.99	82
	March	288	90	0.96	65
	April	129	90	0.95	65
	May	4	86	0.93	78
	June	1	84	1.05	73
	July	N/A	N/A	N/A	N/A
	August	7	114	1.12	27
	September	2	120	1.02	26

Fork length frequency and average condition factor for BY05 HOR supplementation and NOR juvenile Chinook salmon are shown in Figure 12. The figure depicts approximate size and condition factor of fish at the time of migration¹. Based on comparisons using a Student's *t*-test ($\alpha=0.05$) the HOR supplementation migrants were significantly ($P<0.001$) larger (111 mm vs. 90 mm) and had a significantly ($P<0.001$) higher mean condition factor than their NOR counterparts (1.13 vs. 0.96).

Juvenile Migration Timing

Mainstem Arrival Timing (Lower Granite)

Figure 13 shows BY05 juvenile run timing of Chinook salmon captured at the Johnson Creek rotary screw trap. As shown, more than half of all emigrants (primarily parr) were past the trap before August 1, 2006. Presmolt migration occurred in October and November while smolt migration occurred in March and April 2007. Johnson Creek presmolt were the first life history stage to be detected at LGD in 2007 (April 12) while NOR smolt were the last to have an initial detection (April 18; Table 32). Approximately half of all Johnson Creek migrants had arrived at LGD by May 10th, and all migrants had been accounted for at LGD by June 11.

It appears as though NOR and HOR supplementation juveniles mainstem arrival timing to Lower Granite (100% detection dates) were similar, with the NOR fish arriving only slightly earlier than their hatchery counterparts. The greatest disparity in arrival timing between NOR and HOR supplementation juveniles occurs during the early portion of migration between the first week in April and the first week in May. It is during this period that NOR fish arrive appreciably earlier to Lower Granite than HOR supplementation fish ($\leq 50\%$ detection dates). Arrival timing (to Lower Granite) through the remainder of the migration period is, however, similar between both origin types.

¹ For hatchery fish, Figure 12 depicts size and condition of fish at the time they were PIT tagged rather than their actual release in mid-March, which is around a month and a half prior to 'migration'.

Figure 12. Fork length frequency and average condition factor of BY05 hatchery-origin (HOR) supplementation Chinook salmon PIT tagged between January 22 and 24, 2007 and for BY05 natural-origin (NOR) Chinook salmon captured at the Johnson Creek rotary screw trap between March 3 and 31, 2007.

Figure 13. Run timing of BY05 NOR juvenile Chinook salmon captured at the Johnson Creek rotary screw trap.

Table 32. Cumulative percentage of BY05 PIT-tagged hatchery-origin (HOR) supplementation and natural-origin (NOR) juvenile Chinook salmon detections at Lower Granite Dam by life stage. Data markers indicate 0, 10, 50, 90 and 100 percent cumulative detection dates.

Brood Year	Lifestage	LGD Detections	Cumulative Percent Detection Date				
			0%	10%	50%	90%	100%
2005	Natural parr	36	4/14/07	4/18/07	5/6/07	5/17/07	5/25/07
	Natural presmolt	166	4/12/07	4/19/07	5/8/07	5/18/07	5/28/07
	Natural smolt	50	4/18/07	5/3/07	5/12/07	5/21/07	5/26/07
	Total Natural	252	4/12/07	4/18/07	5/7/07	5/17/07	5/28/07
	Hatchery smolt	825	3/29/07	5/2/07	5/10/07	5/19/07	6/11/07
	Overall Total	1,077	3/29/07	4/26/07	5/10/07	5/18/07	6/11/07

CHAPTER 4: MULTI-YEAR ANALYSIS PERFORMANCE MEASURES

INTRODUCTION

This chapter includes an assessment of survival-productivity measures (listed in Table 33) that rely on multiple years of data collection. The Smolt to Adult Return rate (SAR), Migrant to Adult Return rate (MAR), and Progeny to Parent ratio (P:P) performance measures rely upon run reconstructions (i.e., partitioning of abundance) of BY02 adult progeny that returned to Johnson Creek as adults in 2005-2007. As such, the adults that returned as five year olds in 2007 represent the final cohort from BY02, and thus enable the calculation of the respective measures. Similarly, the Recruits per spawner (R/S) estimate, which is used to index adult productivity, relies upon BY05 adult spawner numbers in its derivation, which is unique to the ‘snapshot-in-time’ structure of the information thus far presented in this document.

Table 33. Johnson Creek adult summer Chinook salmon multi-year performance measures and corresponding Monitoring and Evaluation Objectives for natural-origin (NOR) and hatchery-origin (HOR) supplementation Chinook salmon.

Performance Measure		Objectives
Survival - Productivity	Smolt-to-Adult and Migrant-to-Adult Return Rates	1d, 1e
	Progeny-per- Parent Ratio	1a, 1d
	Recruit/spawner	1a, 1d

METHODS

Multi-Year Performance Measures

Adult & Juvenile Survival/Productivity

Smolt to Adult and Migrant to Adult return rates for Brood Year 2002 Chinook Salmon

Smolt-to-adult return rate (SAR) and migrant-to-adult return rate (MAR) for Brood Year 2002 hatchery and natural-origin fish were generated for three performance locations; tributary to tributary (Johnson Creek (JC) to JC), Lower Granite Dam (LGD) to Lower Granite Dam (LGD), and Lower Granite Dam (LGD) to tributary (JC). We used CWT, VIE tags, and PIT tags to generate supplemented HOR SARs. Also, PIT tag methods were utilized for NOR SARs and MARs. Direct counts were used for calculating the estimated number of NOR fish leaving (juvenile abundance estimate at screw trap) and the known number of HOR supplemented fish leaving which were compared to the specific age classes of adults returning. Age class structure used for NOR and unknown aged (HOR) supplemental fish was based on length at age measurements, age 3 (<63 cm), age 4 (64 cm to 84 cm), and age 5 (>85 cm).

Migrant-to-adult return rates for NOR fish for each of the three performance periods were based on respective measures of relative abundance (e.g., PIT tag detections, numbers released, numbers PIT tagged) as they pertained to a given life stage (e.g., parr, presmolt, smolt). The MAR for NOR fish therefore differed from the NOR SAR value since it included three discrete life stage-specific values, whereas the NOR SAR was based exclusively on the single smolt life stage. Calculations for HOR supplementation and NOR SAR and MAR performance measures for the three periods evaluated are provided in Appendix Table 5 and discussed below.

Johnson Creek to Johnson Creek

We used two evaluation methods for calculating SAR and MAR productivity estimates from Johnson Creek to Johnson Creek (JC to JC); life stage-specific PIT tag returns, and abundance estimates (refer to Appendix Table 5 for example). The life stage-specific PIT tag return approach enabled discrete migrant-to-adult return rate comparisons of natural-origin, PIT-tagged juveniles that left Johnson Creek as parr, presmolt, and smolt and returned back to Johnson Creek as adults. A weighted average of the three ratios (e.g., juveniles of a given life stage by adults of the corresponding life stage) was applied to provide a discrete index of PIT tag-based MARs for NOR fish. Since the HOR supplementation fish were only comparable to NOR smolts (i.e., HOR supplementation juveniles were released into Johnson Creek as smolts), the most direct comparison using PIT tags was the SAR, which, like the MAR, was calculated by dividing the total number of smolts that were PIT tagged at Johnson Creek by the total number of corresponding PIT tagged adults (e.g., adults that returned from the same smolt cohort) that were detected at Johnson Creek.

Methods for calculating MARs for JC to JC using the abundance-based approach were the same as those used in the PIT tag approach, yet incorporated total estimated juvenile

migrants (parr, presmolt, smolt) at Johnson Creek as the divisor, and estimated number of corresponding adult returns to Johnson Creek as the numerator.

Lower Granite Dam to Lower Granite Dam

Productivity estimates from Lower Granite Dam to Lower Granite Dam relied exclusively on PIT tagged fish. The MAR for NOR fish was based on the weighted average of each of the three ratios of juvenile parr, presmolt and smolt to corresponding adult detections estimated at Lower Granite Dam. The SAR for NOR/HOR fish was calculated as the ratio of juvenile smolt tagged at Lower Granite Dam to corresponding adult detections at Lower Granite Dam.

Lower Granite Dam to Johnson Creek

Similar to the Granite to Granite calculations, Productivity estimates from Lower Granite Dam to Johnson Creek were based exclusively on PIT tagged fish. The MAR for NOR fish was based on the weighted average of each of the three ratios of estimated abundance of juvenile parr, presmolt and smolt at Lower Granite Dam to corresponding adult detections estimated at Johnson Creek. The SAR for NOR/HOR fish was calculated as the ratio of juvenile smolt tagged at Lower Granite Dam to corresponding adult detections at Johnson Creek.

Progeny per Parent ratios for Brood Year 2002 Chinook Salmon

Progeny per parent (P:P) ratio was calculated from run reconstructions over time. Annual total escapement was determined by summing the expanded number of fish below the weir, mortalities at the weir, number of fish above the weir and number of fish captured at the adult weir and removed for broodstock. Escapement was partitioned for hatchery-origin and natural groups from *hatchery fraction by age class structure and adult spawner sex ratio*. Age class structure used for natural, stray and unknown supplemental fish was based on length age 3 (<63 cm), age 4 (64 cm to 84 cm), age 5 (>85). Partitioned abundance for all adult year classes in a cohort was summed and applied to the P:P ratio calculations. We assigned variance when adjusting escapement estimates to include or exclude known sources of mortality or when describing subsets of the total population.

Recruit per Spawner estimates for Brood Year 2005 Chinook Salmon

Recruit per spawner estimates were used to derive adult productivity from fish that spawned in 2005. The measure represented the number of juvenile fish resulting from the preceding adult life stage. Several forms of recruit/spawner were applicable. We utilized four measures: 1,2) juvenile abundance at tributary to spawner and to female, and 3,4) juvenile abundance at Lower Granite Dam (LGD) to spawner and to female.

RESULTS & DISCUSSION

Multi-Year Performance Measures

Adult & Juvenile Survival/Productivity

Smolt to Adult and Migrant to Adult return rates for Brood Year 2002 Chinook Salmon

Smolt-to-adult return rates (SAR) and migrant-to-adult return rates (MAR) for BY02 NOR and HOR supplemented Johnson Creek Chinook salmon are presented in Table 34. The MAR and SAR values for HOR supplemented and NOR Chinook salmon indicate that NOR Chinook salmon had a distinct survival advantage over their HOR counterparts. This advantage was most pronounced for the JC to JC life stage specific PIT tag returns, where the MAR and SAR values differed by an order of magnitude between NOR and HOR supplementation fish.

Table 34. Hatchery-origin (HOR) supplementation and natural-origin (NOR) BY02 smolt to adult and migrant to adult return rates. Estimates are for juveniles (smolts and/or parr and presmolts) that return as adults over the course of three performance periods; tributary to tributary (JC to JC), Lower Granite to Lower Granite (LGD to LGD), and LGD to tributary (LGD to JC). Calculation methods are provided in Appendix Table 5.

Performance Location	Evaluation Method	Origin	MAR	SAR
JC to JC	Life stage specific PIT tag returns	NOR	0.16%	0.17%
		HOR	0.04%	0.04%
JC to JC	Abundance Estimates	NOR	0.07%	N/A
		HOR	0.06%	N/A
LGD to LGD	Life stage specific PIT tag returns	NOR	1.16%	0.63%
		HOR	0.19%	0.19%
LGD to JC	Life stage specific PIT tag returns	NOR	1.12%	0.42%
		HOR	0.13%	0.13%

In most cases, the SAR for NOR fish was lower than the corresponding MAR, which was counterintuitive based on the fact that smolts tend to have higher survival rates through the hydrosystem than parr or presmolt (which are included in the MAR estimate). The difference in smolt- and migrant-to-adult return rates resulted from differences in various abundance estimates per life history stage and the associated influence on the weighted average calculated in the MAR. In 2007 we estimated the abundance of wild parr to be 175,424 fish, which comprised nearly 90% of the total abundance estimate for NOR juveniles. Despite the fact that parr survival to Lower Granite Dam (0.1262) was the lowest of the three life history stages, the estimated number to Lower Granite (22,139) was the highest of all life history stages. Of the 22,139 parr estimated at Lower Granite, there were an estimated 155 with PIT tags, two of which returned to Lower Granite and

Johnson Creek as adults. The individual MAR rate for parr was 0.16% from JC to JC, and 1.29% for both LGR to LGR and LGR to JC. Rates for smolt at the same locations were 0.17%, 0.63%, and 0.42% (Table 34). The weighted average by location, which combines the life stage-specific MAR rates and respective abundance estimates per life stage, was thus heavily influenced by the parr MAR and contributed to differences in rates utilizing only one life stage (smolt).

The MAR is an important measure to consider when assessing survival-productivity of NOR Johnson Creek Chinook salmon due to the fact that it accounts for survival at multiple life history stages, including parr, which represent the primary life stage at which juveniles migrate from the tributary. Excluding the parr (and presmolt) life history stage and relying solely upon the smolt life history stage (SAR) may invariably provide a less representative assessment of survival-productivity and influence related management decisions.

Progeny per Parent ratios for Brood Year 2002 Chinook salmon

Adult to adult, female to female and male to male ratios for BY02 HOR supplemented and NOR conspecifics are shown in Table 35. Overall, BY02 P:P ratios for both origin types were below the replacement level of 1.0. HOR supplementation adults that spawned in 2002 returned adult progeny in 2005-2007 at a greater proportion than their NOR counterparts.

Table 35. Progeny per Parent ratios (adult to adult, female to female, and male:male) for hatchery (HOR) and natural-origin (NOR) conspecifics for broodyear 2002.

Ratio	Origin	BY02 P:P ¹
Adult to Adult	Natural	0.1293
	Supplemental	0.6522
Female to Female	Natural	0.1315
	Supplemental	0.4794
Male to Male	Natural	0.1276
	Supplemental	0.7842

¹ Age class structure used for NOR and unknown HOR supplemental fish was based on length age 3 (<63 cm), age 4 (64 cm to 84 cm), age 5 (>85).

Recruit per Spawner estimates for Brood Year 2005 Chinook salmon

Recruit per spawner estimates for Brood Year 2005 Johnson Creek Chinook salmon adults spawning naturally (composed of NOR and HOR adults) and artificially (composed of NOR adults) are shown in Table 36. At the tributary scale, there were 231 juvenile recruits per natural spawner versus 1,745 recruits per artificial spawner. An estimated 67 recruits per natural spawner reached LGD compared to 557 recruits per artificial spawner.

Table 36. Recruit per spawner estimates of BY05 Chinook salmon spawning naturally and artificially.

Spawning Type	Number of Spawners	Number of Females	Recruit Location	Juvenile Abundance	Recruit per spawner	Recruit per Female
Natural	148	45	Tributary	34,194	231	760
			LGD	9,929	67	221
Artificial	69	33	Tributary	120,415	1,745	3,649
			LGD	38,436	557	1,165

CHAPTER 5: HABITAT MONITORING

INTRODUCTION

This chapter covers habitat monitoring in Johnson Creek and one of its tributaries (Burntlog Creek) during 2007. We characterize and monitor water temperature zones in critical migration, spawning, and rearing habitat. Water temperatures outside preferred zones may limit juvenile production, stress fish and preclude adult passage (Bjornn and Reiser 1991). Stream discharge is collected and analyzed so that differences in flow between years can be incorporated into the analysis of factors affecting fish densities and migration timing.

METHODS

Temperature Monitoring

A total of six Optic StowAway temperature loggers (temp range -5°C to 37°C) were operated in Johnson Creek at the USGS gauging station, juvenile screw trap, adult weir, Ice Hole campground, Wapiti Meadow Ranch and Rock Creek (Figure 14). One temperature logger was also monitored in Burnt Log Creek near its confluence with Johnson Creek (Figure 14). Temperature loggers were launched, downloaded and re-deployed at various intervals during the year. This data was utilized to formulate seven-day moving mean, minimum and maximum of daily temperature values, which are applicable to stream temperature criteria developed, by the Department of Environmental Quality (DEQ), Environmental Protection Agency (EPA), and United States Forest Service (USFS).

Stream Discharge Monitoring

We utilize instream flow data from the US Geological Survey gauging station on Johnson Creek at [USGS 13313000 JOHNSON CREEK AT YELLOW PINE ID](#) and conduct daily measurements at a staff gage near the confluence. The USGS gage is located at Lat $44^{\circ} 57'44''$, Long $115^{\circ} 29'58''$, in the NE1/4 sec.29, T.19 N., R.8 E., Valley County, Boise National Forest, Hydrologic Unit 17060208, on right bank 700 ft upstream from mouth, and 0.2 mi southwest of Yellow Pine. The contributing drainage area above the gage is 211 square miles. The datum of gage #13313000 is 4,655.75 feet above sea level NGVD29. The period of record for this gage extends from 1928 to the current year. Data for Johnson Creek is presented from 2006 to 2007.

RESULTS & DISCUSSION

Temperature Monitoring

Based on water temperature monitoring data from 2007, seven-day, instream maximums occurred at most sites during the months of July and August (Figure 15). The highest average 7-day maximum temperature was recorded in late July at the Ice Hole monitoring location. On average, stream temperatures were consistently the highest at the Rock Creek location and consistently the lowest at the Burnt Log location. Detailed average daily temperatures and monthly means for all sites are located in Appendix F, Tables 8 to 14.

For Chinook salmon, optimal water temperatures range from 12.0° to 14.0°C (Bjornn and Reiser 1991). Exposure to water temperatures greater than 21.0°C for more than 1 week usually is fatal to adult Chinook salmon, while the upper incipient lethal temperature for Chinook salmon is 26.2°C. Temperatures recorded within key rearing and spawning areas in 2007 were generally within the range of preferred temperatures for summer Chinook salmon and none were determined to inhibit spawning, migration, or rearing.

Figure 14. Location of seven temperature loggers monitored in the Johnson Creek drainage in 2007.

Figure 15. Seven-day mean, maximum, and minimum instream temperatures summarized from six thermographs in Johnson Creek and one thermograph located in Burnt Log Creek during 2007.

Stream Discharge Monitoring

Mean monthly discharge recorded at the [USGS Johnson Creek staff gage \(#13313000\)](#) is shown in Figure 16. Peak discharge months included May and June. A daily maximum discharge of 4,190 cubic feet per second (cfs) occurred on May 20th while a daily minimum of 49 cfs was recorded on October 31.

Figure 16. Johnson Creek hydrograph during 2006 and 2007. Data shown depict monthly mean discharge (cubic feet per second) recorded from USGS gage 13313000.

CHAPTER 6: MANAGEMENT RECOMMENDATIONS

The following management recommendations were developed based on the JCAPE M&E Plan (Vogel et al. 2006), and more specifically, Monitoring and Evaluation Objective 7b contained within the Plan. Specific questions to be evaluated are:

- 1) Are the methods being used to collect data appropriate and the most effective to meet M&E objectives?
- 2) Is the quality (level of statistical power) of data being collected sufficient for management recommendations?
- 3) Has any of the uncertainty been removed and can any M&E activities be discontinued?
- 4) Are the M&E findings sufficient to recommend program operation modification prior to the five-year review?

M&E Objective 7b.1 – Effectiveness of data collection methods

The data collection methods used in 2006 that were designed to address M&E objectives were effective for most measures. With respect to data collection methods used to inform management decisions for adults, the following suggestions were identified:

- A. Relocate adult weir: The current location of the adult weir is 8.2 kilometers upstream of the confluence of Johnson Creek and the East Fork South Fork Salmon River (*refer to* Figure 3). Although the weir has high capture efficiency, the location excludes the lower portion of the river, which is used by adults for staging and spawning. As such, we are currently forced to expand above-weir data (e.g., counts, sex ratios, etc.) to represent conditions below the weir, which contributes considerable variation to our analyses. Movement of the weir to a location closer to the Johnson Creek confluence (i.e. RKM 0.5) would improve the accuracy around adult abundance estimates, fish per redd, spawner abundance and hatchery fraction, age and size at return, sex ratios, adult run timing, and would improve the robustness of adult genetic samples.
- B. Improve aging techniques: Due to the variability in lengths at age, as observed in 2006, there is a high potential for age misclassification of fish if relying only upon a discrete set of length criteria. Further emphasis must be placed on improving our accuracy of adult ageing, including investments of time and funds in age fin analysis, ageing through genotyping adults, and/or taking scales from adults interrogated at the weir.
- C. Improve understanding of spawning distribution: In an effort to improve our understanding of the spawning distribution of NOR and HOR adults, we propose to uniquely mark (with different colored opercle tags) NOR and HOR fish to enable origin-based observations of live fish on redds. Surveyed sections will be delineated by kilometer breaks, within which total numbers of actively spawning

HOR and NOR females will be recorded. This information will subsequently be correlated with GPS collection locations of HOR and NOR female carcasses. The intent of this effort is to evaluate 1) whether or not carcass collections provide a true indicator of origin-based spawning distribution and 2) provide for hypothesis testing under Monitoring and Evaluation Objective 1C (see Vogel et al. 2005).

With respect to data collection methods used to inform management decisions for juveniles, the following suggestions were identified:

- D. Application of an 8.5 mm PIT tag into subyearling migrants: We propose to continue tagging subyearling migrants with the 8.5 mm PIT tag in 2008. A limited number of tags were applied in 2007. We also plan on doing a paired comparison between detection differences of the 8.5 mm PIT tag and Bismark Brown dye. Our null hypothesis is that there will not be differences in detection, while the alternative hypothesis is that the 8.5 mm PIT tag will be more detectable than the dye. Acceptance (validation) of the null hypothesis would potentially enable us to improve our trap efficiency estimates, and reduce associated variation around juvenile abundance estimates. The proposed comparison is contingent, however, on the availability of a sufficient sample of juveniles of differing sizes at a given point in time.
- E. Reduce the number of PIT tags implanted into HOR supplementation smolt: The current protocol of implanting PIT tags into approximately 10-12 percent of hatchery-reared juveniles needs to be reevaluated. The minimum number of fish needed to obtain survival point estimates to Lower Granite Dam with 95% CI of 2.5% ranges between 500-1,500. Further, it is possible to obtain productivity measurements (e.g., SAR's, MAR's, and P:P ratios) without using PIT tags. A reduction in the number of PIT tags would save both money and, based on current research, may reduce tagging-related mortality.

Additional research designed to assess retention of PIT tags in juvenile Chinook salmon is recommended. Knudsen (in press) provides compelling evidence that a substantial number Chinook salmon smolt are PIT tagged subsequently lose the tag upon their release and are consequently identified as NOR upon their return as adults. The JCAPE project could conduct a similar study using HOR supplementation fish however it is not known if the sample size would be sufficient *and* conducting this type of research would negate our desire to tag fewer fish.

- F. Take bimonthly growth measurements in the hatchery: In an effort to improve length weight comparisons between HOR supplementation and NOR juveniles, it would be beneficial to subsample the hatchery population to obtain mean length and weight data at least two times a month. Currently, hatchery personnel conduct FPP counts at the end of each month to estimate total number of fish, and/or total length (mm) per fish. Conversely, JCAPE screw trap operations

sample and measure fish daily over the course of the month, which results in a difference in average fish length per given month; the average length of hatchery fish will be larger than the NOR fish since HOR fish were measured upon the conclusion of a month-long growing cycle while NOR fish were measured continuously over the month-long growing cycle.

M&E Objective 7b.2 – Sufficiency of data quality (statistical power) to enable management recommendations

The quality of data collected for the JCAPE project should be considered at a level that could be used to inform most management decisions. Sufficient replication, however, is currently not available to address some of the more critical recommendations, such as tests of significance between multi-year productivity measures (i.e., P:P ratios, or SAR ratios). Recommendations for improvement in the quality will occur during the five-year review process in January, 2009.

M&E Objective 7b.3 – Removal of uncertainty and subsequent cessation of M&E activities

Most of the JCAPE M&E data collection activities continue to be relevant with respect to informing supplementation-based management decisions, and should not be discontinued. One possible exception may include Monitoring and Evaluation Objective 3a. (Determine and compare genetic characteristics of NOR and HOR supplementation Chinook salmon in Johnson Creek) which has been addressed (see Narum 2005) through the collection and subsequent analysis of genetic samples from juvenile summer Chinook salmon.

Based on the genetic analyses presented in Narum (2005 *draft*) there was a decreased diversity in the first generation of supplemented Chinook salmon. This is expected in a single generation of supportive breeding (Ryman et al. 1999). The decreased diversity in the hatchery-origin fish could have been a result of a founder effect (diversity was reduced in the broodstock and this reduced diversity in the offspring) in addition to reduced effective population size, although it is more likely that it is due to limitations placed upon smolt production. Based on the section 10(a)(1)(A) permit that was issued by NOAA Fisheries, the JCAPE program is limited to producing only 100,000 smolts annually, or an annual broodstock take of 40 pairs of fish, rather than an annual production level of 300,000 smolts, as was initially proposed by the this project. Because of this reduction, it is likely that the number of broodstock needed to sufficiently capture the genetic variability of the population is too low, and is resulting in decreased diversity in the first generation of supplemented salmon. Therefore, in the absence of a change in smolt production levels, the continued collection of juvenile genetic samples should not be expected to provide additional determinations or clarification as to differences in genetic characteristics of NOR and HOR supplementation Chinook salmon in Johnson Creek.

It is recommended that field collections of juvenile genetic samples be discontinued at the conclusion of BY06 and potential savings be deferred towards addressing Monitoring and Evaluation Objective 1b (Genetic parentage analysis to determine and compare relative reproductive success of NOR and HOR supplementation Chinook salmon), which currently remains unfunded.

The reproductive success of supplementation fish continues to represent a key uncertainty in our supplementation efforts. By employing a DNA microsatellite based pedigree or parentage analysis, our progeny could be attributed to specific parents and in turn to particular cross types such as natural x natural, natural x supplementation, and supplementation x supplementation. Since 2001, M&E efforts have determined that the Johnson Creek adult weir is nearly 95% efficient at capturing all migrating adults. In addition, carcass surveys have a recovery rate of 50-60%, enabling samples to be collected from fish missed at the weir and from fish spawning below the weir. Generally, fewer than 10% of the fish spawn below the weir so we are confident that we can sample greater than 90% of the adult spawners at the weir or through carcass surveys.

Recommendations for the cessation (and/or addition) of other M&E activities will occur upon further review and/or following the five-year review process.

M&E Objective 7b.4 – Sufficiency of findings for program modifications prior to five-year review

Modifications to data collection methods (described in M&E Objective 7b.1) should occur as soon as logistically feasible. Our findings are sufficient to support these changes. Broader, programmatic changes should occur following the five-year review.

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APPENDICIES

Appendix A – Adult Abundance

Estimates of unmarked fish above the weir

Appendix Table 1 provides raw data used in calculations of estimated escapement of adult Chinook salmon above the weir. Please refer to methods section for methods used in derivation of values.

Estimates of unmarked fish below the weir

Appendix Table 2 provides raw data used in calculations of estimated escapement of adult Chinook salmon above the weir. Please refer to methods section for methods used in derivation of values.

Appendix Table 1. Escapement estimates of unmarked Johnson Creek summer Chinook salmon located above the weir in 2007.

Location	Origin	NOR						HOR supplemented						HOR stray						Total
	Age	3		4		5		3		4		5		3		4		5		
	Sex	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	
Unmarked carcasses collected above weir		0	0	1	1	4	0	0	1	0	0	0	0	0	0	0	0	0	0	7
Proportion of unmarked carcasses above weir		0	0	0.14	0.14	0.57	0	0	0.14	0	0	0	0	0	0	0	0	0	0	
Additional estimated number of fish above weir		0	0	2	2	8	0	0	2	0	0	0	0	0	0	0	0	0	0	14
Total Estimated unmarked fish above weir		0	0	3	3	12	0	0	3	0	0	0	0	0	0	0	0	0	0	21

Appendix Table 2. Escapement estimates of unmarked Johnson Creek summer Chinook salmon located below the weir in 2007.

Location	Origin	NOR							HOR supplemented						HOR stray						Total	
	Age	3		4		5		6	3			4		5		3		4		5		
	Sex	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F		M
Total Escapement prior to populating fish below weir		0	35	14	58	48	15	3	0	0	144	26	42	2	2	0	7	0	4	0	0	400
Prop. total escapement prior to adding below weir locations		0	0.09	0.04	0.15	0.12	0.04	0.01	0	0	0.36	0.07	0.11	0.01	0.01	0	0.02	0	0.01	0	0	
Carcasses collected between mouth and screwtrap		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Additional Estimated fish between mouth and screwtrap		0	0	0	1	1	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	5
Total Estimated fish between mouth and screwtrap		0	0	0	1	1	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	5

Location	Origin	NOR							HOR supplemented							HOR stray						Total
	Age	3		4		5		6	3			4		5		3		4		5		
	Sex	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	
Carcasses collected between screwtrap and adult weir		0	0	0	0	7	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	8
Additional Estimated fish between screwtrap and weir		0	2	1	3	3	1	0	0	0	9	2	3	0	0	0	0	0	0	0	0	24
Total Estimated fish between screwtrap and weir		0	2	1	3	10	1	0	0	0	9	3	3	0	0	0	0	0	0	0	0	32
Captured at weir and remained downstream of weir		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Total Estimated fish downstream of weir (Calculated by multiplying corrected fish per redd ratio by the total number of redds)																						38

Appendix B – Adult Distribution

Spawner Spatial Distribution

Spawner spatial distribution is shown in Appendix Figure 1 through 5. The figures depict redd locations identified in Sections 1, 2, 4, 5, and in Burnt Log Creek (tributary to Johnson Creek) in 2007.

Appendix Figure 1. Adult Chinook spatial spawner distribution surveyed in Section 1 of Johnson Creek, 2007 (Confluence of Johnson Creek and East Fork South Fork Salmon River to NPT screw trap – 6.28 km).

Appendix Figure 2. Adult Chinook spatial spawner distribution surveyed in Section 2 of Johnson Creek, 2007 (NPT screw trap to NPT adult weir – 1.91 km).

Appendix Figure 3. Adult Chinook spatial spawner distribution surveyed in Section 4 of Johnson Creek, 2007 (Top of Deadhorse rapids to mouth of Moose Creek – 5.45 km).

Appendix Figure 4. Adult Chinook spatial spawner distribution surveyed in Section 5 of Johnson Creek, 2007 (Moose Creek to Burntlog Creek – 6.36 km).

Appendix Figure 5. Adult Chinook spatial spawner distribution surveyed in Burnt Log Creek, 2007 (Mouth of Burnt Log Creek to 1.1 km above mouth of Buck Creek – 2.8 km).

Appendix C – Juvenile Abundance

Juvenile Migrant Trap Summary

Appendix Table 3 provides a summary of BY05 juvenile migrants trapped at the Johnson Creek rotary screw trap between March 2006 and November 2007 and Appendix Table 4 summarizes incidental (bycatch) numbers of fish trapped from March 2006 to June 2007.

Appendix Table 3. Daily summary of BY05 juvenile Chinook salmon captured in the Johnson Creek rotary screw trap from March 2006 to November 2007.

Lifestage	Month/Year	Number Captured	Number Marked	Number Recaptured	Not Marked	Number Mortalities
Fry	Mar-06	0	0	0	0	0
	Apr-06	1	0	0	0	1
	May-06	2	0	0	2	0
	Jun-06	481	222	1	258	0
	Sub Total	484	222	1	260	1
Parr	Jul-06	617	301	32	284	0
	Aug-06	564	416	109	38	1
	Sub Total	1,181	717	141	322	1
Presmolt	Sep-06	781	569	189	0	23
	Oct-06	1244	929	315	0	0
	Nov-06	356	303	53	0	0
	Dec-06	TRAP WAS NOT INSTALLED				
	Sub Total	2,381	1,801	557	0	23
Smolt	Jan-07	TRAP WAS NOT INSTALLED				
	Feb-07	TRAP WAS NOT INSTALLED				
	Mar-07	291	245	46	0	0
	Apr-07	129	107	22	0	0
	May-07	4	3	1	0	0
	Jun-07	1	1	0	0	0
	Sub Total	425	356	69	0	0
Yearling	Jul-07	0	0	0	0	0
	Aug-07	10	8	2	0	0
	Sep-07	4	3	0	1	0
	Oct-07	0	0	0	0	0
	Nov-07	0	0	0	0	0
Sub Total		14	11	2	1	0
TOTAL		4,485	3,107	770	583	25

Appendix Table 4. Daily summary of incidental fish captured in the Johnson Creek rotary screw trap from March 2006 to June 2007.

Data	Steelhead Trout	Mountain Whitefish	Cutthroat Trout	Bull Trout	Longnose Dace	Sculpin	Rainbow-Cutthroat Hybrid	Rainbow Trout	Adult Chinook Salmon
Mar-06	20	271	1	0	0	1	0	0	0
Apr-06	307	28	3	0	1	2	0	0	0
May-06	65	0	0	0	0	1	0	0	0
Jun-06	401	1	1	0	1	1	0	0	0
Jul-06	233	9	3	2	7	1	0	2	0
Aug-06	304	13	6	2	9	2	1	0	0
Sep-06	161	3	4	2	7	2	0	0	0
Oct-06	37	4	0	1	1	0	0	0	0
Nov-06	29	1	0	0	0	0	0	0	0
Dec-06					Trap not installed				
Jan-07					Trap not installed				
Feb-07					Trap not installed				
Mar-07	26	57	0	0	0	0	0	0	0
Apr-07	86	10	1	0	1	0	0	0	0
May-07	84	0	0	0	0	0	0	0	0
Jun-07	139	0	0	1	3	0	0	1	0
Total	1,892	397	19	8	30	10	1	1	0

Appendix D – Juvenile Survival/Productivity

Efficiency Estimates and Separation by Code Technology

Marks, such as PIT tags are used to generate efficiency estimates of migrating fish through the migration traps and to provide life history specific migration timing and survival estimates to LGD and other mainstem dams. However, once at LGD, tagged and non-tagged fish can experience different migration routes. The current default operations at the hydro-facilities are to return to the river all PIT tagged fish entering the bypass facility, while the vast majority of non-tagged fish that enter the bypass facility are transported to below Bonneville Dam. This default operation incrementally increases the relative proportion of PIT tagged to non-PIT tagged fish in the river. With differential mortality rates between the in-river and transportation passage routes, PIT tagged fish are affected at different rates relative to non-PIT tagged fish. This differential mortality will decrease (bias) the number and the overall proportion of PIT tagged to non-tagged fish that migrate to the ocean. Thus PIT tagged fish no longer represent the general non-tagged population of fish after passing LGD and limits, if not eliminates, our ability to calculate representative smolt-to-adult survival rate (SAR) and returning abundance of the general population. The SAR and adult returns calculated from adult PIT tag detections potentially only reflect fish that were bypassed or remained in the river undetected, not the entire migrant group.

With the separation by code (SbyC) technology currently operating in the hydro-system bypass facilities, it is now possible to accurately represent non-PIT tagged fish migrating through the hydro-system using a predetermined group of PIT tagged fish. The PIT tag codes from a predefined group of PIT tags can be entered into the SbyC system and given a specific action. The SbyC system has the ability to bypass or transport all, a predetermined portion, or every n^{th} individual entering each bypass facility and can be modified or eliminated as desired at any time during the migration period. To accurately represent non-tagged fish, a “monitor mode” can be designated for a predefined group of PIT tags, resulting in “no action” taken on the detected PIT tags. The “monitor mode” group of PIT tags will be barged, bypassed, or remain undetected in the same relative proportions as non-PIT tagged fish. Thus, returning PIT tagged adults accurately represent non-tagged adults regardless of juvenile detection rates, transportation rates, in-river survival rates, and potential delayed mortality of in-river and transported fish. These adult PIT tag detections are then used to calculate representative SARs and adult run predictions.

One drawback to the SbyC system and the “monitor mode” action is the loss of in-river juvenile survival rate estimates. Multiple mark-recapture estimators are generally applied to PIT tag detections through the hydro-system to estimate project specific survival and detection rates (bypass efficiency). For these estimators, at least two recapture periods are needed. For juvenile survival estimates to LGD, PIT tags must be available for detection at LGD and at another subsequent dam. In general, PIT tags in the “monitor mode” group likely removed from the river system upon first detection thereby eliminating survival rate estimates from this group. To generate survival rates to LGD and through the remainder of hydro-system, a second group of PIT tags are required to migrate through the hydro-system, available for multiple, hydro-system detections.

Juvenile survivals to LGD and smolt equivalents are determined for all life stages independently. Juvenile survival to other mainstem dams, specifically McNary and Bonneville dams, are also

determined. The minimum number of PIT tags needed to generate life stage specific survival rates to LGD are 500 to 1,500 tags depending upon life stage (Lady et al. 2001). Detections from these groups are modeled through the SURPH sample size program to obtain life-stage specific survival estimates from the natal stream to LGD.

Granite-to-Granite SARs and adult run predictions are generated from the number or relative proportion of PIT tags at LGD. Life stage specific tributary-to-tributary SARs and adult run predictions are generated from the number or relative proportion of each life stage PIT tagged at the natal stream. Use of PIT tags in conjunction with the SbyC system ultimately allows us to minimize bypass assumptions and base our SAR's and adult run estimates on migration estimates (and associated error) and PIT tag proportions (and associated error).

Selecting tags for bypass and the SbyC system occurs from the parr, pre-smolt tag files sorted by date and time of tagging. The PIT tags are split into bypass and transport groups by systematic removal of tags or another appropriate randomized method. The tags slated for transport could then be sent to the PSMFC prior to smolt migration.

Because of the uncertainty in the number of migrants and screw trap capture probability, selecting a representative sample of tagged smolts for bypass or the SbyC system is more problematic. In addition, due to the lead-time required for entering PIT tag codes into the SbyC system, PIT tags must be selected and codes sent to the PSMFC prior to spring smolt tagging. Utilizing all available information, as well as the previous years' results, it is possible to generate a smolt run prediction. This number provides us with the necessary information to allocate bypass and monitor mode in the appropriate levels to ensure survival estimates to LGD.

PIT tag detections at hydroelectric facilities are downloaded from the PTAGIS database. PIT tag recoveries at mainstem dams determine smolt migration timing, survival rates from the natal stream to LGD and total smolts reaching LGD. Migrant trap efficiency estimates are used to calculate the number and confidence interval of life history stage migrating from the natal stream. Lifestage specific migration timing and survival calculated from PIT tagged fish is then applied to the estimated non-tagged migrant population to generate an estimate and confidence interval of the number of migrants that survived to the smolt stage at LGD (smolt equivalents). Survival of PIT-tagged fish to Snake River and Columbia River dams are estimated by the SURPH.2 model (Smith et al. 1994, Lady et al. 2001). Smolt detections are also used to calculate SARs when tagged fish return as adults and are detected. Adult passage through the FCRPS is monitored with queries to the PTAGIS database. The SAR determination back to the tributary via PIT tags will be supported by PIT tag interrogation at Johnson Creek.

Appendix E – Multi-Year Comparisons

Calculations for smolt to adult return rates (SAR) and migrant to adult return rates (MAR) are provided in Appendix Table 5.

Appendix Table 5. Smolt-to-adult return rate (SAR) and migrant-to-adult return rate (MAR) calculations for tributary to tributary (JC to JC), LGD to LGD, and LGD to tributary (LGD to JC) performance periods. Methods of evaluation include life stage specific PIT tag returns and total PIT tag returns

Location	Evaluation Method	Origin	Measure	Calculation
JC to JC	Life stage specific PIT tag returns	NOR	MAR	$(\# \text{ Adult PIT tag Detections @ JC})_{parr} / (\# \text{ Juveniles Tagged @ JC})_{parr} = x_1$
				$(\# \text{ Adult PIT tag Detections @ JC})_{presmolt} / (\# \text{ Juveniles Tagged @ JC})_{presmolt} = x_2$
				$(\# \text{ Adult PIT tag Detections @ JC})_{smolt} / (\# \text{ Juveniles Tagged @ JC})_{smolt} = x_3$
		$MAR = \sum \text{Weighted Average (based on juvenile abundance at JC) of } x_1, x_2, x_3$		
	NOR/HOR	SAR	$(\# \text{ Adult PIT tag Detections @ JC})_{Smolt} / (\# \text{ Juveniles Tagged @ JC})_{Smolt}$	
	Abundance Estimates	NOR	MAR	$(\text{Estimated \# Adult returns @ JC})_{parr,presmolt,smolt} / (\text{Estimated \# Juvenile Migrants @ JC})_{parr,presmolt,smolt}$
		HOR	MAR	$(\text{Estimated \# Adult returns @ JC})_{smolt} / (\text{Estimated \# Juvenile Migrants @ JC})_{smolt}$

Location	Evaluation Method	Origin	Measure	Calculation
LGD to LGD	Life stage specific PIT tag returns	NOR	MAR	$\frac{(\# \text{ Adult PIT tag Detections @ LGD})_{parr}}{(\text{Estimated \# Juveniles Tagged @ LGD})_{parr}} = x_1$
				$\frac{(\# \text{ Adult PIT tag Detections @ LGD})_{presmolt}}{(\text{Estimated \# Juveniles Tagged @ LGD})_{presmolt}} = x_2$
				$\frac{(\# \text{ Adult PIT tag Detections @ LGD})_{smolt}}{(\text{Estimated \# Juveniles Tagged @ LGD})_{smolt}} = x_3$
		$MAR = \sum \text{Weighted Average (based on juvenile abundance at LGD) of } x_1, x_2, x_3$		
		NOR/HOR	SAR	$\frac{(\# \text{ Adult PIT tag Detections @ LGD})_{Smolt}}{(\# \text{ Juveniles Tagged @ LGD})_{Smolt}}$
		NOR	MAR	$\frac{(\# \text{ Adult PIT tag Detections @ JC})_{parr}}{(\text{Estimated \# Juveniles Tagged @ LGD})_{parr}} = x_1$
				$\frac{(\# \text{ Adult PIT tag Detections @ JC})_{presmolt}}{(\text{Estimated \# Juveniles Tagged @ LGD})_{presmolt}} = x_2$
				$\frac{(\# \text{ Adult PIT tag Detections @ JC})_{smolt}}{(\text{Estimated \# Juveniles Tagged @ LGD})_{smolt}} = x_3$
$MAR = \sum \text{Weighted Average (based on juvenile abundace at LGD) of } x_1, x_2, x_3$				
		NOR/HOR	SAR	$\frac{(\# \text{ Adult PIT tag Detections @ JC})_{Smolt}}{(\# \text{ Juveniles Tagged @ LGD})_{Smolt}}$

Appendix F – Habitat

Flow

Daily and monthly mean discharge data for 2006 and 2007 are presented in Appendix Table 6 and Appendix Table 7. Data is collected from USGS gauging station #13313000, 'Johnson Creek at Yellow Pine ID'. The contributing area for the gage is 546.5 km² and the gage datum 1,419 m above sea level NGVD29.

Temperature

Summary data (in tabular format) for 2007 is presented for daily average, and monthly average, maximum and minimum water temperatures (Celsius) in Johnson Creek and Burnt Log Creek, at seven of the stations that thermographs were deployed. Stations include (from downstream to upstream) the USGS gauging station (Appendix Table 8), NPT Screw Trap (Appendix Table 9), NPT Adult Weir (Appendix Table 10), Ice Hole Campground (Appendix Table 11), Wapiti Meadow Ranch (Appendix Table 12), Rock Creek (Appendix Table 13), and Burnt Log Creek Confluence (Appendix Table 14).

Appendix Table 6. Average daily and monthly stream discharge (cubic ft/sec) recorded in Johnson Creek in 2007. Data summarized from United States Geological Survey site #13313000.

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	125	91	102	98	1,200	1,600	561	128	84	73	50	97
2	117	90	93	98	1,140	1,970	511	125	83	72	63	94
3	110	90	94	98	1,040	2,420	469	123	82	71	81	78
4	107	90	93	113	1,050	2,300	433	120	81	73	86	83
5	98	88	88	129	1,080	2,300	410	116	80	79	91	96
6	102	80	92	137	1,190	2,200	400	112	80	87	157	97
7	103	80	92	138	1,190	2,220	386	110	80	88	328	91
8	101	87	90	149	1,080	2,220	347	109	81	80	442	90
9	87	89	89	154	1,040	2,220	322	107	84	78	245	90
10	101	77	81	157	1,020	2,000	303	106	82	76	156	90
11	105	77	89	160	1,140	1,720	285	103	79	75	153	90
12	99	86	87	162	1,370	1,620	270	102	78	75	116	94
13	98	88	86	197	1,580	1,670	259	101	78	74	129	95
14	101	89	86	238	1,780	2,050	245	100	78	73	121	96
15	103	83	87	295	2,150	1,700	230	99	78	73	101	115
16	82	76	87	358	2,620	1,440	218	98	79	77	126	97
17	97	76	87	323	3,030	1,380	208	102	82	80	111	75
18	98	76	88	295	3,340	1,260	198	103	82	79	110	70
19	98	75e	86	283	3,800	1,210	190	98	82	78	99	81
20	96	78	86	293	4,190	1,130	182	94	83	79	112	86
21	94	82	86	334	3,740	1,040	175	92	87	80	120	89
22	83	86	85	423	3,490	968	169	91	94	75	131	94
23	95	85	84	556	3,340	914	163	89	90	73	117	87
24	89	85	84	650	2,890	866	160	87	85	74	110	87
25	90	82	90	582	2,780	827	159	87	82	73	110	93
26	93	82	97	565	2,610	795	153	90	80	70	104	99
27	94	86	89	650	2,130	749	146	90	77	73	105	100
28	92	107	94	776	1,830	691	140	87	76	71	88	92
29	92		94	932	1,620	652	135	86	75	72	63	78
30	93		94	1,150	1,460	636	131	85	74	71	74	83
31	92		95		1,430		128	84		49		90
Avg	97.9	84.3	89.5	349.8	2043.5	1492.3	260.8	100.8	81.2	74.9	130.0	90.2

e – estimated value

Appendix Table 7. Average daily and monthly stream discharge (cubic ft/sec) recorded in Johnson Creek in 2007. Data summarized from United States Geological Survey site #13313000.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	91	73	74	245	1,340	765	189	85	69	93	181p	153p
2	90	69	70	238	1,440	765	179	84	68	105	158p	188p
3	92	71	74	216	1,260	753	174	83	68	96	147p	183p
4	91	75	73	226	1,010	749	166	81	66	96	145p	195p
5	85	74	74	224	890	717	159	80	65	93	139p	215p
6	84	75	75	276	822	695	149	80	65	88	134p	198p
7	81	76	76	348	863	634	141	80	65	84	129p	183p
8	88	77	88	447	1,030	573	138	80	65	84	129p	173p
9	86	78	84	552	1,180	524	133	78	65	90	125p	134p
10	85	77	84	462	1,330	564	129	78	65	89p	125p	167p
11	69	79	85	398	1,420	795	123	76	63	88p	128p	122p
12	68e	80	95	382	1,520	590	118	75	62	87p	106p	149p
13	66e	78	127	345	1,600	521	116	75	62	84p	152p	154p
14	66e	76	133	348	1,470	485	113	75	62	82p	103p	134p
15	68e	76	125	362	1,350	455	109	75	62	80p	138p	136p
16	69e	76	134	354	1,350	426	107	75	62	78p	155p	142p
17	70e	76	147	400	1,380	411	106	74	62	79p	223p	138p
18	72e	76	179	395	1,430	381	118	72	62	82p	550p	142p
19	76e	75	199	358	1,420	357	115	71	71	335p	694p	138p
20	78e	76	227	331	1,390	336	108	71	76	432p	461p	136p
21	78e	76	212	317	1,450	315	104	82	74	229p	314p	125p
22	78e	76	200	313	1,150	298	102	84	71	181p	287p	105p
23	78e	76	205	336	1,010	282	97	78	116	175p	280p	137p
24	78	72	217	389	900	265	96	75	121	192p	265p	138p
25	77	77	254	429	835	252	96	73	100	211p	256p	115p
26	76	76	289	478	813	241	96	71	92	206p	214p	118p
27	75	74	285	555	839	232	101	70	88	179p	228p	112p
28	72	75	262	735	902	218	95	70	83	166p	200p	114p
29	74		241	995	787	206	90	70	89	160p	205p	120p
30	78		242	1,210	759	198	88	70	88	222p	182p	118p
31	75		252		760		86	69		220p		111p
Avg	77.9	75.5	157.5	422.1	1151.6	466.8	120.7	76.1	74.2	144.7p	218.4p	144.9p

e – estimated value

p – provisional value

Appendix Table 8. Daily average and monthly average, maximum and minimum water temperatures (°C) in Johnson Creek at the USGS gauging station, 2007.

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.8	0.5	0.6	4.2	4.9	10.0	13.7	14.4	13.0	6.7	2.6	0.3
2	0.9	0.5	0.6	3.5	4.3	10.1	13.3	13.5	12.7	6.2	2.1	0.4
3	0.9	0.6	1.3	2.9	3.7	10.2	14.0	14.6	11.7	6.9	1.8	0.4
4	0.8	0.7	1.9	4.3	3.1	10.3	15.2	14.4	11.7	5.5	2.1	0.9
5	0.6	0.8	2.3	5.0	3.6	9.3	16.1	12.5	11.8	5.3	2.3	1.3
6	0.5	0.9	2.9	5.2	4.7	7.2	16.4	11.8	10.9	5.2	2.4	1.6
7	0.6	0.9	3.1	5.1	6.2	7.3	17.0	12.0	10.6	5.4	2.3	1.2
8	0.9	1.0	3.3	5.2	6.4	8.0	16.3	12.2	9.9	7.4	3.0	0.9
9	1.6	1.4	2.9	3.8	6.4	9.0	15.9	12.9	8.9	6.2	3.1	0.3
10	1.2	1.3	3.6	2.5	6.4	9.4	16.0	13.5	8.3		3.2	0.4
11	0.4	1.8	3.9	2.1	6.3	9.2	16.5	12.2	8.8		3.1	0.5
12	0.8	1.7	3.3	3.1	6.9	9.6	16.7	11.9	9.3		1.5	0.5
13	0.6	1.7	2.8	3.5	6.8	10.4	16.5	10.9	9.1		2.0	0.5
14	0.8	1.5	2.7	4.4	6.5	12.0	17.4	10.5	8.8		0.6	0.5
15	0.6	1.7	2.4	5.0	7.0	11.7	16.2	10.9	9.2		1.7	0.6
16	0.4	1.9	3.7	4.6	7.3	12.0	16.0	12.1	9.4		2.6	0.6
17	0.5	2.0	3.3	4.1	7.7	10.8	16.3	12.3	8.8		3.0	0.7
18	0.5	1.4	2.9	3.2	8.0	10.2	16.9	11.2	7.1		2.9	0.9
19	0.6	1.5	2.6	2.9	8.1	11.3	16.8	10.4	6.8		2.6	1.0
20	0.6	1.7	2.2	3.1	7.1	12.0	15.8	9.7	8.4		1.3	0.8
21	0.9	1.5	2.5	3.6	5.2	12.8	15.6	11.6	9.0		0.2	0.5
22	0.6	1.8	2.4	4.4	5.1	13.2	15.8	12.0	8.2		0.2	0.3
23	0.6	1.8	4.1	5.1	5.8	13.6	15.3	11.9	7.0		0.2	0.5
24	0.6	0.9	3.5	5.2	6.5	12.5	15.8	11.4	7.0		0.2	0.7
25	0.6	1.1	3.4	4.7	7.3	11.8	15.5	11.9	6.8		0.5	0.4
26	0.6	1.4	3.0	5.7	8.0	11.4	15.2	12.2	7.1		0.5	0.5
27	0.5	0.9	3.2	5.1	7.8	12.9	15.1	11.6	7.7		0.8	0.5
28	0.5	0.9	3.2	5.9	7.3	14.0	15.5	10.9	7.7		0.4	0.5
29	0.6		3.1	5.1	7.5	13.8	15.4	10.7	6.8		0.7	0.5
30	0.6		3.2	5.1	8.3	13.9	15.4	10.7	5.9	5.5	0.4	0.5
31	0.6		3.7		9.2		15.9	12.4		3.0		0.5
Avg	0.7	1.3	2.8	4.1	6.4	11.0	15.8	12.0	8.9	5.7	1.7	0.6
Max	2.5	2.8	6.2	7.9	11.5	16.9	19.8	16.8	14.6	8.9	3.9	2.0
Min	0.2	0.4	0.2	0.2	1.7	5.8	10.4	9.0	4.2	2.0	0.1	0.2
Count	2,976	2,688	2,976	2,879	2,976	2,880	2,977	2,976	2,880	966	2,880	2,976

Appendix Table 9. Daily average and monthly average, maximum and minimum water temperatures (°C) at the Johnson Creek screw trap, 2007.

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.2	0.0	0.1	3.7		9.6	13.7	14.7	13.7	6.2	2.1	0.0
2	0.5	0.0	0.0	3.0		9.7	13.1	13.9	13.2	5.8	1.5	0.0
3	0.4	0.0	0.7	2.4		9.8	14.1	15.0	12.3	6.6	1.2	0.0
4	0.4	0.2	1.2	3.8		9.9	15.4	14.9	12.5	5.1	1.6	0.3
5	0.0	0.4	1.7	4.5		8.9	16.3	12.7	12.2	4.7	1.7	0.7
6	0.1	0.5	2.3	4.6		6.8	16.7	12.1	11.0	4.7	1.8	1.0
7	0.1	0.6	2.3	4.5		7.0	17.1	12.0	11.0	5.0	1.8	0.6
8	0.6	0.7	2.6	4.6		7.7	16.5	12.5	9.9	7.2	2.5	0.4
9	0.8	0.7	2.1	3.1		8.8	16.0	13.3	8.9	5.1	2.6	0.0
10	0.5	0.6	3.0	2.0		9.0	16.1	13.8	8.2		2.7	0.0
11	0.0	0.8	3.1	1.7		8.9	16.8	12.5	8.8		2.4	0.0
12	0.0	0.8	2.5	2.7	7.7	9.3	16.9	11.9	9.6		0.6	0.0
13	0.0	0.8	2.0	3.2	6.4	10.1	16.6	11.1	9.0		1.4	0.0
14	0.0	0.7	2.1	4.0	6.1	11.6	17.9	10.7	9.1		0.2	0.0
15	0.0	0.8	1.9	4.5	6.7	11.4	16.5	11.1	9.3		1.1	0.1
16	0.0	1.1	3.0	4.1	6.9	11.6	16.2	12.5	9.5		1.9	0.1
17	0.0	1.2	2.6	3.5	7.3	10.3	16.7	12.6	8.6		2.4	0.2
18	0.0	0.7	2.2	2.7	7.7	9.9	17.1	11.5	6.8		2.5	0.2
19	0.0	0.8	2.0	2.5	7.8	11.0	17.3	10.6	6.6		2.2	0.3
20	0.0	0.9	1.7	2.7	6.7	11.7	16.1	9.8	8.5		0.9	0.1
21	0.0	0.8	2.0	3.2	4.7	12.6	16.0	11.9	8.9		0.0	0.0
22	0.0	1.0	1.9	3.9	4.8	12.9	16.3	12.1	7.8		0.0	0.0
23	0.0	1.0	3.5	4.7	5.4	13.4	15.7	11.8	6.7		0.0	0.0
24	0.0	0.2	2.9	4.7	6.1	12.2	16.1	11.7	6.7		0.0	0.1
25	0.0	0.4	2.8	4.3	6.9	11.5	16.0	12.3	6.6		0.1	0.0
26	0.0	0.7	2.5	5.2	7.7	11.3	15.4	12.6	6.9		0.1	0.0
27	0.0	0.2	2.7	5.4	7.4	12.8	15.5	11.8	7.5		0.3	0.0
28	0.0	0.3	2.8	5.4	6.9	13.9	15.9	11.1	7.3		0.0	0.0
29	0.0		2.6	3.5	7.1	13.8	15.9	10.9	6.5		0.2	0.1
30	0.0		2.8		7.9	13.8	15.9	11.3	5.6	5.0	0.1	0.1
31	0.0		3.2		8.8		16.5	13.2		2.4		0.0
Avg	0.1	0.6	2.2	3.7	6.8	10.7	16.1	12.3	9.0	5.3	1.2	0.1
Max	1.3	2.4	6.5	8.2	11.4	17.5	21.4	17.7	15.4	9.1	3.8	1.4
Min	0.0	0.0	0.0	0.0	3.2	5.4	10.0	8.5	3.3	1.3	0.0	0.0
Count	2,976	2,688	2,976	2,715	1,867	2,880	2,973	2,976	2,880	962	2,880	2,976

Appendix Table 10. Daily average and monthly average, maximum and minimum water temperatures (°C) at the Johnson Creek adult weir, 2007.

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.6	0.4	0.6	3.9		9.5		14.8	13.9	6.3	1.5	-0.4
2	0.7	0.4	0.5	3.3		9.5		13.9	13.4	5.9	0.9	-0.5
3	0.7	0.5	1.1	2.8		9.6		15.0	12.4	6.7	0.6	-0.5
4	0.7	0.7	1.7	4.0		9.7		15.0	12.6	5.2	1.0	-0.3
5	0.5	0.7	2.1	4.7		8.7		12.8	12.1	4.8	1.1	0.0
6	0.4	0.8	2.7	4.8		6.9		12.3	11.1	4.9	1.2	0.4
7	0.5	0.8	2.7	4.8		7.0		12.1	11.2	5.2	1.1	0.0
8	0.8	0.9	3.0	4.8		7.8		12.7	10.0	7.3	1.9	-0.2
9	0.9	0.9	2.5	3.3		8.7		13.4	9.2	5.1	2.0	-0.5
10	0.7	0.9	3.4	2.3		8.9		13.8	8.5		2.1	-0.5
11	0.4	1.0	3.5	2.0		8.8		12.6	9.0		1.8	-0.5
12	0.4	1.0	2.8	3.0		9.2		11.9	9.9		0.0	-0.4
13	0.4	1.0	2.2	3.4		9.8		11.1	9.0		0.8	-0.4
14	0.4	1.0	2.3	4.3		11.1		10.6	9.3		-0.3	-0.4
15	0.4	1.1	2.2	4.7		10.9		11.0	9.4		0.5	-0.4
16	0.4	1.3	3.2	4.4		11.1		12.5	9.7		1.2	-0.4
17	0.4	1.5	2.8	3.8	7.3	9.9		12.6	8.7		1.6	-0.4
18	0.4	1.1	2.4	2.9	7.7	9.5		11.6	7.0		1.8	-0.3
19	0.5	1.2	2.2	2.8	7.8		17.4	10.6	6.7		1.5	-0.3
20	0.5	1.2	1.9	2.9	6.7		16.2	9.8	8.8		0.3	-0.4
21	0.5	1.2	2.3	3.4	4.8		16.1	12.1	9.1		-0.5	-0.5
22	0.5	1.3	2.2	4.2	5.0		16.4	12.4	7.8		-0.4	-0.5
23	0.5	1.3	3.8	5.0	5.6		15.7	11.9	6.8		-0.5	-0.4
24	0.5	0.6	3.1	4.9	6.3		16.2	11.9	6.9		-0.5	-0.4
25	0.5	0.7	3.0	4.6	7.1		16.0	12.6	6.8		-0.4	-0.5
26	0.5	1.1	2.8	5.4	7.8		15.4	12.8	7.1		-0.4	-0.4
27	0.4	0.6	2.9	5.6	7.5		15.6	12.1	7.7		-0.3	-0.4
28	0.4	0.7	3.0	5.5	7.0		16.0	11.2	7.3		-0.4	-0.4
29	0.5		2.9	3.6	7.3		16.0	11.0	6.7		-0.4	-0.4
30	0.6		3.0		8.0		16.0	11.5	5.8	4.3	-0.5	-0.4
31	0.5		3.5		8.8		16.6	13.3		1.9		-0.4
Avg	0.5	0.9	2.5	4.0	7.0	9.3	16.1	12.4	9.1	5.3	0.6	-0.4
Max	1.4	3.2	7.0	8.2	11.1	13.3	20.7	17.8	16.2	9.9	3.6	0.9
Min	0.4	0.4	0.4	0.4	3.4	5.4	12.5	8.4	3.3	0.7	-0.6	-0.6
Count	2,976	2,688	2,976	2,717	1,440	1,728	1,248	2,976	2,880	960	2,880	2,976

Appendix Table 11. Daily average and monthly average, maximum and minimum water temperatures (°C) in Johnson Creek at Ice Hole campground, 2007.

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.1	0.1	0.2	3.7	4.4	9.5	13.7	14.9	14.2	6.0	1.9	0.1
2	0.2	0.1	0.2	3.0	3.8	9.6	13.2	14.0	13.6	5.6	1.3	0.1
3	0.2	0.1	0.5	2.4	3.2	9.6	14.2	15.3	12.6	6.5	1.0	0.1
4	0.1	0.1	1.1	3.7	2.7	9.7	15.5	15.1	12.8	4.9	1.5	0.2
5	0.1	0.1	1.5	4.4	3.3	8.7	16.5	12.8	12.2	4.4	1.6	0.4
6	0.1	0.2	2.0	4.5	4.4	6.7	17.1	12.4	11.1	4.5	1.7	0.7
7	0.1	0.2	2.2	4.4	5.8	6.8	17.3	12.2	11.2	4.9	1.6	0.5
8	0.2	0.3	2.4	4.5	6.0	7.7	16.7	12.8	9.9	7.2	2.4	0.3
9	0.3	0.2	2.0	3.1	5.9	8.7	16.2	13.5	9.1	4.5	2.4	0.1
10	0.2	0.2	3.0	2.0	5.9	9.0	16.2	14.0	8.3		2.5	0.1
11	0.1	0.3	3.0	1.6	5.8	8.8	17.0	12.6	9.0		2.2	0.1
12	0.1	0.3	2.3	2.7	6.4	9.2	17.0	11.7	9.7		0.4	0.1
13	0.1	0.4	1.7	3.1	6.3	10.1	16.8	11.2	8.7		1.3	0.1
14	0.1	0.3	1.9	4.0	6.0	11.6	18.2	10.6	9.3		0.4	0.1
15	0.1	0.4	1.9	4.5	6.6	11.4	16.6	11.0	9.3		0.9	0.1
16	0.1	0.6	2.8	4.0	6.8	11.6	16.2	12.7	9.7		1.6	0.1
17	0.1	0.8	2.4	3.5	7.1	10.2	16.9	12.6	8.4		2.1	0.1
18	0.1	0.5	2.1	2.6	7.5	9.8	17.5	11.7	6.6		2.3	0.1
19	0.1	0.6	1.9	2.5	7.7	11.0	17.5	10.5	6.5		2.0	0.1
20	0.1	0.5	1.5	2.6	6.5	11.7	16.3	9.8	8.9		0.8	0.1
21	0.1	0.6	2.0	3.1	4.5	12.6	16.3	12.2	9.0		0.1	0.1
22	0.1	0.8	1.8	3.9	4.7	13.0	16.6	12.4	7.4		0.1	0.1
23	0.1	0.7	3.4	4.7	5.3	13.4	15.9	11.8	6.5		0.1	0.1
24	0.1	0.2	2.7	4.7	6.1	12.3	16.3	12.0	6.6		0.2	0.1
25	0.1	0.2	2.6	4.3	6.9	11.6	16.3	12.7	6.6		0.2	0.1
26	0.1	0.6	2.5	5.1	7.7	11.2	15.6	13.0	6.9		0.1	0.1
27	0.1	0.2	2.6	5.3	7.4	12.8	15.9	12.3	7.5		0.2	0.1
28	0.1	0.2	2.7	5.2	6.8	14.0	16.2	11.2	7.1		0.1	0.1
29	0.1		2.6	4.5	7.1	13.9	16.1	11.0	6.5		0.1	0.1
30	0.1		2.7	4.5	7.9	13.8	16.3	11.7	5.6	4.9	0.1	0.1
31	0.1		3.2		8.8		16.8	13.6		2.3		0.1
Avg	0.1	0.3	2.1	3.7	6.0	10.7	16.3	12.4	9.0	5.1	1.1	0.1
Max	0.6	2.2	6.9	7.9	11.3	17.9	22.7	18.9	17.8	10.4	4.2	1.2
Min	0.1	0.1	0.1	0.1	1.0	5.1	9.9	7.8	2.6	1.2	0.1	0.1
Count	2,976	2,686	2,976	2,880	2,976	2,880	2,977	2,976	2,880	959	2,880	2,976

Appendix Table 12. Daily average and monthly average, maximum and minimum water temperatures (°C) in Johnson Creek at Wapiti Meadow ranch, 2007.

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.5	0.2	0.4	3.2	4.3	9.2	12.9	13.9	13.4	5.6	1.8	0.1
2	0.6	0.2	0.3	2.7	3.7	9.3	12.5	13.1	12.9	5.1	1.2	0.2
3	0.5	0.3	0.9	2.0	3.1	9.4	13.3	14.6	12.0	5.9	1.0	0.2
4	0.5	0.5	1.2	3.4	2.6	9.4	14.6	14.0	12.3	4.3	1.5	0.4
5	0.3	0.5	1.7	4.0	3.2	8.4	15.5	11.9	11.2	4.1	1.5	0.7
6	0.3	0.6	1.8	4.0	4.2	6.4	16.1	11.6	10.3	4.1	1.6	1.0
7	0.3	0.6	2.1	4.0	5.6	6.6	16.3	11.4	10.6	4.5	1.7	0.7
8	0.7	0.7	1.9	4.1	5.7	7.5	15.6	12.0	9.0	6.4	2.4	0.5
9	0.8	0.7	1.9	2.8	5.6	8.5	15.1	12.4	8.2	4.3	2.5	0.2
10	0.5	0.7	2.5	1.9	5.7	8.7	15.1	12.9	7.6		2.6	0.2
11	0.2	0.9	2.7	1.4	5.6	8.5	15.9	11.5	8.5		2.0	0.2
12	0.2	0.8	2.1	2.5	6.2	8.9	15.9	10.7	9.0		0.6	0.3
13	0.3	1.0	1.4	2.8	6.1	9.8	15.8	10.6	8.1		1.1	0.3
14	0.2	1.1	1.6	3.7	5.8	11.1	17.0	10.0	9.1		0.4	0.3
15	0.2	1.5	1.6	4.1	6.4	10.9	15.6	10.5	8.9		0.8	0.3
16	0.2	1.6	2.3	3.7	6.6	11.1	15.1	12.0	9.1		1.5	0.4
17	0.2	1.6	1.9	3.3	6.9	9.6	15.8	12.0	7.8		2.0	0.4
18	0.2	1.1	1.6	2.5	7.3	9.3	16.3	11.0	6.3		2.3	0.4
19	0.3	0.9	1.6	2.3	7.4	10.5	16.2	9.8	6.2		2.0	0.4
20	0.3	1.0	1.5	2.4	6.3	11.2	15.1	9.3	8.1		0.8	0.4
21	0.3	1.1	1.7	2.8	4.3	12.0	15.1	11.2	8.0		0.1	0.2
22	0.4	1.3	1.6	3.7	4.5	12.4	15.6	11.3	7.1		0.1	0.2
23	0.3	1.0	2.8	4.4	5.1	12.8	14.9	10.7	6.1		0.1	0.3
24	0.3	0.4	2.3	4.3	5.9	11.7	15.4	11.1	6.3		0.2	0.4
25	0.3	0.5	2.2	4.1	6.7	10.8	15.3	11.8	5.9		0.2	0.3
26	0.3	1.0	2.2	4.7	7.5	10.6	14.7	12.1	6.1		0.3	0.3
27	0.2	0.5	2.4	4.9	7.2	12.2	14.9	11.6	6.8		0.2	0.3
28	0.2	0.6	2.4	4.8	6.6	13.2	15.1	10.6	6.6		0.2	0.3
29	0.3		2.2	4.2	6.8	13.2	15.0	10.7	5.8		0.3	0.4
30	0.4		2.4	4.2	7.6	13.0	15.3	11.4	5.0	4.3	0.2	0.3
31	0.3		3.0		8.5		15.6	13.0		2.1		0.2
Avg	0.3	0.8	1.9	3.4	5.8	10.2	15.2	11.6	8.4	4.6	1.1	0.3
Max	1.6	6.1	5.8	7.5	11.1	17.2	21.9	19.4	18.3	9.8	4.0	1.6
Min	0.1	0.1	0.1	0.1	1.0	4.9	9.4	7.4	2.7	1.3	0.1	0.1
Count	2,976	2,687	2,976	2,878	2,976	2,880	2,976	2,976	2,880	957	2,880	2,976

Appendix Table 13. Daily and monthly average, maximum and minimum water temperatures (°C) in Johnson near the confluence of Rock Creek and Johnson Creek, 2007.

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.1	0.1	0.0	1.1	3.7	9.7	14.5	16.3	14.2	5.2	1.4	0.0
2	0.1	0.1	0.0	0.9	2.3	9.2	14.1	14.4	14.4	4.6	0.8	0.0
3	0.1	0.1	0.1	0.9	1.9	9.0	14.9	15.8	13.7	3.9	0.7	0.0
4	0.1	0.1	0.1	2.0	2.3	9.3	16.4	15.3	13.9	3.6	0.8	0.1
5	0.1	0.1	0.1	2.9	3.0	7.8	17.4	12.3	11.7	3.4	1.0	0.0
6	0.0	0.1	0.2	2.7	3.9	5.7	18.0	12.1	11.4	3.2	1.0	0.0
7	0.1	0.1	0.2	2.5	5.0	6.5	18.2	12.2	11.6	4.2	0.9	0.0
8	0.1	0.1	0.2	2.4	5.3	7.4	17.4	12.5	10.6	5.9	1.4	0.0
9	0.1	0.1	0.2	1.1	5.4	8.4	17.1	12.5	9.5	5.8	1.4	0.0
10	0.1	0.1	0.3	0.7	5.4	8.3	17.3	13.5	9.3	4.8	1.0	0.0
11	0.1	0.1	0.3	0.8	5.8	8.3	17.8	12.0	10.3	5.2	0.7	0.0
12	0.1	0.1	0.3	1.4	6.6	9.2	17.1	11.3	10.6	5.5	0.1	0.1
13	0.1	0.1	0.3	2.1	6.7	10.0	17.0	10.9	10.6	6.4	0.1	0.1
14	0.1	0.1	0.2	2.7	6.3	11.5	18.7	9.1	10.7	5.5	0.1	0.0
15	0.1	0.1	0.2	2.4	6.8	11.6	17.3		10.0	5.3	0.1	0.1
16	0.1	0.2	0.3	2.7	7.0	11.4	16.4		9.6	5.5	0.1	0.1
17	0.1	0.2	0.3	1.9	7.6	10.2	17.3		8.2	3.4	0.1	0.1
18	0.1	0.1	0.2	1.1	8.0	10.2	18.2		6.2	1.6	0.1	0.0
19	0.1	0.1	0.2	1.3	8.0	11.5	17.6		5.7	1.3	0.2	0.0
20	0.1	0.0	0.1	1.3	5.8	12.0	17.1		8.0	0.2	0.0	0.0
21	0.1	0.1	0.2	1.8	3.8	12.9	16.7	13.0	8.7	1.4	0.0	0.0
22	0.1	0.1	0.2	2.1	4.2	13.6	17.1	12.9	7.7	2.5	0.0	0.0
23	0.1	0.0	0.3	3.2	3.3	14.1	16.0	13.0	5.8	3.1	0.0	0.1
24	0.1	0.0	0.2	3.2	5.5	13.1	16.8	12.9	5.9	3.0	0.0	0.0
25	0.1	0.0	0.1	2.8	7.0	12.2	16.3	13.3	6.1	3.3	0.0	0.0
26	0.1	0.0	0.2	3.4	7.1	12.3	16.3	13.5	6.7	2.9	0.0	0.0
27	0.1	0.0	0.1	3.3	7.1	13.5	16.7	13.2	7.4	2.1	0.0	0.0
28	0.1	0.0	0.1	3.1	7.3	14.5	16.9	13.0	7.0	2.3	0.0	0.0
29	0.1		0.3	2.6	7.1	14.1	16.8	13.2	5.4	2.8	0.0	0.0
30	0.1		0.5	2.9	8.1	14.4	17.0	13.3	5.1	3.5	0.0	0.0
31	0.1		0.8		9.1		17.6	14.4		1.8		0.0
Avg	0.1	0.1	0.2	2.1	6.2	10.7	16.9	13.2	9.2	3.7	0.6	0.0
Max	0.1	0.6	1.7	6.8	12.4	18.6	22.7	20.5	18.9	9.3	3.3	0.2
Min	-0.1	-0.1	-0.1	-0.1	-0.1	4.0	10.3	8.2	2.2	-0.1	-0.1	-0.1
Count	1,240	1,120	1,240	1,200	1,718	2,880	2,976	2,298	2,880	2,976	2,057	744

Appendix Table 14. Daily average and monthly average, maximum and minimum water temperatures (°C) at Burntlog Creek mouth, 2007.

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	-0.2	-0.2	-0.2	2.3	3.4	7.6	11.0	12.9	11.9	4.7	0.9	-0.2
2	-0.1	-0.2	-0.2	1.7	2.9	7.9	10.7	12.2	11.8	4.1	0.2	-0.2
3	0.1	-0.2	-0.2	1.1	2.3	8.2	11.6	13.3	11.4	4.7	0.3	-0.2
4	0.1	-0.2	-0.1	2.4	1.7	8.1	12.8	13.0	11.6	3.2	0.6	-0.2
5	-0.1	-0.2	0.3	2.9	2.1	7.1	13.6	10.9	10.5	3.2	0.6	-0.2
6	-0.2	-0.1	0.6	2.8	2.9	5.1	14.4	10.6	9.5	3.0	0.7	-0.2
7	-0.2	0.0	0.6	2.8	4.1	5.8	14.5	10.4	9.4	3.4	0.9	-0.2
8	0.3	0.2	0.3	2.9	4.1	6.1	13.7	11.0	8.0	5.4	1.5	-0.2
9	0.4	0.3	0.7	2.0	4.1	7.2	13.3	11.4	7.2	4.6	1.6	-0.2
10	0.3	0.2	0.9	1.1	4.3	7.1	13.5	11.7	6.8	4.5	1.8	-0.2
11	-0.2	0.3	0.8	0.7	4.2	7.3	14.1	10.2	7.8	4.6	1.2	-0.2
12	-0.2	0.4	0.3	1.7	4.6	7.5	14.1	10.1	8.3	4.7	-0.2	-0.2
13	-0.2	0.3	0.1	1.8	4.5	8.4	14.4	9.8	7.9	5.5	0.2	-0.2
14	-0.2	0.1	1.0	2.6	4.2	9.5	15.2	8.9	9.0	4.1	-0.2	-0.2
15	-0.2	0.4	0.6	3.0	4.7	9.3	13.9	9.7	8.5	4.0	-0.2	-0.2
16	-0.2	0.5	1.5	2.7	4.9	9.4	13.8	11.3	7.9	4.9	0.7	-0.2
17	-0.2	0.4	1.2	2.2	5.3	7.9	14.4	11.2	7.0	3.5	1.7	-0.2
18	-0.2	0.1	1.0	1.8	5.6	7.9	14.8	10.4	5.5	2.0	2.0	-0.2
19	-0.2	0.0	1.2	1.6	5.7	9.0	14.3	9.0	5.3	2.4	1.8	-0.2
20	-0.2	0.2	1.2	1.4	4.8	9.5	13.7	8.6	7.0	1.4	0.4	-0.2
21	-0.2	0.2	1.2	1.9	3.2	10.4	13.6	10.1	6.7	1.7	-0.2	-0.2
22	-0.2	0.4	1.2	2.7	3.2	10.8	14.2	9.7	6.5	2.5	-0.2	-0.2
23	-0.2	0.3	2.2	3.4	3.6	11.0	13.6	9.6	5.0	2.6	-0.2	-0.2
24	-0.2	-0.2	1.9	3.1	4.5	9.8	14.2	9.7	5.1	2.6	-0.2	-0.2
25	-0.2	-0.2	1.8	3.0	5.3	8.8	14.1	10.3	4.5	3.0	-0.2	-0.2
26	-0.2	0.1	1.9	3.6	5.8	8.9	13.6	10.7	4.7	2.6	-0.2	-0.2
27	-0.2	-0.2	1.8	3.7	5.8	10.6	13.6	10.1	5.4	1.3	-0.2	-0.2
28	-0.2	-0.1	1.8	3.6	5.1	11.5	13.8	9.5	5.4	1.8	-0.2	-0.2
29	-0.2		1.4	3.3	5.1	11.2	14.0	9.9	4.5	3.1	-0.2	-0.2
30	-0.2		1.5	3.5	6.0	11.1	14.2	10.3	3.7	3.4	-0.2	-0.2
31	-0.2		2.1		5.4		14.5	12.0		1.0		-0.2
Avg	-0.1	0.1	1.0	2.4	4.5	8.7	13.7	10.6	7.5	3.3	0.7	-0.2
Max	0.6	0.7	3.9	7.2	9.9	15.1	19.0	16.3	15.1	7.3	2.8	-0.2
Min	-0.2	-0.2	-0.2	-0.2	0.1	3.7	7.5	6.7	1.7	0.1	-0.2	-0.2
Count	1,240	1,120	1,240	1,200	1,272	2,880	2,976	2,968	2,880	2,976	1,869	744