BONNEVILLE POWER ADMINISTRATION

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 2001 – December 2001

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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 sites upstream of Lower Granite Dam along with yearlings released on-station from Lyons Ferry Hatchery in 2001. This was the sixth year of a long-term project to supplement natural spawning populations of Snake River stock fall Chinook salmon upstream of Lower Granite Dam. The 318,932 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 7,503 PIT tagged yearlings from Pittsburg Landing, 7,499 from Big Canyon and 2,518 from Captain John Rapids. The Washington Department of Fish and Wildlife released 991 PIT tagged yearlings from Lyons Ferry Hatchery. Fish health sampling indicated that, overall, bacterial kidney disease levels could be considered relatively low. Compared to prior years, Quantitative Health Assessment Indices were relatively low at Big Canyon and Captain John Rapids and about average at Pittsburg Landing and Lyons Ferry Hatchery.

Mean fork lengths (95% confidence interval) of the PIT tagged groups ranged from 155.4 mm (154.7-156.1 mm) at Captain John Rapids to 171.6 mm (170.7-172.5 mm) at Lyons Ferry Hatchery. Mean condition factors ranged from 1.02 at Lyons Ferry Hatchery to 1.16 at Big Canyon and Captain John Rapids.

Estimated survival (95% confidence interval) of PIT tagged yearlings from release to Lower Granite Dam ranged from 74.4% (73.2-75.5%) for Big Canyon to 85.2% (83.5-87.0%) for Captain John Rapids. Estimated survival from release to McNary Dam ranged from 37.9% (36.0-40.0%) for Pittsburg Landing to 57.9% (53.0-62.8%) for Lyons Ferry Hatchery.

Median migration rates to Lower Granite Dam, based on all observations of PIT tagged yearlings from the FCAP facilities, ranged from 6.3 river kilometers per day (rkm/d) for Big Canyon to 10.8 rkm/d for Pittsburg Landing. Median migration rates to McNary Dam ranged from 5.2 rkm/d for Lyons Ferry Hatchery to 10.9 rkm/d for Pittsburg Landing. Median travel times from the FCAP facilities were about 13-17 days to Lower Granite Dam and 31-37 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, were all from April 26-27. Median arrival dates at McNary Dam for Pittsburg Landing, Big Canyon and Captain John Rapids groups were all from May 14-18. The median arrival date at McNary Dam was May 13 for Lyons Ferry Hatchery yearlings.

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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 and LFH in 2001. This was the sixth 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 2001. We are in the fifth year of a radio telemetry study to monitor yearling fall Chinook salmon post-release movement patterns. In addition, we assist the USFWS in monitoring adult fall Chinook salmon migration and spawning distribution, which is conducted and reported by the USFWS under Bonneville Power Administration (BPA) Project number 199801003. Results of this study have also been published in the North American Journal of Fisheries Management (Garcia et al. 2004). For a detailed discussion of monitoring and evaluation activities, procedures and analyses for on-station yearling fall Chinook salmon releases from LFH in 2001 please reference Milks et al. (2005).

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.

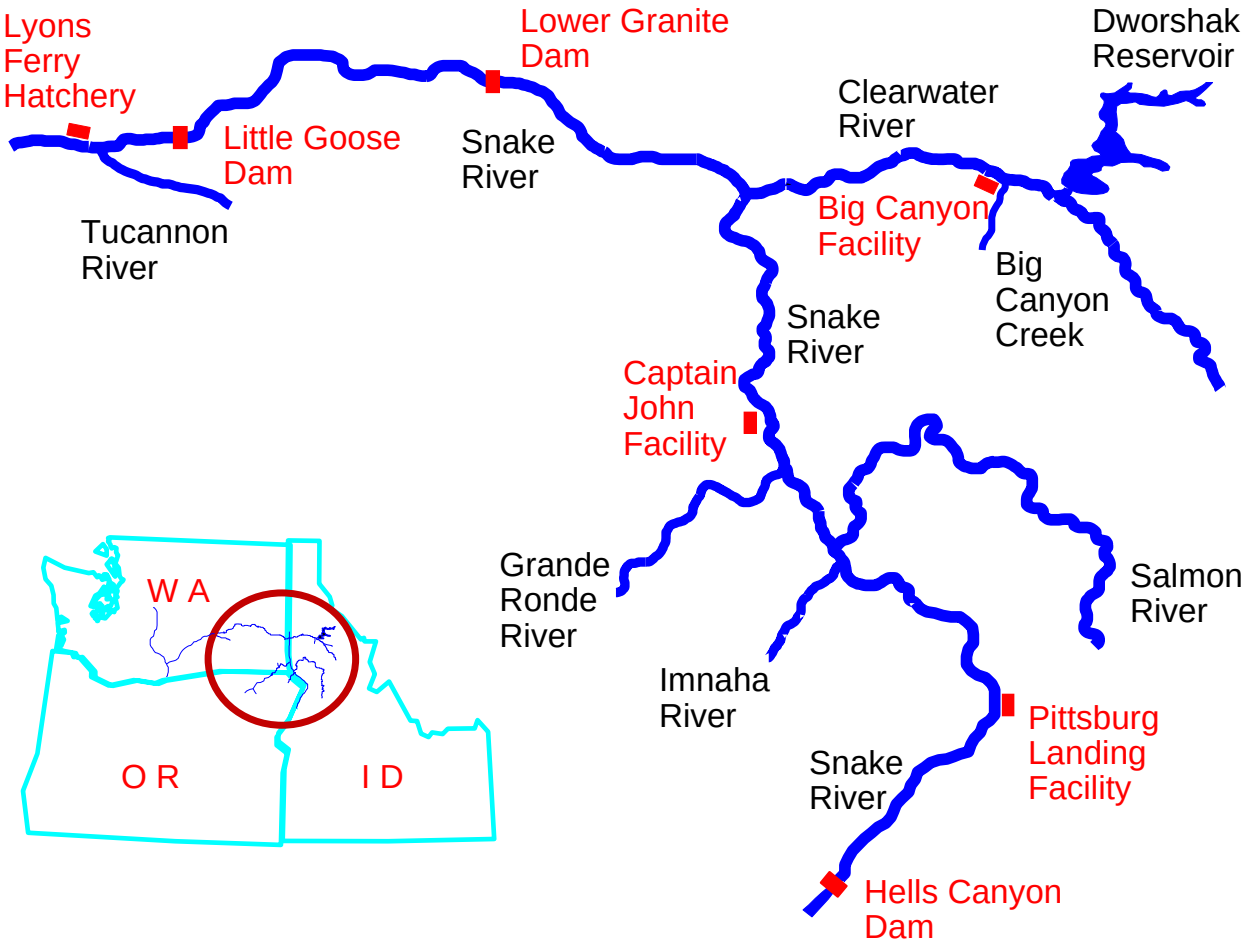

Figure 1.—Map of primary study area highlighting FCAP acclimation facilities, Lyons Ferry Hatchery and various Snake River dams.

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, 7 and 13 at Pittsburg Landing and tanks 6, 10 and 13 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 about 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. At LFH, yearlings were captured from the exit flume, tagged, allowed to recover and released directly back into the exit flume to the river. 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) to determine the level of Bacterial Kidney Disease (BKD), *Renibacterium salmoninarum,* antigen in each of the fish. Samples with absorbances between the control and 0.099 were considered to be undetected, those with absorbances of 0.100 to 0.199 were considered to have low infection levels, those with absorbances of 0.200 to 0.999 were considered to have medium infection levels and those with absorbances $\geq$ 1.000 were considered to have high infection levels (Pascho et al. 1991). 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

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 and Captain John Rapids. WDFW personnel conducted PIT tagging activities on April 11 and 17 for the on-station release from LFH. 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. This also applies to observations of fish from LFH at Lower Monumental Dam.

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: Upstream 522 km from the mouth of the Columbia River to the mouth of the Snake River, then upstream 346 km from the mouth of the Snake River to the Pittsburg Landing Acclimation Facility.

RESULTS AND DISCUSSION

A total of 103,741 yearlings were released from Pittsburg Landing and 113,215 from Big Canyon. The fish were released in stages, about one-third of each group per day for three days. Pittsburg Landing was released from April 10-12 and Big Canyon from April 9-11. A total of 101,976 yearlings were released volitionally from Captain John Rapids from April 4-13. The total FCAP release number of 318,932 fell short of the release quota of 450,000 yearlings. Lyons Ferry Hatchery also missed its quota, volitionally releasing an estimated 338,757 yearlings April 1-24.

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.

This was the fifth year of our radio telemetry study on yearlings released from the FCAP facilities. As this is a small-scale study intended to last 5 years, in this report we only describe general activities performed in 2001. A comprehensive report detailing activities and results for the entire study will be submitted upon completion of the study.

We released a total of 150 radio tagged yearling fall Chinook salmon from the FCAP facilities (50 from each facility) using the same capture and anesthesia procedures described for PIT tagging with the exception that the fish were not crowded in the tanks for capture. We configured receivers with fixed antennas at the transition from free-flowing to impounded reach at the head of Lower Granite pool near Asotin on the Snake River and at Potlatch Mill on the Clearwater River. These receivers were operated continuously throughout, and several days beyond, the tag life of about 20 days. The data were downloaded from the receivers about once per week to insure that data collection did not exceed memory capacity. We also tracked radio tagged yearlings by fixed-wing aircraft and boat. We conducted 5 fixed-wing aircraft tracking flights ranging in distance from the FCAP facilities downstream as far as McNary Dam. We tracked by boat for 8 days on Lower Granite Reservoir and 3 days on Little Goose Reservoir.

Fish Health

In 2000, co-managers agreed to discontinue organosomatic sampling, which we have reported on in previous years. Personnel from the USFWS Idaho Fish Health Center collected yearlings for BKD monitoring at the FCAP facilities and LFH from April 9-12, 2001. Table 2 summarizes the ELISA results for all groups during pre-release exam. Overall, based on ELISA values, 2001 can be considered a year of relatively high BKD levels in yearling fall Chinook salmon from LFH. Over half of the fish sampled from the FCAP facilities graded medium or high, which is in sharp contrast to previous years. Unlike 2000, overall BKD levels appeared to increase after transport from LFH to the FCAP facilities. 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 2001.

		ELISA			
Location	*n*	Not Detected	Low	Medium	High
Pittsburg Landing	63	1 (2%)	0	16 (25%)	37 (59%)
Big Canyon	60	7 (12%)	0	21 (35%)	30 (50%)
Captain John Rapids	60	5 (8%)	0	24 (40%)	26 (43%)
Lyons Ferry	60	19 (32%)	0	27 (45%)	9 (15%)

Flow and Temperature

Overall, 2001 was a low water year. Flows in the Snake and Clearwater rivers were consistently below the historical averages throughout the year.

The average flow in the Snake River near Hell's Canyon Dam in April was about 60% below the 35-year average from 1965 to 2000. Overall, flows fluctuated regularly between about 9,000-20,000 cfs (Figure 2). Spring flow patterns in 2001 did not resemble the historical hydrograph. Flow patterns at the Hell's Canyon gauge are dictated 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 52% below the 42-year average from 1958 to 2000 (Figure 3). Flows at Anatone peaked at 58,021 cfs on May 17. The daily mean water temperature during April ranged from 8.0^{O} to 13.5^{O} C with an overall mean of 9.7^{O} C.

The average daily discharge in the Clearwater River at Peck in April was about 44% below the 36-year average from 1964 to 2000, peaking at 38,900 cfs on May 15. 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 5.8^{O} to 10.5^{O} C with an overall mean of 7.6^{O} C.

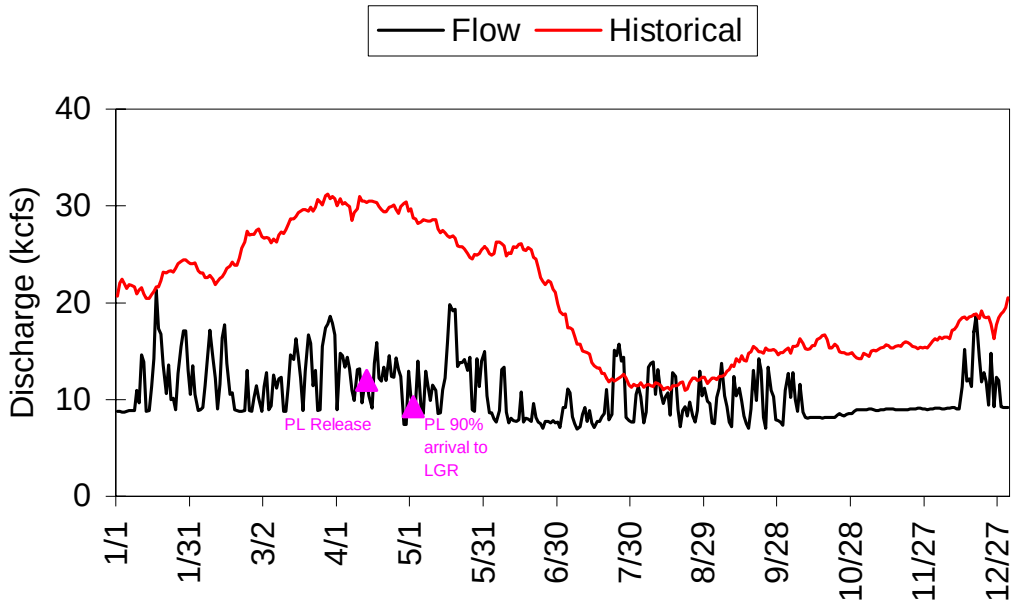

Figure 2.—Mean daily flow in 2001 and historical mean flow from 1965-2000 for the Snake River as measured at USGS gauge 13290450 near Hell's Canyon Dam.

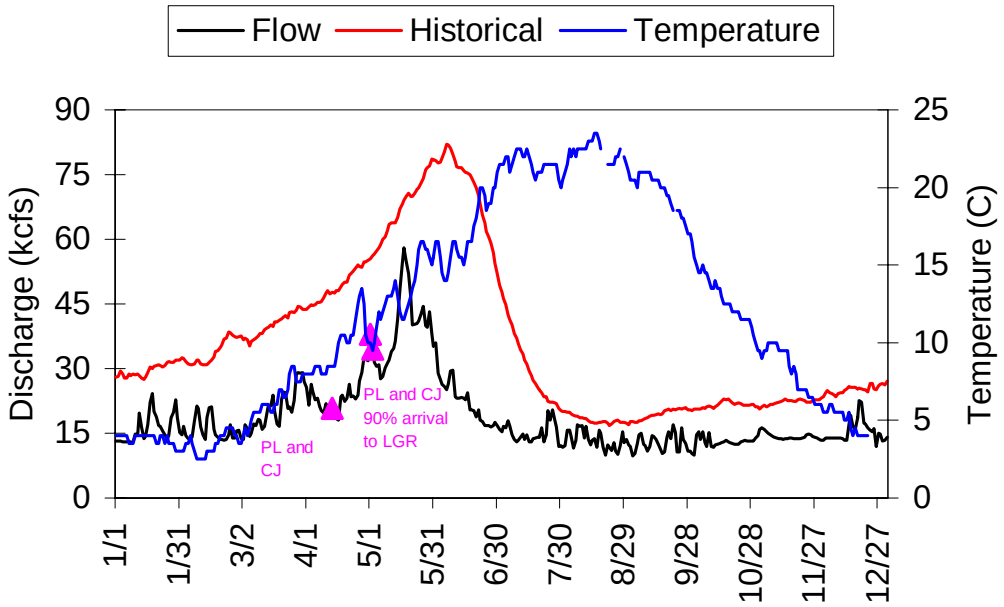

Figure 3.—Mean daily flow and temperature in 2001 and historical mean flow from 1958-2000 for the Snake River as measured at USGS gauge 13334300 near Anatone, Washington.

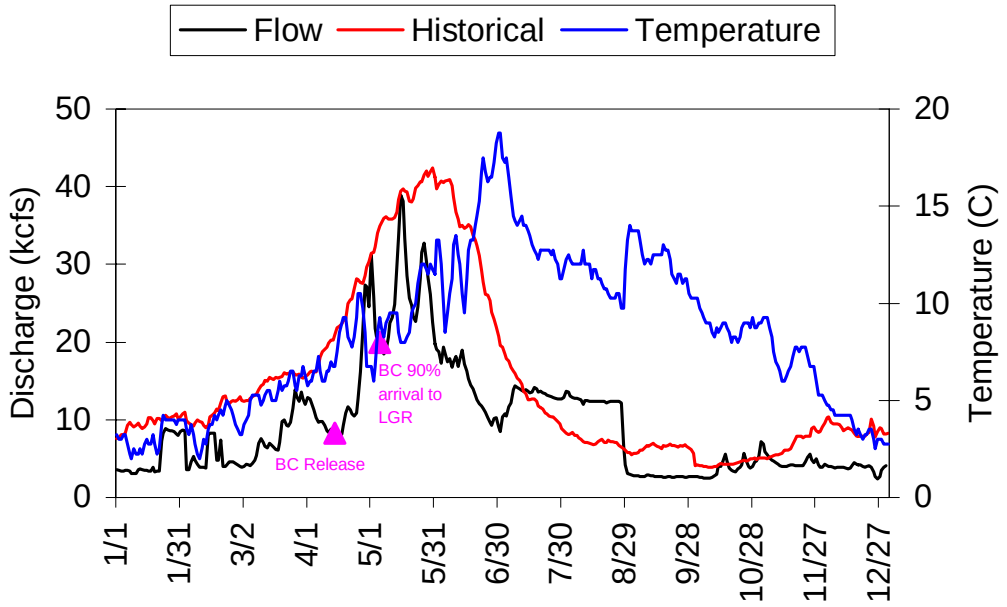

Figure 4.—Mean daily flow and temperature in 2001 and historical mean flow from 1964-2000 for the Clearwater River as measured at USGS gauge 13341050 near Peck, Idaho.

Average daily outflow as measured in the tailrace at Lower Granite Dam began increasing with spring runoff from 12.4 kcfs on March 1 peaking at 91.3 kcfs on May 16 (Figure 5). There was no significant spill at Lower Granite Dam in 2001.

Average daily outflow as measured in the tailrace at McNary Dam remained fairly steady from the beginning of the year through mid-June, fluctuating between about 100-150 kcfs without the typical significantly pronounced peak (Figure 6). There was no significant spill at McNary Dam in 2001.

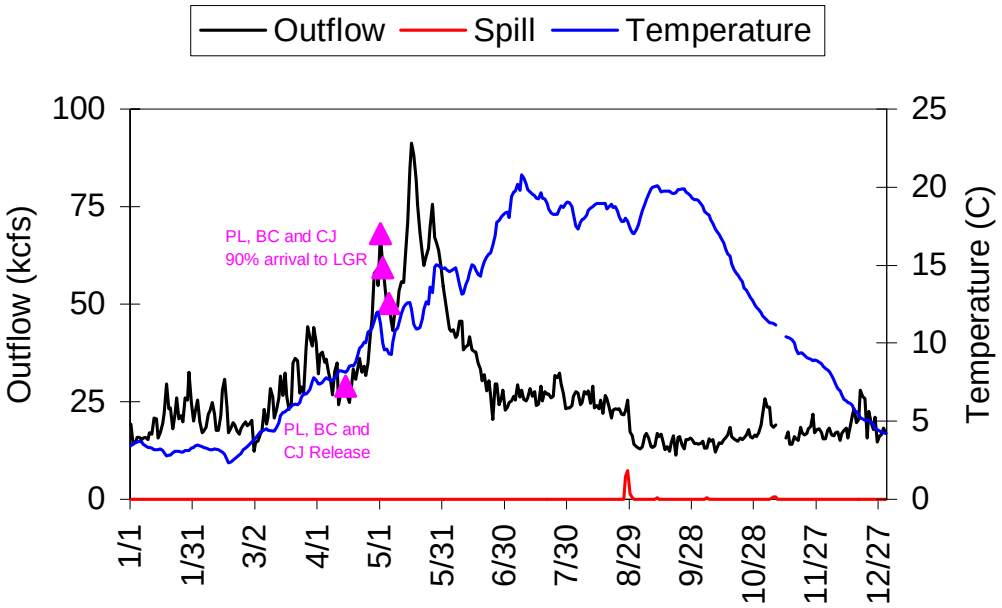

Figure 5.—Mean daily flow, spill, and temperature for the Snake River in 2001 as measured by the USACE at Lower Granite Dam.

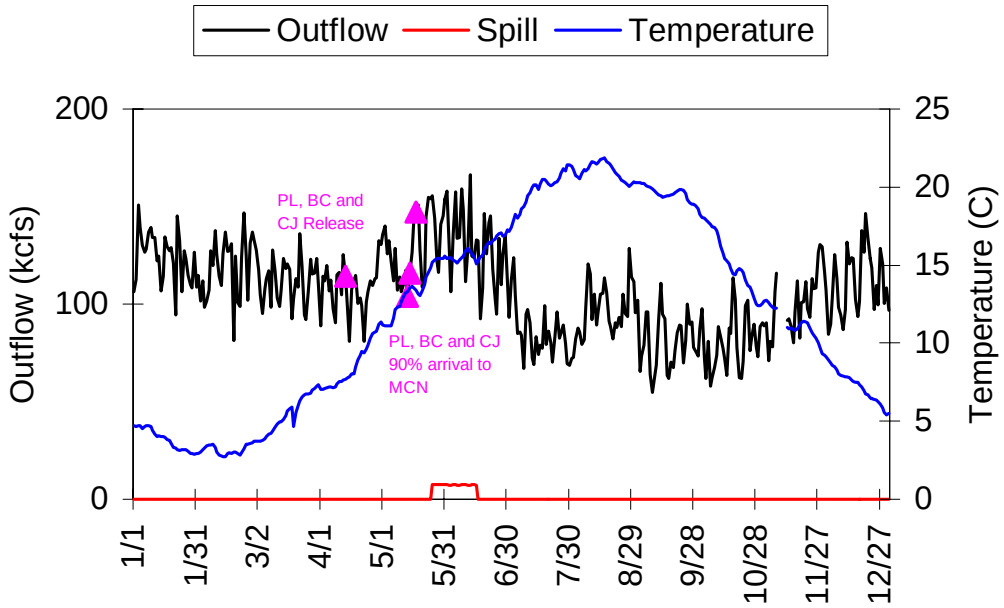

Figure 6.—Mean daily flow, spill, and temperature for the Columbia River in 2001 as measured by the USACE at McNary Dam.

PIT Tagging

PIT tagging operations went fairly smoothly this year. We experienced some difficulty in collecting lengths on the digitizer at Pittsburg Landing, but were still able to get lengths on over 4,800 fish. No other mechanical or electronic problems were encountered with the equipment and there was no immediate post-tagging mortality. A total of 7,503 and 7,499 yearling fall Chinook salmon were PIT tagged at Pittsburg Landing and Big Canyon, respectively (Table 3). A total of 2,518 yearlings were PIT tagged at Captain John Rapids. WDFW personnel PIT tagged a total of 991 yearlings at LFH. 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 released from the FCAP facilities and LFH in 2001.

Facility	Date Tagged	Number Tagged	Date Released
Pittsburg Landing	April 2	2,512	April 10
	April 3	2,491	April 11
	April 4	2,500	April 12
	Total	7,503	
Big Canyon	April 2	2,487	April 9
	April 3	2,493	April 10
	April 5	2,519	April 11
	Total	7,499	
Captain John Rapids	April 6	2,518	April 4-13
Lyons Ferry Hatchery	April 11	499	April 12
	April 17	492	April 18
	Total	991	

Biological Characteristics

The ANOVA on fork lengths shows a significant between-groups effect ($P = 0.0032$). Multiple comparisons indicate that the Pittsburg Landing and Captain John Rapids groups were similar to each other and the Big Canyon and LFH groups were significantly different from all groups (Appendix B, Table B.1). Biologically there is no difference in mean length between the Big Canyon group and Pittsburg Landing and Captain John Rapids (Table 4). The statistical difference was due to the large sample sizes. Yearlings from LFH were larger than the FCAP groups. This was the first year that the Captain John yearlings were consistent in length to the other FCAP sites. Fork length distributions of PIT tagged fish from the yearling release groups

all differed significantly from each other with $P < 0.01$ (Appendix B; Table B.2); although visual inspection shows that the shapes of the distributions were similar to each other (much more so than in previous years) and probably not biologically different (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 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 2001.

Facility		*n*	Mean	Standard Deviation	95% C.I. (+/- mean)	Median	Range
Pittsburg Landing	Fork Length (mm)	4,877	156.2	14.9	0.4	157	84 - 205
	Weight (g)	1,217	43.5	12.5	0.7	43.1	6.9 - 88.3
	Condition Factor	1,217	1.15	0.07	0.00	1.15	0.67 - 1.35
Big Canyon	Fork Length (mm)	7,461	157.0	14.9	0.3	158	83 - 206
	Weight (g)	1,185	44.5	12.6	0.7	44.1	6.6 - 90.4
	Condition Factor	1,185	1.16	0.07	0.00	1.16	0.84 - 1.45
Captain John Rapids	Fork Length (mm)	1,554	155.4	14.8	0.7	156	89 - 200
	Weight (g)	401	44.8	12.5	1.2	43.6	17.8 - 89.7
	Condition Factor	401	1.16	0.09	0.01	1.16	0.60 - 1.37
Lyons Ferry Hatchery	Fork Length (mm)	990	171.6	14.9	0.9	171	126 - 230
	Weight (g)	504	52.2	15.2	1.3	50	20.6 - 134.9
	Condition Factor	504	1.02	0.12	0.01	1.04	0.75 - 1.28

The ANOVA on condition factors also shows a significant between-groups effect ($P = 0.0036$). Multiple comparisons indicate that the Big Canyon and Captain John Rapids groups were similar to each other and the Pittsburg Landing and LFH groups were significantly different from all groups (Appendix B, Table B.1). The Pittsburg Landing group was not biologically different than the other FCAP groups. Mean condition factors ranged from 1.16 for Big Canyon and Captain John Rapids to 1.02 for and LFH (Table 4). All condition factor distributions were significantly different ($P < 0.05$). Results of all statistical tests are included in Appendix B.

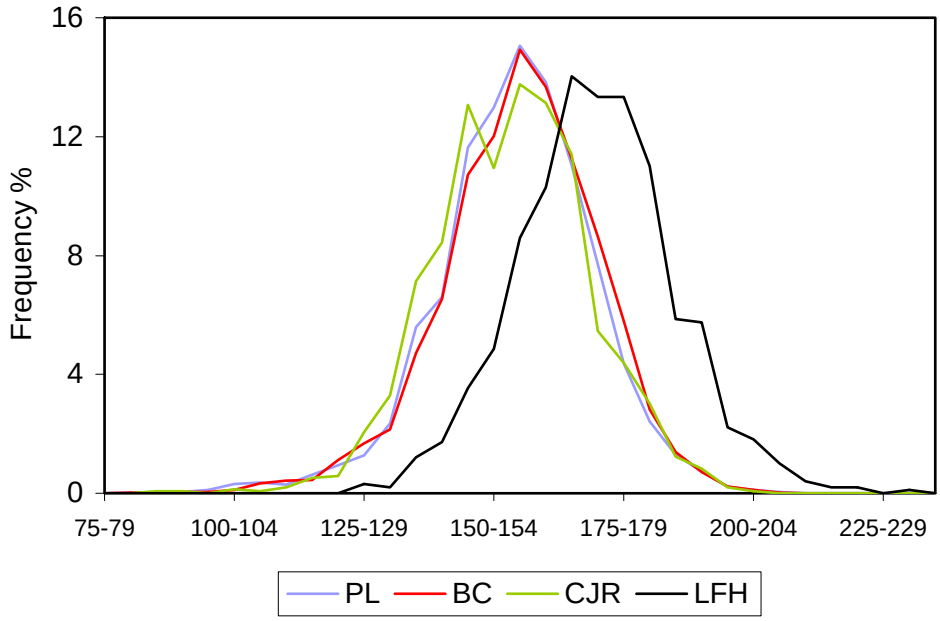

Figure 7.—Fork length frequency of PIT tagged yearling fall Chinook salmon at the FCAP facilities and LFH in 2001.

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).

Coded wire tag retention was 99.0% or better for yearlings from all facilities. The only yearling group with adipose fin clip retention under 99.0% was LFH at 96.9%. Retention of VIE marks was lower and more variable than for adipose fin clips and coded wire tags, ranging from 85.1% at Pittsburg Landing to 93.8% at Big Canyon (Table 5). A total of one FCAP and four LFH fish (0.0003% and 0.001% 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 2001. 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	1,227	100.0	99.3	85.1	0.0000000	0
Big Canyon	1,200	99.8	99.9	93.8	0.0000001	0
Captain John Rapids	404	99.5	99.0	88.1	0.0000058	1
Lyons Ferry Hatchery	1,233	99.5	96.9	92.8	0.0000108	4

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 74.4% (73.2-75.5%) for Big Canyon to 85.2% (83.5-87.0%) for Captain John Rapids. Estimated survival from release to McNary Dam ranged from 37.9% (36.0-40.0%) for Pittsburg Landing to 57.9% (53.0-62.8%) for LFH (Table 6). Yearling survival from Captain John Rapids to Lower Granite Dam and McNary Dam was significantly higher than from Pittsburg Landing ($P < 0.0001$) and Big Canyon ($P < 0.0001$). To McNary Dam, survival from LFH was significantly higher than from all FCAP facilities. Table 7 outlines all pairwise comparisons of survival from the FCAP facilities and LFH to Lower Granite and McNary dams in 2001.

Yearling survival to Lower Granite and McNary dams in 2001 declined dramatically from past years (Appendix C, Tables C.1 and C.2). The primary implication is the low river flows. Until this year, the point estimates for survival from Captain John Rapids had increased each year since it began operations in 1998 (Appendix C, Table C.2 and Figure C.6). It is worth noting that survival from LFH to McNary Dam was significantly higher than from the FCAP facilities, which contrasts what we have seen in the past two years when survival from LFH was similar to survival from the FCAP facilities (Rocklage and Kellar 2005a, 2005b). Being released further downstream may provide a survival advantage in low water years such as 2001. See Appendix C for a complete yearling survival summary from the FCAP facilities to Lower Granite and McNary dams and from LFH to McNary Dam from 1996-2001.

Table 6.—Estimated survivals and 95% confidence intervals of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Granite and McNary dams in 2001.

Facility	Release to:	Estimated Survival	95% C.I. Lower Bound	95% C.I. Upper Bound
Pittsburg Landing	Lower Granite	0.7491	0.7377	0.7605
	McNary	0.3786	0.3604	0.3968
Big Canyon	Lower Granite	0.7437	0.7321	0.7553
	McNary	0.3952	0.3781	0.4123
Captain John Rapids	Lower Granite	0.8523	0.8351	0.8695
	McNary	0.4853	0.4567	0.5139
Lyons Ferry Hatchery	Lower Monumental	0.7711	0.7301	0.8121
	McNary	0.5792	0.5302	0.6282

Table 7.—Results of the Z-test for pairwise comparisons of SURPH survival estimates for PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Granite and McNary dams in 2001.

To Lower Granite Dam

	BC	CJ	LFH
PL	$P = 0.5156$	$P < 0.0001$	n/a
BC		$P < 0.0001$	n/a

To McNary Dam

	BC	CJ	LFH
PL	$P = 0.2030$	$P < 0.0001$	$P < 0.0001$
BC		$P < 0.0001$	$P < 0.0001$
CJ			$P = 0.0012$

Travel Time and Migration Rate

Median travel times based on all obs are typically 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 to Lower Granite Dam was about 13-17 days, which was 4-7 days longer than in 2000. Median travel times from the FCAP facilities to McNary Dam was about 31-37 days, which was 9-14 days longer than in 2000. 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 each successive observation point downstream (Appendix D, Tables D.1 and D.2).

The ANOVA on migration rates to Lower Granite, McNary and Bonneville dams show a significant between-groups effect ($P < 0.01$ for each). Multiple comparisons of migration rates showed that all FCAP PIT tagged groups differed significantly to Lower Granite Dam (Appendix B, Table B.3). For first obs to McNary Dam, the LFH group differed from all FCAP groups while the Pittsburg Landing group was similar Big Canyon and Big Canyon and Captain John Rapids were similar to each other. However, for all obs to McNary Dam, all groups differed from each other. For all obs migration rates to Bonneville Dam, Big Canyon and Captain John Rapids were similar to each other while Pittsburg Landing and LFH differed from all other groups.

When considering migration rates from the FCAP facilities to Lower Granite Dam, it is important to remember that these reaches include 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). However, for the Big Canyon and Captain John Rapids groups below Lower Granite Dam there tends to be an increase in migration rate of PIT tagged yearlings as they move downstream (Figures 8 and 9). This trend was less pronounced in the Pittsburg Landing group, but was especially apparent in yearlings from LFH. The initial migration rate for LFH yearlings, as measured to Lower Monumental Dam, was relatively quite low. However, their overall migration rate rapidly increased to each downstream observation point to where their migration rate to Bonneville Dam was relatively much closer to the FCAP groups. Because the migration rate at each observation point includes the entire distance from point of release, this indicates that migration rates for LFH fish in each reach between observation points below Lower Monumental Dam were quite high in order to make the overall migration rate to each point increase so rapidly. 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. This is one objective of the radio telemetry study that will be reported on at the end of the study. 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.

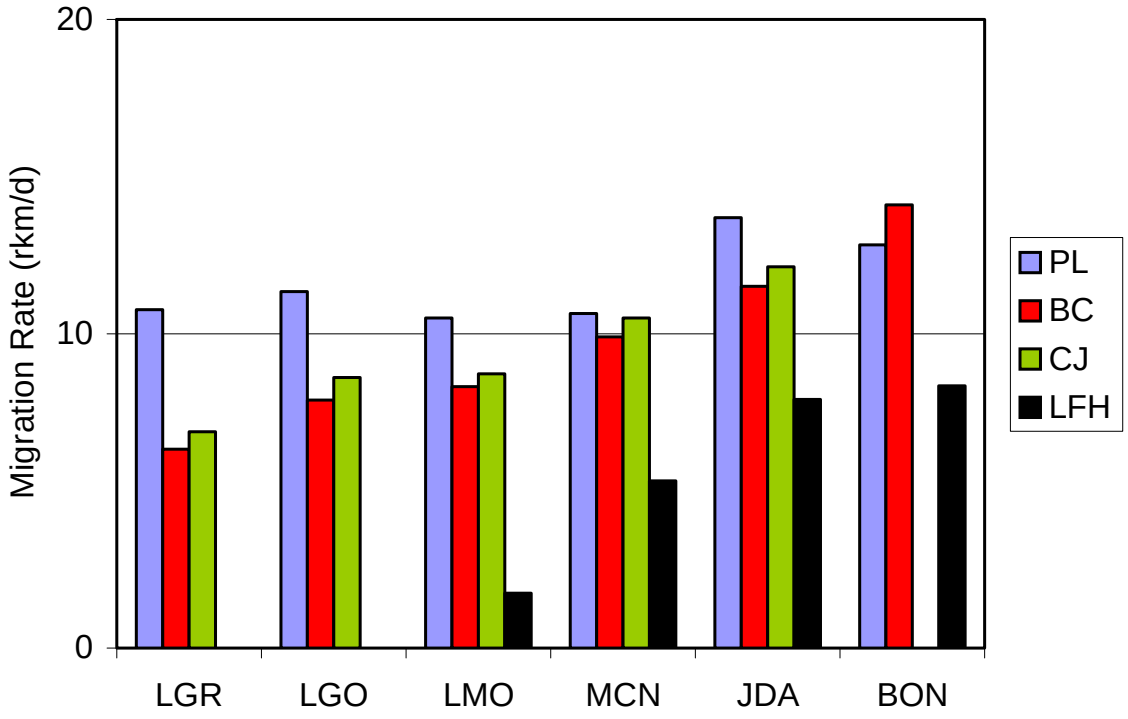

Figure 8.—First obs migration rate (rkm/d) of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 2001.

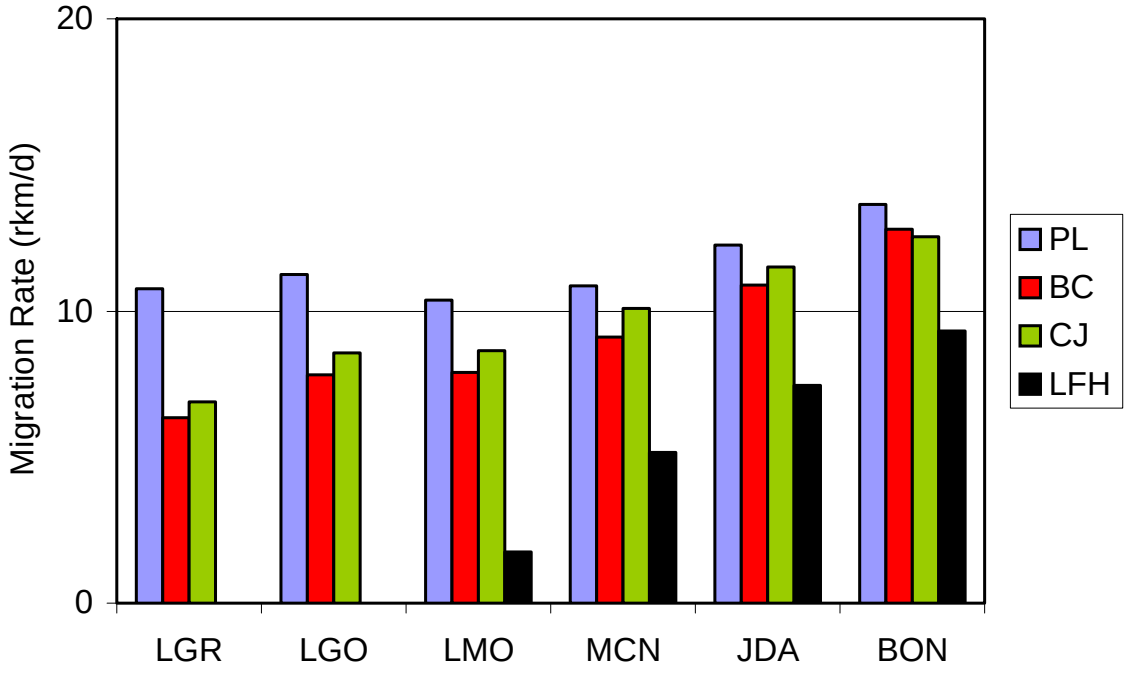

Figure 9.—All obs migration rate (rkm/d) of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 2001.

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 1996-2001 had significant positive correlations with flow at Hell's Canyon Dam ($r = 0.91$, $P = 0.0110$) and Anatone ($r = 0.95$, $P = 0.0035$), while being negatively correlated with temperature at Anatone ($r = -0.33$, $P = 0.526$), as illustrated in Figures 10 and 11. Migration rates from Big Canyon to Lower Granite Dam during 1997-2001 were positively correlated with flow ($r = 0.85$, $P = 0.0707$) and negatively correlated with temperature ($r = -0.80$, $P = 0.1033$) at Peck (Figures 12 and 13). Migration rates from Captain John Rapids were positively correlated with both flow ($r = 0.85$, $P = 0.1495$) and temperature ($r = 0.44$, $P = 0.5567$) at Anatone (Figures 14 and 15).

Migration rate from Pittsburg Landing has a significant positive correlation with flow and a lesser negative correlation with temperature. It appears that 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 slightly weaker positive correlation with flow and 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.

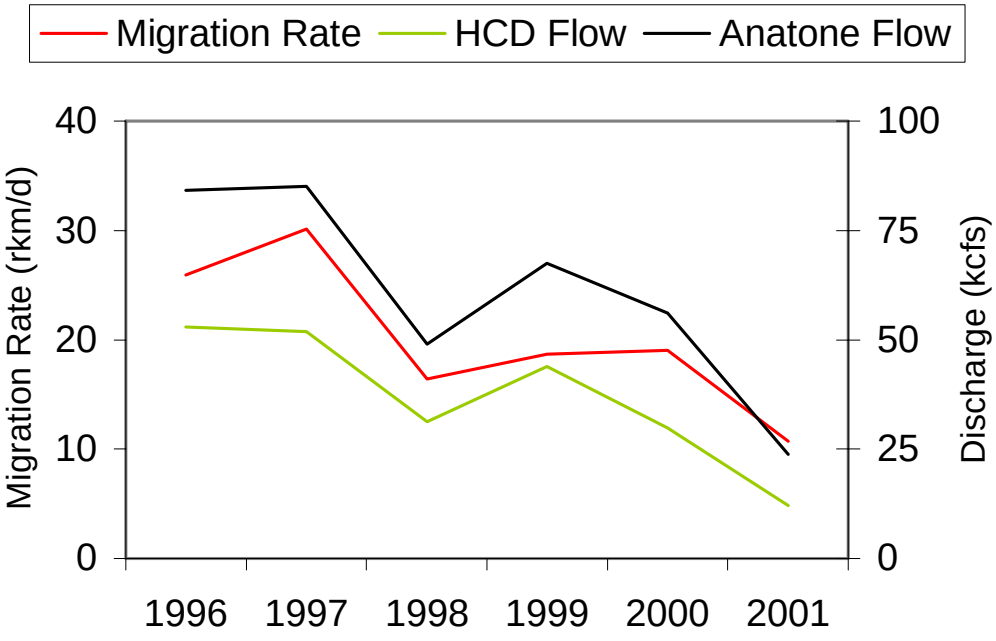

Figure 10.—Yearling migration rate (rkm/d) from Pittsburg Landing to Lower Granite Dam versus Snake River flow at Hell's Canyon Dam and Anatone, 1996-2001.

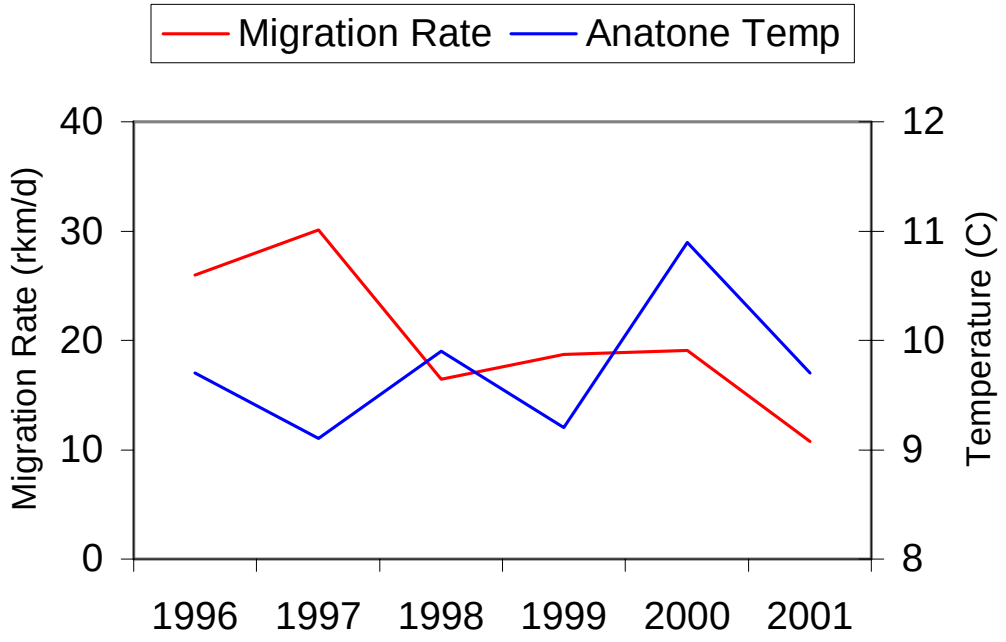

Figure 11.—Yearling migration rate (rkm/d) from Pittsburg Landing to Lower Granite Dam versus Snake River temperature at Anatone, 1996-2001.

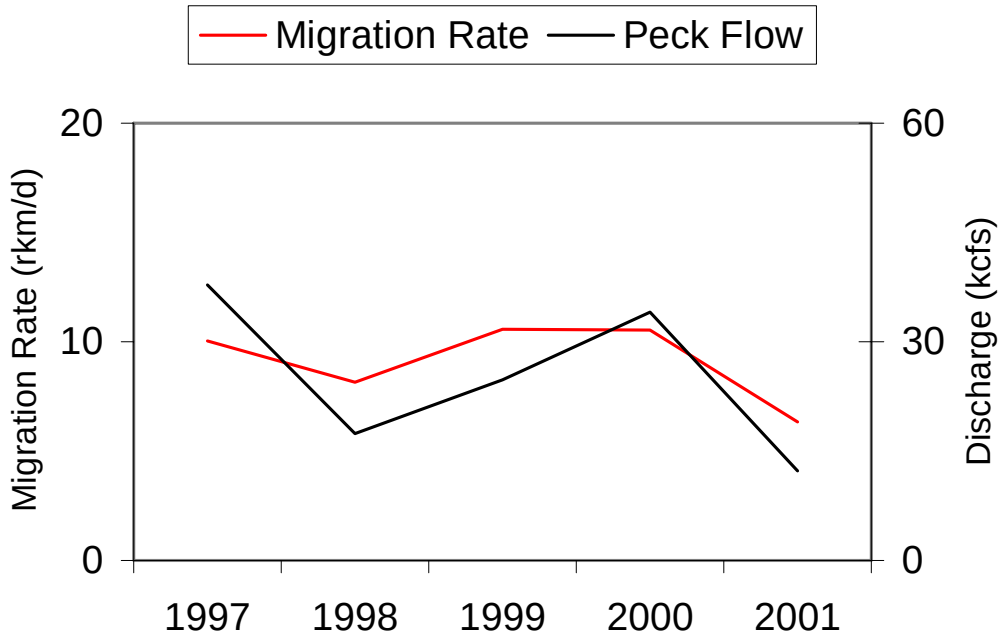

Figure 12.—Yearling migration rate (rkm/d) from Big Canyon to Lower Granite Dam versus Clearwater River flow at Peck, 1997-2001.

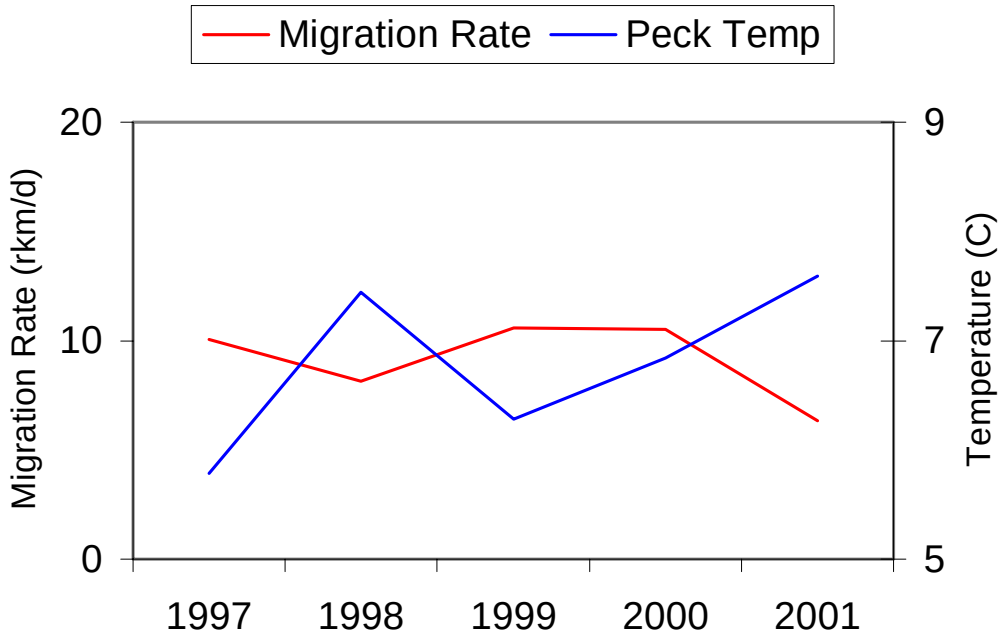

Figure 13.—Yearling migration rate (rkm/d) from Big Canyon to Lower Granite Dam versus Clearwater River temperature at Peck, 1997-2001.

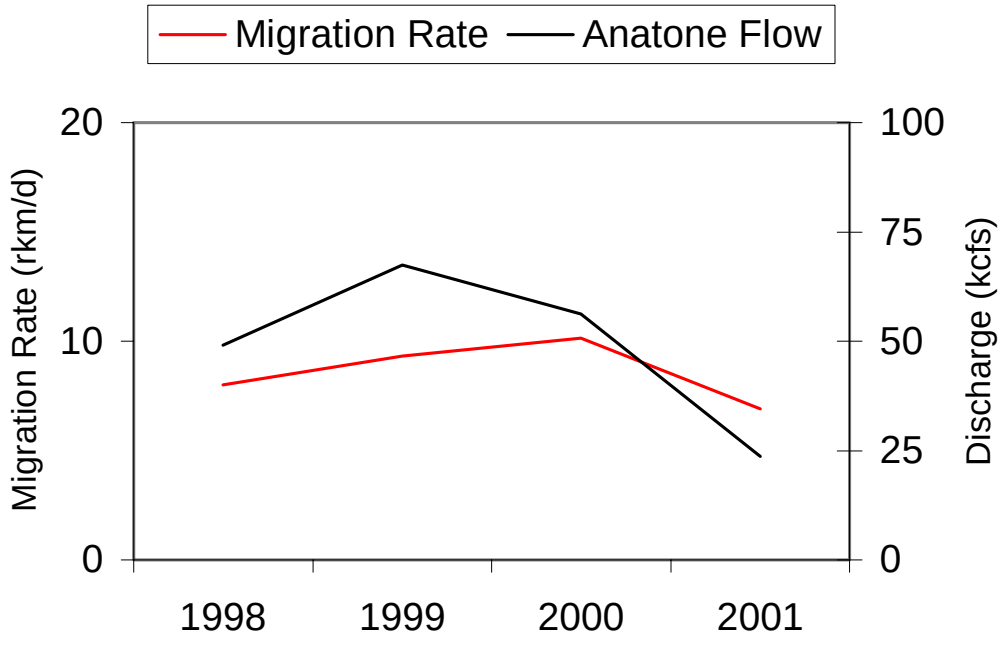

Figure 14.—Yearling migration rate (rkm/d) from Captain John Rapids to Lower Granite Dam versus Snake River flow at Anatone, 1998-2001.

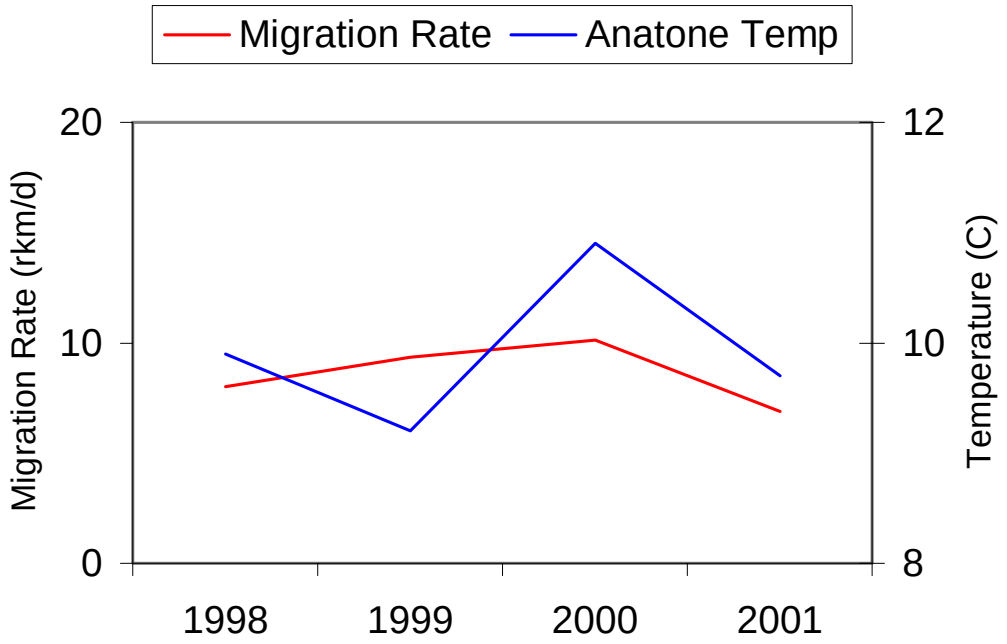

Figure 15.—Yearling migration rate (rkm/d) from Captain John Rapids to Lower Granite Dam versus Snake River temperature at Anatone, 1998-2001.

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 13. The volitional release occurred from April 4-13, however, no PIT tagged fish from Captain John Rapids were detected at Lower Granite Dam until after 17:00 on April 14. 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 timing of release groups to given locations are simply a function of release date, migration rate and distance. Arrival date distributions to Lower Granite Dam were significantly different ($P < 0.0001$) for all FCAP groups (Appendix B; Table B.4), though this does not likely represent a biological difference as visual inspection of Appendix Tables E.9 and E.23 indicates. While all FCAP groups had median arrival dates to Lower Granite Dam between April 26-28 (Tables 8 and 9), cumulative frequencies indicate that the Captain John group completed passage prior to the other FCAP groups (Appendix Tables E.10 and E.24). The Big Canyon group had the latest median arrival date, which is generally similar to what we have seen from Big Canyon yearlings from 1997 through 2000 relative to Pittsburg Landing. As stated previously, the lower migration rates documented from Big Canyon relative to Pittsburg Landing could be the result of lower flows or temperatures in the Clearwater River relative to the Snake River or a combination of both.

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. No clear pattern emerged from statistical analysis of first and all obs arrival date distributions at McNary and Bonneville dams, except for the Pittsburg Landing group differed significantly from all other groups at both dams under all obs (Appendix B; Table B.6). Under all obs, Big Canyon differed significantly from all other groups at McNary Dam, but not at Bonneville Dam. 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.

Yearlings from Captain John Rapids achieved 90% arrival to Lower Granite Dam about 4-5 days earlier than Pittsburg Landing and Big Canyon, but timing was similar at McNary and Bonneville dams (Tables 8 and 9). The Big Canyon group achieved 90% arrival to Lower Granite Dam one day faster than the Pittsburg Landing group, but the differential increased to 2 days at McNary Dam and to 3 days at Bonneville Dam. The differential at Lower Granite Dam could be expected as the Big Canyon fish were released one day earlier than the Pittsburg Landing group, but we have no explanation for the increased differential downstream.

There was no typical hydrographic peak flow for the Snake River at Hell's Canyon Dam in 2001, so comparisons to release and arrival timing cannot be done. Yearlings from the FCAP facilities were released about 5 weeks before and achieved 90% arrival to Lower Granite Dam about 2 weeks before flows peaked at Anatone and Peck. Yearlings from the FCAP sites achieved 90% arrival to Lower Granite Dam about 2 weeks before peak flows at the dam (Figure 5). Yearlings from the FCAP facilities achieved 90% arrival to McNary Dam almost a month before peak flows at the dam (Figure 6).

Travel time and arrival date data are evidence that passage through the collection and bypass facilities delays migration. Analysis indicates that all obs travel time to each dam below Lower Granite averages about one day longer than first obs. As mentioned previously, because the all obs group wholly contains the first obs group at each location, the differences presented here are minimum differences between the two groups.

Table 8.—First Obs arrival date at Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from FCAP facilities and LFH in 2001.

Release Group	Interrogation Site	*n*	Mean	Median	90%
Pittsburg Landing	Lower Granite	3,644	4/28	4/27	5/5
	Little Goose	1,404	5/4	5/2	5/14
	Lower Monumental	221	5/10	5/8	5/21
	McNary	63	5/18	5/18	5/27
	John Day	11	5/20	5/18	5/29
	Bonneville	1	5/29	5/29	n/a
Big Canyon	Lower Granite	3,629	4/28	4/27	5/4
	Little Goose	1,345	5/4	5/2	5/14
	Lower Monumental	219	5/8	5/6	5/16
	McNary	82	5/15	5/14	5/23
	John Day	16	5/22	5/19	5/30
	Bonneville	7	5/22	5/21	5/26
Captain John Rapids	Lower Granite	1,342	4/26	4/26	4/30
	Little Goose	558	5/2	4/30	5/10
	Lower Monumental	117	5/7	5/5	5/16
	McNary	29	5/14	5/13	5/26
	John Day	8	5/17	5/19	5/23
	Bonneville	0	n/a	n/a	n/a
Lyons Ferry Hatchery	Lower Monumental	502	5/1	4/30	5/9
	McNary	134	5/12	5/12	5/22
	John Day	25	5/19	5/18	5/25
	Bonneville	3	5/26	5/27	n/a

Table 9.—All Obs arrival date to Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from FCAP facilities and LFH in 2001.

Release Group	Interrogation Site	*n*	Mean	Median	90%
Pittsburg Landing	Lower Granite	3,644	4/28	4/27	5/5
	Little Goose	3,933	5/5	5/2	5/16
	Lower Monumental	2,953	5/10	5/8	5/22
	McNary	375	5/19	5/18	5/31
	John Day	797	5/25	5/24	6/5
	Bonneville	223	5/28	5/28	6/7
Big Canyon	Lower Granite	3,629	4/28	4/27	5/4
	Little Goose	3,809	5/4	5/2	5/15
	Lower Monumental	2,865	5/9	5/8	5/19
	McNary	918	5/17	5/17	5/29
	John Day	902	5/23	5/23	6/1
	Bonneville	266	5/26	5/25	6/4
Captain John Rapids	Lower Granite	1,342	4/26	4/26	4/30
	Little Goose	1,507	5/2	4/30	5/11
	Lower Monumental	1,198	5/8	5/6	5/19
	McNary	158	5/16	5/14	5/30
	John Day	426	5/22	5/21	6/1
	Bonneville	125	5/27	5/27	6/5
Lyons Ferry Hatchery	Lower Monumental	502	5/1	4/30	5/9
	McNary	379	5/14	5/13	5/24
	John Day	199	5/21	5/19	5/30
	Bonneville	58	5/26	5/25	6/3

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APPENDICES

Appendix A. List of PIT tag files and observation numbers and rates at Lower Snake and Columbia River dams for PIT tagged yearling fall Chinook salmon released from the FCAP facilities and LFH in 2001. 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 and LFH in 2001.

Facility	Filename
Pittsburg Landing	SJR01092.P13
	SJR01093.P07
	SJR01094.P05
Big Canyon	SJR01092.B06
	SJR01093.B10
	SJR01095.B13
Captain John Rapids	MLS01101.YRL
	MLS01107.YRL
Lyons Ferry Hatchery	SJR01096.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 and LFH in 2001.

Release Group	LGR	LGO	LMO	MCN	JDA	BON	Cumulative Interrogations	Cumulative %
Pittsburg Landing	3,644	1,404	221	63	11	1	5,344	71.2
Big Canyon	3,629	1,345	219	82	16	7	5,298	70.6
Captain John Rapids	1,342	558	117	29	8	0	2,054	81.6
Lyons Ferry Hatchery	n/a	n/a	502	134	25	3	664	67.0

Appendix A (continued).

Table A.3.—All obs interrogations at Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH in 2001.

Release Group	LGR	LGO	LMO	MCN	JDA	BON	Total Interrogations
Pittsburg Landing	3,644	3,933	2,953	375	797	223	11,925
Big Canyon	3,629	3,809	2,865	918	902	266	12,389
Captain John Rapids	1,342	1,507	1,198	158	426	125	4,756
Lyons Ferry Hatchery	n/a	n/a	502	379	199	58	1,138

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 and LFH in 2001. 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 2001.

		Tukey's HSD Multiple Comparisons			
	ANOVA	PL	BC	CJ	LFH
Length	$P = 0.0032$	1	2	1	3
Condition	$P = 0.0036$	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 2001.

	Fork Length			Condition Factor		
	BC	CJ	LFH	BC	CJ	LFH
PL	$P = 0.0081$	$P = 0.0022$	$P < 0.0001$	$P = 0.0043$	$P < 0.0001$	$P < 0.0001$
BC		$P < 0.0001$	$P < 0.0001$		$P = 0.0303$	$P < 0.0001$
CJ			$P < 0.0001$			$P < 0.0001$

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 and LFH to Lower Granite, McNary and Bonneville dams in 2001.

			Tukey's HSD Multiple Comparisons			
		ANOVA	PL	BC	CJ	LFH
Lower Granite		$P = 0.0096$	1	2	3	n/a
McNary	First Obs	$P < 0.0001$	1	2	1, 2	3
	All Obs	$P = 0.0026$	1	2	3	4
Bonneville	First Obs	n/a	n/a	n/a	n/a	n/a
	All Obs	$P < 0.0001$	1	2	2	3

Appendix B (continued).

Table B.4.—Results of the Kolmogorov-Smirnov Test for travel time and arrival date distributions of PIT tagged yearling fall Chinook salmon from the FCAP facilities to Lower Granite Dam in 2001.

	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 first and all obs travel time distributions of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to McNary and Bonneville dams in 2001.

To McNary Dam

	1st Obs Travel Time			All Obs Travel Time		
	BC	CJ	LFH	BC	CJ	LFH
PL	$P = 0.0167$	$P = 0.0021$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$
BC		$P = 0.0110$	$P < 0.0001$		$P < 0.0001$	$P < 0.0001$
CJ			$P = 0.3291$			$P = 0.0012$

To Bonneville Dam

	1st Obs Travel Time			All Obs Travel Time		
	BC	CJ	LFH	BC	CJ	LFH
PL	n/a	n/a	n/a	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$
BC		n/a	n/a		$P = 0.1018$	$P = 0.0002$
CJ			n/a			$P = 0.1435$

Appendix B (continued).

Table B.6.—Results of the Kolmogorov-Smirnov Test for first and all obs arrival date distributions at McNary and Bonneville Dams of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH in 2001.

To McNary Dam

	1st Obs Arrival Date				All Obs Arrival Date			
	BC	CJ	LFH		BC	CJ	LFH
PL	$P = 0.0056$	$P = 0.1578$	$P = 0.0008$	PL	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$
BC		$P = 0.3340$	$P = 0.0292$	BC		$P = 0.0392$	$P < 0.0001$
CJ			$P = 0.6838$	CJ			$P = 0.2540$

To Bonneville Dam

	1st Obs Arrival Date				All Obs Arrival Date			
	BC	CJ	LFH		BC	CJ	LFH
PL	n/a	n/a	n/a	PL	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$
BC		n/a	n/a	BC		$P = 0.2097$	$P = 0.7782$
CJ			n/a	CJ			$P = 0.3091$

APPENDIX C. SURPH survival estimates for yearling fall Chinook salmon from release at FCAP facilities and LFH to Lower Snake and Columbia River dams from 1996 through 2001. 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, 1996-2001.

Release Group	Year	CJS Estimate	S.E.	95% C.I. Lower	95% C.I. Upper
Pittsburg	1996	0.9878	0.0140	0.9604	1.0152
Landing	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
Big Canyon	1997	0.9359	0.0147	0.9071	0.9647
Large	1998	0.8472	0.0146	0.8186	0.8758
Small	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
Big Canyon	1997	0.9325	0.0429	0.8484	1.0166
Surplus	1999	0.8775	0.0289	0.8209	0.9341
Captain John	1998	0.7698	0.0274	0.7161	0.8235
Rapids	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

Appendix C (continued).

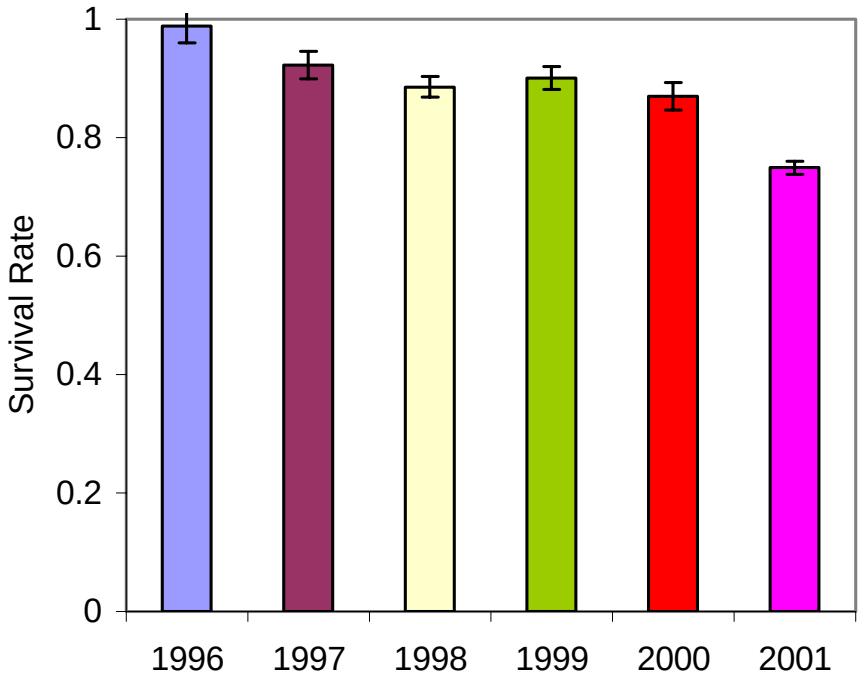

Figure C.1.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to Lower Granite Dam, 1996-2001.

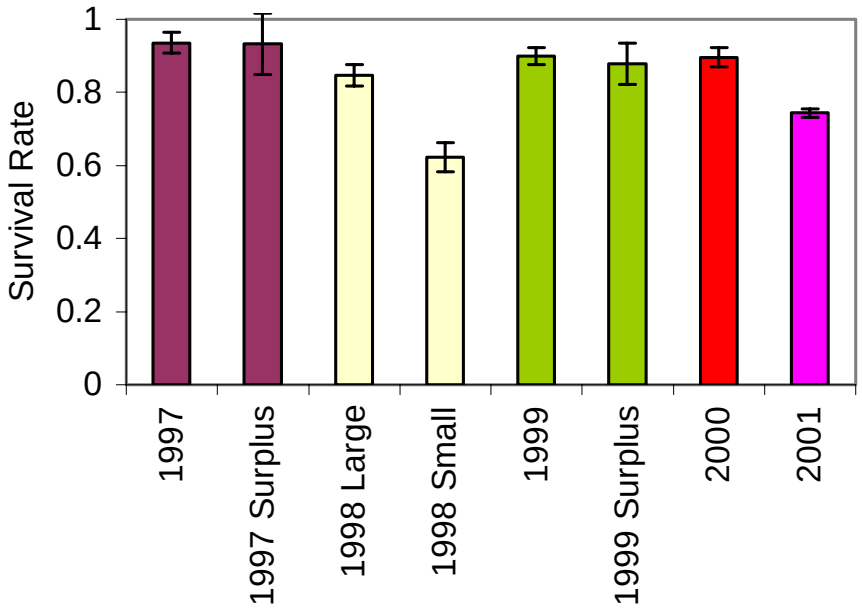

Figure C.2.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to Lower Granite Dam, 1997-2001.

Appendix C (continued).

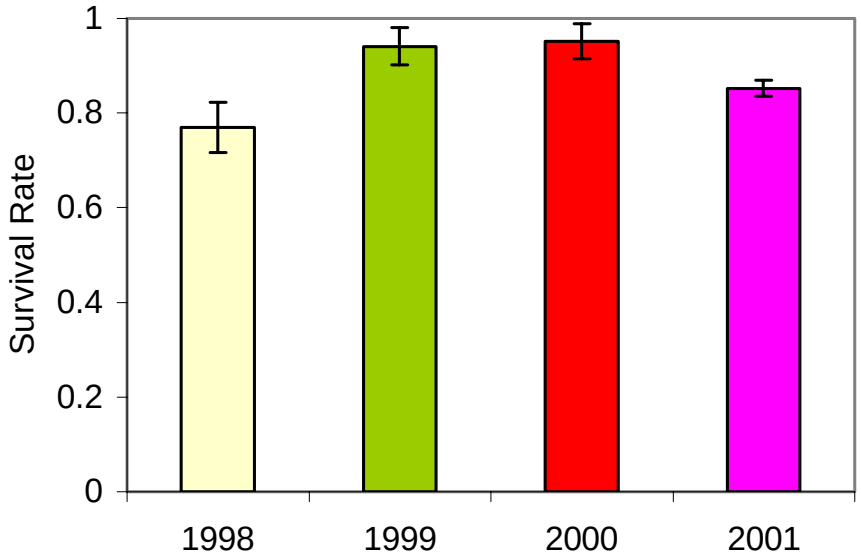

Figure C.3.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to Lower Granite Dam, 1998-2001.

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, 1996-2001.

Release Group	Year	CJS Estimate	S.E.	95% C.I. Lower	95% C.I. Upper
Pittsburg Landing	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
Big Canyon Large	1997	0.8328	0.1792	0.4816	1.1840
	1998	0.5168	0.0658	0.3878	0.6458
Big Canyon Small	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
Big Canyon Surplus	1997	0.7382	0.7130	-0.6593	2.1357
	1999	0.5869	0.0479	0.4930	0.6808
Captain John Rapids	1998	0.5049	0.1168	0.7377	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
Lyons Ferry Hatchery	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).

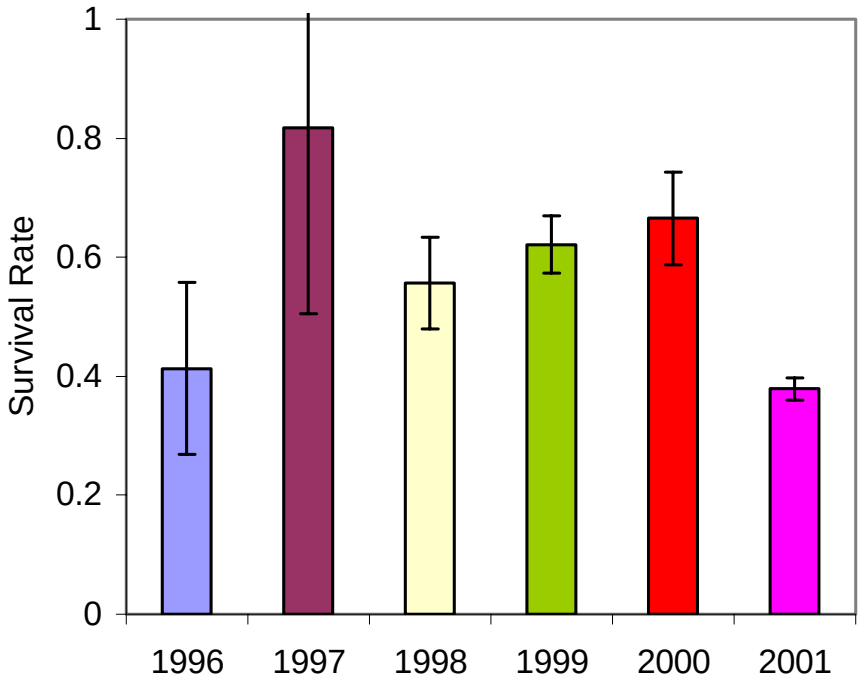

Figure C.4.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to McNary Dam, 1996-2001.

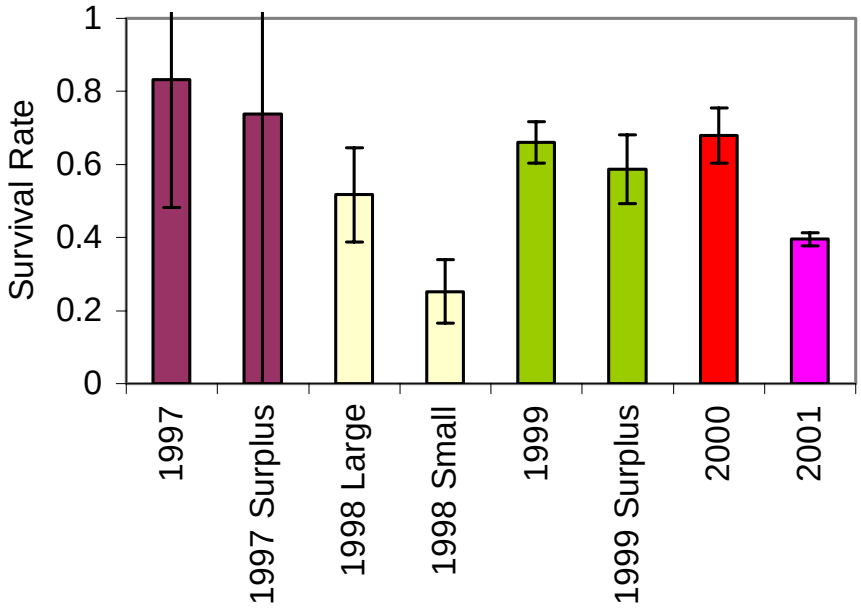

Figure C.5.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to McNary Dam, 1997-2001.

Appendix C (continued).

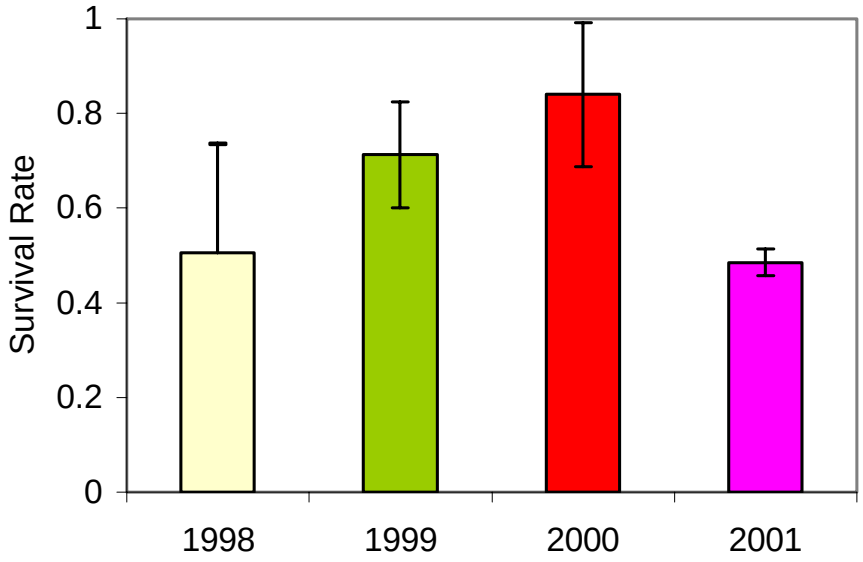

Figure C.6.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to McNary Dam, 1998-2001.

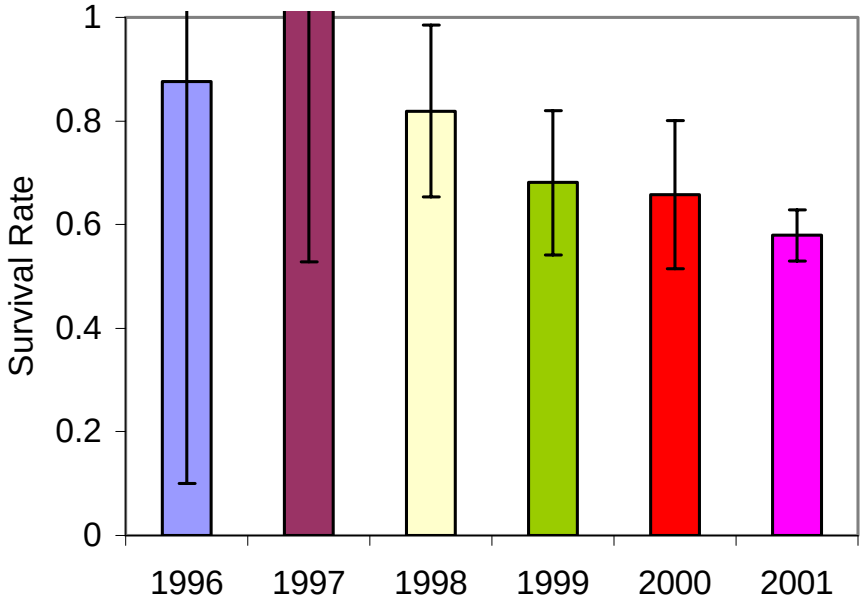

Figure C.7.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from LFH to McNary Dam, 1996-2001.

Appendix D. Descriptive statistics for travel times (days) and migration rates (rkm/d) of PIT tagged yearling fall Chinook from the FCAP sites and LFH to Lower Snake and Columbia River dams in 2001.

Table D.1.—First Obs travel time (days) of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 2001.

Release Group	Interrogation Site	*n*	Mean	Standard Deviation	95% C.I. (+/-)	Median	Range
Pittsburg Landing	Lower Granite	3,644	17.4	6.4	0.2	16.1	7.1 - 83.9
	Little Goose	1,404	22.7	7.2	0.4	20.6	10.9 - 66.4
	Lower Monumental	221	28.8	26.6	1.1	26.6	15.5 - 64.6
	McNary	63	37.0	8.6	2.2	37.4	22.8 - 65.0
	John Day	11	39.2	8.6	5.8	38.1	27.8 - 56.9
	Bonneville	1	49.4	n/a	n/a	49.4	49.4 - 49.4
Big Canyon	Lower Granite	3,629	17.8	6.0	0.2	17.0	5.1 - 65.8
	Little Goose	1,345	23.2	7.1	0.4	21.3	10.9 - 62.1
	Lower Monumental	219	27.9	25.7	1.0	25.7	16.2 - 69.6
	McNary	82	34.1	6.0	1.3	33.6	21.8 - 51.4
	John Day	16	41.9	8.3	4.4	39.6	32.5 - 62.9
	Bonneville	7	41.3	6.7	6.2	40.4	33.6 - 54.4
Captain John Rapids	Lower Granite	1,342	13.2	4.1	0.2	13.1	1.2 - 49.7
	Little Goose	558	18.9	6.3	0.5	17.4	9.9 - 49.3
	Lower Monumental	117	24.2	22.5	1.2	22.5	13.5 - 49.6
	McNary	29	30.9	8.4	3.2	30.0	19.9 - 48.4
	John Day	8	33.7	7.1	5.9	36.1	22.5 - 42.7
	Bonneville	0	n/a	n/a	n/a	n/a	n/a
Lyons Ferry Hatchery	Lower Monumental	502	16.7	15.9	0.6	15.9	3.5 - 51.0
	McNary	134	28.0	8.1	1.4	27.6	12.8 - 73.2
	John Day	25	33.5	7.4	3.1	34.2	18.3 - 55.7
	Bonneville	3	40.9	9.6	23.8	45.9	29.9 - 46.9

Appendix D (continued).

Table D.2.—All Obs travel time (days) of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 2001.

Release Group	Interrogation Site	*n*	Mean	Standard Deviation	95% C.I. (+/-)	Median	Range
Pittsburg Landing	Lower Granite	3,644	17.4	6.4	0.2	16.1	7.1 - 83.9
	Little Goose	3,933	23.6	8.3	0.3	20.7	10.9 - 93.3
	Lower Monumental	2,953	29.1	26.9	0.3	26.9	14.4 - 85.8
	McNary	375	37.8	8.6	0.9	36.6	20.1 - 62.9
	John Day	797	43.5	9.1	0.6	42.5	25.8 - 110.5
	Bonneville	223	47.1	8.9	1.2	46.4	30.8 - 81.4
Big Canyon	Lower Granite	3,629	17.8	6.0	0.2	17.0	5.1 - 65.8
	Little Goose	3,809	23.7	7.6	0.2	21.5	9.5 - 69.9
	Lower Monumental	2,865	28.8	27.1	0.3	27.1	12.0 - 89.1
	McNary	918	36.4	7.7	0.5	36.6	19.3 - 82.8
	John Day	902	42.5	8.1	0.5	41.9	23.5 - 112.9
	Bonneville	266	45.2	7.9	1.0	44.5	25.7 - 80.4
Captain John Rapids	Lower Granite	1,342	13.2	4.1	0.2	13.1	1.2 - 49.7
	Little Goose	1,507	19.3	6.6	0.3	17.5	9.9 - 54.7
	Lower Monumental	1,198	25.2	22.7	0.5	22.7	13.2 - 78.0
	McNary	158	32.6	8.3	1.3	31.3	17.8 - 61.8
	John Day	426	39.1	7.7	0.7	38.0	22.5 - 71.7
	Bonneville	125	43.9	7.7	1.4	44.0	27.3 - 65.2
Lyons Ferry Hatchery	Lower Monumental	502	16.7	15.9	0.6	15.9	3.5 - 51.0
	McNary	379	29.3	8.3	0.8	28.5	12.8 - 76.9
	John Day	199	35.9	7.5	1.0	36.2	18.3 - 57.9
	Bonneville	58	41.2	8.6	2.3	41.1	23.2 - 66.9

Appendix D (continued).

Table D.3.—First Obs migration rate (rkm/d) of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 2001.

Release Group	Interrogation Site	*n*	Mean	Median	Range
Pittsburg Landing	Lower Granite	3,644	9.9	10.8	2.1 - 24.5
	Little Goose	1,404	10.3	11.3	3.5 - 21.4
	Lower Monumental	221	9.7	10.5	4.3 - 18.1
	McNary	63	10.8	10.6	6.1 - 17.4
	John Day	11	13.3	13.7	9.2 - 18.8
	Bonneville	1	12.8	12.8	12.8 - 12.8
Big Canyon	Lower Granite	3,629	6.1	6.3	1.6 - 21.3
	Little Goose	1,345	7.2	7.9	2.7 - 15.5
	Lower Monumental	219	7.7	8.3	3.1 - 13.2
	McNary	82	9.8	9.9	6.5 - 15.2
	John Day	16	10.9	11.5	7.2 - 14.0
	Bonneville	7	13.8	14.1	10.5 - 16.9
Captain John Rapids	Lower Granite	1,342	6.8	6.9	1.8 - 72.5
	Little Goose	558	7.9	8.6	3.0 - 15.2
	Lower Monumental	117	8.1	8.7	4.0 - 14.6
	McNary	29	10.2	10.5	6.5 - 15.9
	John Day	8	13.0	12.1	10.3 - 19.4
	Bonneville	0	n/a	n/a	n/a
Lyons Ferry Hatchery	Lower Monumental	502	1.7	1.8	0.5 - 8.1
	McNary	134	5.2	5.3	2.0 - 11.4
	John Day	25	8.1	7.9	4.8 - 14.7
	Bonneville	3	9.4	8.3	8.2 - 12.8

Appendix D (continued).

Table D.4.—All Obs migration rate (rkm/d) of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 2001.

Release Group	Interrogation Site	*n*	Mean	Median	Range
Pittsburg Landing	Lower Granite	3,644	9.9	10.8	2.1 - 24.5
	Little Goose	3,933	9.9	11.2	2.5 - 21.4
	Lower Monumental	2,953	9.6	10.4	3.3 - 19.4
	McNary	375	10.5	10.9	6.3 - 19.8
	John Day	797	12.0	12.3	4.7 - 20.2
	Bonneville	223	13.5	13.7	7.8 - 20.6
Big Canyon	Lower Granite	3,629	6.1	6.3	1.6 - 21.3
	Little Goose	3,809	7.1	7.8	2.4 - 17.7
	Lower Monumental	2,865	7.4	7.9	2.4 - 17.9
	McNary	918	9.1	9.1	4.0 - 17.2
	John Day	902	10.7	10.9	4.0 - 19.4
	Bonneville	266	12.6	12.8	7.1 - 22.2
Captain John Rapids	Lower Granite	1,342	6.8	6.9	1.8 - 72.5
	Little Goose	1,507	7.8	8.6	2.7 - 15.2
	Lower Monumental	1,198	7.8	8.6	2.5 - 14.9
	McNary	158	9.6	10.1	5.1 - 17.7
	John Day	426	11.2	11.5	6.1 - 19.4
	Bonneville	125	12.6	12.5	8.4 - 20.2
Lyons Ferry Hatchery	Lower Monumental	502	1.7	1.8	0.5 - 8.1
	McNary	379	5.0	5.2	1.9 - 11.4
	John Day	199	7.5	7.5	4.7 - 14.7
	Bonneville	58	9.3	9.3	5.7 - 16.5

Appendix E. Arrival date frequency distributions and cumulative frequencies for PIT tagged yearling fall Chinook from the FCAP sites and LFH based on first and all obs at Lower Snake and Columbia River dams in 2001.

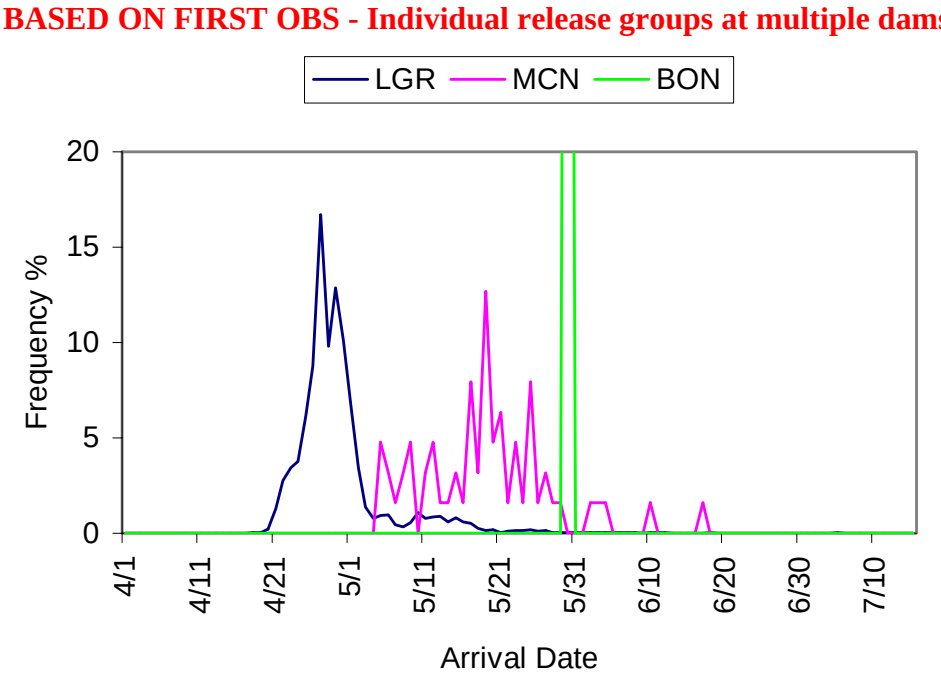

Figure E.1.—First obs arrival date frequency distribution of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2001.

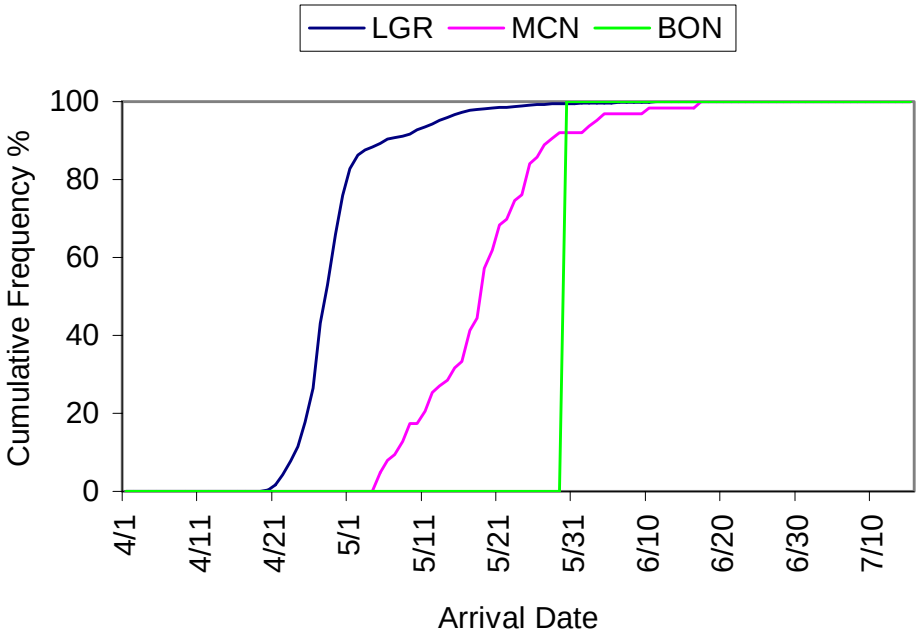

Figure E.2.—First obs arrival date cumulative frequency of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2001.

Appendix E (continued).

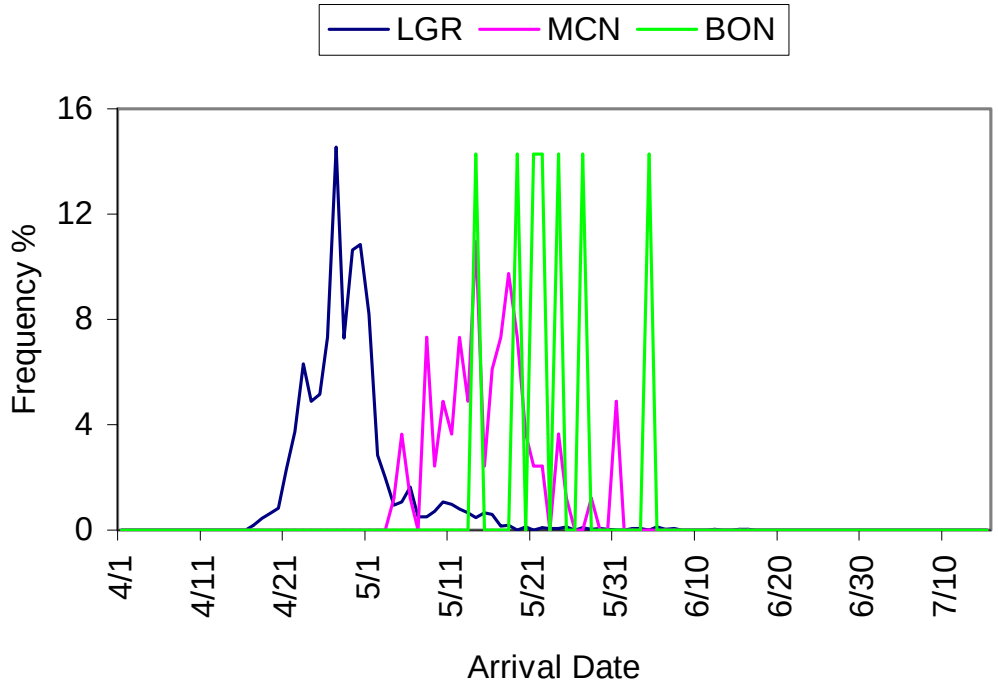

Figure E.3.—First obs arrival date frequency distribution of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2001.

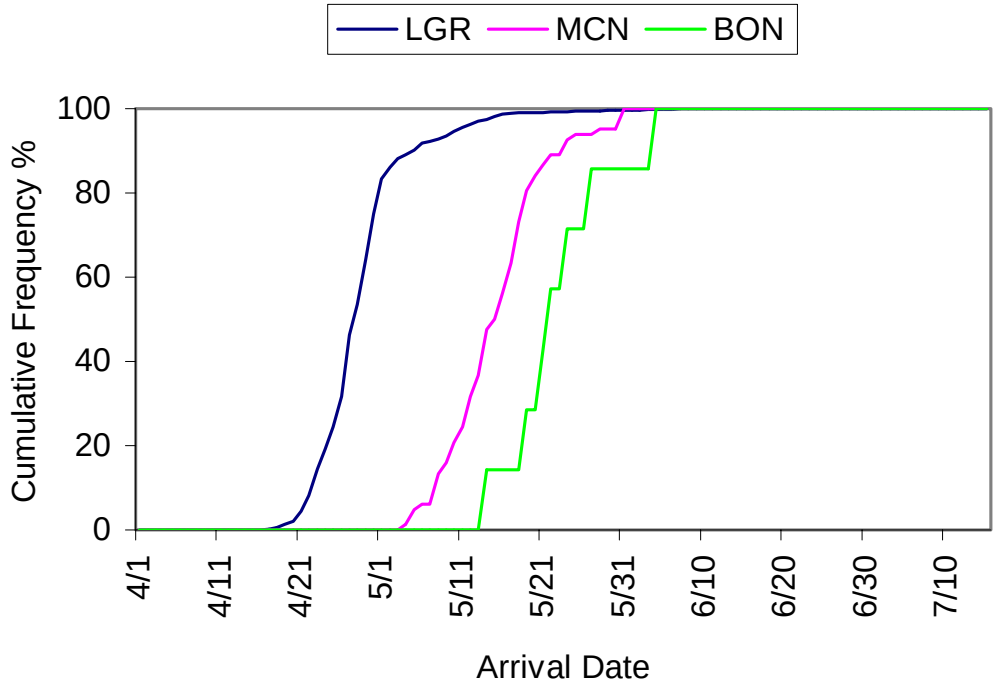

Figure E.4.—First obs arrival date cumulative frequency of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2001.

Appendix E (continued).

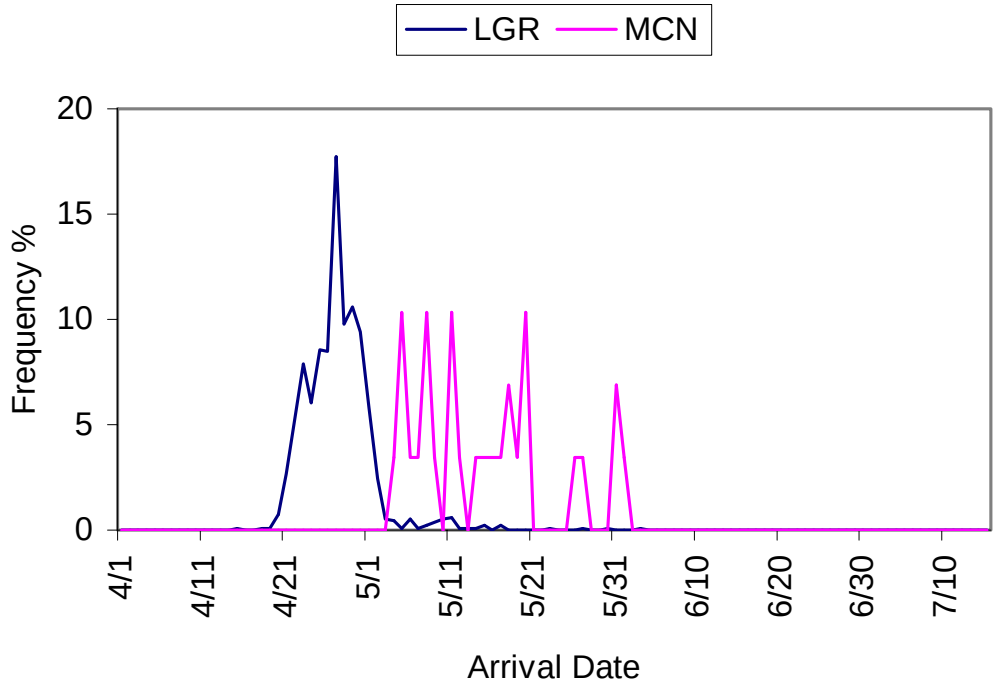

Figure E.5.—First obs arrival date frequency distribution of Captain John Rapids yearlings at Lower Granite and McNary dams in 2001. Zero first obs at Bonneville Dam.

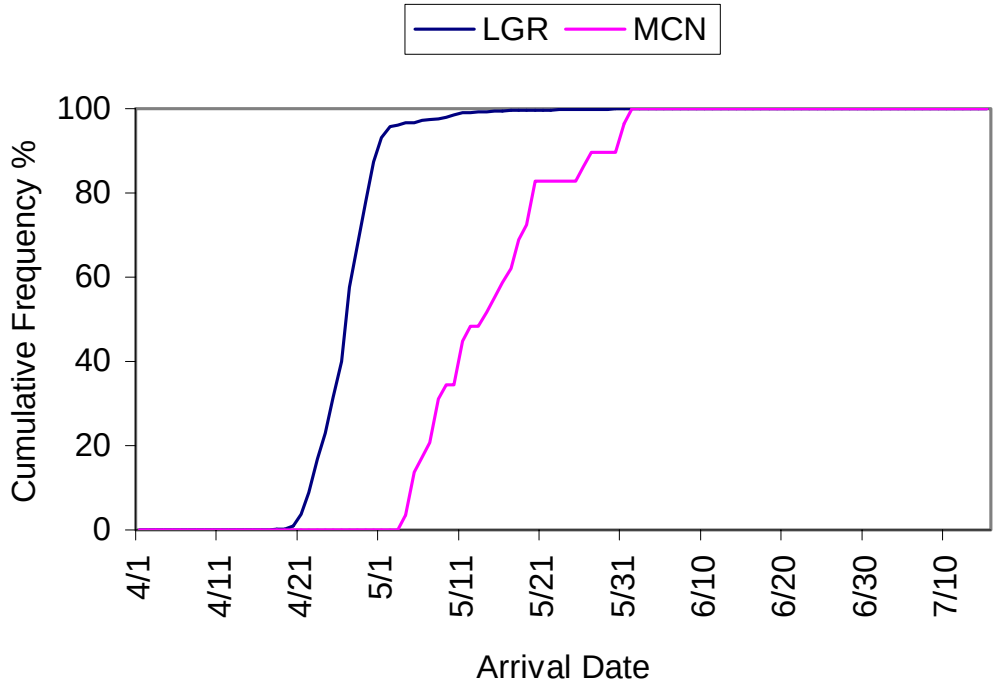

Figure E.6.—First obs arrival date cumulative frequency of Captain John Rapids yearlings at Lower Granite and McNary dams in 2001. Zero first obs at Bonneville Dam.

Appendix E (continued).

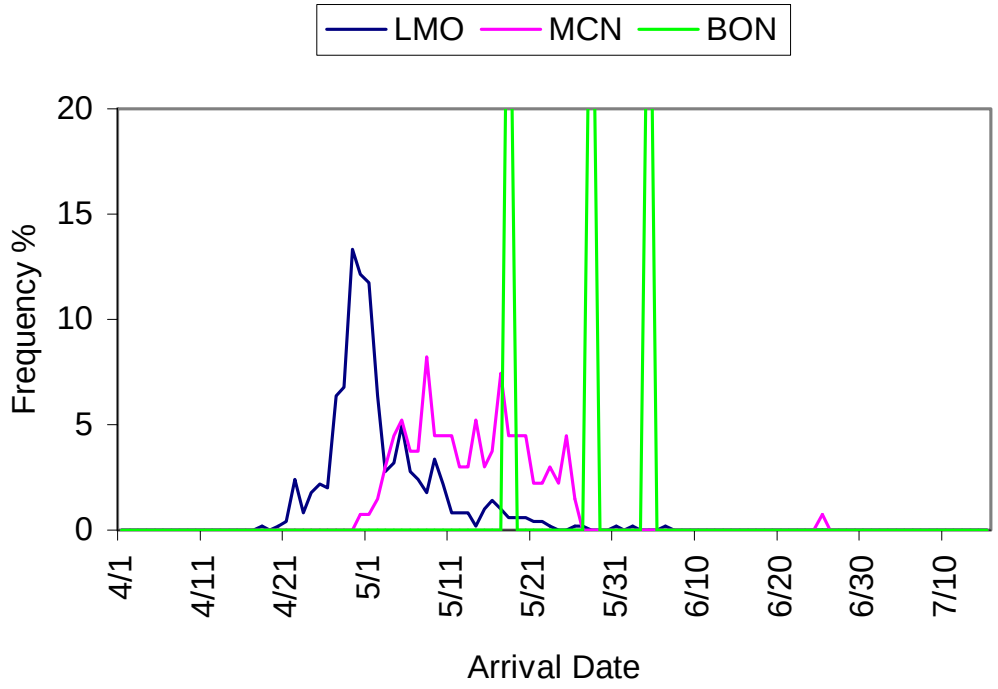

Figure E.7.—First obs arrival date frequency distribution of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 2001.

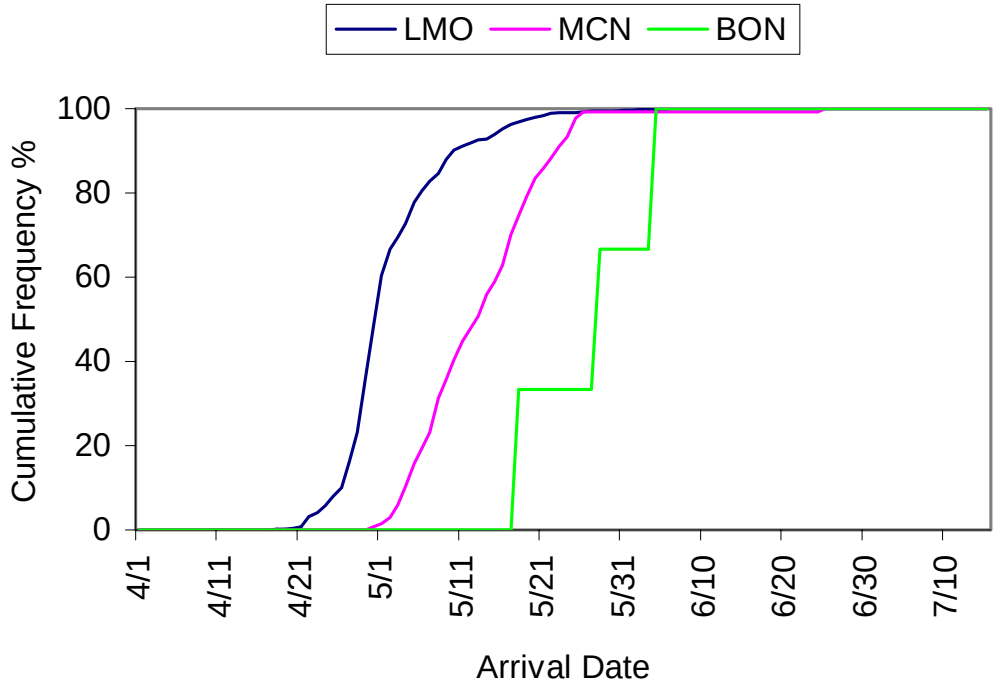

Figure E.8.—First obs arrival date cumulative frequency of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 2001.

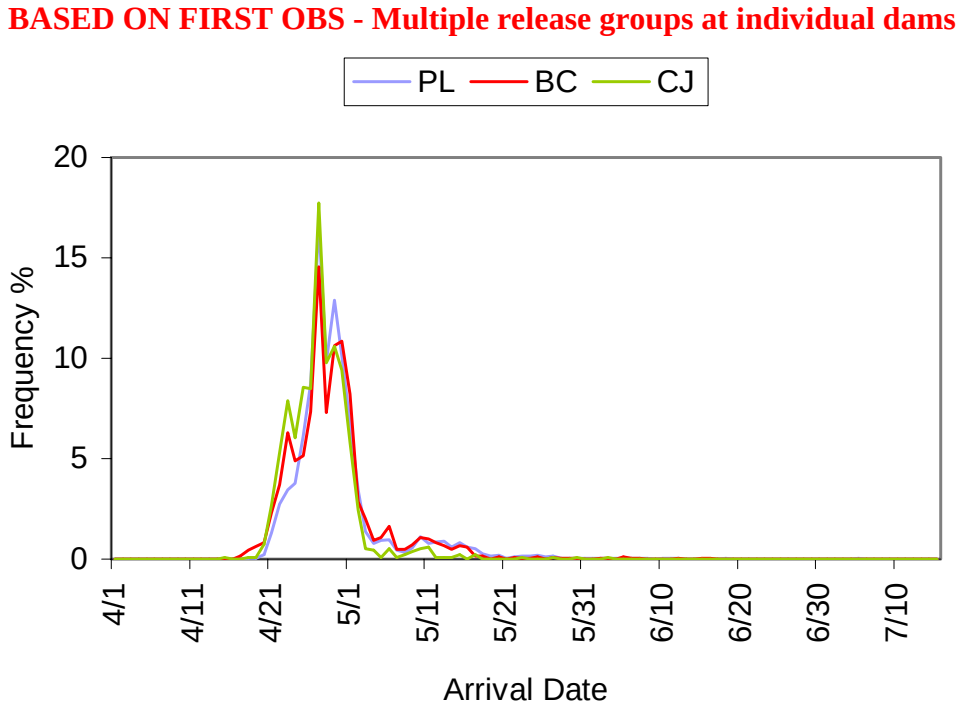

Figure E.9.—First obs arrival date frequency distribution of FCAP yearlings at Lower Granite Dam in 2001.

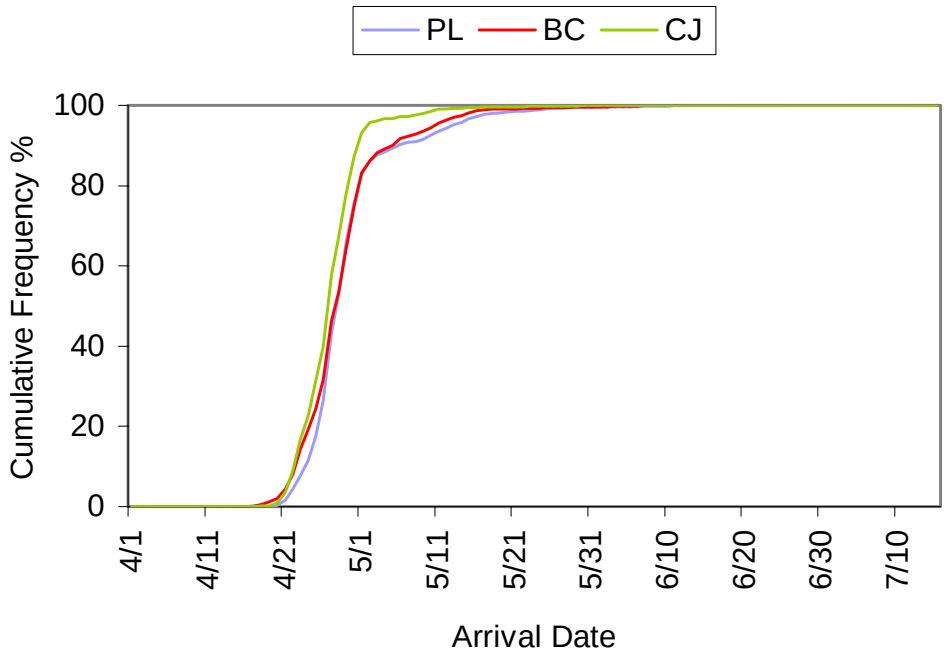

Figure E.10.—First obs arrival date cumulative frequency of FCAP yearlings at Lower Granite Dam in 2001.

Appendix E (continued).

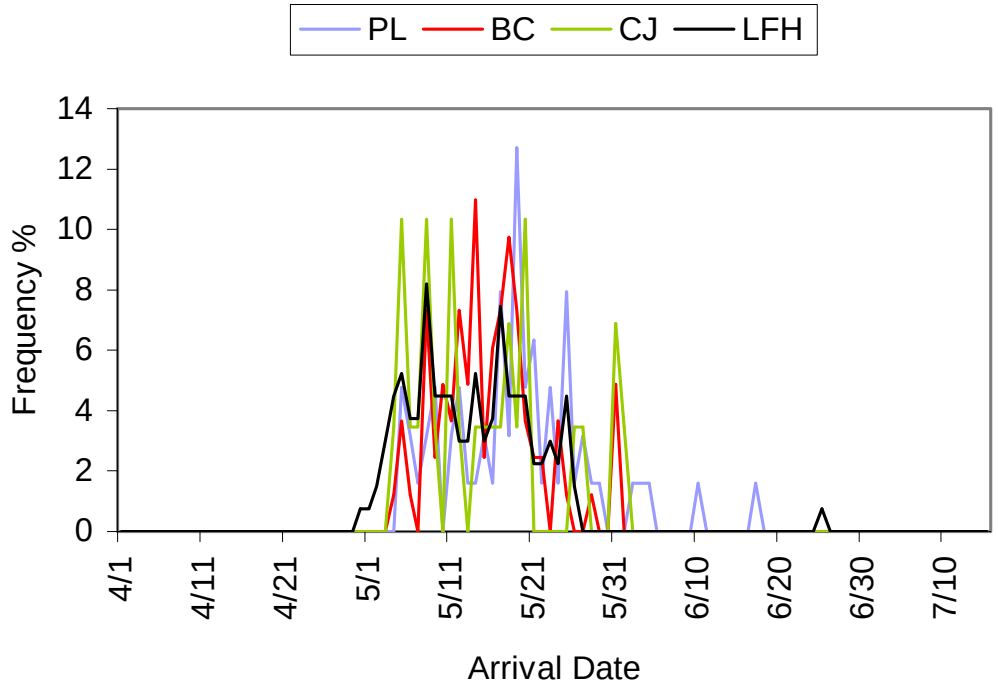

Figure E.11.—First obs arrival date frequency distribution of FCAP and LFH yearlings at McNary Dam in 2001.

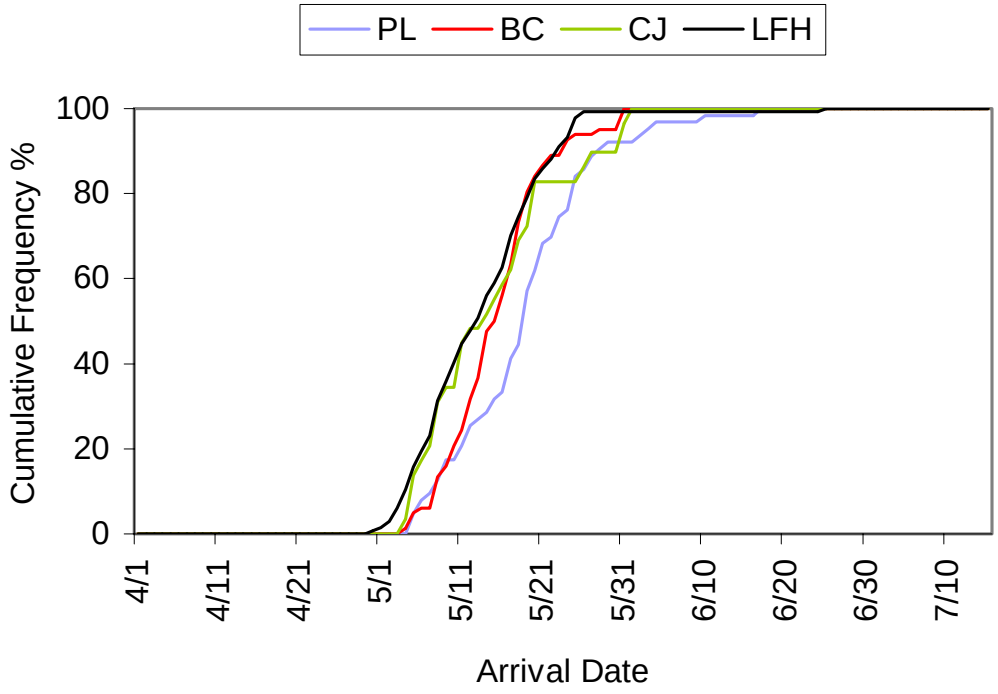

Figure E.12.—First obs arrival date cumulative frequency of FCAP and LFH yearlings at McNary Dam in 2001.

Appendix E (continued).

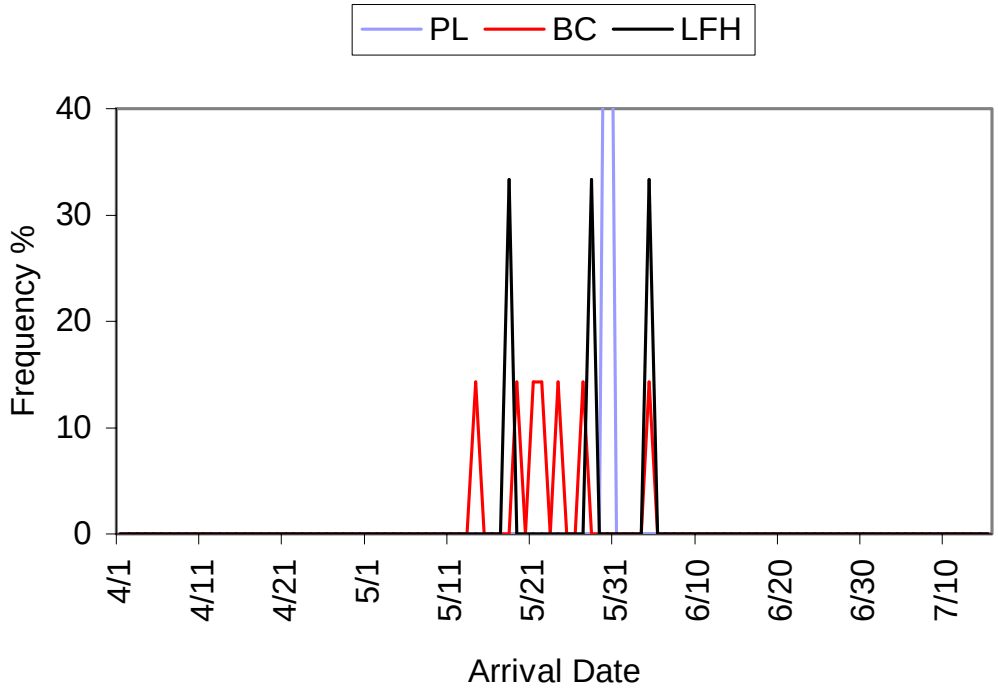

Figure E.13.—First obs arrival date frequency distribution of FCAP and LFH yearlings at Bonneville Dam in 2001. Captain John Rapids had zero first obs at Bonneville Dam.

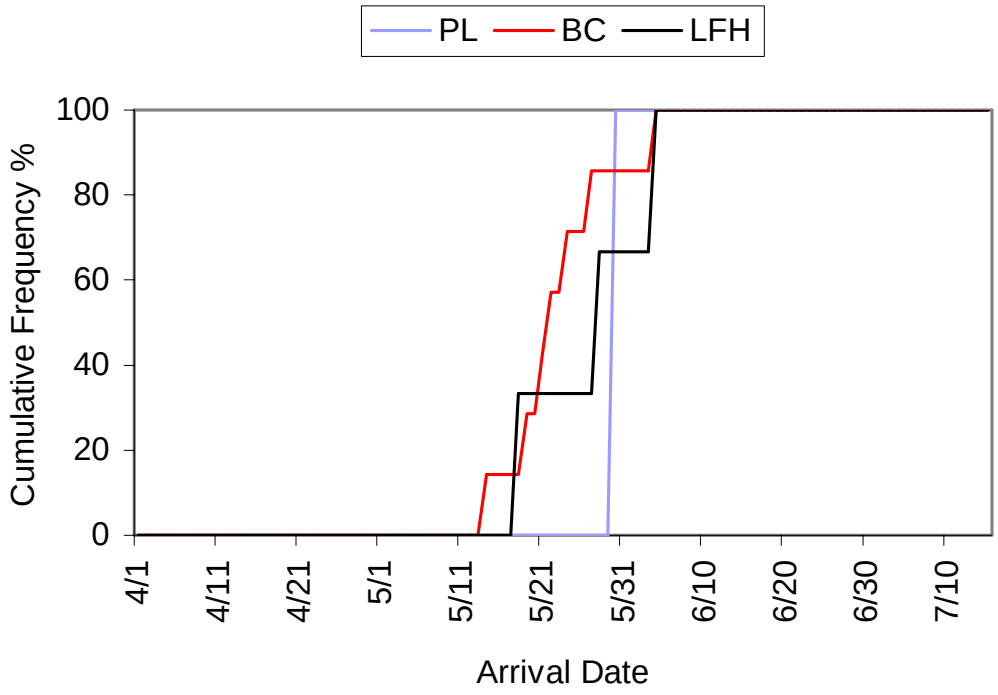

Figure E.14.—First obs arrival date cumulative frequency of FCAP and LFH yearlings at Bonneville Dam in 2001. Captain John Rapids had zero first obs at Bonneville Dam.

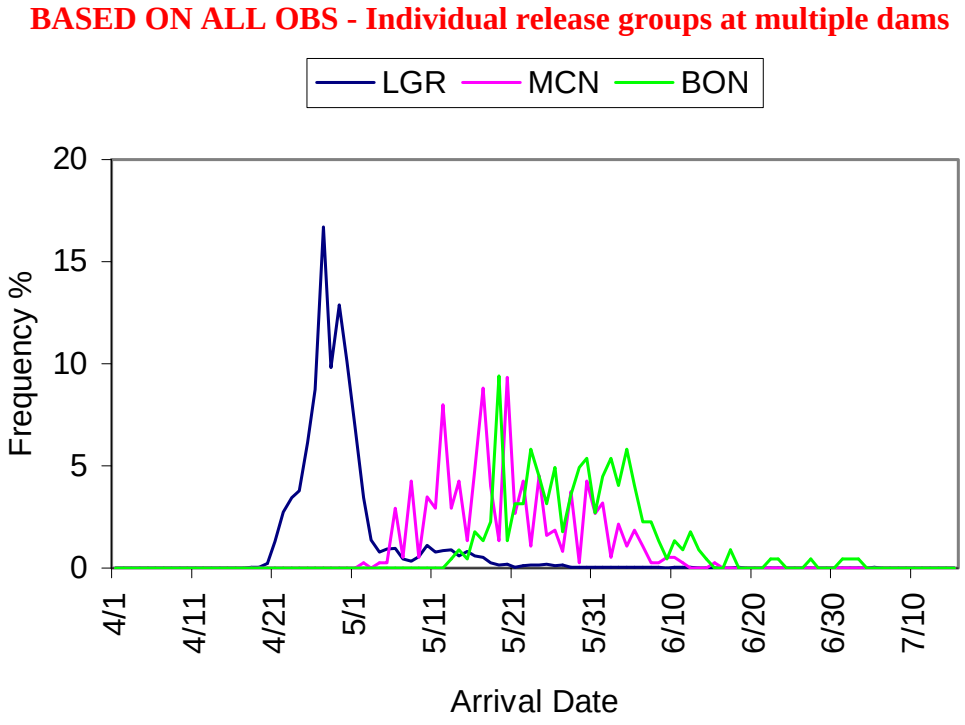

Figure E.15.—All obs arrival date frequency distribution of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2001.

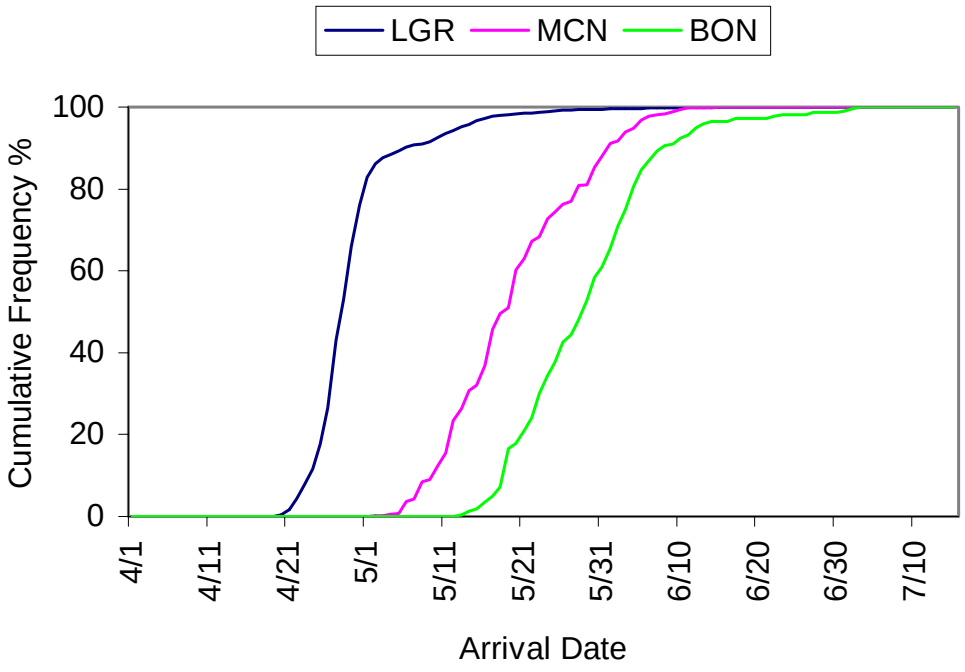

Figure E.16.—All obs arrival date cumulative frequency of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2001.

Appendix E (continued).

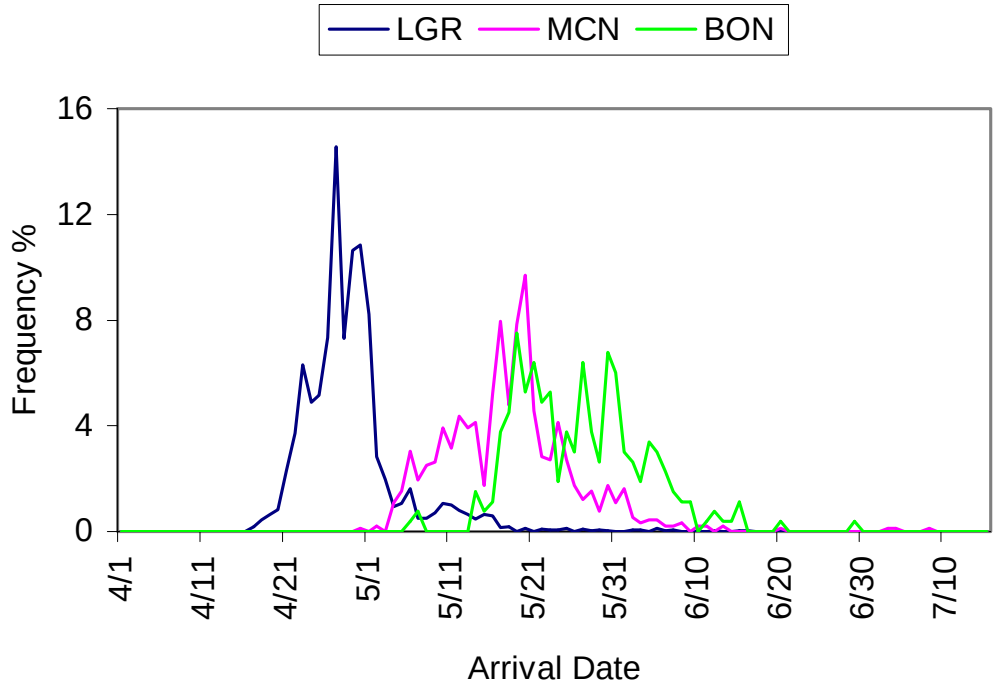

Figure E.17.—All obs arrival date frequency distribution of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2001.

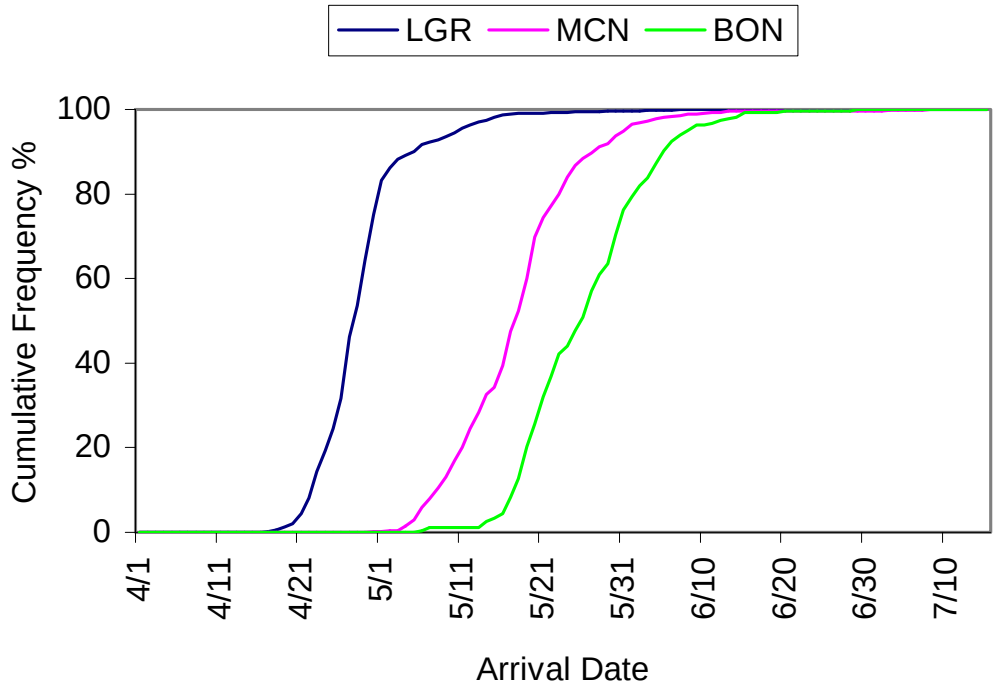

Figure E.18.—All obs arrival date cumulative frequency of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2001.

Appendix E (continued).

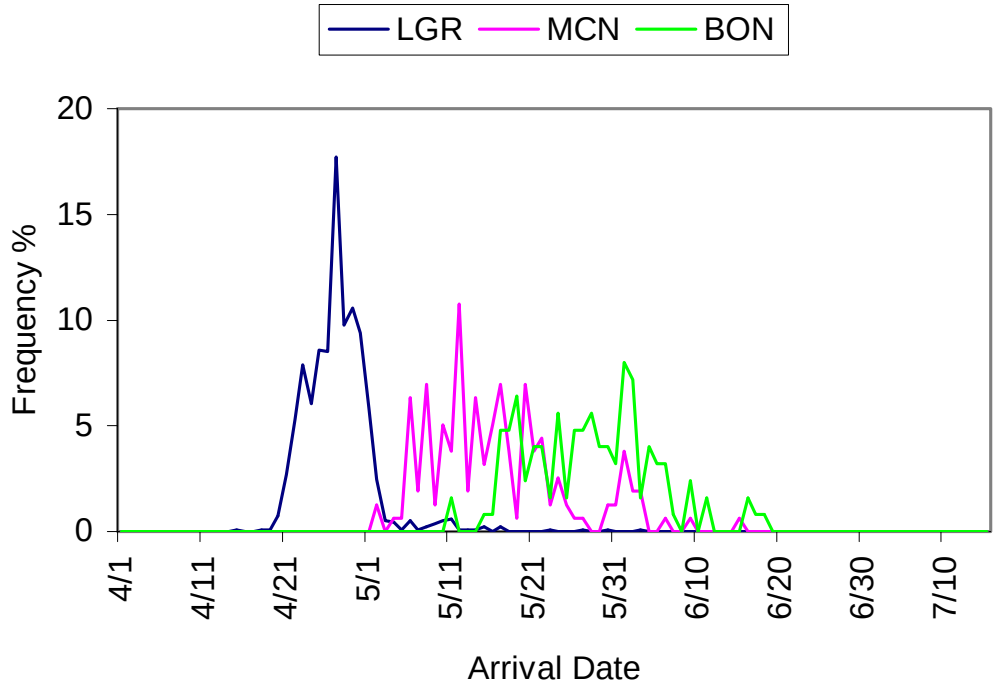

Figure E.19.—All obs arrival date frequency distribution of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2001.

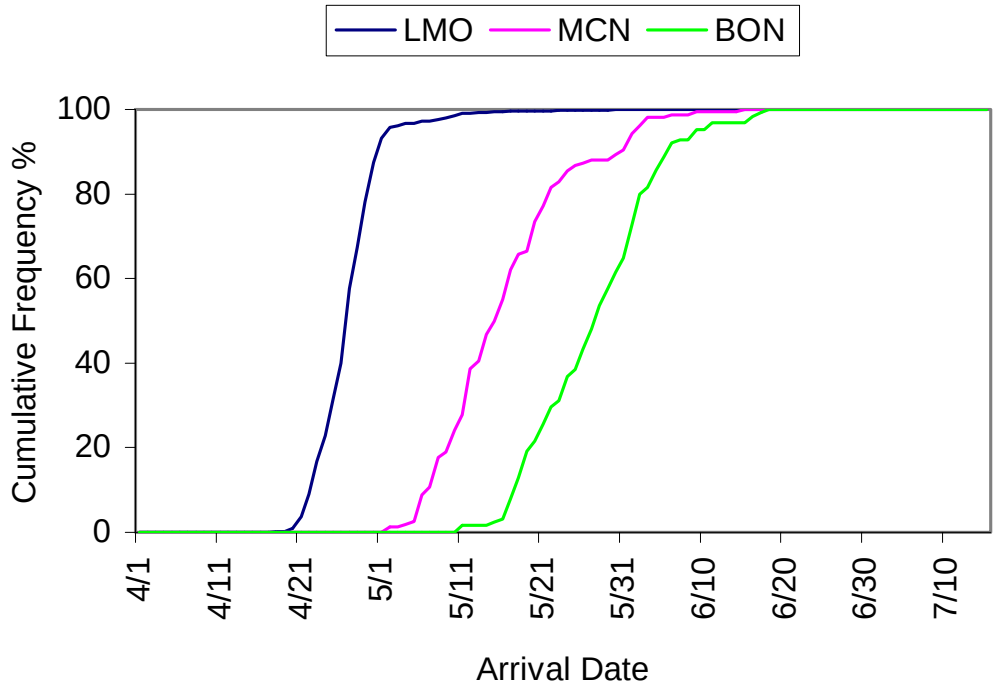

Figure E.20.—All obs arrival date cumulative frequency of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2001.

Appendix E (continued).

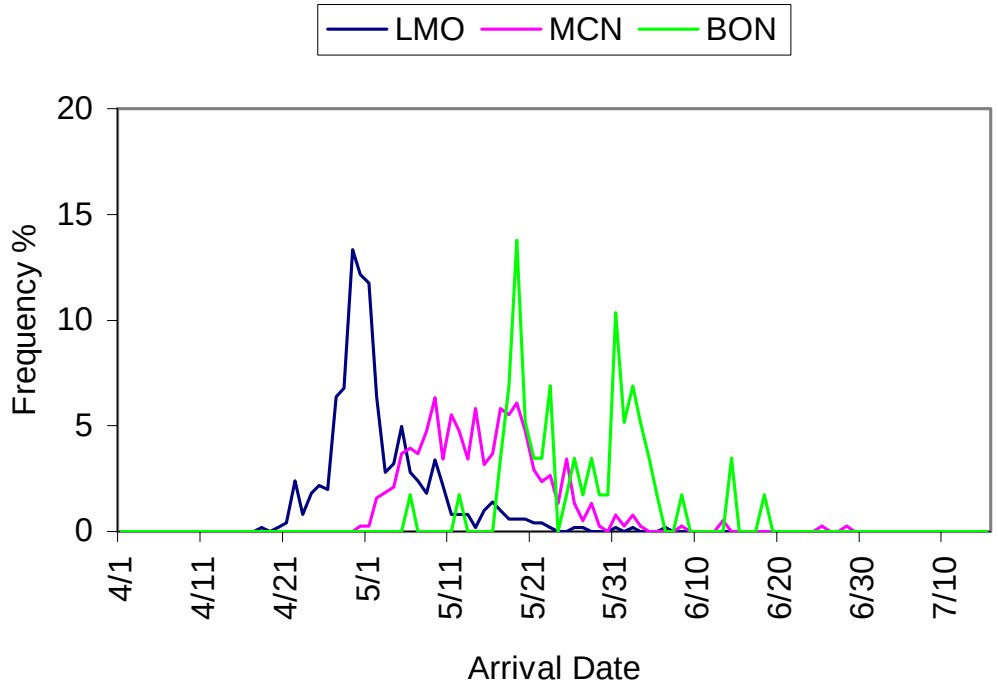

Figure E.21.—All obs arrival date frequency distribution of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 2001.

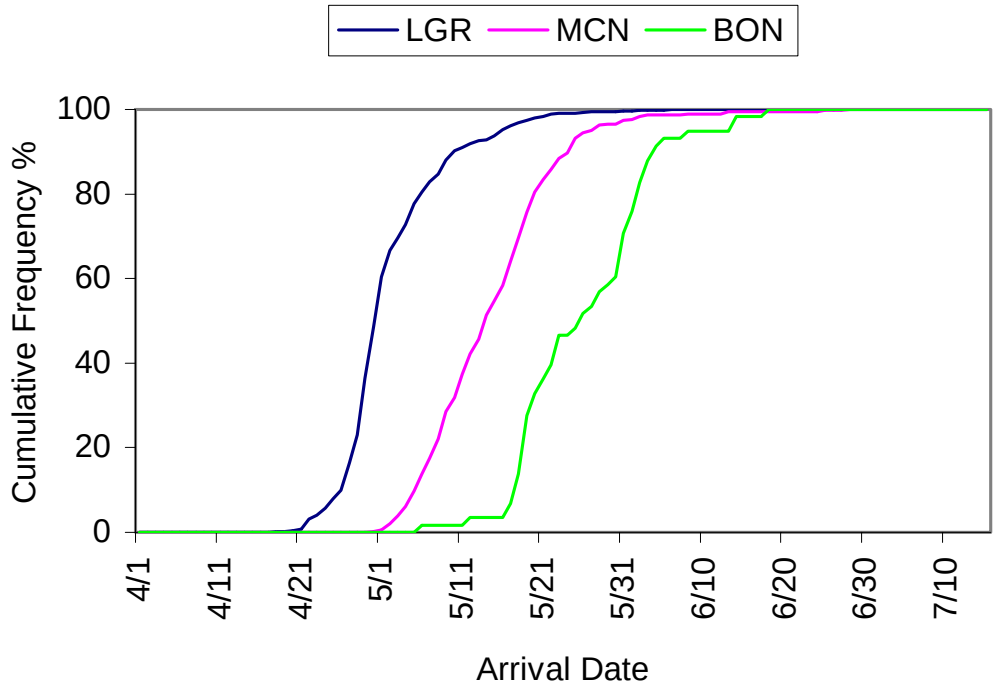

Figure E.22.—All obs arrival date cumulative frequency of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 2001.

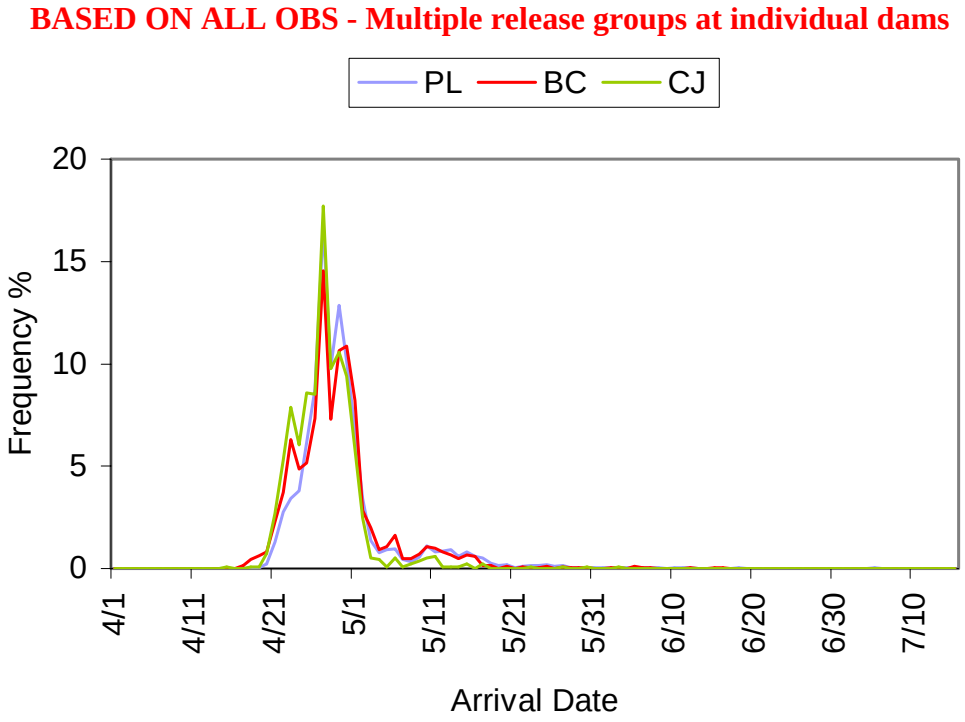

Figure E.23.—All obs arrival date frequency distribution of FCAP yearlings at Lower Granite Dam in 2001.

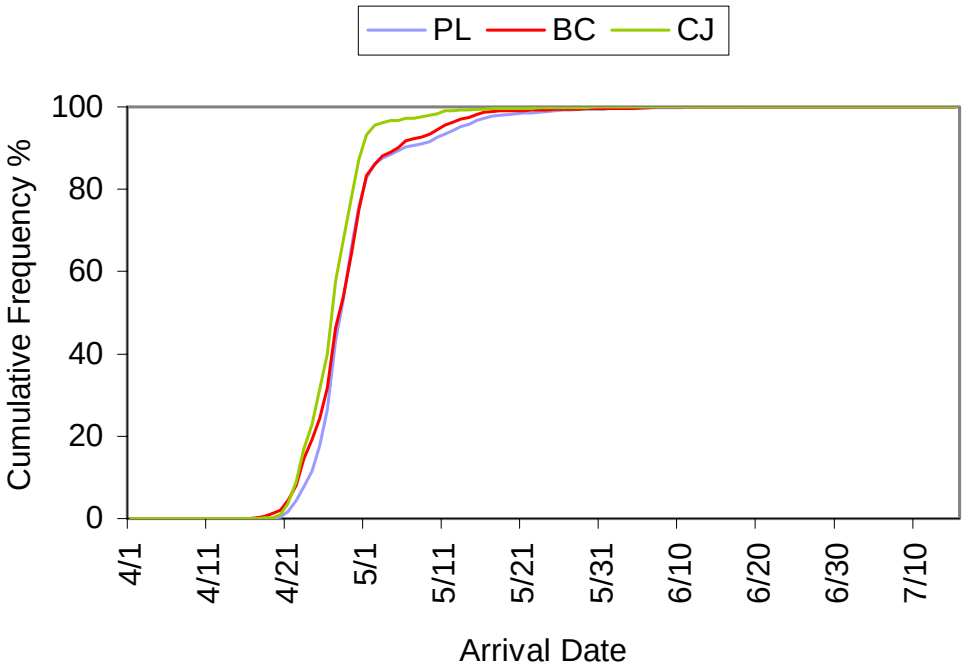

Figure E.24.—All obs arrival date cumulative frequency of FCAP yearlings at Lower Granite Dam in 2001.

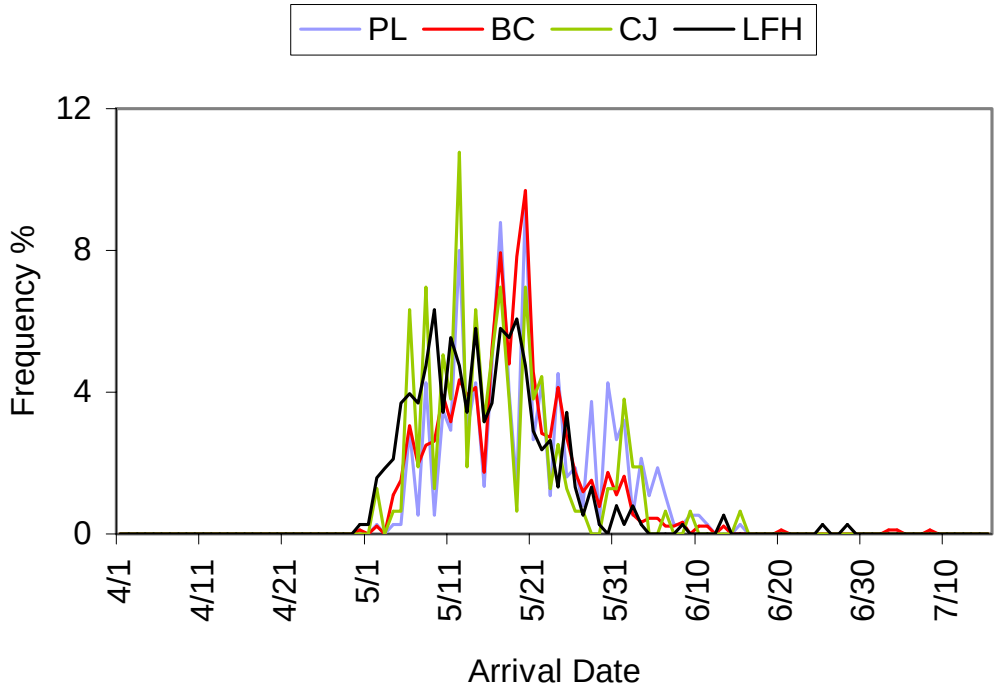

Figure E.25.—All obs arrival date frequency distribution of FCAP and LFH yearlings at McNary Dam in 2001.

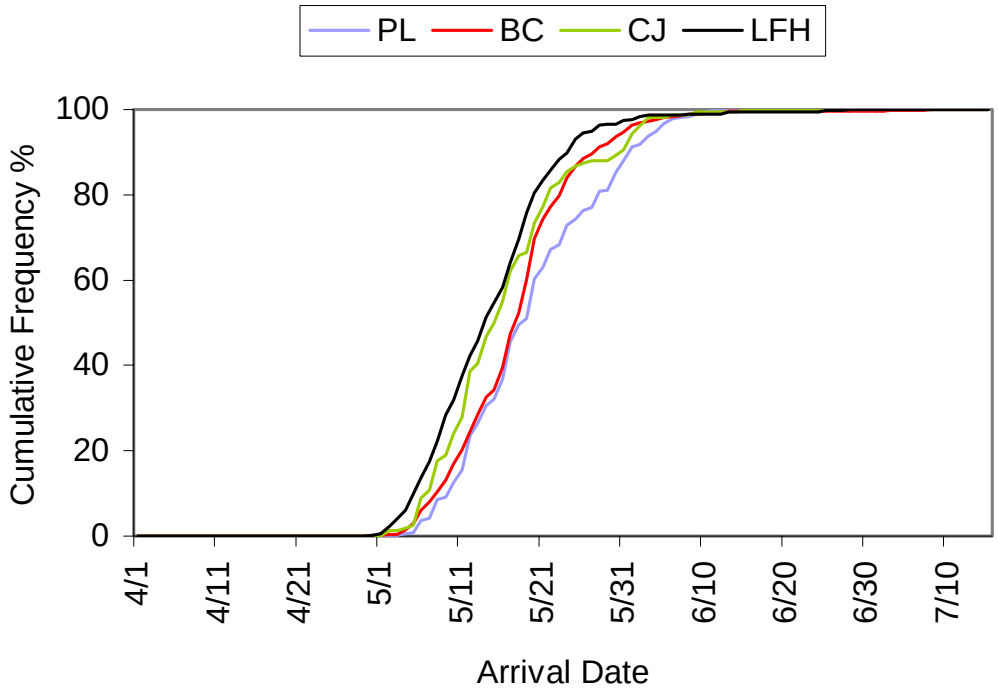

Figure E.26.—All obs arrival date cumulative frequency of FCAP and LFH yearlings at McNary Dam in 2001.

Appendix E (continued).

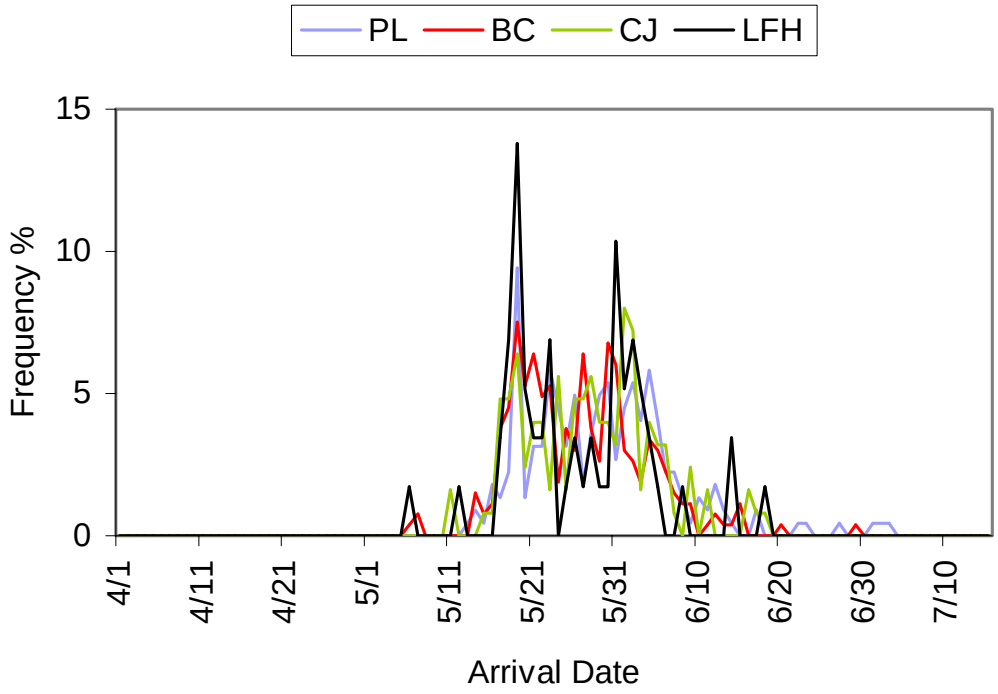

Figure E.27.—All obs arrival date frequency distribution of FCAP and LFH yearlings at Bonneville Dam in 2001.

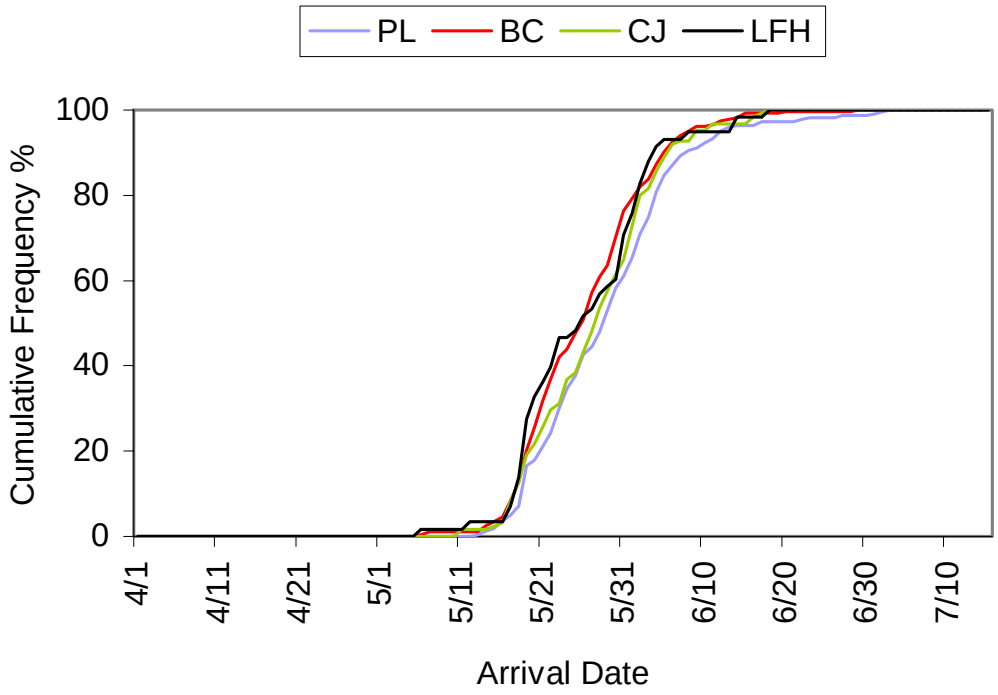

Figure E.28.—All obs arrival date cumulative frequency of FCAP and LFH yearlings at Bonneville Dam in 2001.