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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 1999 – December 1999

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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 along with yearlings released on-station from Lyons Ferry Hatchery in 1999. This was the fourth year of a long-term project to supplement natural spawning populations of Snake River stock fall Chinook salmon upstream of Lower Granite Dam. The 453,117 yearlings released from the Fall Chinook Acclimation Project facilities not only slightly exceeded the 450,000 fish quota, but a second release of 76,386 yearlings (hereafter called Surplus) were acclimated at the Big Canyon facility and released about two weeks after the primary releases. 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 9,941 PIT tagged yearlings from Pittsburg Landing, 9,583 from Big Canyon, 2,511 Big Canyon Surplus and 2,494 from Captain John Rapids. The Washington Department of Fish and Wildlife released 983 PIT tagged yearlings from Lyons Ferry Hatchery. Fish health sampling indicated that, overall, bacterial kidney disease levels could be considered relatively low and did not appear to increase after transport to the acclimation facilities. Compared to prior years, Quantitative Health Assessment Indices were relatively low at Pittsburg Landing and Lyons Ferry Hatchery and relatively high at Big Canyon and Captain John Rapids.

Mean fork lengths (95% confidence interval) of the release groups ranged from 147.4 mm (146.7-148.1 mm) at Captain John Rapids to 163.7 mm (163.3-164.1 mm) at Pittsburg Landing. Mean condition factors ranged from 1.04 at Pittsburg Landing to 1.23 at Captain John Rapids.

Estimated survival (95% confidence interval) of PIT tagged yearlings from release to Lower Granite Dam ranged from 87.8% (82.1-93.4%) for Big Canyon Surplus to 94.1% (90.1-98.1%) for Captain John Rapids. Estimated survival from release to McNary Dam ranged from 58.7% (49.3-68.1%) for Big Canyon Surplus to 71.3% (60.1-82.5%) for Captain John Rapids.

Median migration rates to Lower Granite Dam, based on all observations of PIT tagged yearlings from the FCAP facilities, ranged from 9.3 river kilometers per day (rkm/d) for Captain John Rapids to 18.7 rkm/d for Pittsburg Landing. Median migration rates to McNary Dam ranged from 9.0 rkm/d for Lyons Ferry Hatchery to 17.3 rkm/d for Pittsburg Landing. Median travel times from the FCAP facilities were about 7-10 days to Lower Granite Dam and 21-23 days to McNary Dam.

Median arrival dates at Lower Granite Dam, based on all observations of PIT tagged yearling groups from the FCAP facilities, were all from April 23-25. The median arrival date for Big Canyon Surplus was May 4. Median arrival dates at McNary Dam for Pittsburg Landing, Big Canyon and Captain John Rapids groups were all from May 7-8. Median arrival dates at McNary Dam were May 17 for Big Canyon Surplus and April 26 for Lyons Ferry Hatchery.

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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 1999. This was the fourth 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 1999. We are in the third 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 1999 please reference Milks et al. (2000).

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.

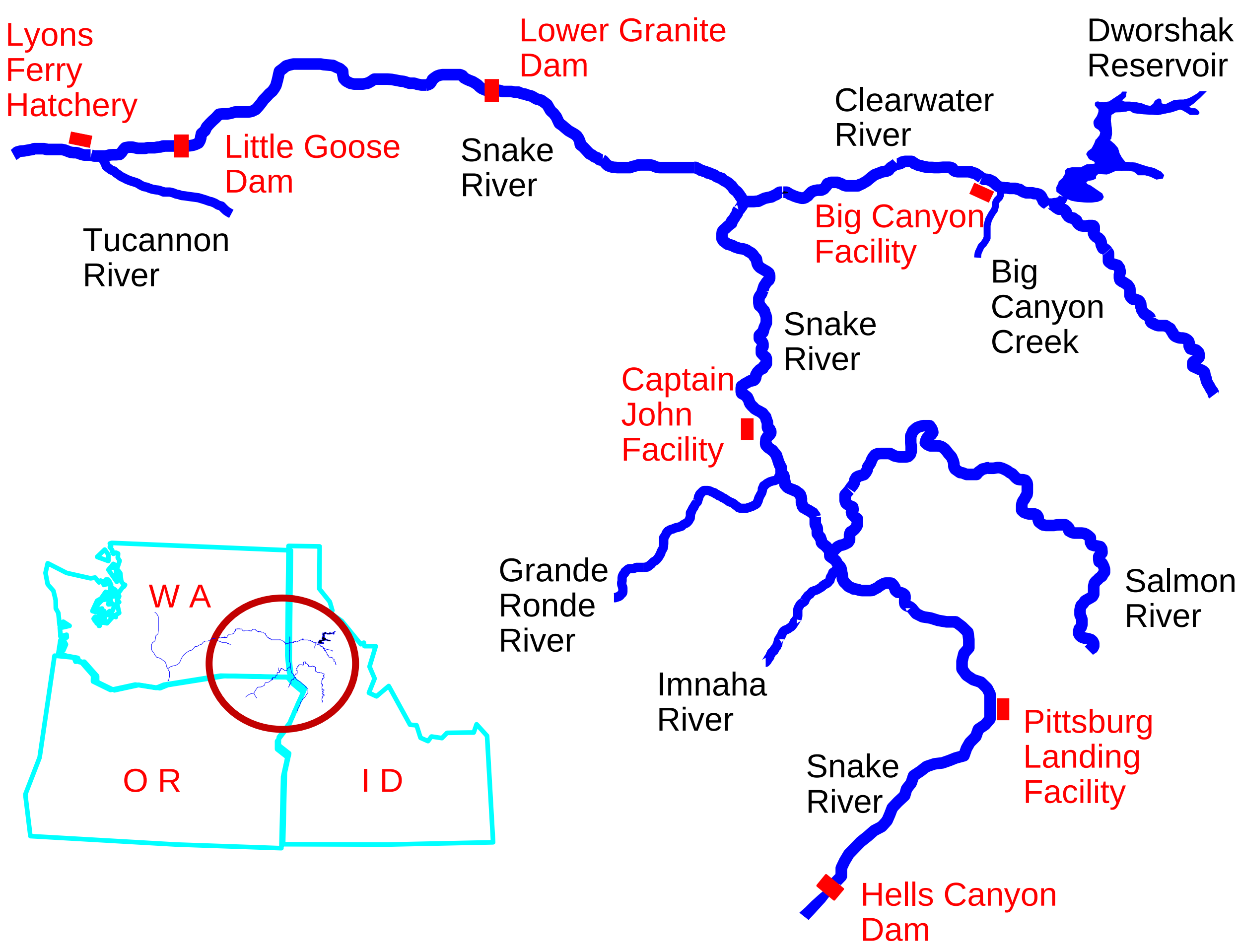

Figure 1.—Map of primary study area highlighting FCAP acclimation facilities, Lyons Ferry Hatchery and various Snake River dams.

Fish Handling and Anesthetization

Yearlings at Pittsburg Landing and Big Canyon were acclimated in 16 tanks (6 m diameter) and released in stages over four 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 3, 7, 9 and 16 at Pittsburg Landing and tanks 0A4, 0B1, 0C4 and 0D3 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 and LFH were captured from the pond and Lake 2, respectively, tagged, allowed to recover and released back into the pond or lake to migrate volitionally with the rest of the fish. For a detailed description of fall Chinook salmon broodstock collection, incubation, rearing, and marking procedures at LFH please reference Milks et al. 2000.

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. An Organosomatic Index (Goede's Index) was determined for individual fish from each release group (Goede and Barton 1990). The Goede's Index was then converted to the Quantitative Health Assessment Index (QHAI), which takes the multiple Organosomatic Index scores and converts them into one overall QHAI value for each individual fish, with zero being the best possible value (Adams et al. 1993). The overall QHAI for a group was the mean of QHAI values of all the individual fish sampled from that group. In addition, 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 ≥ 1.000 were considered to have high infection levels (Pascho et al. 1991). The QHAI data was collected specifically as baseline data and 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. Captain John Rapids was excluded from this analysis as it has only been in operation for two years.

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. NPT and WDFW personnel PIT tagged the Surplus yearlings at LFH prior to transfer to Big Canyon. WDFW personnel conducted PIT tagging activities 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. The 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 or 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. This was the first year that John Day and Bonneville dams served as fully-functional main interrogation sites. 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 volitional releases were employed at Captain John Rapids and LFH, we are reporting travel times and migration rates for these fish 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, with no single fish being recorded at more than one dam. This provides a measure of “in-river” specific migration to a 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 142,885 yearlings were released from Pittsburg Landing and 153,222 from Big Canyon. The fish were released in stages, about one-fourth of each group per day for four days from April 12-15. A total of 157,010 yearlings were released volitionally from Captain John Rapids from April 12-15. Even though Pittsburg Landing came up short of its release quota, the total FCAP release number of 453,117 slightly exceeded the overall release quota of 450,000 yearlings. In addition, a total of 76,386 Surplus yearlings were transferred to Big Canyon after the first release, acclimated approximately ten days and released April 26-28. Lyons Ferry Hatchery was short of its 450,000 release quota, volitionally releasing 432,166 yearlings March 25 – April 13 (Milks et al. 2000).

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 small differences between groups.

This was the third 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 1999. 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 ensure that data collection did not exceed memory capacity. We also tracked radio tagged yearlings by fixed-wing aircraft and boat. We conducted 8 fixed-wing aircraft tracking flights ranging in distance from the FCAP facilities downstream as far as McNary Dam. We tracked by boat for 6 days on Lower Granite Reservoir and 5 days on Little Goose Reservoir.

Fish Health

Personnel from the USFWS Idaho Fish Health Center collected yearlings at the FCAP facilities and LFH from April 7-13, 1999 for health analysis. Table 2 summarizes the QHAI and ELISA results for all groups during pre-release exam. Compared to previous years at the same facilities, QHAI values were about average at Pittsburg Landing, Big Canyon and Captain John Rapids, but showed improvement at LFH. Overall, based on ELISA values, 1999 may be considered a year of relatively low levels of BKD in yearling fall Chinook salmon from LFH. Overall BKD levels did not appear 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.—Pre-release Quantitative Field Health Index mean values and the number of yearling fall Chinook salmon (with % of number sampled) in each ELISA level category at the FCAP facilities and LFH in 1999.

			ELISA			
Release Group	QHAI	*n*	Not Detected	Low	Medium	High
Pittsburg Landing	14.8	58	51 (88%)	0	7 (12%)	0 (0%)
Big Canyon	18.7	59	47 (80%)	0	10 (17%)	2 (3%)
Captain John Rapids	10.2	60	60 (100%)	0	0 (0%)	0 (0%)
Lyons Ferry Hatchery	14.3	59	50 (85%)	0	8 (14%)	1 (2%)

Flow and Temperature

The average flow in the Snake River near Hell's Canyon Dam in April was about 43% higher than the 33-year average from 1965 to 1998. Flows began to increase rapidly on February 25, rising from 30,300 cfs on February 24 to peak at 63,600 cfs on March 27 (Figure 2). Spring flow patterns at this location in 1999 did not resemble flow patterns in 1998. Flows peaked two months earlier than in 1998. Snake River flows near Hell's Canyon Dam were in a declining trend from the peak on March 27 throughout the rest of the spring and summer. Flow patterns at the Hell's Canyon gauge location are 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 37% higher than the 40-year average from 1958 to 1998, peaking at 131,604 cfs on May 31 (Figure 3). Flows at Anatone began to rise on February 19, about the same time as at Hell's Canyon Dam. The daily mean water temperature during April ranged from 7.5^{O} -10.8^{O} C with an overall mean of 9.2^{O} C.

The average daily discharge in the Clearwater River at Peck in April was about 13% higher than the 34-year average from 1964 to 1998. Discharge peaked at 60,200 cfs on May 26. The higher than normal flows seen at Peck from July 16 through September 5 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 4.8^{O}-8.0^{O} C with an overall mean of 6.3^{O} C.

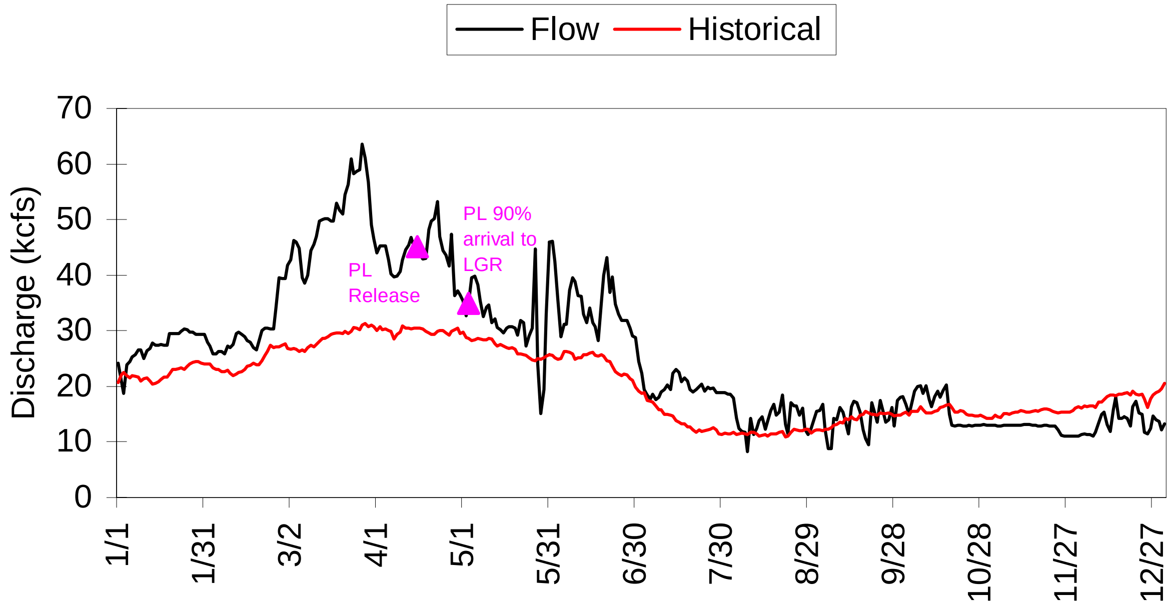

Figure 2.—Mean daily flow in 1999 and historical mean flow from 1965-1998 for the Snake River as measured at USGS gauge 13290450 near Hell's Canyon Dam.

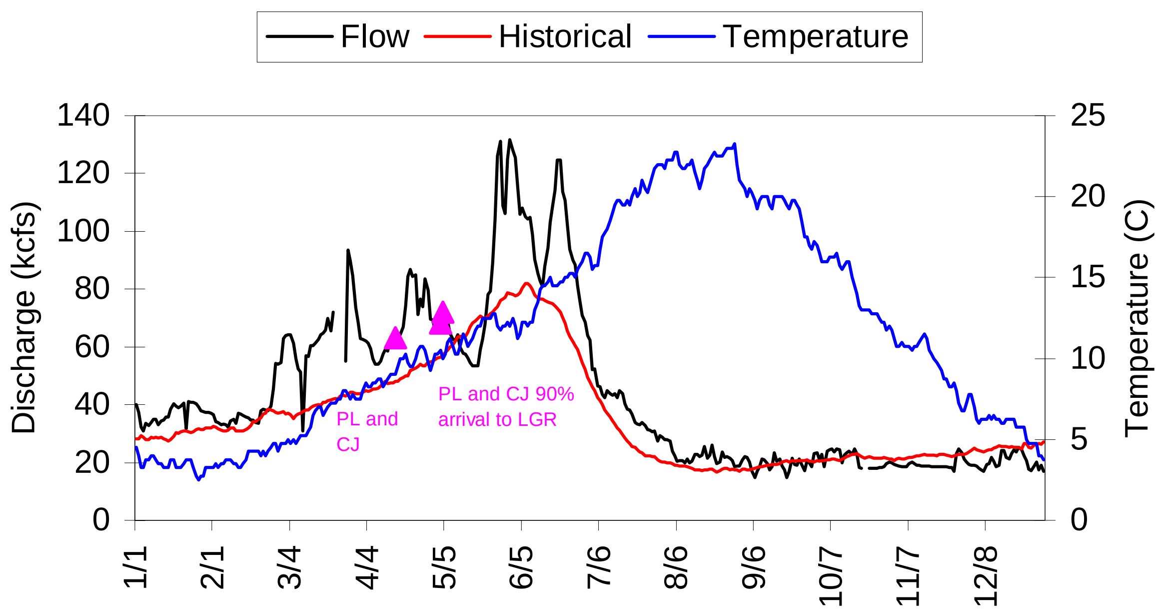

Figure 3.—Mean daily flow and temperature in 1999 and historical mean flow from 1958-1998 for the Snake River as measured at USGS gauge 13334300 near Anatone, Washington.

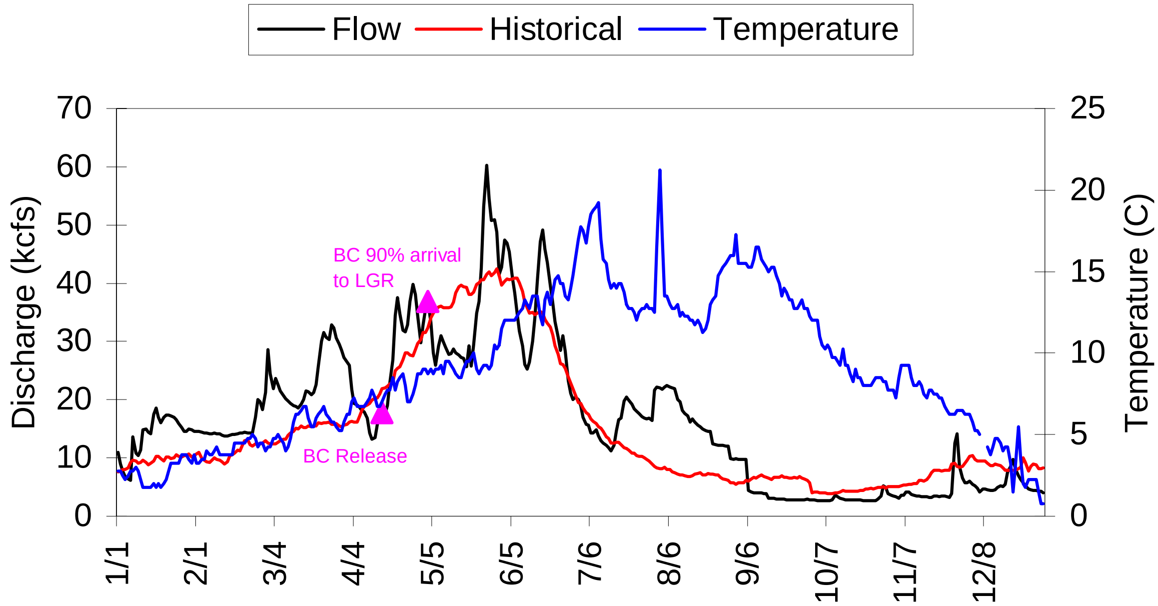

Figure 4.—Mean daily flow and temperature in 1999 and historical mean flow from 1964-1998 for the Clearwater River as measured at USGS gauge 13341050 near Peck, Idaho.

Average daily outflow as measured in the tailrace at Lower Granite Dam began increasing with spring runoff from 51.2 kcfs on February 23 peaking at 187.5 kcfs on May 27 (Figure 5). The main period of spill was from March 21 through June 2 with daily spill averaging 37.1 kcfs and peaking at 84.6 kcfs on May 27. During periods of spill, spill closely tracked the total outflow pattern from mid-March through the end of June.

Average daily outflow as measured in the tailrace at McNary Dam increased from about 160 kcfs at the beginning of the year, peaking at 369.4 kcfs on June 5 (Figure 6). The main period of spill was from January 6 through September 4 with daily spill averaging 80.4 kcfs and peaking at 218.9 kcfs on May 27. During periods of spill, spill closely tracked the total outflow pattern for the entire year.

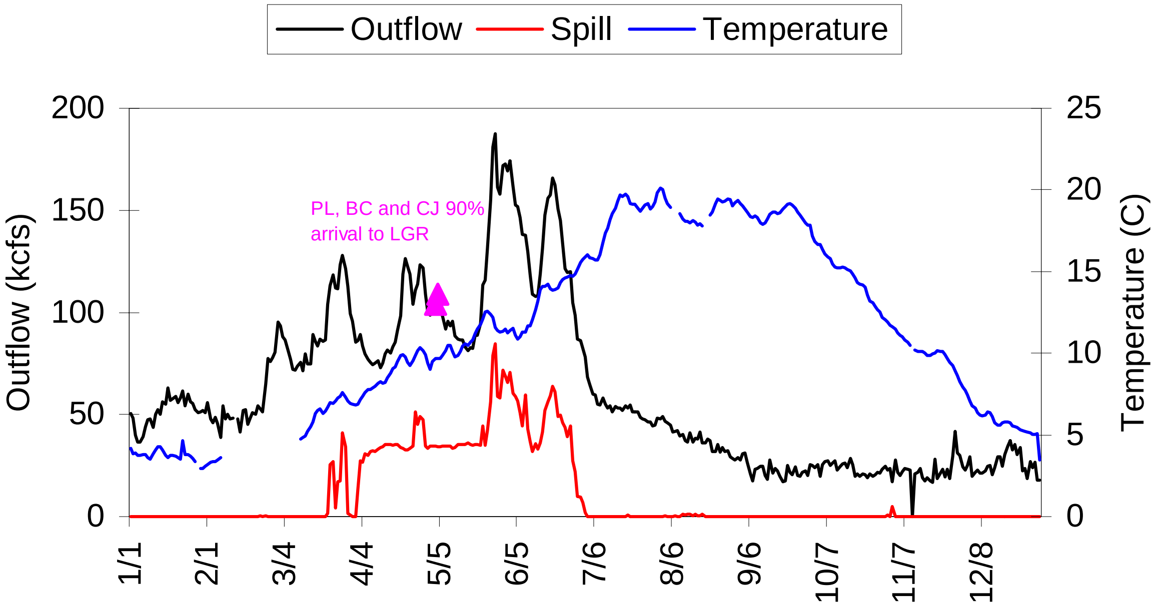

Figure 5.—Mean daily flow, spill, and temperature for the Snake River in 1999 as measured by the USACE at Lower Granite Dam.

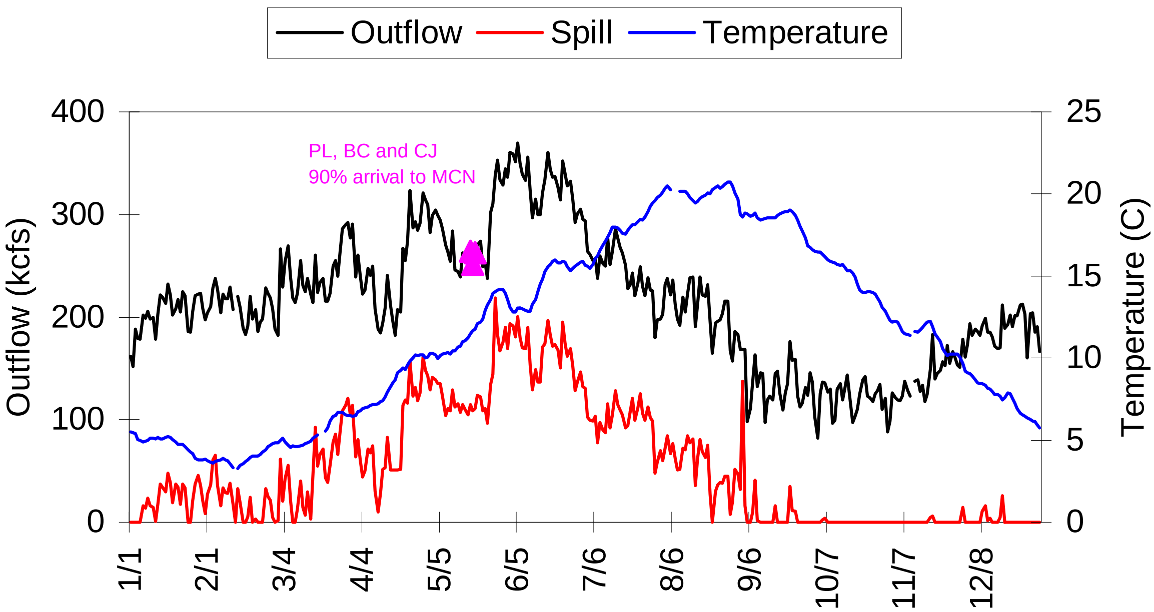

Figure 6.—Mean daily flow, spill, and temperature for the Columbia River in 1999 as measured by the USACE at McNary Dam.

PIT Tagging

PIT tagging operations went smoothly this year. We experienced no mechanical or electronic problems with the equipment and there was no immediate post-tagging mortality. A total of 9,941 and 9,583 yearling fall Chinook salmon were PIT tagged at Pittsburg Landing and Big Canyon, respectively (Table 3). A total of 2,494 yearlings were PIT tagged at Captain John Rapids. WDFW personnel PIT tagged a total of 983 at LFH. A total of 2,511 Surplus yearlings for Big Canyon were PIT tagged by NPT and WDFW personnel at LFH on April 1, prior to transfer to Big Canyon. See Appendix A for a complete 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 and LFH in 1999.

Facility	Date Tagged	Number Tagged	Date Released
Pittsburg Landing	April 5	2,539	April 12
	April 6	2,244	April 13
	April 7	2,623	April 14
	April 8	2,535	April 15
	Total	9,941	
Big Canyon	April 5	2,483	April 12
	April 6	2,126	April 13
	April 7	2,478	April 14
	April 8	2,496	April 15
	Total	9,583	
Big Canyon - Surplus	April 1	508	April 26
	April 1	2,003	
	Total	2,511	
Captain John Rapids	March 23	1,645	April 12-15
	March 24	849	
	Total	2,494	
Lyons Ferry Hatchery	3/24	983	March 25-April 13

Biological Characteristics

The ANOVA on fork lengths showed a significant between-group effect ($P = 0.0084$) and post hoc multiple comparisons showed that all PIT tagged groups differed significantly (Table B.1), with yearlings at Pittsburg Landing, Big Canyon and LFH clearly larger than Captain John Rapids and Big Canyon Surplus yearlings (Table 4). All length distributions significantly differed from each other ($P < 0.0001$; Table B.2). The groups from Captain John and Big Canyon Surplus had distributions with a higher proportion of smaller fish (Figure 7). This result for Captain John yearlings is similar to 1998.

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. This is the second consecutive year that a difference in length distribution was seen at Captain John Rapids in relation to the other facilities. We will continue to monitor this trend to try and determine if there is a sampling bias at the Captain John Rapids facility.

The ANOVA on condition factors also showed a significant between-group effect ($P = 0.0036$) and post hoc multiple comparisons indicated that all groups differed significantly from each other (Table B.1). In contrast to 1998, the mean condition factor of 1.04 for Pittsburg Landing yearlings was the lowest of the three FCAP facilities. Mean condition factors were 1.11 for Big Canyon, 1.09 for Big Canyon Surplus, and 1.23 for Captain John Rapids (Table 4). Condition factor distributions for all FCAP groups differed significantly from each other ($P < 0.001$; Table B.2). Condition factors for LFH fish were not available as weights were not taken on that group of PIT tagged yearlings.

Table 4.—Fork length, weight and condition factor of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH in 1999.

Release Group	Variable	*n*	Mean	Standard Deviation	95% C.I. (mean +/-)	Median	Range
Pittsburg Landing	Fork Length (mm)	9,726	163.7	18.1	0.4	167	63 - 213
	Weight (g)	1,309	45.1	14.3	0.8	46.7	4.6 - 83.2
	Condition Factor	1,309	1.04	0.07	0.00	1.05	0.27 - 1.51
Big Canyon	Fork Length (mm)	9,552	158.6	16.8	0.3	160	85 - 295
	Weight (g)	989	43.7	13.2	0.8	43.7	7.1 - 90.9
	Condition Factor	987	1.11	0.12	0.01	1.11	0.33 - 4.24
Big Canyon Surplus	Fork Length (mm)	2,497	149.5	21.1	0.8	151	91 - 228
	Weight (g)	398	40.7	15.9	1.6	39.6	11.9 - 105.2
	Condition Factor	398	1.09	0.08	0.01	1.09	0.85 - 1.37
Captain John Rapids	Fork Length (mm)	2,494	147.4	17.7	0.7	149	78 - 285
	Weight (g)	427	38.4	13.7	1.3	39.5	5.7 - 88.6
	Condition Factor	427	1.23	0.08	0.01	1.23	1.01 - 1.56
Lyons Ferry Hatchery	Fork Length (mm)	983	161.7	13.1	0.8	161	100 - 211
	Weight (g)	0					
	Condition Factor	0					

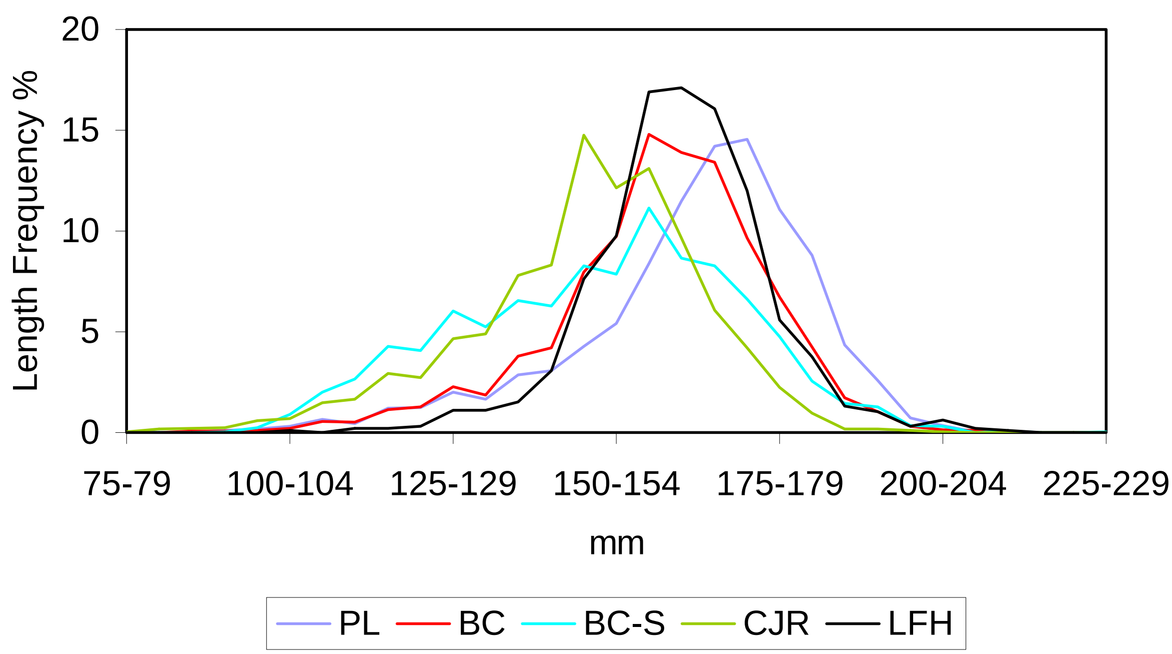

Figure 7.—Fork length frequency of PIT tagged yearling fall Chinook salmon at the FCAP facilities and LFH in 1999.

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 required for expanding sample counts during run reconstruction at Lower Granite Dam and from ocean and in-river harvest CWT sampling.

Retention of CWT, AD clips and VIE was similar to what we have seen in past years (Rocklage 2004; unpublished data). Coded wire tag retention ranged from 97.1% for Big Canyon Surplus yearlings to 99.5% for Captain John Rapids and LFH. Adipose fin clip retention ranged from 96.8% for Pittsburg Landing yearlings to 99.4% for Big Canyon Surplus yearlings. Retention of VIE tags was lower and more variable than for adipose fin clips and coded wire tags, ranging from 73.6% at Pittsburg Landing to 97.7% for Big Canyon Surplus (Table 5). A total of 32 FCAP and 4 LFH fish (0.007% and 0.0009% 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 1999. Also shown are the probability that a fish was unmarked and unclipped and the estimated number released unmarked and unclipped.

Release Group	*n*	% Retention CWT	AD	VIE	Probability of no marks	Estimated number with no marks
Pittsburg Landing	1,681	97.6	96.8	73.6	0.000203	29
Big Canyon	1,370	99.1	99.1	87.7	0.000010	2
Big Canyon - Surplus	519	97.1	99.4	97.7	0.000004	0
Captain John Rapids	1,530	99.5	99.1	80.3	0.000009	1
Lyons Ferry Hatchery	1,493	99.5	98.5	85.1	0.000010	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 87.8% (82.1-93.4%) for Big Canyon Surplus to 94.1% (90.1-98.1%) for Captain John Rapids. Estimated survival from release to McNary Dam ranged from 58.7% (49.3-68.1%) for Big Canyon Surplus to 71.3% (60.1-82.5%) for Captain John Rapids (Table 6). There were no statistically significant differences in survival between any of the release groups in 1999 (Table 7). Yearling survival from the FCAP facilities to Lower Granite and McNary dams in 1999 (excluding Surplus) represented an across-the-board increase from 1998 (Appendix C). In contrast, survival from LFH to McNary Dam declined from 1998. It is interesting to note that survival from LFH to McNary Dam was comparable to those from the FCAP facilities even though the migration distance is 168-251 rkm shorter. 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 1996-1999.

Table 6.—Estimated survivals and 95% confidence intervals of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 1999.

Release Group	Evaluation Point	Estimated Survival	95% C.I. Lower Bound	95% C.I. Upper Bound
Pittsburg Landing	Lower Granite	0.9004	0.8810	0.9198
	McNary	0.6212	0.5734	0.6690
Big Canyon	Lower Granite	0.9000	0.8773	0.9227
	McNary	0.6605	0.6046	0.7164
Big Canyon Surplus	Lower Granite	0.8775	0.8209	0.9341
	McNary	0.5869	0.4930	0.6808
Captain John Rapids	Lower Granite	0.9409	0.9013	0.9805
	McNary	0.7129	0.6008	0.8250
Lyons Ferry Hatchery	Lower Monumental	0.8937	0.7851	1.0023
	McNary	0.6808	0.5418	0.8198

Table 7.—Results of the Z-test for pairwise comparisons of SURPH survival estimates of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Granite and McNary dams in 1999.

To Lower Granite Dam	BC	BC-S	CJ	LFH
PL	P = 0.9791	P = 0.4534	P = 0.0718	n/a
BC		P = 0.4700	P = 0.0792	n/a
BC-S			P = 0.0721	n/a

To McNary Dam	BC	BC-S	CJ	LFH
PL	P = 0.2953	P = 0.5235	P = 0.1405	P = 0.4270
BC		P = 0.1862	P = 0.4120	P = 0.7905
BC-S			P = 0.0911	P = 0.2724
CJ				P = 0.7246

Travel Time and Migration Rate

Median travel times based on all obs are typically somewhat 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 7-10 days to Lower Granite Dam and 21-23 days to McNary Dam. For this type of study, which compares fish released from and observed at multiple locations, travel time from release to a given point is of limited utility because of differences in distance between release points to a given observation site as well as in distance between observation sites. As would be expected, median travel time increases from point of release to each successive observation point downstream (Appendix D, Tables D.1 and D.2). Results of all statistical tests for travel time and migration rate are included in Appendix B (Tables B.3, B.4 and B.5).

In our study, the only meaningful within-year comparison of travel time is for Big Canyon and Big Canyon Surplus since they were both released from the same location. For all other comparisons, converting travel time to migration rate is much more meaningful. Of note is that the travel time of the Big Canyon Surplus group from release to Lower Granite Dam was somewhat shorter (i.e. higher migration rate) than for the first Big Canyon group ($P < 0.0001$). This could be due to higher flows in the Clearwater River at time of release. Another possible factor for the shorter travel time is a physiological response to a more advanced degree of smoltification at the later release date, however, travel times based on first obs were not significantly different between the two groups to McNary ($P = 0.3176$) and Bonneville ($P = 0.0696$) dams.

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

The migration rate of the Big Canyon Surplus group to Lower Granite Dam was about 40% higher than the Big Canyon group (Appendix D, Tables D.3 and D.4). This indicates that time of release may effect migration rate. 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). Migration rates for Pittsburg Landing and Big Canyon Surplus to Lower Granite Dam are slightly higher than migration rates to Little Goose Dam (Figures 8 and 9). However, for all 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 is 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 about equal 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 relatively very high in order to make the overall migration rate to each point increase so rapidly.

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.

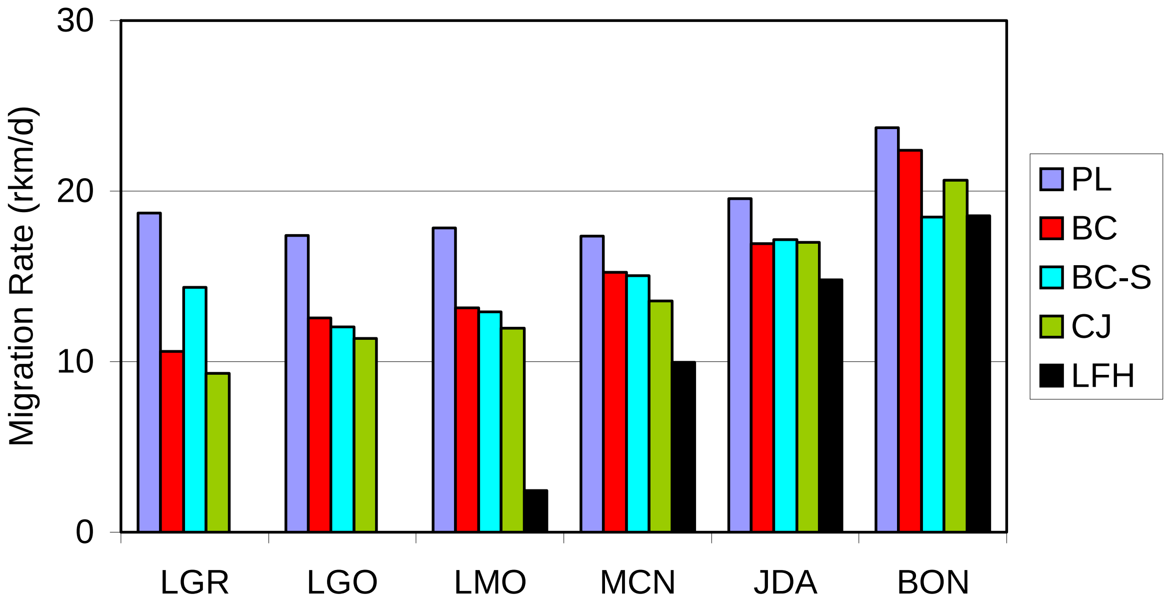

Figure 8.—First obs migration rate (rkm/d) of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 1999.

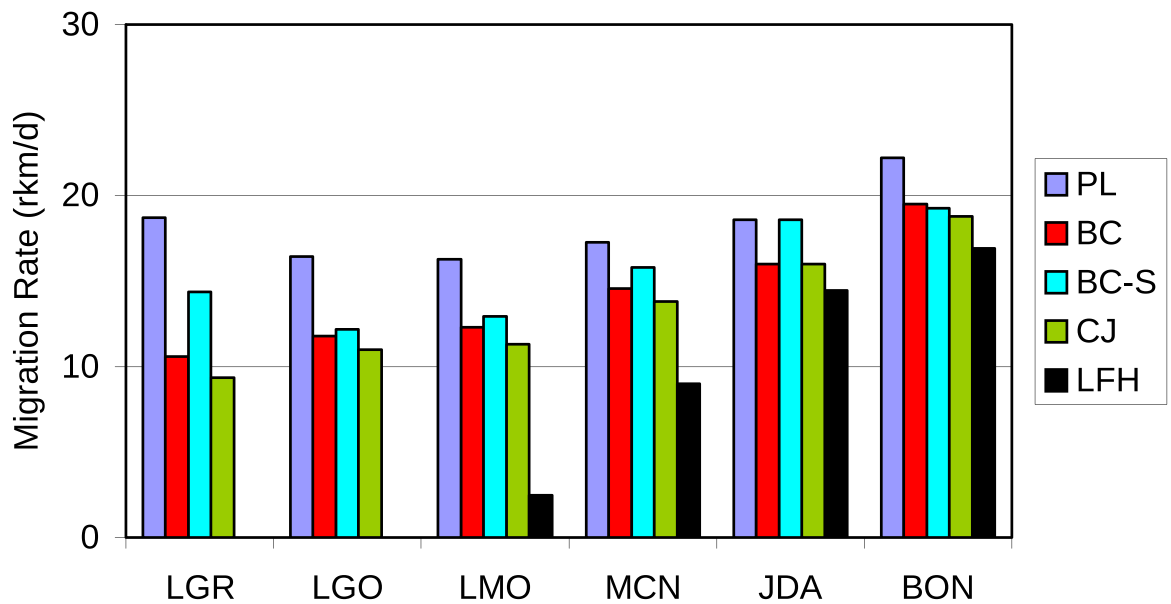

Figure 9.—All obs migration rate (rkm/d) of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 1999.

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 based on first obs and all obs are detailed in Appendix D, Tables D.3 and D.4, respectively.

Migration rates from Pittsburg Landing to Lower Granite Dam during 1996-1999 were positively correlated with flow at Hell's Canyon Dam (r = 0.8786, P = 0.1214) and Anatone (r = 0.9238, P = 0.0762), while negatively correlated with temperature at Anatone (r = -0.4908, P = 0.5092), as illustrated in Figures 10 and 11. Migration rates from Big Canyon to Lower Granite Dam during 1997-1999 were positively correlated with flow (r = 0.6296 P = 0.5664) and negatively correlated with temperature (r = -0.8746, P = 0.3222) at Peck (Figures 12 and 13). While none of these correlations are statistically significant, bear in mind that the correlations for Pittsburg Landing and Big Canyon contain only four and three data points, respectively. We currently do not have enough years of release data to form solid conclusions about how flow levels generally affect migration rates to Lower Granite Dam for releases from all FCAP facilities, which subsequently affect downstream arrival timing. More comprehensive analyses will be reported as additional data are gathered in future years.

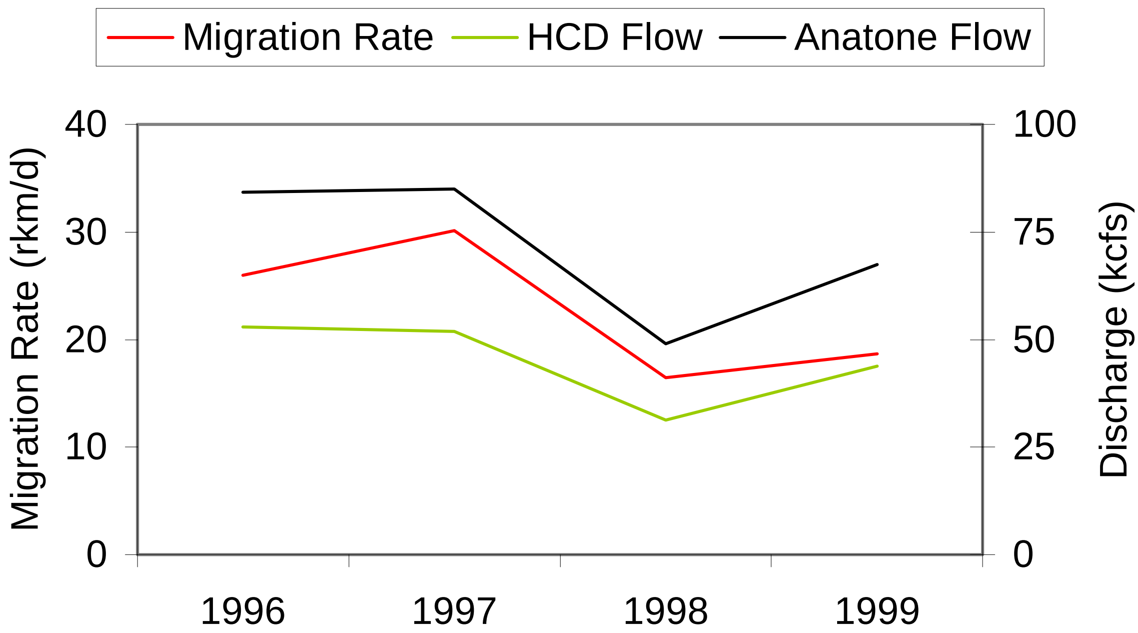

Figure 10.—Yearling migration rate (rkm/d) from Pittsburg Landing to Lower Granite Dam versus Snake River flow at Hell's Canyon Dam and Anatone, 1996-1999.

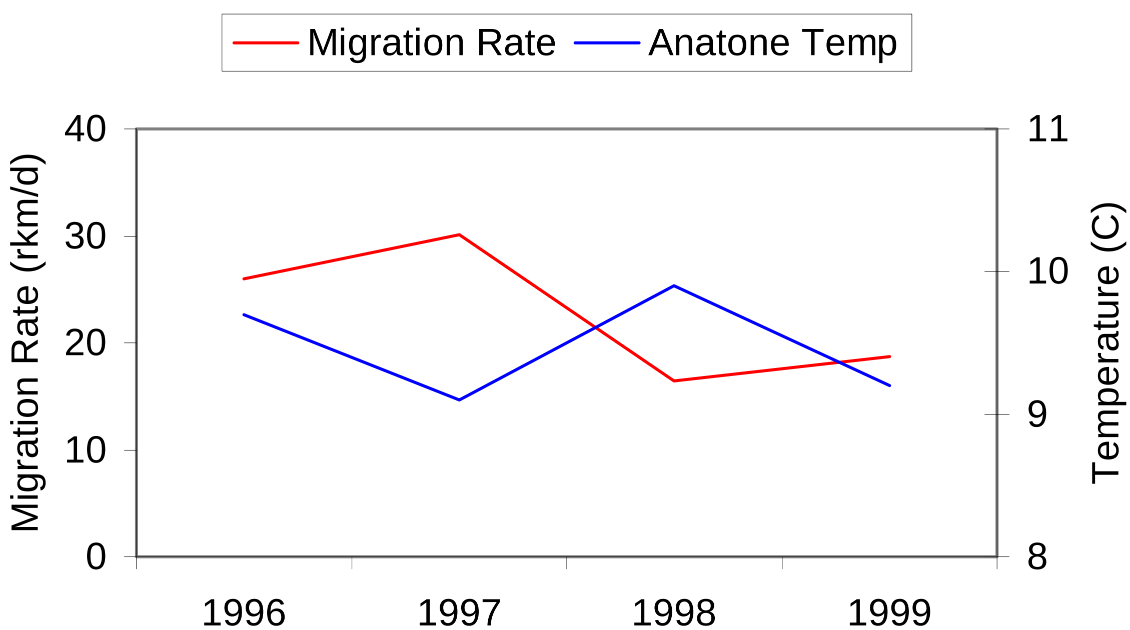

Figure 11.—Yearling migration rate (rkm/d) from Pittsburg Landing to Lower Granite Dam versus Snake River temperature at Anatone, 1996-1999.

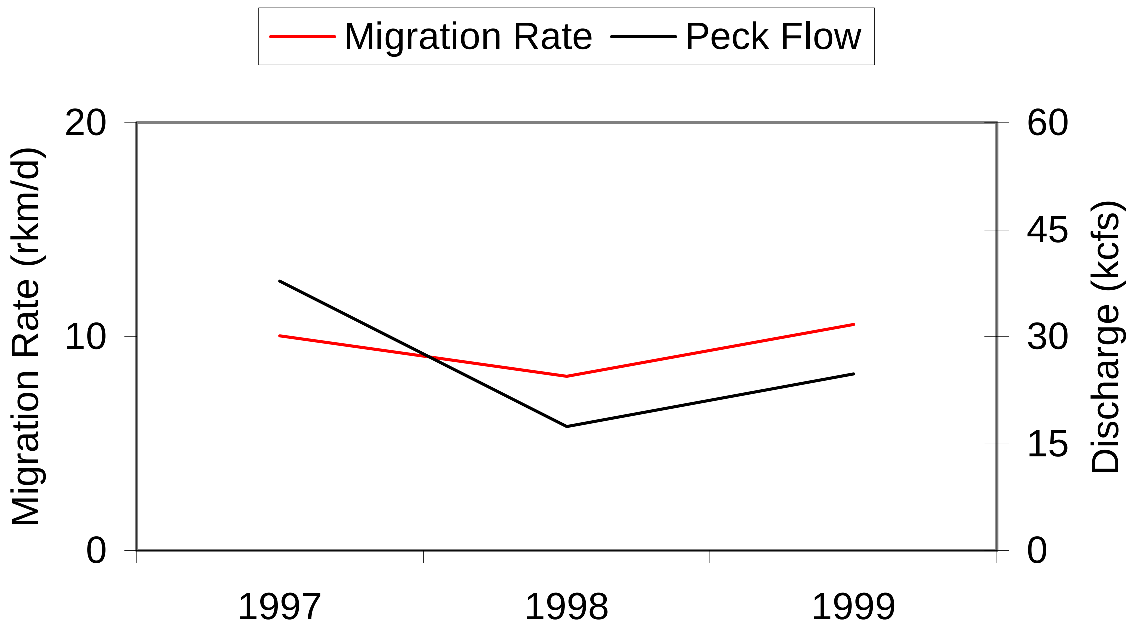

Figure 12.—Yearling migration rate (rkm/d) from Big Canyon to Lower Granite Dam versus Clearwater River flow at Peck, 1997-1999.

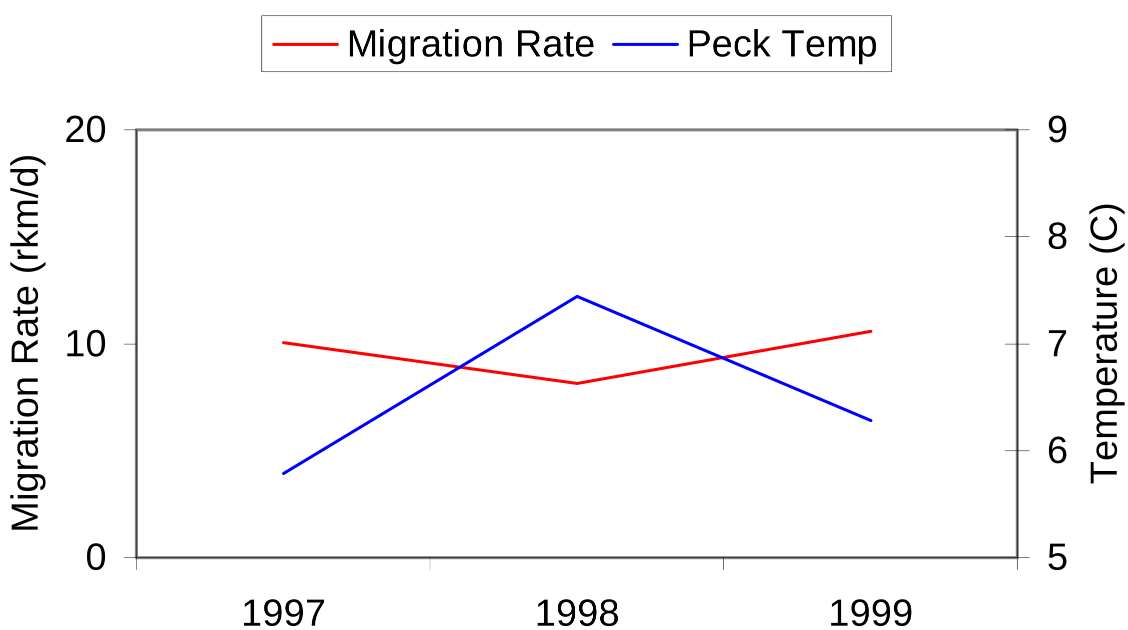

Figure 13.—Yearling migration rate (rkm/d) from Big Canyon to Lower Granite Dam versus Clearwater River temperature at Peck, 1997-1999.

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 15. The volitional release occurred from April 12-15, which was a much shorter period than previous years. Regardless, only one PIT tagged fish from Captain John Rapids was detected at Lower Granite Dam before April 16. That fish was detected at Lower Granite Dam at about 07:30 on April 13. 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. 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 median arrival date, based on all obs, to Lower Granite Dam for the Big Canyon Surplus group ranged from 9-11 days later than all other yearlings released from the FCAP facilities with the differential remaining similar at downstream dams, which was not unexpected since the Big Canyon Surplus group was released 11-14 days later. Though the Pittsburg Landing group had a higher migration rate to Lower Granite Dam than the Big Canyon Surplus group, the median arrival dates were closer together than the release dates because Pittsburg Landing is considerably farther from Lower Granite Dam.

In general, arrival date frequency distributions and cumulative frequencies for the FCAP facilities were more similar to each other at Lower Granite Dam and less so at McNary and Bonneville dams (Appendix E). Pittsburg Landing and Big Canyon yearlings showed no significant differences in arrival date distribution at McNary and Bonneville dams for both first obs ($P = 0.9100$ and $P = 0.6836$, respectively) and all obs ($P = 1.0000$ and $P = 0.7282$, respectively). Only Big Canyon and Captain John Rapids had similar ($P = 0.0625$) arrival date distributions at Lower Granite Dam. Other significant similarities were scattered about, for example, the first obs arrival date to Bonneville Dam was similar for Pittsburg Landing, Big Canyon and Captain John Rapids. However, this similarity did not completely hold up for first obs at McNary Dam or for all obs at either McNary or Bonneville dams. 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 with results of all statistical tests included in Appendix B, Tables B.4 and B.6.

Yearlings from Pittsburg Landing achieved 90% arrival to every dam except Bonneville earlier than those from Big Canyon and Captain John Rapids. The Big Canyon Surplus group achieved 90% arrival, based on all obs, to Lower Granite, Little Goose and Lower Monumental dams consistently ranging from 11-13 days later than all other FCAP groups, which was not surprising given they were released 11-14 days later. What was surprising was that the differential in 90% arrival was reduced at McNary, John Day and Bonneville dams to a range of 7-9 days, which remained consistent at all three dams. The data indicate that the Big Canyon Surplus group did not have a dramatically higher migration rate between Lower Monumental and McNary dams relative to the other FCAP groups (Figures 8 and 9). The frequency distributions at Lower Granite, McNary and Bonneville (Appendix E; Figures 27, 29 and 31) show that the Surplus yearlings had a more similar frequency distribution to Pittsburg Landing and Big Canyon at Lower Granite Dam, with distributions that slowly tailed off at later dates, than at McNary and Bonneville dams. At McNary and Bonneville dams, the frequency distribution for the Pittsburg and Big Canyon groups remained similar to Lower Granite Dam, while the Big Canyon Surplus group had distributions with more abrupt ends. This indicates that instead of achieving 90% passage during the extended post-peak passage period, the Big Canyon Surplus groups achieved 90% passage more during the peak passage phase with a much smaller fraction of the fish passing McNary and Bonneville dams after this point. This pattern is worth noting; however, no explanation is readily evident.

Yearlings released from Pittsburg Landing and Captain John Rapids achieved 90% arrival to Lower Granite Dam well before the flows peaked at Anatone. Yearlings released from Big Canyon achieved 90% arrival to Lower Granite Dam well before the flows peaked at Peck. Yearlings from the FCAP sites achieved 90% arrival to Lower Granite Dam several weeks prior to peak flows at the dam. Yearlings from the FCAP facilities achieved 90% arrival to McNary Dam about two weeks prior to peak flows at the dam.

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 1999.

Release Group	Interrogation Site	*N*	Mean	Median	90%
Pittsburg Landing	Lower Granite	2,551	4/25	4/23	5/3
	Little Goose	2,872	4/28	4/27	5/7
	Lower Monumental	1,243	5/1	4/29	5/11
	McNary	364	5/8	5/6	5/18
	John Day	168	5/12	5/11	5/22
	Bonneville	87	5/11	5/11	5/22
Big Canyon	Lower Granite	2,108	4/25	4/24	5/3
	Little Goose	2,827	4/29	4/27	5/8
	Lower Monumental	1,189	5/2	4/30	5/12
	McNary	403	5/8	5/6	5/19
	John Day	178	5/13	5/11	5/25
	Bonneville	84	5/11	5/9	5/22
Big Canyon - Surplus	Lower Granite	508	5/6	5/4	5/15
	Little Goose	565	5/12	5/10	5/23
	Lower Monumental	237	5/15	5/13	5/24
	McNary	128	5/20	5/18	5/27
	John Day	74	5/23	5/23	6/2
	Bonneville	33	5/26	5/27	6/1
Captain John Rapids	Lower Granite	679	4/26	4/25	5/4
	Little Goose	742	4/30	4/28	5/9
	Lower Monumental	310	5/3	5/1	5/11
	McNary	80	5/10	5/8	5/23
	John Day	52	5/11	5/11	5/17
	Bonneville	26	5/15	5/12	5/27
Lyons Ferry Hatchery	Lower Monumental	310	4/22	4/21	4/30
	McNary	122	4/27	4/25	5/7
	John Day	68	5/2	4/28	5/13
	Bonneville	18	5/26	3/8	5/6

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 1999.

Release Group	Interrogation Site	*N*	Mean	Median	90%
Pittsburg Landing	Lower Granite	2,551	4/25	4/23	5/3
	Little Goose	3,943	4/29	4/28	5/8
	Lower Monumental	3,192	5/2	5/1	5/11
	McNary	1,551	5/8	5/7	5/17
	John Day	1,047	5/13	5/12	5/23
	Bonneville	606	5/13	5/12	5/23
Big Canyon	Lower Granite	2,108	4/25	4/24	5/3
	Little Goose	3,637	4/30	4/28	5/9
	Lower Monumental	2,929	5/3	5/1	5/12
	McNary	1,434	5/8	5/7	5/18
	John Day	1,021	5/14	5/12	5/24
	Bonneville	554	5/14	5/12	5/25
Big Canyon - Surplus	Lower Granite	508	5/6	5/4	5/15
	Little Goose	703	5/12	5/10	5/21
	Lower Monumental	512	5/14	5/13	5/24
	McNary	337	5/19	5/17	5/26
	John Day	268	5/22	5/21	5/31
	Bonneville	128	5/25	5/26	6/1
Captain John Rapids	Lower Granite	679	4/26	4/25	5/4
	Little Goose	1,008	4/30	4/29	5/9
	Lower Monumental	830	5/3	5/2	5/12
	McNary	384	5/9	5/8	5/19
	John Day	317	5/13	5/12	5/22
	Bonneville	154	5/15	5/14	5/25
Lyons Ferry Hatchery	Lower Monumental	310	4/22	4/21	4/30
	McNary	184	4/28	4/26	5/8
	John Day	145	5/2	4/29	5/13
	Bonneville	59	5/4	5/3	5/13

LITERATURE CITED

Adams, S. M., A. M. Brown and R. W. Goede. 1993. A quantitative health assessment index for rapid evaluation of fish condition in the field. Transactions of the American Fisheries Society 122:63-73.

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.P., Connor, W.P., Milks, D.J., Rocklage, S.J. and R.K. Steinhorst. 2004. Movement and Spawner Distribution of Hatchery Fall Chinook Salmon Adults Acclimated and Released as Yearlings at Three Locations in the Snake River Basin. North American Journal of Fisheries Management 24: 1134–1144.

Goede, R. W. and B. A. Barton. 1990. Organismic indices and an autopsy-based assessment as indicators of health and condition of fish. Transactions of the American Fisheries Society 8:93-108.

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., L. Wargo and M. Varney. 2000. Lyons Ferry Hatchery Evaluation, Fall Chinook Salmon, Annual Report: 1998 and 1999. Washington Department of Fish and Wildlife Hatcheries Report # FPA00-21 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.

Pascho, R. J., D. G. Elliott, and J. M. Streufert. 1991. Brood stock segregation of spring Chinook salmon *Oncorhynchus tschawytscha* by use of the enzyme-linked immunosorbent assay (ELISA) and the fluorescent antibody technique (FAT) affects the prevalence and levels of *Renibacterium salmoninarum* infection in progeny. Diseases of Aquatic Organisms 12:25-40.

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)

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. In National Wild Fish Health Survey Laboratory Procedure Manual, First 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 at Lower Snake and Columbia River dams for PIT tagged yearling fall Chinook salmon released from the FCAP facilities and LFH in 1999. 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 tag files for yearling fall Chinook salmon from the FCAP facilities and LFH in 1999.

Release Group	Filename
Pittsburg Landing	SJR99095.PL3
	SJR99096.PL7
	SJR99097.PL9
	SJR99098.P16
Big Canyon	SJR99095.0D3
	SJR99096.0C4
	SJR99097.0B1
	SJR99098.0A4
Big Canyon-Surplus	SJR99091.XY1
	SJR99091.XY2
Captain John Rapids	SJR99082.CJ1
	SJR99083.CJ1
Lyons Ferry Hatchery	MLS99083.LFH

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 1999.

Release Group	LGR	LGO	LMO	MCN	JDA	BON	Cumulative Observations	Cumulative %
Pittsburg Landing	2,551	2,872	1,243	364	168	87	7,285	73.3
Big Canyon	2,108	2,827	1,189	403	178	84	6,789	70.8
Big Canyon-Surplus	508	565	237	128	74	33	1,545	61.5
Captain John Rapids	679	742	310	80	52	26	1,889	75.7
Lyons Ferry Hatchery	n/a	n/a	310	122	68	18	518	52.7

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 1999.

Release Group	LGR	LGO	LMO	MCN	JDA	BON	Total Observations
Pittsburg Landing	2,551	3,943	3,192	1,551	1,047	606	12,890
Big Canyon	2,108	3,637	2,929	1,434	1,021	554	11,683
Big Canyon - Surplus	508	703	512	337	268	128	2,456
Captain John Rapids	679	1,008	830	384	317	154	3,372
Lyons Ferry	n/a	n/a	310	184	145	59	698

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 1999. 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 1999.

		Tukey's HSD Multiple Comparisons				
	ANOVA	PL	BC	BC-S	CJ	LFH
Length	P = 0.0084	1	2	3	4	5
Condition	P = 0.0036	1	2	3	4	n/a

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 1999.

	Fork Length			
	BC	BC-S	CJ	LFH
PL	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001
BC		P < 0.0001	P < 0.0001	P < 0.0001
BC-S			P < 0.0001	P < 0.0001
CJ				P < 0.0001

	Condition Factor		
	BC	BC-S	CJ
PL	P < 0.0001	P < 0.0001	P < 0.0001
BC		P = 0.0004	P < 0.0001
BC-S			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 1999.

			Tukey's HSD Multiple Comparisons				
		ANOVA	PL	BC	BC-S	CJ	LFH
Lower Granite		P = 0.0036	1	2	3	4	n/a
McNary	First Obs	P < 0.0001	1	2	2, 3	3	4
	All Obs	P = 0.0019	1	2	3	4	5
Bonneville	First Obs	P < 0.0001	1	1, 2	2	2	2
	All Obs	P < 0.0001	1	2	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 1999.

	Travel Time			Arrival Date		
	BC	BC-S	CJ	BC	BC-S	CJ
PL	P = 0.0001	P < 0.0001	P = 0.0228	P = 0.0002	P < 0.0001	P = 0.0004
BC		P < 0.0001	P = 0.0002		P < 0.0001	P = 0.0625
BC-S			P = 0.0016			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 1999.

To McNary Dam

	1st Obs Travel Time				All Obs Travel Time			
	BC	BC-S	CJ	LFH	BC	BC-S	CJ	LFH
PL	P = 0.5866	P = 0.2770	P = 0.3445	P < 0.0001	P = 0.7670	P = 0.0010	P = 0.0558	P < 0.0001
BC		P = 0.3176	P = 0.0940	P < 0.0001		P = 0.0002	P = 0.3242	P < 0.0001
BC-S			P = 0.1035	P < 0.0001			P = 0.0009	P < 0.0001
CJ				P < 0.0001				P < 0.0001

To Bonneville Dam

	1st Obs Travel Time				All Obs Travel Time			
	BC	BC-S	CJ	LFH	BC	BC-S	CJ	LFH
PL	P = 1.0000	P = 0.1828	P = 0.5097	P = 0.0033	P = 0.4005	P = 0.1707	P = 0.9966	P < 0.0001
BC		P = 0.0696	P = 0.7901	P = 0.0271		P = 0.1006	P = 1.0000	P < 0.0001
BC-S			P = 0.5326	P = 0.0015			P = 0.3407	P < 0.0001
CJ				P = 0.0198				P < 0.0001

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 1999.

To McNary Dam

1st Obs Arrival Date	BC	BC-S	CJ	LFH
PL	$P = 0.9100$	$P < 0.0001$	$P = 0.0151$	$P < 0.0001$
BC		$P < 0.0001$	$P = 0.0010$	$P < 0.0001$
BC-S			$P < 0.0001$	$P < 0.0001$
CJ				$P < 0.0001$

All Obs Arrival Date	BC	BC-S	CJ	LFH
PL	$P = 1.0000$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$
BC		$P < 0.0001$	$P < 0.0001$	$P < 0.0001$
BC-S			$P < 0.0001$	$P < 0.0001$
CJ				$P < 0.0001$

To Bonneville Dam

1st Obs Arrival Date	BC	BC-S	CJ	LFH
PL	$P = 0.6836$	$P < 0.0001$	$P = 0.3551$	$P < 0.0001$
BC		$P < 0.0001$	$P = 0.1525$	$P < 0.0001$
BC-S			$P < 0.0001$	$P < 0.0001$
CJ				$P < 0.0001$

All Obs Arrival Date	BC	BC-S	CJ	LFH
PL	$P = 0.7282$	$P < 0.0001$	$P = 0.0276$	$P < 0.0001$
BC		$P < 0.0001$	$P = 0.0405$	$P < 0.0001$
BC-S			$P < 0.0001$	$P < 0.0001$
CJ				$P < 0.0001$

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 1999. 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, 1996-1999.

Release Group	Year	CJS Estimate	S.E.	95% C.I. Lower	95% C.I. Upper
Pittsburg Landing	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
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
Big Canyon Surplus	1997	0.9325	0.0429	0.8484	1.0166
	1999	0.8775	0.0289	0.8209	0.9341
Captain John Rapids	1998	0.7698	0.0274	0.7161	0.8235
	1999	0.9409	0.0202	0.9013	0.9805

Appendix C (continued).

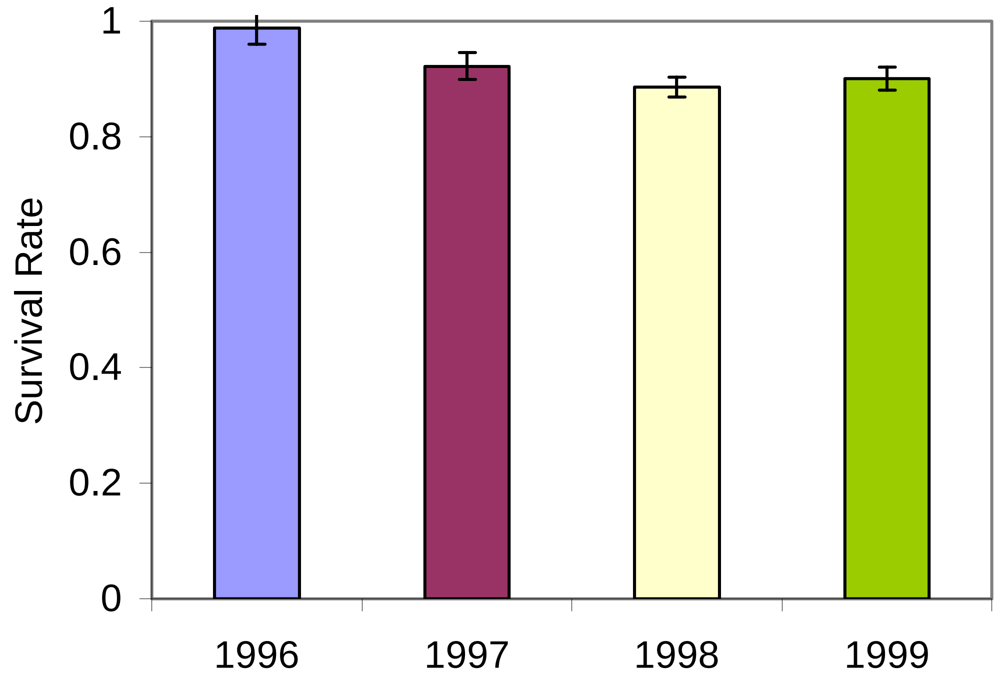

Figure C.1.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to Lower Granite Dam, 1996-1999.

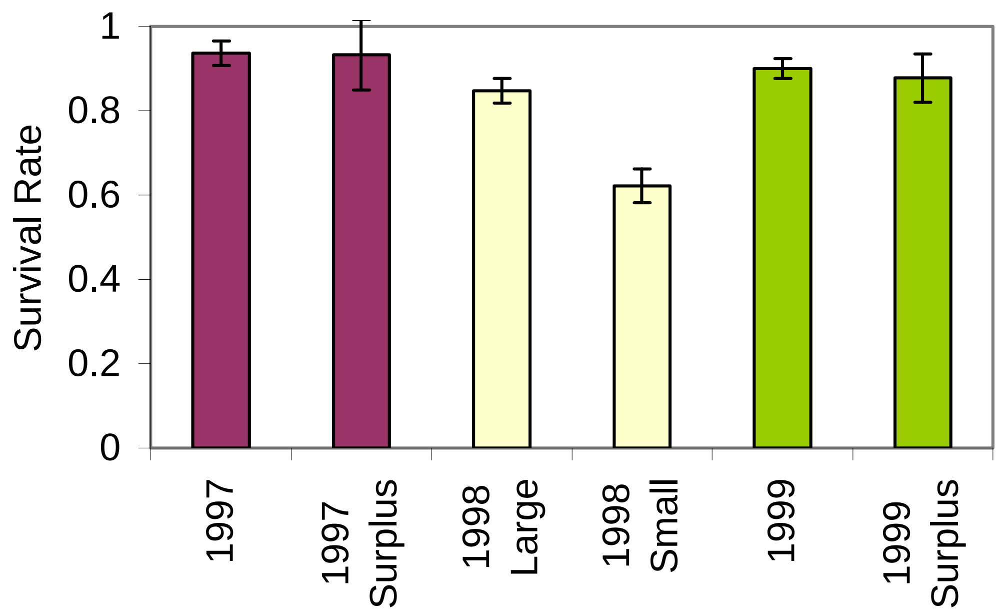

Figure C.2.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to Lower Granite Dam, 1997-1999.

Appendix C (continued).

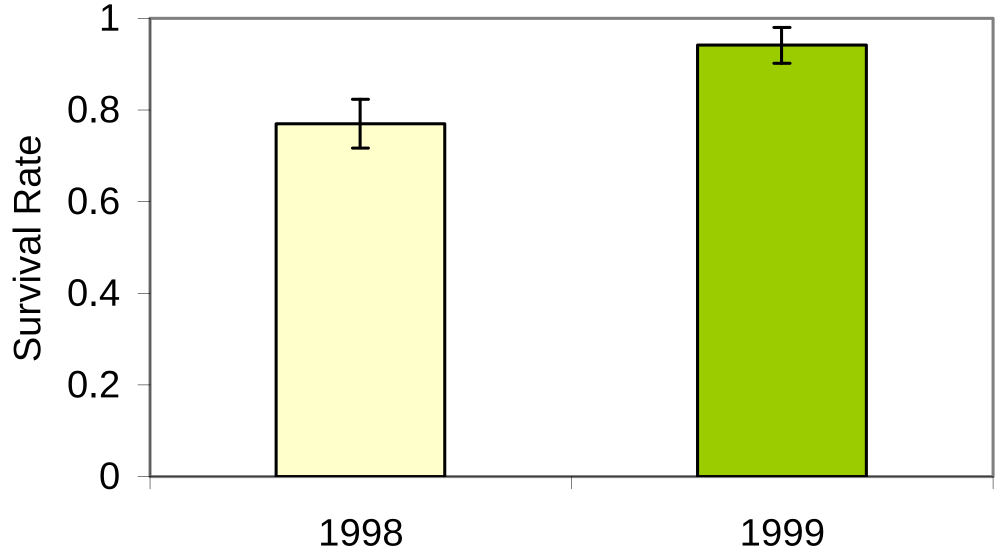

Figure C.3.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to Lower Granite Dam, 1998-1999.

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, 1996-1999.

Release Group	Year	CJS Estimate	S.E.	95% C.I. Lower	95% C.I. Upper
Pittsburg	1996	0.4131	0.0738	0.2685	0.5577
Landing	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
Big Canyon	1997	0.8328	0.1792	0.4816	1.1840
Large	1998	0.5168	0.0658	0.3878	0.6458
Small	1998	0.2518	0.0445	0.1646	0.3390
	1999	0.6605	0.0285	0.6046	0.7164
Big Canyon	1997	0.7382	0.7130	-0.6593	2.1357
Surplus	1999	0.5869	0.0479	0.4930	0.6808
Captain John	1998	0.5049	0.1168	0.2760	0.7338
Rapids	1999	0.7129	0.0572	0.6008	0.8250
Lyons Ferry	1996	0.8755	0.3955	0.1003	1.6507
Hatchery	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

Appendix C (continued).

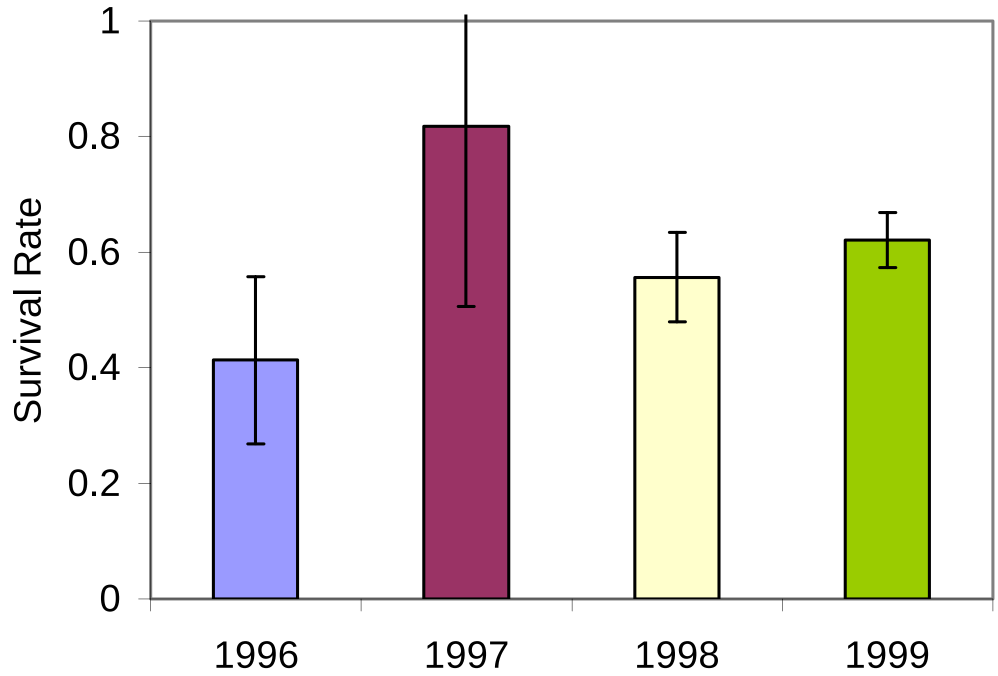

Figure C.4.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to McNary Dam, 1996-1999.

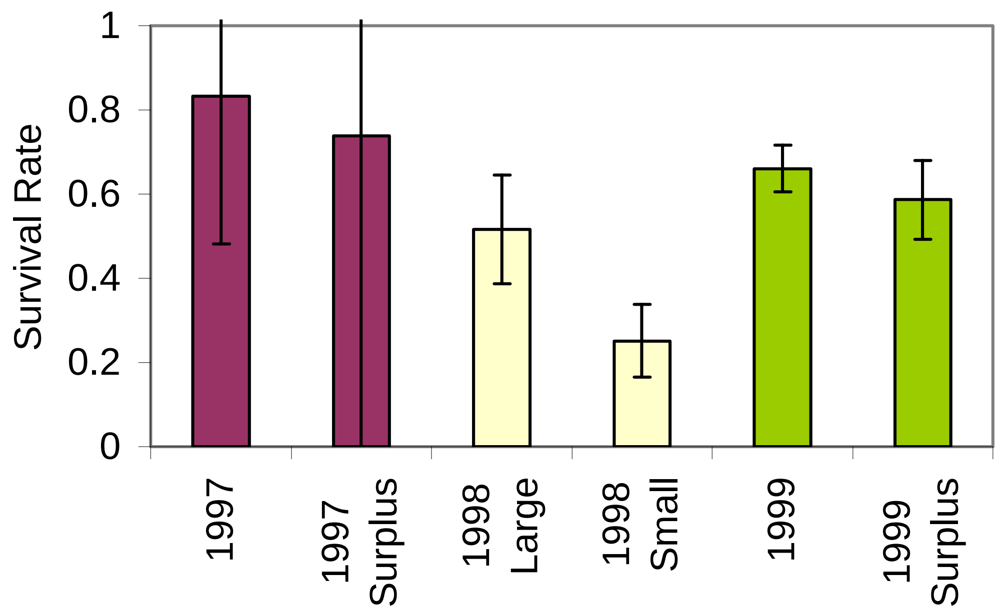

Figure C.5.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to McNary Dam, 1997-1999.

Appendix C (continued).

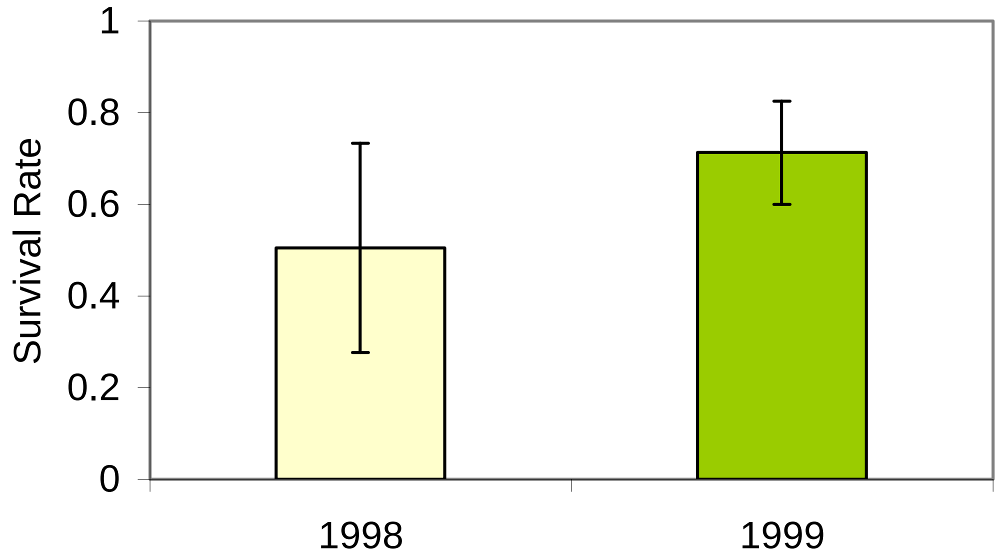

Figure C.6.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to McNary Dam, 1998-1999.

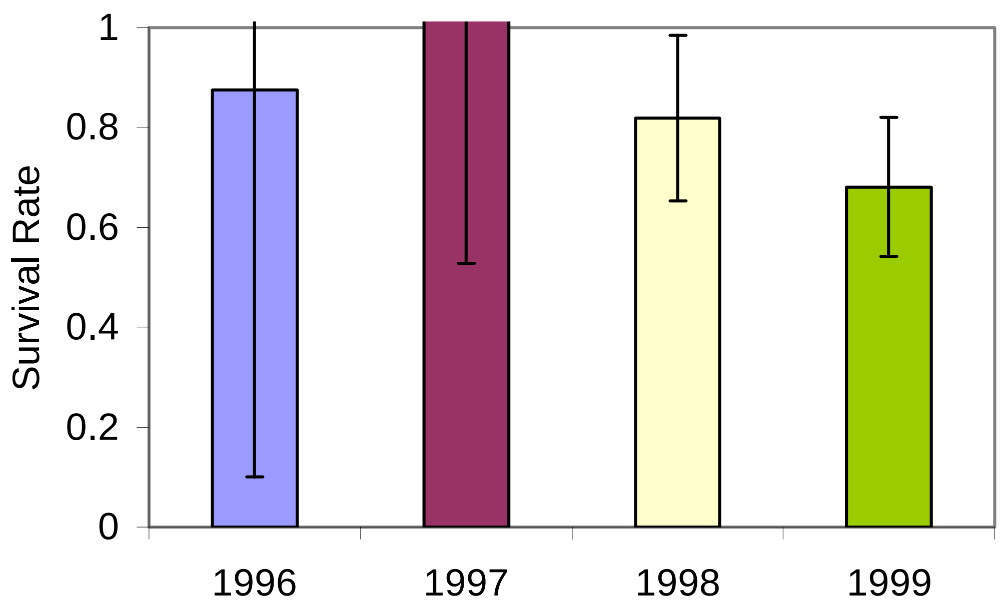

Figure C.7.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from LFH to McNary Dam, 1996-1999.

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 1999.

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 1999.

Release Group	Interrogation Site	*N*	Mean	Standard Deviation	95% C.I. (+/-)	Median	Range
Pittsburg Landing	Lower Granite	2,551	11.0	6.0	0.2	9.2	2.8 - 52.5
	Little Goose	2,872	14.8	6.6	0.2	13.4	4.2 - 49.8
	Lower Monumental	1,243	17.2	15.6	0.4	15.6	6.2 - 72.7
	McNary	364	23.9	7.5	0.8	22.9	8.1 - 50.0
	John Day	168	28.5	8.7	1.3	26.6	10.9 - 57.2
	Bonneville	87	27.6	6.9	1.5	26.7	15.3 - 43.5
Big Canyon	Lower Granite	2,108	11.6	6.6	0.3	10.2	2.5 - 55.4
	Little Goose	2,827	15.0	7.4	0.3	13.4	3.9 - 67.2
	Lower Monumental	1,189	18.0	16.3	0.5	16.3	6.0 - 68.1
	McNary	403	23.7	8.7	0.9	21.9	8.6 - 63.2
	John Day	178	29.1	9.8	1.5	26.9	12.4 - 60.5
	Bonneville	84	27.0	7.2	1.6	25.4	15.2 - 44.9
Big Canyon - Surplus	Lower Granite	508	10.4	7.5	0.7	7.5	2.1 - 53.0
	Little Goose	565	15.9	8.1	0.7	14.0	4.3 - 77.3
	Lower Monumental	237	18.6	16.5	1.0	16.5	6.3 - 49.6
	McNary	128	23.5	8.5	1.5	22.1	8.2 - 59.9
	John Day	74	26.9	6.7	1.6	26.5	14.5 - 47.4
	Bonneville	33	30.1	7.2	2.6	30.8	18.8 - 52.8
Captain John Rapids	Lower Granite	679	10.8	6.2	0.5	9.6	1.1 - 43.7
	Little Goose	742	14.6	6.7	0.5	13.2	3.4 - 45.1
	Lower Monumental	310	17.6	16.4	0.8	16.4	6.5 - 46.8
	McNary	80	25.3	7.8	1.7	23.3	10.9 - 43.1
	John Day	52	25.8	5.9	1.6	25.8	13.8 - 40.7
	Bonneville	26	29.6	8.8	3.6	26.7	18.1 - 45.6
Lyons Ferry Hatchery	Lower Monumental	310	12.0	11.4	0.8	11.4	0.4 - 46.4
	McNary	122	16.7	7.8	1.4	14.8	2.8 - 44.8
	John Day	68	21.6	9.3	2.3	18.2	4.5 - 45.7
	Bonneville	18	21.3	4.3	2.1	20.6	15.2 - 30.3

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 1999.

Release Group	Interrogation Site	*N*	Mean	Standard Deviation	95% C.I. (+/-)	Median	Range
Pittsburg Landing	Lower Granite	2,551	11.0	6.0	0.2	9.2	2.8 - 52.5
	Little Goose	3,943	15.4	6.6	0.2	14.2	4.2 - 54.7
	Lower Monumental	3,192	18.2	17.2	0.3	17.2	5.9 - 72.7
	McNary	1,551	23.9	7.1	0.4	23.0	7.5 - 60.5
	John Day	1,047	29.0	7.7	0.5	28.1	10.1 - 70.4
	Bonneville	606	29.5	7.2	0.6	28.5	12.6 - 51.6
Big Canyon	Lower Granite	2,108	11.6	6.6	0.3	10.2	2.5 - 55.4
	Little Goose	3,637	15.9	7.4	0.2	14.2	3.9 - 67.2
	Lower Monumental	2,929	19.2	17.4	0.3	17.4	5.9 - 69.2
	McNary	1,434	24.3	7.7	0.4	22.8	9.8 - 64.9
	John Day	1,021	30.0	8.6	0.5	28.5	13.1 - 76.4
	Bonneville	554	30.6	8.2	0.7	29.2	16.2 - 67.0
Big Canyon - Surplus	Lower Granite	508	10.4	7.5	0.7	7.5	2.1 - 53.0
	Little Goose	703	15.9	8.1	0.6	13.8	4.0 - 77.3
	Lower Monumental	512	18.5	16.5	0.7	16.5	6.3 - 54.7
	McNary	337	22.8	7.9	0.8	21.1	8.2 - 60.3
	John Day	268	26.3	7.3	0.9	24.5	11.7 - 61.6
	Bonneville	128	29.3	6.7	1.2	29.6	15.8 - 58.5
Captain John Rapids	Lower Granite	679	10.8	6.2	0.5	9.6	1.1 - 43.7
	Little Goose	1,008	15.0	6.5	0.4	13.7	2.0 - 45.1
	Lower Monumental	830	18.4	17.4	0.5	17.4	5.4 - 46.8
	McNary	384	24.3	6.7	0.7	22.8	10.5 - 45.3
	John Day	317	27.9	6.8	0.8	27.4	13.3 - 57.6
	Bonneville	154	29.9	7.3	1.2	29.3	14.0 - 59.8
Lyons Ferry Hatchery	Lower Monumental	310	12.0	11.4	0.8	11.4	0.4 - 46.4
	McNary	184	17.7	8.0	1.2	16.4	2.8 - 44.8
	John Day	145	21.7	8.7	1.4	18.7	4.5 - 45.7
	Bonneville	59	23.6	6.1	1.6	22.7	14.4 - 40.0

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 1999.

Release Group	Interrogation Site	*N*	Mean	Median	Range
Pittsburg Landing	Lower Granite	2,551	15.8	18.7	3.3 - 61.1
	Little Goose	2,872	15.8	17.4	4.7 - 55.5
	Lower Monumental	1,243	16.3	17.8	3.8 - 45.3
	McNary	364	16.7	17.3	8.0 - 49.1
	John Day	168	18.3	19.6	9.1 - 48.0
	Bonneville	87	23.0	23.7	14.6 - 41.3
Big Canyon	Lower Granite	2,108	9.3	10.6	2.0 - 43.4
	Little Goose	2,827	11.2	12.6	2.5 - 43.0
	Lower Monumental	1,189	11.9	13.1	3.1 - 35.6
	McNary	403	14.0	15.2	5.3 - 38.6
	John Day	178	15.7	16.9	7.5 - 36.8
	Bonneville	84	21.1	22.4	12.7 - 37.5
Big Canyon - Surplus	Lower Granite	508	10.3	14.4	2.0 - 50.3
	Little Goose	565	10.6	12.0	2.2 - 39.4
	Lower Monumental	237	11.5	12.9	4.3 - 33.8
	McNary	128	14.2	15.0	5.6 - 40.5
	John Day	74	17.0	17.2	9.6 - 31.4
	Bonneville	33	18.9	18.5	10.8 - 30.3
Captain John Rapids	Lower Granite	679	8.3	9.3	2.1 - 85.1
	Little Goose	742	10.2	11.3	3.3 - 44.6
	Lower Monumental	310	11.1	12.0	4.2 - 30.3
	McNary	80	12.5	13.5	7.3 - 28.8
	John Day	52	17.0	17.0	10.8 - 31.8
	Bonneville	26	18.6	20.6	12.1 - 30.4
Lyons Ferry Hatchery	Lower Monumental	310	2.3	2.4	0.6 - 63.1
	McNary	122	8.8	10.0	3.3 - 52.0
	John Day	68	12.5	14.8	5.9 - 59.7
	Bonneville	18	18.0	18.6	12.6 - 25.3

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 1999.

Release Group	Interrogation Site	*N*	Mean	Median	Range
Pittsburg Landing	Lower Granite	2,551	15.8	18.7	3.3 - 61.1
	Little Goose	3,943	15.1	16.4	4.3 - 55.5
	Lower Monumental	3,192	15.3	16.3	3.8 - 47.0
	McNary	1,551	16.6	17.3	6.6 - 53.0
	John Day	1,047	17.9	18.6	7.4 - 51.4
	Bonneville	606	21.5	22.2	12.3 - 50.4
Big Canyon	Lower Granite	2,108	9.3	10.6	2.0 - 43.4
	Little Goose	3,637	10.6	11.8	2.5 - 43.0
	Lower Monumental	2,929	11.2	12.3	3.1 - 36.5
	McNary	1,434	13.7	14.6	5.1 - 34.1
	John Day	1,021	15.2	16.0	6.0 - 34.7
	Bonneville	554	18.6	19.5	8.5 - 35.1
Big Canyon - Surplus	Lower Granite	508	10.3	14.4	2.0 - 50.3
	Little Goose	703	10.6	12.2	2.2 - 42.2
	Lower Monumental	512	11.6	12.9	3.9 - 33.8
	McNary	337	14.6	15.8	5.5 - 40.5
	John Day	268	17.4	18.6	7.4 - 38.9
	Bonneville	128	19.4	19.2	9.7 - 36.1
Captain John Rapids	Lower Granite	679	8.3	9.3	2.1 - 85.1
	Little Goose	1,008	10.0	11.0	3.3 - 74.9
	Lower Monumental	830	10.6	11.3	4.2 - 36.5
	McNary	384	13.0	13.8	7.0 - 29.9
	John Day	317	15.7	16.0	7.6 - 32.9
	Bonneville	154	18.4	18.8	9.2 - 39.4
Lyons Ferry Hatchery	Lower Monumental	310	2.3	2.4	0.6 - 63.1
	McNary	184	8.3	9.0	3.3 - 52.0
	John Day	145	12.4	14.5	5.9 - 59.7
	Bonneville	59	16.2	16.9	9.6 - 26.7

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 1999.

BASED ON FIRST OBS - Individual release groups at multiple dams

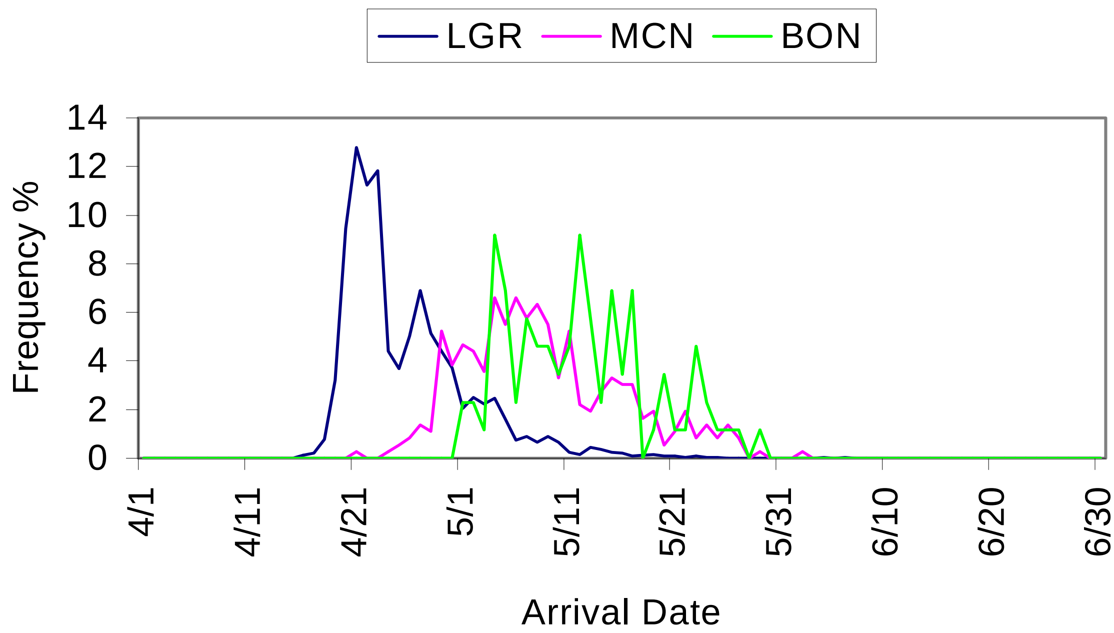

Figure E.1.—First obs arrival date frequency distribution of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 1999.

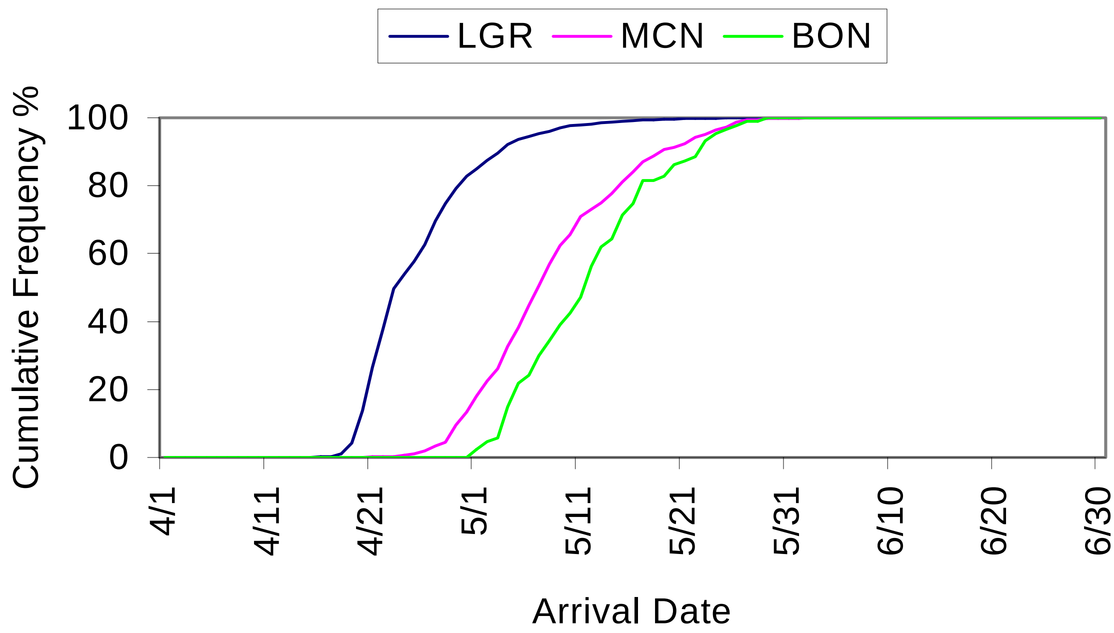

Figure E.2.—First obs arrival date cumulative frequency of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 1999.

Appendix E (continued).

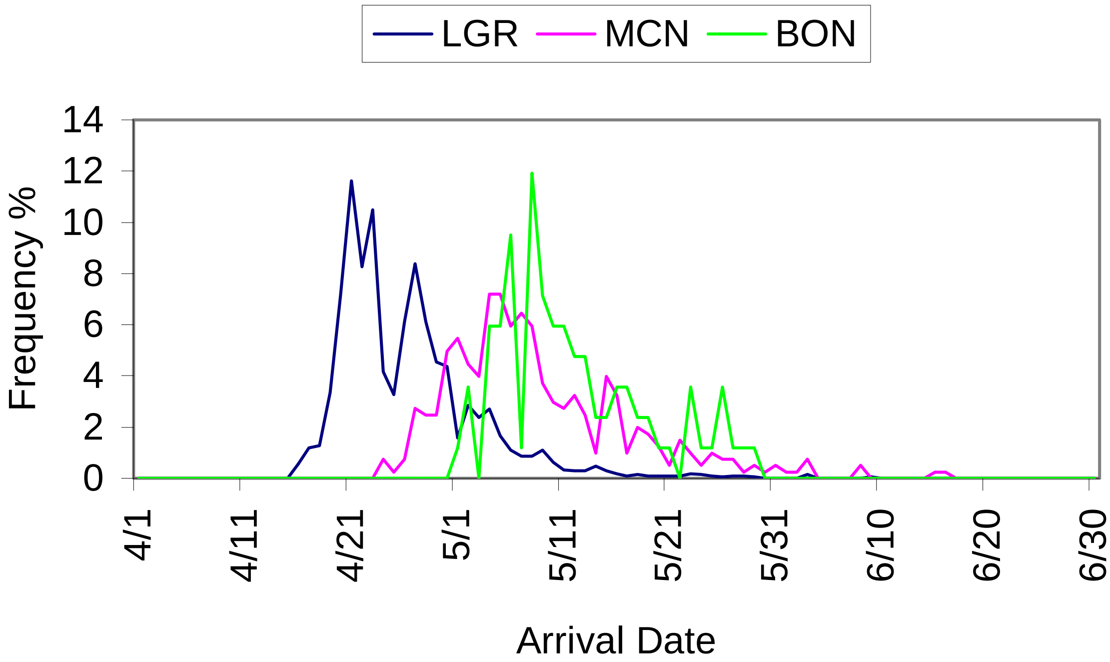

Figure E.3.—First obs arrival date frequency distribution of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 1999.

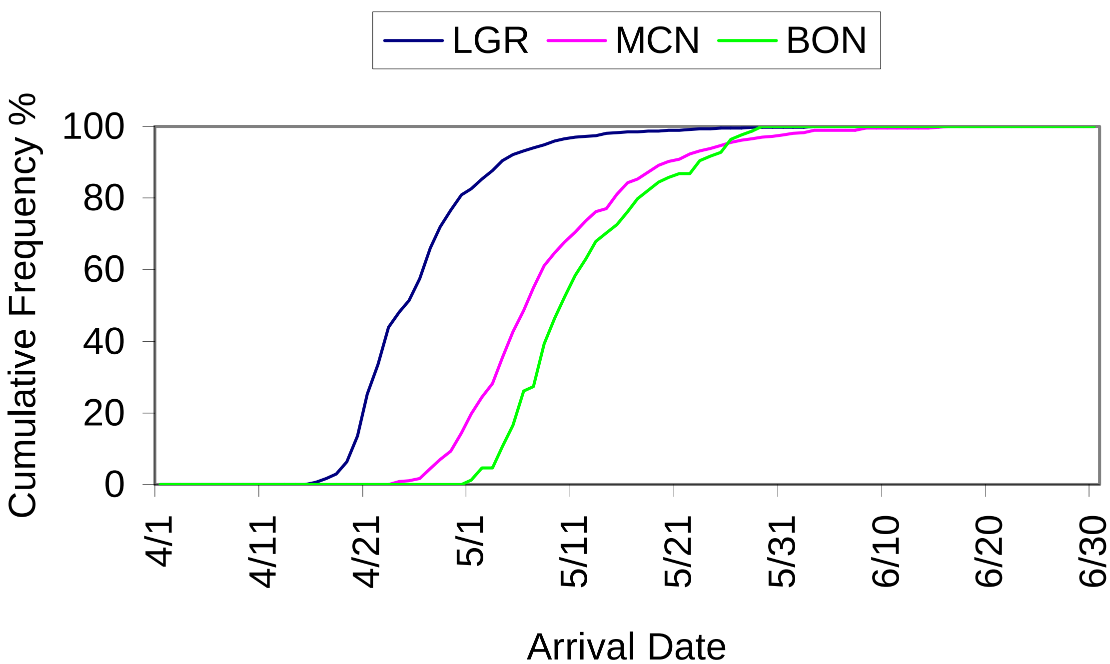

Figure E.4.—First obs arrival date cumulative frequency of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 1999.

Appendix E (continued).

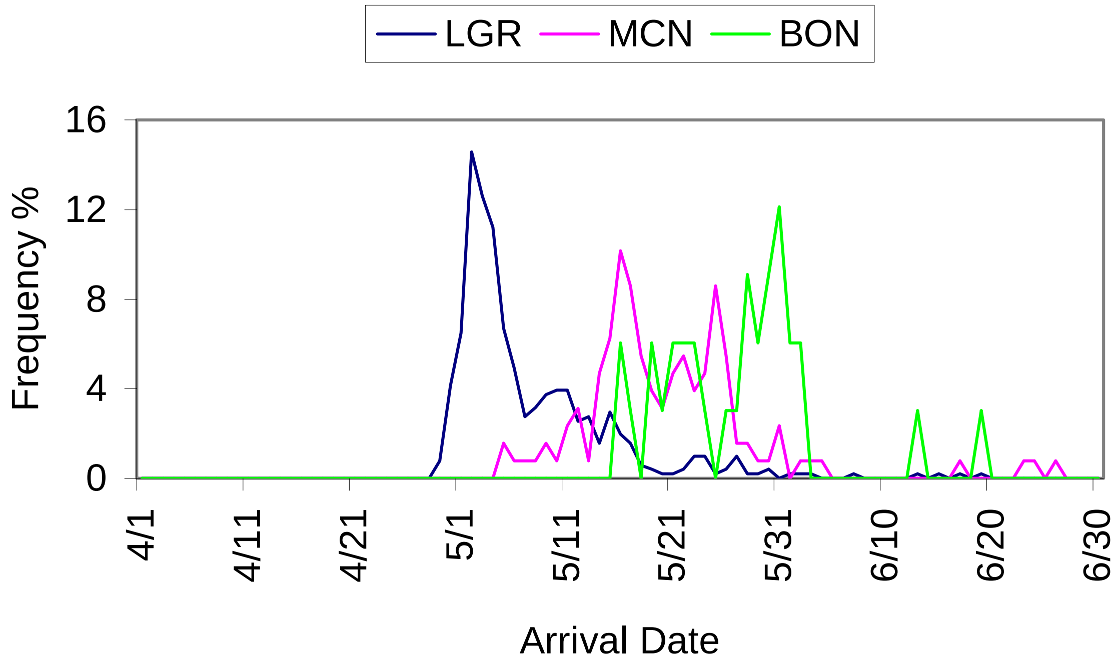

Figure E.5.—First obs arrival date frequency distribution of Big Canyon Surplus yearlings at Lower Granite, McNary and Bonneville dams in 1999.

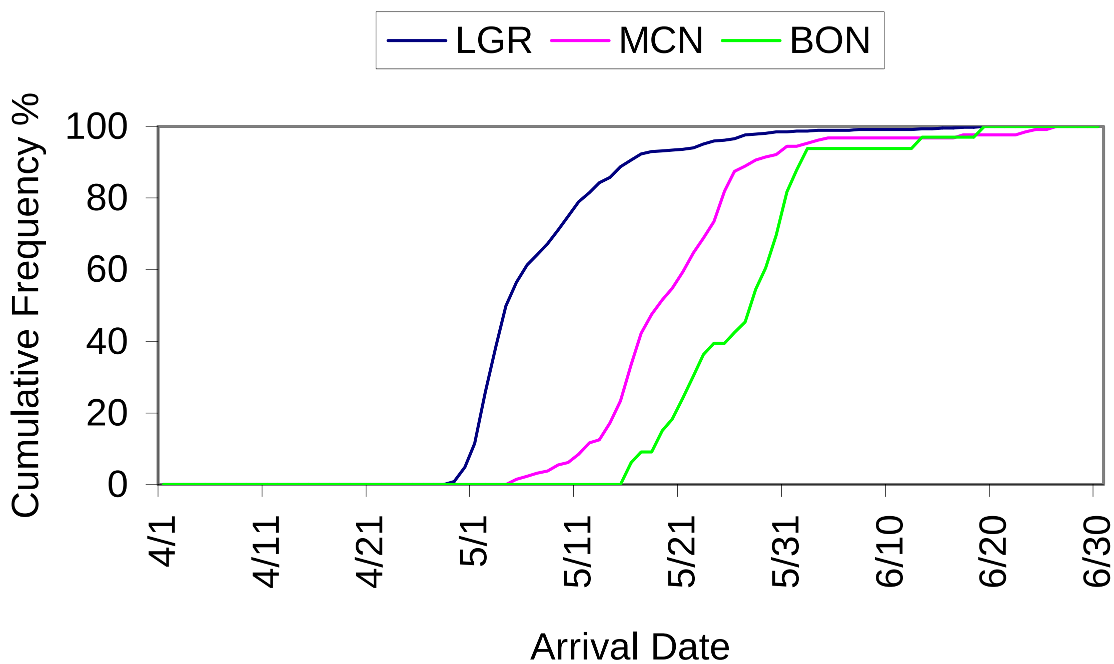

Figure E.6.—First obs arrival date cumulative frequency of Big Canyon Surplus yearlings at Lower Granite, McNary and Bonneville dams in 1999.

Appendix E (continued).

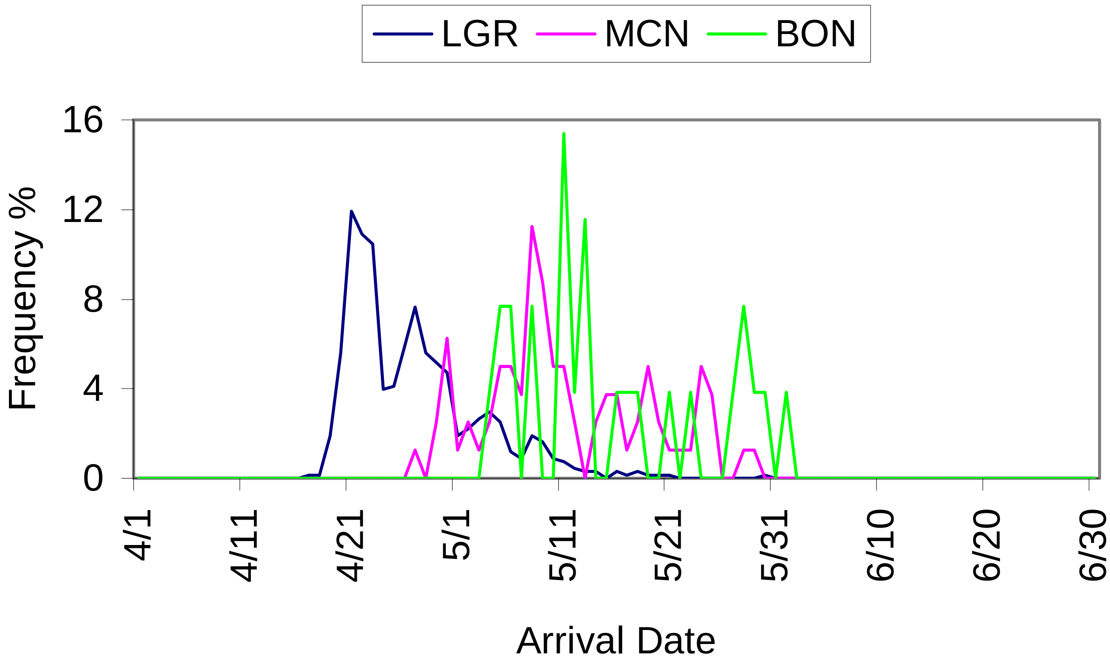

Figure E.7.—First obs arrival date frequency distribution of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 1999.

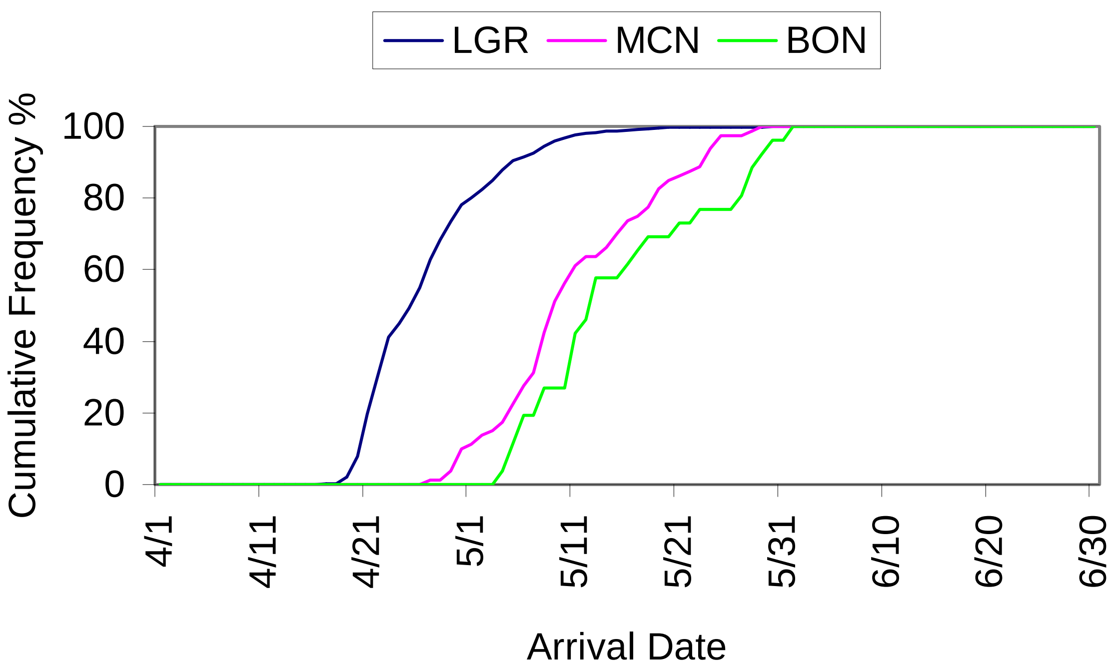

Figure E.8.—First obs arrival date cumulative frequency of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 1999.

Appendix E (continued).

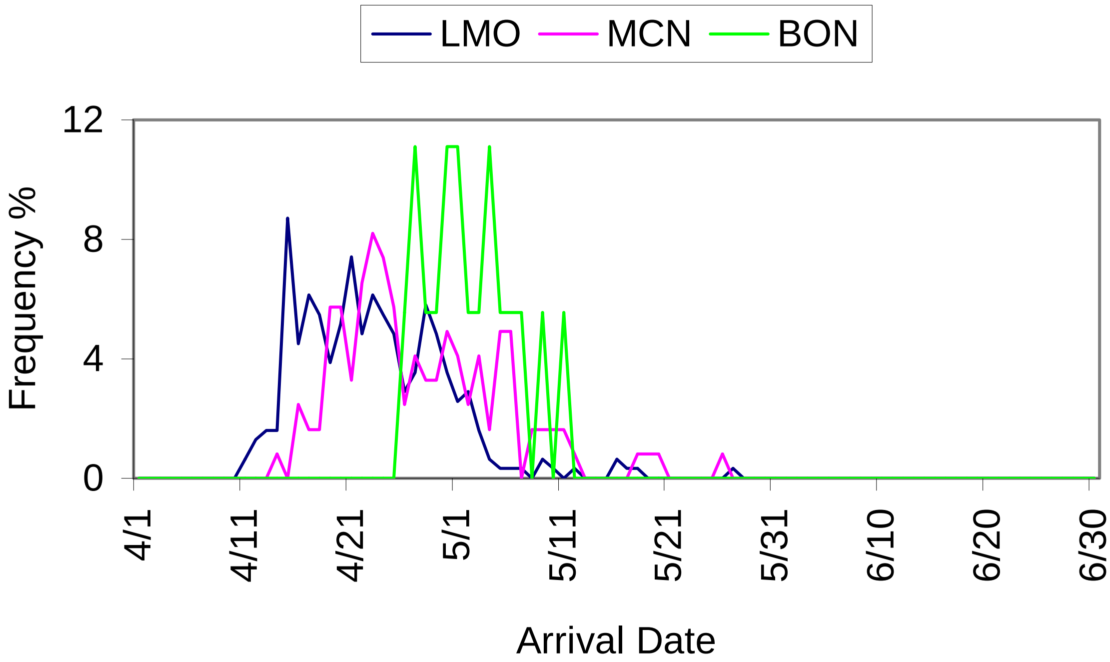

Figure E.9.—First obs arrival date frequency distribution of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 1999.

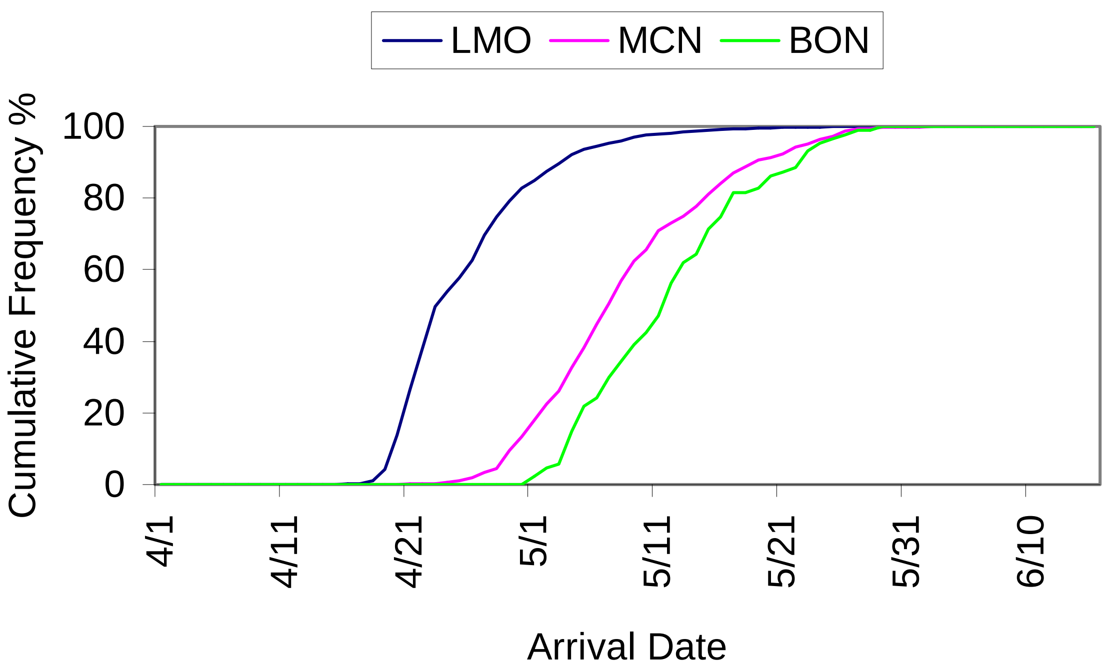

Figure E.10.—First obs arrival date cumulative frequency of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 1999.

Appendix E (continued).

BASED ON FIRST OBS - Multiple release groups at individual dams

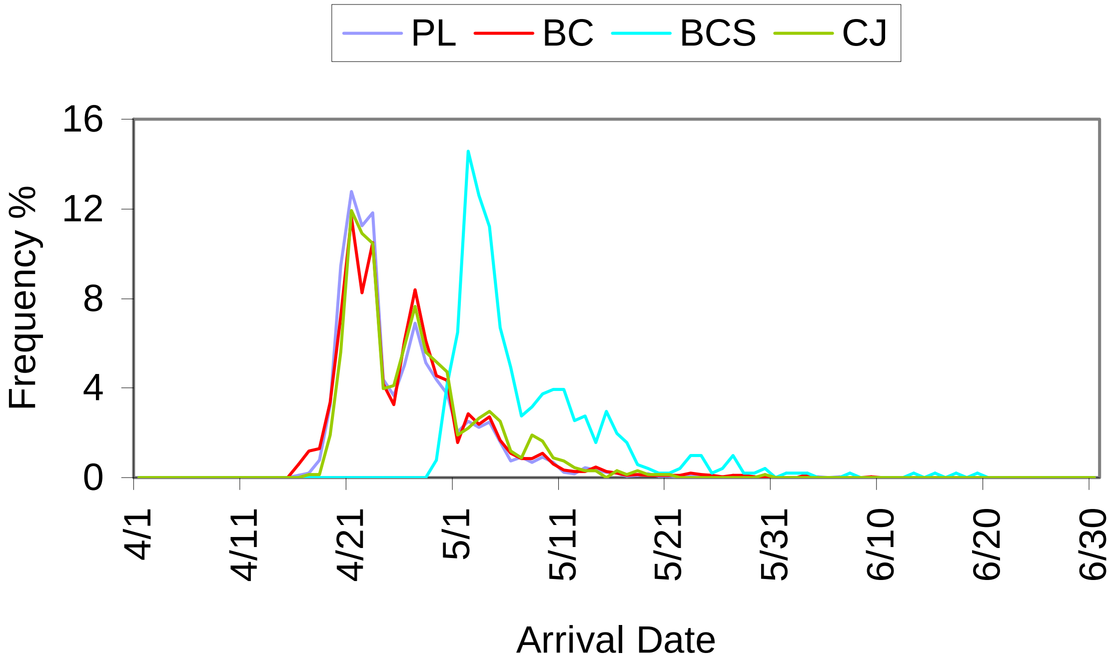

Figure E.11.—First obs arrival date frequency distribution of FCAP yearlings at Lower Granite Dam in 1999.

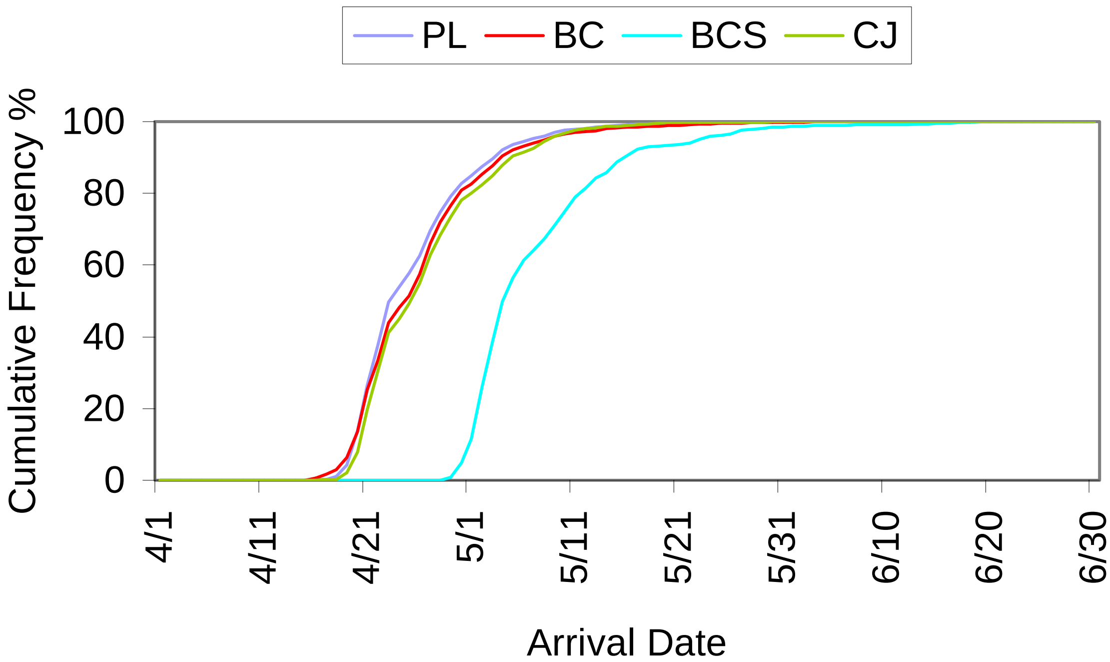

Figure E.12.—First obs arrival date cumulative frequency of FCAP yearlings at Lower Granite Dam in 1999.

Appendix E (continued).

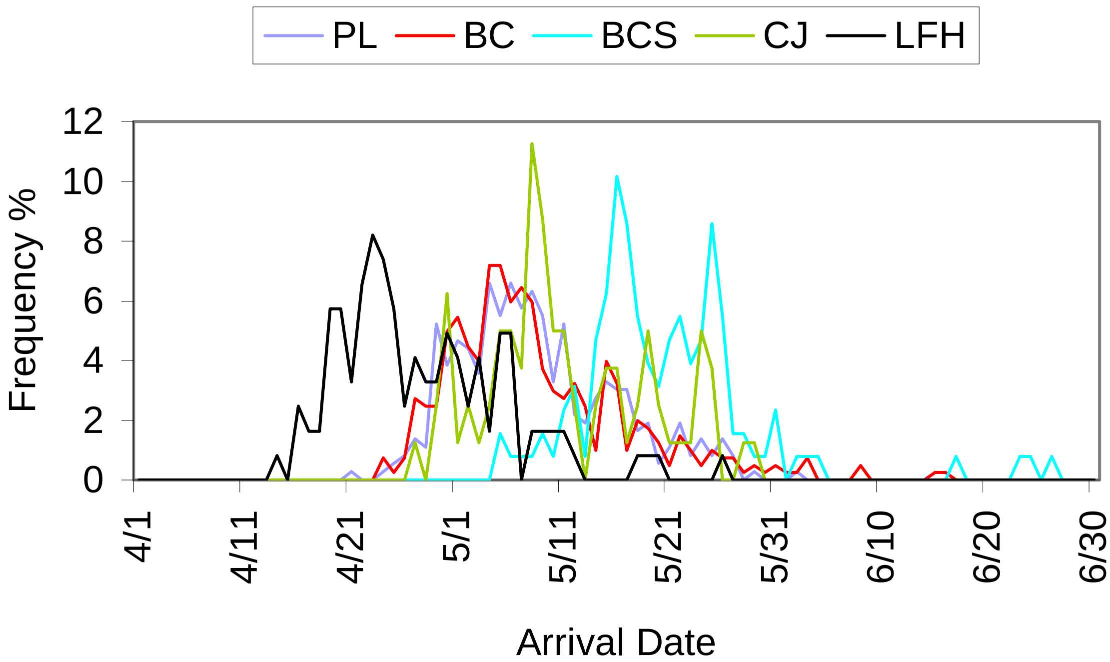

Figure E.13.—First obs arrival date frequency distribution of FCAP and LFH yearlings at McNary Dam in 1999.

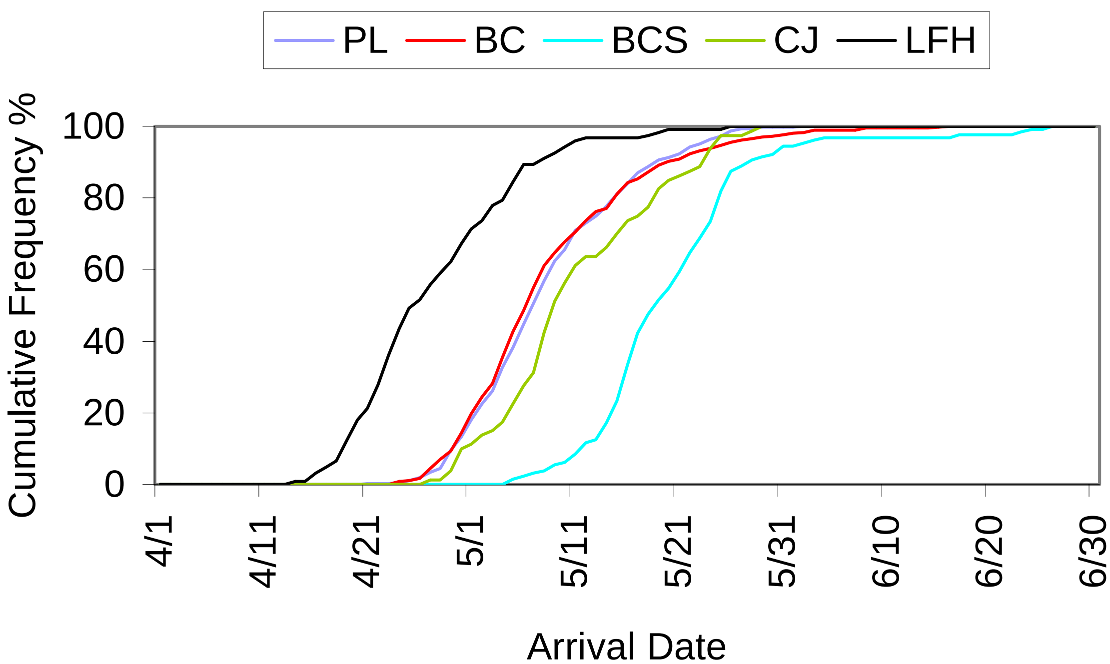

Figure E.14.—First obs arrival date cumulative frequency of FCAP and LFH yearlings at McNary Dam in 1999.

Appendix E (continued).

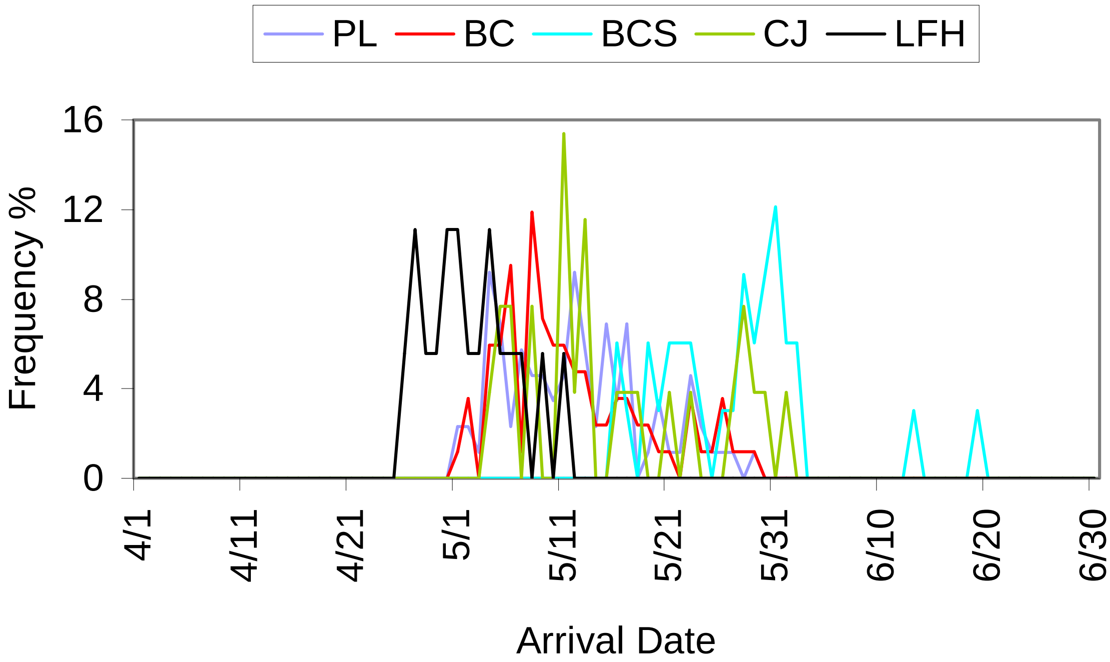

Figure E.15.—First obs arrival date frequency distribution of FCAP and LFH yearlings at Bonneville Dam in 1999.

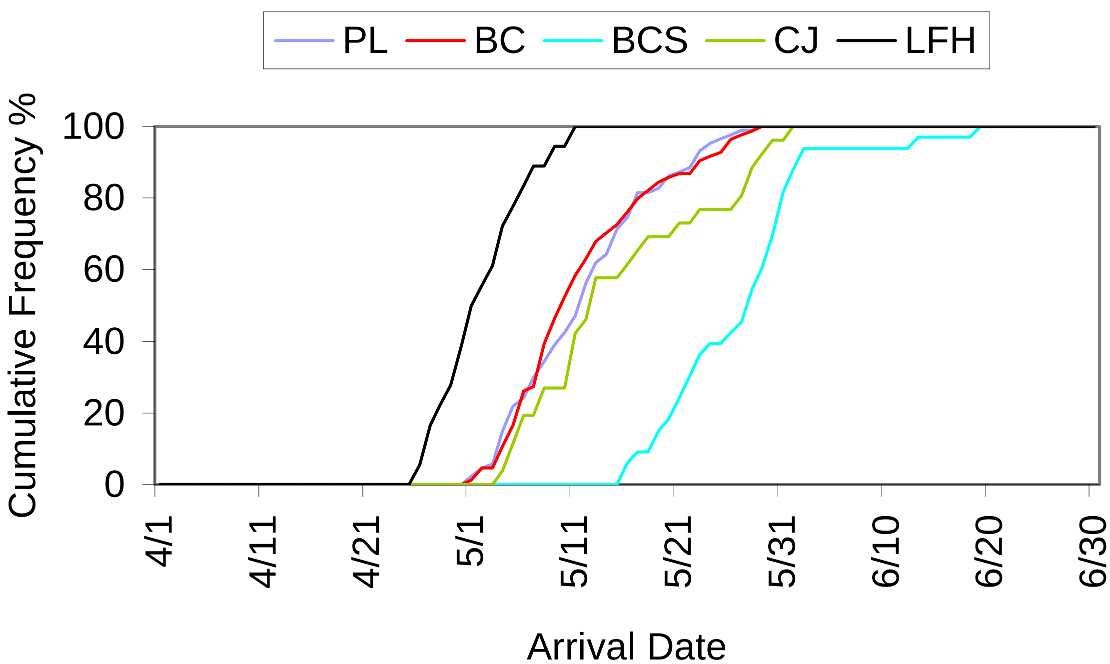

Figure E.16.—First obs arrival date cumulative frequency of FCAP and LFH yearlings at Bonneville Dam in 1999.

Appendix E (continued).

BASED ON ALL OBS - Individual release groups at multiple dams

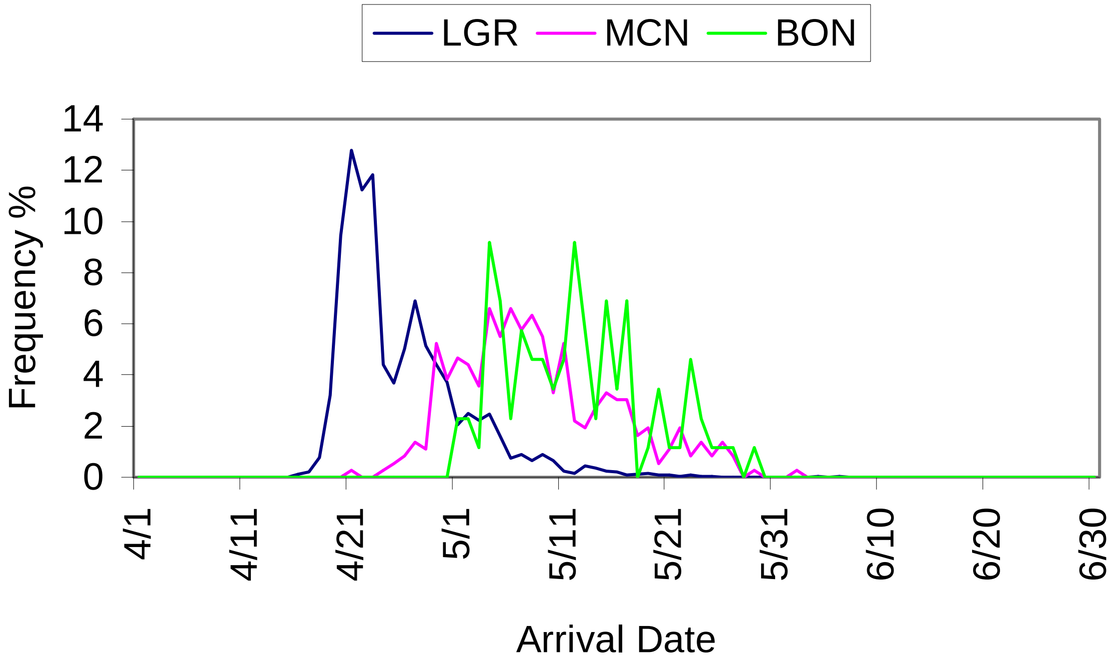

Figure E.17.—All obs arrival date frequency distribution of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 1999.

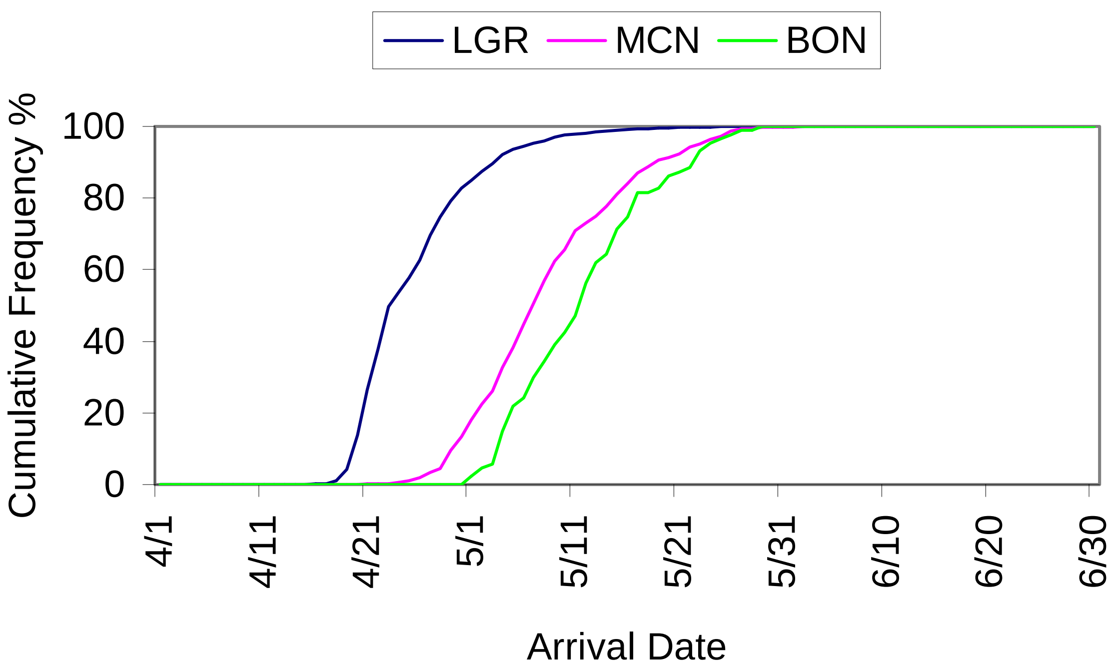

Figure E.18.—All obs arrival date cumulative frequency of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 1999.

Appendix E (continued).

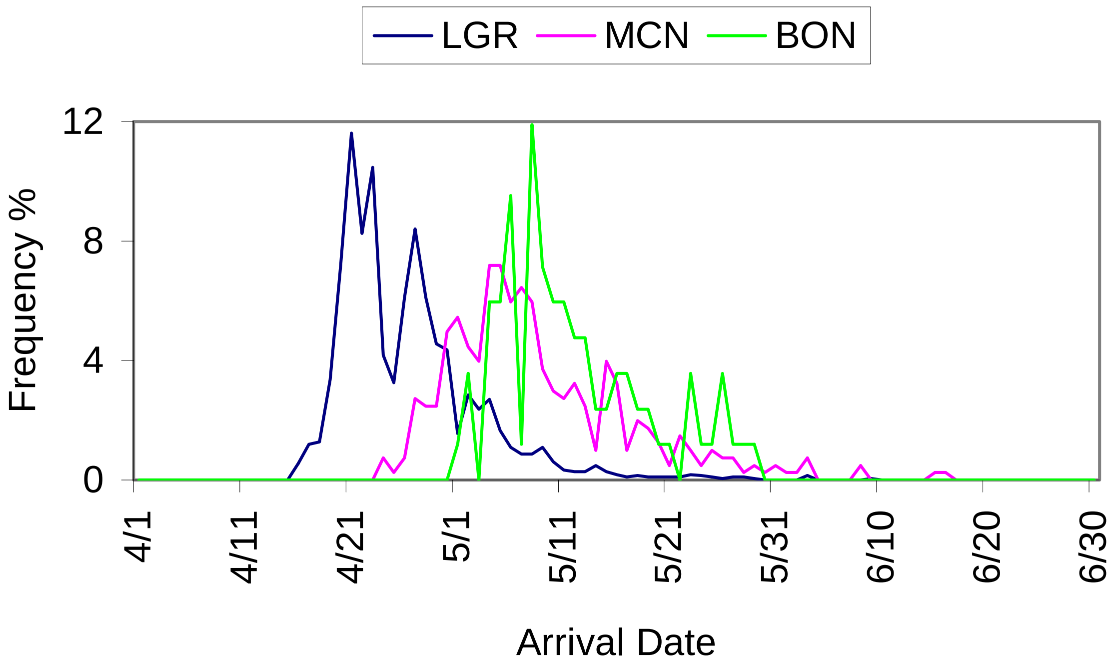

Figure E.19.—All obs arrival date frequency distribution of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 1999.

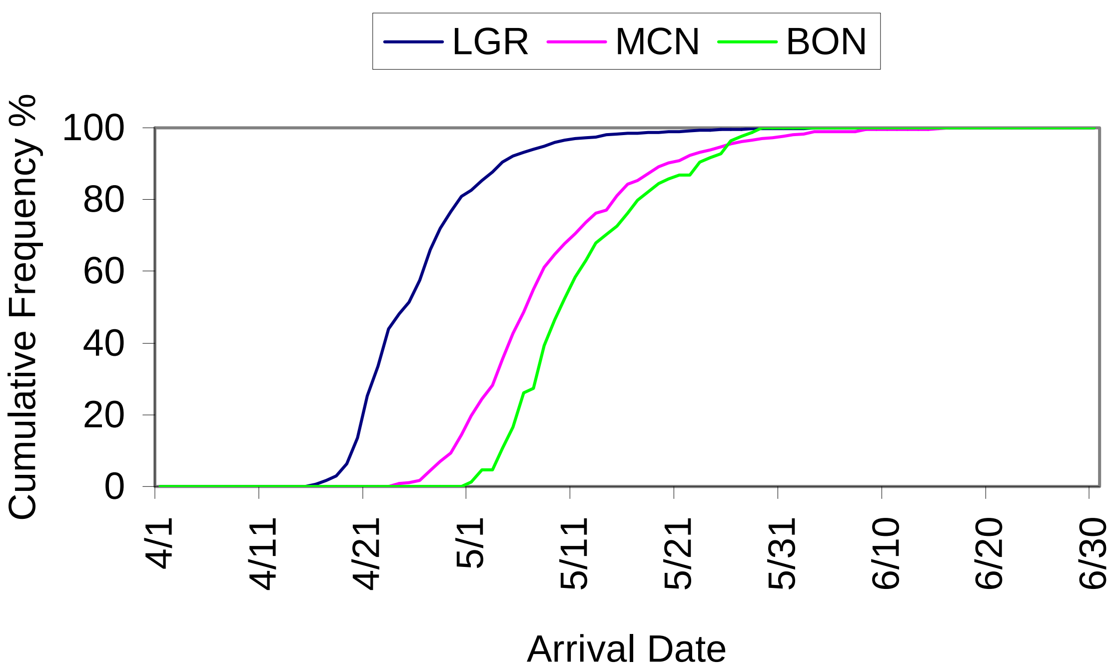

Figure E.20.—All obs arrival date cumulative frequency of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 1999.

Appendix E (continued).

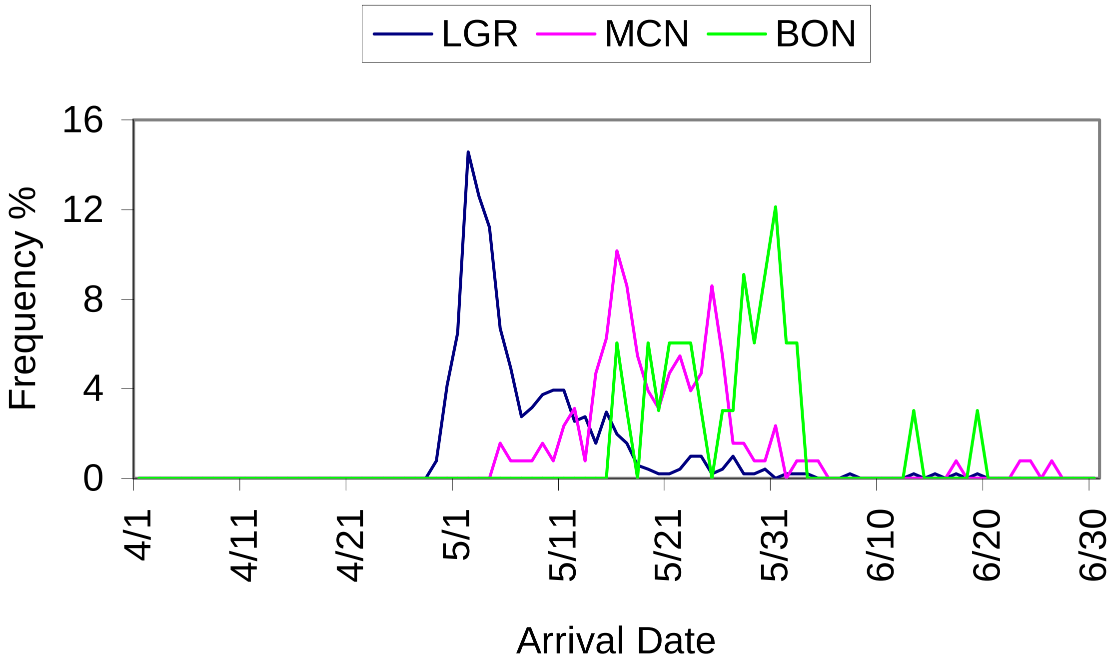

Figure E.21.—All obs arrival date frequency distribution of Big Canyon Surplus yearlings at Lower Granite, McNary and Bonneville dams in 1999.

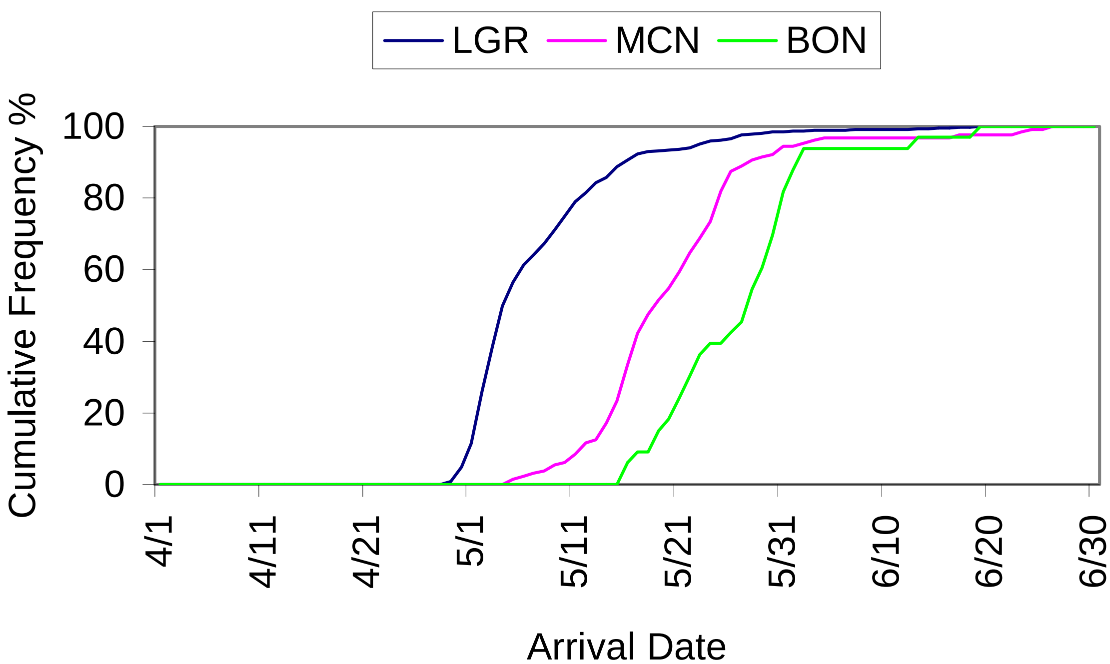

Figure E.22.—All obs arrival date cumulative frequency of Big Canyon Surplus yearlings at Lower Granite, McNary and Bonneville dams in 1999.

Appendix E (continued).

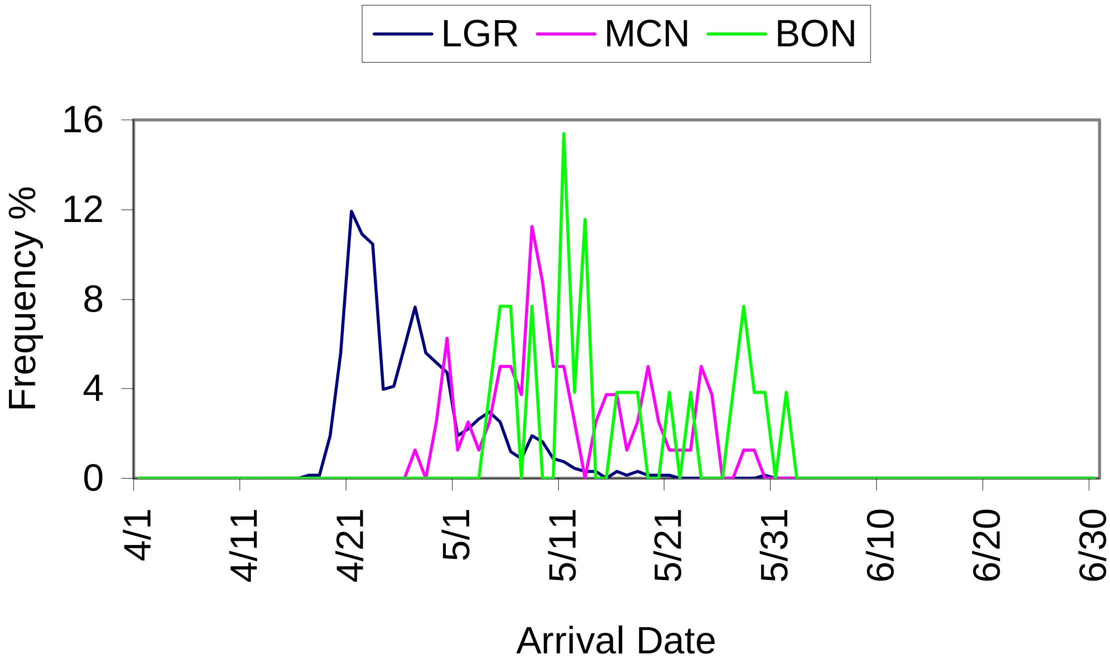

Figure E.23.—All obs arrival date frequency distribution of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 1999.

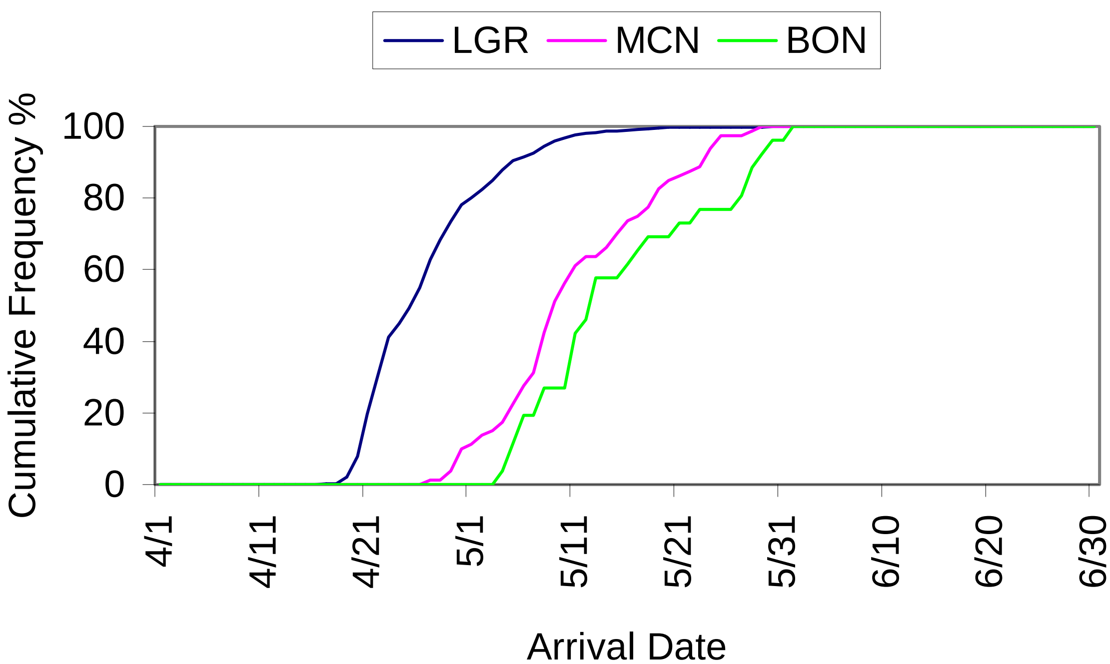

Figure E.24.—All obs arrival date cumulative frequency of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 1999.

Appendix E (continued).

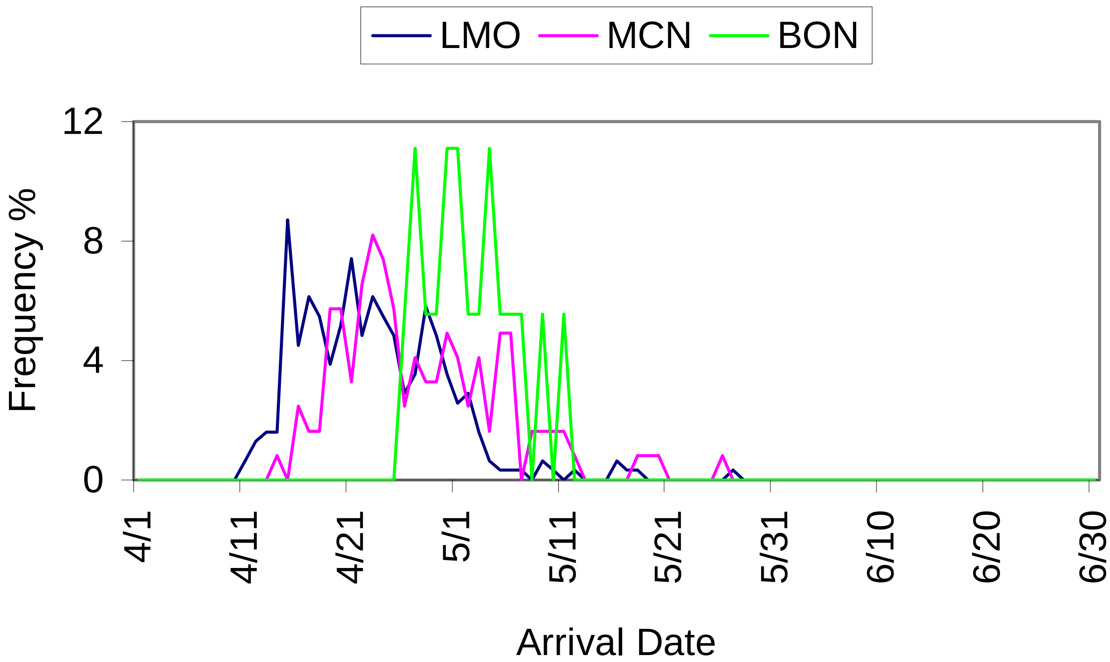

Figure E.25.—All obs arrival date frequency distribution of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 1999.

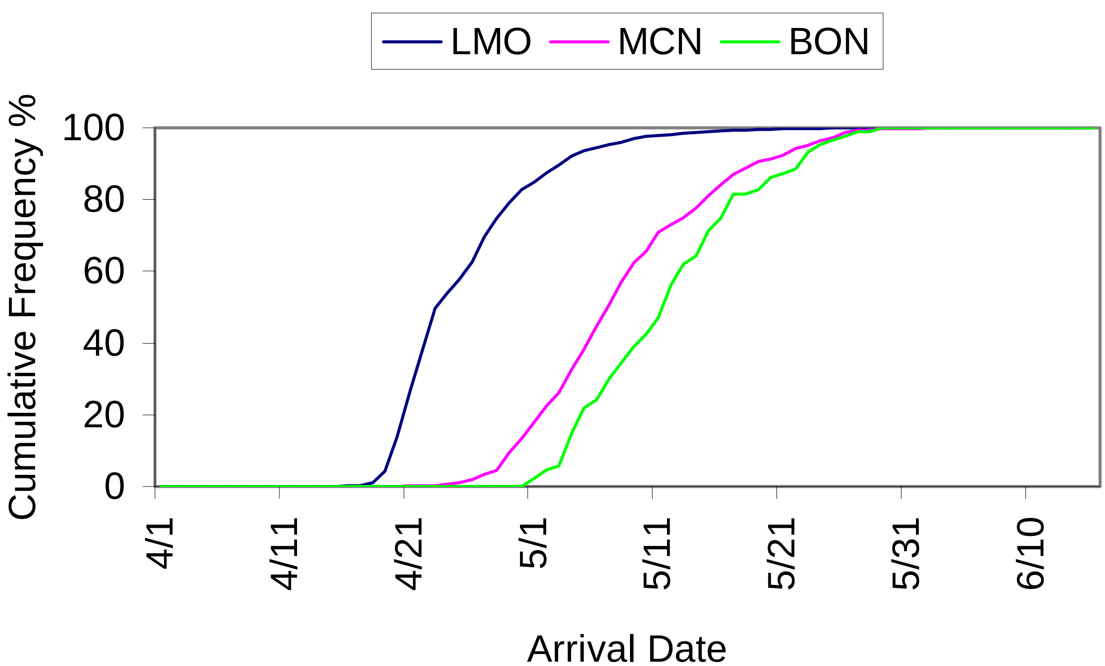

Figure E.26.—All obs arrival date cumulative frequency of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 1999.

Appendix E (continued).

BASED ON ALL OBS - Multiple release groups at individual dams

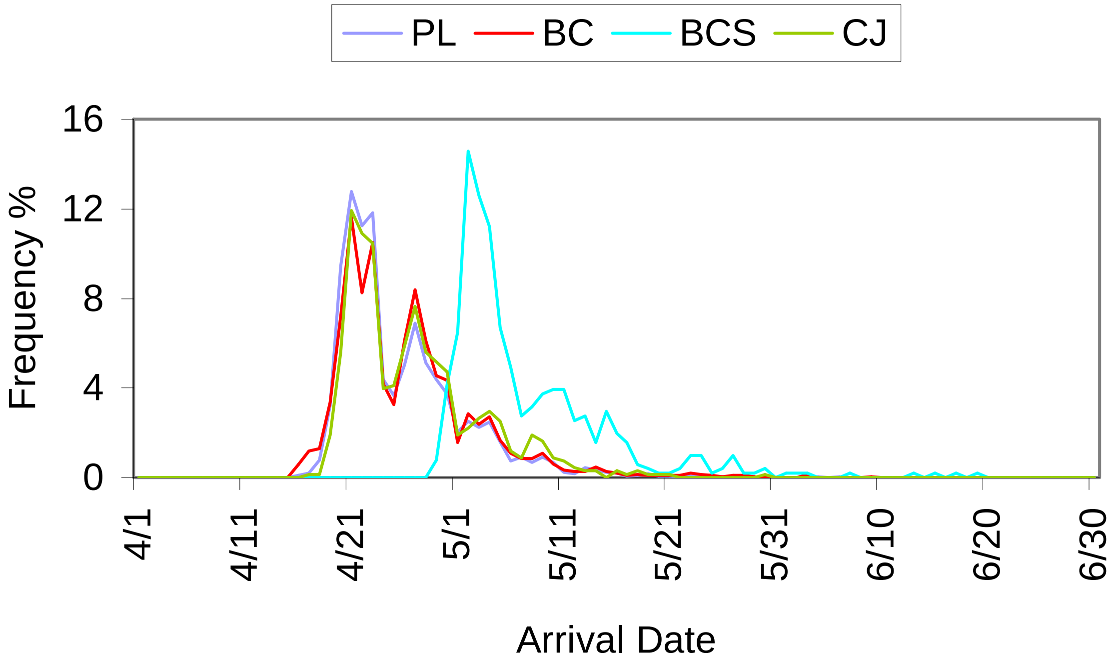

Figure E.27.—All obs arrival date frequency distribution of FCAP yearlings at Lower Granite Dam in 1999.

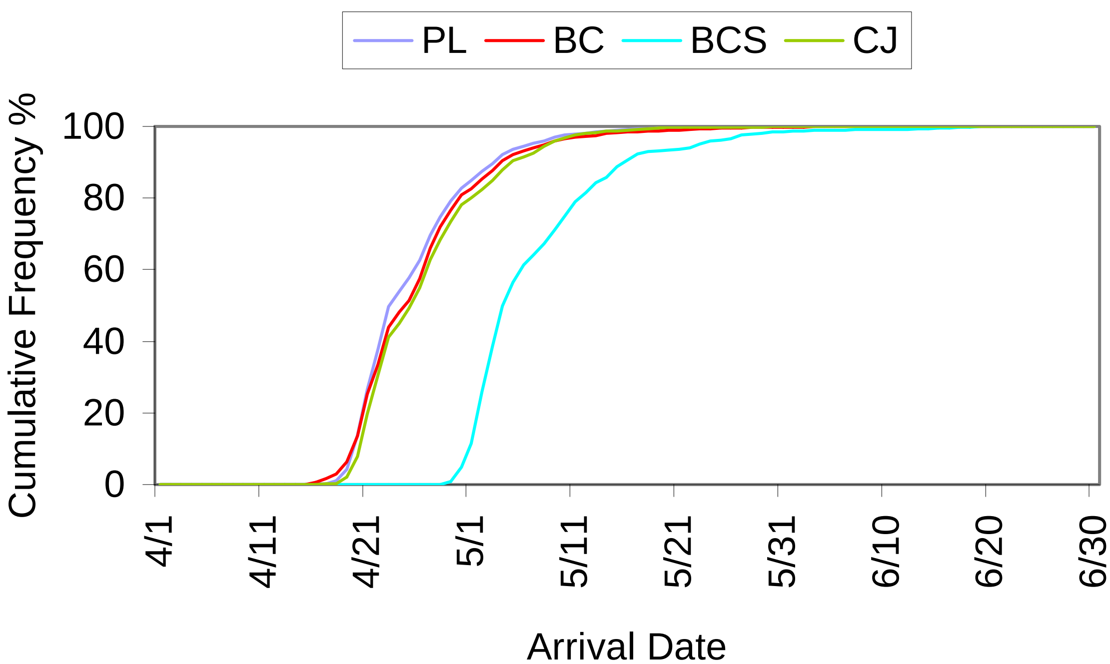

Figure E.28.—All obs arrival date cumulative frequency of FCAP yearlings at Lower Granite Dam in 1999.

Appendix E (continued).

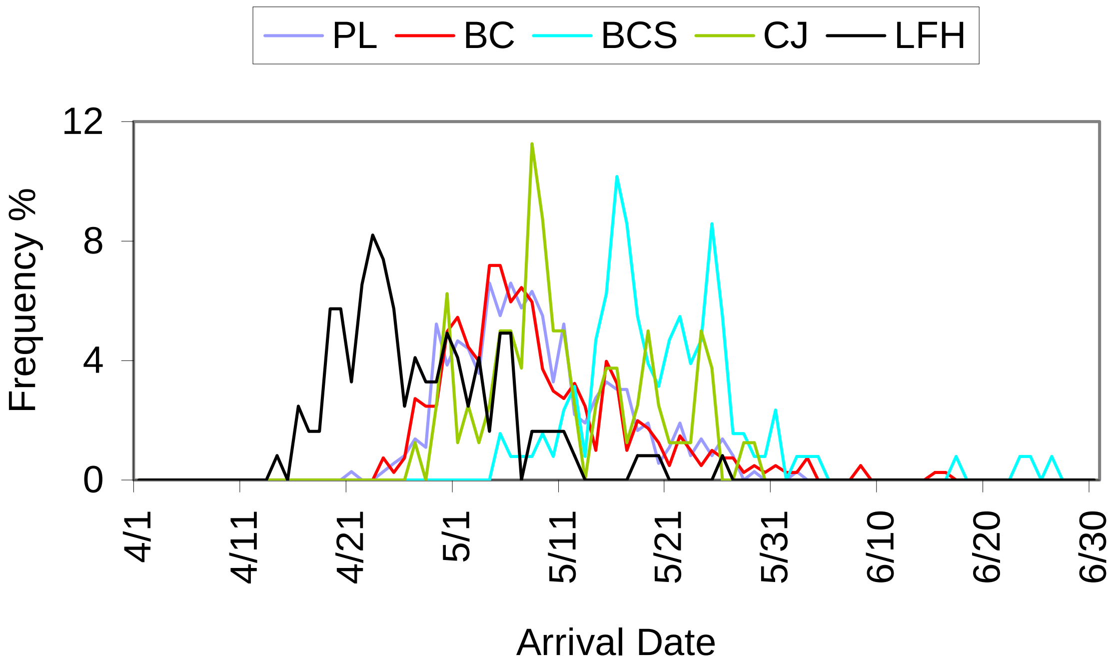

Figure E.29.—All obs arrival date frequency distribution of FCAP and LFH yearlings at McNary Dam in 1999.

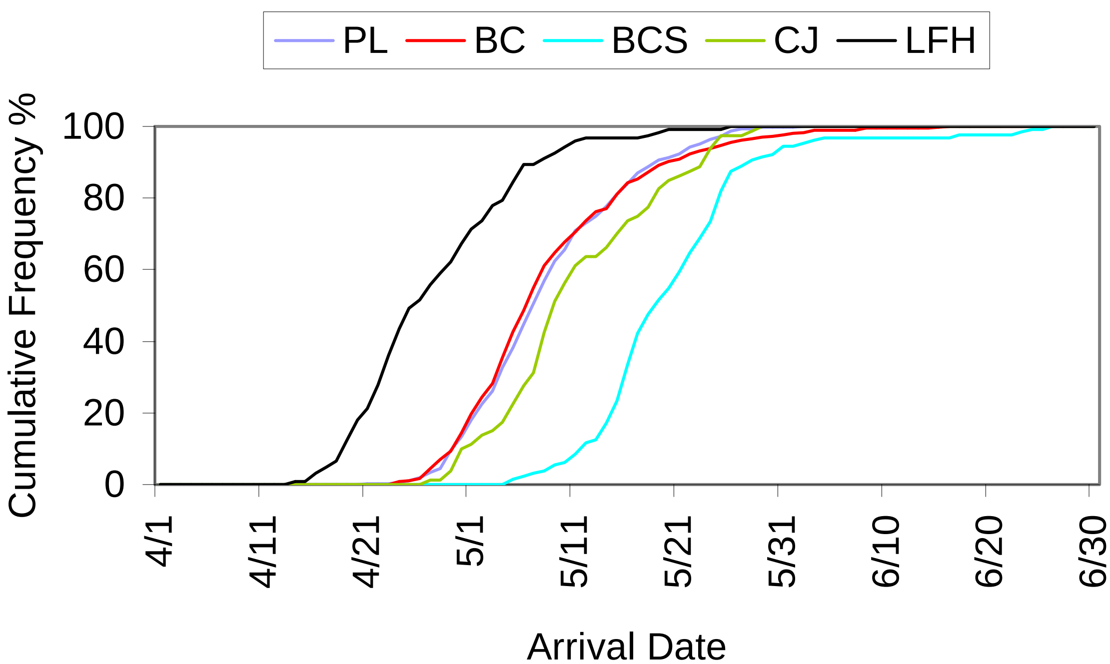

Figure E.30.—All obs arrival date cumulative frequency of FCAP and LFH yearlings at McNary Dam in 1999.

Appendix E (continued).

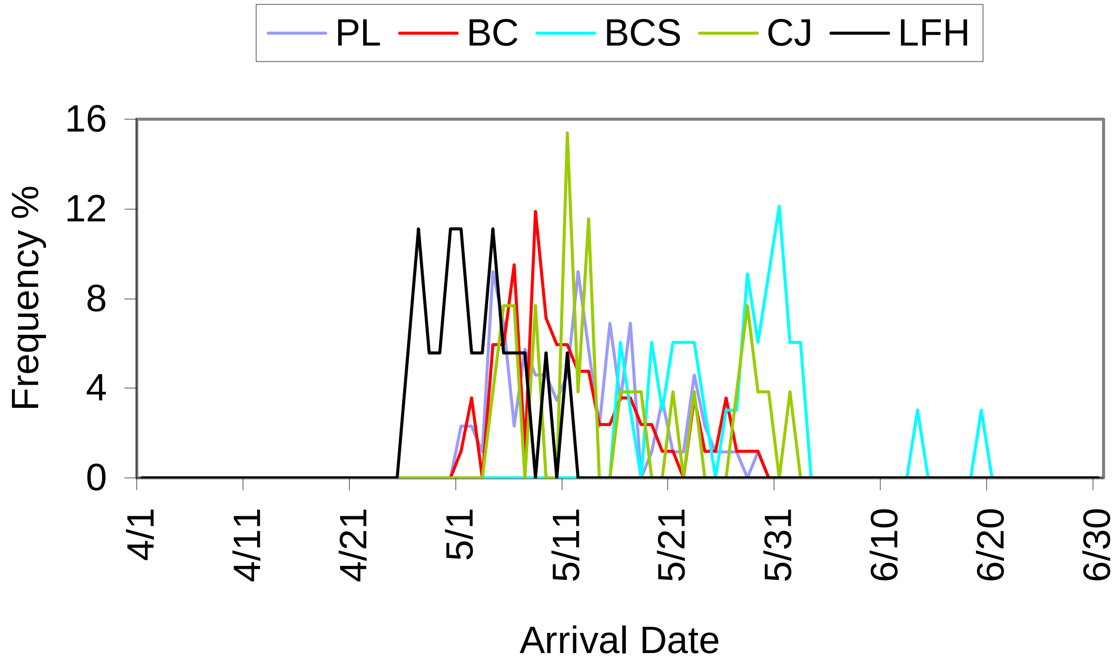

Figure E.31.—All obs arrival date frequency distribution of FCAP and LFH yearlings at Bonneville Dam in 1999.

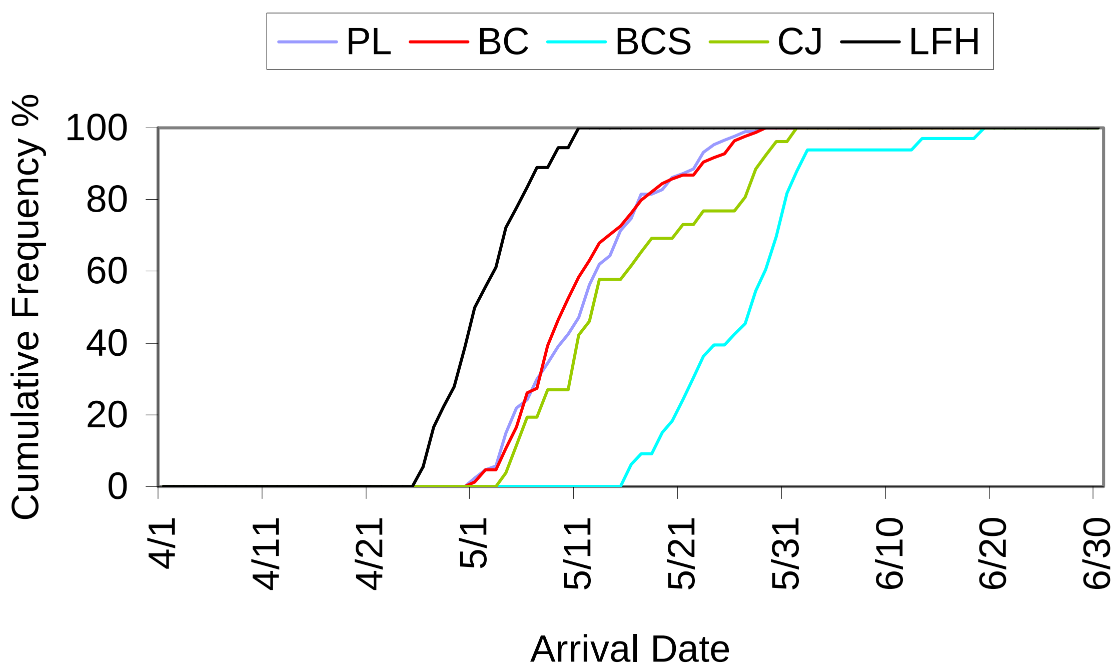

Figure E.32.—All obs arrival date cumulative frequency of FCAP and LFH yearlings at Bonneville Dam in 1999.