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

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

Annual Report
January 2004 – December 2004

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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 2004. This was the ninth year of a long-term project to supplement natural spawning populations of Snake River stock fall Chinook salmon upstream of Lower Granite Dam. The 414,452 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 4,983 PIT tagged yearlings from Pittsburg Landing, 4,984 from Big Canyon and 4,982 from Captain John Rapids. Fish health sampling indicated that, overall, bacterial kidney disease levels could be considered low with 53-94% rating not detected to low.

Mean fork lengths (95% confidence interval) of the PIT tagged groups ranged from 154.6 mm (154.0-155.2 mm) at Pittsburg Landing to 163.0 mm (162.6-163.4 mm) at Captain John Rapids. Mean condition factors ranged from 1.06 at Lyons Ferry Hatchery to 1.16 at Big Canyon.

Estimated survival (95% confidence interval) of PIT tagged yearlings from release to Lower Granite Dam ranged from 74.7% (72.9-76.5%) for Big Canyon to 88.1% (85.7-90.6%) for Captain John Rapids. Estimated survival from release to McNary Dam ranged from 45.3% (39.2-51.5%) for Pittsburg Landing to 52.1% (42.9-61.2%) for Big Canyon.

Median migration rates to Lower Granite Dam, based on all observations of PIT tagged yearlings from the FCAP facilities, ranged from 5.5 river kilometers per day (rkm/d) for Captain John Rapids to 12.8 rkm/d for Pittsburg Landing. Median migration rates to McNary Dam ranged from 10.9 rkm/d for Captain John Rapids to 17.6 rkm/d for Pittsburg Landing. Median travel times from the FCAP facilities were about 13-16 days to Lower Granite Dam and 23-29 days to McNary Dam.

Median arrival dates at Lower Granite Dam, based on all observations of PIT tagged yearling groups from Pittsburg Landing, Big Canyon and Captain John Rapids, ranged from April 18-29. Median arrival dates at McNary Dam for Pittsburg Landing, Big Canyon and Captain John Rapids groups ranged from May 1-8.

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Additional thanks go to our colleagues at the Washington Department of Fish and Wildlife – Snake River Laboratory and the U.S. Fish and Wildlife Service – Idaho Fishery Resource Office for their cooperation and assistance. Special thanks go to Kathy Clemens and the staff at the Idaho Fish Health Center for their efforts in providing the fish health data.

We would like to extend our appreciation to the Nez Perce Tribe personnel whose coordination efforts and assistance in the field make this project successful: Bill Arnsberg, Dale Kellar, Mark Pishl, Bruce McLeod, Mike Key, Scott Everett, Brenda Axtell, Letitia Whitman, Arnold Henry, Austin Samuels, Lou Ann Laswell, George Growing-Thunder, Brad Mitchell, Charles Axtell, Raphael Johnnie, and Mike Bisbee.

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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 2004. This was the ninth 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 2004. In addition, we are 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 typical 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). Reports detailing LFH activities for 2003 and 2004 are 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

Study Area Description

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.

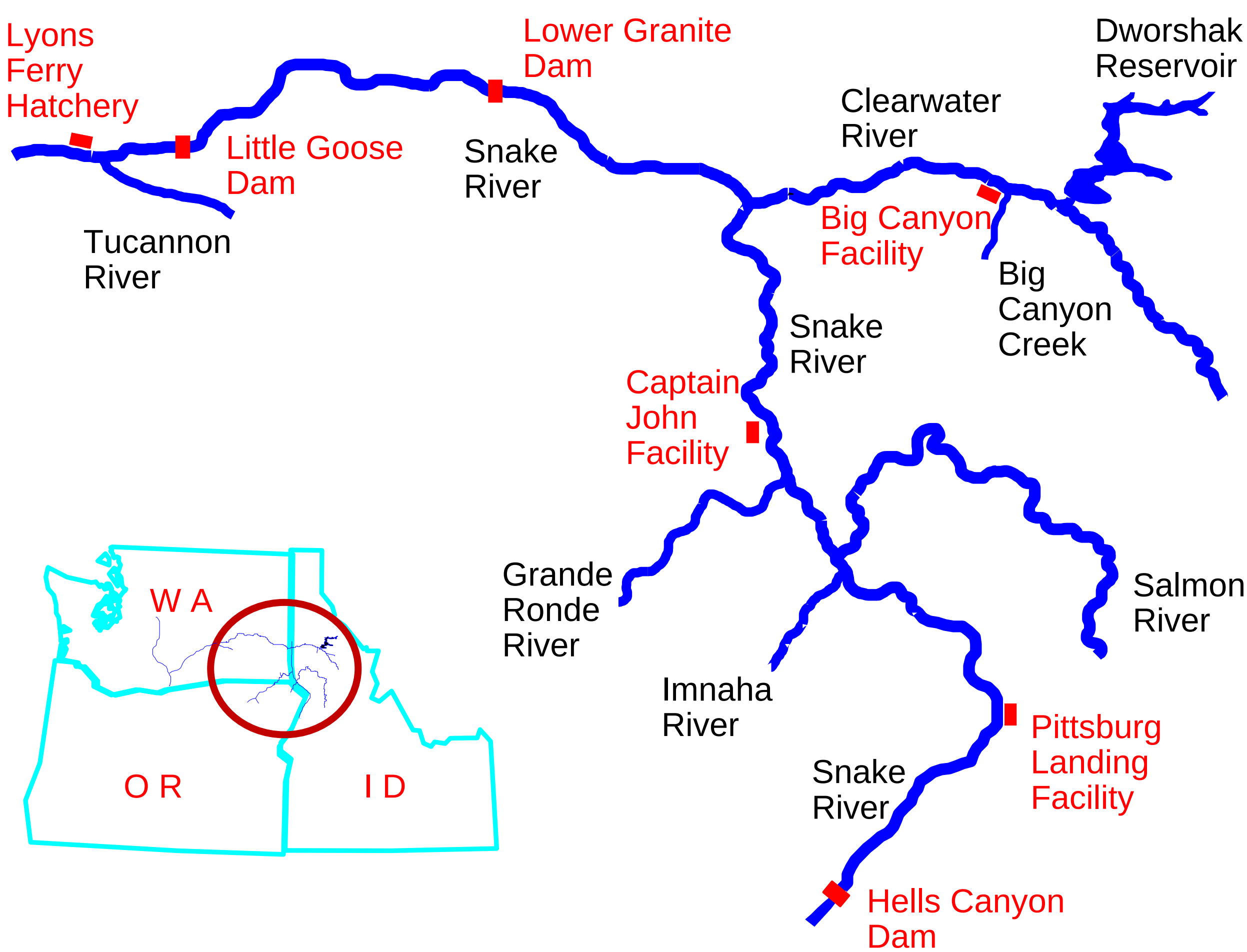

Figure 1.—Map of primary study area highlighting FCAP facilities, Lyons Ferry Hatchery and various Snake River dams.

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 7 and 9 at Pittsburg Landing and tanks 8 and 11 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 typical 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 goal was 5,000 fish at each FCAP facility. Tagging was conducted to be representative across the release dates. NPT personnel conducted PIT tagging at all FCAP facilities. The WDFW discontinued PIT tagging of the on-station yearling fall Chinook salmon release after 2001. All PIT tagged fish had the default 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 151,443 yearlings were released from Pittsburg Landing and 109,758 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 12-13 and Big Canyon from April 14-15. A total of 153,251 yearlings were released volitionally from Captain John Rapids from April 1-7. The total FCAP release number of 414,452 fell short of the release quota of 450,000 yearlings. Lyons Ferry Hatchery also missed its quota, volitionally releasing an estimated 425,316 yearlings April 12-14.

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 April 5-13. Table 2 summarizes the ELISA results for all groups during pre-release exam. Overall, based on ELISA values, 2004 can be considered a year of fairly low BKD levels in FCAP and LFH yearling fall Chinook salmon. From 53-94% of the fish sampled graded from not detected to low. The overall BKD levels appeared to increase slightly after transport from LFH to the Big Canyon and Captain John Rapids 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 2004.

		ELISA					
Location	*n*	Not Detected	Very Low	Low	Medium	High	Very High
Pittsburg Landing	60	1 (2%)	41 (69%)	14 (24%)	1 (2%)	1 (2%)	1 (2%)
Big Canyon	60	0 (0%)	1 (2%)	35 (58%)	10 (17%)	6 (10%)	8 (13%)
Captain John Rapids	61	0 (0%)	12 (20%)	20 (33%)	12 (20%)	9 (15%)	7 (12%)
Lyons Ferry Hatchery	57	0 (0%)	23 (38%)	29 (48%)	3 (5%)	3 (5%)	2 (3%)

Flow and Temperature

Overall, 2004 was a below average water year. Flows in the Snake River were consistently below the historical averages throughout the year, while those in the Clearwater River were closer to historical averages.

The average flow in the Snake River near Hell's Canyon Dam in April was about 63% below the 38-year average from 1966 to 2003. Overall, flows fluctuated regularly between about 9,000-20,000 cfs (Figure 2). Spring flow patterns in 2004 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 39% below the 45-year average from 1959 to 2003 (Figure 3). Flows at Anatone peaked at 71,300 cfs on May 30. The daily mean water temperature during April ranged from 8.1^{O} to 13.0^{O} C with an overall mean of 10.4^{O} C.

The average daily discharge in the Clearwater River at Peck in April was about 9% below the 39-year average from 1965 to 2003, peaking at 63,600 cfs on May 29. 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 6.5^{O} to 9.0^{O} C with an overall mean of 7.6^{O} C.

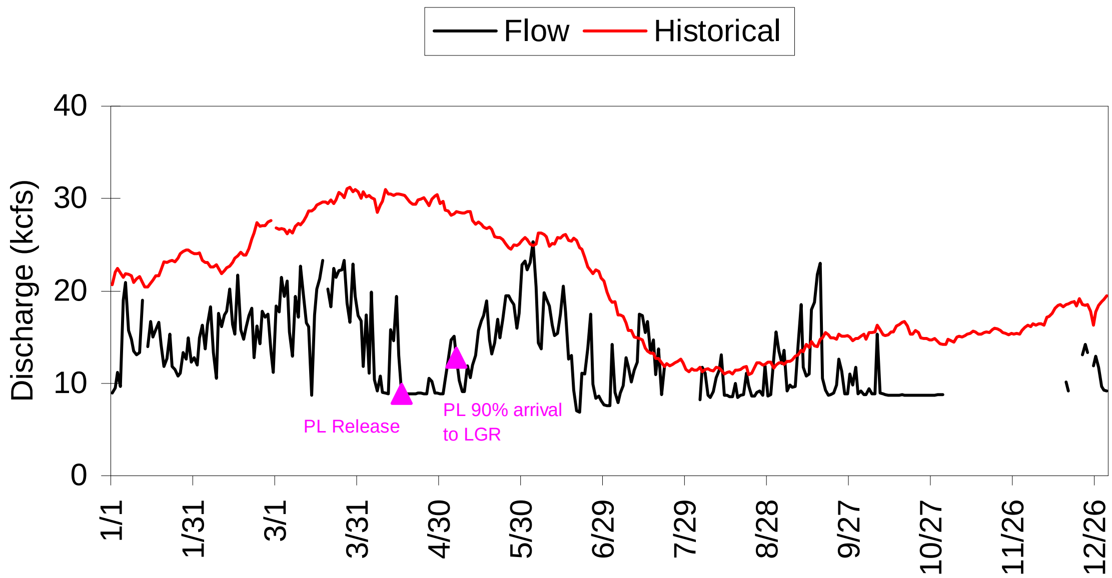

Figure 2.—Mean daily flow in 2004 and historical mean flow from 1966-2003 for the Snake River as measured at USGS gauge 13290450 near Hell's Canyon Dam.

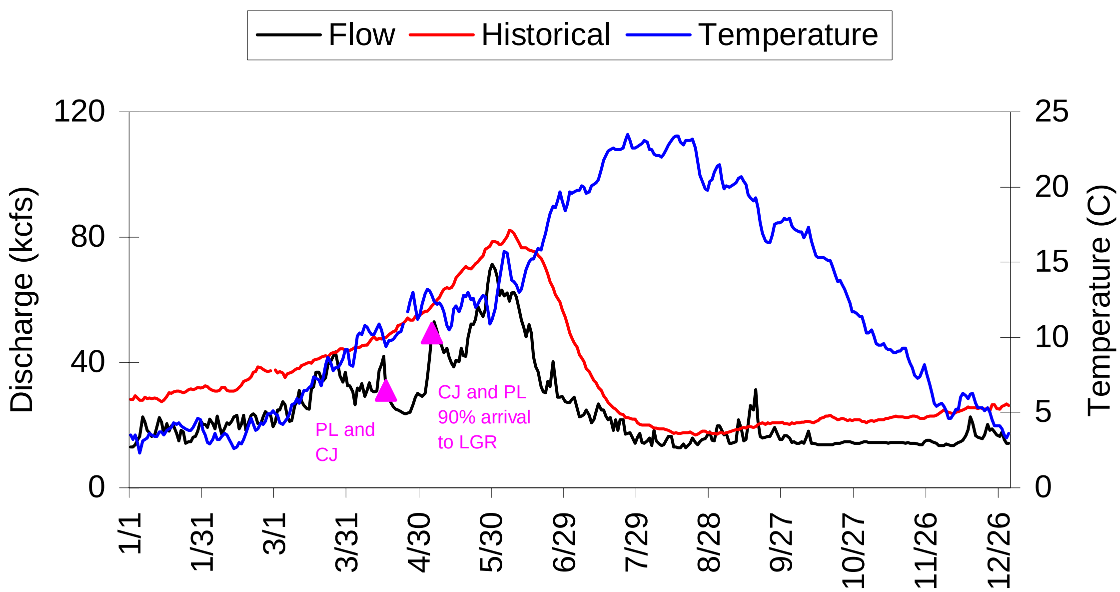

Figure 3.—Mean daily flow and temperature in 2004 and historical mean flow from 1959-2003 for the Snake River as measured at USGS gauge 13334300 near Anatone, Washington.

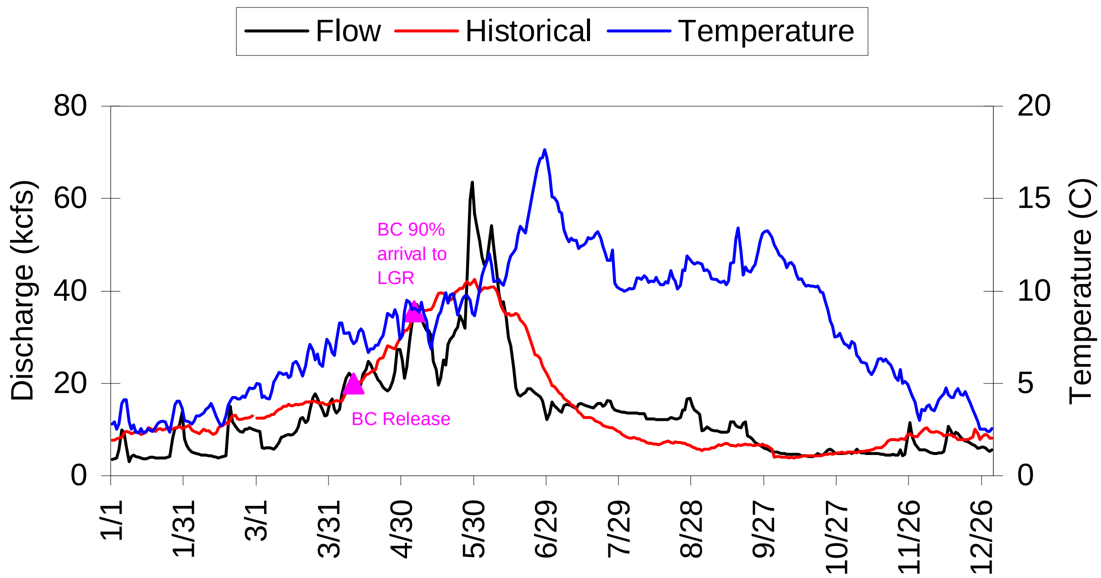

Figure 4.—Mean daily flow and temperature in 2004 and historical mean flow from 1965-2003 for the Clearwater River as measured at USGS gauge 13341050 near Peck, Idaho.

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 132.4 kcfs on May 29 (Figure 5). The main period of spill was intermittent from April 3 through June 9 with daily spill averaging 9.7 kcfs and peaking at 39.4 kcfs on May 29. During periods of spill, spill somewhat represented the total outflow pattern.

Average daily outflow as measured in the tailrace at McNary Dam averaged about 125.0 kcfs daily until it began increasing with spring runoff in early April to peak at 279.9 kcfs on June 5 (Figure 6). The main period of spill was from April 12 through July 1 with daily spill averaging 68.7 kcfs and peaking at 112.5 kcfs on May 31. During periods of spill, spill somewhat represented the total outflow pattern.

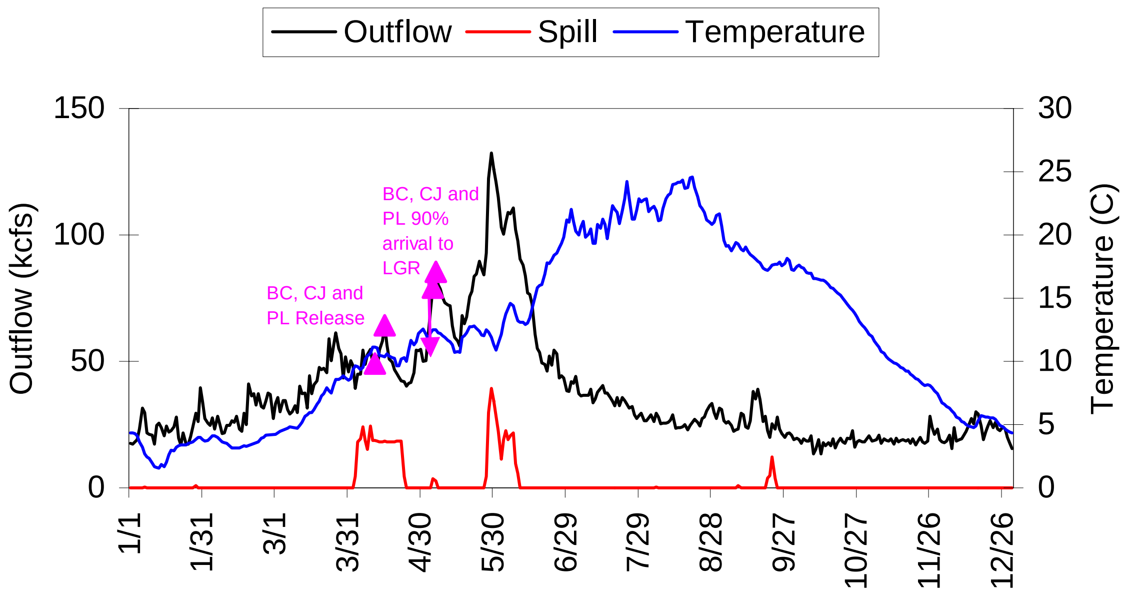

Figure 5.—Mean daily flow, spill, and temperature for the Snake River in 2004 as measured by the USACE at Lower Granite Dam.

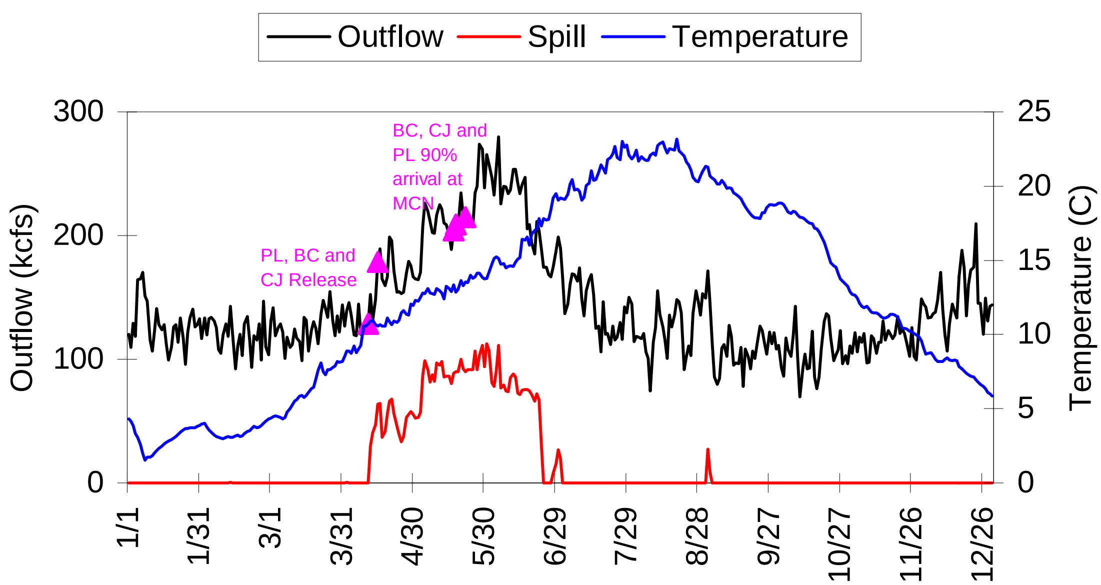

Figure 6.—Mean daily flow, spill, and temperature for the Columbia River in 2004 as measured by the USACE at McNary Dam.

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 4,983 and 4,984 yearling fall Chinook salmon were PIT tagged at Pittsburg Landing and Big Canyon, respectively (Table 3). A total of 4,982 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 2004.

Facility	Date Tagged	Number Tagged	Date Released
Pittsburg Landing	April 5	2,495	April 12
	April 6	2,488	April 13
	Total	4,983	
Big Canyon	April 7	2,497	April 14
	April 8	2,487	April 15
	Total	4,984	
Captain John Rapids	March 31	3,069	April 1-7
	April 1	1,913	
	Total	4,982	

Biological Characteristics

Overall, mean lengths across the FCAP and LFH yearling release groups were more consistent in 2004 than any year prior. The ANOVA on fork lengths shows a significant between-groups effect ($P = 0.0019$). Multiple comparisons indicate that groups from all three FCAP facilities were significantly different from each other, but LFH was similar to both Big Canyon and Captain John Rapids (Appendix B, Table B.1). Biologically there is no difference in mean length between the Big Canyon, Captain John Rapids and LFH groups (Table 4). The statistical difference was due to the large sample sizes. Yearlings from Pittsburg Landing were smaller than the other FCAP groups, and the 6-8 mm difference may be biologically significant. Fork length distributions of PIT tagged fish from the FCAP release groups all differed significantly ($P < 0.001$) from each other while the LFH group was different from the Pittsburg Landing and Big Canyon groups ($P < 0.0001$), but similar ($P = 0.0866$) to the Captain John Rapids group (Appendix B; Table B.2). Visual inspection shows that the Pittsburg Landing and Big Canyon groups had a higher proportion of smaller fish (Figure 7). On a biological basis, the Pittsburg Landing and Big Canyon groups are similar to each other and the Captain John Rapids and LFH groups are similar to each other.

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 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 2004.

Facility		Number Sampled	Mean	Standard Deviation	95% C.I. (+/- mean)	Median	Range
Pittsburg Landing	Fork Length (mm)	4,970	154.6	20.4	0.6	158	80 - 202
	Weight (g)	813	45.6	14.7	1.0	46.8	6.7 - 84.4
	Condition Factor	813	1.12	0.06	0.004	1.12	0.95 - 1.35
Big Canyon	Fork Length (mm)	4,920	160.7	18.0	0.5	164	89 - 205
	Weight (g)	814	48.2	15.0	1.0	49.1	8.7 - 94.5
	Condition Factor	814	1.16	0.06	0.004	1.16	0.95 - 1.37
Captain John Rapids	Fork Length (mm)	4,980	163.0	13.0	0.4	164	94 - 210
	Weight (g)	781	50.0	12.0	0.8	50.1	15.9 - 88.6
	Condition Factor	780	1.15	0.06	0.004	1.15	0.92 - 1.40
Lyons Ferry Hatchery[1]	Fork Length (mm)	619	162.5	11.9	0.9	163	118 - 213
	Weight (g)	619	45.9	9.9	0.8	45	18.0 - 108.7
	Condition Factor	619	1.06	0.07	0.01	1.05	0.86 - 1.49

[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 showed a significant between-groups effect ($P = 0.0028$). Multiple comparisons indicate that the Big Canyon and Captain John Rapids groups were similar while the Pittsburg Landing and LFH groups differed from all others (Appendix B, Table B.1). Mean condition factors at Big Canyon and Captain John Rapids were not likely different on a biological basis, but Pittsburg Landing may be different from them. However, the lower condition factor at LFH did likely represent a biological difference from the FCAP groups (Table 4). All condition factor distributions significantly differed from each other except the Big

Canyon and Captain John Rapids groups were similar to each other (Appendix B; Table B.2). Results of all statistical tests are included in Appendix B.

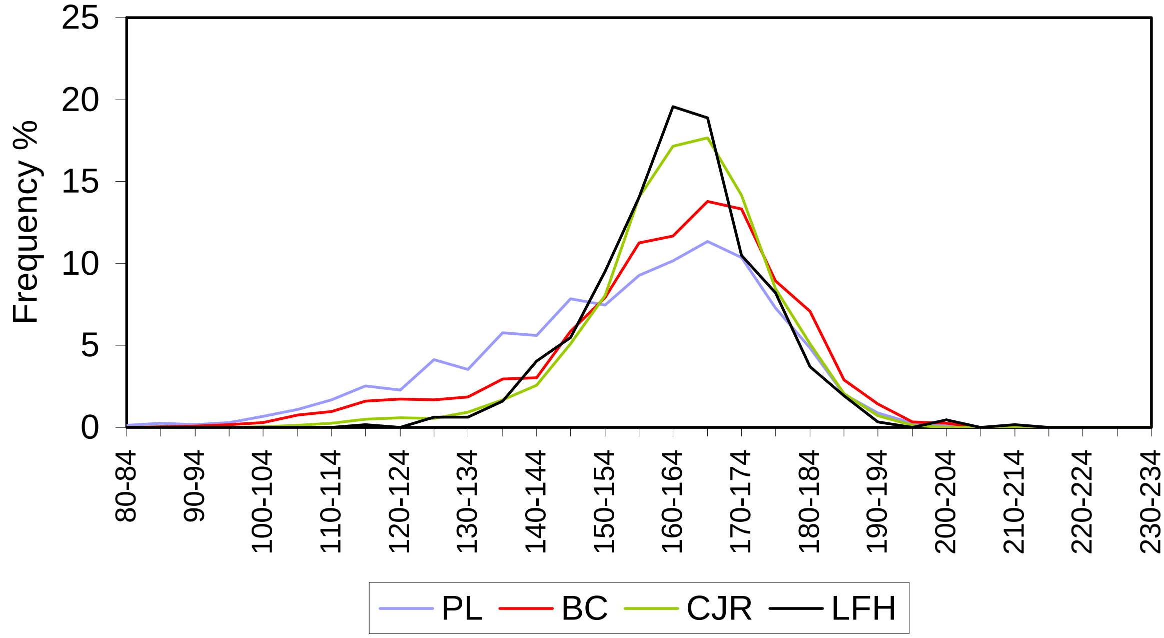

Figure 7.—Fork length frequency of PIT tagged yearling fall Chinook salmon at the FCAP facilities and LFH in 2004.

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, 2005; Rocklage and Kellar 2005a, 2005b, 2005c, 2005d).

Coded wire tag retention ranged from 95.9% at LFH to 99.6% at Pittsburg Landing and Captain John Rapids. Adipose fin clip retention ranged from 94.8% at Pittsburg Landing to 99.5% at LFH. Retention of VIE marks was lower and more variable than for adipose fin clips and coded wire tags, ranging from 81.9% at Pittsburg Landing to 91.3% at Big Canyon (Table 5). A total of 8 FCAP and 15 LFH fish (0.002% 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 2004. Also shown is 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	814	99.6	94.8	81.9	0.000034	5
Big Canyon	816	98.9	98.2	91.3	0.000018	2
Captain John Rapids	800	99.6	98.6	86.0	0.000007	1
Lyons Ferry Hatchery	1,676	95.9	99.5	84.7	0.000034	15

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 74.7% (72.9-76.5%) for Big Canyon to 88.1% (85.7-90.6%) for Captain John Rapids. Estimated survival from release to McNary Dam ranged from 45.3% (39.2-51.5%) for Pittsburg Landing to 52.1% (42.9-61.2%) for Big Canyon (Table 6). All survival estimates to Lower Granite Dam differed significantly, but 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 2004 was lower than 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 2004.

Facility	Evaluation Point	Estimated Survival	95% C.I. Lower Bound	95% C.I. Upper Bound
Pittsburg Landing	Lower Granite	0.7848	0.7668	0.8028
	McNary	0.4532	0.3915	0.5149
Big Canyon	Lower Granite	0.7470	0.7294	0.7646
	McNary	0.5206	0.4291	0.6121
Captain John Rapids	Lower Granite	0.8811	0.8566	0.9056
	McNary	0.5075	0.4497	0.5653

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 2004.

To Lower Granite Dam		
	BC	CJ
PL	$P = 0.0033$	$P < 0.0001$
BC		$P < 0.0001$

To McNary Dam		
	BC	CJ
PL	$P = 0.2313$	$P = 0.2080$
BC		$P = 0.8125$

Travel Time and Migration Rate

In 2004, as 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 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 13-16 days to Lower Granite Dam and about 22-29 days to McNary Dam. For a study that compares fish released from and observed at multiple locations, travel time from release to a given point is of limited utility due to 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 ($P = 0.008$ 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).

Migration rate trends were different in 2004 than in most past years. In past years our data indicated 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, Little Goose and Lower Monumental reservoirs (Figures 8 and 9). Our data indicate that migration rates generally increase as each release group moves further downstream. 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). 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.

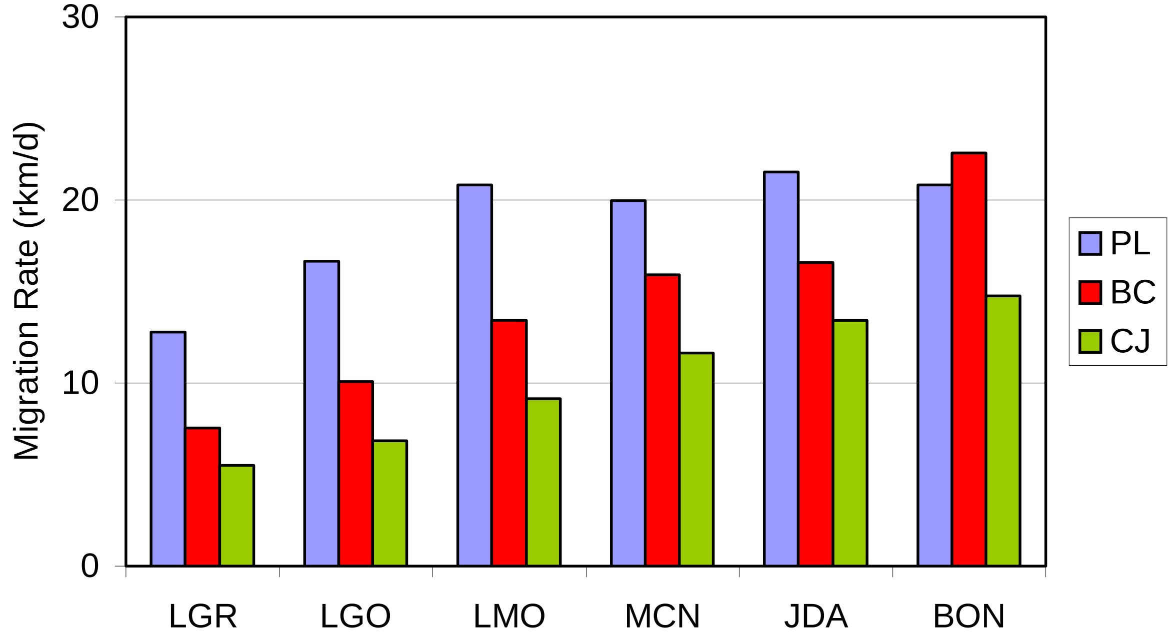

Figure 8.—First obs migration rate (rkm/d) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2004.

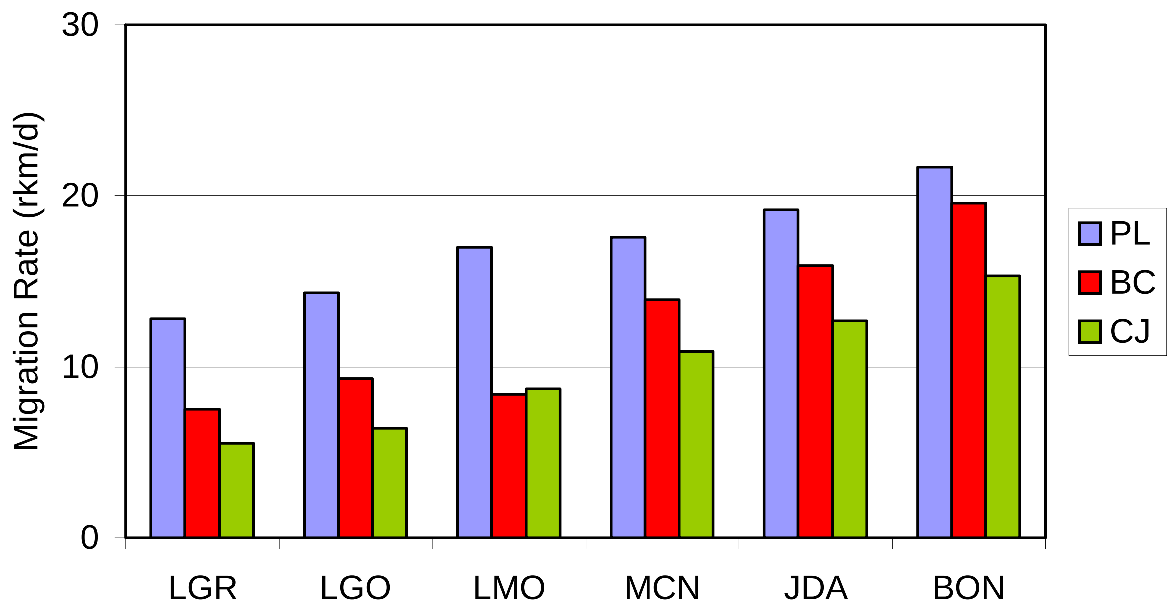

Figure 9.—All obs migration rate (rkm/d) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2004.

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 rate from Pittsburg Landing to Lower Granite Dam during 1996-2004 had a significant positive correlation with flow at both Hell's Canyon Dam (r = 0.9122, P = 0.0006) and Anatone (r = 0.9517, P = 0.0001), while having essentially no correlation with temperature at Anatone (r = -0.1673, P = 0.6670), as illustrated in Figures 10 and 11. Migration rates from Big Canyon to Lower Granite Dam during 1997-2004 also had a significant positive correlation with flow (r = 0.7974, P = 0.0177) and a significant negative correlation with temperature (r = -0.7661, P = 0.0266) at Peck (Figures 12 and 13). Migration rates from Captain John Rapids to Lower Granite Dam during 1998-2002 had a significant positive correlation with flow (r = 0.8103, P = 0.0271) and essentially no correlation temperature (r = 0.0441, P = 0.9251) at Anatone (Figures 14 and 15).

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. More comprehensive analyses will be reported as additional data are gathered in future years.

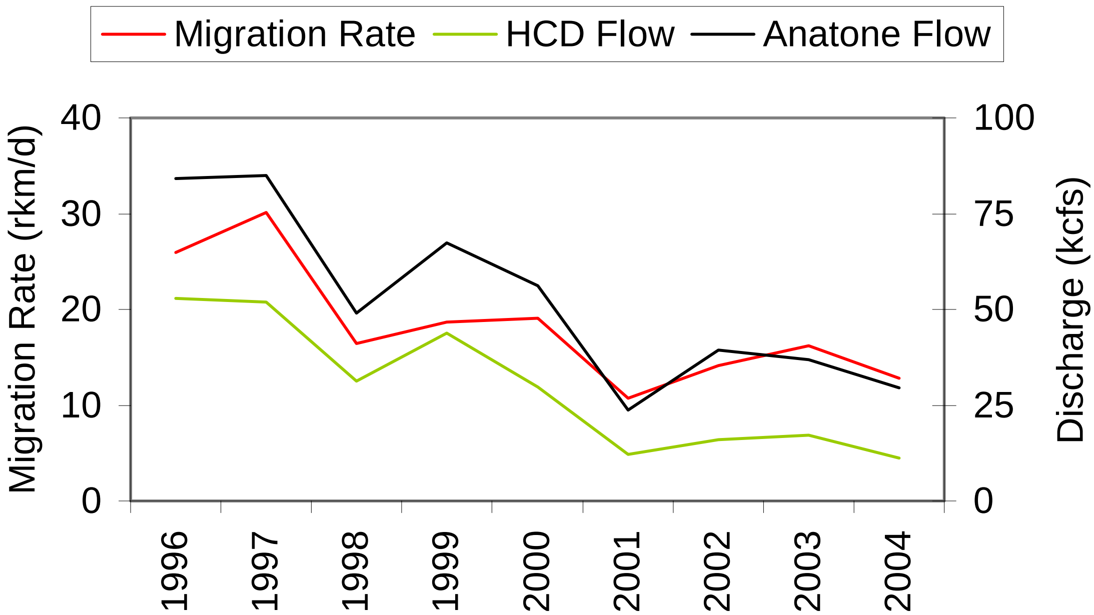

Figure 10.—Yearling migration rate (rkm/d) from Pittsburg Landing to Lower Granite Dam versus Snake River flow at Hell's Canyon Dam and Anatone, 1996-2004.

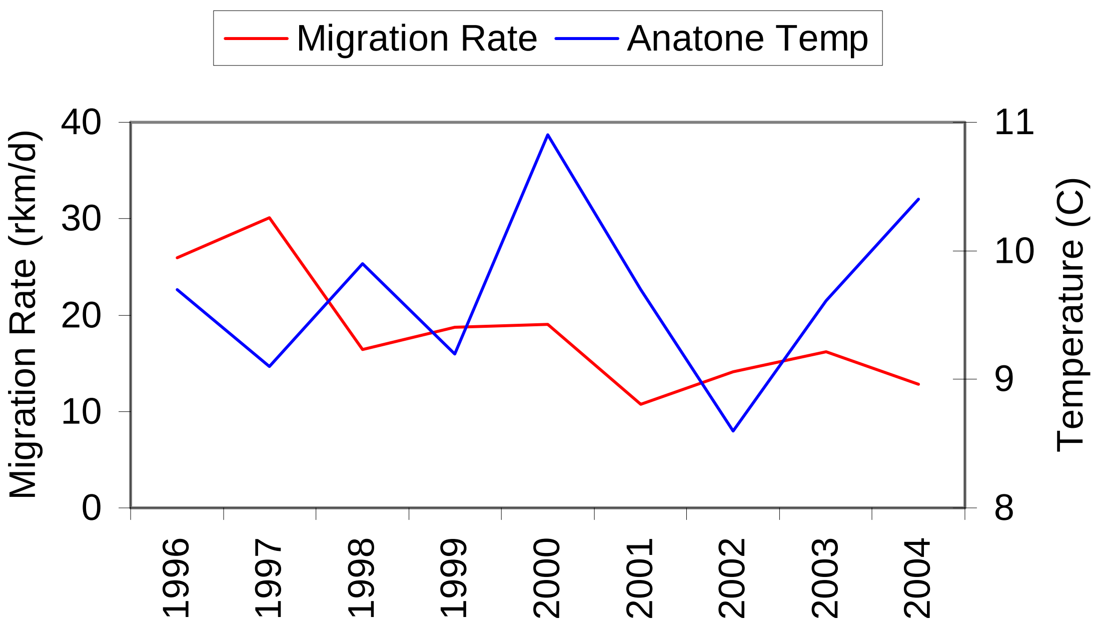

Figure 11.—Yearling migration rate (rkm/d) from Pittsburg Landing to Lower Granite Dam versus Snake River temperature at Anatone, 1996-2004.

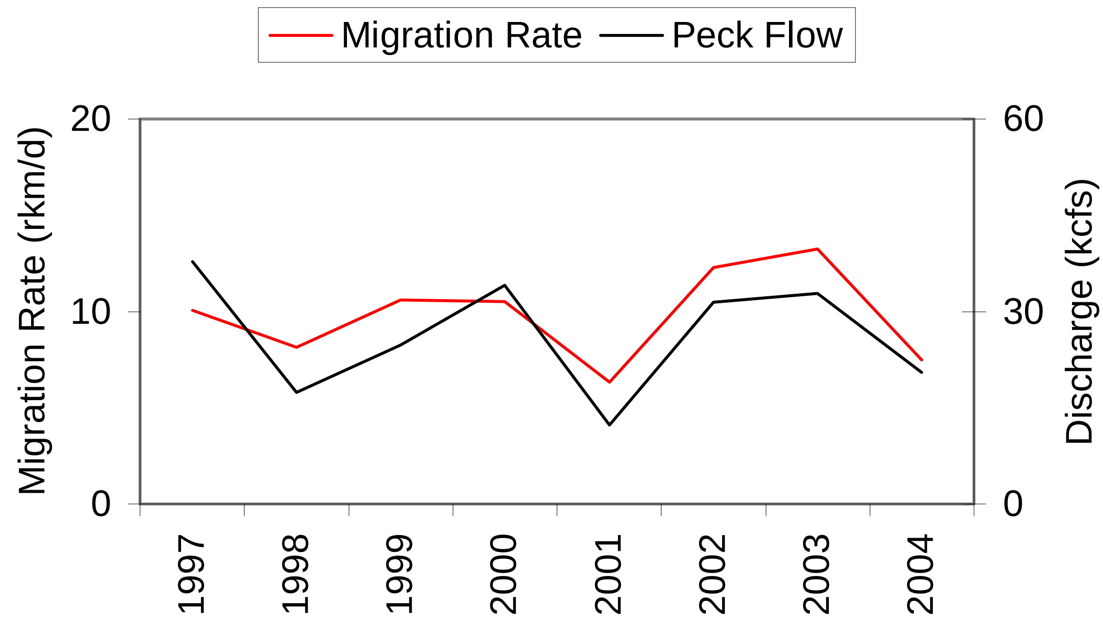

Figure 12.—Yearling migration rate (rkm/d) from Big Canyon to Lower Granite Dam versus Clearwater River flow at Peck, 1997-2004.

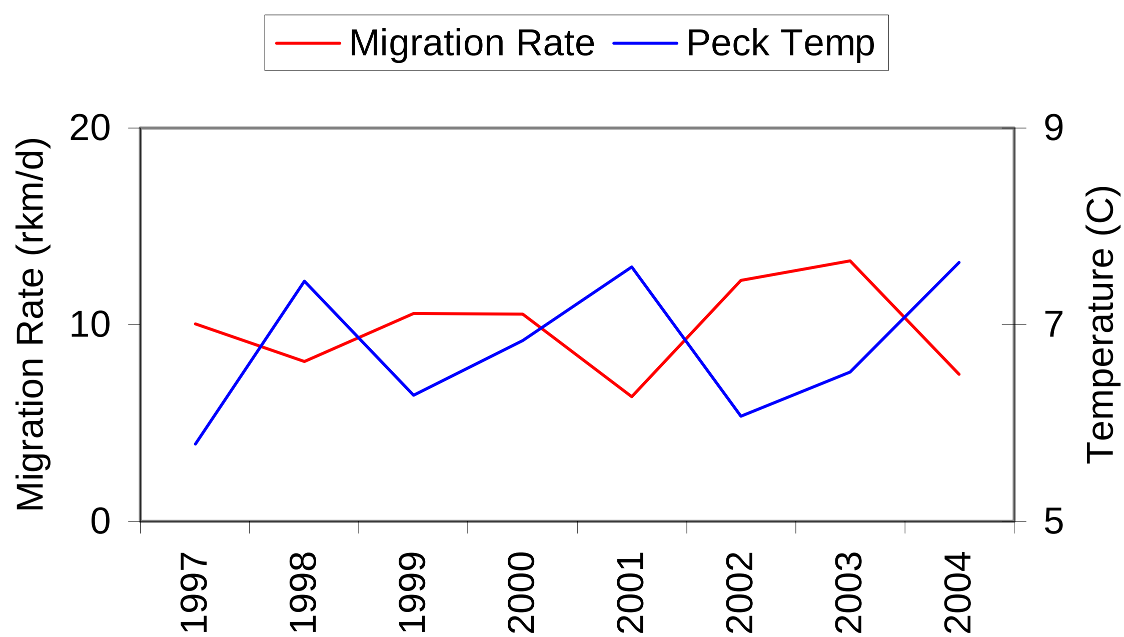

Figure 13.—Yearling migration rate (rkm/d) from Big Canyon to Lower Granite Dam versus Clearwater River temperature at Peck, 1997-2004.

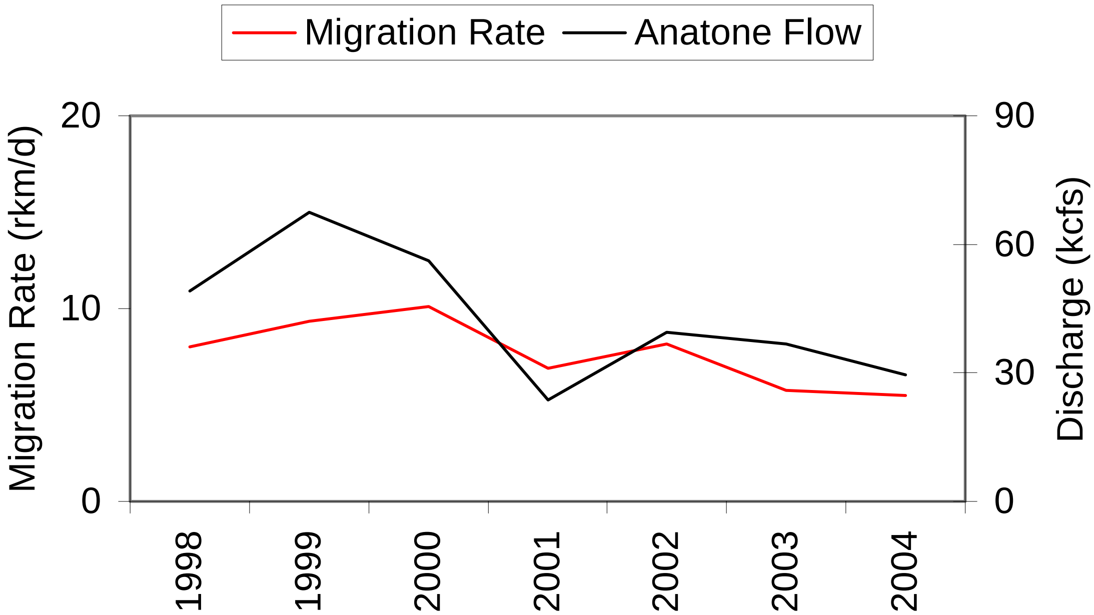

Figure 14.—Yearling migration rate (rkm/d) from Captain John Rapids to Lower Granite Dam versus Snake River flow at Anatone, 1998-2004.

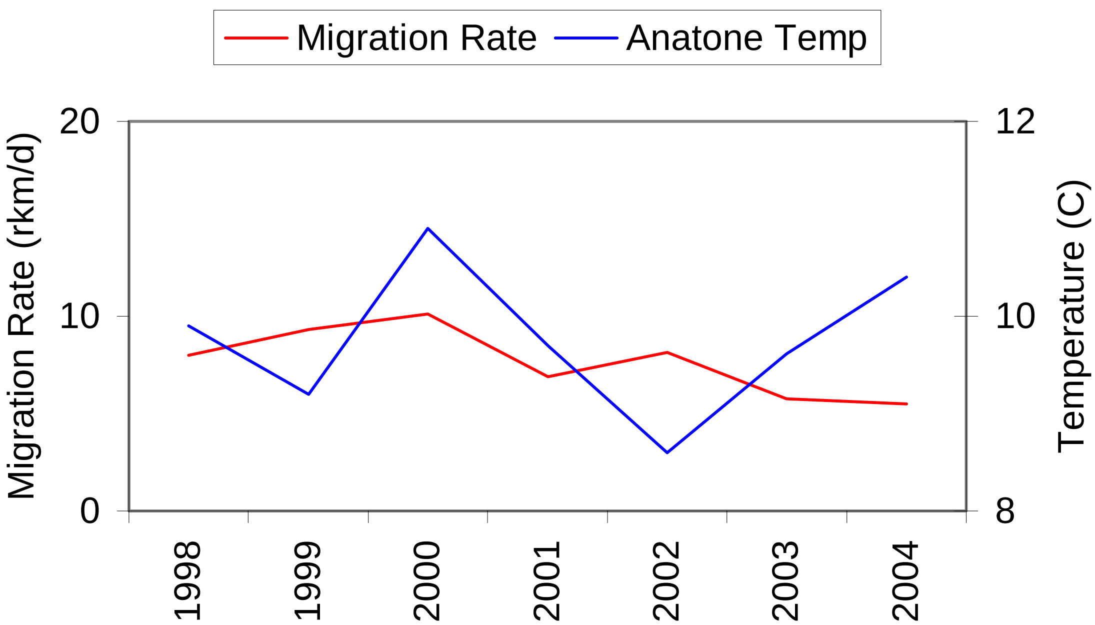

Figure 15.—Yearling migration rate (rkm/d) from Captain John Rapids to Lower Granite Dam versus Snake River temperature at Anatone, 1998-2004.

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 April 1-7, but the first PIT tagged fish from Captain John Rapids was detected at Lower Granite Dam at about 14:00 on April 8. 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 ($P < 0.05$) from each other (Appendix B; Table B.4). These results are not surprising as none of the release dates coincided (Table 3). 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. The one clear pattern that emerged from arrival timing analysis was that the median and 90% passage dates throughout the FCRPS remained fairly consistent with the differential in release dates between the groups. 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.

There was no typical hydrographic peak flow for the Snake River at Hell's Canyon Dam in 2004, so good comparisons to release and arrival timing cannot be done. All FCAP groups achieved 90% passage at Lower Granite Dam about one month before flows peaked at the dam. Yearlings from Pittsburg Landing and Captain John Rapids were released during increasing flows at Anatone, but achieved 90% arrival to Lower Granite Dam just after a subsequent trough in flows at Anatone (Figure 3). Yearlings were released from Big Canyon as flows were steadily increasing and achieved 90% arrival to Lower Granite Dam later during the flow increase (but before the peak flow) at Peck (Figure 4). Yearlings from the FCAP sites achieved 90% arrival to Lower Granite Dam during increasing flow levels, but still nearly a month before peak flows at the dam (Figure 5). Yearlings from the FCAP facilities achieved 90% arrival to McNary Dam during increasing flows and about two weeks before peak flows at the dam (Figure 6).

Table 8.—First Obs arrival date at Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from FCAP facilities in 2004.

Release Group	Interrogation Site	*n*	Mean	Median	90%
Pittsburg Landing	Lower Granite	1,931	4/27	4/26	5/4
	Little Goose	1,292	4/28	4/27	5/4
	Lower Monumental	106	4/29	4/25	5/9
	McNary	83	5/4	5/2	5/11
	John Day	26	5/9	5/7	5/19
	Bonneville	3	5/21	5/12	1/0
Big Canyon	Lower Granite	2,084	4/30	4/29	5/5
	Little Goose	1,064	5/2	5/1	5/8
	Lower Monumental	48	5/7	4/30	5/26
	McNary	59	5/6	5/5	5/13
	John Day	22	5/14	5/12	5/20
	Bonneville	4	5/10	5/10	1/0
Captain John Rapids	Lower Granite	1,571	4/21	4/18	4/30
	Little Goose	1,169	4/25	4/24	5/2
	Lower Monumental	527	4/24	4/23	4/29
	McNary	227	4/30	4/29	5/4
	John Day	52	5/5	5/5	5/10
	Bonneville	11	5/9	5/9	5/11

Table 9.—All Obs arrival date to Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from FCAP facilities in 2004.

Release Group	Interrogation Site	*n*	Mean	Median	90%
Pittsburg Landing	Lower Granite	1,931	4/27	4/26	5/4
	Little Goose	2,634	4/30	4/29	5/6
	Lower Monumental	525	5/3	4/29	5/21
	McNary	654	5/6	5/5	5/13
	John Day	351	5/11	5/10	5/19
	Bonneville	70	5/14	5/11	5/23
Big Canyon	Lower Granite	2,084	4/30	4/29	5/5
	Little Goose	2,443	5/4	5/2	5/10
	Lower Monumental	335	5/12	5/10	5/28
	McNary	497	5/10	5/8	5/18
	John Day	361	5/14	5/13	5/22
	Bonneville	71	5/15	5/13	5/24
Captain John Rapids	Lower Granite	1,571	4/21	4/18	4/30
	Little Goose	1,954	4/26	4/25	5/4
	Lower Monumental	1,055	4/26	4/25	5/2
	McNary	862	5/2	5/1	5/9
	John Day	390	5/8	5/7	5/14
	Bonneville	88	5/8	5/8	5/14

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. 2005. Monitoring and Evaluation of Yearling Fall Chinook Salmon Released from Acclimation Facilities Upstream of Lower Granite Dam: Annual Report 2003, Project No. 1998-01004, In Press.

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 2004. 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 2004.

Facility	Filename
Pittsburg Landing	SJR04096.P09 SJR04097.P07
Big Canyon	SJR04098.B08 SJR04099.B11
Captain John Rapids	SJR04091.CJ1 SJR04092.CJ1

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 2004.

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 2004.

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 2004. 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 2004.

		Tukey's HSD Multiple Comparisons			
	ANOVA	PL	BC	CJ	LFH
Length	$P = 0.0019$	1	2	3	2,3
Condition	$P = 0.0028$	1	2	2	3

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 2004.

	Fork Length			Condition Factor		
	BC	CJ	LFH	BC	CJ	LFH
PL	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$
BC		$P < 0.0001$	$P = 0.0002$		$P = 0.1211$	$P < 0.0001$
CJ			$P = 0.0866$			$P < 0.0001$

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 2004.

			Tukey's HSD Multiple Comparisons		
		ANOVA	PL	BC	CJ
Lower Granite		$P = 0.0080$	1	2	3
McNary	First Obs	$P < 0.0001$	1	2	3
	All Obs	$P = 0.0024$	1	2	3
Bonneville	First Obs	n/a	n/a	n/a	n/a
	All Obs	$P < 0.0001$	1	2	3

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 2004.

	Travel Time			Arrival Date	
	BC	CJ		BC	CJ
PL	$P = 0.0002$	$P < 0.0001$	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 2004.

To McNary Dam					
	1st Obs Travel Time			All Obs Travel Time	
	BC	CJ		BC	CJ
PL	$P = 1.00$	$P < 0.0001$	PL	$P < 0.0001$	$P < 0.0001$
BC		$P < 0.0001$	BC		$P < 0.0001$

To Bonneville Dam					
	1st Obs Travel Time			All Obs Travel Time	
	BC	CJ		BC	CJ
PL	n/a	n/a	PL	$P = 1.00$	$P < 0.0001$
BC		n/a	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 2004.

To McNary Dam

	1st Obs Arrival Date			All Obs Arrival Date	
	BC	CJ		BC	CJ
PL	$P = 0.0124$	$P < 0.0001$	PL	$P < 0.0001$	$P < 0.0001$
BC		$P < 0.0001$	BC		$P < 0.0001$

To Bonneville Dam

	1st Obs Arrival Date			All Obs Arrival Date	
	BC	CJ		BC	CJ
PL	n/a	n/a	PL	$P = 0.0056$	$P < 0.0001$
BC		n/a	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 2004. 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, 1996-2004.

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
	2004	0.7848	0.0092	0.7668	0.8028
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
	2004	0.7470	0.0090	0.7294	0.7646
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
	2004	0.8811	0.0125	0.8566	0.9056

Appendix C (continued).

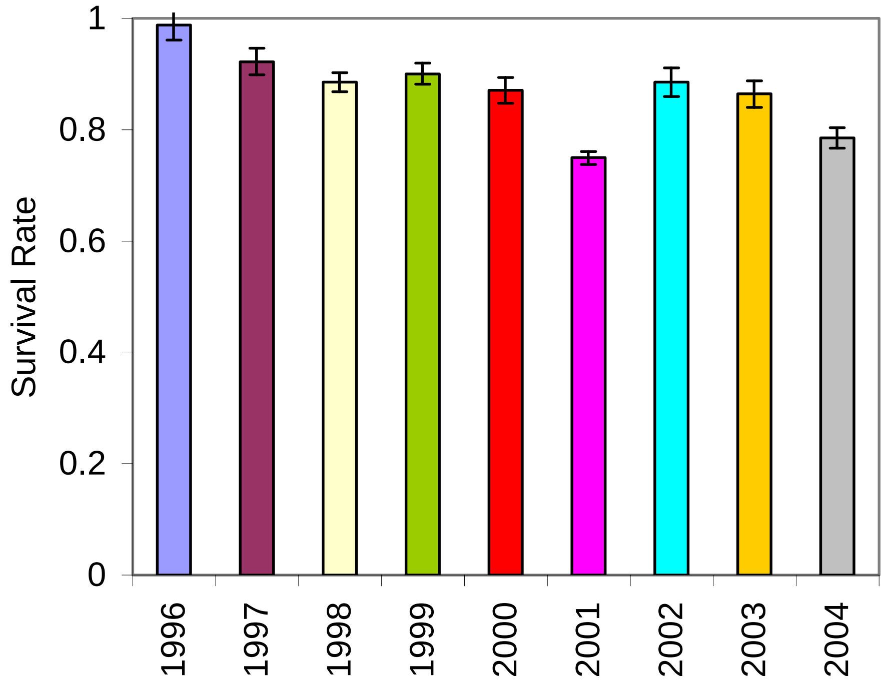

Figure C.1.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to Lower Granite Dam, 1996-2004.

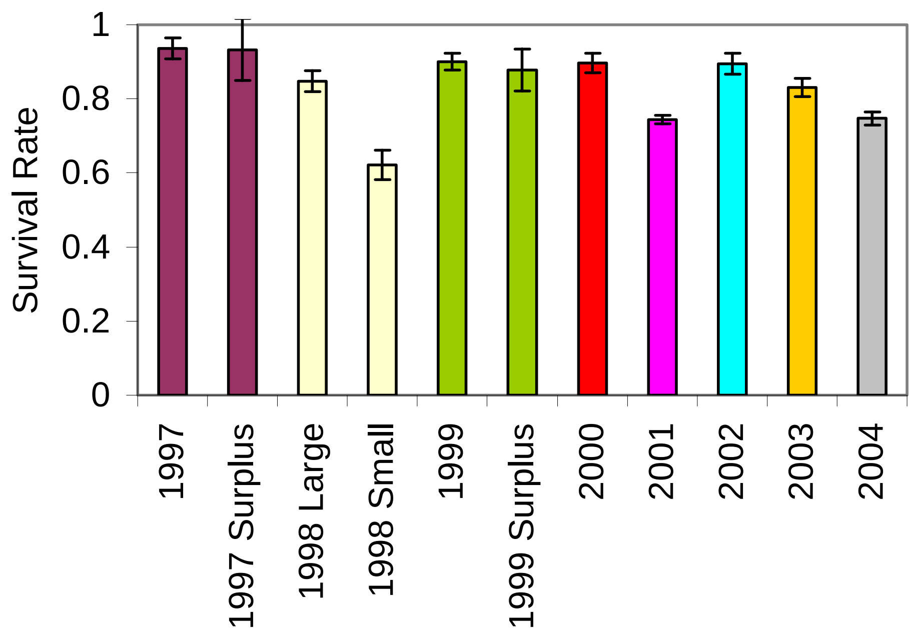

Figure C.2.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to Lower Granite Dam, 1997-2004.

Appendix C (continued).

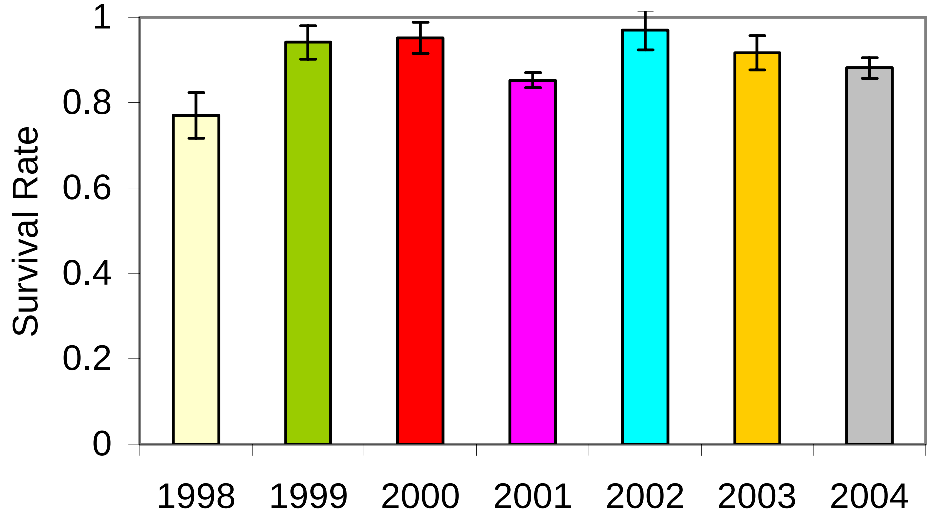

Figure C.3.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to Lower Granite Dam, 1998-2004.

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, 1996-2004.

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
	2004	0.4532	0.0315	0.3915	0.5149
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
	2004	0.5206	0.0467	0.4291	0.6121
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
	2004	0.5075	0.0295	0.4497	0.5653
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).

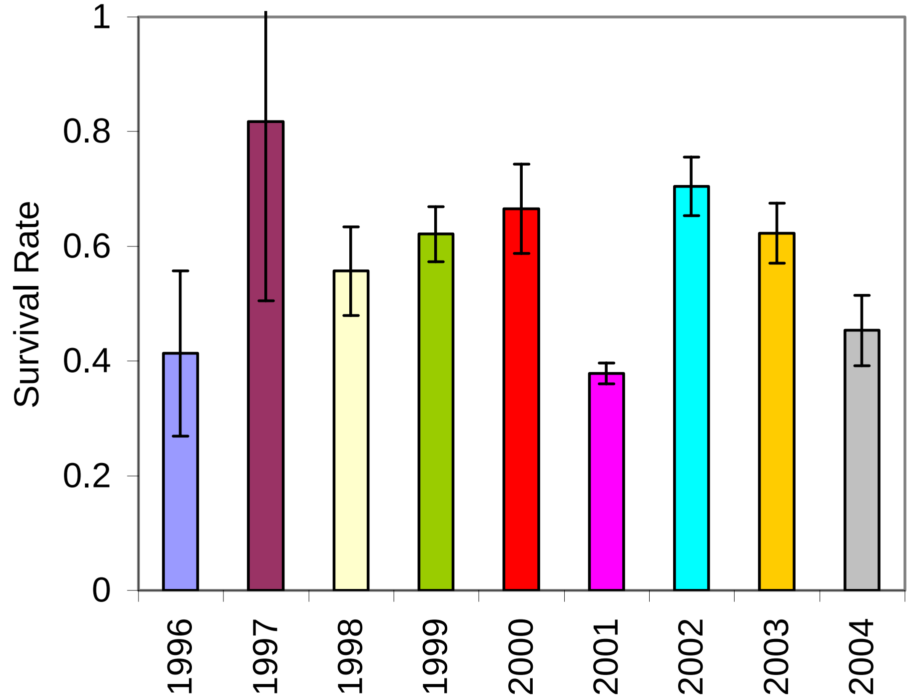

Figure C.4.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to McNary Dam, 1996-2004.

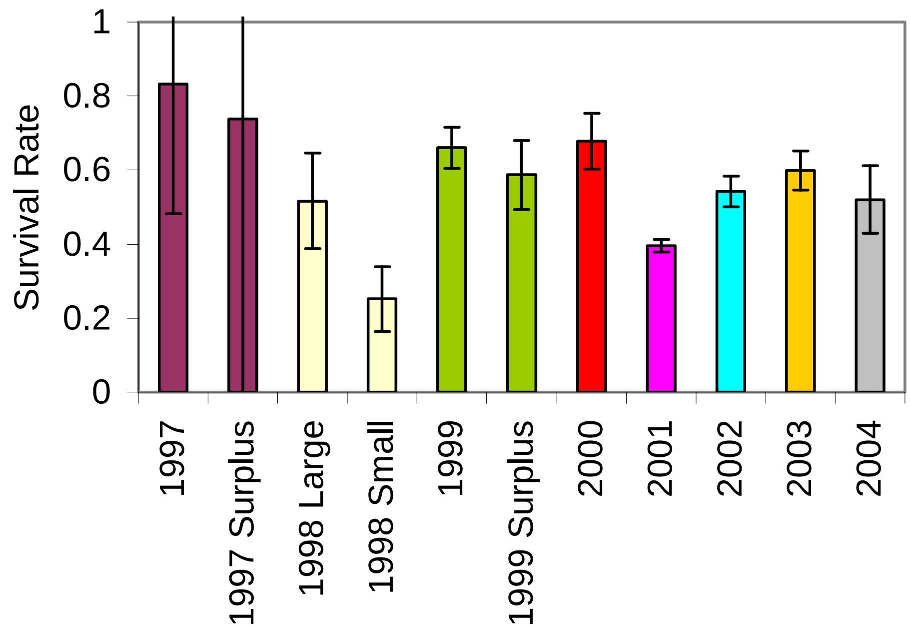

Figure C.5.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to McNary Dam, 1997-2004.

Appendix C (continued).

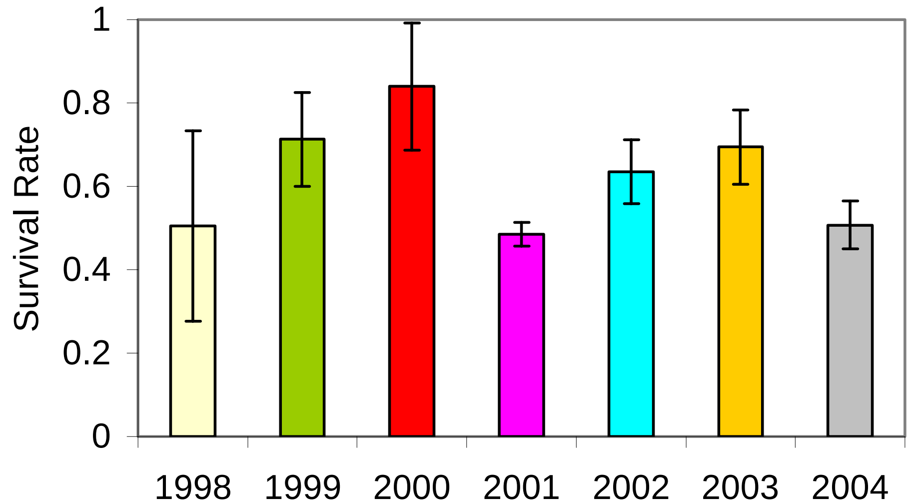

Figure C.6.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to McNary Dam, 1998-2004.

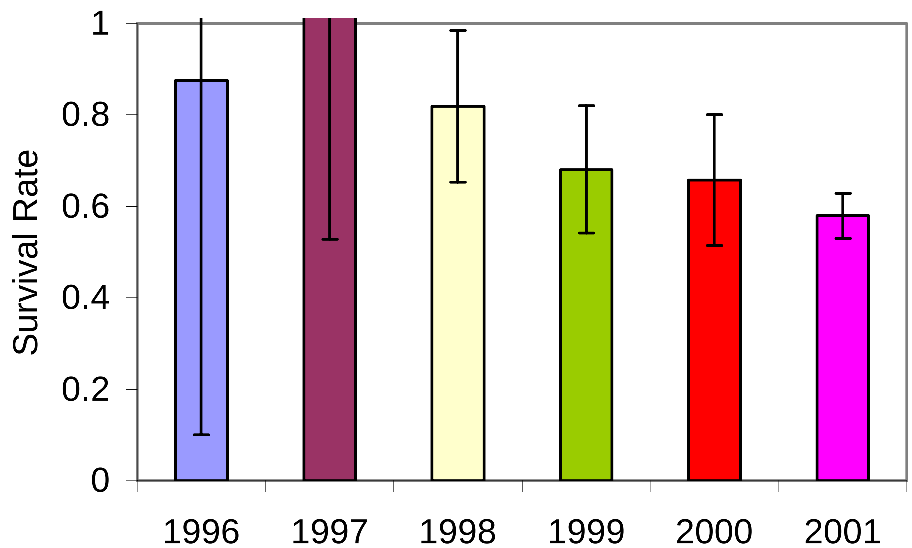

Figure C.6.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Lyons Ferry Hatchery to McNary Dam, 1998-2001.

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 2004.

Table D.1.—First Obs travel time (days) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2004.

Release Group	Interrogation Site	*n*	Mean	Standard Deviation	95% C.I. (+/-)	Median	Range
Pittsburg Landing	Lower Granite	1,931	14.1	5.8	0.3	13.5	3.4 - 59.4
	Little Goose	1,292	15.4	5.5	0.3	14.0	6.9 - 67.1
	Lower Monumental	106	16.3	13.4	1.9	13.4	9.4 - 69.9
	McNary	83	21.4	6.0	1.3	19.9	12.8 - 51.7
	John Day	26	26.8	6.6	2.7	24.2	20.2 - 45.6
	Bonneville	3	39.0	15.3	38.1	30.5	29.8 - 56.7
Big Canyon	Lower Granite	2,084	15.0	6.7	0.3	14.3	3.4 - 63.0
	Little Goose	1,064	17.4	6.6	0.4	16.6	6.9 - 69.1
	Lower Monumental	48	22.0	16.0	3.5	16.0	7.8 - 48.5
	McNary	59	21.9	6.0	1.6	20.9	12.9 - 44.3
	John Day	22	28.9	6.0	2.7	27.5	21.1 - 42.7
	Bonneville	4	25.2	1.4	2.2	25.2	23.8 - 26.8
Captain John Rapids	Lower Granite	1,571	18.6	6.7	0.3	16.3	6.0 - 49.9
	Little Goose	1,169	22.7	5.0	0.3	22.0	12.3 - 53.4
	Lower Monumental	527	22.2	21.4	0.4	21.4	14.2 - 51.4
	McNary	227	27.7	3.8	0.5	27.1	18.0 - 44.9
	John Day	52	33.1	5.5	1.5	32.7	22.0 - 49.0
	Bonneville	11	36.7	4.1	2.7	37.4	30.1 - 45.5

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 2004.

Release Group	Interrogation Site	*n*	Mean	Standard Deviation	95% C.I. (+/-)	Median	Range
Pittsburg Landing	Lower Granite	1,931	14.1	5.8	0.3	13.5	3.4 - 59.4
	Little Goose	2,634	17.3	5.9	0.2	16.2	6.9 - 67.1
	Lower Monumental	525	20.8	16.4	0.9	16.4	9.0 - 69.9
	McNary	654	23.8	6.7	0.5	22.6	12.8 - 72.4
	John Day	351	28.8	7.2	0.8	27.2	18.2 - 75.4
	Bonneville	70	31.2	6.7	1.6	29.2	22.2 - 56.7
Big Canyon	Lower Granite	2,084	15.0	6.7	0.3	14.3	3.4 - 63.0
	Little Goose	2,443	19.1	6.8	0.3	18.0	6.9 - 69.1
	Lower Monumental	335	27.5	25.5	1.2	25.5	7.8 - 54.1
	McNary	497	25.2	7.3	0.6	23.9	12.9 - 56.4
	John Day	361	29.6	6.7	0.7	28.6	17.2 - 53.3
	Bonneville	71	30.7	6.4	1.5	29.1	20.0 - 50.7
Captain John Rapids	Lower Granite	1,571	18.6	6.7	0.3	16.3	6.0 - 49.9
	Little Goose	1,954	24.4	5.8	0.3	23.4	12.1 - 62.4
	Lower Monumental	1,055	24.1	22.5	0.4	22.5	14.2 - 54.8
	McNary	862	29.9	5.5	0.4	28.9	17.7 - 67.7
	John Day	390	35.6	5.9	0.6	34.5	21.0 - 63.4
	Bonneville	88	36.4	5.3	1.1	36.0	26.4 - 59.7

Table D.3.—First Obs migration rate (rkm/d) of FCAP yearling fall Chinook salmon to Lower Snake and Columbia River dams in 2004.

Release Group	Interrogation Site	*n*	Mean	Median	Range
Pittsburg Landing	Lower Granite	1,931	12.3	12.8	2.9 - 51.1
	Little Goose	1,292	15.1	16.7	3.5 - 34.0
	Lower Monumental	106	17.1	20.8	4.0 - 29.7
	McNary	83	18.6	20.0	7.7 - 31.1
	John Day	26	19.5	21.5	11.4 - 25.7
	Bonneville	3	16.3	20.8	11.2 - 21.2
Big Canyon	Lower Granite	2,084	7.2	7.5	1.7 - 31.8
	Little Goose	1,064	9.7	10.1	2.4 - 24.2
	Lower Monumental	48	9.7	13.4	4.4 - 27.4
	McNary	59	15.2	15.9	7.5 - 25.7
	John Day	22	15.8	16.6	10.7 - 21.6
	Bonneville	4	22.5	22.6	21.2 - 23.9
Captain John Rapids	Lower Granite	1,571	4.8	5.5	1.8 - 14.9
	Little Goose	1,169	6.6	6.8	2.8 - 12.2
	Lower Monumental	527	8.8	9.1	3.8 - 13.8
	McNary	227	11.4	11.6	7.0 - 17.5
	John Day	52	13.2	13.4	8.9 - 19.9
	Bonneville	11	15.0	14.7	12.1 - 18.3

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 2004.

Release Group	Interrogation Site	*n*	Mean	Median	Range
Pittsburg Landing	Lower Granite	1,931	12.3	12.8	2.9 - 51.1
	Little Goose	2,634	13.4	14.3	3.5 - 34.0
	Lower Monumental	525	13.4	17.0	4.0 - 30.9
	McNary	654	16.7	17.6	5.5 - 31.1
	John Day	351	18.1	19.2	6.9 - 28.5
	Bonneville	70	20.3	21.7	11.2 - 28.5
Big Canyon	Lower Granite	2,084	7.2	7.5	1.7 - 31.8
	Little Goose	2,443	8.8	9.3	2.4 - 24.2
	Lower Monumental	335	7.8	8.4	4.0 - 27.4
	McNary	497	13.2	13.9	5.9 - 25.7
	John Day	361	15.4	15.9	8.6 - 26.5
	Bonneville	71	18.5	19.6	11.2 - 28.5
Captain John Rapids	Lower Granite	1,571	4.8	5.5	1.8 - 14.9
	Little Goose	1,954	6.2	6.4	2.4 - 12.4
	Lower Monumental	1,055	8.1	8.7	3.6 - 13.8
	McNary	862	10.5	10.9	4.7 - 17.8
	John Day	390	12.3	12.7	6.9 - 20.8
	Bonneville	88	15.1	15.3	9.2 - 20.9

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 2004.

BASED ON FIRST OBS - Individual release groups at multiple dams

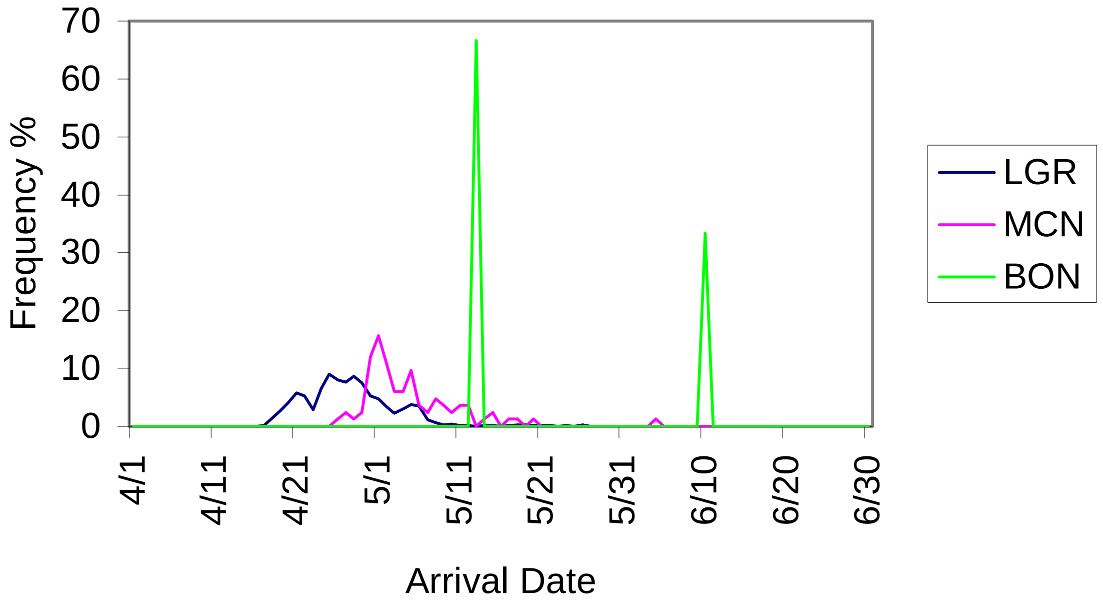

Figure E.1.—First obs arrival date frequency distribution of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2004.

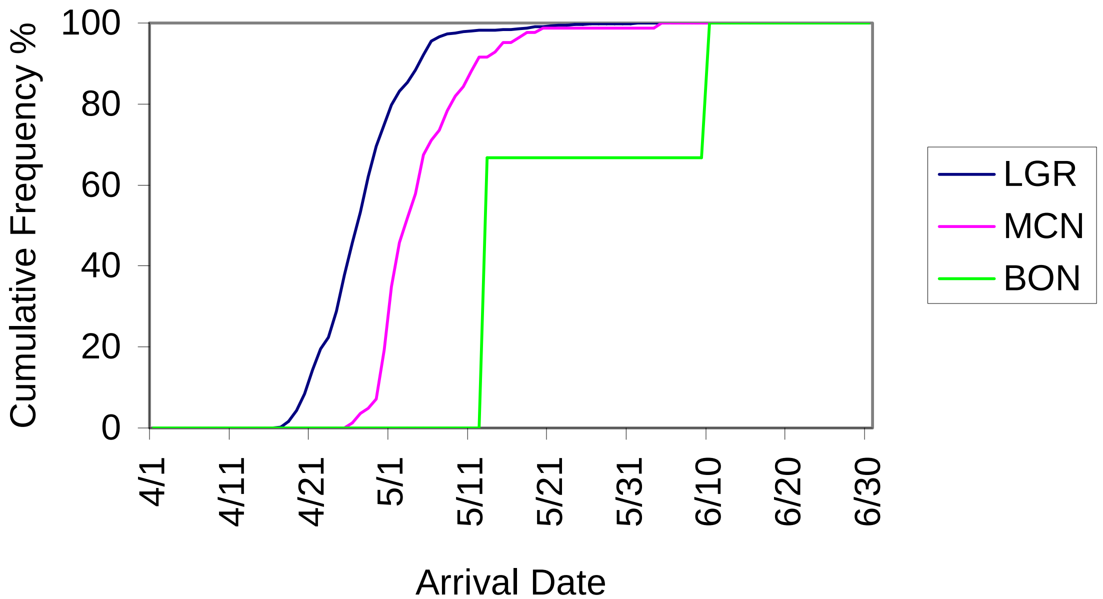

Figure E.2.—First obs arrival date cumulative frequency of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2004.

Appendix E (continued).

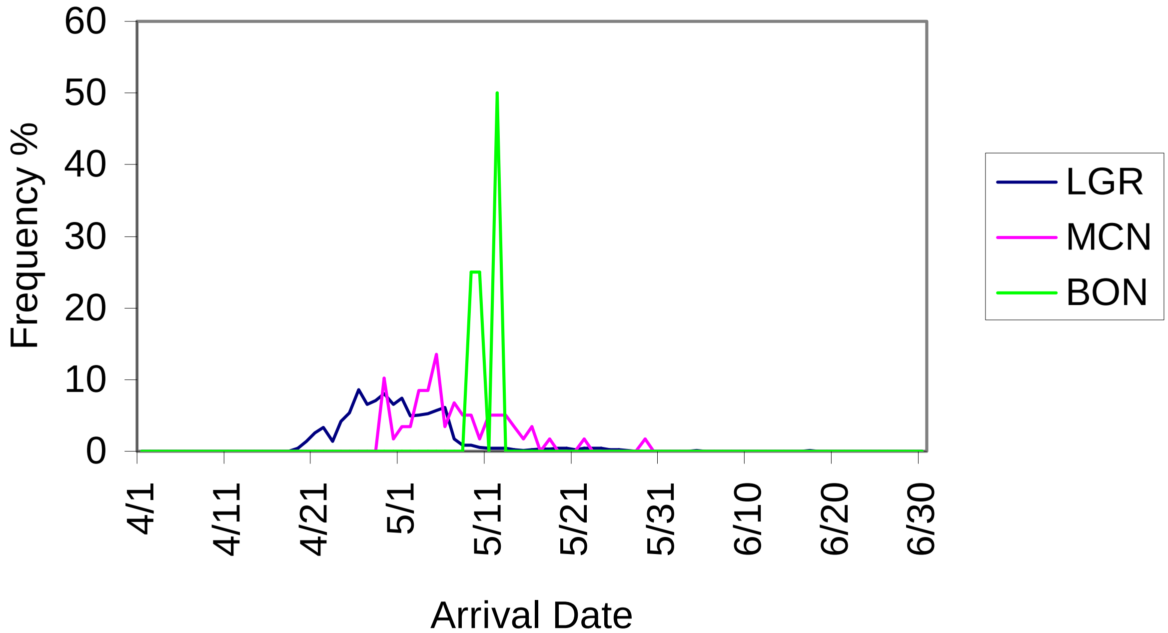

Figure E.3.—First obs arrival date frequency distribution of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2004.

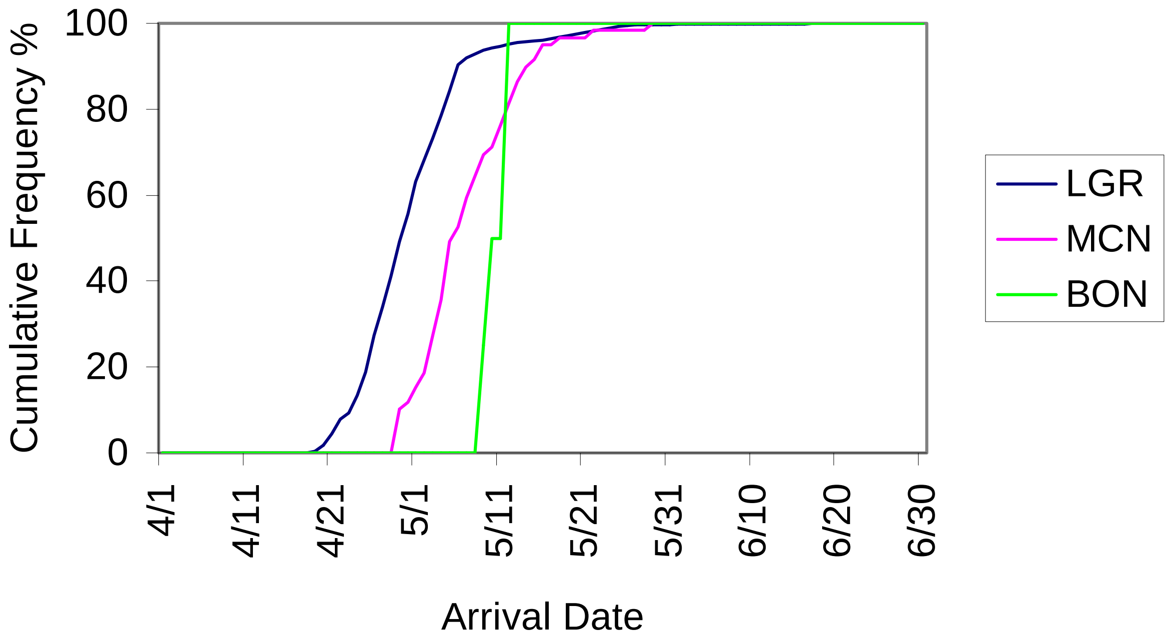

Figure E.4.—First obs arrival date cumulative frequency of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2004.

Appendix E (continued).

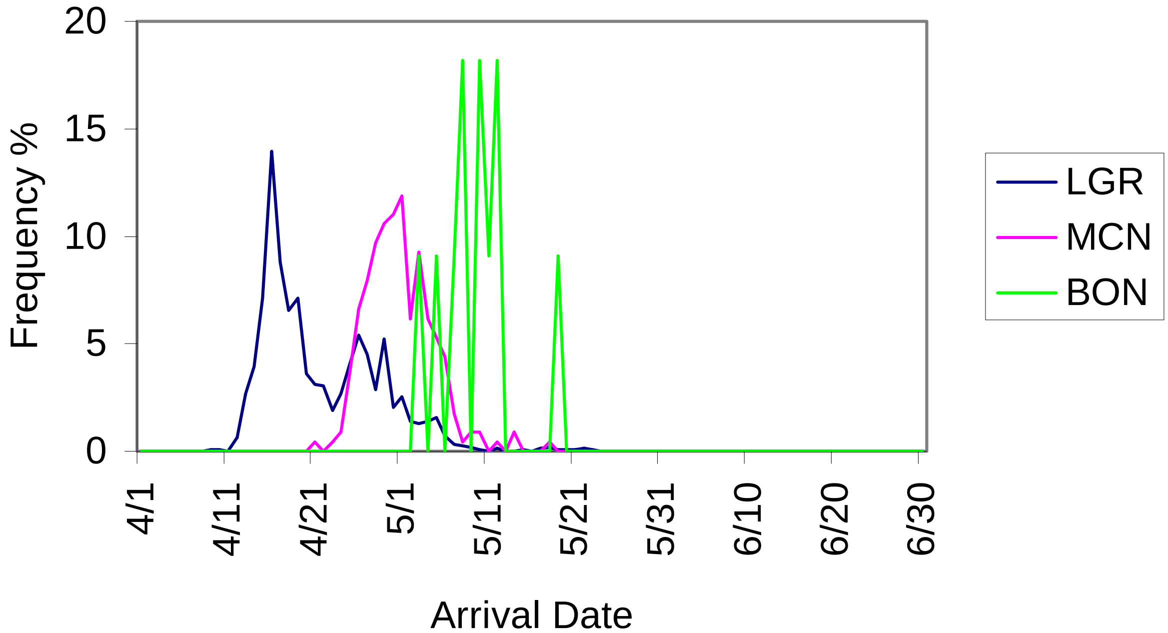

Figure E.5.—First obs arrival date frequency distribution of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2004.

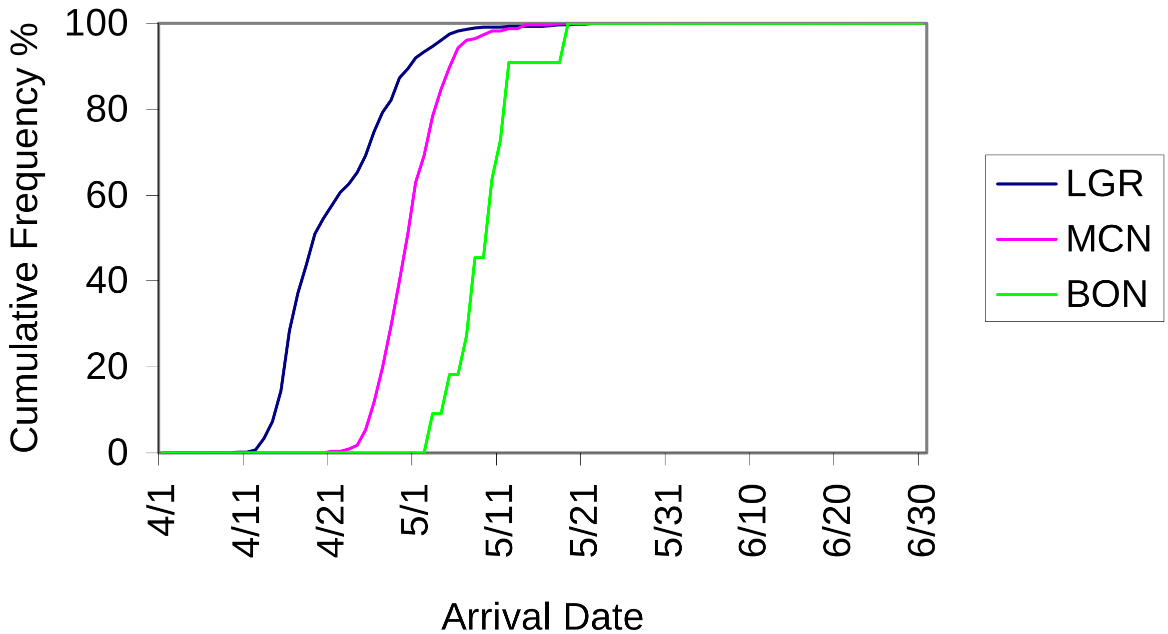

Figure E.6.—First obs arrival date cumulative frequency of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2004.

Appendix E (continued).

BASED ON FIRST OBS - Multiple release groups at individual dams

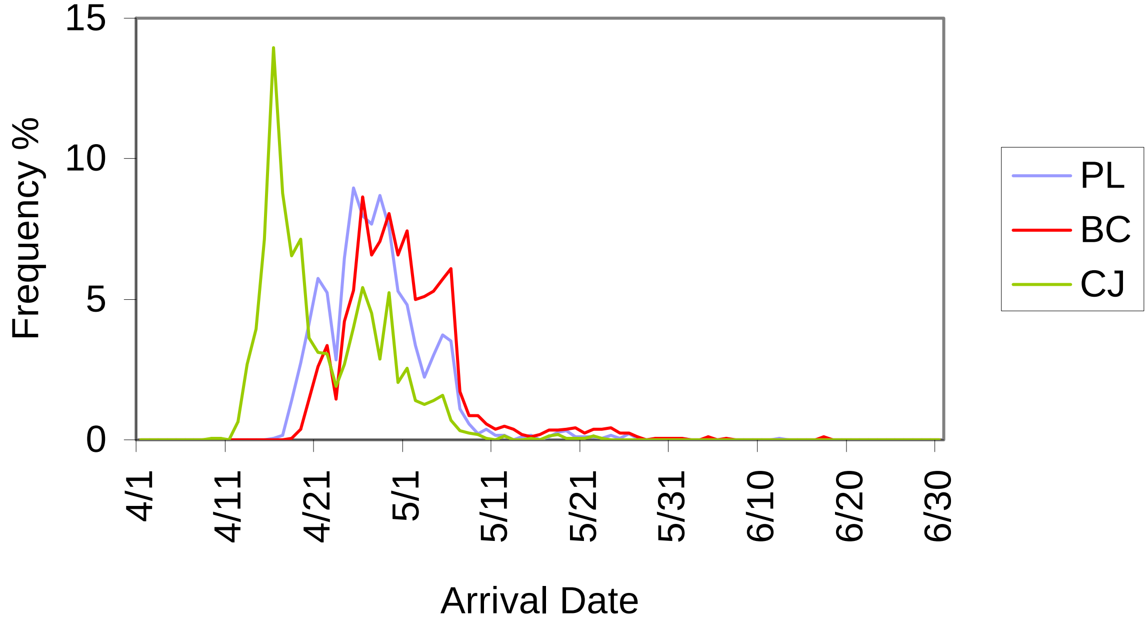

Figure E.7.—First obs arrival date frequency distribution of FCAP yearlings at Lower Granite Dam in 2004.

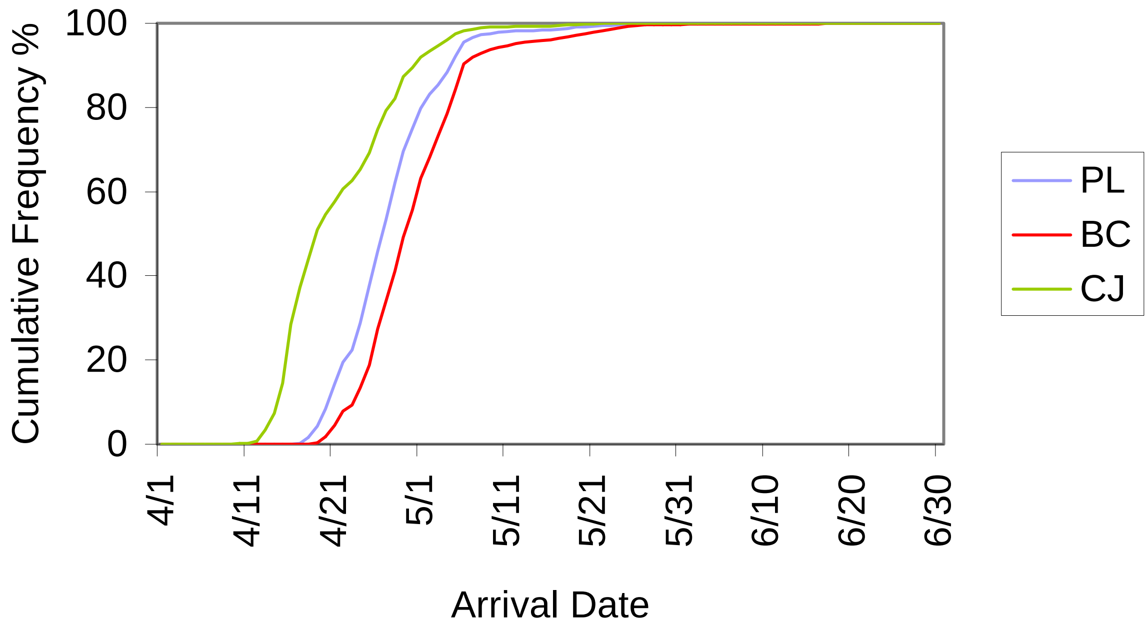

Figure E.8.—First obs arrival date cumulative frequency of FCAP yearlings at Lower Granite Dam in 2004.

Appendix E (continued).

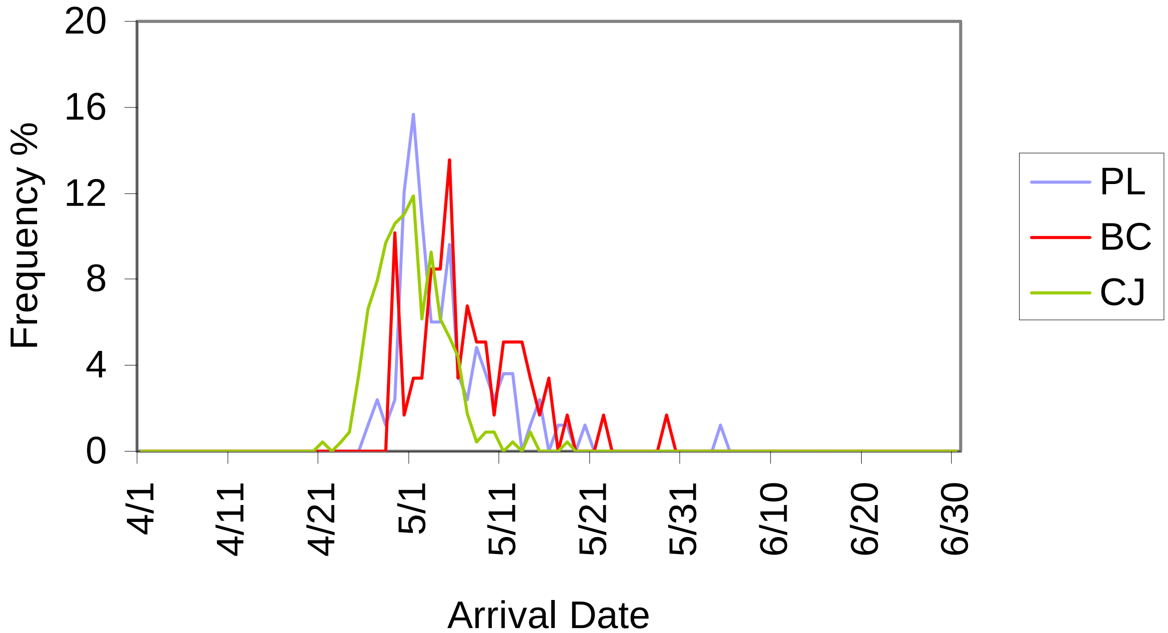

Figure E.9.—First obs arrival date frequency distribution of FCAP yearlings at McNary Dam in 2004.

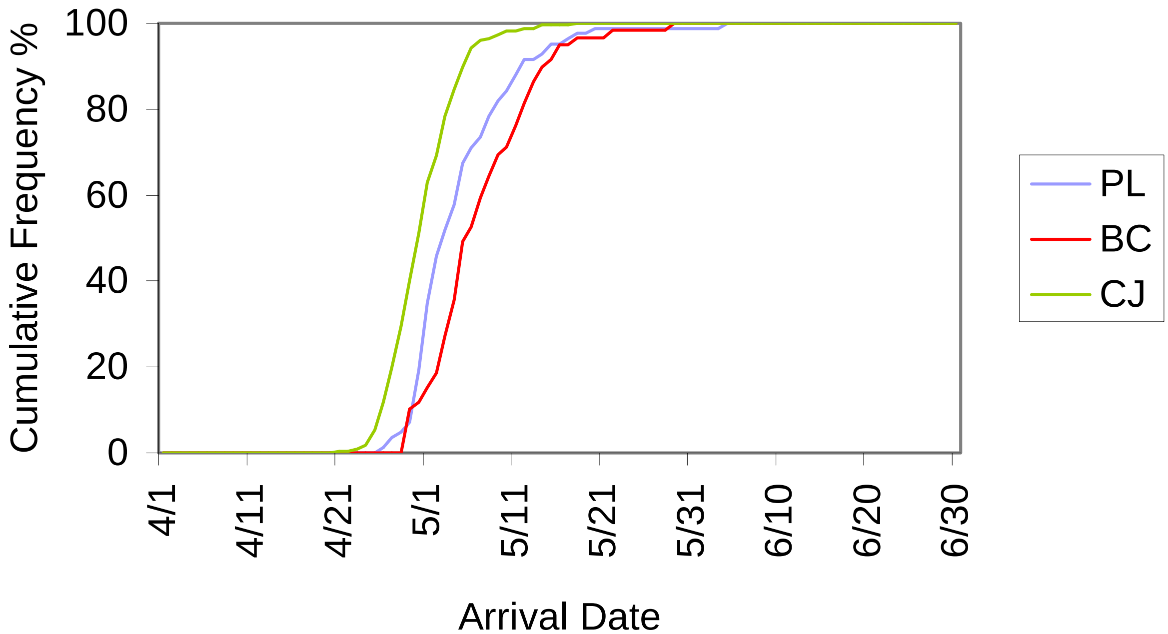

Figure E.10.—First obs arrival date cumulative frequency of FCAP yearlings at McNary Dam in 2004.

Appendix E (continued).

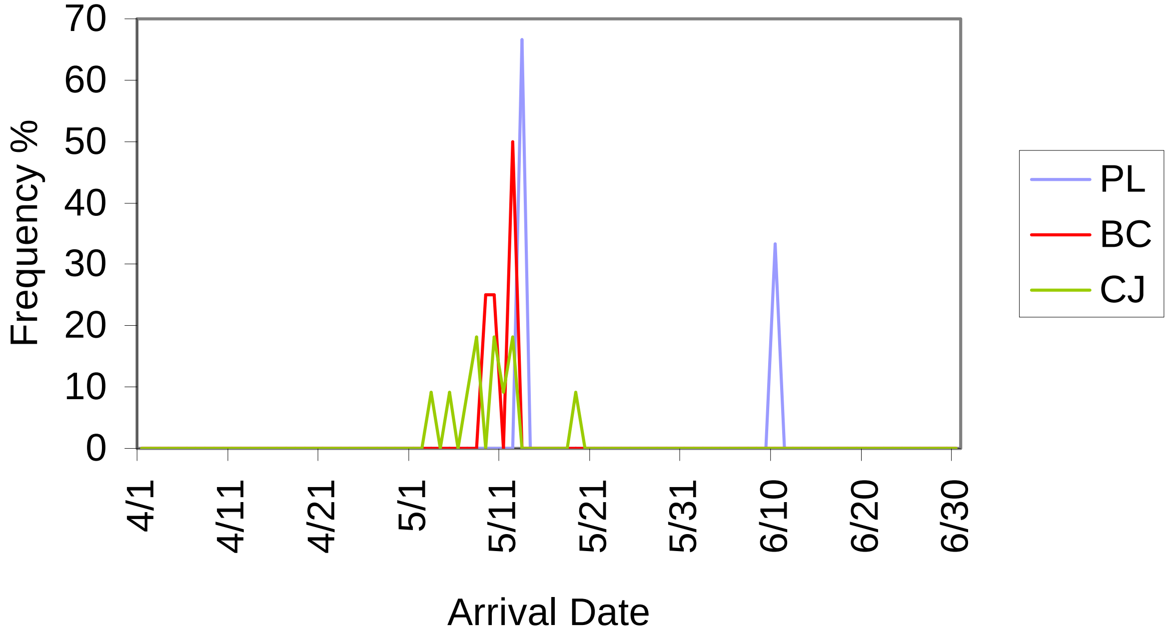

Figure E.11.—First obs arrival date frequency distribution of FCAP yearlings at Bonneville Dam in 2004.

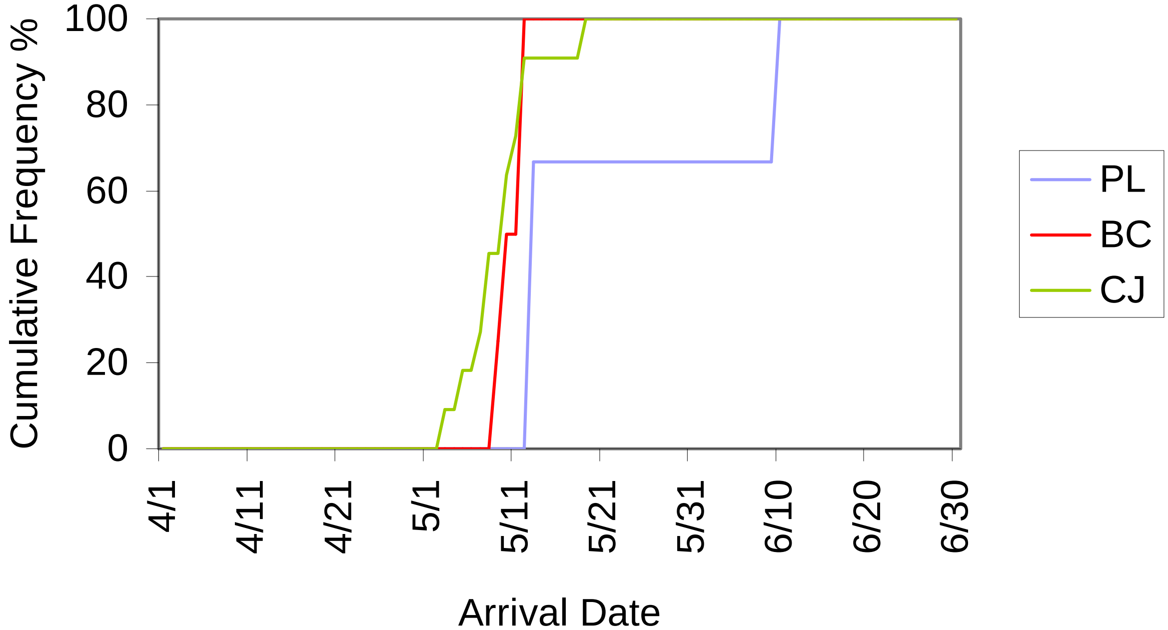

Figure E.12.—First obs arrival date cumulative frequency of FCAP yearlings at Bonneville Dam in 2004.

Appendix E (continued).

BASED ON ALL OBS - Individual release groups at multiple dams

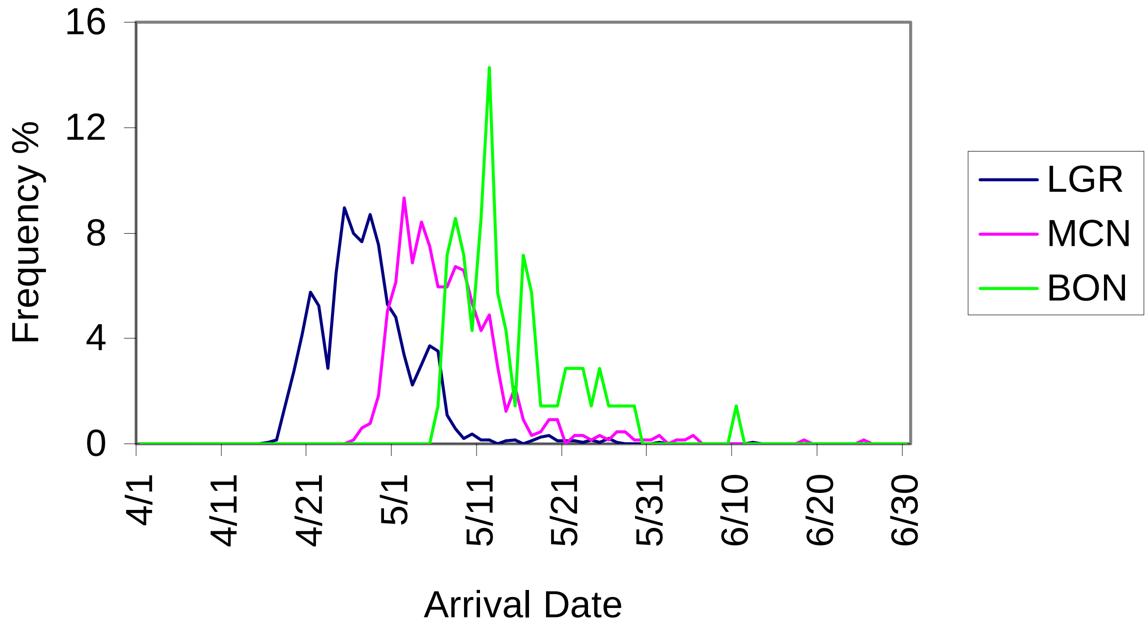

Figure E.13.—All obs arrival date frequency distribution of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2004.

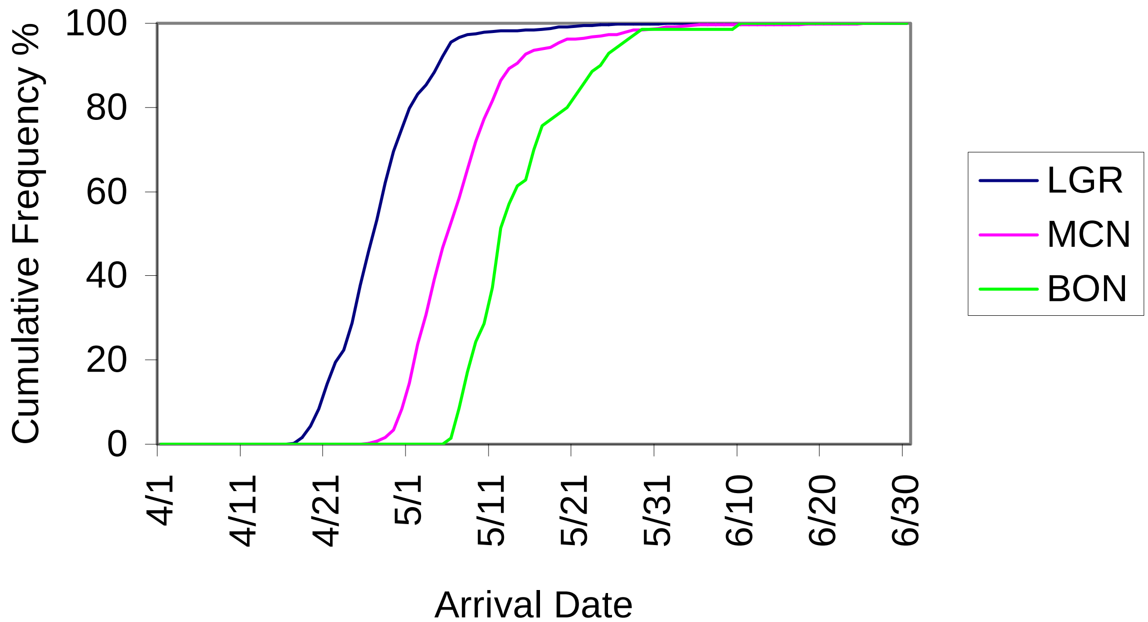

Figure E.14.—All obs arrival date cumulative frequency of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2004.

Appendix E (continued).

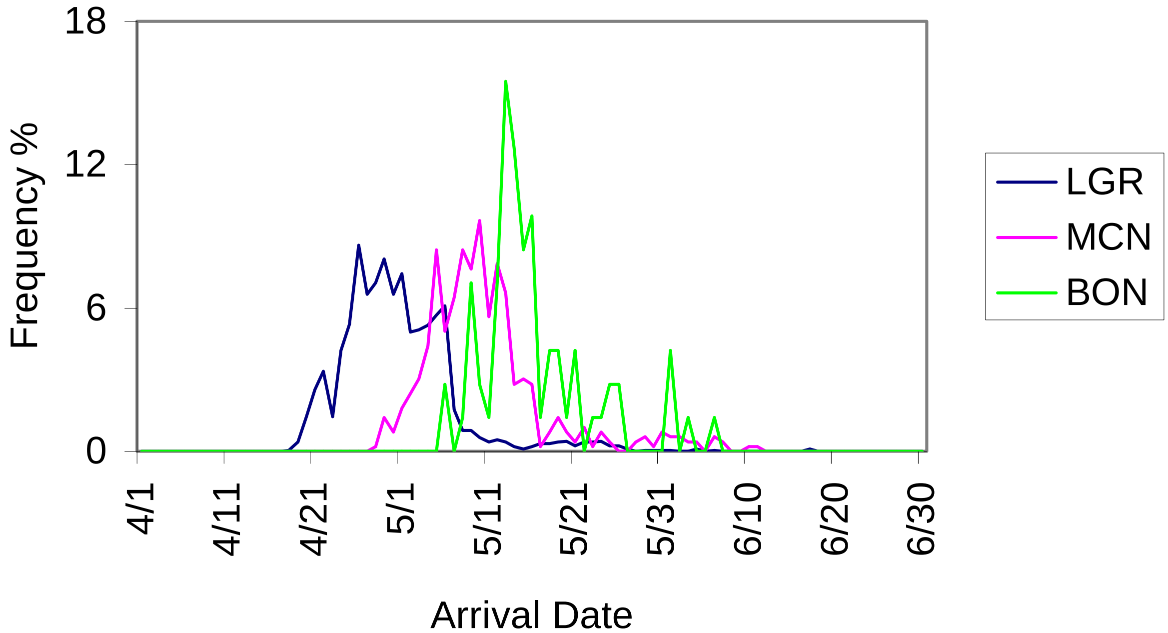

Figure E.15.—All obs arrival date frequency distribution of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2004.

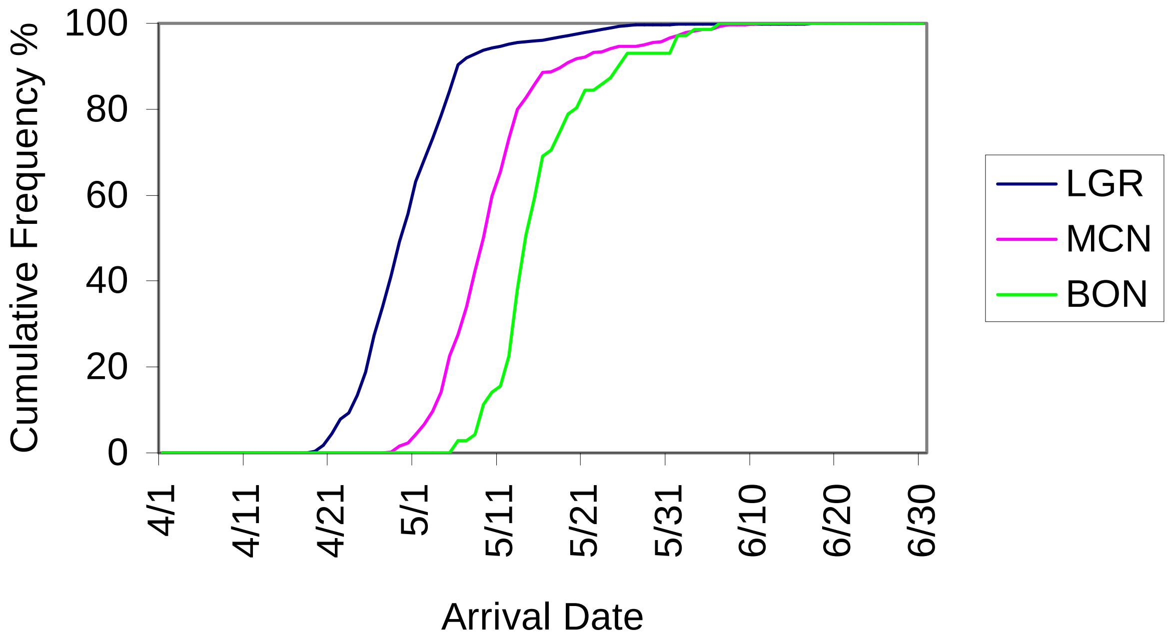

Figure E.16.—All obs arrival date cumulative frequency of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2004.

Appendix E (continued).

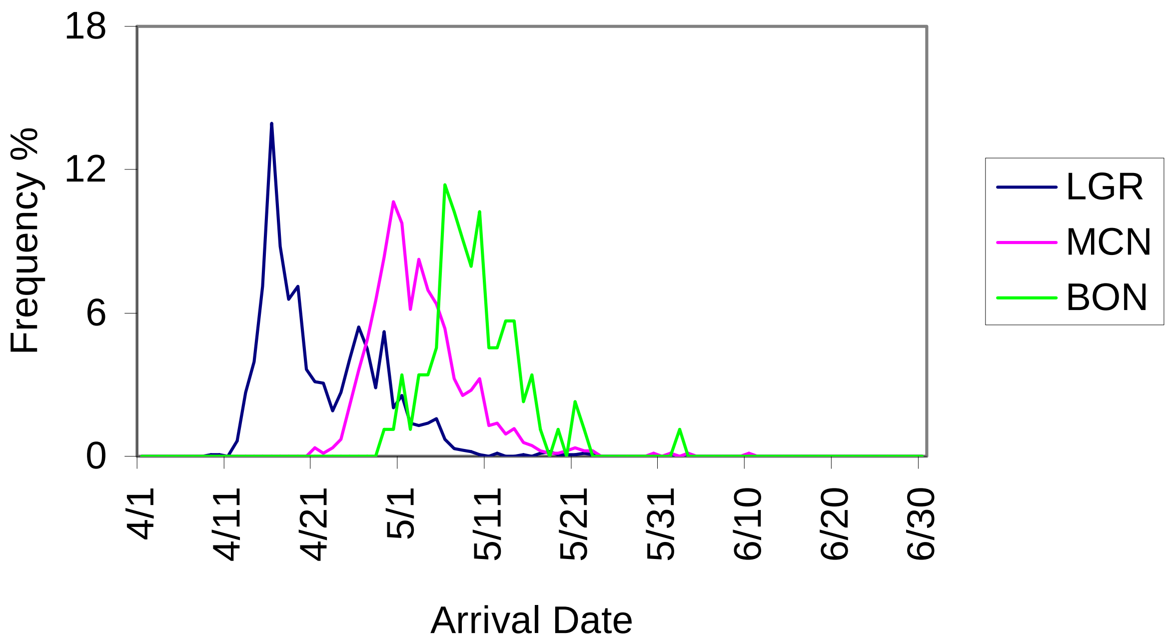

Figure E.17.—All obs arrival date frequency distribution of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2004.

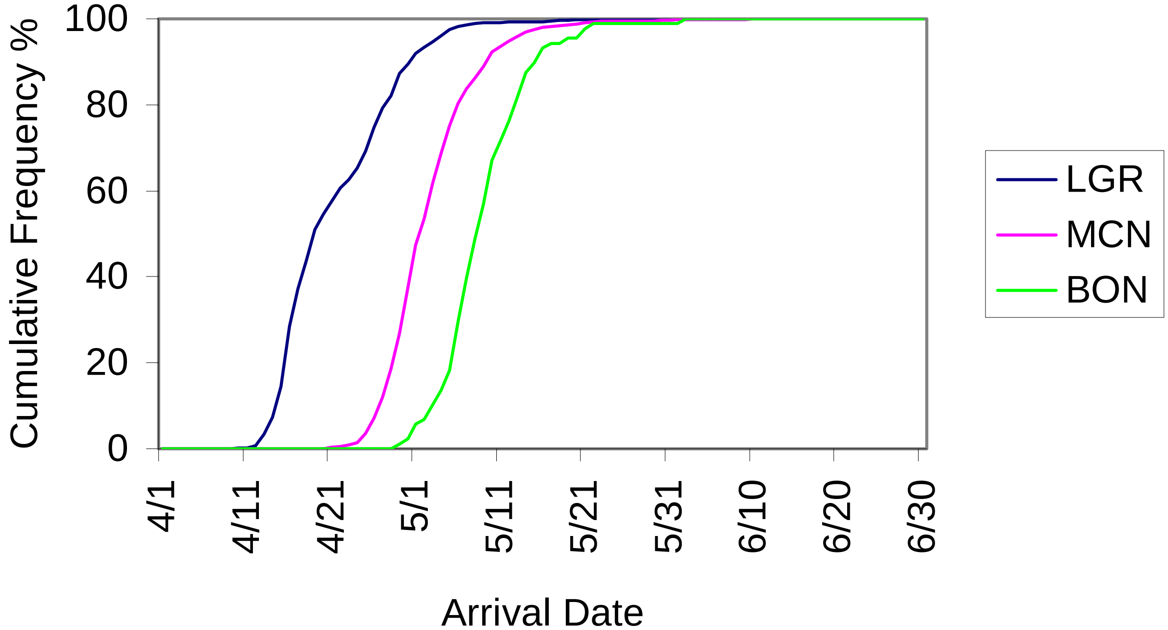

Figure E.18.—All obs arrival date cumulative frequency of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2004.

Appendix E (continued).

BASED ON ALL OBS - Multiple release groups at individual dams

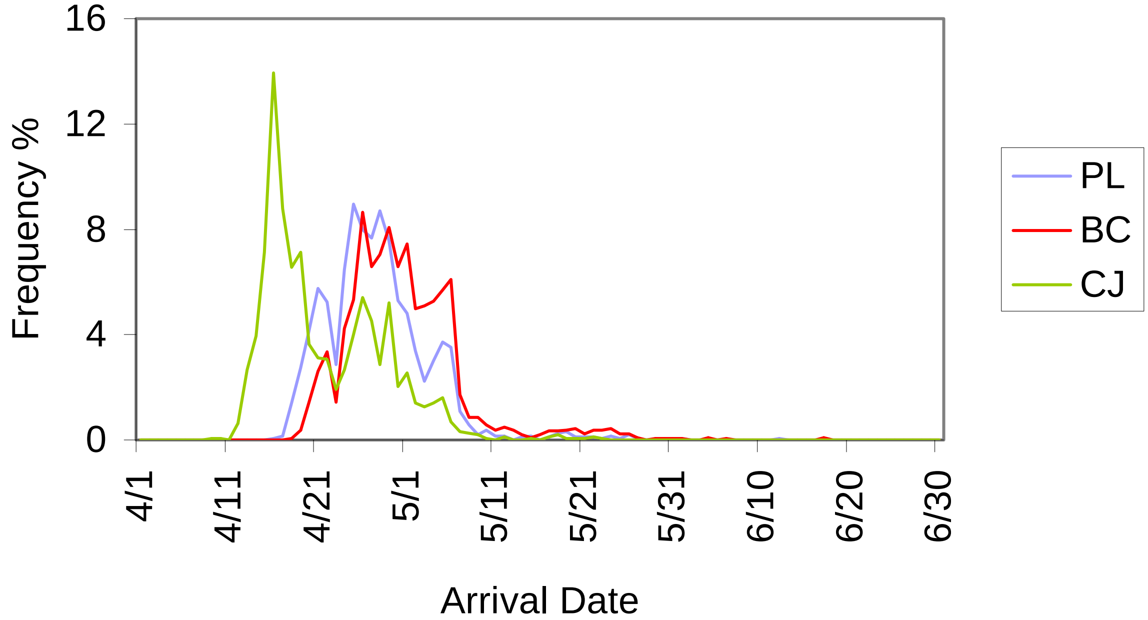

Figure E.19.—All obs arrival date frequency distribution of FCAP yearlings at Lower Granite Dam in 2004.

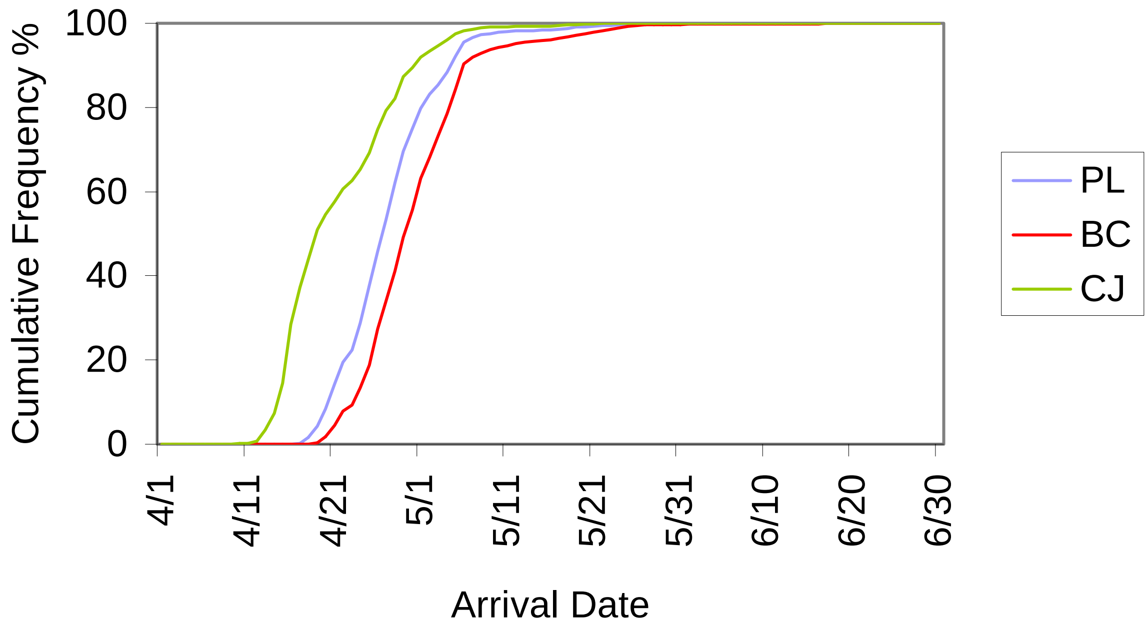

Figure E.20.—All obs arrival date cumulative frequency of FCAP yearlings at Lower Granite Dam in 2004.

Appendix E (continued).

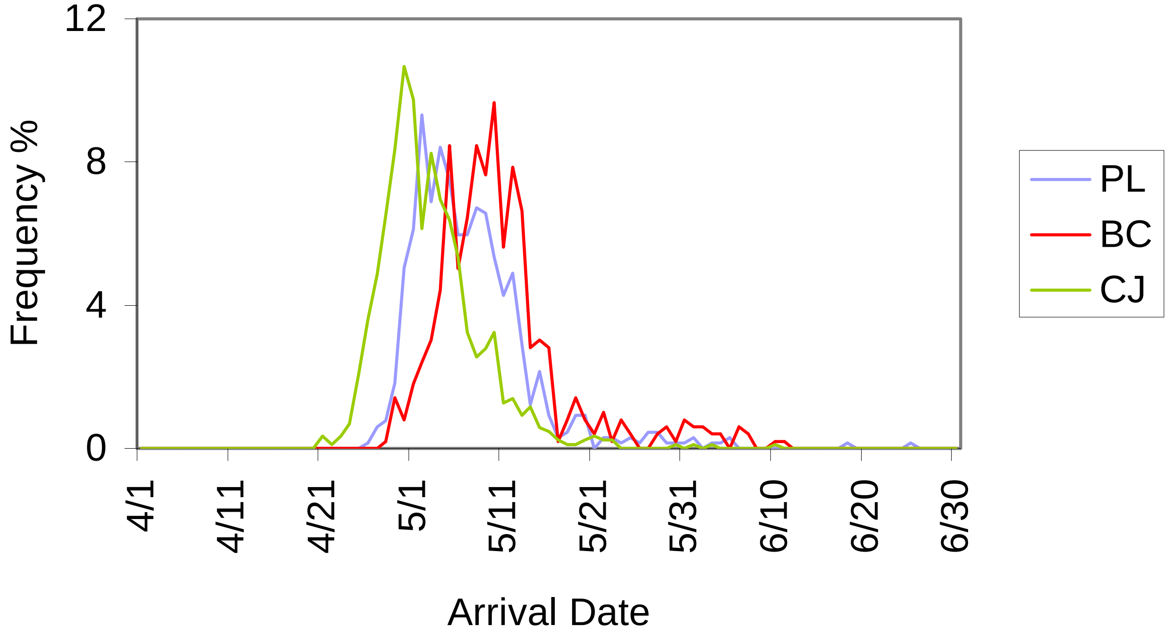

Figure E.21.—All obs arrival date frequency distribution of FCAP yearlings at McNary Dam in 2004.

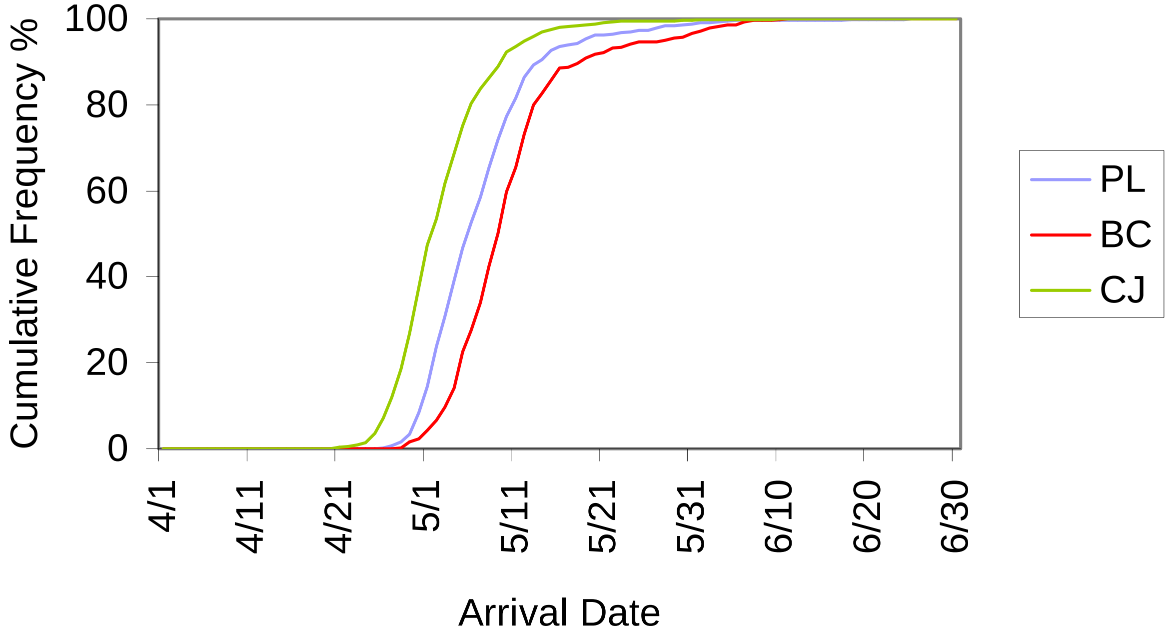

Figure E.22.—All obs arrival date cumulative frequency of FCAP yearlings at McNary Dam in 2004.

Appendix E (continued).

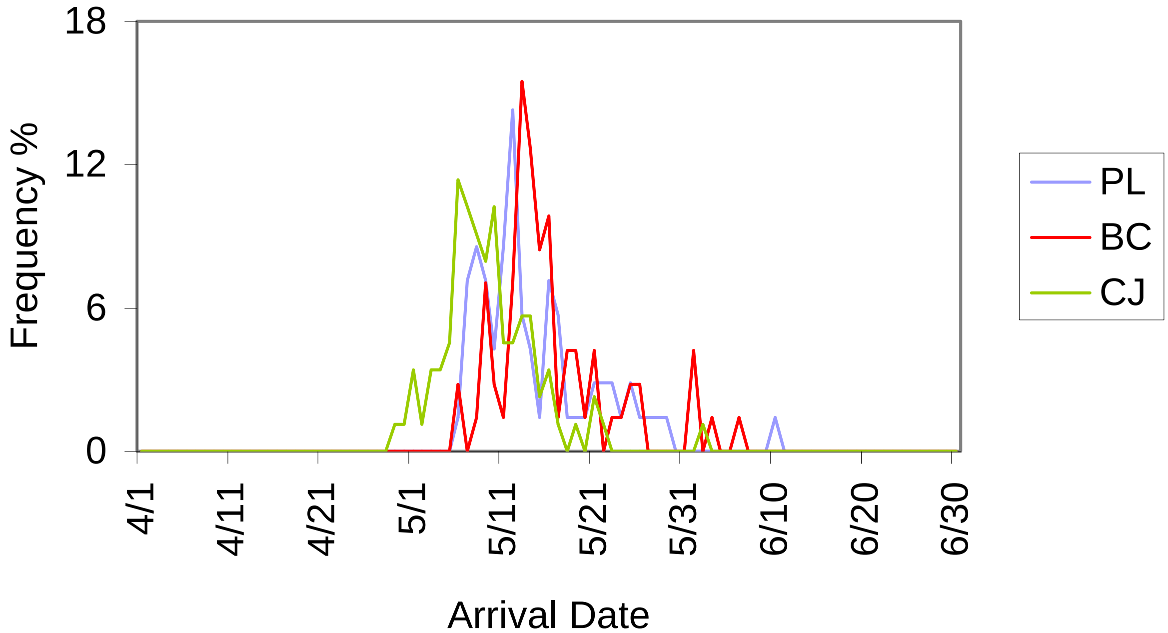

Figure E.23.—All obs arrival date frequency distribution of FCAP yearlings at Bonneville Dam in 2004.

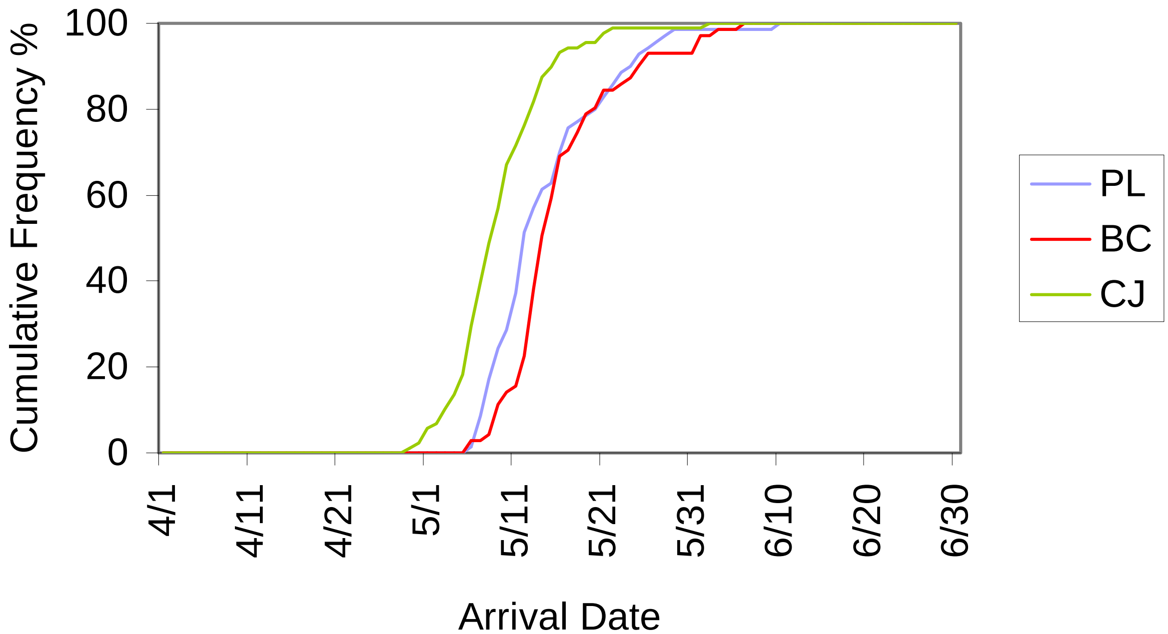

Figure E.24.—All obs arrival date cumulative frequency of FCAP yearlings at Bonneville Dam in 2004.