Monitoring and Evaluation of Yearling Fall Chinook Salmon (Oncorhynchus tshawytscha) Released from Acclimation Facilities Upstream

This Document should be cited as follows:

Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208

**Monitoring and Evaluation of Yearling Fall Chinook Salmon *Oncorhynchus tshawytscha*
Released from Acclimation Facilities Upstream of Lower Granite Dam**

**Annual Report
January 2003 – December 2003**

Prepared by:

Stephen J. Rocklage
Nez Perce Tribe
Department of Fisheries Resources Management
Lapwai, ID 83540

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project Number 1998-010-04
Contract Number 00004025

July 2005

© 1995 Nez Perce Tribe

EXECUTIVE SUMMARY

The Nez Perce Tribe, in cooperation with the U.S. Fish and Wildlife Service and Washington Department of Fish and Wildlife, conducted monitoring and evaluation studies on Lyons Ferry Hatchery reared yearling fall Chinook salmon *Oncorhynchus tshawytscha* that were acclimated and released at three Fall Chinook Acclimation Project (FCAP) sites upstream of Lower Granite Dam in 2003. This was the eighth year of a long-term project to supplement natural spawning populations of Snake River stock fall Chinook salmon upstream of Lower Granite Dam. The 437,633 yearlings released from the Fall Chinook Acclimation Project facilities were short of the 450,000 fish quota. We use Passive Integrated Transponder (PIT) tag technology to monitor the primary performance measures of survival to mainstem dams and migration timing. We also monitor size, condition and tag/mark retention at release.

We released 7,492 PIT tagged yearlings from Pittsburg Landing, 7,494 from Big Canyon and 2,497 from Captain John Rapids. Fish health sampling indicated that, overall, bacterial kidney disease levels at the acclimation facilities could be considered medium with 37-83% of the fish sampled rating medium to very high.

Mean fork lengths (95% confidence interval) of the PIT tagged groups ranged from 153.7 mm (153.2-154.2 mm) at Captain John Rapids to 164.2 mm (163.9-164.5 mm) at Pittsburg Landing. Mean condition factors ranged from 1.06 at Lyons Ferry Hatchery to 1.22 at Captain John Rapids.

Estimated survival (95% confidence interval) of PIT tagged yearlings from release to Lower Granite Dam ranged from 83.1% (80.7-85.5%) for Big Canyon to 91.7% (87.7-95.7%) for Captain John Rapids. Estimated survival from release to McNary Dam ranged from 59.9% (54.6-65.2%) for Big Canyon to 69.4% (60.5-78.4%) for Captain John Rapids.

Median migration rates to Lower Granite Dam, based on all observations of PIT tagged yearlings from the FCAP facilities, ranged from 5.8 river kilometers per day (rkm/d) for Captain John Rapids to 16.2 rkm/d for Pittsburg Landing. Median migration rates to McNary Dam ranged from 11.7 rkm/d for Captain John Rapids to 17.6 rkm/d for Pittsburg Landing. Median travel times from the FCAP facilities were about 8-15 days to Lower Granite Dam and 22-27 days to McNary Dam.

Median arrival dates at Lower Granite Dam, based on all observations of PIT tagged yearling groups from the FCAP facilities, ranged from April 23-25. Median arrival dates at McNary Dam for Pittsburg Landing, Big Canyon and Captain John Rapids groups ranged from May 4-10.

ACKNOWLEDGEMENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDIX TABLES AND FIGURES

Appendix A. List of PIT tag files and observation numbers and rates of PIT tagged yearling fall Chinook salmon released from the FCAP facilities at Lower Snake and Columbia River dams in 2003. All PIT tag files reside in the PTAGIS database managed by the PSMFC and are accessible at http://www.pittag.org/Data_and_Reports/index.html.

Table A.1.—List of PIT tagging files for yearling fall Chinook salmon from the FCAP facilities in 2003.

Table A.2.—First obs interrogation rates at Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from the FCAP facilities in 2003.

Table A.3.—All obs interrogations at Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from the FCAP facilities in 2003.

Appendix B. Results of statistical tests on length, condition factor, travel time, migration rate and arrival date for yearling fall Chinook salmon PIT tagged at the FCAP facilities in 2003. Significant differences for the ANOVA and Kolmogorov-Smirnov tests are highlighted in yellow.

Table B.1.—Results of the ANOVA Test and Tukey's HSD multiple comparisons for length and condition factor of yearling fall Chinook salmon PIT tagged at the FCAP facilities in 2003.

Table B.2.—Results of the Kolmogorov-Smirnov Test for pairwise comparisons of length and condition factor distributions for PIT tagged yearling fall Chinook salmon at the FCAP facilities in 2003.

Table B.3.—Results of the ANOVA Test and Tukey's HSD multiple comparisons for first and all obs migration rates of PIT tagged yearling fall Chinook salmon from the FCAP facilities to Lower Granite, McNary and Bonneville Dams in 2003.

Table B.4.—Results of the Kolmogorov-Smirnov Test for pairwise comparisons of travel time and arrival date distributions to Lower Granite Dam for yearling fall Chinook salmon PIT tagged at the FCAP facilities in 2003.

Table B.5.—Results of the Kolmogorov-Smirnov Test for pairwise comparisons of first and all obs travel time distributions to McNary and Bonneville Dams for yearling fall Chinook salmon PIT tagged at the FCAP facilities in 2003.

Table B.6.—Results of the Kolmogorov-Smirnov Test for pairwise comparisons of first and all obs arrival date distributions to McNary and Bonneville Dams for yearling fall Chinook salmon PIT tagged at the FCAP facilities in 2003.

APPENDIX C. SURPH survival estimates for PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams from 1996 through 2003. In figures, like colors indicate the same year across multiple figures. For instance, green indicates 1999 in all figures containing data for 1999.

Table C.1.—SURPH survival estimates, standard errors and 95% confidence limits for PIT tagged yearling fall Chinook salmon from the FCAP facilities to Lower Granite Dam, 1996-2003.

Figure C.1.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to Lower Granite Dam, 1996-2003.

Figure C.2.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to Lower Granite Dam, 1997-2003.

Figure C.3.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to Lower Granite Dam, 1998-2003.

Table A.2. SURPH survival estimates, standard errors and 95% confidence limits for PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to McNary Dam, 1996-2003.

Figure C.4.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to McNary Dam, 1996-2003.

Figure C.5.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to McNary Dam, 1997-2003.

Figure C.6.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to McNary Dam, 1998-2003.

Figure C.7.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from LFH to McNary Dam, 1996-2001.

Appendix D. Descriptive statistics for travel times (days) and migration rates (rkm/d) of PIT tagged yearling fall Chinook from the FCAP sites to Lower Snake and Columbia River dams in 2003.

Table D.1.—First Obs travel time (days) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2003.

Table D.2.—All Obs travel time (days) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2003.

Table D.3.—First Obs migration rate (rkm/d) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2003.

Table D.4.—All Obs migration rate (rkm/d) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2003.

Appendix E. Arrival date frequency distributions and cumulative frequencies for PIT tagged yearling fall Chinook from the FCAP sites based on first and all obs at Lower Snake and Columbia River dams in 2003.

INTRODUCTION

Historically, the Snake River basin represented a significant portion of the fall Chinook salmon *Oncorhynchus tshawytscha* production in the Columbia River system. However, construction of the Lewiston Dam in 1927 nearly eliminated Chinook salmon from the Clearwater River subbasin (CBFWA 1990; Fulton 1968) and construction of the Hell's Canyon complex of dams on the Snake River blocked salmon migration to the upper Snake River basin. Fall Chinook salmon escapement to the Snake River basin was estimated to average 72,000 adults annually from 1939-1949, declining to an average of 29,000 adults from 1950-1959 (Bjornn and Horner 1980). Even as recently as 1968, fall Chinook salmon counts at Ice Harbor Dam were about 20,000 fish. Since Lower Granite Dam was constructed on the Snake River in 1975, adult fall Chinook salmon counts decreased to an average of 600 fish between 1975 and 1980. Natural-origin fall Chinook salmon returns fell to a low of 78 in 1990, then increased to 318 in 1991, 533 in 1992 (WDF 1993) and 742 in 1993 (WDF 1994). Counts declined again in 1994 and 1995 to 406 and 350, respectively. Since 1995 there has been an upward trend in the number of fall Chinook salmon adults counted at Lower Granite Dam. The National Marine Fisheries Service (NMFS) listed Snake River fall Chinook salmon as "threatened" in 1992 in accordance with provisions of the Endangered Species Act (NMFS 1992). The status was reclassified as "endangered" under emergency action in 1994 and restored to "threatened" in 1995.

In 1994, through *U.S. v. Oregon*, the Columbia River Inter-Tribal Fish Commission (representing the four Columbia River Treaty Tribes) reached an agreement with States and Federal agencies to release yearling fall Chinook salmon beginning in 1996 as replacement of lost production from adults trapped at Lower Granite Dam and hauled to Lyons Ferry Hatchery (LFH) for broodstock needs and to cull non-Snake River Basin strays. The agreement stipulated the release of 450,000 yearlings annually on-station from LFH and outplanting of an additional 450,000 to acclimation facilities upstream of Lower Granite Dam to supplement natural fall Chinook salmon production. The Nez Perce Tribe (NPT) operates the Fall Chinook Acclimation Project (FCAP), which consists of three juvenile acclimation facilities along the Snake and Clearwater rivers with the intent of effectively enhancing population size and distributing natural fall Chinook salmon spawning throughout the existing habitat areas above Lower Granite Dam. The FCAP facilities began operation at Pittsburg Landing (PL) on the Snake River in 1996, Big Canyon Creek (BC) on the Clearwater River in 1997 and at Captain John Rapids (CJ) on the Snake River in 1998.

The Nez Perce Tribe, in cooperation with the Washington Department of Fish and Wildlife (WDFW) and U.S. Fish and Wildlife Service (USFWS), conducted monitoring and evaluation studies on yearling fall Chinook salmon that were acclimated and released from the FCAP facilities in 2003. This was the eighth year of a long-term project to monitor and evaluate the success of efforts to supplement natural spawning populations of fall Chinook salmon upstream of Lower Granite Dam.

The role of this project in the fall Chinook salmon supplementation program is to monitor and evaluate pre- and post-release performance of yearling fall Chinook salmon from the FCAP facilities. We primarily monitor pre-release yearling size, condition, and post-release emigration characteristics and survival through the Federal Columbia River Power System using passive

integrated transponder (PIT) tagging. In this report, we present a summary of the activities and data collection in 2003. In addition, this year we became part of a multi-agency effort to conduct fall Chinook salmon spawning ground surveys in the Snake River basin above Lower Granite Dam. Our role consists of conducting aerial spawning ground surveys in the Grande Ronde, Imnaha and Salmon rivers. The results of these surveys have been published by the USFWS under Bonneville Power Administration (BPA) project number 199801003 and are accessible on the BPA website at http://www.efw.bpa.gov/searchpublications/. For a detailed discussion of monitoring and evaluation activities, procedures and analyses for on-station yearling fall Chinook salmon releases from LFH in 2001-2002 please reference Milks et al. (2005). A report detailing LFH activities for 2003 is forthcoming (D. Milks, personal communication).

PROJECT OBJECTIVES

The objectives of this project are to quantify and evaluate pre-release fish health, condition and mark retention as well as post-release survival, migration timing, migration rates, travel times and movement patterns of fall Chinook salmon from supplementation releases at the FCAP facilities, then provide feedback to co-managers for project specific and basin wide management decision-making.

METHODS

<u>Study Area Description</u>

The FCAP facilities are located on the Snake River at Pittsburg Landing (rkm 346) and Captain John Rapids (rkm 263) and on the Clearwater River at Big Canyon Creek (rkm 57) (Figure 1). Lyons Ferry Hatchery is located at rkm 95 on the Snake River. Our study area continues downstream from the FCAP facilities to Bonneville Dam (rkm 234) on the Columbia River.
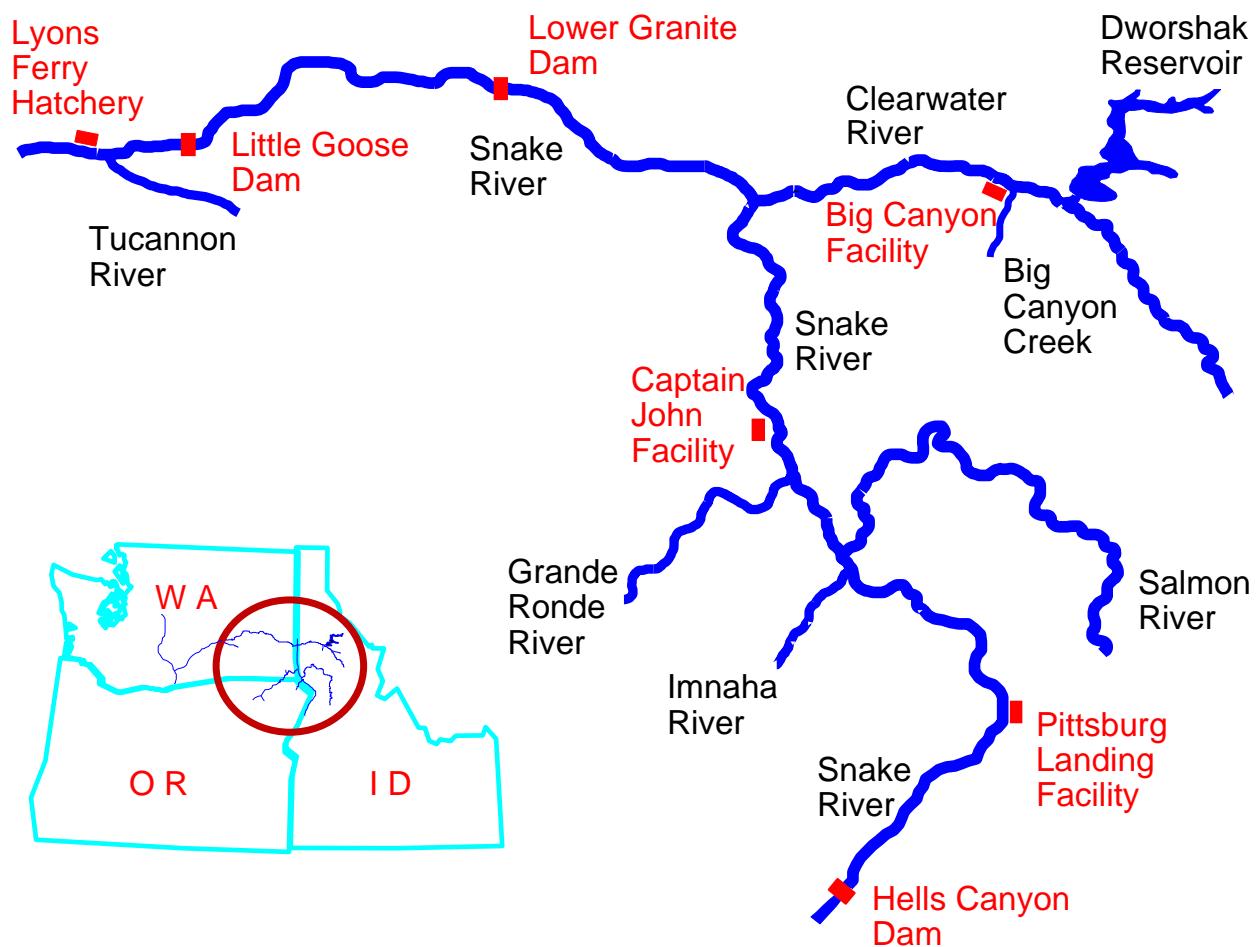
Figure 1.—Map of primary study area highlighting FCAP acclimation facilities, Lyons Ferry Hatchery and various Snake River dams.

Fish Handling and Anesthetization

Yearlings at Pittsburg Landing and Big Canyon were acclimated in 16 tanks (6 m diameter) and released in stages over three consecutive days. Yearlings at Captain John Rapids were acclimated in a single in-ground 150'X 50' acclimation pond and released volitionally with any fish remaining by the final release date forced out by draining the pond. Yearlings from LFH were also released using a similar volitional strategy. Reports with detailed descriptions of FCAP facilities and operations for projects 199801005, 199801007 and 199801008 (Pittsburg Landing, Captain John Rapids and Big Canyon, respectively) are accessible on the BPA website at http://www.efw.bpa.gov/searchpublications/.

Fish sampled for PIT tagging were captured with dip nets from tanks 5, 9 and 16 at Pittsburg Landing and tanks 6, 7 and 12 at Big Canyon. A screen was used to crowd fish in the tanks to improve capture efficiency and to obtain a representative subsample. Fish captured for PIT tagging were anesthetized in an MS-222 bath consisting of 3 mL stock solution (100 g/L) per 8 L of water buffered with sodium bicarbonate solution. PIT tagging at Pittsburg Landing and Big Canyon took place one week prior to release. Fish for PIT tagging at Captain John Rapids were captured from the pond, tagged, allowed to recover and released back into the pond to migrate volitionally with the rest of the fish. For a detailed description of fall Chinook salmon broodstock collection, incubation, rearing, and marking procedures at LFH please reference Milks et al. (2005).

Fish Health

To monitor fish health, USFWS personnel from the Idaho Fish Health Center sampled yearlings at the FCAP facilities and LFH approximately one week prior to release. Enzyme-linked immunosorbent assays (ELISA) were performed following methods as described in Chapter 6 of the U.S. Fish and Wildlife Service National Wild Fish Health Survey Laboratory Procedure Manual (True 2001, 2004) to determine the level of Bacterial Kidney Disease (BKD), *Renibacterium salmoninarum,* antigen in each of the fish. Infections levels were categorized as not detected, very low, low, medium, high or very high. Because ELISA tests were conducted using a new reagent in 2002, direct optical density comparisons to previous years cannot be made. However, categorical trends can be compared (Kathy Clemens, USFWS, personal communication). The ELISA was collected primarily as part of interstate fish transfer protocol. As such, the health monitoring results presented in this report are stand-alone because the sampling was not designed for direct comparison to the post-release survival estimates we present in this report.

Flow and Temperature

Flow data for the Clearwater River at Peck (gauge 13341050), Snake River near Hell's Canyon Dam (gauge 13290450) and Snake River at Anatone (gauge 13334300) were obtained online from the U.S. Geological Survey (USGS) at http://waterdata.usgs.gov/nwis/nwis. River temperature data for these sites (except for Hell's Canyon Dam where continuous temperature is not monitored) were obtained from the USGS Water Resources Division in Boise, Idaho. It is important to note that flows measured at the Snake River gauge near Hell's Canyon Dam are

controlled and more reflective of dam operations within the Hell's Canyon complex of dams rather than indicative of actual flow contribution from the Snake River basin above Hell's Canyon. Flow, spill and temperature data for the Snake River at Lower Granite Dam and the Columbia River at McNary Dam were provided by the U.S. Army Corps of Engineers (USACE) and obtained online from Columbia River DART at http://www.cqs.washington.edu/dart. There are gaps in some of the flow and temperature data, which are reflected in the figures as missing (or blank) segments.

We used the Pearson product moment correlation coefficient ($\alpha = 0.05$) to examine the relationship between migration rates to Lower Granite Dam with flows at Hell's Canyon Dam and flows and temperatures at Anatone and Peck.

PIT Tagging

Our PIT tagging goals for the Pittsburg Landing and Big Canyon acclimation facilities were 2,500 yearlings for each release date at each facility in order to representatively distribute tags across each release date. The PIT tagging goal at Captain John Rapids was 2,500 yearlings because fish were released volitionally (as one group) from a pond rather than in groups over several days.   NPT personnel conducted PIT tagging at all FCAP facilities with assistance from WDFW personnel at Pittsburg Landing. The WDFW discontinued PIT tagging of the on-station yearling fall Chinook salmon release in 2002. We have included some biological, mark retention and health information for the LFH yearling release, but because there were no PIT tagged fish released we excluded the LFH release from all statistical comparisons with the FCAP releases. All PIT tagged fish had a passage route designation of "return-to-river" for all dam collection and bypass facilities.

All fish selected for tagging were examined for existing PIT tags with a subsample examined for presence of coded wire tag (CWT). The fish were then PIT tagged, measured and examined for general condition, with a subsample weighed and examined for adipose fin (AD) clip and visible implant elastomer (VIE) tag retention. All tag, length, weight, mark retention and general condition data were recorded using a computerized data collection station manufactured by Biomark Inc. (Boise, Idaho). PIT tags were injected into the abdomen using manual hypodermic injectors following the general methods described by Prentice et al. (1986, 1990) and Matthews et al. (1990, 1992). Hypodermic injectors and PIT tags were sterilized in ethanol for at least ten minutes and allowed to dry prior to each usage. Tagging data were proofed for mistakes, validated for format compliance and uploaded to the Pacific States Marine Fisheries Commission (PSMFC) PIT Tag Information System (PTAGIS) database.

Biological Characteristics

Fork lengths of yearlings were measured to the nearest 1.0 mm using a CalComp 2000 digitized measuring board. The lengths were then categorized into 5 mm increment groups to calculate the frequency distributions. Weights were collected to the nearest 0.1 g using an Ohaus FY-3000 balance. Fulton's condition factor was calculated by

$$K = (\text{Weight (g)}/\text{Length (mm)}^3) \times 10^5$$

and categorized into increments of 0.05 for frequency distributions (Murphy and Willis 1996).

We used a One-way ANOVA to test the hypotheses: there is no difference in fork length and there is no difference in condition factor between release sites. We then used Tukey's HSD for multiple comparisons. In addition, we used a Kolmogorov-Smirnov two-sample test to test the hypotheses: there is no difference in fork length distribution and there is no difference in condition factor distribution between release sites. Differences were considered significant at $\alpha = 0.05$.

Mark Retention

All yearlings at the FCAP facilities and LFH were marked with CWT, AD clips and VIE tags by WDFW personnel. FCAP yearlings were marked prior to transfer from LFH. Yearlings from all facilities were differentially marked with VIE tags so that their point of origin could be determined visually during collection as returning adults at Lower Granite Dam and as post-spawning carcasses during spawning ground surveys. Yearlings received a green VIE behind the right eye for Pittsburg Landing, a green VIE behind the left eye for Big Canyon, a blue VIE behind the left eye for Captain John Rapids and a red VIE behind the left eye for LFH. We sampled for CWT using a Northwest Marine Technologies field sampling detector model FSD-I. We visually determined retention of AD clips and VIE tags. The probability of observing a fish with none of these marks was calculated by

$$p_0 = p_1 * p_2 * p_3$$

where p_0 is the proportion of fish expected to have no marks and p_1, p_2 and p_3 are the proportions of fish without CWT, AD clip and VIE, respectively.

Survival Estimation

Survival probabilities of PIT tagged yearlings from point of release to the Lower Snake River dams were estimated by the Cormack, Jolly, and Seber (1964, 1965, and 1965, respectively, as cited in Smith et al. 1994) methodology using the Survival Under Proportional Hazards (SURPH, version 2.2a) computer modeling program (Lady et al. 2002) as described in Statistical Survival Analysis of Fish and Wildlife Tagging Studies (Smith et. al. 1994). We used a Z-test to test the hypotheses: there is no difference in survival to Lower Granite Dam and there is no difference in survival to McNary Dam between release sites. Differences were considered significant at $\alpha = 0.05$.

PIT Tag Observation

The six main PIT tag observation (also called detection or interrogation) locations in the study area are Lower Granite (LGR), Little Goose (LGO), Lower Monumental (LMO), McNary (MCN), John Day (JDA) and Bonneville (BON) dams. PIT tag observation data were downloaded from the PTAGIS database. Arrival timing dates, cumulative observations, survival estimates, travel times in days, and migration rates in river kilometers per day (rkm/d) to the main observation sites were calculated from these data. Even though a volitional release was

employed at Captain John Rapids, we are reporting travel times and migration rates calculated from the final date of the volitional release. However, because of the inability to identify the actual date and time a given fish left the facility under the volitional release strategy, these measurements of travel time and migration rate are minimum and maximum values, respectively. Fish with single coil detections or negative travel times were removed from analyses where applicable.

PIT tag observations used for travel times, migration rates and arrival timing were compiled using two methods. Observations were analyzed by first detection only of individual fish regardless of location (hereafter referred to as first obs) and by detections of all individual fish at each dam (hereafter referred to as all obs). Under the first obs method, a fish that is detected at Lower Granite Dam and then again at Little Goose (or any other) Dam will only be included as an observation at Lower Granite Dam and excluded from the observation record at all other dams. Under the all obs method, a fish that is detected at multiple dams will be included in the observation record at each dam where it is detected. It is important to note that, by definition, all observations of FCAP fish at Lower Granite Dam are first observations and therefore both data sets are identical so all analyses are redundant and presented only once.

There are advantages to both methods. The first obs method excludes fish that pass a given dam through the collection and bypass facility from analyses at all other downstream dams where it was observed. Using the first obs method, data collected at each dam are essentially being recorded for completely different groups of fish with no single fish being recorded at more than one dam. This method provides a measure of "in-river" specific migration to the given observation location as these fish have passed previous dams though routes other than the collection and bypass facility (i.e. stayed in the river), thus effectively removing passage through the collection and bypass facility of any dam as a factor from the travel time, migration rate and arrival date calculations.

The all obs method can be considered a "return-to-river" method providing comprehensive detection data for all yearlings at a given dam regardless of how many previous dam collection and bypass facilities they have been detected in. Non-PIT tagged fish that enter the collection and bypass facilities of dams are typically loaded to barges and transported for release below Bonneville Dam rather than diverted back to the river, which is the default action for PIT tagged fish. Consequently, the all obs method should not be considered representative of travel times, migration rates and arrival dates for non-PIT tagged fish to dams downstream of Lower Granite, but rather only for those fish that are diverted back to the river for any reason. By including all fish observed at each dam, this method affords a different level of comparability because the observation data at one dam includes some of the same fish as observation data from other dams, providing a more comprehensive assessment of the overall release of PIT tagged fish by including all dam passage routes including the collection and bypass facilities. Estimating the effect on passage rate of non-PIT tagged fish that enter the collection and bypass facilities but get diverted back to the river for various reasons can be useful for management of dam operations. This provides some measure of effects of prior collection and bypass at upstream dams on migration rates and arrival dates at subsequent dams downstream, but not a complete segregation from the "in-river" segment. Therefore, any differences seen in results between first obs and all obs should be considered minimum differences.

The primary differences in river reaches between PIT tag observation sites are the distance and river characteristics from acclimation facility sites (Table 1). The approximate length of free-flowing river from Pittsburg Landing, Big Canyon and Captain John Rapids to the upstream end of Lower Granite pool is 112, 50 and 29 rkm, respectively. The reaches from Lower Monumental Dam to McNary Dam and John Day Dam to Bonneville Dam include two reservoirs between observation sites (Ice Harbor and The Dalles, respectively), which should be kept in mind when considering analyses through these reaches.

We used a Kolmogorov-Smirnov two-Sample Test to test the hypotheses: there is no difference in travel time distribution and there is no difference in arrival date distribution between release sites. We used a One-way ANOVA to test the hypothesis: there is no difference in migration rate to Lower Granite, McNary and Bonneville dams between release sites. We then used Tukey's HSD for multiple comparisons. Differences were considered significant at $\alpha = 0.05$.

Table 1.—Important sites in the study area and associated river kilometer[1].

Location	RKM
Bonneville Dam	234
John Day Dam	347
McNary Dam	470
Columbia/Snake River Confluence	522
Ice Harbor Dam	522.16
Lower Monumental Dam	522.67
Lyons Ferry Hatchery	522.95
Little Goose Dam	522.113
Lower Granite Dam	522.173
Snake/Clearwater River Confluence	522.224
Big Canyon Acclimation Facility	522.224.57
Captain John Rapids Acclimation Facility	522.263
Pittsburg Landing Acclimation Facility	522.346

[1]Kilometers for individual rivers are separated by periods. For the Pittsburg Landing Acclimation Facility, the notation is: From the mouth of the Columbia River upstream 522 km to the mouth of the Snake River, then from the mouth of the Snake River upstream 346 km to the Pittsburg Landing Acclimation Facility.

RESULTS AND DISCUSSION

A total of 140,383 yearlings were released from Pittsburg Landing and 145,331 from Big Canyon. The fish were released in stages, about one-half of each group per day for two days. Pittsburg Landing was released from April 13-14 and Big Canyon from April 14-15. A total of 151,919 yearlings were released volitionally from Captain John Rapids from March 30 – April 7. The total FCAP release number of 437,633 fell short of the release quota of 450,000 yearlings. Lyons Ferry Hatchery exceeded its quota, volitionally releasing an estimated 518,436 yearlings April 1-9.

We would like to note that while many of our comparative analyses show significant statistical differences between groups in regard to means or distributions, we consider some of these differences to not be biologically significant. For several of our comparisons, our sample sizes are very large, oftentimes making statistical tests sensitive to even small differences between groups.

Fish Health

Personnel from the USFWS Idaho Fish Health Center collected yearlings for BKD monitoring at the FCAP facilities and LFH from March 24 – April 10. Table 2 summarizes the ELISA results for all groups during pre-release exam. Overall, based on ELISA values, 2003 can be considered a year of medium BKD levels in yearling fall Chinook salmon from the FCAP facilities and LFH. From 37-83% of the fish sampled from the FCAP facilities graded medium to very high. Overall, BKD levels did not appear to increase after transport from LFH to the FCAP facilities. Infectious Hematopoietic Necrosis Virus (IHNV) was isolated in the pre-release exam on the Big Canyon yearlings, but no other pathogenic agents were found in the fish sampled.

When considering the overall health of a release group, WDFW researchers have theorized that BKD infected fish die during or soon after transport to FCAP facilities (prior to PIT tagging), but BKD infected fish at LFH struggle along in the lake unstressed until release and then die at a higher rate after release (M. Schuck, WDFW, personal communication). This mortality would likely result in the FCAP facilities releasing a relatively "healthier" population of fish compared to LFH by essentially weeding out the sickest fish from the FCAP populations. Direct and indirect mortality rates from transport to the FCAP facilities may be quite variable from year to year based on severity of BKD infection and the level of stress inflicted by the transport process. The ELISA results presented here do not conclusively support or refute this theory. We believe it is most likely that BKD related mortality would primarily manifest as delayed mortality during estuary and early-ocean entry due to experiencing passage related stress rather than prior to and during migration through the FCRPS (Budy et al. 2002).

Table 2.—Number of yearling fall Chinook salmon (with % of number sampled) in each ELISA level category at the FCAP facilities and LFH in 2003.

Location	n	Not Detected	Very Low	Low	Medium	High	Very High
					ELISA		
Pittsburg Landing	60	0 (0%)	0 (0%)	10 (17%)	6 (10%)	15 (25%)	29 (48%)
Big Canyon	60	0 (0%)	16 (27%)	22 (37%)	10 (17%)	3 (5%)	9 (15%)
Captain John Rapids	61	0 (0%)	5 (8%)	24 (40%)	10 (17%)	12 (20%)	9 (15%)
Lyons Ferry Hatchery	57	0 (0%)	1 (2%)	24 (41%)	13 (22%)	14 (24%)	7 (12%)

Flow and Temperature

The average flow in the Snake River near Hell's Canyon Dam in April was about 43% below the 37-year average from 1966 to 2002. Overall, flows fluctuated regularly between about 9,000-20,000 cfs except for one spike up to over 41,000 cfs that lasted about one week at the end of May (Figure 2). Spring flow patterns in 2003 did not resemble the historical hydrograph. Flow patterns at the Hell's Canyon gauge location are essentially dictated entirely by operations at Hell's Canyon Dam.

The daily average discharge in the Snake River at Anatone is considerably higher than the discharge at Hell's Canyon Dam due to input from the Salmon, Imnaha and Grande Ronde Rivers. Flows in the Snake River at Anatone in April were about 25% below the 44-year average from 1959 to 2002 (Figure 3). Flows at Anatone peaked at 147,000 cfs on May 31. The daily mean water temperature during April ranged from 7.3^O to 11.2^O C with an overall mean of 9.6^O C.

The average daily discharge in the Clearwater River at Peck in April was about 47% above the 38-year average from 1965 to 2002, peaking at 62,900 cfs on May 30-31. The higher than normal flows seen at Peck in July and August were due to water releases from Dworshak Reservoir on the North Fork Clearwater River (Figure 4). The daily mean water temperature during April ranged from 5.4^O to 7.6^O C with an overall mean of 6.5^O C.
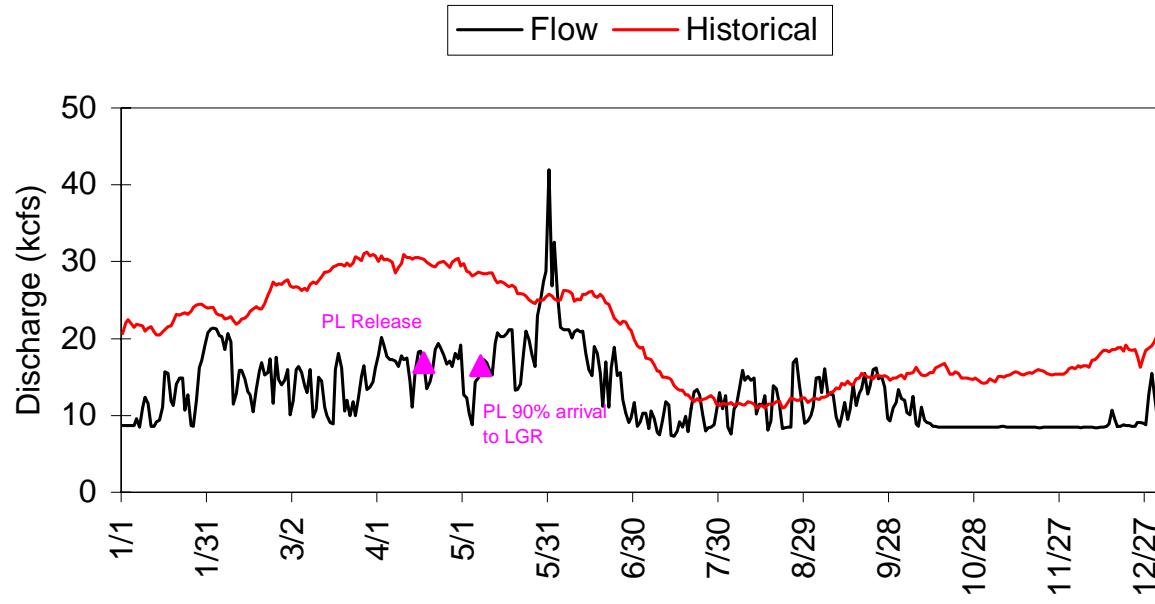
Figure 2.—Mean daily flow in 2003 and historical mean flow from 1966-2002 for the Snake River as measured at USGS gauge 13290450 near Hell's Canyon Dam.
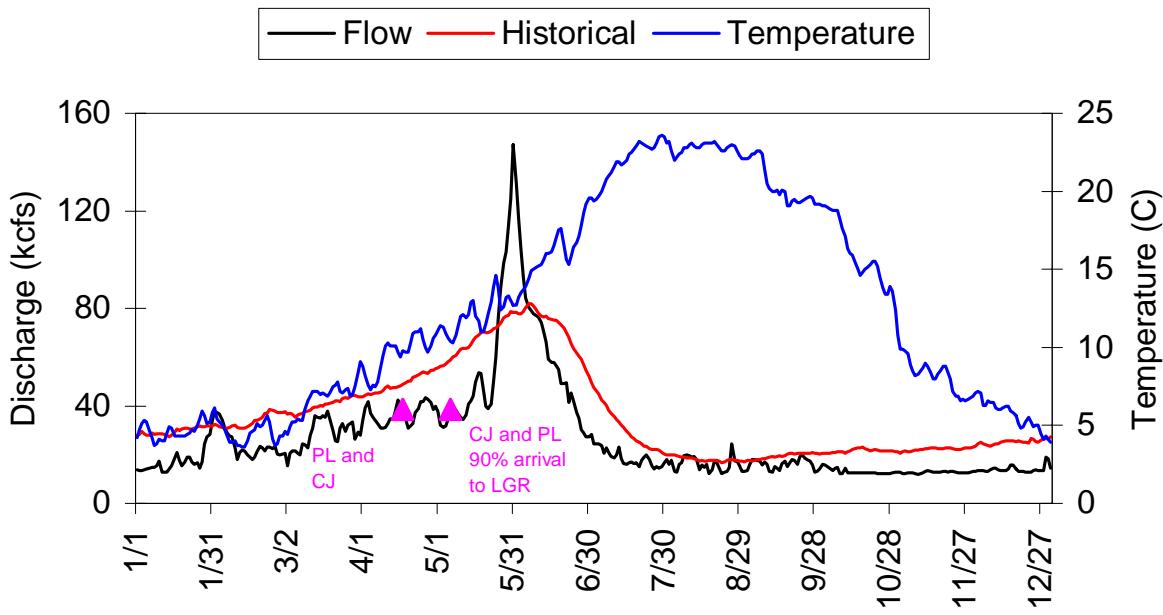
Figure 3.—Mean daily flow and temperature in 2003 and historical mean flow from 1959-2002 for the Snake River as measured at USGS gauge 13334300 near Anatone, Washington.

11
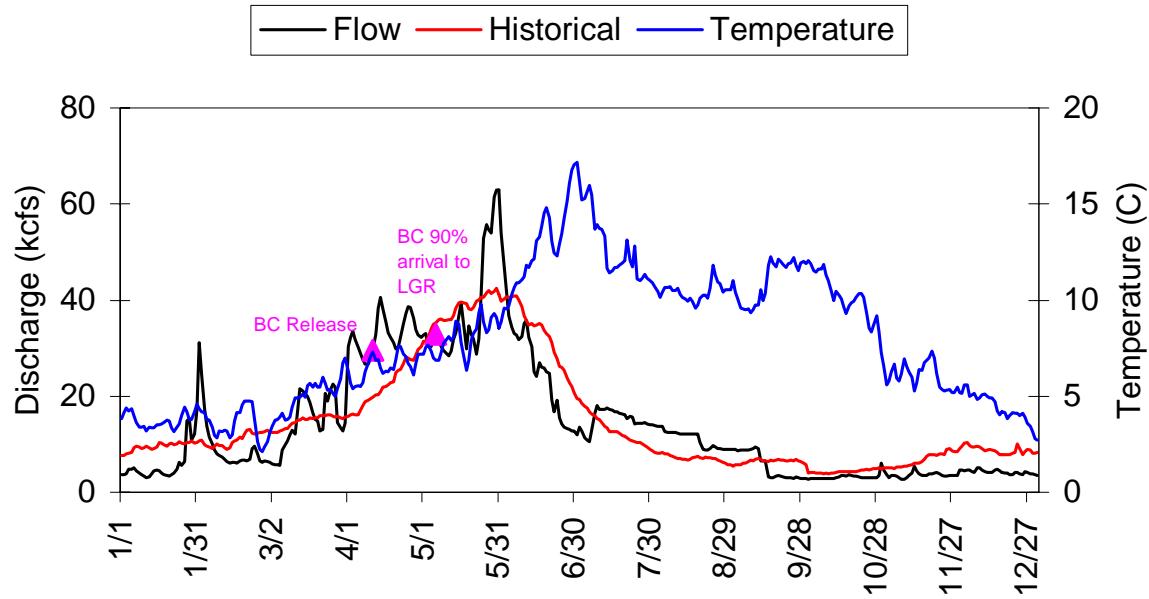
Figure 4.—Mean daily flow and temperature in 2003 and historical mean flow from 1965-2002 for the Clearwater River as measured at USGS gauge 13341050 near Peck, Idaho.

Average daily outflow as measured in the tailrace at Lower Granite Dam increased steadily from the beginning of the year until peaking sharply up to 208.2 kcfs on May 31 (Figure 5). The main period of spill was from April 3 through June 20 with daily spill averaging 27.8 kcfs and peaking at 114.3 kcfs on May 31. During periods of spill, spill generally tracked the total outflow pattern.

Average daily outflow as measured in the tailrace at McNary Dam began increasing with spring runoff from 111.0 kcfs on March 23 peaking at 352.5 kcfs on May 30 (Figure 6). The main period of spill was from April 14 through June 29 with daily spill averaging 80.4 kcfs and peaking at 176.8 kcfs on May 31. During periods of spill, spill tracked the total outflow pattern.
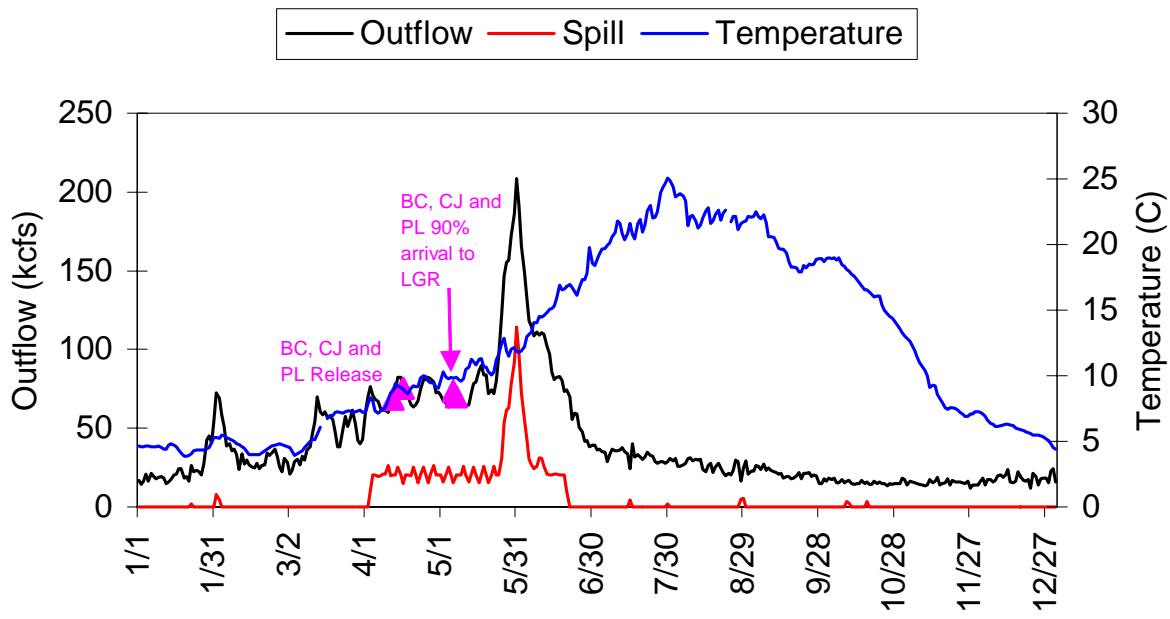
Figure 5.—Mean daily flow, spill, and temperature for the Snake River in 2003 as measured by the USACE at Lower Granite Dam.
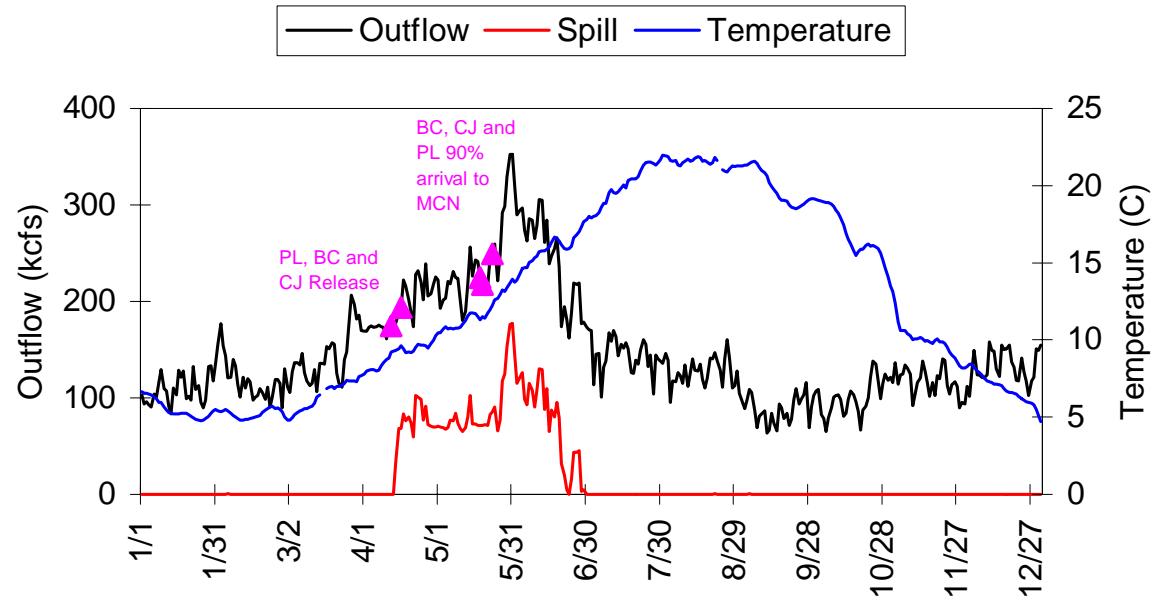
Figure 6.—Mean daily flow, spill, and temperature for the Columbia River in 2003 as measured by the USACE at McNary Dam.

PIT Tagging

PIT tagging operations went smoothly this year. No mechanical or electronic problems were encountered with the equipment and there was no immediate post-tagging mortality. A total of 7,492 and 7,494 yearling fall Chinook salmon were PIT tagged at Pittsburg Landing and Big Canyon, respectively (Table 3). A total of 2,497 yearlings were PIT tagged at Captain John Rapids. See Appendix A for a list of PIT tag files and synopsis of PIT tag observations at Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville dams.

Table 3.—Number of PIT tagged yearling fall Chinook salmon released from the FCAP facilities in 2003.

Facility	Date Tagged	Number Tagged	Date Released
	April 8	2,497	April 13
	April 9	2,497	April 14
Pittsburg Landing	April 10	2,498	April 15
	Total	7,492	
	April 1	2,495	April 16
	April 2	2,499	April 17
Big Canyon	April 3	2,500	April 18
	Total	7,494	
Captain John Rapids	March 26	2,497	March 30-April 7

Biological Characteristics

The ANOVA on fork lengths shows a significant between-groups effect ($P = 0.007$). Multiple comparisons indicate that groups from all three FCAP facilities were significantly different from each other, but Pittsburg Landing was similar to LFH (Appendix B, Table B.1). Biologically there is no difference in mean length between the Big Canyon group and Captain John Rapids (Table 4). The statistical difference was due to the large sample sizes. Yearlings from Pittsburg Landing and LFH were larger than the other FCAP groups, and the 8-10 mm difference may be biologically significant. Fork length distributions of PIT tagged fish from the FCAP release groups all differed significantly ($P < 0.0001$) from each other, but Pittsburg Landing and LFH were similar ($P = 0.2304$) to each other (Appendix B; Table B.2); although visual inspection shows that the distributions were all shaped similarly and probably do not represent a biological difference (Figure 7).

The development of differences in fork length distribution between groups is possible for several reasons. First, the fish are differentially marked at LFH and must be reared separately afterward. In addition, the Captain John Rapids facility is a single permanent pond and the Pittsburg Landing and Big Canyon facilities consist of 16 temporarily constructed aluminum tanks. It is

14

possible that growth rates may differ due to differences in rearing conditions (such as loading densities, exchange rates, etc.), feeding behavior between the facilities, feed distribution efficiency between personnel at each facility. In addition, each FCAP facility uses river water as its source as opposed to the well water source used at LFH. Differences in water temperature could account for the differences in growth rate as well; however this should not cause a change in the length distribution, only the mean length. It is also possible that there was a bias due to sampling methods. The fish at Pittsburg Landing and Big Canyon were crowded in the tanks and captured by dip net while the fish at Captain John Rapids were captured from the pond using a cast net.

Table 4.—Fork length, weight and condition factor of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH in 2003.

Facility		Number Sampled	Mean	Standard Deviation	95% C.I. (+/- mean)	Median	Range
Pittsburg Landing	Fork Length (mm)	7,439	164.2	12.7	0.3	164	94 - 210
	Weight (g)	1,213	50.1	11.0	0.6	49.7	9.1 - 90.6
	Condition Factor	1,212	1.13	0.05	0.00	1.13	0.89 - 1.34
Big Canyon	Fork Length (mm)	7,456	155.4	14.7	0.3	157	94 - 204
	Weight (g)	1,217	42.8	11.5	0.6	42.9	12.2 - 92.7
	Condition Factor	1,217	1.12	0.06	0.00	1.12	0.86 - 1.33
Captain John Rapids	Fork Length (mm)	2,481	153.7	13.9	0.5	155	100 - 200
	Weight (g)	426	45.4	9.7	0.9	45.6	18.2 - 73.6
	Condition Factor	422	1.22	0.07	0.01	1.22	1.03 - 1.40
Lyons Ferry Hatchery[1]	Fork Length (mm)	709	162.8	14.5	1.1	163	103 - 207
	Weight (g)	678	46.7	12.1	0.9	46	12.5 - 102.8
	Condition Factor	678	1.06	0.06	0.00	1.06	0.92 - 1.19

[1] No yearlings were PIT tagged at LFH, a subsample from the population was collected specifically for length and weight measurement.

The ANOVA on condition factors also shows a significant between-groups effect ($P = 0.0057$). Multiple comparisons indicate that groups from all three FCAP facilities and LFH were significantly different from each other (Appendix B, Table B.1). Mean condition factors at Pittsburg Landing and Big Canyon were not likely different on a biological basis. However, the higher condition factor at Captain John Rapids and lower condition factor at LFH were likely biologically different than the other FCAP groups (Table 4). Condition factor distributions of PIT tagged fish from the yearling release groups all differed significantly from each other (Appendix B; Table B.2). Results of all statistical tests are included in Appendix B.
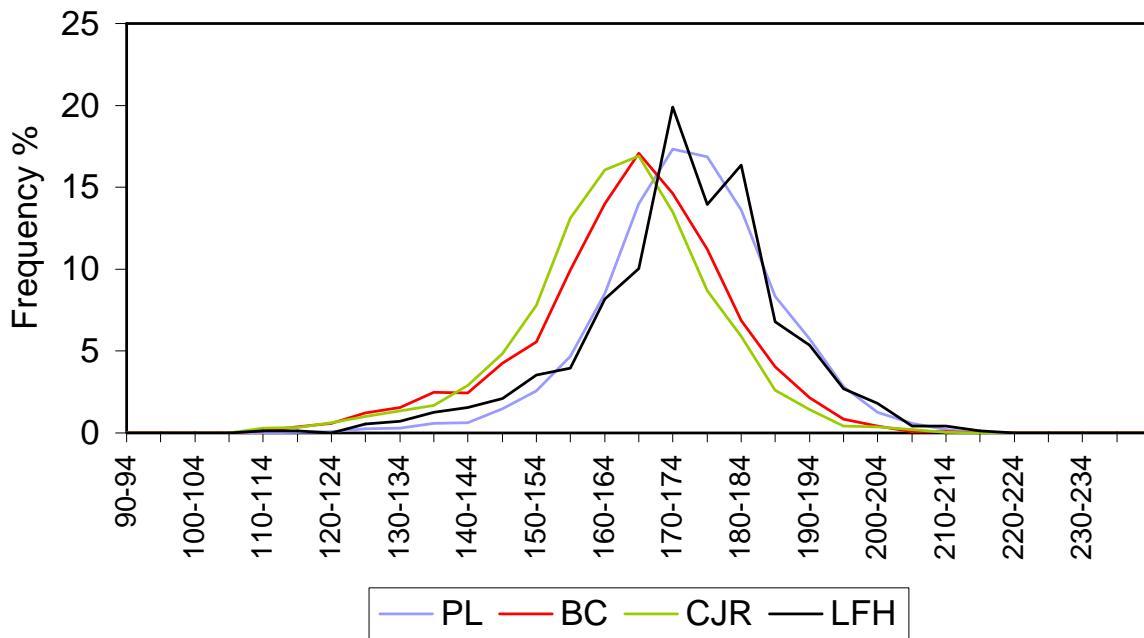
Figure 7.—Fork length frequency of PIT tagged yearling fall Chinook salmon at the FCAP facilities and LFH in 2003.

Mark Retention

Marking fish with externally identifiable marks or tags is an important management tool for identification and sorting of adults captured at Lower Granite Dam for passage above the dam or transport to LFH. Quantifying tag and mark retention is important for expanding sample counts during run reconstruction at Lower Granite Dam and from ocean and in-river harvest CWT sampling. Retention of CWTs, VIE tags and adipose fin clips was typical of what we have seen in past years (Rocklage 2004; Rocklage and Kellar 2005a, 2005b, 2005c, 2005d).

Coded wire tag retention was 98.8% or better for yearlings from all facilities. Adipose fin clip retention ranged from 97.2% at LFH to 98.4% at Pittsburg Landing and Captain John Rapids. Retention of VIE marks was lower and more variable than for adipose fin clips and coded wire tags, ranging from 84.3% at Pittsburg Landing to 91.0% at Big Canyon (Table 5). A total of 11 FCAP and 19 LFH fish (0.003% and 0.004% of each release, respectively) were estimated to have been released with no marks, which could potentially return as adults to either Lower Granite Dam or LFH and be mistakenly identified as wild origin.

Table 5.—Retention of coded wire tags, adipose fin clips and visible implant elastomer tags in yearling fall Chinook salmon at the FCAP facilities and LFH in 2003. Also shown are the probability that a fish was unmarked and unclipped and the estimated number released unmarked and unclipped.

		% Retention			Probability of	Estimated number
	n	CWT	AD	VIE	no marks	with no marks
Pittsburg Landing	1,215	98.8	98.4	84.3	0.0000303	4
Big Canyon	1,222	98.8	97.6	91.0	0.0000262	4
Captain John Rapids	425	99.1	98.4	88.9	0.0000171	3
Lyons Ferry Hatchery	2,395	99.1	97.2	84.7	0.0000375	19

Survival

The SURPH model analyzes PIT tag detections and provides a point estimate for survival and standard error, from which we calculated 95% confidence intervals for each release group. The primary points to where we estimate survival are Lower Granite and McNary dams. Estimated survival (95% confidence interval) from release to Lower Granite Dam ranged from 83.1% (80.1-85.5%) for Big Canyon to 91.7% (87.7-95.7%) for Captain John Rapids. Estimated survival from release to McNary Dam ranged from 59.9% (54.6-65.2%) for Big Canyon to 69.4% (60.5-78.4%) for Captain John Rapids (Table 6). Yearling survival from Captain John Rapids to Lower Granite Dam was significantly higher than from Pittsburg Landing ($P = 0.0258$) and Big Canyon ($P = 0.0003$). There were no significant differences in survival to McNary Dam between the FCAP facilities (Table 7). Yearling survival to Lower Granite and McNary dams in 2003 was similar to those seen in most years prior (Appendix C).

Table 6.—Estimated survivals and 95% confidence intervals of PIT tagged yearling fall Chinook salmon from the FCAP facilities to Lower Granite and McNary dams in 2003.

Facility	Evaluation Point	Estimated Survival	95% C.I. Lower Bound	95% C.I. Upper Bound
Pittsburg Landing	Lower Granite	0.8642	0.8403	0.8881
	McNary	0.6228	0.5709	0.6747
Big Canyon	Lower Granite	0.8309	0.8066	0.8552
	McNary	0.5990	0.5463	0.6517
Captain John Rapids	Lower Granite	0.9172	0.8772	0.9572
	McNary	0.6943	0.6051	0.7835

Table 7.—Results of the Z-test for pairwise comparisons of SURPH survival estimates to Lower Granite and McNary dams for yearling fall Chinook salmon PIT tagged at the FCAP facilities in 2003.

	To Lower Granite Dam	
	BC	CJ
PL	*P* = 0.0557	*P* = 0.0258
BC		*P* = 0.0003

	To McNary Dam	
	BC	CJ
PL	*P* = 0.5277	*P* = 0.1743
BC		*P* = 0.0712

Travel Time and Migration Rate

In previous years, median travel times based on all obs have typically been slightly longer (i.e. lower migration rates) than for those based on first obs. This was observed again in 2003. This indicates that the collection and bypass facilities delay passage at dams relative to other passage routes such as spillways. Median travel times from the FCAP facilities were about 8-15 days to Lower Granite Dam and about 22-27 days to McNary Dam. For this type of study, which compares fish released from and observed at multiple locations, travel time from release to a given point is of limited utility because of differences in distance between release points to a given observation site as well as in distance between observation sites. As would be expected, median travel time increases from point of release to successive observation points downstream (Appendix D, Tables D.1 and D.2).

The ANOVA on migration rates to Lower Granite, McNary and Bonneville dams each show significant between-groups effects ($P < 0.01$ for all). Multiple comparisons of migration rates showed that all FCAP PIT tagged groups differed significantly to Lower Granite, McNary and Bonneville dams (Appendix B, Table B.3).

Our data indicates that the migration rates from Pittsburg Landing and Big Canyon in the free-flowing reach above Lower Granite Reservoir were higher than through Lower Granite and Little Goose and Lower Monumental reservoirs (Figures 8 and 9). We have observed this pattern in most years. When considering migration rates from the FCAP facilities to Lower Granite Dam, it is important to remember that these reaches includes about 29-112 rkm of free-flowing river, where our radio telemetry study has shown migration rates to be higher than through the impounded reaches (unpublished data). As shown in Figures 8 and 9, the overall migration rate from release to Lower Granite Dam is easily higher than for the migration rate from release to Little Goose and Lower Monumental dams, and was especially evident at Big Canyon. We would like to reiterate that the migration rates we present are calculated from the point of release to each dam. As a result, the higher migration rates above Lower Granite Dam (specifically

above the impounded reach) average up the lower migration rates below, which means that the specific migration rates through Little Goose and Lower Monumental pools are even lower than indicated in Figures 8 and 9. This pattern has typically not been evident from Captain John Rapids, which is only 29 rkm of free-flowing river above Lower Granite Reservoir. Below Lower Monumental Dam there tended to be an increase in migration rate of PIT tagged yearlings as they move downstream, which was apparent in all FCAP groups. Migration rates based on first obs and all obs are detailed in Appendix D, Tables D.3 and D.4, respectively.

Current PIT tag technology is such that effectively segregating the free-flowing reach of the Snake River from the upper reach of Lower Granite pool is not possible. The increasing migration rates in downstream reaches may be due to the fact that these fish have been actively migrating for over 3 weeks by the time they reach McNary Dam on the Columbia River and are likely at an advanced stage of smoltification, yet still 470 rkm from the ocean.
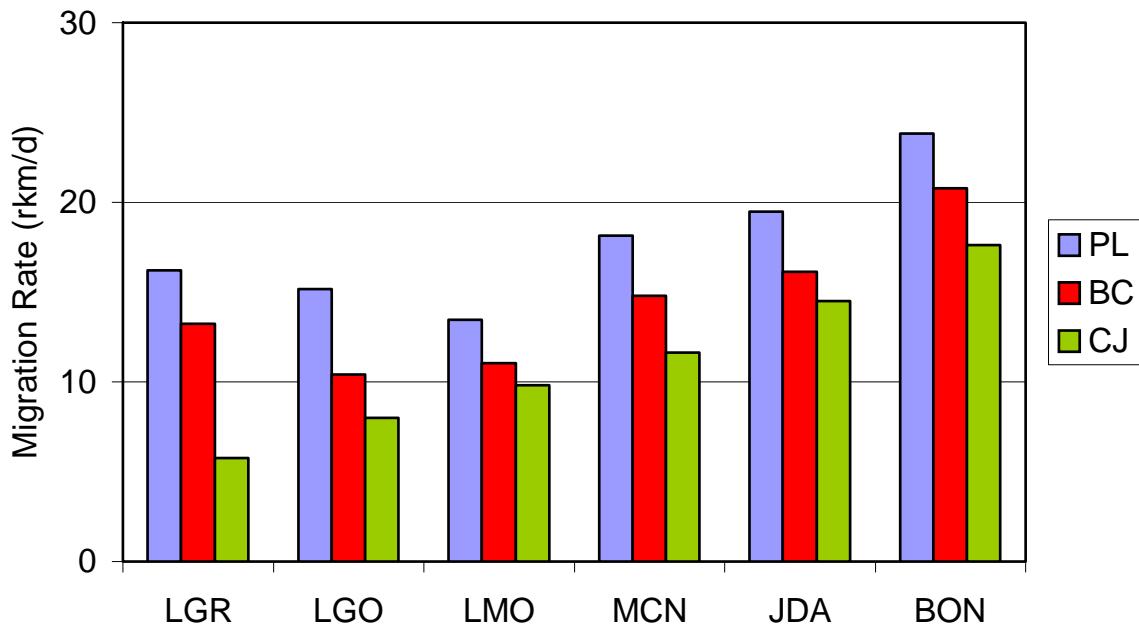

Figure 8.—First obs migration rate (rkm/d) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2003.

19
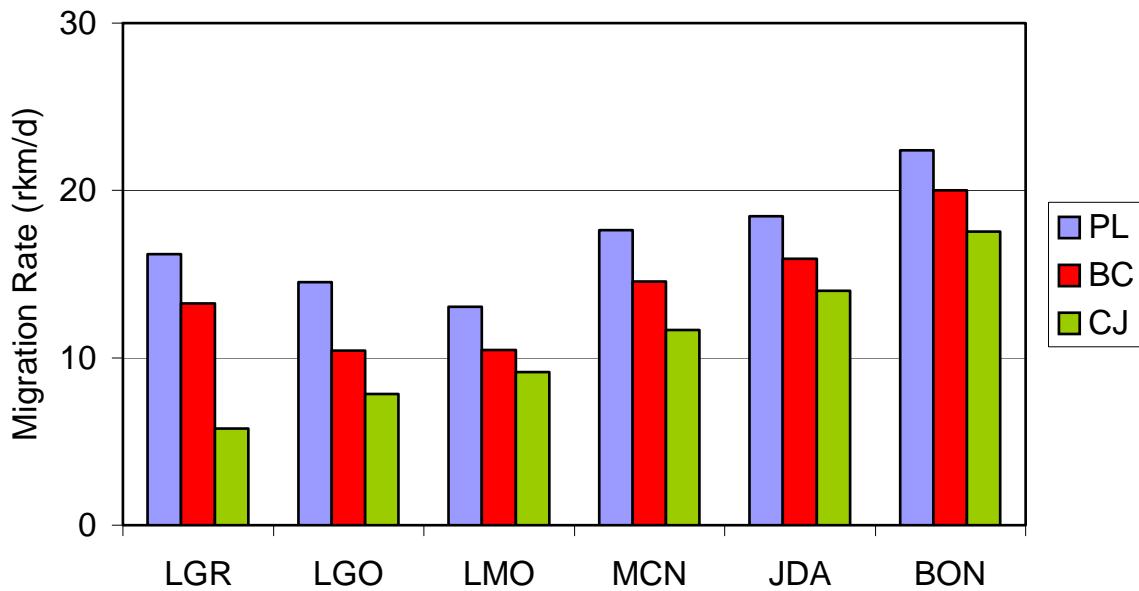
Figure 9.—All obs migration rate (rkm/d) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2003.

Flow patterns do not appear to greatly affect timing of when FCAP yearlings begin to migrate downstream after being released from the acclimation facilities. We have observed that the fish appear to be well into the smoltification process and ready to migrate immediately upon release from the FCAP facilities.

Migration rates from Pittsburg Landing to Lower Granite Dam during 1996-2003 had a significant positive correlation with flow at both Hell's Canyon Dam ($r = 0.9032$, $P = 0.0021$) and Anatone ($r = 0.9466$, $P = 0.0004$), while having essentially no correlation with temperature at Anatone ($r = -0.0469$, $P = 0.9121$), as illustrated in Figures 10 and 11. Migration rates from Big Canyon to Lower Granite Dam during 1997-2003 also had a significant positive correlation with flow ($r = 0.7823$, $P = 0.0367$) and negative correlation with temperature ($r = -0.7154$, $P = 0.0707$) at Peck (Figures 12 and 13). Migration rates from Captain John Rapids to Lower Granite Dam during 1998-2002 had a positive correlation with flow ($r = 0.7733$, $P = 0.0713$) and a weak positive correlation temperature ($r = 0.3192$, $P = 0.5375$) at Anatone (Figures 14 and 15).

Migration rate from Pittsburg Landing has a positive correlation with flow and essentially no correlation with temperature. It appears that flow is the primary driving factor for Pittsburg Landing and Captain John Rapids fish, while flow and temperature may be about equal driving factors in migration rate for yearlings from Big Canyon. Relative to Pittsburg Landing, migration rate from Big Canyon has a somewhat weaker positive correlation with flow but a much stronger negative correlation with temperature. The lower migration rates and correlation to flow for Big Canyon relative to Pittsburg Landing could simply be a result of the relative flow levels between the two rivers or the water velocity. It is also possible that the lower flows work in conjunction with the lower temperatures in the Clearwater River compounding the effect on the early migration rate of yearlings after they are released. We are beginning to see an increase

20

significant correlations between migration rate and flow as we gather more data points. Additional years of data will provide more clarity to these relationships.
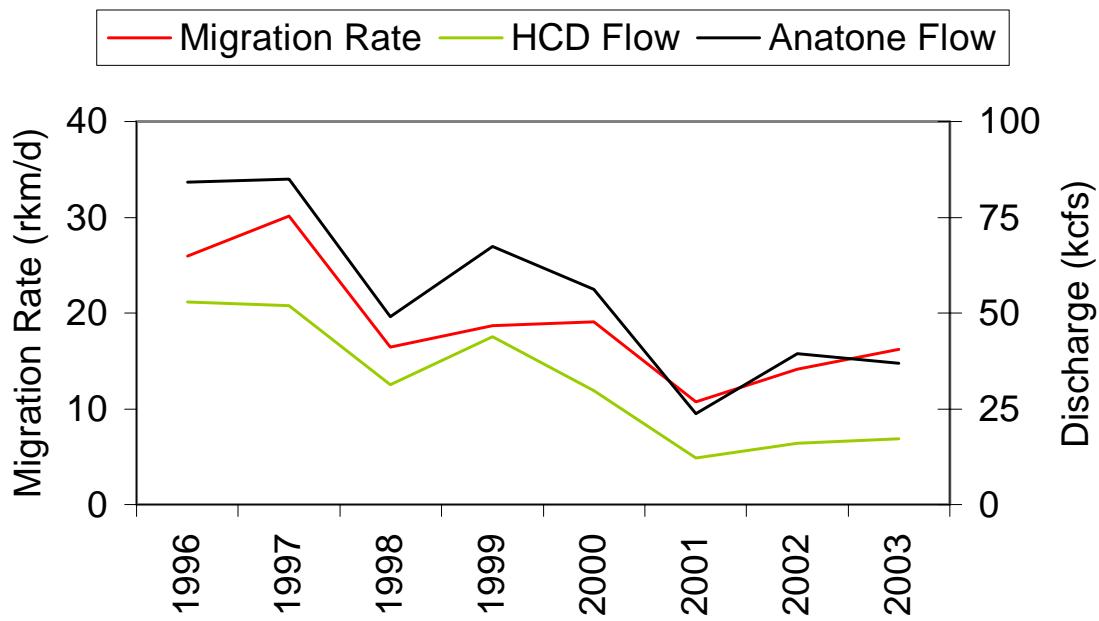
Figure 10.—Yearling migration rate (rkm/d) from Pittsburg Landing to Lower Granite Dam versus Snake River flow at Hell's Canyon Dam and Anatone, 1996-2003.
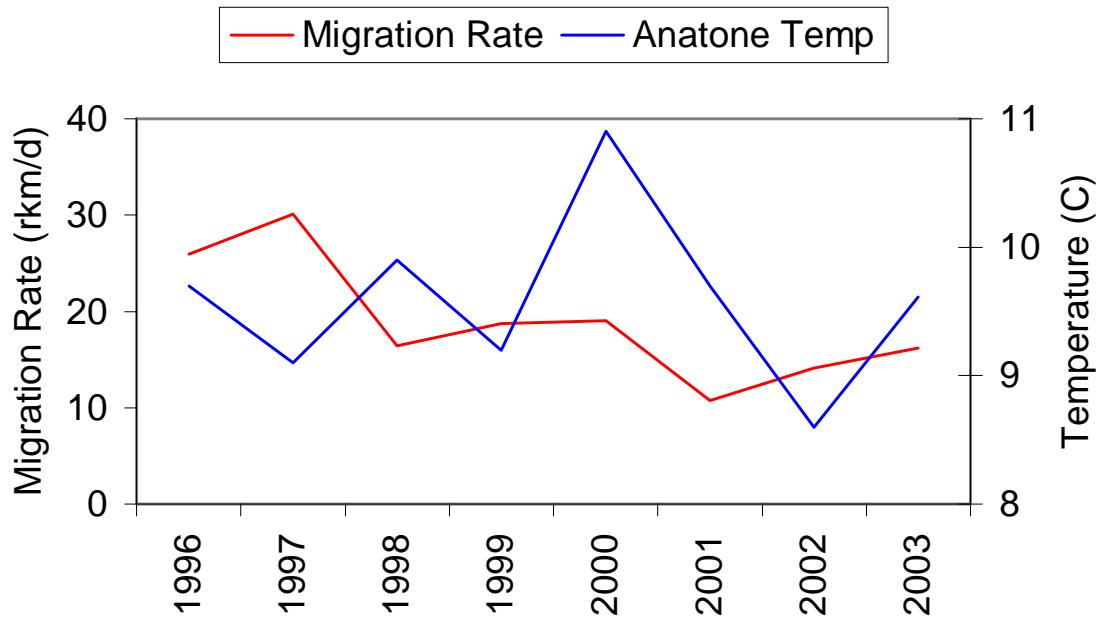
Figure 11.—Yearling migration rate (rkm/d) from Pittsburg Landing to Lower Granite Dam versus Snake River temperature at Anatone, 1996-2003.

21
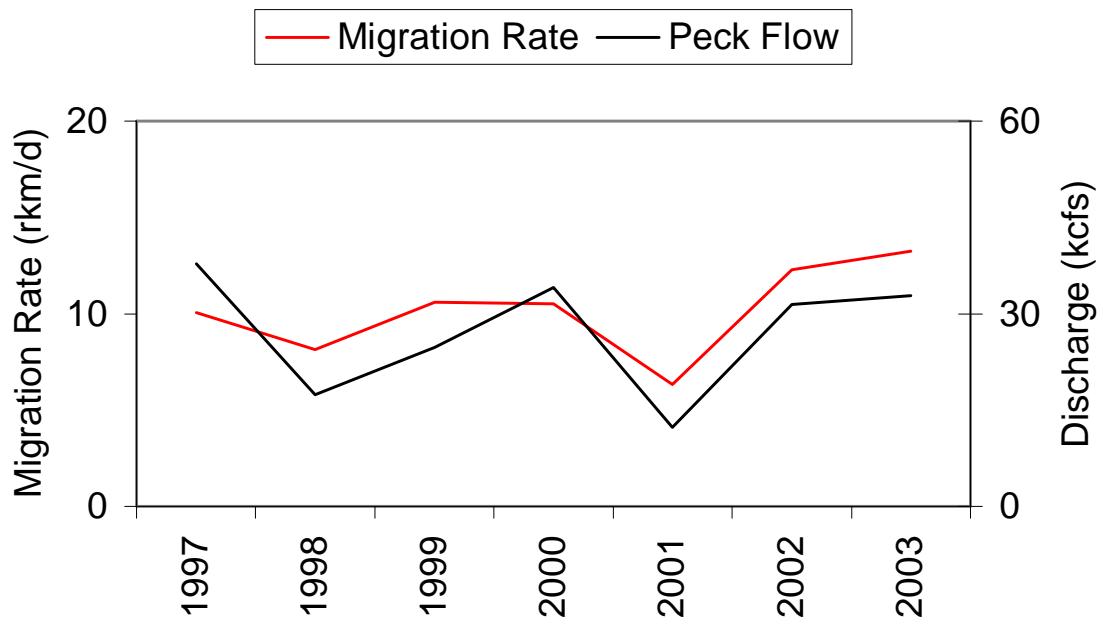
Figure 12.—Yearling migration rate (rkm/d) from Big Canyon to Lower Granite Dam versus Clearwater River flow at Peck, 1997-2003.
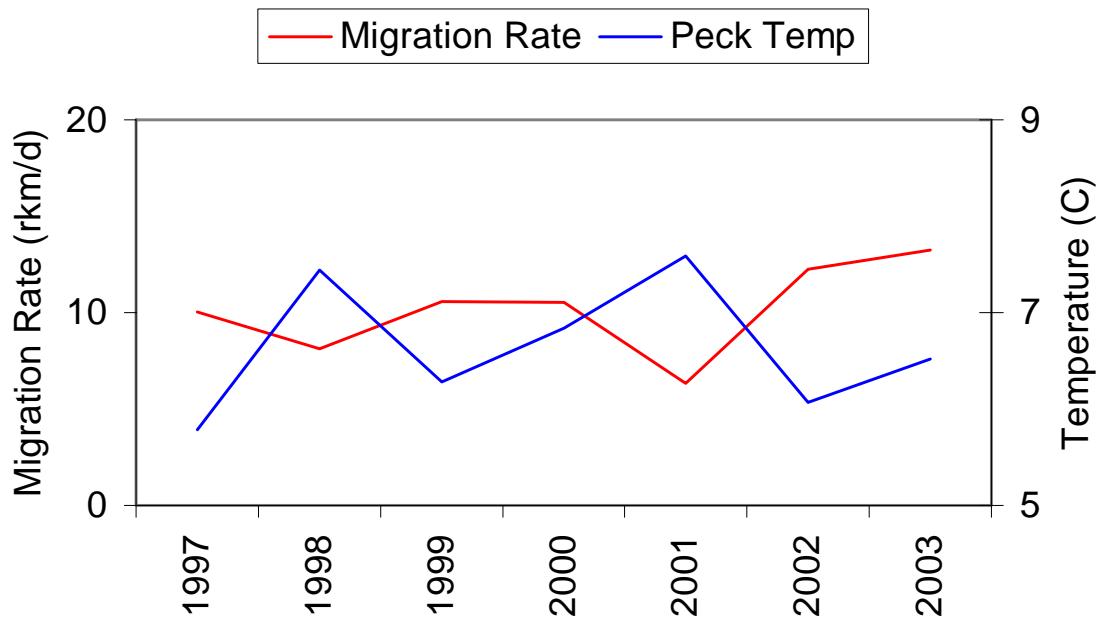
Figure 13.—Yearling migration rate (rkm/d) from Big Canyon to Lower Granite Dam versus Clearwater River temperature at Peck, 1997-2003.

22
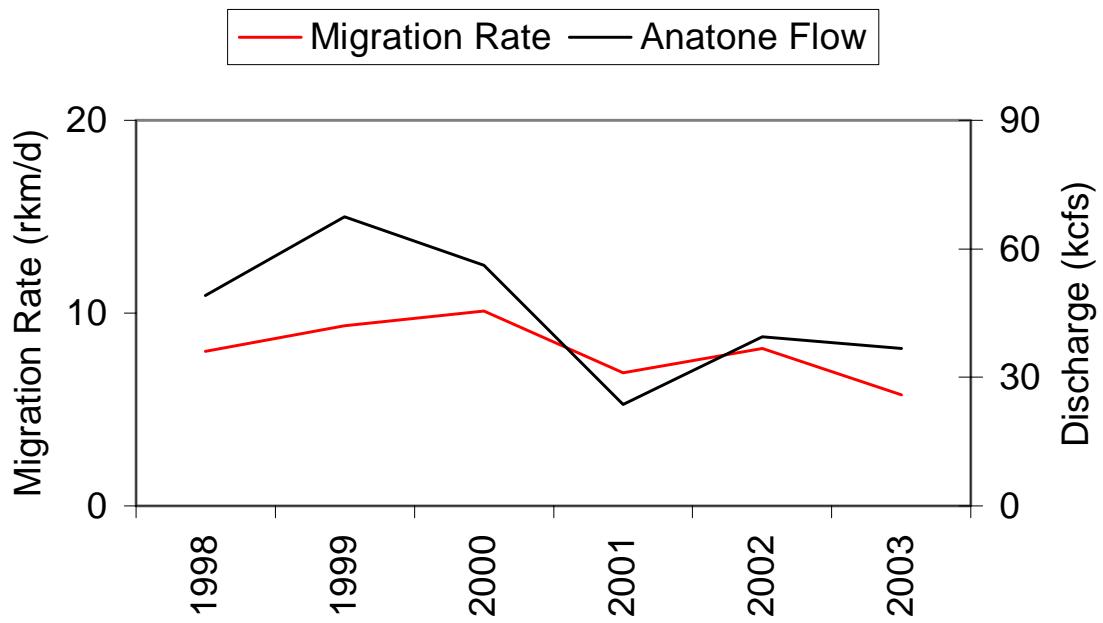
Figure 14.—Yearling migration rate (rkm/d) from Captain John Rapids to Lower Granite Dam versus Snake River flow at Anatone, 1998-2003.
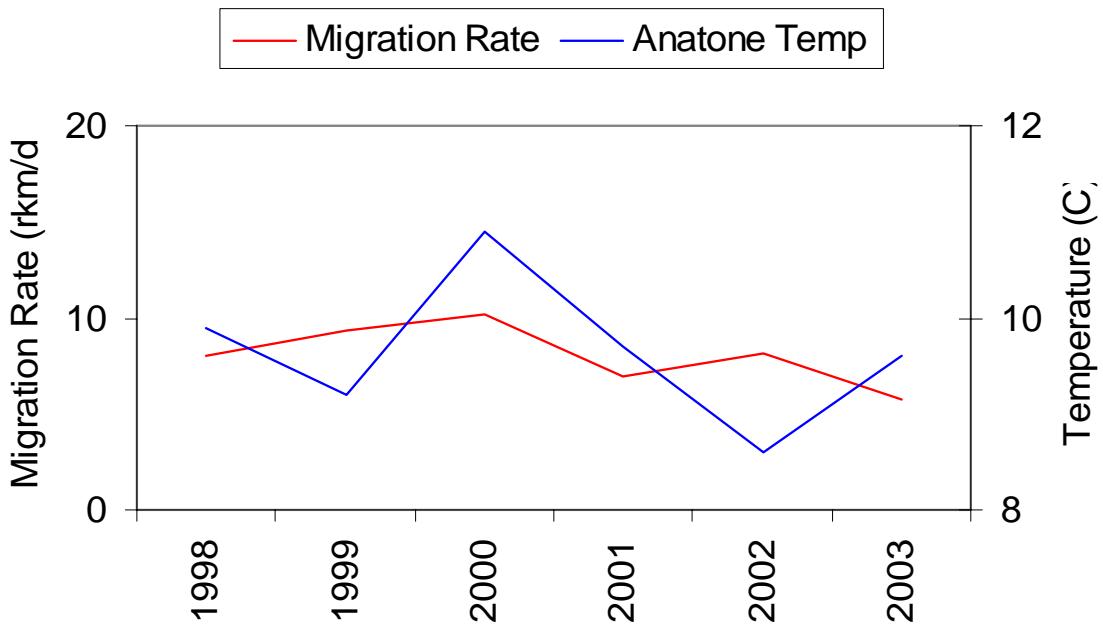

Figure 15.—Yearling migration rate (rkm/d) from Captain John Rapids to Lower Granite Dam versus Snake River temperature at Anatone, 1998-2003.

Arrival Timing

Arrival timing data for the Captain John Rapids group suggest that the majority of the fish remained in the facility during the volitional release period and did not leave the facility until forced out on April 7. The volitional release occurred from March 30 – April 7, but only one PIT tagged fish from Captain John Rapids was detected at Lower Granite Dam at about 01:00 on April 11 and only a total of four detected through April 12. This is typical of what we have seen since Captain John Rapids began operations in 1998 and supported by personnel observations at the facility (B. McLeod, personal communication).

Arrival date distributions to Lower Granite, McNary and Bonneville dams for all FCAP groups were significantly different from each other (Appendix B; Table B.4). These results are not surprising as none of the release dates coincided (Table 3). The median arrival date for the Captain John Rapids group to Lower Granite Dam was only 2 days ahead of the other FCAP groups, but the 90% passage date was 6-13 days ahead. The median arrival date for the Captain John Rapids group to McNary Dam was 3-6 days ahead of the other FCAP groups, but the 90% passage date was 4-11 days ahead. The Captain John Rapids group had consistently earlier passage dates than the Big Canyon and Pittsburg Landing groups, which was completely consistent with the earlier release date. However, the differential in median passage date continued to increase through Bonneville Dam, indicating that their migration rate increased at a relatively higher rate as the groups moved downstream.

Mean, median and 90% arrival dates of all FCAP yearling release groups to Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville dams are detailed in Tables 8 and 9 for first obs and all obs, respectively. One basic pattern emerged from statistical analysis of first and all obs arrival date distributions at Lower Granite, McNary and Bonneville dams (Appendix B; Tables B.4 and B.6). The arrival date distributions of all of the FCAP groups significantly differed from each other at each dam under both first and all obs ($P < 0.01$ for all). The hydrographs for all locations showed a sharp, but quick spike around May 31. All of the FCAP groups were released and achieved 90% arrival to both Lower Granite and McNary dams before this spike in flows (Figures 2-6). There is overlap in passage date distributions for individual groups at multiple dams, indicating that release groups are spread out over nearly the entire length of the Snake and Columbia River migration corridor. A comprehensive summary of arrival timing distributions is presented in Appendix E.

Table 8.—First Obs arrival date at Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from FCAP facilities in 2003.

Release Group	Interrogation Site	*n*	Mean	Median	90%
Pittsburg Landing	Lower Granite	2,733	4/26	4/25	5/4
	Little Goose	1,185	5/1	4/29	5/8
	Lower Monumental	160	5/6	5/5	5/17
	McNary	397	5/7	5/6	5/15
	John Day	216	5/12	5/11	5/21
	Bonneville	117	5/11	5/11	5/18
Big Canyon	Lower Granite	2,567	4/29	4/25	5/11
	Little Goose	1,128	5/5	5/3	5/17
	Lower Monumental	154	5/10	5/6	5/26
	McNary	376	5/11	5/10	5/20
	John Day	252	5/16	5/15	5/28
	Bonneville	105	5/15	5/14	5/22
Captain John Rapids	Lower Granite	947	4/23	4/23	4/29
	Little Goose	428	4/27	4/26	5/4
	Lower Monumental	86	4/28	4/27	5/4
	McNary	144	5/4	5/4	5/11
	John Day	91	5/8	5/7	5/15
	Bonneville	39	5/8	5/8	5/15

Table 9.—All Obs arrival date at Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from FCAP facilities in 2003.

Release Group	Interrogation Site	n	Mean	Median	90%
Pittsburg Landing	Lower Granite	2,734	4/26	4/25	5/4
	Little Goose	1,946	5/1	4/30	5/9
	Lower Monumental	439	5/7	5/5	5/19
	McNary	1,109	5/8	5/7	5/16
	John Day	901	5/13	5/12	5/22
	Bonneville	452	5/13	5/12	5/20
Big Canyon	Lower Granite	2,568	4/29	4/25	5/11
	Little Goose	1,849	5/6	5/3	5/18
	Lower Monumental	421	5/11	5/7	5/29
	McNary	975	5/12	5/10	5/23
	John Day	881	5/17	5/15	5/29
	Bonneville	447	5/17	5/15	5/28
Captain John Rapids	Lower Granite	947	4/23	4/23	4/29
	Little Goose	692	4/28	4/26	5/4
	Lower Monumental	191	4/30	4/28	5/6
	McNary	433	5/5	5/4	5/12
	John Day	329	5/9	5/8	5/17
	Bonneville	200	5/10	5/8	5/17

LITERATURE CITED

Bjornn, T. C. and N. Horner. 1980. Biological criteria for classification of Pacific salmon and steelhead as threatened or endangered under the Endangered Species Act.

Budy, P., Thiede, G.P., Bouwes, N., Petrosky, C.E. and H. Schaller. 2002. Evidence Linking Delayed Mortality of Snake River Salmon to Their Earlier Hydrosystem Experience. North American Journal of Fisheries Management 22:35-51.

CBFWA (Columbia Basin Fish and Wildlife Authority). 1990. Proposed mainstem flows for Columbia basin anadromous fish. March 1990.

Fulton, L. 1968. Spawning areas and abundance of Chinook salmon *Oncorhynchus tshawytscha* in the Columbia River – past and present. USFWS, Special Scientific Report – Fisheries No. 571.

Garcia, A., S. Bradbury, B. Arnsberg, S. Rocklage and P. Groves. 2004. Fall Chinook Salmon Spawning Ground Surveys in the Snake River Basin upriver of Lower Granite Dam: Annual Report 2002-2003, Project No. 199801003, 60 electronic pages, (BPA Report DOE/BP-00004700-3).

Lady, J., Westhagen, P., and J.R. Skalski. 2002. SURPH: SURvival Under Proportional Hazards [Computer Program], Version 2.1. Columbia Basin Research, University of Washington, Seattle, WA. Prepared for U.S. Department of Energy, Bonneville Power Administrations, Division of Fish and Wildlife. Contract No. DE-B179-90BP02341

Matthews, G. M., J. R. Harmon, S. Achord, 0. W. Johnson, and L. A. Kubin. 1990. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1989. Report to the U.S. Army Corps of Engineers, Contract DACW68-84-H0034. National Marine Fisheries Service, Seattle, WA.

Matthews, G. M., S. Accord, J. R. Harmon, 0. W. Johnson, D. M. Marsh, B. P. Sandford, N. N. Paasch, K. W. McIntyre, and K. L. Thomas. 1992. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1990. Report the U.S. Army Corps of Engineers, Contract DACW68-84-H0034. National Marine Fisheries Service, Seattle, WA.

Milks, D., M. Varney, M. Schuck and N. Sands. 2005. Lyons Ferry Hatchery Evaluation: Fall Chinook Salmon Annual Report 2001 and 2002. Washington Department of Fish and Wildlife Hatcheries Report # FPA05-02 to U.S. Fish and Wildlife Service, Lower Snake River Compensation Plan Office, Boise, ID.

Murphy, B.R. and D.W. Willis. 1996. Fisheries Techniques, Second Edition. American Fisheries Society, Bethesda, Maryland.

NMFS (National Marine Fisheries Service). 1992. Threatened status for Snake River spring/summer Chinook salmon, threatened status for Snake River fall Chinook salmon. Federal Register [Docket 910847-2043 22 April 1992] 57(78):14653-14663.

Prentice, E. F., D. L. Park, T. A. Flagg, and S. McCutcheon. 1986. A study to determine the biological feasibility of a new fish tagging system, 1985-1986. Report to the Bonneville Power Administration, Contract DE-A179-83BP11982, Project 83-l 19. National Marine Fisheries Service, Seattle, WA.

Prentice, E. F., T. A. Flagg, C. S. McCutcheon, D. F. Brastow, and D. C. Cross. 1990. Equipment, methods, and an automated data-entry station for PIT tagging. American Fisheries Society Symposium 7:335-340.

Rocklage, S.J. 2004. Monitoring and Evaluation of Yearling Fall Chinook Salmon Released from Acclimation Facilities Upstream of Lower Granite Dam: Annual Report 1998, Project No. 1998-01004, 49 electronic pages, (BPA Report DOE/BP-00004025-1)

Rocklage, S.J. and D.S. Kellar. 2005a. Monitoring and Evaluation of Yearling Fall Chinook Salmon Released from Acclimation Facilities Upstream of Lower Granite Dam: Annual Report 1999, Project No. 1998-01004, In Press.

Rocklage, S.J. and D.S. Kellar. 2005b. Monitoring and Evaluation of Yearling Fall Chinook Salmon Released from Acclimation Facilities Upstream of Lower Granite Dam: Annual Report 2000, Project No. 1998-01004, In Press.

Rocklage, S.J. and D.S. Kellar. 2005c. Monitoring and Evaluation of Yearling Fall Chinook Salmon Released from Acclimation Facilities Upstream of Lower Granite Dam: Annual Report 2001, Project No. 1998-01004, In Press.

Rocklage, S.J. and D.S. Kellar. 2005d. Monitoring and Evaluation of Yearling Fall Chinook Salmon Released from Acclimation Facilities Upstream of Lower Granite Dam: Annual Report 2002, Project No. 1998-01004, In Press.

Smith, S.G., J.R. Skalski, J. W. Schlechte, A. Hoffmann, and V. Cassen, J.R.1994. Statistical Survival Analysis of Fish and Wildlife Tagging Studies. Contract DE-BI79-90BP02341. Project 89-107. Bonneville Power Administration. Portland, Oregon.

True, K., (ed.) 2001. Enzyme Linked Immunosorbent Assay (ELISA) for Detection of *Renibacterium salmoninarum* Antigen in Fish Tissue. Chapter 6 *in* National Wild Fish Health Survey Laboratory Procedure Manual, First Edition. U.S. Fish and Wildlife Service.

True, K., (ed.) 2004. Enzyme Linked Immunosorbent Assay (ELISA) for Detection of *Renibacterium salmoninarum* Antigen in Fish Tissue. Chapter 6 *in* National Wild Fish Health Survey Laboratory Procedure Manual, Second Edition. U.S. Fish and Wildlife Service.

WDF (Washington Department of Fisheries). 1993. Stock composition of fall Chinook at Lower Granite Dam in 1992. Columbia River Laboratory Progress Report 93-5. Battleground, WA.

WDF (Washington Department of Fisheries). 1994. Stock composition of fall Chinook at Lower Granite Dam in 1993. Columbia River Laboratory Progress Report 94-10. Battleground, WA.

APPENDICES

Appendix A. List of PIT tag files and observation numbers and rates of PIT tagged yearling fall Chinook salmon released from the FCAP facilities at Lower Snake and Columbia River dams in 2003. All PIT tag files reside in the PTAGIS database managed by the PSMFC and are accessible at http://www.pittag.org/Data_and_Reports/index.html.

Table A.1.—List of PIT tagging files for yearling fall Chinook salmon from the FCAP facilities in 2003.

Facility	Filename
Pittsburg Landing	SJR03098.P16
	SJR03099.PL9
	SJR03100.PL5
Big Canyon	SJR03091.BC6
	SJR03092.BC7
	SJR03093.B12
Captain John Rapids	SJR03085.CJR

Table A.2.—First obs interrogation rates at Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from the FCAP facilities in 2003.

Release Group	LGR	LGO	LMO	MCN	JDA	BON	Cumulative Observations	Cumulative %
Pittsburg Landing	2,734	1,185	160	396	216	117	4,808	64.2
Big Canyon	2,567	1,128	154	376	252	105	4,582	61.1
Captain John Rapids	947	428	86	144	91	39	1,735	69.5

Table A.3.—All obs interrogations at Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from the FCAP facilities in 2003.

Release Group	LGR	LGO	LMO	MCN	JDA	BON	Total Observations
Pittsburg Landing	2,734	1,946	439	1,109	901	452	7,581
Big Canyon	2,568	1,849	421	975	881	447	7,141
Captain John Rapids	947	692	191	433	329	200	2,792

Appendix B. Results of statistical tests on length, condition factor, travel time, migration rate and arrival date for yearling fall Chinook salmon PIT tagged at the FCAP facilities in 2003. Significant differences for the ANOVA and Kolmogorov-Smirnov tests are highlighted in yellow.

Note: For Tukey's HSD multiple comparisons, groups with like numbers do not differ significantly while different numbers indicate significant differences between groups.

Table B.1.—Results of the ANOVA Test and Tukey's HSD multiple comparisons for length and condition factor of yearling fall Chinook salmon PIT tagged at the FCAP facilities and LFH in 2003.

| | ANOVA | Tukey's HSD Multiple Comparisons | | | |
		PL	BC	CJ	LFH
Length	$P = 0.0070$	1	2	3	1
Condition	$P = 0.0057$	1	2	3	4

Table B.2.—Results of the Kolmogorov-Smirnov Test for length and condition factor distributions of PIT tagged yearling fall Chinook salmon at the FCAP facilities and LFH in 2003.

| | Fork Length | | | | Condition Factor | | |
	BC	CJ	LFH		BC	CJ	LFH
PL	$P < 0.0001$	$P < 0.0001$	$P = 0.2304$	PL	$P = 0.0256$	$P < 0.0001$	$P < 0.0001$
BC		$P < 0.0001$	$P < 0.0001$	BC		$P < 0.0001$	$P < 0.0001$
CJ			$P < 0.0001$	CJ			$P < 0.0001$

Table B.3.—Results of the ANOVA Test and Tukey's HSD multiple comparisons for first and all obs migration rates of PIT tagged yearling fall Chinook salmon from the FCAP facilities to Lower Granite, McNary and Bonneville Dams in 2003.

| | | ANOVA | Tukey's HSD Multiple Comparisons | | |
			PL	BC	CJ
Lower Granite		$P = 0.0032$	1	2	3
McNary	First Obs	$P = 0.0006$	1	2	3
	All Obs	$P = 0.0017$	1	2	3
Bonneville	First Obs	$P < 0.0001$	1	2	3
	All Obs	$P = 0.0005$	1	2	3

31

Appendix B (continued).

Table B.4.—Results of the Kolmogorov-Smirnov Test for pairwise comparisons of travel time and arrival date distributions to Lower Granite Dam for yearling fall Chinook salmon PIT tagged at the FCAP facilities in 2003.

	Travel Time				Arrival Date	
	BC	CJ			BC	CJ
PL	$P < 0.0001$	$P < 0.0001$		PL	$P < 0.0001$	$P < 0.0001$
BC		$P < 0.0001$		BC		$P < 0.0001$

Table B.5.—Results of the Kolmogorov-Smirnov Test for pairwise comparisons of first and all obs travel time distributions to McNary and Bonneville Dams for yearling fall Chinook salmon PIT tagged at the FCAP facilities in 2003.

To McNary Dam

	1st Obs Travel Time				All Obs Travel Time	
	BC	CJ			BC	CJ
PL	$P = 0.0567$	$P < 0.0001$		PL	$P = 0.0005$	$P < 0.0001$
BC		$P < 0.0001$		BC		$P < 0.0001$

To Bonneville Dam

	1st Obs Travel Time				All Obs Travel Time	
	BC	CJ			BC	CJ
PL	$P = 0.4919$	$P = 0.0005$		PL	$P = 0.3485$	$P < 0.0001$
BC		$P = 0.0031$		BC		$P < 0.0001$

Appendix B (continued).

Table B.6.—Results of the Kolmogorov-Smirnov Test for pairwise comparisons of first and all obs arrival date distributions to McNary and Bonneville Dams for yearling fall Chinook salmon PIT tagged at the FCAP facilities in 2003.

	To McNary Dam					
	1st Obs Arrival Date			All Obs Arrival Date		
	BC	CJ			BC	CJ
PL	$P < 0.0001$	$P = 0.0025$		PL	$P < 0.0001$	$P = 0.0018$
BC		$P < 0.0001$		BC		$P < 0.0001$

	To Bonneville Dam					
	1st Obs Arrival Date			All Obs Arrival Date		
	BC	CJ			BC	CJ
PL	$P = 0.0012$	$P = 0.0079$		PL	$P < 0.0001$	$P = 0.0009$
BC		$P < 0.0001$		BC		$P < 0.0001$

APPENDIX C. SURPH survival estimates for PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams from 1996 through 2003. In figures, like colors indicate the same year across multiple figures. For instance, green indicates 1999 in all figures containing data for 1999.

Table C.1.—SURPH survival estimates, standard errors and 95% confidence limits for PIT tagged yearling fall Chinook salmon from the FCAP facilities to Lower Granite Dam, 1996-2003.

| Release Group	Year	CJS Estimate	S.E.	95% C.I. Lower	95% C.I. Upper
PL	1996	0.9878	0.0140	0.9604	1.0152
	1997	0.9224	0.0119	0.8991	0.9457
	1998	0.8857	0.0087	0.8686	0.9028
	1999	0.9004	0.0099	0.8810	0.9198
	2000	0.8702	0.0119	0.8469	0.8935
	2001	0.7491	0.0058	0.7377	0.7605
	2002	0.8855	0.0130	0.8600	0.9110
	2003	0.8642	0.0122	0.8403	0.8881
BC	1997	0.9359	0.0147	0.9071	0.9647
BC-LRG	1998	0.8472	0.0146	0.8186	0.8758
BC-SML	1998	0.6217	0.0203	0.5819	0.6615
	1999	0.9000	0.0116	0.8773	0.9227
	2000	0.8957	0.0134	0.8694	0.9220
	2001	0.7437	0.0059	0.7321	0.7553
	2002	0.8947	0.0148	0.8657	0.9237
	2003	0.8309	0.0124	0.8066	0.8552
BC-XY	1997	0.9325	0.0429	0.8484	1.0166
	1999	0.8775	0.0289	0.8209	0.9341
CJ	1998	0.7698	0.0274	0.7161	0.8235
	1999	0.9409	0.0202	0.9013	0.9805
	2000	0.9520	0.0187	0.9153	0.9887
	2001	0.8523	0.0088	0.8351	0.8695
	2002	0.9702	0.0237	0.9237	1.0167
	2003	0.9172	0.0204	0.8772	0.9572

Appendix C (continued).

Figure C.1.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to Lower Granite Dam, 1996-2003.


Figure C.2.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to Lower Granite Dam, 1997-2003.

35

Appendix C (continued).

Figure C.3.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to Lower Granite Dam, 1998-2003.

Appendix C (continued).

Table C.2.—SURPH survival estimates, standard errors and 95% confidence limits for PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to McNary Dam, 1996-2003.

Release Group	Year	CJS Estimate	S.E.	95% C.I. Lower	95% C.I. Upper
PL	1996	0.4131	0.0738	0.2685	0.5577
	1997	0.8176	0.1593	0.5054	1.1298
	1998	0.5568	0.0394	0.4796	0.6340
	1999	0.6212	0.0244	0.5734	0.6690
	2000	0.6657	0.0397	0.5879	0.7435
	2001	0.3786	0.0093	0.3604	0.3968
	2002	0.7046	0.0259	0.6538	0.7554
	2003	0.6228	0.0265	0.5709	0.6747
BC	1997	0.8328	0.1792	0.4816	1.1840
BC-LRG	1998	0.5168	0.0658	0.3878	0.6458
BC-SML	1998	0.2518	0.0445	0.1646	0.3390
	1999	0.6605	0.0285	0.6046	0.7164
	2000	0.6785	0.0385	0.6030	0.7540
	2001	0.3952	0.0087	0.3781	0.4123
	2002	0.5425	0.0208	0.5017	0.5833
	2003	0.5990	0.0269	0.5463	0.6517
BC-XY	1997	0.7382	0.7130	-0.6593	2.1357
	1999	0.5869	0.0479	0.4930	0.6808
CJ	1998	0.5049	0.1168	0.2760	0.7338
	1999	0.7129	0.0572	0.6008	0.8250
	2000	0.8398	0.0778	0.6873	0.9923
	2001	0.4853	0.0146	0.4567	0.5139
	2002	0.6354	0.0390	0.5590	0.7118
	2003	0.6943	0.0455	0.6051	0.7835
LFH	1996	0.8755	0.3955	0.1003	1.6507
	1997	1.3479	0.4180	0.5286	2.1672
	1998	0.8189	0.0847	0.6529	0.9849
	1999	0.6808	0.0709	0.5418	0.8198
	2000	0.6577	0.0729	0.5148	0.8006
	2001	0.5792	0.0250	0.5302	0.6282

Appendix C (continued).
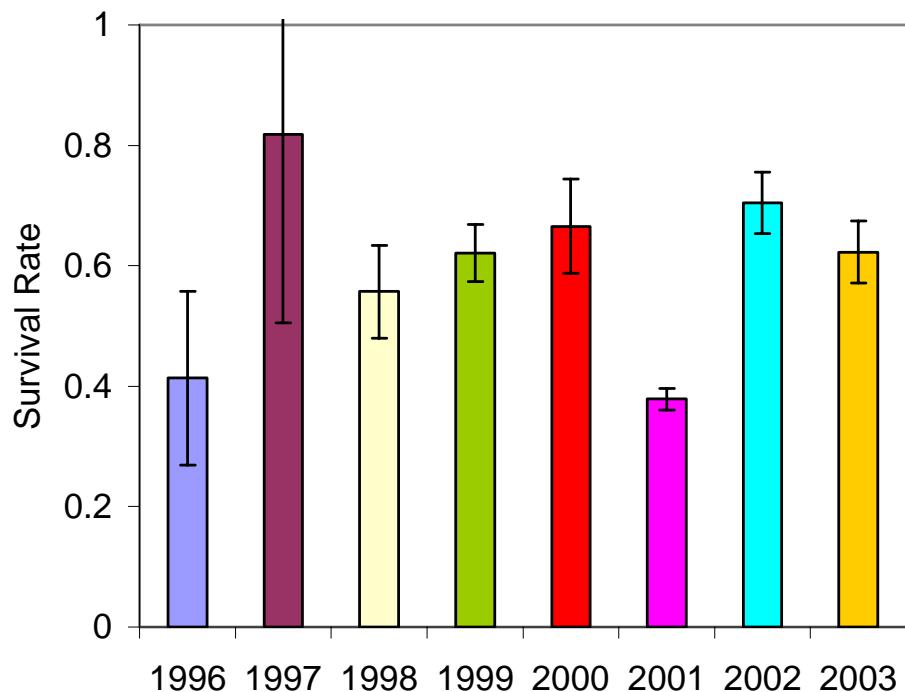
Figure C.4.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to McNary Dam, 1996-2003.
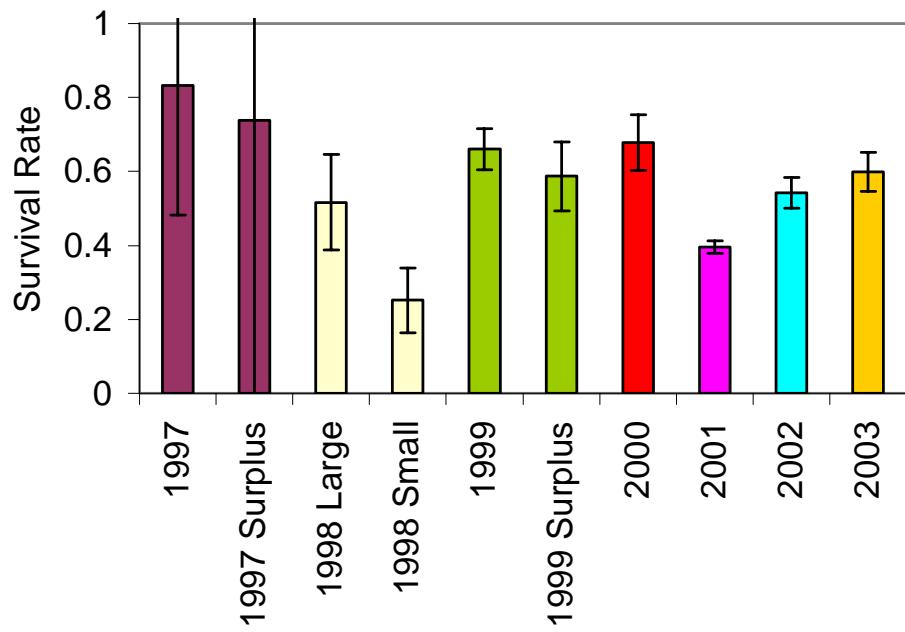

Figure C.5.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to McNary Dam, 1997-2003.

Appendix C (continued).
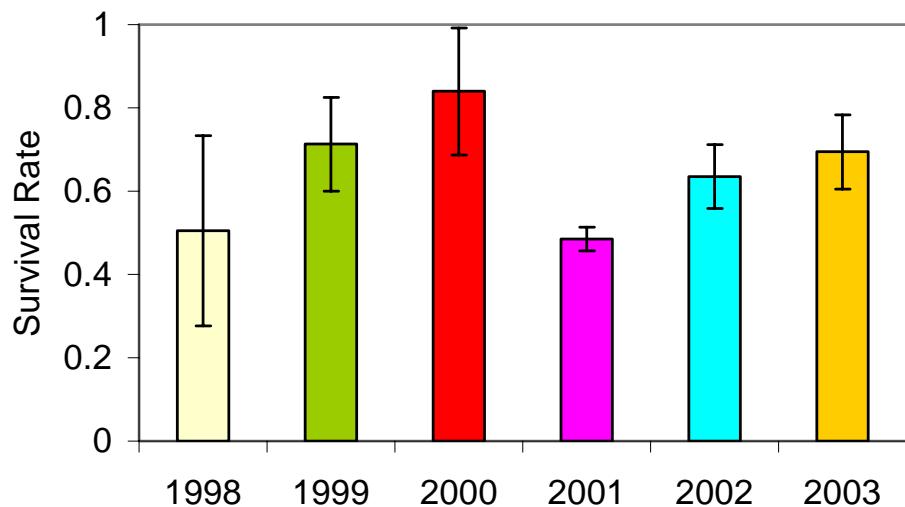
Figure C.6.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to McNary Dam, 1998-2003.
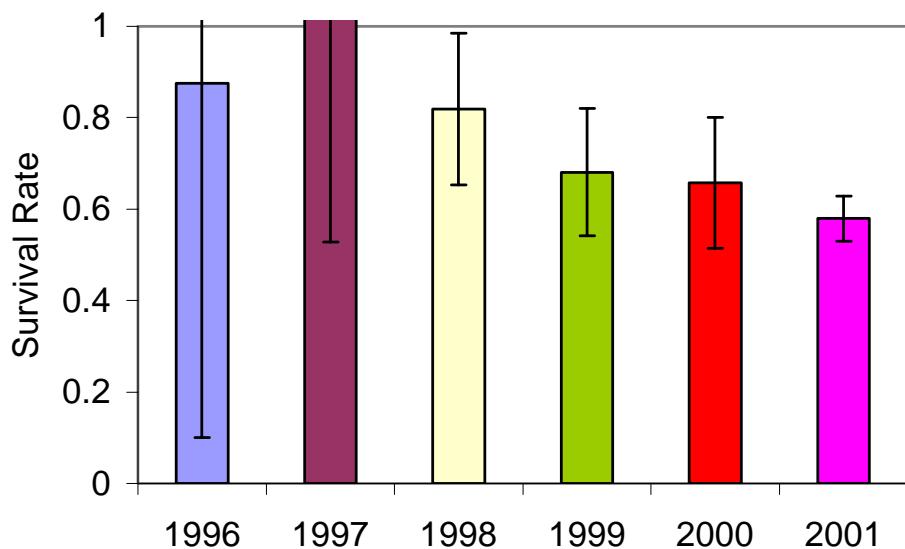
Figure C.6.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Lyons Ferry Hatchery to McNary Dam, 1998-2001.

Appendix D. Descriptive statistics for travel times (days) and migration rates (rkm/d) of PIT tagged yearling fall Chinook from the FCAP sites to Lower Snake and Columbia River dams in 2003.

Table D.1.—First Obs travel time (days) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2003.

Release Group	Interrogation Site	n	Mean	Standard Deviation	95% C.I. (+/-)	Median	Range
Pittsburg Landing	Lower Granite	2,733	12.2	5.9	0.2	10.7	1.8 - 63.4
	Little Goose	1,184	16.7	6.4	0.4	15.4	5.8 - 56.0
	Lower Monumental	160	22.2	20.8	1.4	20.8	9.5 - 54.4
	McNary	397	22.9	6.1	0.6	21.9	11.8 - 54.0
	John Day	216	27.8	6.1	0.8	26.7	16.5 - 49.9
	Bonneville	117	27.5	4.6	0.8	26.6	18.7 - 38.4
Big Canyon	Lower Granite	2,567	11.5	8.6	0.3	8.2	0.8 - 63.6
	Little Goose	1,128	18.3	9.6	0.6	16.1	4.7 - 94.2
	Lower Monumental	154	22.5	19.4	1.7	19.4	8.4 - 52.4
	McNary	376	23.9	7.5	0.8	22.5	9.9 - 73.0
	John Day	252	29.1	8.2	1.0	28.3	15.0 - 55.7
	Bonneville	105	27.9	5.9	1.1	27.4	17.3 - 49.7
Captain John Rapids	Lower Granite	947	15.8	5.3	0.3	15.6	3.5 - 44.6
	Little Goose	428	19.9	5.8	0.6	18.8	6.5 - 53.0
	Lower Monumental	86	21.3	20.0	1.1	20.0	12.6 - 38.4
	McNary	144	27.5	5.3	0.9	27.0	17.0 - 53.4
	John Day	91	30.8	6.2	1.3	30.2	19.0 - 51.7
	Bonneville	39	31.5	5.5	1.8	31.3	22.5 - 47.4

Appendix D (continued).

Table D.2.—All Obs travel time (days) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2003.

Release Group	Interrogation Site	n	Mean	Standard Deviation	95% C.I. (+/-)	Median	Range
Pittsburg Landing	Lower Granite	2,734	12.2	5.9	0.2	10.7	1.8 - 63.4
	Little Goose	1,946	17.3	6.6	0.3	16.1	4.0 - 56.0
	Lower Monumental	439	23.1	21.4	0.9	21.4	8.3 - 66.9
	McNary	1,109	23.8	6.4	0.4	22.6	11.3 - 70.8
	John Day	901	29.0	6.6	0.4	28.2	14.7 - 55.2
	Bonneville	452	29.0	6.0	0.6	28.3	15.3 - 57.4
Big Canyon	Lower Granite	2,568	11.5	8.6	0.3	8.2	0.8 - 63.6
	Little Goose	1,849	18.5	9.5	0.4	16.1	4.4 - 94.2
	Lower Monumental	421	24.4	20.5	1.1	20.5	7.4 - 76.0
	McNary	975	24.9	8.9	0.6	22.9	9.9 - 113.4
	John Day	881	30.0	8.3	0.5	28.7	14.1 - 55.7
	Bonneville	447	30.3	8.4	0.8	28.4	17.3 - 62.2
Captain John Rapids	Lower Granite	947	15.8	5.3	0.3	15.6	3.5 - 44.6
	Little Goose	692	20.5	6.0	0.4	19.2	6.5 - 56.1
	Lower Monumental	191	23.2	21.5	1.1	21.5	8.1 - 57.4
	McNary	433	27.8	6.1	0.6	27.0	14.2 - 59.8
	John Day	329	32.2	6.3	0.7	31.2	19.0 - 61.6
	Bonneville	200	32.8	6.1	0.8	31.4	19.4 - 64.4

Appendix D (continued).

Table D.3.—First Obs migration rate (rkm/d) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2003.

Release Group	Interrogation Site	*n*	Mean	Median	Range
	Lower Granite	2,733	14.2	16.2	2.7 - 95.4
	Little Goose	1,184	13.9	15.2	4.2 - 40.2
Pittsburg	Lower Monumental	160	12.6	13.4	5.1 - 29.5
Landing	McNary	397	17.4	18.1	7.4 - 33.8
	John Day	216	18.7	19.5	10.4 - 31.6
	Bonneville	117	23.1	23.8	16.5 - 33.9
	Lower Granite	2,567	9.4	13.2	1.7 - 143.8
	Little Goose	1,128	9.2	10.4	1.8 - 35.5
Big Canyon	Lower Monumental	154	9.5	11.0	4.1 - 25.4
	McNary	376	13.9	14.8	4.6 - 33.6
	John Day	252	15.7	16.1	8.2 - 30.3
	Bonneville	105	20.4	20.8	11.4 - 32.8
	Lower Granite	947	5.7	5.8	2.0 - 25.4
	Little Goose	428	7.5	8.0	2.8 - 23.2
Captain John	Lower Monumental	86	9.2	9.8	5.1 - 15.6
Rapids	McNary	144	11.5	11.6	5.9 - 18.6
	John Day	91	14.2	14.5	8.5 - 23.1
	Bonneville	39	17.5	17.6	11.6 - 24.5

Appendix D (continued).

Table D.4.—All Obs migration rate (rkm/d) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2003.

Release Group	Interrogation Site	n	Mean	Median	Range
Pittsburg Landing	Lower Granite	2,734	14.2	16.2	2.7 - 95.4
	Little Goose	1,946	13.5	14.5	4.2 - 57.6
	Lower Monumental	439	12.1	13.1	4.2 - 33.4
	McNary	1,109	16.8	17.6	5.6 - 35.2
	John Day	901	17.9	18.5	9.4 - 35.5
	Bonneville	452	21.8	22.4	11.0 - 41.5
Big Canyon	Lower Granite	2,568	9.4	13.3	1.7 - 143.8
	Little Goose	1,849	9.1	10.4	1.8 - 38.5
	Lower Monumental	421	8.8	10.5	2.8 - 29.1
	McNary	975	13.4	14.6	2.9 - 33.6
	John Day	881	15.2	15.9	8.2 - 32.3
	Bonneville	447	18.8	20.0	9.1 - 32.8
Captain John Rapids	Lower Granite	947	5.7	5.8	2.0 - 25.4
	Little Goose	692	7.3	7.8	2.7 - 23.2
	Lower Monumental	191	8.4	9.1	3.4 - 24.2
	McNary	433	11.3	11.7	5.3 - 22.2
	John Day	329	13.6	14.0	7.1 - 23.1
	Bonneville	200	16.8	17.5	8.6 - 28.4

Appendix E. Arrival date frequency distributions and cumulative frequencies for PIT tagged yearling fall Chinook from the FCAP sites based on first and all obs at Lower Snake and Columbia River dams in 2003.

BASED ON FIRST OBS - Individual release groups at multiple dams
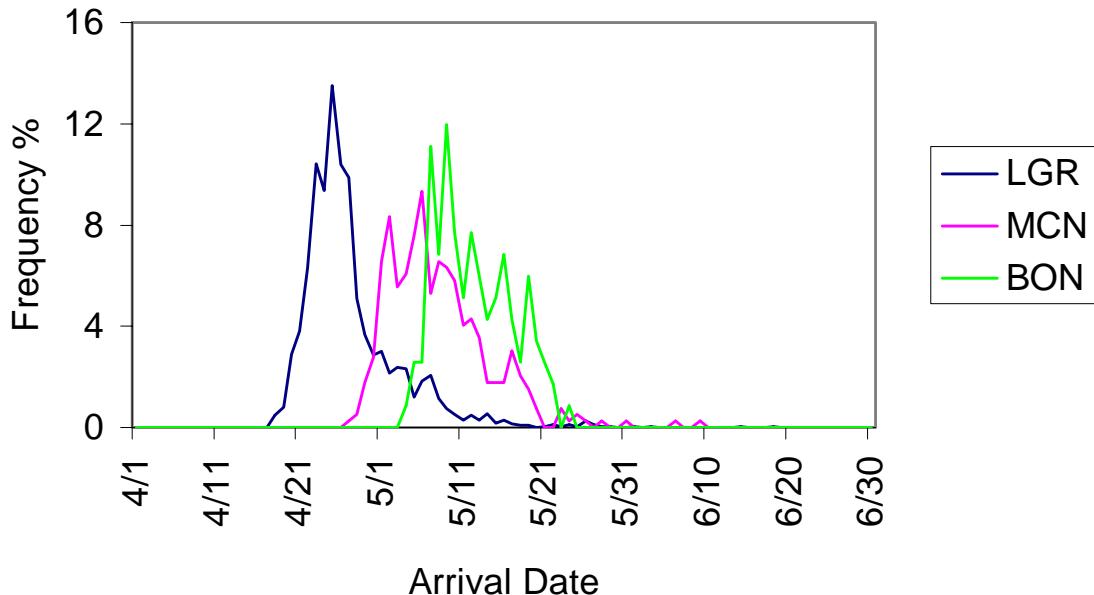
Figure E.1.—First obs arrival date frequency distribution of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2003.
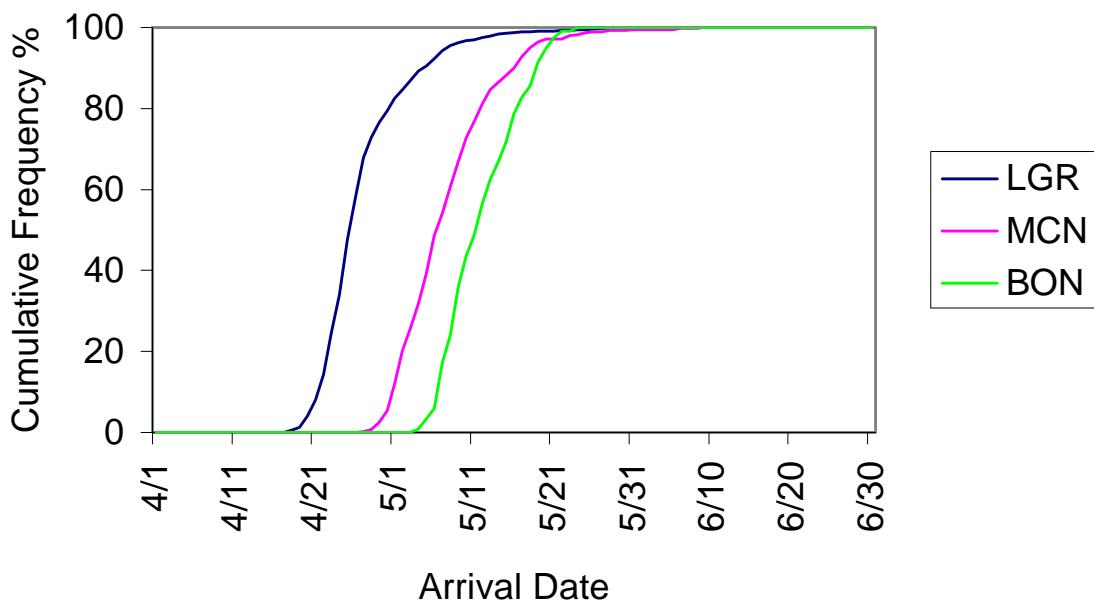
Figure E.2.—First obs arrival date cumulative frequency of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2003.

44
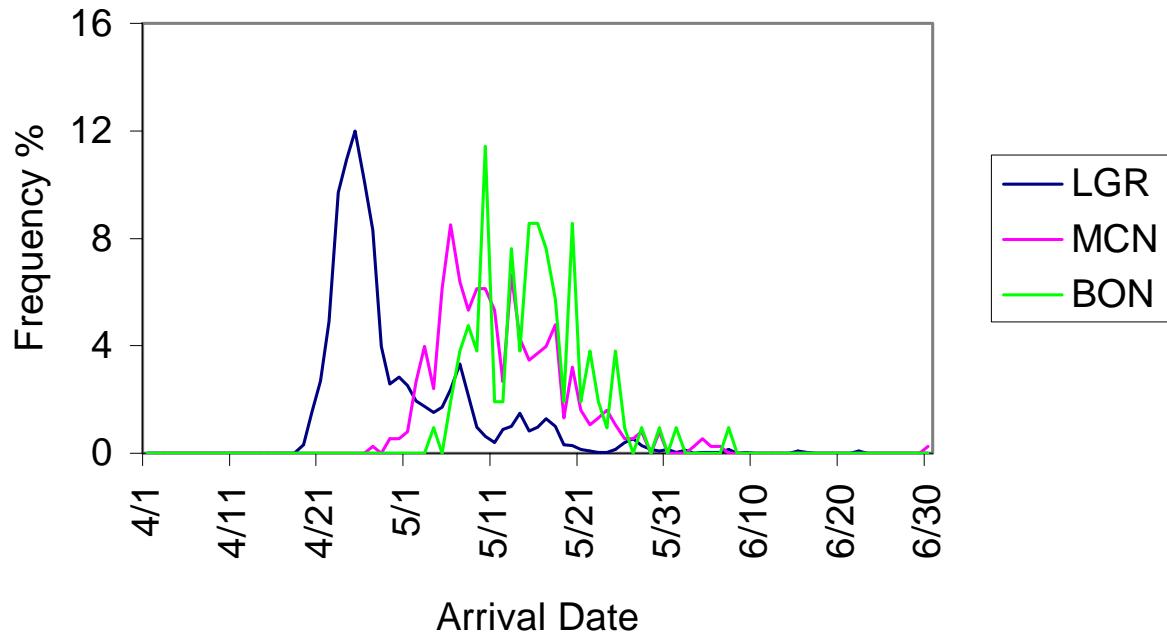
Figure E.3.—First obs arrival date frequency distribution of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2003.
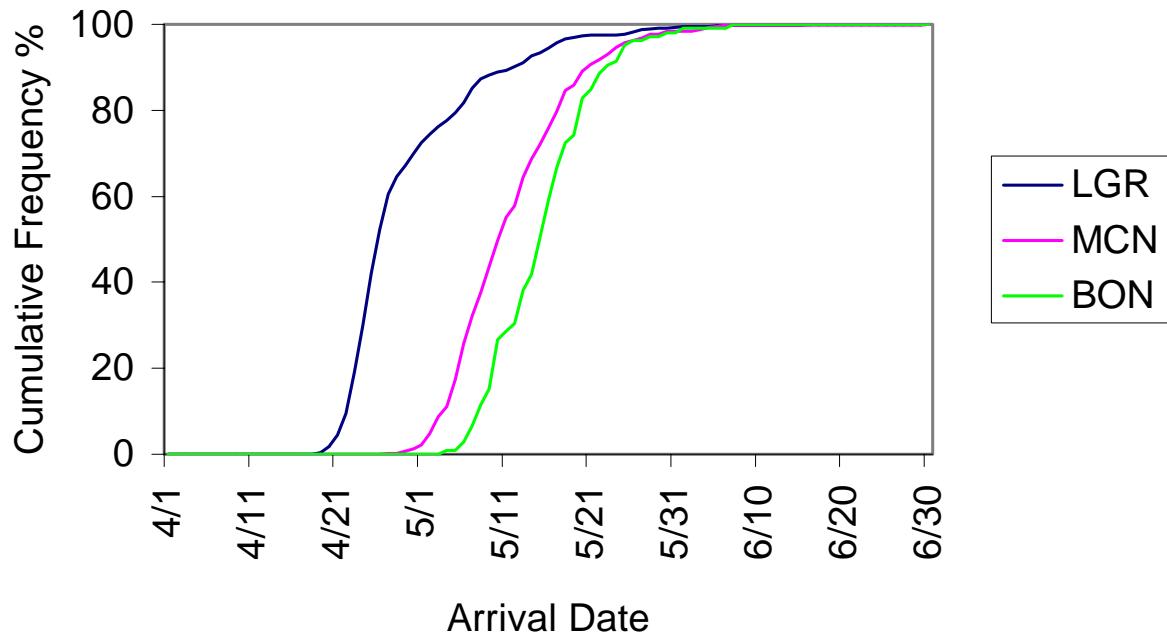
Figure E.4.—First obs arrival date cumulative frequency of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2003.

Appendix E (continued).
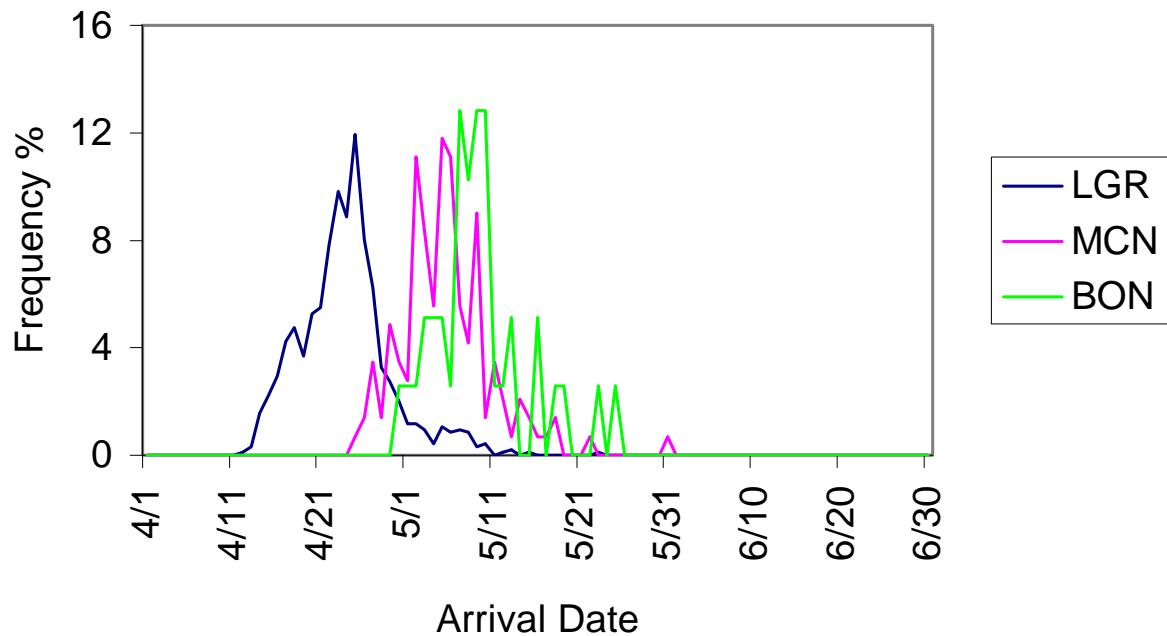
Figure E.5.—First obs arrival date frequency distribution of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2003.
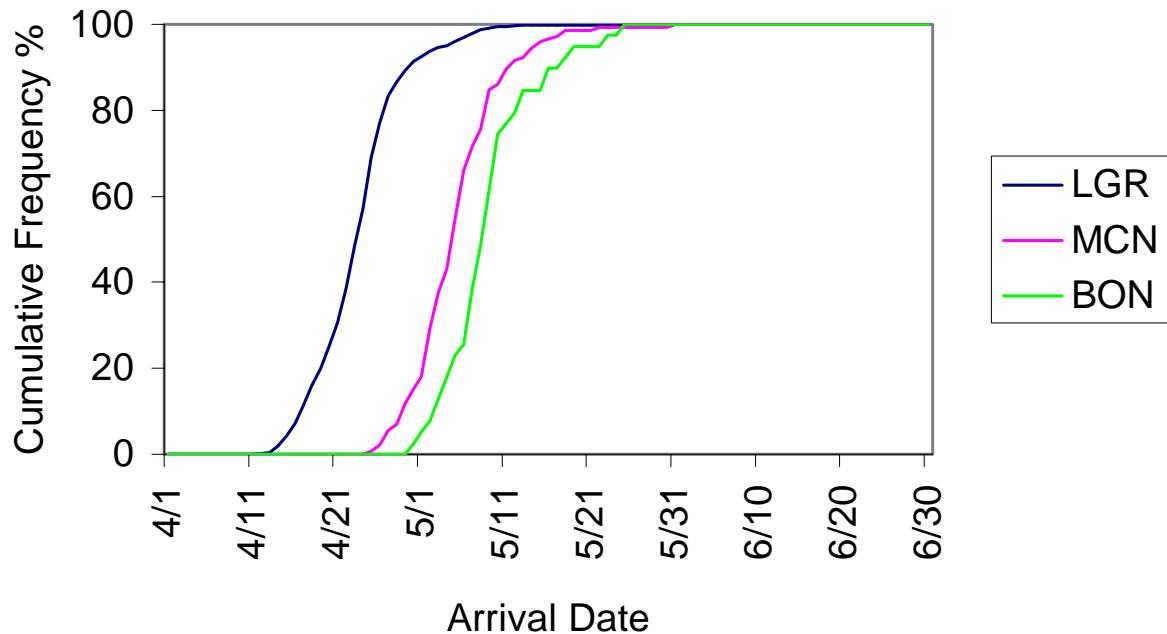

Figure E.6.—First obs arrival date cumulative frequency of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2003.

Appendix E (continued).

BASED ON FIRST OBS - Multiple release groups at individual dams
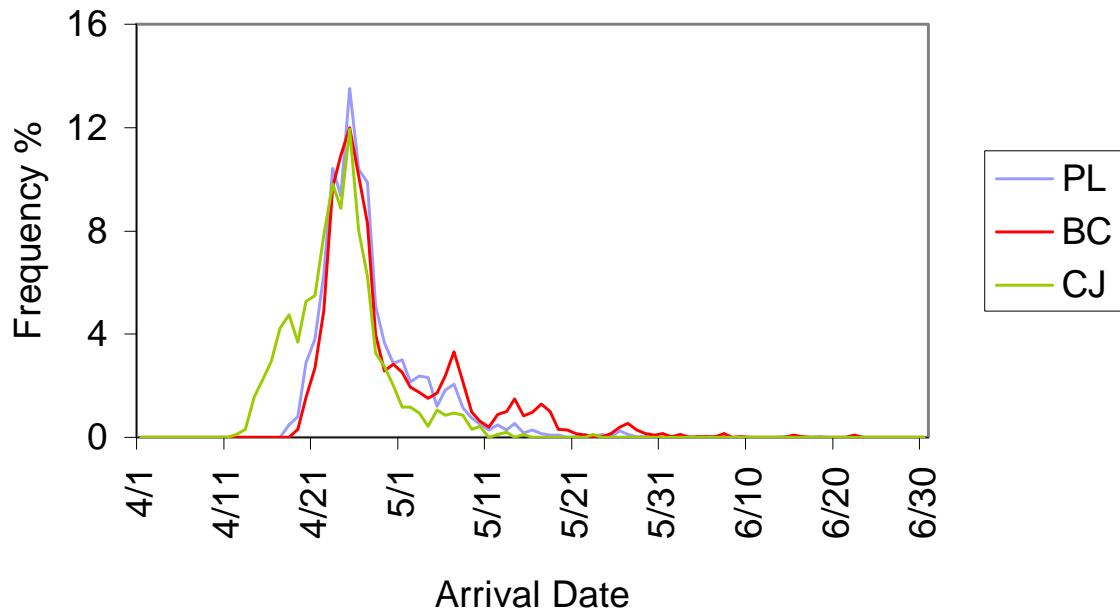
Figure E.7.—First obs arrival date frequency distribution of FCAP yearlings at Lower Granite Dam in 2003.
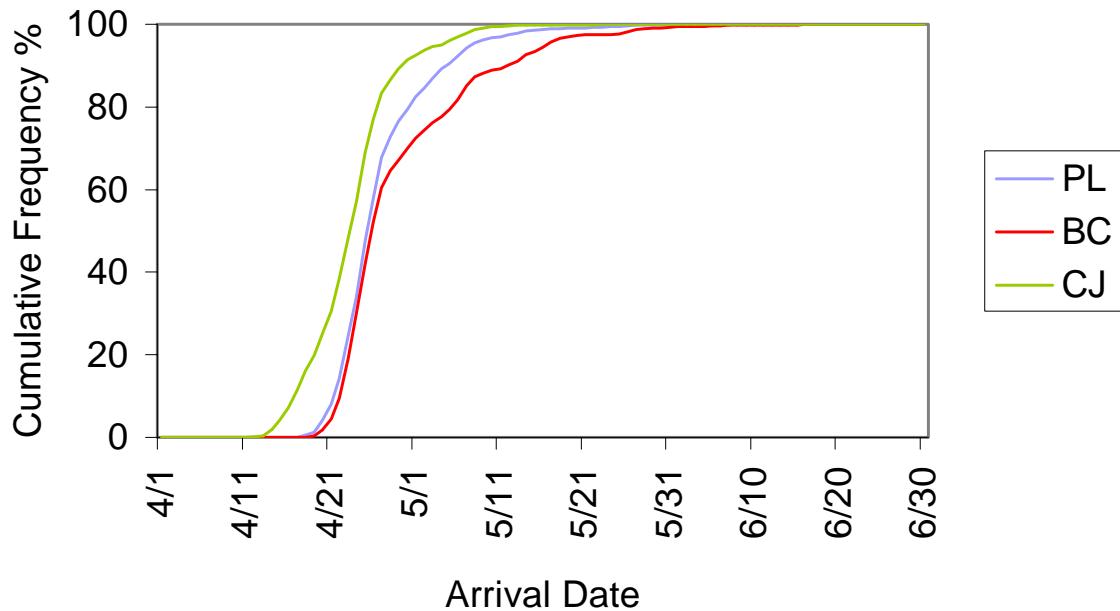
Figure E.8.—First obs arrival date cumulative frequency of FCAP yearlings at Lower Granite Dam in 2003.

Appendix E (continued).
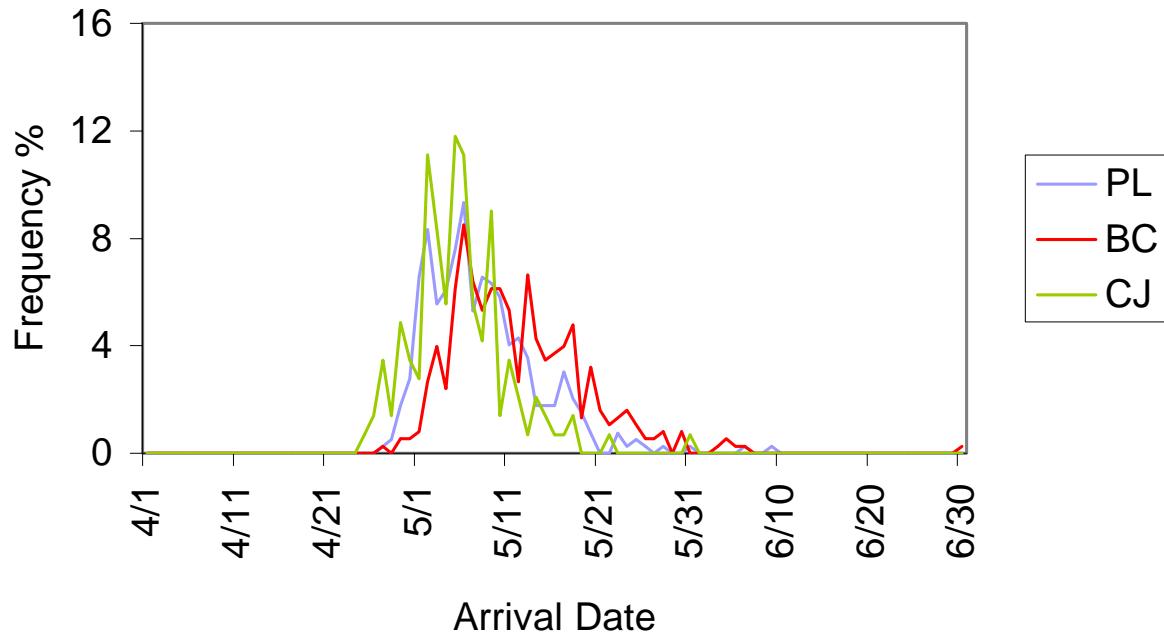
Figure E.9.—First obs arrival date frequency distribution of FCAP yearlings at McNary Dam in 2003.
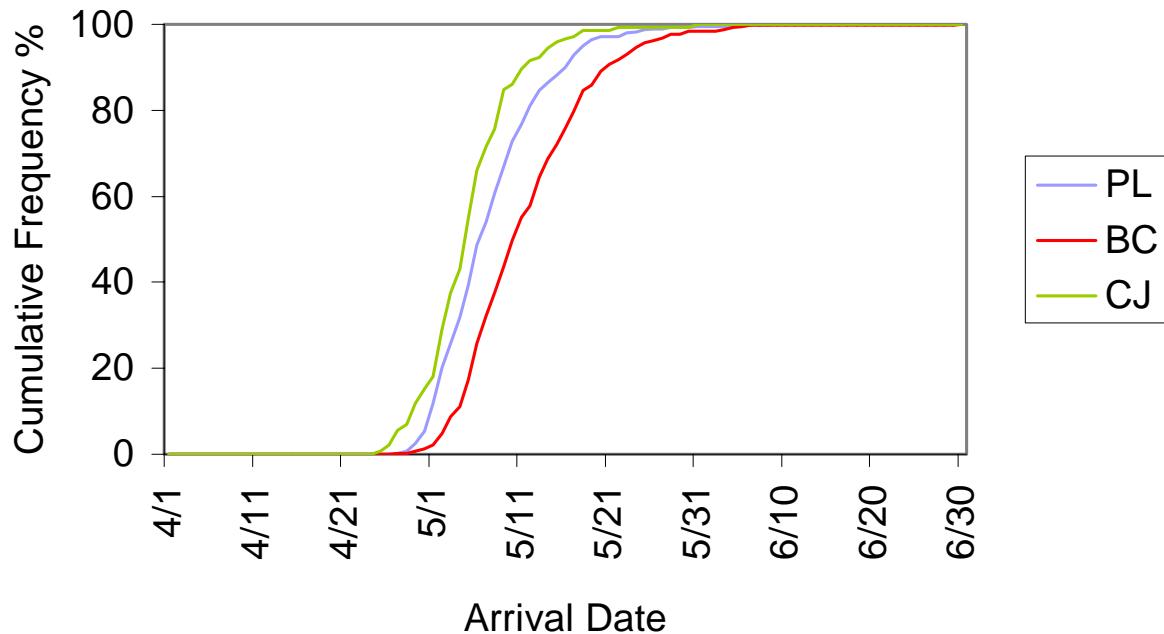
Figure E.10.—First obs arrival date cumulative frequency of FCAP yearlings at McNary Dam in 2003.

Appendix E (continued).
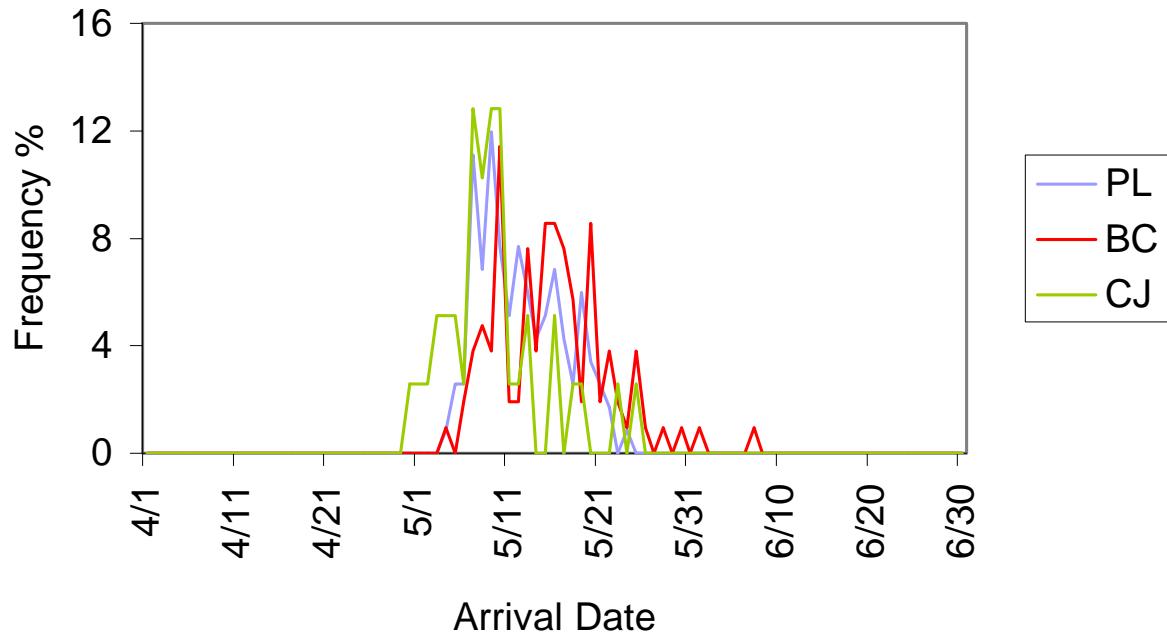
Figure E.11.—First obs arrival date frequency distribution of FCAP yearlings at Bonneville Dam in 2003.
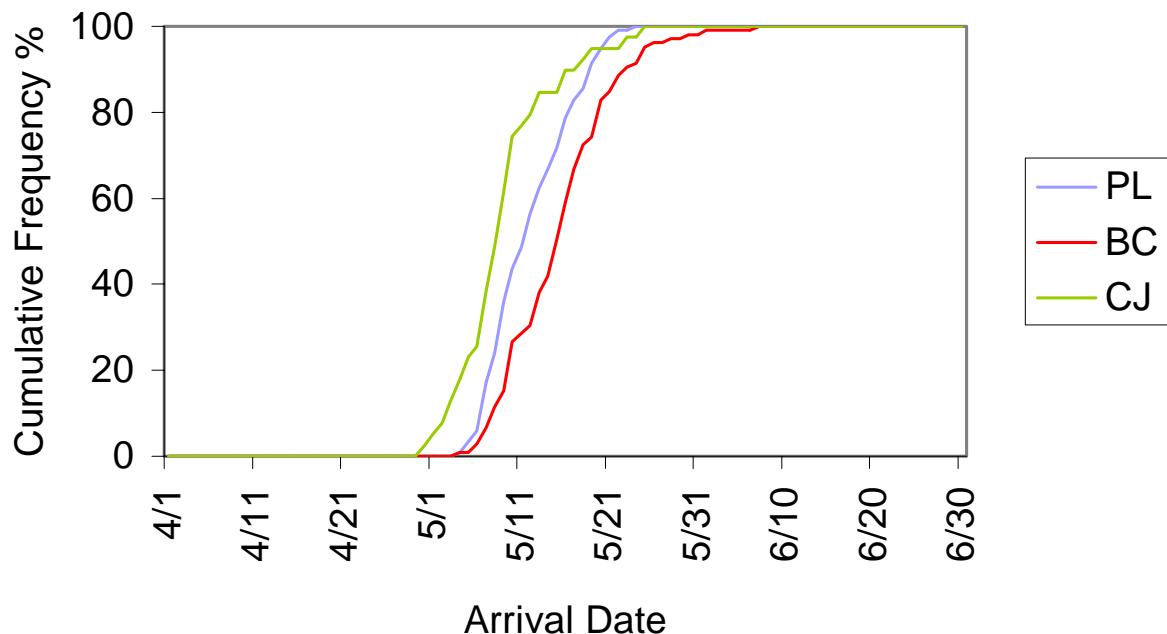
Figure E.12.—First obs arrival date cumulative frequency of FCAP yearlings at Bonneville Dam in 2003.

Appendix E (continued).

Figure E.13.—All obs arrival date frequency distribution of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2003.
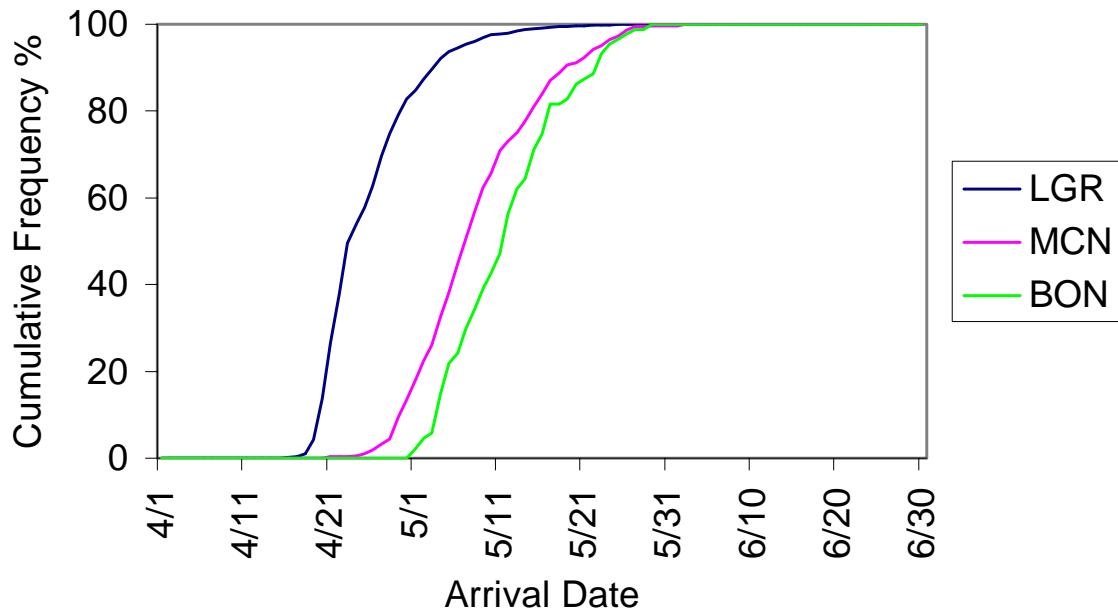

Figure E.14.—All obs arrival date cumulative frequency of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2003.

50

Appendix E (continued).
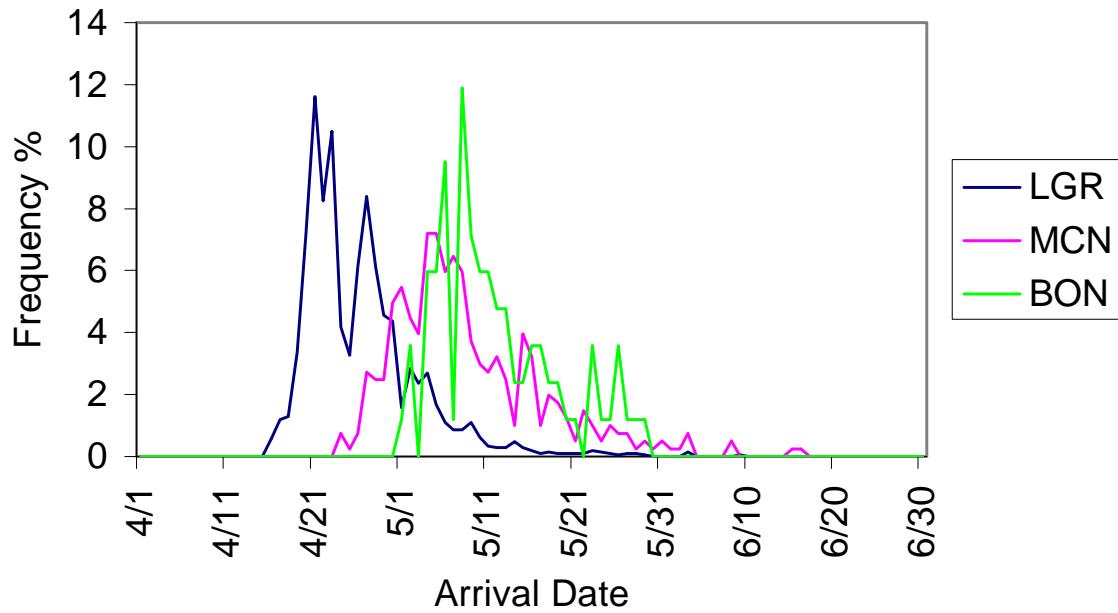
Figure E.15.—All obs arrival date frequency distribution of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2003.
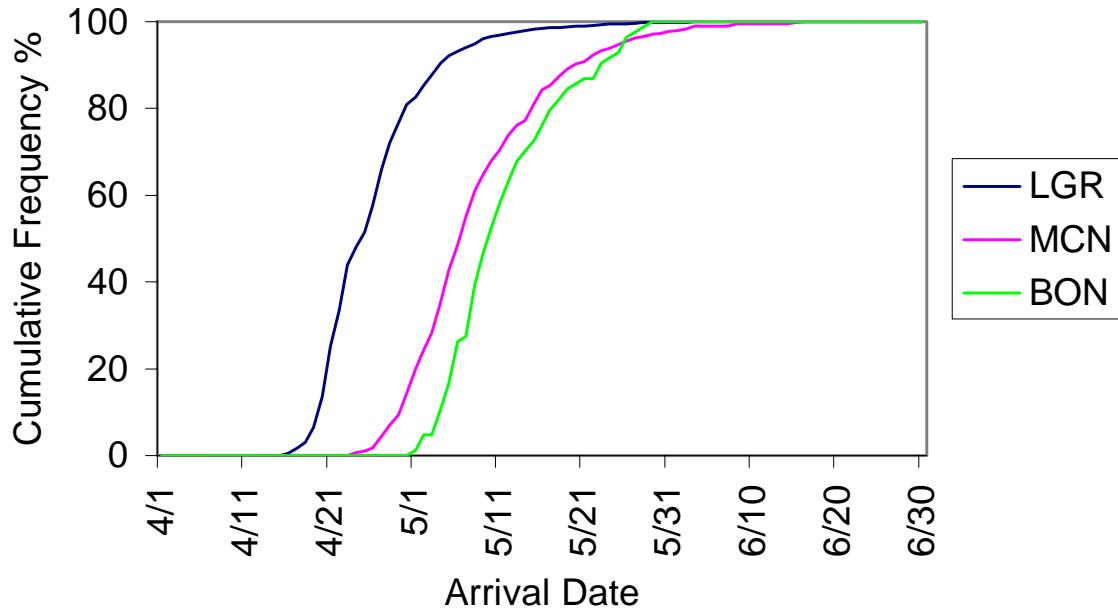
Figure E.16.—All obs arrival date cumulative frequency of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2003.
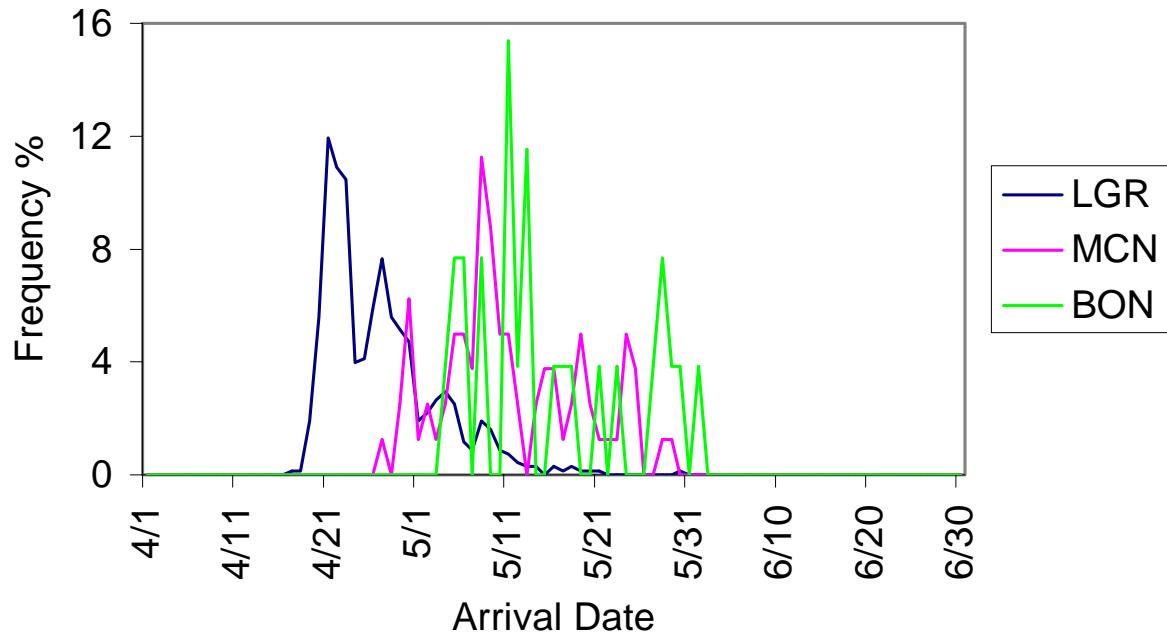
Figure E.17.—All obs arrival date frequency distribution of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2003.
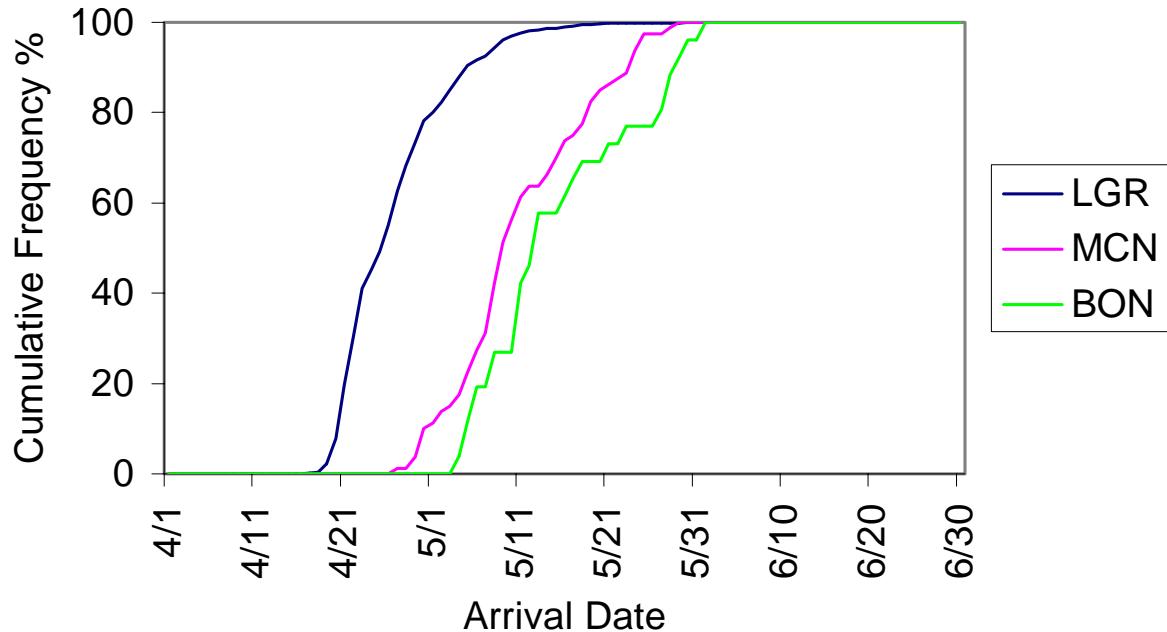
Figure E.18.—All obs arrival date cumulative frequency of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2003.

Appendix E (continued).

Figure E.19.—All obs arrival date frequency distribution of FCAP yearlings at Lower Granite Dam in 2003.
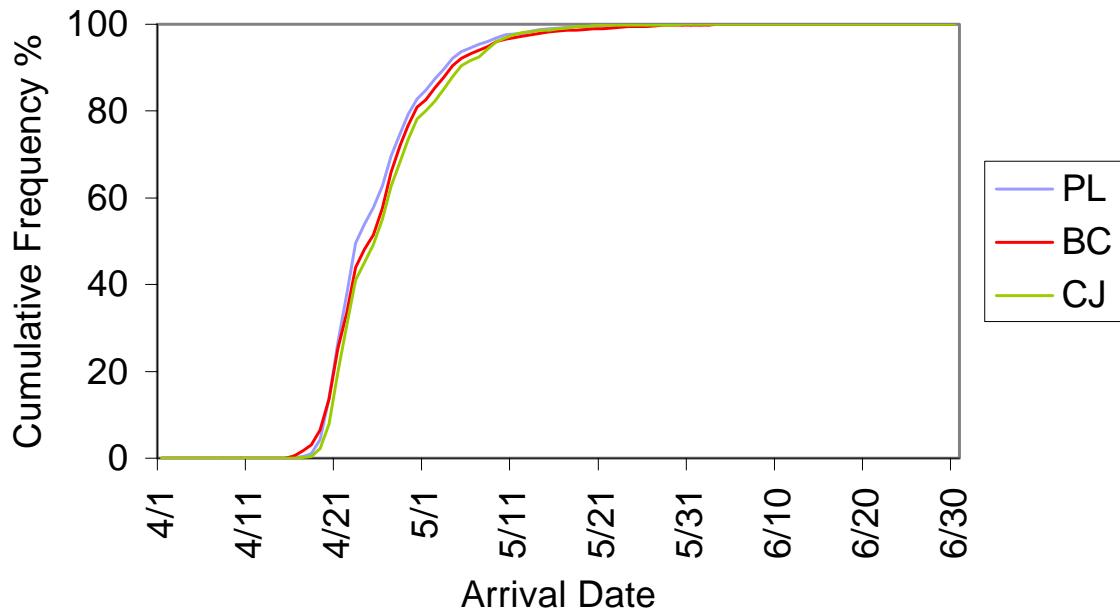
Figure E.20.—All obs arrival date cumulative frequency of FCAP yearlings at Lower Granite Dam in 2003.

Figure E.21.—All obs arrival date frequency distribution of FCAP yearlings at McNary Dam in 2003.
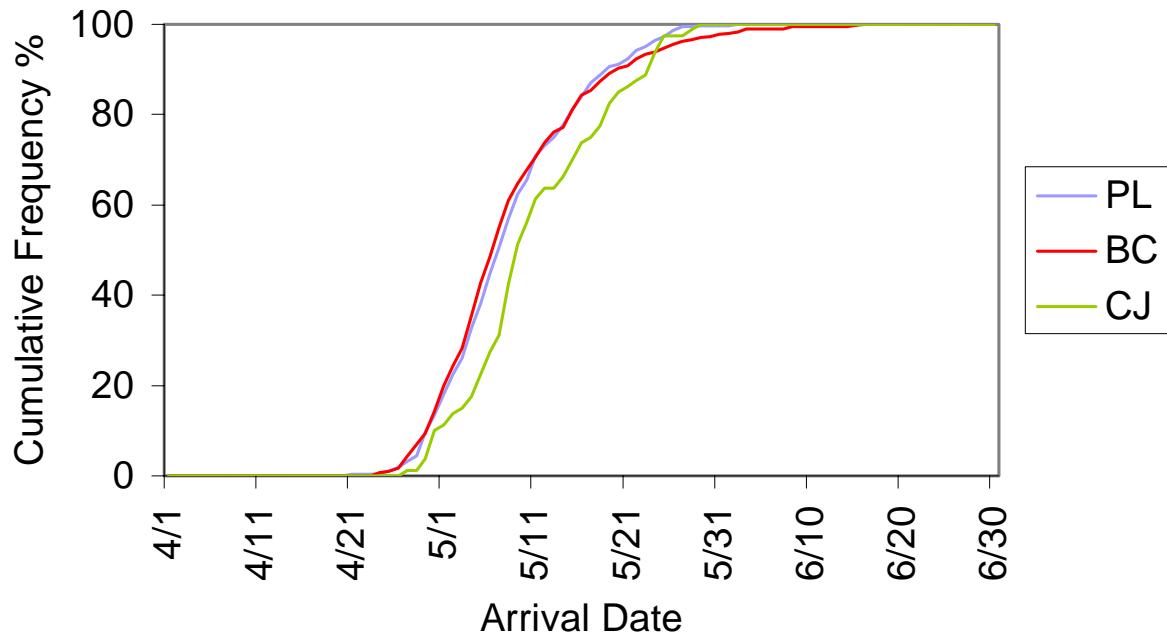
Figure E.22.—All obs arrival date cumulative frequency of FCAP yearlings at McNary Dam in 2003.

Appendix E (continued).
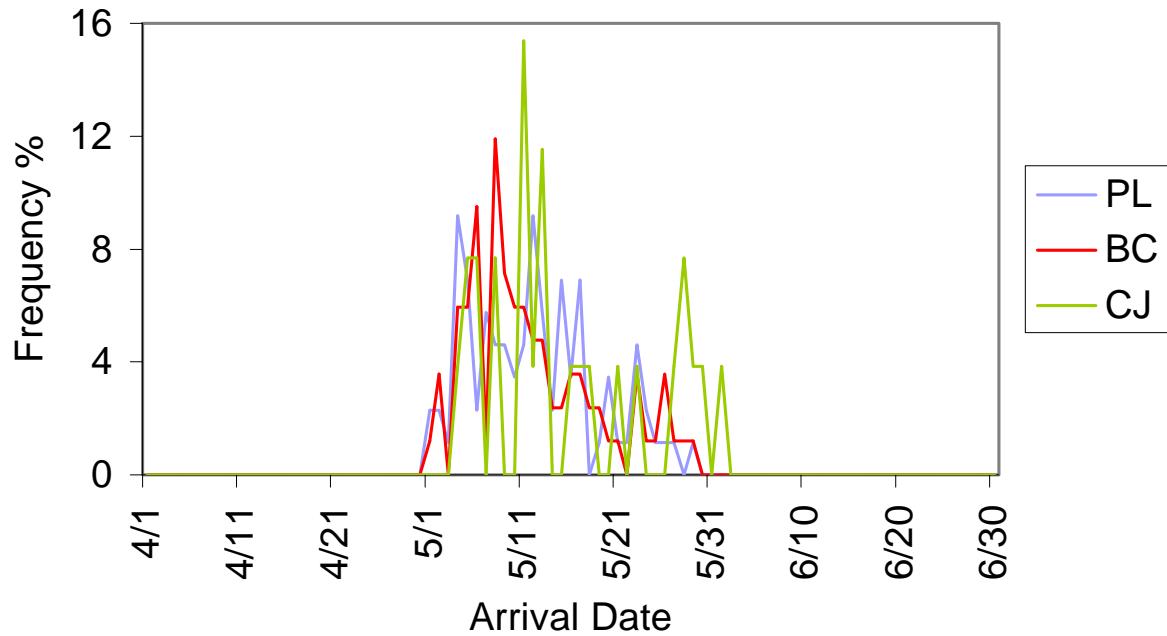
Figure E.23.—All obs arrival date frequency distribution of FCAP yearlings at Bonneville Dam in 2003.
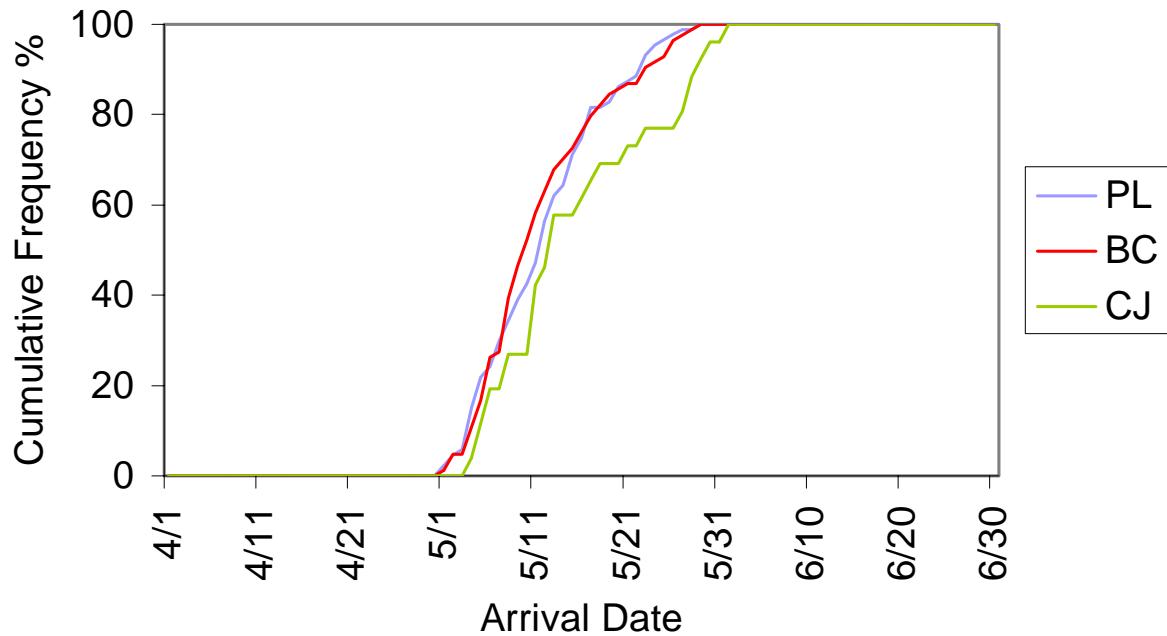

Figure E.24.—All obs arrival date cumulative frequency of FCAP yearlings at Bonneville Dam in 2003.