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

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

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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 2000 – December 2000**

Prepared by:


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

Dale S. Kellar
Nez Perce Tribe
Department of Fisheries Resources Management
Orofino, ID 83544


Prepared for:


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

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# EXECUTIVE SUMMARY

The Nez Perce Tribe, in cooperation with the U.S. Fish and Wildlife Service and Washington Department of Fish and Wildlife, conducted monitoring and evaluation studies on Lyons Ferry Hatchery reared yearling fall Chinook salmon *Oncorhynchus tshawytscha* that were acclimated and released at three Fall Chinook Acclimation Project sites upstream of Lower Granite Dam along with yearlings released on-station from Lyons Ferry Hatchery in 2000. This was the fifth year of a long-term project to supplement natural spawning populations of Snake River stock fall Chinook salmon upstream of Lower Granite Dam. The 397,339 yearlings released from the Fall Chinook Acclimation Project facilities were short of the 450,000 fish quota. We use Passive Integrated Transponder (PIT) tag technology to monitor the primary performance measures of survival to mainstem dams and migration timing. We also monitor size, condition and tag/mark retention at release.

We released 7,477 PIT tagged yearlings from Pittsburg Landing, 7,421 from Big Canyon and 2,488 from Captain John Rapids. The Washington Department of Fish and Wildlife released 980 PIT tagged yearlings from Lyons Ferry Hatchery. Fish health sampling indicated that, overall, bacterial kidney disease levels could be considered relatively low. Compared to prior years, Quantitative Health Assessment Indices were relatively low at Big Canyon and Captain John Rapids and about average at Pittsburg Landing and Lyons Ferry Hatchery.

Mean fork lengths (95% confidence interval) of the PIT tagged groups ranged from 157.7 mm (157.3-158.1 mm) at Big Canyon to 172.9 mm (172.2-173.6 mm) at Captain John Rapids. Mean condition factors ranged from 1.06 at Captain John Rapids and Lyons Ferry Hatchery to 1.12 at Big Canyon.

Estimated survival (95% confidence interval) of PIT tagged yearlings from release to Lower Granite Dam ranged from 87.0% (84.7-89.4%) for Pittsburg Landing to 95.2% (91.5-98.9%) for Captain John Rapids. Estimated survival from release to McNary Dam ranged from 65.8% (58.5-73.1%) for Lyons Ferry Hatchery to 84.0% (76.2-91.8%) 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 10.1 river kilometers per day (rkm/d) for Captain John Rapids to 19.1 rkm/d for Pittsburg Landing. Median migration rates to McNary Dam ranged from 6.0 rkm/d for Lyons Ferry Hatchery to 17.3 rkm/d for Pittsburg Landing. Median travel times from the FCAP facilities were about 9-10 days to Lower Granite Dam and 22-25 days to McNary Dam.

Median arrival dates at Lower Granite Dam, based on all observations of PIT tagged yearling groups from Pittsburg Landing, Big Canyon and Captain John Rapids, were all from April 21-22. Median arrival dates at McNary Dam for Pittsburg Landing, Big Canyon and Captain John Rapids groups were all from May 5-6. The median arrival date at McNary Dam was April 24 for Lyons Ferry Hatchery yearlings.

## ACKNOWLEDGEMENTS

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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 2000. This was the fifth 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 2000. We are in the fourth 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 2000 please reference Milks et al. (2000 and 2003).

## PROJECT OBJECTIVES

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

## METHODS

<u>Study Area Description</u>

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

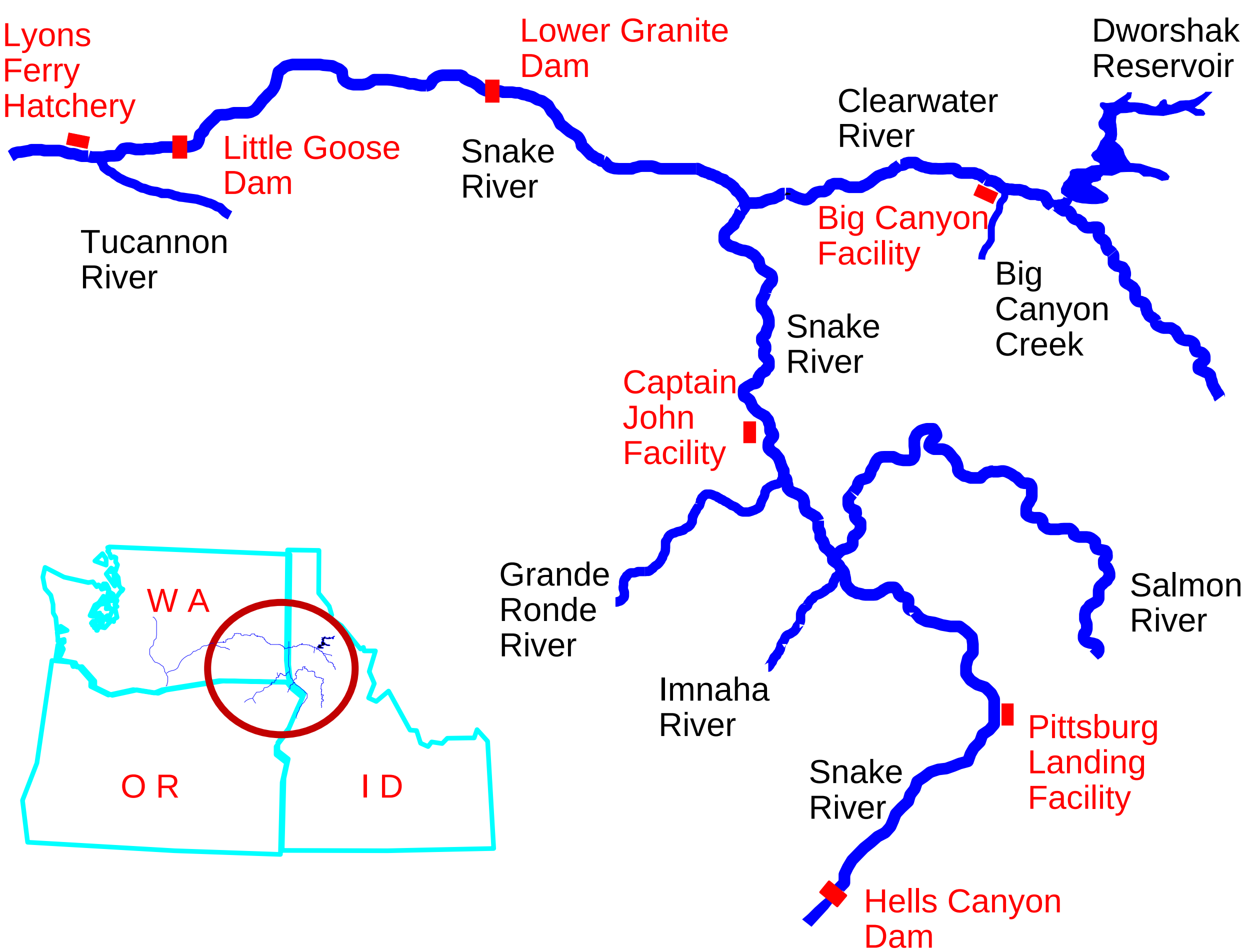


Figure 1.—Map of primary study area highlighting FCAP acclimation facilities, Lyons Ferry Hatchery and various Snake River dams.

Fish Handling and Anesthetization

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

Fish sampled for PIT tagging were captured with dip nets from tanks 5, 9 and 16 at Pittsburg Landing and tanks 1, 11 and 16 at Big Canyon. A screen was used to crowd fish in the tanks to improve capture efficiency and to obtain a representative subsample. Fish captured for PIT tagging were anesthetized in an MS-222 bath consisting of 3 mL stock solution (100 g/L) per 8 L of water buffered with sodium bicarbonate solution. PIT tagging at Pittsburg Landing and Big Canyon took place one week prior to release. Fish for PIT tagging at Captain John Rapids were captured from the pond, tagged, allowed to recover and released back into the pond to migrate volitionally with the rest of the fish. At LFH, yearlings were captured from the exit flume, tagged, allowed to recover and released directly back into the exit flume to the river. For a detailed description of fall Chinook salmon broodstock collection, incubation, rearing, and marking procedures at LFH please reference Milks et al. (2000 and 2003).

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 $\geq$ 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.

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 Captain John Rapids. WDFW personnel conducted PIT tagging activities on March 31 and April 11 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 and VIE, respectively.

Survival Estimation

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

PIT Tag Observation

The six main PIT tag observation (also called detection or interrogation) locations in the study area are Lower Granite (LGR), Little Goose (LGO), Lower Monumental (LMO), McNary (MCN), John Day (JDA) and Bonneville (BON) dams. PIT tag observation data were downloaded from the PTAGIS database. Arrival timing dates, cumulative observations, survival estimates, travel times in days, and migration rates in river kilometers per day (rkm/d) to the main observation sites were calculated from these data. Even though a volitional release was employed at Captain John Rapids, we are reporting travel times and migration rates calculated from the final date of the volitional release. However, because of the inability to identify the actual date and time a given fish left the facility under the volitional release strategy, these measurements of travel time and migration rate are minimum and maximum values, respectively. Fish with single coil detections or negative travel times were removed from analyses where applicable.

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

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

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

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

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

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

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

[1]Kilometers for individual rivers are separated by periods. For the Pittsburg Landing Acclimation Facility, the notation is: 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 134,709 yearlings were released from Pittsburg Landing and 131,306 from Big Canyon. The fish were released in stages, about one-third of each group per day for three days from April 11-13. A total of 131,324 yearlings were released volitionally from Captain John Rapids from April 1-12. The total FCAP release number of 397,339 fell short of the release quota of 450,000 yearlings. Lyons Ferry Hatchery met its 450,000 release quota, volitionally releasing 456,401 yearlings March 24 – April 14.

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

This was the fourth 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 2000. A comprehensive report detailing activities and results for the entire study will be submitted upon completion of the study.

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

### Fish Health

Personnel from the USFWS Idaho Fish Health Center collected yearlings for health analysis at the FCAP facilities and LFH from April 11-13, 2000. 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 and LFH, but showed improvement at Big Canyon and Captain John Rapids. Overall, based on ELISA values, 2000 can be considered a year of moderately low levels of BKD in yearling fall Chinook salmon from LFH. Overall BKD levels did not increase after transport from LFH to the FCAP facilities; in fact, they may have decreased slightly based on the ELISA values observed from yearlings at 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 2000.

| | | | ELISA | | | |
|---|---|---|---|---|---|---|
| Location | QHAI | *n* | Not Detected | Low | Medium | High |
| Pittsburg Landing | 18.7 | 60 | 32 (53%) | 0 | 23 (38%) | 4 (7%) |
| Big Canyon | 4.2 | 60 | 33 (55%) | 0 | 23 (38%) | 4 (7%) |
| Captain John Rapids | 5.5 | 59 | 44 (75%) | 0 | 10 (17%) | 4 (7%) |
| Lyons Ferry Hatchery | 23.5 | 60 | 33 (55%) | 0 | 13 (22%) | 10 (17%) |

Flow and Temperature

The average flow in the Snake River near Hell’s Canyon Dam in April was about 4% below the 34-year average from 1965 to 1999. Overall, flows rose gradually from the beginning of 2000 to peak at 32,400 cfs on April 19-22 (Figure 2). Spring flow patterns in 2000 did not resemble flow patterns in 1998 and 1999. Flows were considerably lower and steadier, without the pronounced peaks seen in 1998 and 1999. Flow patterns at the Hell’s Canyon gauge location are essentially dictated entirely by operations at Hell’s Canyon Dam.

The daily average discharge in the Snake River at Anatone is considerably higher than the discharge at Hell’s Canyon Dam due to input from the Salmon, Imnaha and Grande Ronde Rivers. Flows in the Snake River at Anatone in April were about 13% above the 41-year average from 1958 to 1999 (Figure 3). Flows at Anatone peaked at 68,200 cfs, which was nearly 50% lower than the peak flow in 1999. The daily mean water temperature during April ranged from $8.8^{O}$ to $12.5^{O}$ C with an overall mean of $10.9^{O}$ C.

The average daily discharge in the Clearwater River at Peck in April was about 55% above the 35-year average from 1964 to 1999, peaking at 45,700 cfs on April 22. The higher than normal flows seen at Peck from about July 8 through the end of August were due to water releases from Dworshak Reservoir on the North Fork Clearwater River (Figure 4). The daily mean water temperature during April ranged from $5.8^{O}$ to $8.0^{O}$ C with an overall mean of $6.8^{O}$ C.

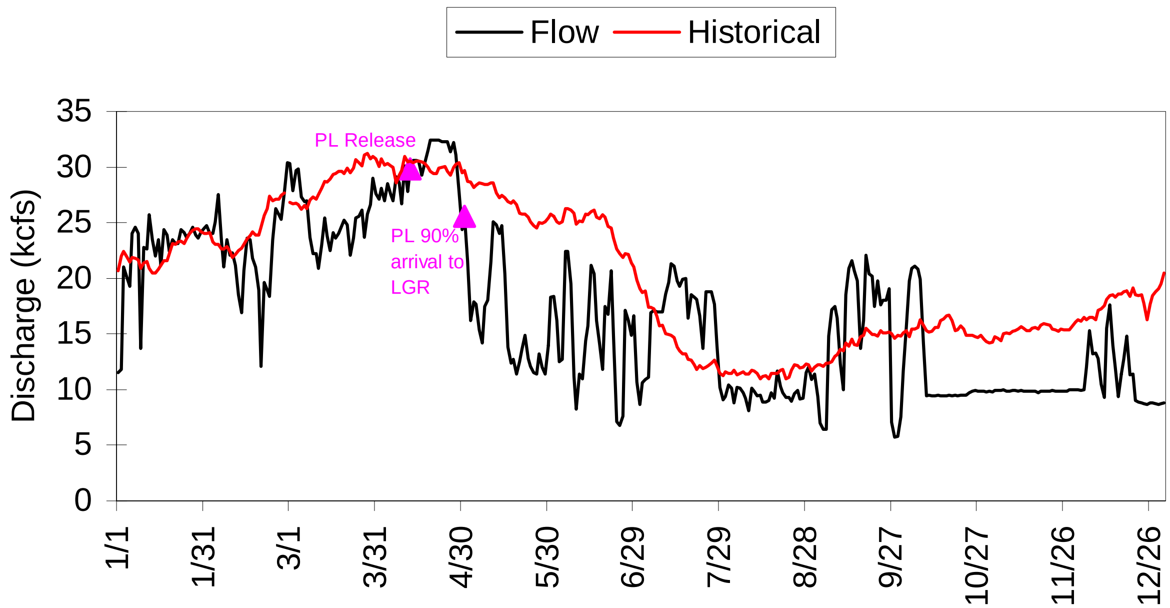


Figure 2.—Mean daily flow in 2000 and historical mean flow from 1965-1999 for the Snake River as measured at USGS gauge 13290450 near Hell's Canyon Dam.

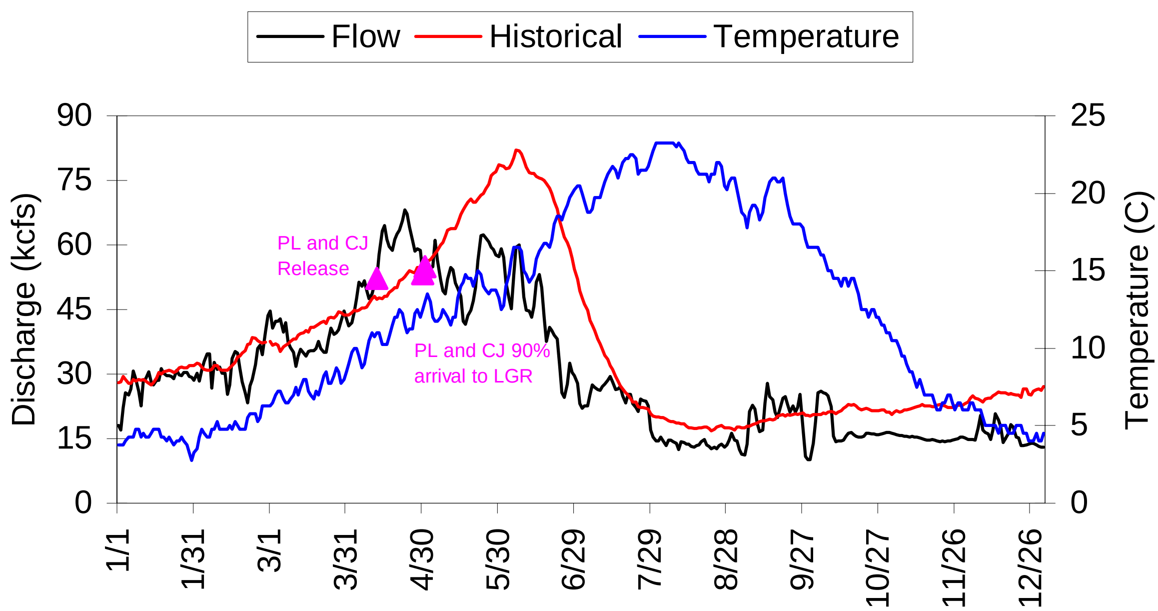


Figure 3.—Mean daily flow and temperature in 2000 and historical mean flow from 1958-1999 for the Snake River as measured at USGS gauge 13334300 near Anatone, Washington.

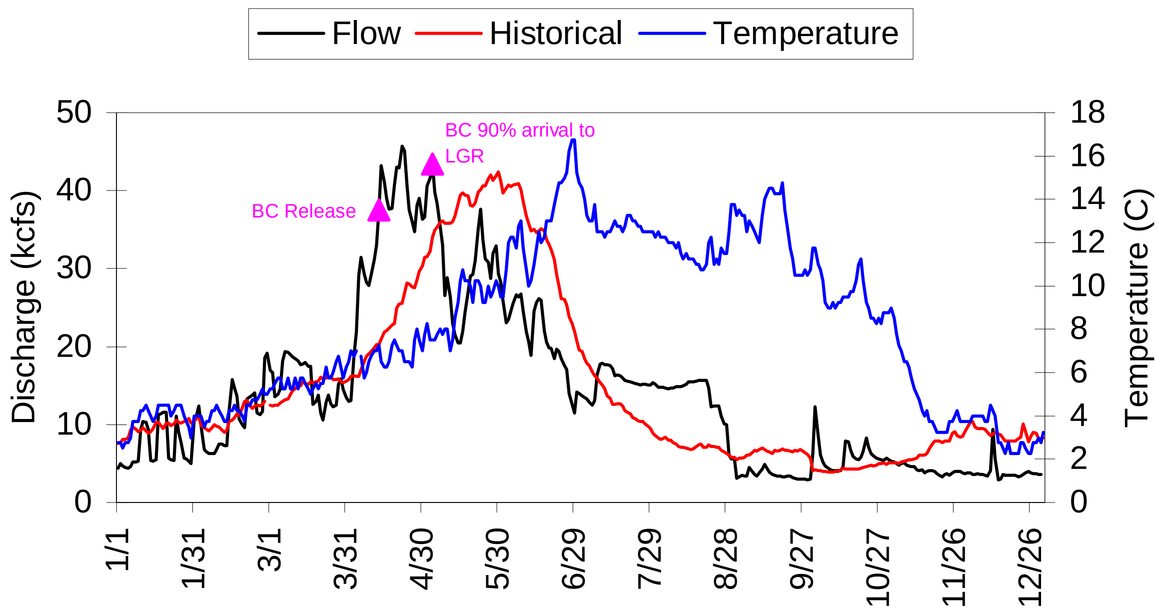


Figure 4.—Mean daily flow and temperature in 2000 and historical mean flow from 1964-1999 for the Clearwater River as measured at USGS gauge 13341050 near Peck, Idaho.

Average daily outflow as measured in the tailrace at Lower Granite Dam began increasing with spring runoff from 44.0 kcfs on March 22 peaking at 115.4 kcfs on April 23 (Figure 5). The main period of spill was from April 5 through June 20 with daily spill averaging 24.6 kcfs and peaking at 49.7 kcfs on April 23. During periods of spill, spill closely tracked the total outflow pattern from early April through the late June.

Average daily outflow as measured in the tailrace at McNary Dam showed a rapid increase from about 142.8 kcfs on April 1, peaking at 359.3 kcfs on April 23 (Figure 6). The main period of spill was from April 4 through August 19 with daily spill averaging 60.3 kcfs and peaking at 190.3 kcfs on May 27. During periods of spill, spill closely tracked the total outflow pattern.

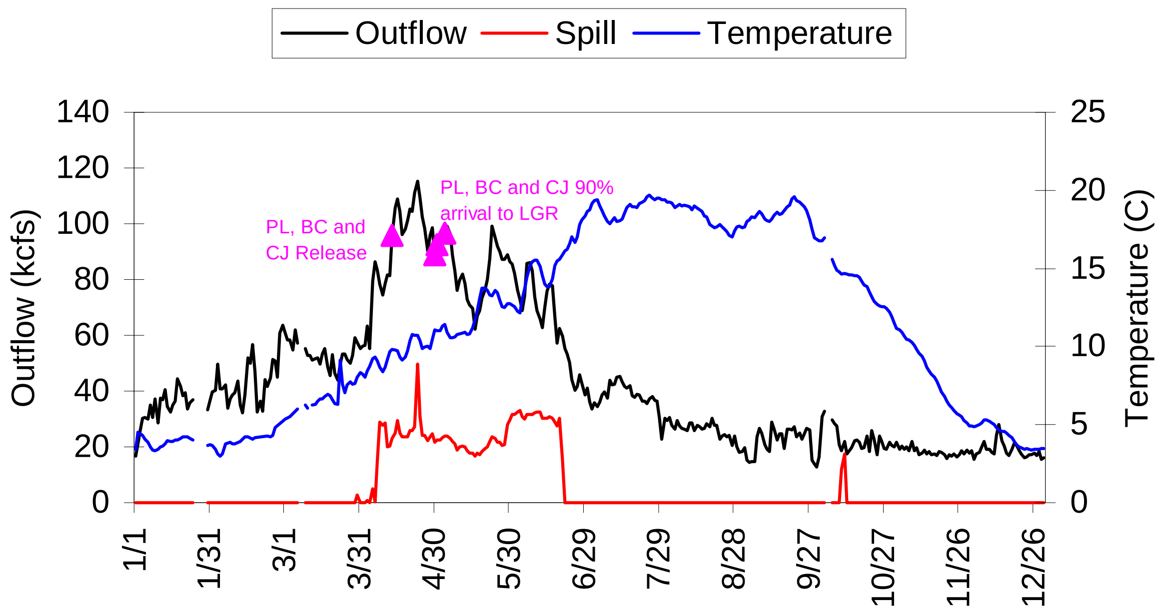


Figure 5.—Mean daily flow, spill, and temperature for the Snake River in 2000 as measured by the USACE at Lower Granite Dam.

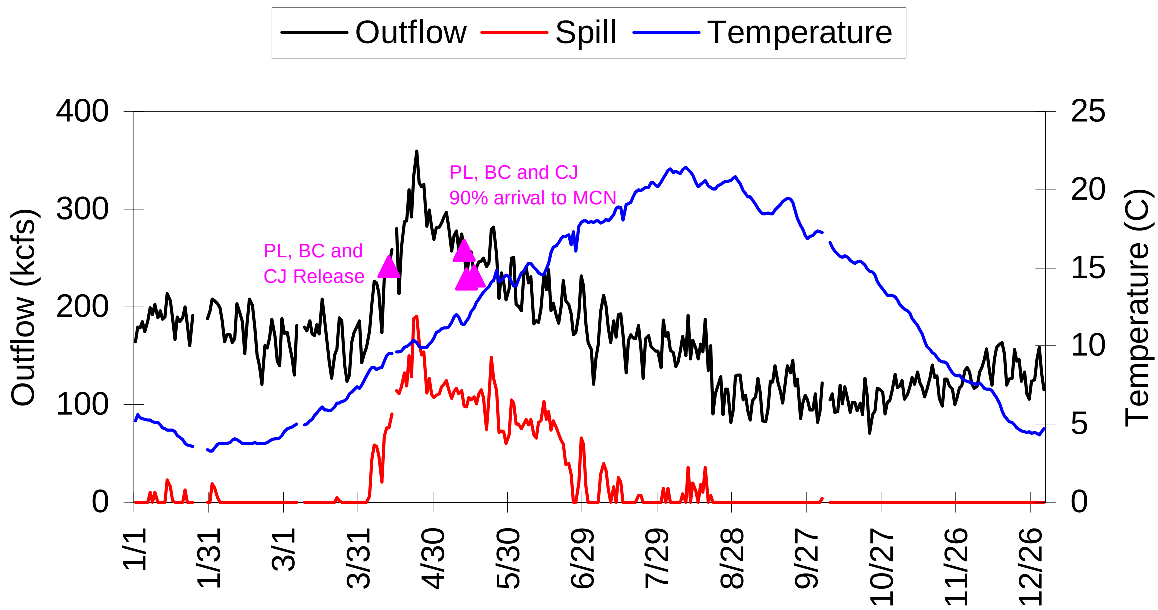


Figure 6.—Mean daily flow, spill, and temperature for the Columbia River in 2000 as measured by the USACE at McNary Dam.

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 7,477 and 7,421 yearling fall Chinook salmon were PIT tagged at Pittsburg Landing and Big Canyon, respectively (Table 3). A total of 2,488 yearlings were PIT tagged at Captain John Rapids. WDFW personnel PIT tagged a total of 980 yearlings at LFH. See Appendix A for a list of PIT tag files and synopsis of PIT tag observations at Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville dams.

Table 3.—Number of PIT tagged yearling fall Chinook salmon released from the FCAP facilities and LFH in 2000.

| Facility | Date Tagged | Number Tagged | Date Released |
|---|---|---|---|
| Pittsburg Landing | April 4 | 2,476 | April 11 |
| | April 5 | 2,499 | April 12 |
| | April 6 | 2,502 | April 13 |
| | Total | 7,477 | |
| Big Canyon | April 4 | 2,462 | April 11 |
| | April 5 | 2,466 | April 12 |
| | April 6 | 2,493 | April 13 |
| | Total | 7,421 | |
| Captain John Rapids | April 7 | 1,220 | April 1-12 |
| | April 7 | 1,268 | |
| | Total | 2,488 | |
| Lyons Ferry Hatchery | March 31 | 71 | March 31 |
| | March 31 | 421 | March 31 |
| | April 11 | 488 | April 11 |
| | Total | 980 | |

Biological Characteristics

The ANOVA on fork lengths shows a significant between-groups effect ($P = 0.0051$). Multiple comparisons indicate that the Pittsburg Landing and LFH groups were similar to each other and the Big Canyon and Captain John Rapids groups were significantly different from all groups (Appendix B, Table B.1). Yearlings from Big Canyon were smaller while those from Captain John Rapids were larger than yearlings from Pittsburg Landing and LFH (Table 4). The larger mean fork lengths at Captain John in 2000 is in sharp contrast to what we saw in 1998 and 1999 when the mean fork length at Captain John was significantly smaller than at the other locations.

Fork length distributions of PIT tagged fish from the yearling release groups all differed significantly from each other with $P < 0.01$ (Appendix B; Table B.2), although visual inspection indicates that the shapes of the distributions were more similar to each other in 2000 than in 1999 (Figure 7).

The development of differences in fork length distribution between groups is possible for several reasons. First, the fish are differentially marked at LFH and must be reared separately afterward. In addition, the Captain John Rapids facility is a single permanent pond and the Pittsburg Landing and Big Canyon facilities consist of 16 temporarily constructed aluminum tanks. It is possible that growth rates may differ due to differences in rearing conditions (such as loading densities, exchange rates, etc.), feeding behavior between the facilities, feed distribution efficiency between personnel at each facility. In addition, each FCAP facility uses river water as its source as opposed to the well water source used at LFH. Differences in water temperature could account for the differences in growth rate as well; however this should not cause a change in the length distribution, only the mean length. It is also possible that there was a bias due to sampling methods. The fish at Pittsburg Landing and Big Canyon were crowded in the tanks and captured by dip net while the fish at Captain John Rapids were captured from the pond using a cast net.

Table 4.—Fork length, weight and condition factor of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH in 2000.

| Facility | | *n* | Mean | Standard Deviation | 95% C.I. (+/- mean) | Median | Range |
|---|---|---|---|---|---|---|---|
| Pittsburg Landing | Fork Length (mm) | 7,465 | 165.0 | 16.9 | 0.4 | 166 | 81 - 233 |
| | Weight (g) | 899 | 47.2 | 14.2 | 0.9 | 46.6 | 8.6 - 102.7 |
| | Condition Factor | 898 | 1.10 | 0.17 | 0.01 | 1.09 | 0.81 - 5.96 |
| Big Canyon | Fork Length (mm) | 7,391 | 157.7 | 18.6 | 0.4 | 159 | 75 - 237 |
| | Weight (g) | 841 | 43.3 | 15.0 | 1.0 | 42.8 | 7.8 - 102.8 |
| | Condition Factor | 841 | 1.12 | 0.07 | 0.00 | 1.12 | 0.85 - 1.41 |
| Captain John Rapids | Fork Length (mm) | 2,454 | 172.9 | 17.5 | 0.7 | 173 | 98 - 224 |
| | Weight (g) | 446 | 55.3 | 15.5 | 1.4 | 55.9 | 12.5 - 108.0 |
| | Condition Factor | 444 | 1.06 | 0.09 | 0.01 | 1.05 | 0.45 - 1.32 |
| Lyons Ferry Hatchery | Fork Length (mm) | 971 | 166.2 | 14.6 | 0.9 | 165 | 103 - 222 |
| | Weight (g) | 498 | 49.1 | 13.2 | 1.2 | 47 | 11.1 - 128.0 |
| | Condition Factor | 497 | 1.06 | 0.08 | 0.01 | 1.06 | 0.86 - 1.31 |

The ANOVA on condition factors also shows a significant between-groups effect ($P = 0.0006$). Multiple comparisons indicate that the Captain John Rapids and LFH groups were similar to each other and the Pittsburg Landing and Big Canyon groups were significantly different from all groups (Appendix B, Table B.1). All conidition factor distribution were significantly different ($P < 0.0001$) except for Captain John Rapids and LFH ($P = 0.1315$). Mean condition factors ranged from 1.12 for Big Canyon to 1.06 for Captain John Rapids and LFH (Table 4). Results of all statistical tests are included in Appendix B.

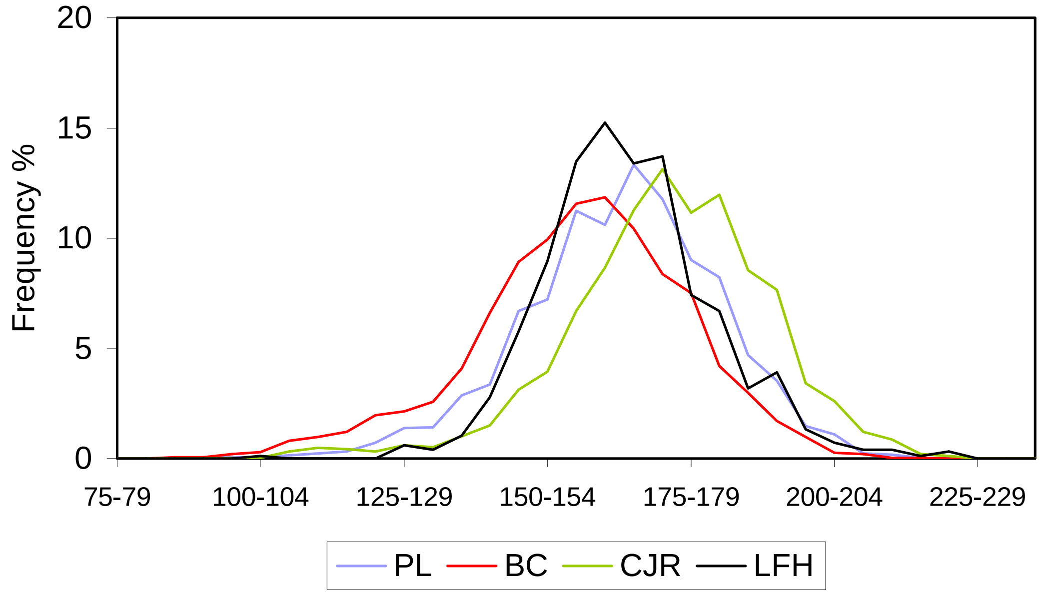


Figure 7.—Fork length frequency of PIT tagged yearling fall Chinook salmon at the FCAP facilities and LFH in 2000.

<u>Mark Retention</u>

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, Rocklage and Kellar 2005; unpublished data).

Coded wire tag retention was 99.0% or better for yearlings from all facilities. The only yearling group with adipose fin clip retention under 99.0% was LFH at 98.4%. Retention of VIE marks was lower and more variable than for AD clips and CWT, ranging from 78.6% at Pittsburg Landing to 89.4% at LFH (Table 5). A total of two FCAP and seven LFH fish (0.0005% and 0.002% 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 2000. Also shown are the probability that a fish was unmarked and unclipped and the estimated number released unmarked and unclipped.

| | | % Retention | | | Probability | Estimated number |
|---|---|---|---|---|---|---|
| | *n* | CWT | AD | VIE | of no marks | with no marks |
| Pittsburg Landing | 1,245 | 99.0 | 99.4 | 78.6 | 0.0000116 | 2 |
| Big Canyon | 3,405 | 99.8 | 99.7 | 87.3 | 0.0000008 | 0 |
| Captain John Rapids | 950 | 99.9 | 99.9 | 86.9 | 0.0000001 | 0 |
| Lyons Ferry Hatchery | 1,193 | 99.1 | 98.4 | 89.4 | 0.0000156 | 7 |

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 87.0% (84.7-89.4%) for Pittsburg Landing to 95.2% (91.5-98.9%) for Captain John Rapids. Estimated survival from release to McNary Dam ranged from 65.8% (58.5-73.1%) for LFH to 84.0% (76.2-91.8%) for Captain John Rapids. Table 6 details survival estimates with 95% confidence intervals to Lower Granite and McNary dams for the FCAP and LFH yearling releases in 2000. Yearling survival from Captain John Rapids to Lower Granite Dam was significantly higher than from Pittsburg Landing ($P < 0.001$) and Big Canyon ($P < 0.05$). To McNary Dam, survival from Captain John Rapids was significantly higher than Pittsburg Landing ($P < 0.05$), but not Big Canyon ($P = 0.0631$). Table 7 outlines all pairwise comparisons of survival from the FCAP facilities and LFH to Lower Granite and McNary dams in 2000.

Yearling survival to Lower Granite and McNary dams in 2000 remained very similar to 1999 with the exception of Captain John Rapids, which appeared to increase in 2000 (Appendix C, Tables C.1 and C.2). The point estimates for survival from Captain John Rapids have increased each year since it began operations in 1998 (Appendix C, Table C.2 and Figure C.6). This trend from may be due to annual improvements in the operations of the facility. 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. No reason for this is readily evident, but we did see this similar results in 1999 (Rocklage and Kellar 2005). 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 1996-2000.

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 2000.

| Facility | Evaluation Point | Estimated Survival | 95% C.I. Lower Bound | 95% C.I. Upper Bound |
|---|---|---|---|---|
| Pittsburg Landing | Lower Granite | 0.8702 | 0.8469 | 0.8935 |
| | McNary | 0.6657 | 0.5879 | 0.7435 |
| Big Canyon | Lower Granite | 0.8957 | 0.8694 | 0.9220 |
| | McNary | 0.6785 | 0.6400 | 0.7540 |
| Captain John Rapids | Lower Granite | 0.9520 | 0.9153 | 0.9887 |
| | McNary | 0.8398 | 0.7620 | 0.9176 |
| Lyons Ferry Hatchery | Lower Monumental | 0.7854 | 0.6754 | 0.8954 |
| | McNary | 0.6577 | 0.5848 | 0.7306 |

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 2000.

| **To Lower Granite Dam** | | | |
|---|---|---|---|
| | BC | CJ | LFH |
| PL | $P$ = 0.1553 | $P$ = 0.0002 | n/a |
| BC | | $P$ = 0.0145 | n/a |

| **To McNary Dam** | | | |
|---|---|---|---|
| | BC | CJ | LFH |
| PL | $P$ = 0.8170 | $P$ = 0.0462 | $P$ = 0.9232 |
| BC | | $P$ = 0.0631 | $P$ = 0.8007 |
| CJ | | | $P$ = 0.0875 |

Travel Time and Migration Rate

Median travel times based on all obs are typically slightly longer (i.e. lower migration rates) than for those based on first obs. This indicates that the collection and bypass facilities delay passage at dams relative to other passage routes such as spillways. Median travel times from the FCAP facilities were about 9-10 days to Lower Granite Dam and 22-25 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).

Unlike 1999, this year there was only one yearling release from each FCAP facility, which differ in distance from all interrogation locations. Therefore, converting travel time to migration rate is much more meaningful. One interesting result though, is that there was no significant difference ($P = 0.3886$) in travel time to Lower Granite Dam between yearlings from Pittsburg Landing and Captain John Rapids. These two groups had similar travel times even though Pittsburg Landing is nearly twice as far from Lower Granite Dam as is Captain John Rapids. No explanation for this is readily evident.

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

Migration rates from Pittsburg Landing to Lower Granite Dam are slightly higher than migration rates to Little Goose Dam. When considering migration rates from the FCAP facilities to Lower Granite Dam, it is important to remember that these reaches include about 29-112 rkm of free-flowing river, where our radio telemetry study has shown migration rates to be higher than through the impounded reaches (unpublished data). However, for 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 more similar to the FCAP groups. Because the migration rate at each observation point includes the entire distance from point of release, this indicates that migration rates for LFH fish in each reach between observation points below Lower Monumental Dam were quite high in order to make the overall migration rate to each point increase so rapidly. Migration rates based on first obs and all obs are detailed in Appendix D, Tables D.3 and D.4, respectively.

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

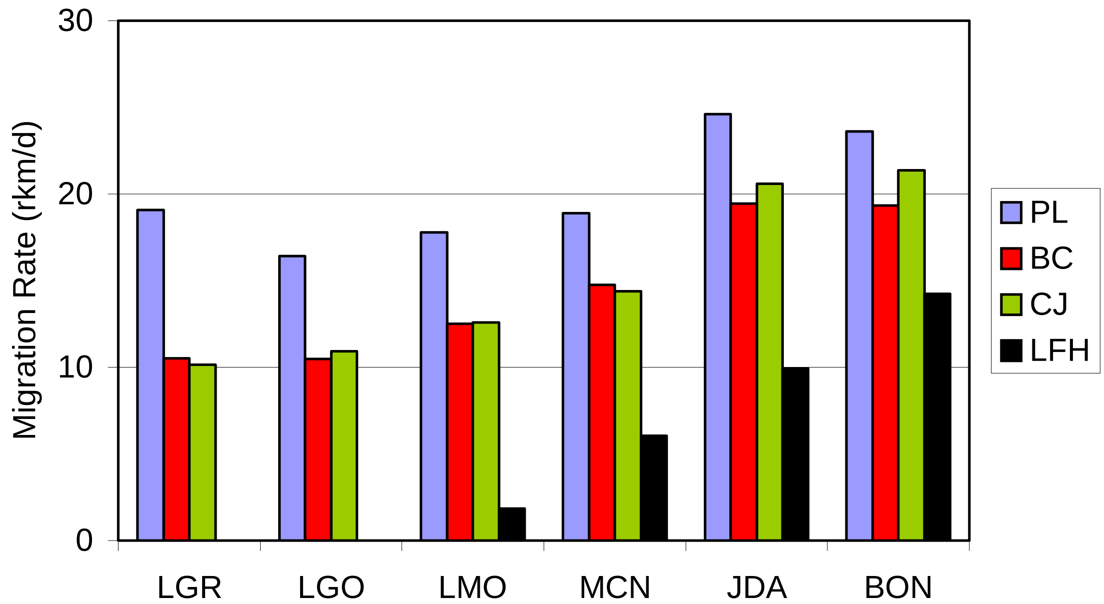


Figure 8.—First obs migration rate (rkm/d) of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 2000.

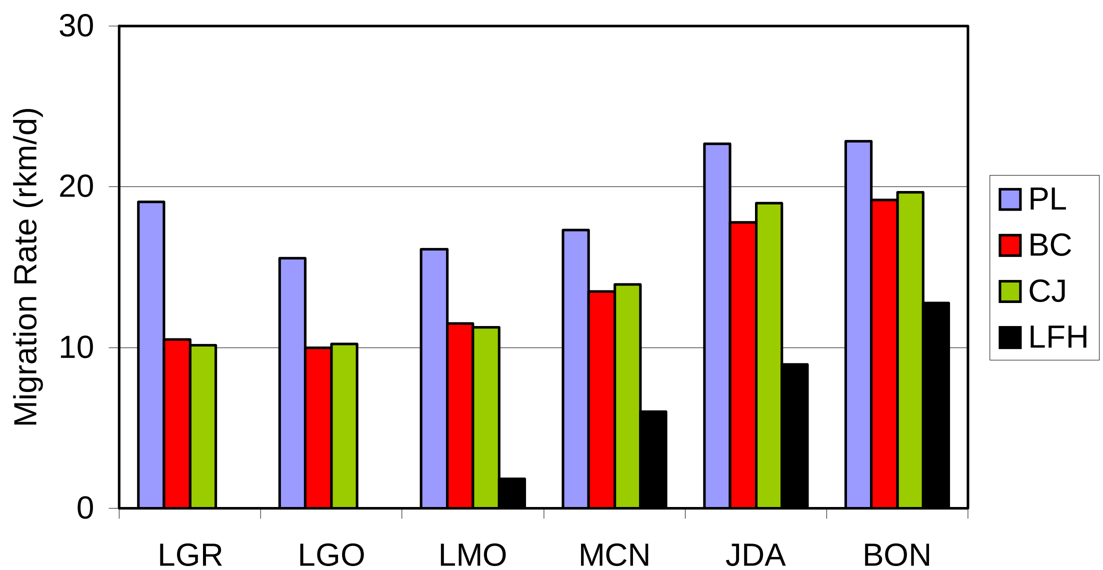


Figure 9.—All obs migration rate (rkm/d) of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to Lower Snake and Columbia River dams in 2000.

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

Migration rates from Pittsburg Landing to Lower Granite Dam during 1996-2000 were positively correlated with flow at Hell's Canyon Dam ($r$ = 0.8407, $P$ = 0.0745) and Anatone ($r$ = 0.9243, $P$ = 0.0247), while negatively correlated with temperature at Anatone ($r$ = -0.4757, $P$ = 0.418), as illustrated in Figures 10 and 11. Migration rates from Big Canyon to Lower Granite Dam during 1997-2000 were positively correlated with flow ($r$ = 0.6898, $P$ = 0.3102) and negatively correlated with temperature ($r$ = -0.6821, $P$ = 0.3179) at Peck (Figures 12 and 13). Migration rates from Captain John Rapids had a weak positive correlation with both flow ($r$ = 0.5141, $P$ = 0.6562) and temperature ($r$ = 0.4632, $P$ = 0.6934) at Anatone (Figures 14 and 15). While the only statistically significant correlation was Pittsburg Landing with flow at Anatone, bear in mind that we only have 3-5 data points for each correlation to date.

Migration rate from Pittsburg Landing has a positive correlation with flow and a weak negative correlation with temperature. It appears that flow and temperature may equally influence migration rate for yearlings from Big Canyon. Relative to Pittsburg Landing, migration rate from Big Canyon has a weaker positive correlation with flow and a stronger negative correlation with temperature. Flows during April in the Clearwater River were about 55% above average while flows in the Snake River were only 13% above average at Anatone. Despite the Clearwater River being so much higher relative to historical flows, mean daily discharge through April was still less than half that in the Snake River at Anatone. In addition, the mean water temperature during April was 4.1$^{O}$ C lower in the Clearwater River than in the Snake River. The lower migration rates and correlation to flow for Big Canyon relative to Pittsburg Landing could simply be a result of the relative flow levels between the two rivers or the water velocity. It is also possible that the lower flows work in conjunction with the lower temperatures in the Clearwater River compounding the effect on the early migration rate of yearlings after they are released. More comprehensive analyses will be reported as additional data are gathered.

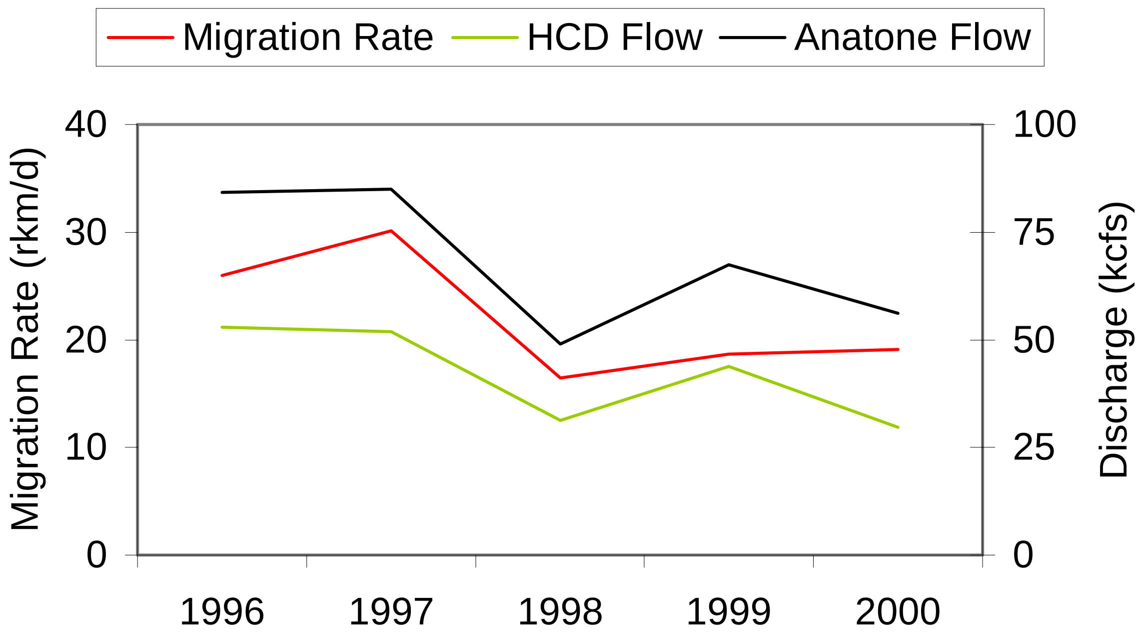


Figure 10.—Yearling migration rate (rkm/d) from Pittsburg Landing to Lower Granite Dam versus Snake River flow at Hell's Canyon Dam and Anatone, 1996-2000.

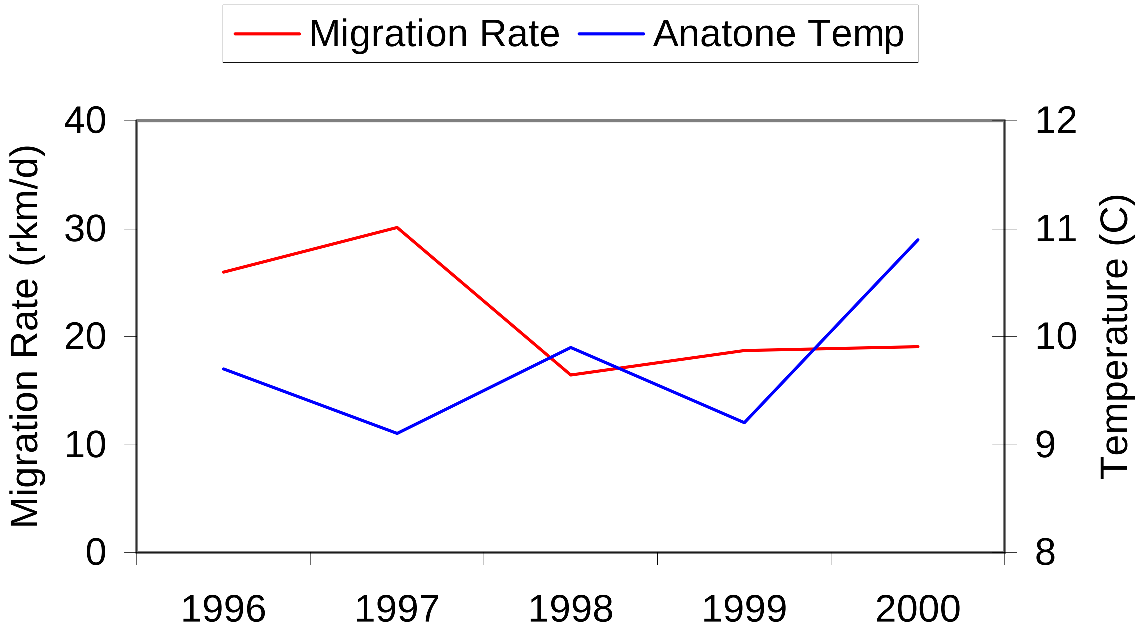


Figure 11.—Yearling migration rate (rkm/d) from Pittsburg Landing to Lower Granite Dam versus Snake River temperature at Anatone, 1996-2000.

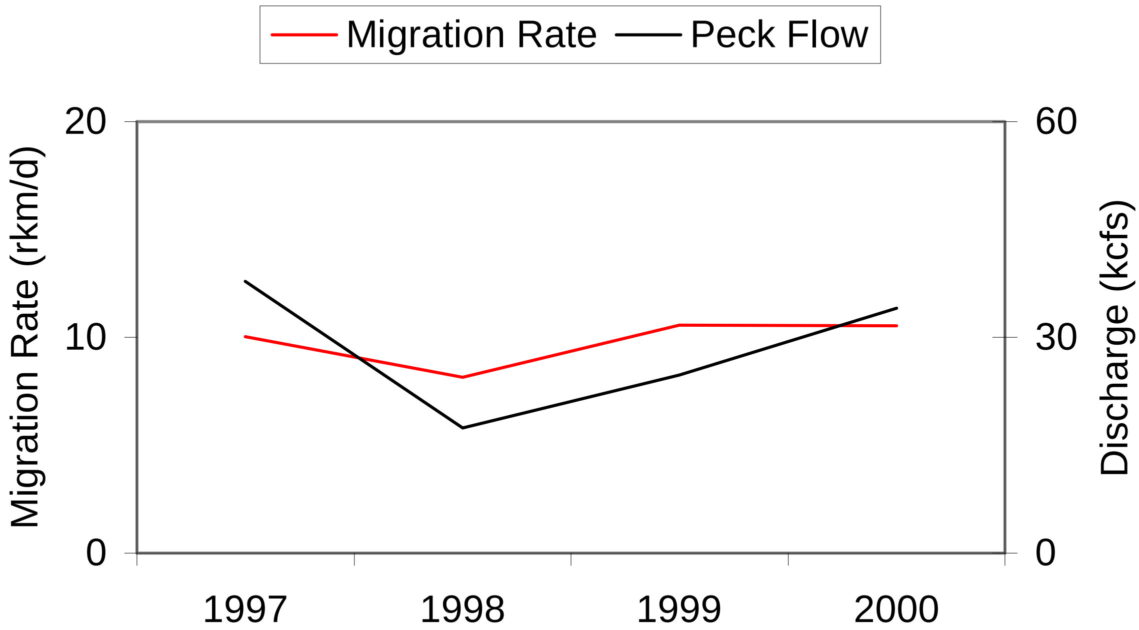


Figure 12.—Yearling migration rate (rkm/d) from Big Canyon to Lower Granite Dam versus Clearwater River flow at Peck, 1997-2000.

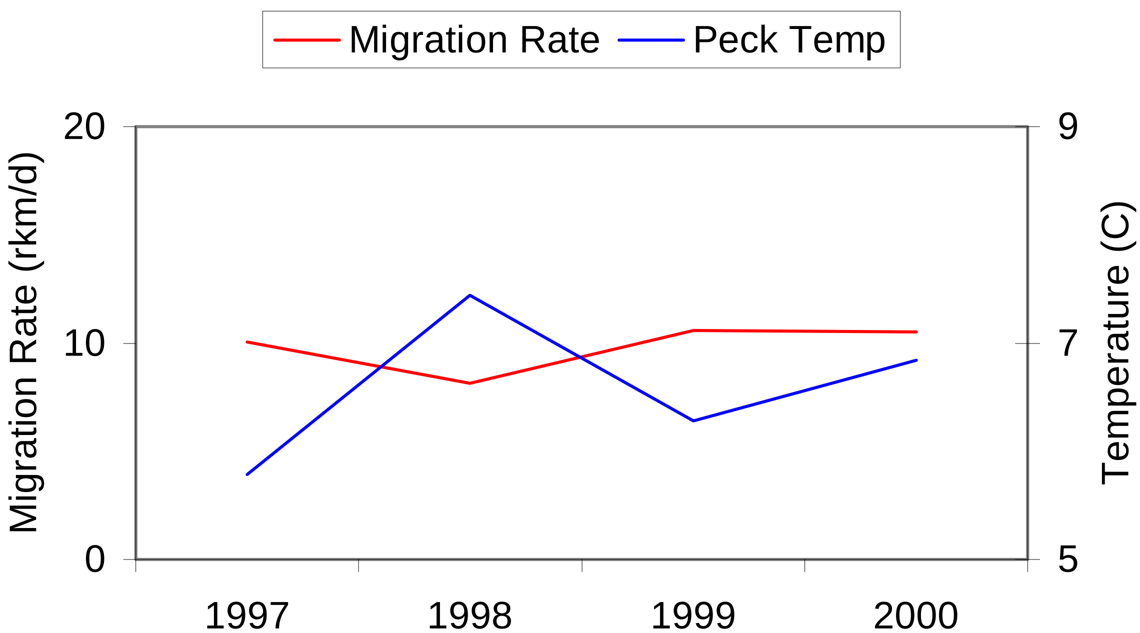


Figure 13.—Yearling migration rate (rkm/d) from Big Canyon to Lower Granite Dam versus Clearwater River temperature at Peck, 1997-2000.

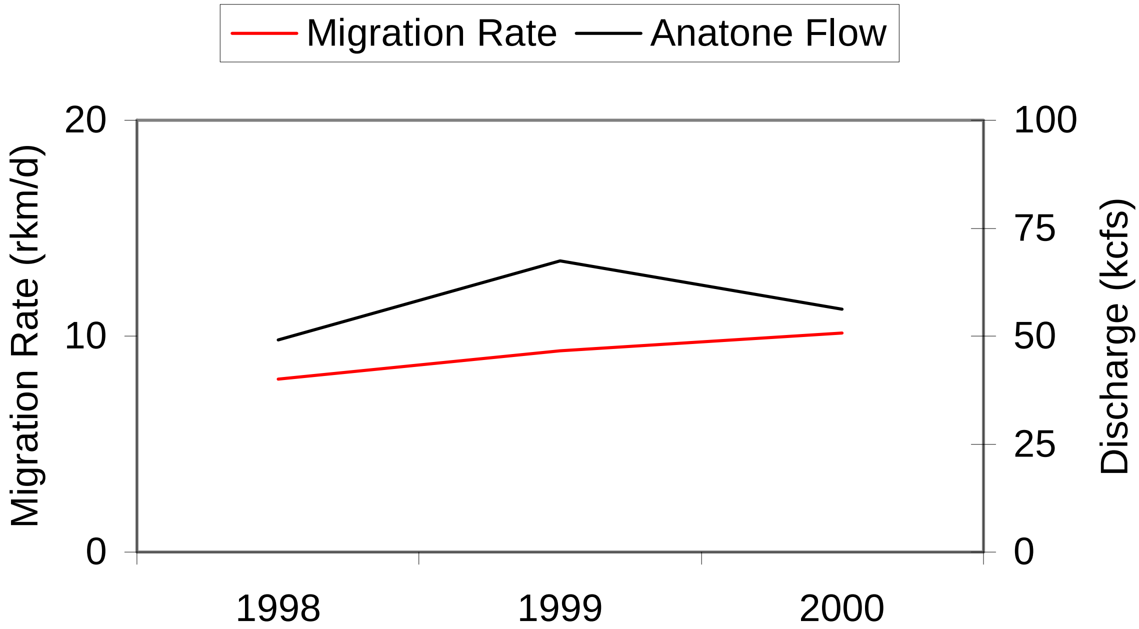


Figure 14.—Yearling migration rate (rkm/d) from Captain John Rapids to Lower Granite Dam versus Snake River flow at Anatone, 1998-2000.

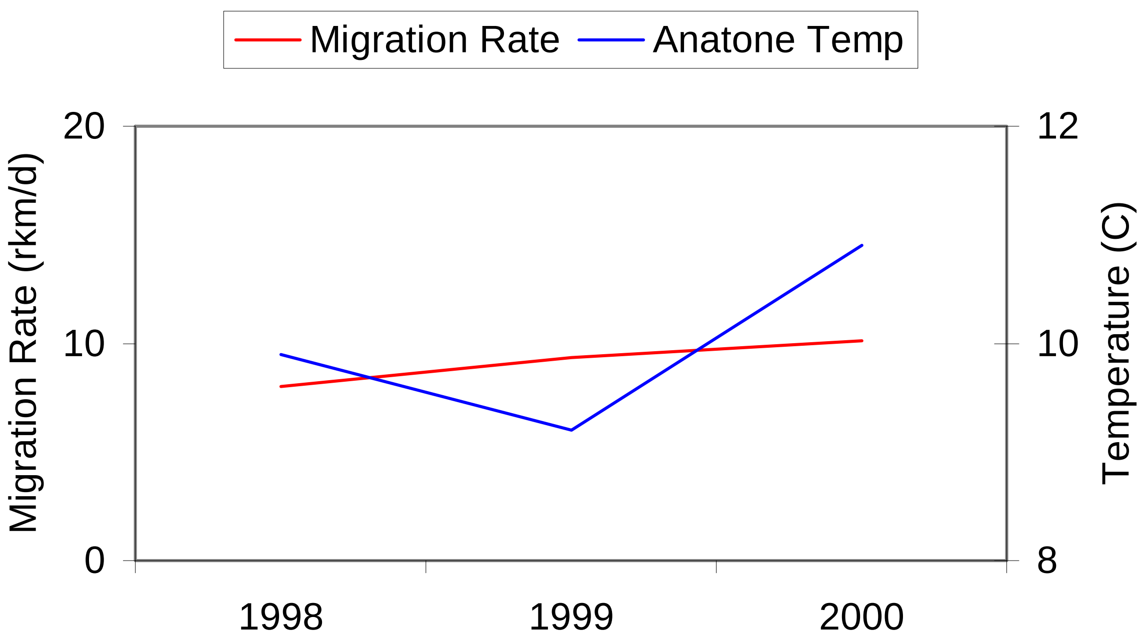


Figure 15.—Yearling migration rate (rkm/d) from Captain John Rapids to Lower Granite Dam versus Snake River temperature at Anatone, 1998-2000.

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 12. The volitional release occurred from April 1-12, however, only one PIT tagged fish from Captain John Rapids was detected at Lower Granite Dam before April 14. That fish was detected at Lower Granite Dam at about 13:00 on April 12. This is typical of what we have seen since Captain John Rapids began operations in 1998 and supported by personnel observations at the facility (B. McLeod, personal communication).

Arrival timing of release groups to given locations are simply a function of release date, migration rate and distance. Arrival date distributions to Lower Granite Dam were similar ($P$ = 0.2287) for the Pittsburg Landing and Captain John Rapids groups (Appendix E; Figures E.9 and E.23), though the Big Canyon yearlings lagged behind, achieving 90% arrival 3-4 days later than the yearlings from Pittsburg Landing and Captain John (Tables 8 and 9). This is generally similar to what we have seen from Big Canyon yearlings from 1997 through 1999 relative to Pittsburg Landing. As stated previously, the lower migration rates documented from Big Canyon relative to Pittsburg Landing could be the result of lower flows or temperatures in the Clearwater River relative to the Snake River or a combination of both.

Mean, median and 90% arrival dates of all FCAP yearling release groups to Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville dams are detailed in Tables 8 and 9 for first obs and all obs, respectively. In general, arrival date frequency distributions and cumulative frequencies for the FCAP groups were more similar to each other at McNary and Bonneville dams in 2000 than they were in 1999. No clear pattern emerged from statistical analysis of first and all obs arrival date distributions at McNary and Bonneville dams, except for the LFH group differing significantly from all of the FCAP groups at both dams (Appendix B; Table B.6). Under first obs, the significant differences seen between FCAP groups were Pittsburg Landing from both Big Canyon and Captain John Rapids at McNary Dam ($P$ < 0.0001). There is overlap in passage date distributions for individual groups at multiple dams, indicating that release groups are spread out over nearly the entire length of the Snake and Columbia River migration corridor. A comprehensive summary of arrival timing distributions is presented in Appendix E.

Yearlings from Big Canyon achieved 90% arrival to Lower Granite, McNary and Bonneville dams later than Pittsburg Landing and Captain John Rapids. Pittsburg Landing and Captain John Rapid's groups had very similar 90% arrival dates to Lower Granite and McNary dams under both first and all obs methods, but the Captain John Rapids group achieved 90% arrival at Bonneville Dam 3-5 days earlier than the Pittsburg Landing group. Indeed, migration rate data indicates that the Pittsburg Landing group either maintained speed or slowed below John Day Dam while the Captain John Rapids group continued to increase their migration rate.

Yearlings from Pittsburg Landing were released shortly before and achieved 90% arrival to Lower Granite Dam within a week after peak flows at Hell's Canyon Dam. Yearlings from Pittsburg Landing and Captain John Rapids were released shortly before and achieved 90% arrival to Lower Granite Dam within a week after peak flows at Anatone. Yearlings were released from Big Canyon on the front end and achieved 90% arrival to Lower Granite Dam just on the back end of the peak flow period at Peck. Yearlings from the FCAP sites achieved 90% arrival to Lower Granite Dam about 7-10 days after peak flows at the dam (Figure 5). Yearlings from the FCAP facilities achieved 90% arrival to McNary Dam about three weeks after peak flows at the dam (Figure 6). It is interesting to note that peak flows at all locations occurred at nearly the same time, April 22-23 and coincided with yearling migration from release at the FCAP facilities to Lower Granite and McNary dams.

Travel time and arrival timing 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 2000.

| Release Group | Interrogation Site | *n* | Mean | Median | 90% |
|---|---|---|---|---|---|
| Pittsburg Landing | Lower Granite | 2,472 | 4/22 | 4/21 | 5/1 |
| | Little Goose | 1,373 | 4/27 | 4/26 | 5/4 |
| | Lower Monumental | 554 | 4/29 | 4/28 | 5/5 |
| | McNary | 308 | 5/4 | 5/3 | 5/12 |
| | John Day | 142 | 5/5 | 5/3 | 5/16 |
| | Bonneville | 85 | 5/11 | 5/9 | 5/20 |
| Big Canyon | Lower Granite | 2,275 | 4/24 | 4/22 | 5/4 |
| | Little Goose | 1,438 | 4/29 | 4/28 | 5/7 |
| | Lower Monumental | 565 | 4/30 | 4/29 | 5/9 |
| | McNary | 356 | 5/6 | 5/5 | 5/16 |
| | John Day | 133 | 5/8 | 5/5 | 5/19 |
| | Bonneville | 82 | 5/12 | 5/12 | 5/22 |
| Captain John Rapids | Lower Granite | 987 | 4/22 | 4/21 | 4/30 |
| | Little Goose | 429 | 4/27 | 4/26 | 5/4 |
| | Lower Monumental | 231 | 4/29 | 4/28 | 5/6 |
| | McNary | 109 | 5/4 | 5/4 | 5/11 |
| | John Day | 57 | 5/5 | 5/3 | 5/11 |
| | Bonneville | 33 | 5/9 | 5/8 | 5/15 |
| Lyons Ferry Hatchery | Lower Monumental | 246 | 4/15 | 4/15 | 4/23 |
| | McNary | 114 | 4/25 | 4/24 | 5/8 |
| | John Day | 65 | 4/28 | 4/27 | 5/11 |
| | Bonneville | 31 | 4/29 | 4/27 | 5/8 |

Table 9.—All Obs arrival date at Lower Snake and Columbia River dams of PIT tagged yearling fall Chinook salmon from FCAP facilities and LFH in 2000.

| Release Group | Interrogation Site | *n* | Mean | Median | 90% |
|---|---|---|---|---|---|
| | Lower Granite | 2,472 | 4/22 | 4/21 | 5/1 |
| | Little Goose | 2,207 | 4/28 | 4/27 | 5/5 |
| Pittsburg Landing | Lower Monumental | 1,430 | 4/30 | 4/29 | 5/6 |
| | McNary | 459 | 5/5 | 5/5 | 5/12 |
| | John Day | 548 | 5/7 | 5/5 | 5/16 |
| | Bonneville | 389 | 5/12 | 5/10 | 5/21 |
| | Lower Granite | 2,275 | 4/24 | 4/22 | 5/4 |
| | Little Goose | 2,118 | 4/30 | 4/29 | 5/8 |
| Big Canyon | Lower Monumental | 1,360 | 5/1 | 5/1 | 5/9 |
| | McNary | 732 | 5/7 | 5/6 | 5/16 |
| | John Day | 533 | 5/9 | 5/8 | 5/19 |
| | Bonneville | 423 | 5/13 | 5/12 | 5/23 |
| | Lower Granite | 988 | 4/22 | 4/21 | 4/30 |
| | Little Goose | 746 | 4/28 | 4/27 | 5/4 |
| Captain John Rapids | Lower Monumental | 579 | 4/30 | 4/29 | 5/6 |
| | McNary | 276 | 5/5 | 5/5 | 5/13 |
| | John Day | 247 | 5/6 | 5/5 | 5/13 |
| | Bonneville | 191 | 5/11 | 5/10 | 5/18 |
| | Lower Monumental | 246 | 4/15 | 4/15 | 4/23 |
| Lyons Ferry Hatchery | McNary | 152 | 4/25 | 4/24 | 5/8 |
| | John Day | 127 | 4/29 | 4/30 | 5/11 |
| | Bonneville | 71 | 5/1 | 4/30 | 5/14 |

## 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.

Milks, D., M. Varney and M. Schuck. 2003. Lyons Ferry Hatchery Evaluation: Fall Chinook Salmon Annual Report 2000. Washington Department of Fish and Wildlife Hatcheries Report # FPA03-04 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)

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

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 2000. All PIT tag files reside in the PTAGIS database managed by the PSMFC and are accessible at http://www.pittag.org/Data_and_Reports/index.html.

Table A.1.—List of PIT tagging files for yearling fall Chinook salmon from the FCAP facilities and LFH in 2000.

| Release Group | Filename |
|---|---|
| Pittsburg Landing | SJR00095.P16 |
| | SJR00096.P09 |
| | SJR00097.P05 |
| Big Canyon | SJR00095.B01 |
| | SJR00096.B11 |
| | SJR00097.B16 |
| Captain John Rapids | MLS00098.CJ1 |
| | SJR00098.CJ2 |
| Lyons Ferry Hatchery | MLS00091.LF1 |
| | MLS00091.LF2 |
| | MLS00102.LF1 |

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 2000.

| Release Group | LGR | LGO | LMO | MCN | JDA | BON | Cumulative Interrogations | Cumulative % |
|---|---|---|---|---|---|---|---|---|
| Pittsburg Landing | 2,472 | 1,373 | 554 | 308 | 142 | 85 | 4,934 | 66.0 |
| Big Canyon | 2,275 | 1,438 | 565 | 356 | 133 | 82 | 4,849 | 65.3 |
| Captain John Rapids | 987 | 429 | 231 | 109 | 57 | 33 | 1,846 | 74.2 |
| Lyons Ferry Hatchery | n/a | n/a | 246 | 114 | 65 | 31 | 456 | 46.5 |

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 2000.

| Release Group | LGR | LGO | LMO | MCN | JDA | BON | Total Interrogations |
|---|---|---|---|---|---|---|---|
| Pittsburg Landing | 2,472 | 2,207 | 1,430 | 459 | 548 | 389 | 7,505 |
| Big Canyon | 2,275 | 2,118 | 1,360 | 732 | 533 | 423 | 7,441 |
| Captain John Rapids | 987 | 746 | 579 | 276 | 247 | 191 | 3,026 |
| Lyons Ferry | n/a | n/a | 246 | 152 | 127 | 71 | 596 |

**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 2000. 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 2000.

| | | Tukey's HSD Multiple Comparisons | | | |
|---|---|---|---|---|---|
| | ANOVA | PL | BC | CJ | LFH |
| Length | $P = 0.0051$ | 1 | 2 | 3 | 1 |
| Condition | $P = 0.0006$ | 1 | 2 | 3 | 3 |

Table B.2.—Results of the Kolmogorov-Smirnov Test for length and condition factor distributions of PIT tagged yearling fall Chinook salmon at the FCAP facilities and LFH in 2000.

| | Fork Length | | | | Condition Factor | | |
|---|---|---|---|---|---|---|---|
| | BC | CJ | LFH | | BC | CJ | LFH |
| PL | $P < 0.0001$ | $P < 0.0001$ | $P = 0.0011$ | PL | $P < 0.0001$ | $P < 0.0001$ | $P < 0.0001$ |
| BC | | $P < 0.0001$ | $P < 0.0001$ | BC | | $P < 0.0001$ | $P < 0.0001$ |
| CJ | | | $P < 0.0001$ | CJ | | | $P = 0.1315$ |

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 2000.

| | | | Tukey's HSD Multiple Comparisons | | | |
|---|---|---|---|---|---|---|
| | | ANOVA | PL | BC | CJ | LFH |
| Lower Granite | | $P = 0.0035$ | 1 | 2 | 3 | n/a |
| McNary | First Obs | $P = 0.0012$ | 1 | 2 | 2 | 3 |
| | All Obs | $P = 0.0018$ | 1 | 2 | 2 | 3 |
| Bonneville | First Obs | $P < 0.0001$ | 1 | 2 | 1, 2 | 3 |
| | All Obs | $P = 0.0006$ | 1 | 2 | 2 | 3 |

Appendix B (continued).

Table B.4.—Results of the Kolmogorov-Smirnov Test for travel time and arrival date distributions of PIT tagged yearling fall Chinook salmon from the FCAP facilities to Lower Granite Dam in 2000.

| | Travel Time | | | Arrival Date | |
|---|---|---|---|---|---|
| | BC | CJ | | BC | CJ |
| PL | $P < 0.0001$ | $P = 0.3886$ | PL | $P < 0.0001$ | $P = 0.2287$ |
| BC | | $P < 0.0001$ | BC | | $P < 0.0001$ |

Table B.5.—Results of the Kolmogorov-Smirnov Test for first and all obs travel time distributions of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH to McNary and Bonneville dams in 2000.

| **To McNary Dam** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1st Obs Travel Time | | | | All Obs Travel Time | | |
| | BC | CJ | LFH | | BC | CJ | LFH |
| PL | $P = 0.0791$ | $P = 0.8965$ | $P = 0.0133$ | PL | $P = 0.0019$ | $P = 0.9676$ | $P = 0.0017$ |
| BC | | $P = 0.1054$ | $P = 0.1179$ | BC | | $P = 0.0009$ | $P = 0.0033$ |
| CJ | | | $P = 0.0275$ | CJ | | | $P = 0.0250$ |

| **To Bonneville Dam** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1st Obs Travel Time | | | | All Obs Travel Time | | |
| | BC | CJ | LFH | | BC | CJ | LFH |
| PL | $P = 0.1537$ | $P = 0.7279$ | $P = 1.00$ | PL | $P = 0.0061$ | $P = 0.3323$ | $P = 0.4286$ |
| BC | | $P = 0.1324$ | $P = 0.2956$ | BC | | $P = 0.0301$ | $P = 1.00$ |
| CJ | | | $P = 1.00$ | CJ | | | $P = 0.1299$ |

Appendix B (continued).

Table B.6.—Results of the Kolmogorov-Smirnov Test for first and all obs arrival date distributions at McNary and Bonneville Dams of PIT tagged yearling fall Chinook salmon from the FCAP facilities and LFH in 2000.

| **To McNary Dam** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1st Obs Arrival Date | | | | All Obs Arrival Date | | |
| | BC | CJ | LFH | | BC | CJ | LFH |
| PL | $P < 0.0001$ | $P < 0.0001$ | $P < 0.0001$ | PL | $P = 0.0105$ | $P = 0.7529$ | $P < 0.0001$ |
| BC | | $P = 0.1467$ | $P < 0.0001$ | BC | | $P = 0.0072$ | $P < 0.0001$ |
| CJ | | | $P < 0.0001$ | CJ | | | $P < 0.0001$ |

| **To Bonneville Dam** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1st Obs Arrival Date | | | | All Obs Arrival Date | | |
| | BC | CJ | LFH | | BC | CJ | LFH |
| PL | $P = 0.2169$ | $P = 0.3617$ | $P < 0.0001$ | PL | $P = 0.0632$ | $P = 0.2713$ | $P < 0.0001$ |
| BC | | $P = 0.1146$ | $P < 0.0001$ | BC | | $P = 0.0305$ | $P < 0.0001$ |
| CJ | | | $P < 0.0001$ | 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 2000. 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, 1996-2000.

| 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 |
| | 2000 | 0.8702 | 0.0119 | 0.8469 | 0.8935 |
| Big Canyon | 1997 | 0.9359 | 0.0147 | 0.9071 | 0.9647 |
| Large | 1998 | 0.8472 | 0.0146 | 0.8186 | 0.8758 |
| Small | 1998 | 0.6217 | 0.0203 | 0.5819 | 0.6615 |
| | 1999 | 0.9000 | 0.0116 | 0.8773 | 0.9227 |
| | 2000 | 0.8957 | 0.0134 | 0.8694 | 0.9220 |
| 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 |
| | 2000 | 0.9520 | 0.0187 | 0.9153 | 0.9887 |

Appendix C (continued).

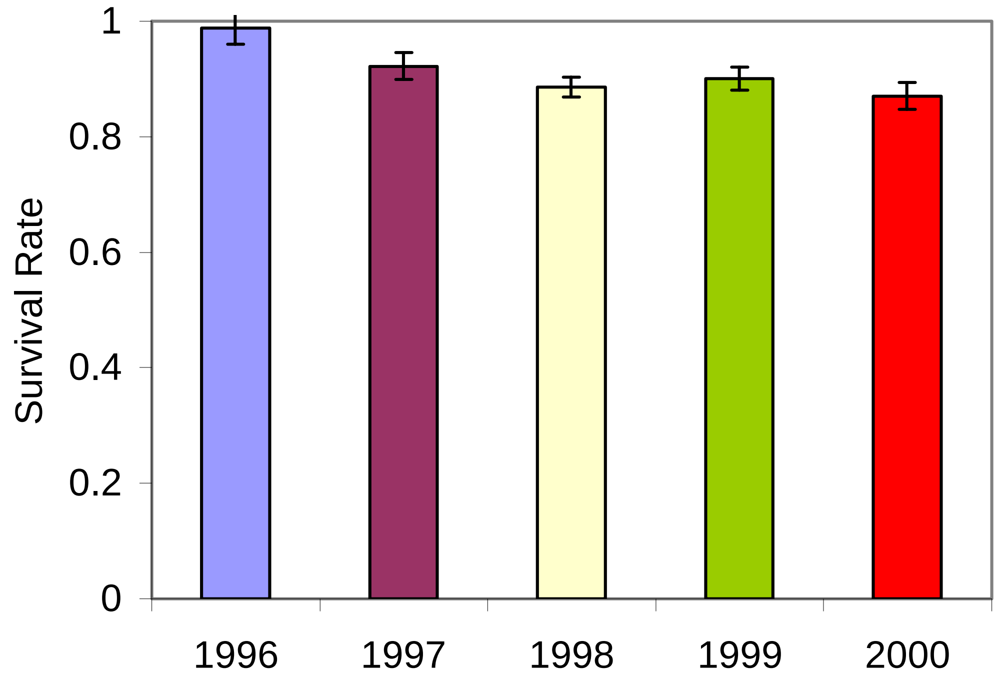


Figure C.1.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to Lower Granite Dam, 1996-2000.

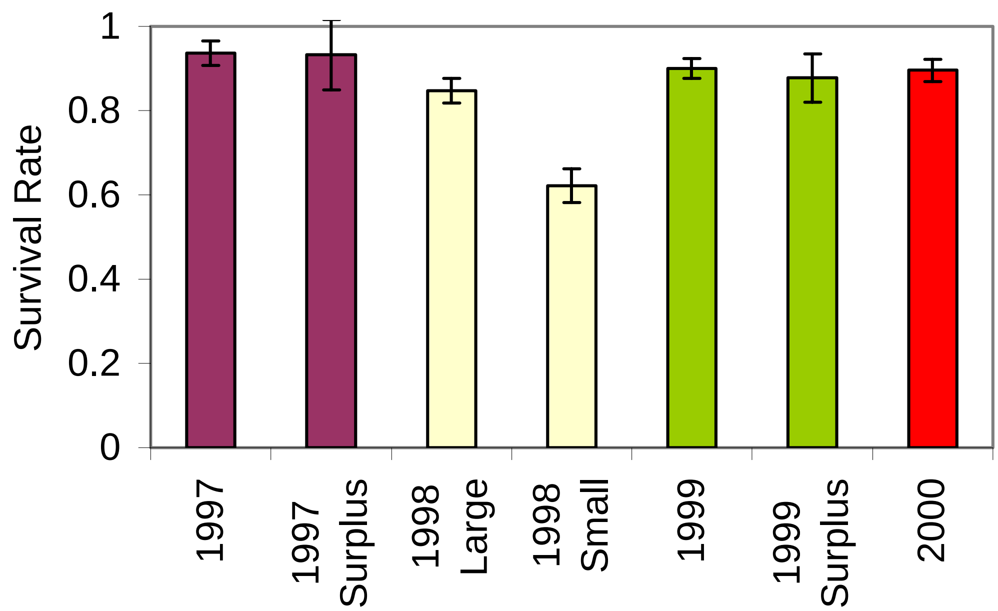


Figure C.2.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to Lower Granite Dam, 1997-2000.

Appendix C (continued).

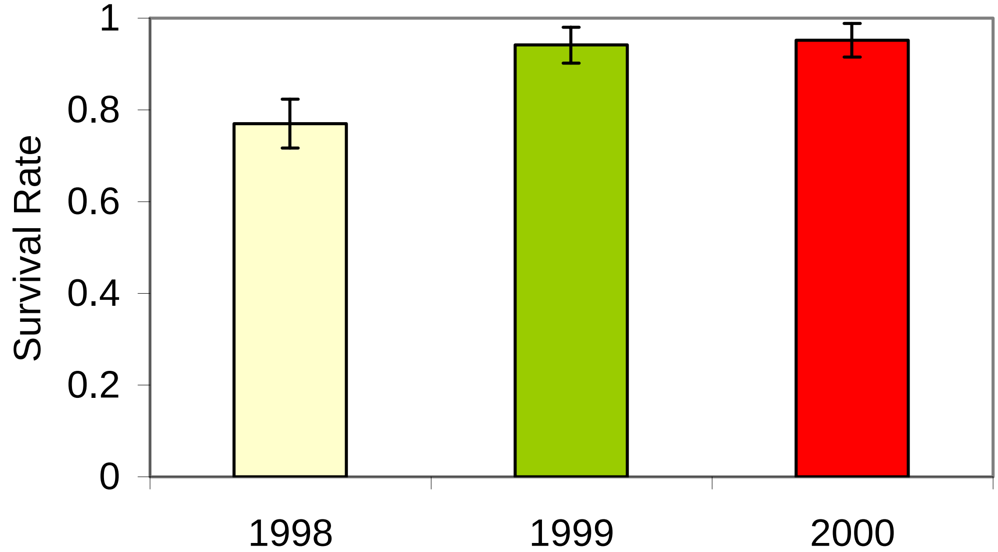


Figure C.3.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to Lower Granite Dam, 1998-2000.

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, 1996-2000.

| Release Group | Year | CJS Estimate | S.E. | 95% C.I. Lower | 95% C.I. Upper |
|---|---|---|---|---|---|
| Pittsburg Landing | 1996 | 0.4131 | 0.0738 | 0.2685 | 0.5577 |
| | 1997 | 0.8176 | 0.1593 | 0.5054 | 1.1298 |
| | 1998 | 0.5568 | 0.0394 | 0.4796 | 0.6340 |
| | 1999 | 0.6212 | 0.0244 | 0.5734 | 0.6690 |
| | 2000 | 0.6657 | 0.0397 | 0.5879 | 0.7435 |
| 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 |
| | 2000 | 0.6785 | 0.0385 | 0.6030 | 0.7540 |
| Big Canyon Surplus | 1997 | 0.7382 | 0.7130 | -0.6593 | 2.1357 |
| | 1999 | 0.5869 | 0.0479 | 0.4930 | 0.6808 |
| Captain John Rapids | 1998 | 0.5049 | 0.1168 | 0.2760 | 0.7338 |
| | 1999 | 0.7129 | 0.0572 | 0.6008 | 0.8250 |
| | 2000 | 0.8398 | 0.0778 | 0.6873 | 0.9923 |
| Lyons Ferry Hatchery | 1996 | 0.8755 | 0.3955 | 0.1003 | 1.6507 |
| | 1997 | 1.3479 | 0.4180 | 0.5286 | 2.1672 |
| | 1998 | 0.8189 | 0.0847 | 0.6529 | 0.9849 |
| | 1999 | 0.6808 | 0.0709 | 0.5418 | 0.8198 |
| | 2000 | 0.6577 | 0.0729 | 0.5148 | 0.8006 |

Appendix C (continued).

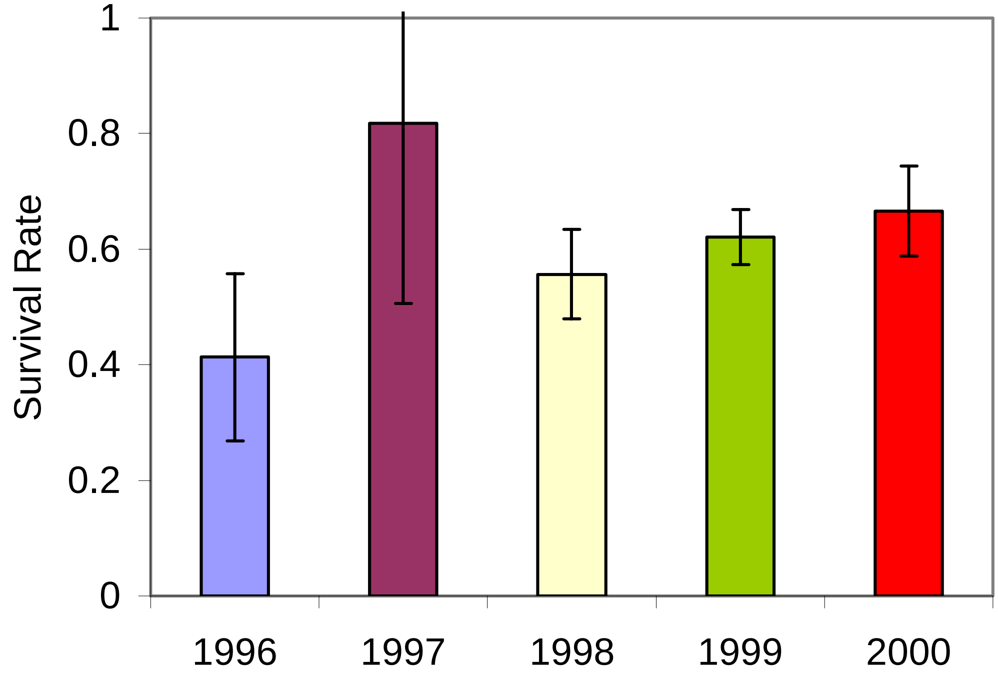


Figure C.4.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Pittsburg Landing to McNary Dam, 1996-2000.

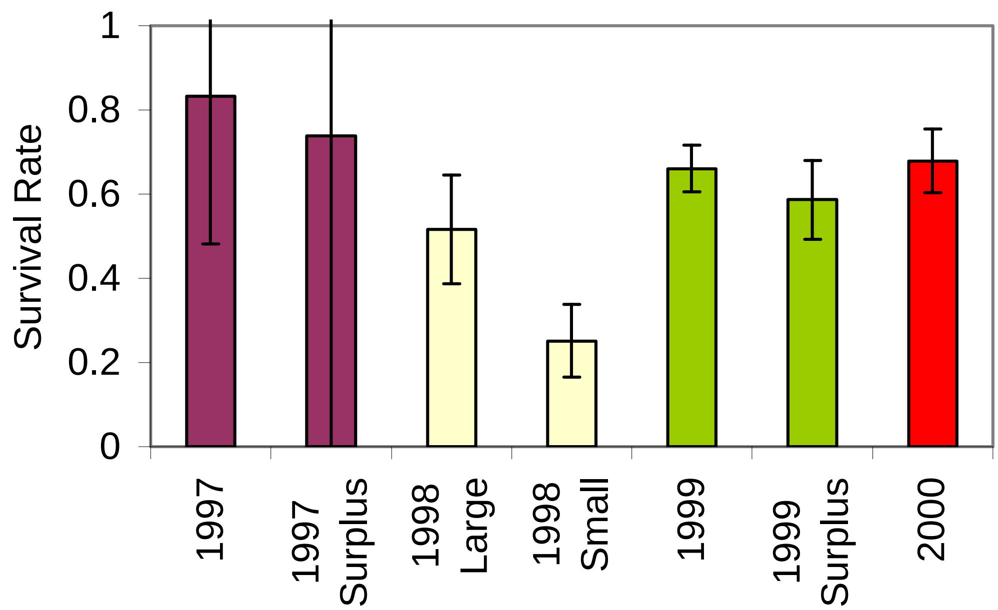


Figure C.5.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Big Canyon to McNary Dam, 1997-2000.

Appendix C (continued).

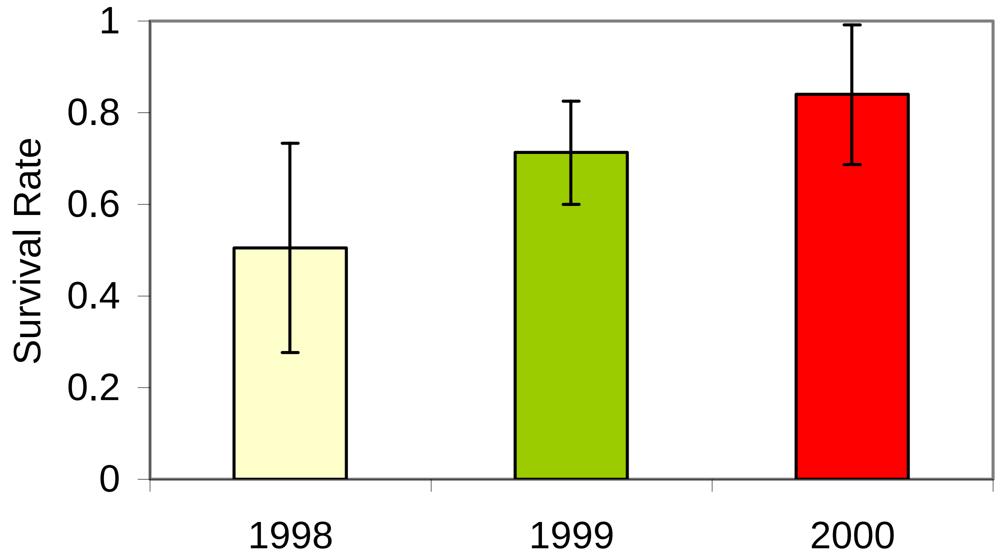


Figure C.6.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Captain John Rapids to McNary Dam, 1998-2000.

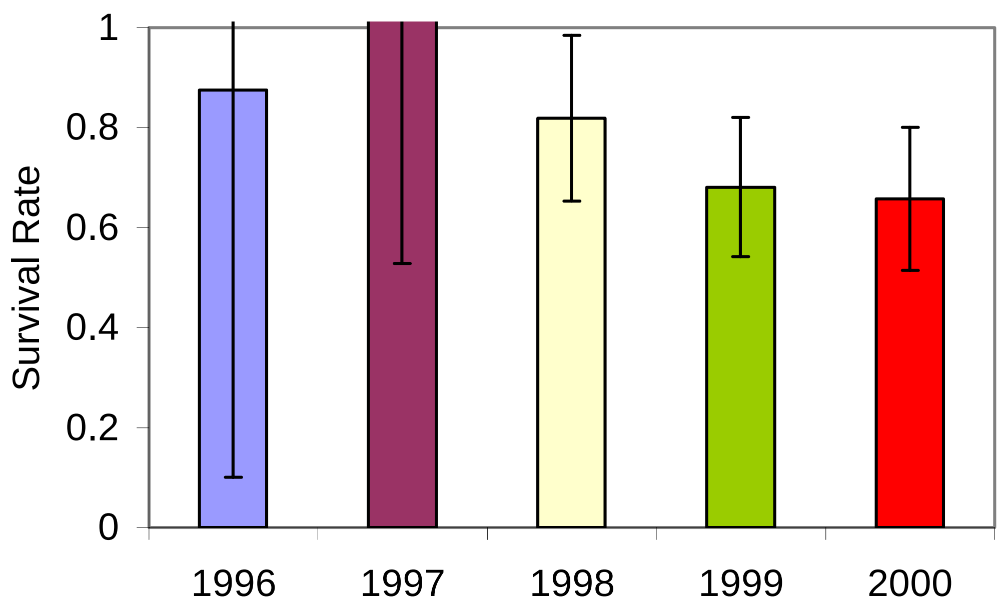


Figure C.7.—Estimated survival (+/- 95% C.I.) of PIT tagged yearling fall Chinook salmon from Lyons Ferry Hatchery to McNary Dam, 1996-2000.

**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 2000.

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 2000.

| Release Group | Interrogation Site | *n* | Mean | Standard Deviation | 95% C.I. (+/-) | Median | Range |
|---|---|---|---|---|---|---|---|
| Pittsburg Landing | Lower Granite | 2,472 | 10.1 | 6.1 | 0.2 | 9.1 | 2.3 - 55.1 |
| | Little Goose | 1,373 | 15.0 | 6.1 | 0.3 | 14.2 | 4.2 - 45.1 |
| | Lower Monumental | 554 | 16.8 | 15.7 | 0.5 | 15.7 | 6.3 - 54.5 |
| | McNary | 308 | 22.3 | 7.0 | 0.8 | 21.1 | 8.3 - 55.6 |
| | John Day | 142 | 23.2 | 7.4 | 1.2 | 21.2 | 11.9 - 47.4 |
| | Bonneville | 85 | 29.1 | 7.3 | 1.6 | 26.9 | 16.2 - 52.6 |
| Big Canyon | Lower Granite | 2,275 | 11.6 | 7.3 | 0.3 | 10.3 | 2.1 - 66.7 |
| | Little Goose | 1,438 | 17.1 | 7.7 | 0.4 | 16.0 | 4.2 - 57.1 |
| | Lower Monumental | 565 | 18.0 | 17.1 | 0.6 | 17.1 | 6.3 - 73.8 |
| | McNary | 356 | 24.2 | 8.5 | 0.9 | 22.6 | 10.6 - 60.5 |
| | John Day | 133 | 25.6 | 8.0 | 1.4 | 23.4 | 12.1 - 51.1 |
| | Bonneville | 82 | 30.4 | 8.1 | 1.8 | 29.4 | 11.6 - 52.8 |
| Captain John Rapids | Lower Granite | 987 | 9.9 | 5.7 | 0.4 | 8.9 | 1.4 - 53.6 |
| | Little Goose | 429 | 15.0 | 5.7 | 0.5 | 13.7 | 5.4 - 47.0 |
| | Lower Monumental | 231 | 17.1 | 15.6 | 0.8 | 15.6 | 8.4 - 41.4 |
| | McNary | 109 | 22.4 | 5.7 | 1.1 | 21.9 | 9.1 - 42.3 |
| | John Day | 57 | 22.5 | 6.6 | 1.8 | 21.3 | 12.5 - 58.7 |
| | Bonneville | 33 | 27.1 | 5.9 | 2.1 | 25.8 | 17.8 - 42.4 |
| Lyons Ferry Hatchery | Lower Monumental | 246 | 14.8 | 15.3 | 0.9 | 15.3 | 2.0 - 40.4 |
| | McNary | 114 | 24.5 | 9.9 | 1.8 | 24.3 | 8.5 - 56.4 |
| | John Day | 65 | 28.0 | 8.3 | 2.1 | 27.2 | 14.3 - 45.0 |
| | Bonneville | 31 | 29.2 | 9.2 | 3.4 | 26.9 | 16.3 - 54.7 |

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 2000.

| Release Group | Interrogation Site | *n* | Mean | Standard Deviation | 95% C.I. (+/-) | Median | Range |
|---|---|---|---|---|---|---|---|
| Pittsburg Landing | Lower Granite | 2,472 | 10.1 | 6.1 | 0.2 | 9.1 | 2.3 - 55.1 |
| | Little Goose | 2,207 | 15.8 | 6.3 | 0.3 | 15.0 | 4.2 - 47.9 |
| | Lower Monumental | 1,430 | 17.8 | 17.3 | 0.3 | 17.3 | 5.5 - 54.5 |
| | McNary | 459 | 23.0 | 6.2 | 0.6 | 23.0 | 9.1 - 52.0 |
| | John Day | 548 | 24.6 | 7.0 | 0.6 | 23.0 | 11.9 - 56.0 |
| | Bonneville | 389 | 29.6 | 7.2 | 0.7 | 27.8 | 16.1 - 53.7 |
| Big Canyon | Lower Granite | 2,275 | 11.6 | 7.3 | 0.3 | 10.3 | 2.1 - 66.7 |
| | Little Goose | 2,118 | 17.6 | 7.7 | 0.3 | 16.8 | 4.2 - 60.9 |
| | Lower Monumental | 1,360 | 19.1 | 18.6 | 0.4 | 18.6 | 6.3 - 73.8 |
| | McNary | 732 | 25.4 | 7.7 | 0.6 | 24.7 | 10.6 - 68.3 |
| | John Day | 533 | 26.7 | 7.9 | 0.7 | 25.6 | 12.1 - 64.6 |
| | Bonneville | 423 | 30.6 | 7.7 | 0.7 | 29.6 | 11.6 - 57.6 |
| Captain John Rapids | Lower Granite | 987 | 9.9 | 5.7 | 0.4 | 8.9 | 1.4 - 53.6 |
| | Little Goose | 746 | 15.5 | 5.6 | 0.4 | 14.7 | 4.7 - 47.0 |
| | Lower Monumental | 579 | 17.8 | 17.4 | 0.5 | 17.4 | 7.5 - 45.3 |
| | McNary | 276 | 23.4 | 6.7 | 0.8 | 22.6 | 11.0 - 56.2 |
| | John Day | 247 | 24.2 | 6.1 | 0.8 | 23.1 | 12.5 - 58.7 |
| | Bonneville | 191 | 28.6 | 5.6 | 0.8 | 28.0 | 17.8 - 50.4 |
| Lyons Ferry Hatchery | Lower Monumental | 246 | 14.8 | 15.3 | 0.9 | 15.3 | 2.0 - 40.4 |
| | McNary | 152 | 24.6 | 9.8 | 1.6 | 24.5 | 8.5 - 56.4 |
| | John Day | 127 | 28.9 | 8.8 | 1.6 | 30.1 | 12.6 - 52.6 |
| | Bonneville | 71 | 31.1 | 8.9 | 2.1 | 30.0 | 16.3 - 55.4 |

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 2000.

| Release Group | Interrogation Site | *n* | Mean | Median | Range |
|---|---|---|---|---|---|
| Pittsburg Landing | Lower Granite | 2,472 | 17.2 | 19.1 | 3.1 - 76.4 |
| | Little Goose | 1,373 | 15.5 | 16.4 | 5.2 - 55.6 |
| | Lower Monumental | 554 | 16.6 | 17.8 | 5.1 - 44.5 |
| | McNary | 308 | 17.8 | 18.9 | 7.2 - 47.9 |
| | John Day | 142 | 22.5 | 24.6 | 11.0 - 43.9 |
| | Bonneville | 85 | 21.8 | 23.6 | 12.1 - 39.1 |
| Big Canyon | Lower Granite | 2,275 | 9.3 | 10.5 | 1.6 - 52.6 |
| | Little Goose | 1,438 | 9.8 | 10.5 | 2.9 - 40.3 |
| | Lower Monumental | 565 | 11.9 | 12.5 | 2.9 - 33.8 |
| | McNary | 356 | 13.7 | 14.7 | 5.5 - 31.5 |
| | John Day | 133 | 17.8 | 19.5 | 8.9 - 37.8 |
| | Bonneville | 82 | 18.7 | 19.3 | 10.8 - 48.9 |
| Captain John Rapids | Lower Granite | 987 | 9.1 | 10.1 | 1.7 - 65.2 |
| | Little Goose | 429 | 10.0 | 10.9 | 3.2 - 27.7 |
| | Lower Monumental | 231 | 11.5 | 12.6 | 4.7 - 23.4 |
| | McNary | 109 | 14.1 | 14.4 | 7.4 - 34.8 |
| | John Day | 57 | 19.5 | 20.6 | 7.5 - 35.2 |
| | Bonneville | 33 | 20.3 | 21.4 | 13.0 - 31.0 |
| Lyons Ferry Hatchery | Lower Monumental | 246 | 1.9 | 1.8 | 0.7 - 13.9 |
| | McNary | 114 | 6.0 | 6.0 | 2.6 - 17.4 |
| | John Day | 65 | 9.6 | 9.9 | 6.0 - 18.8 |
| | Bonneville | 31 | 13.1 | 14.3 | 7.0 - 23.5 |

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 2000.

| Release Group | Interrogation Site | *n* | Mean | Median | Range |
|---|---|---|---|---|---|
| Pittsburg Landing | Lower Granite | 2,472 | 17.2 | 19.1 | 3.1 - 76.4 |
| | Little Goose | 2,207 | 14.7 | 15.6 | 4.9 - 55.6 |
| | Lower Monumental | 1,430 | 15.7 | 16.1 | 5.1 - 50.8 |
| | McNary | 459 | 17.3 | 17.3 | 7.7 - 43.8 |
| | John Day | 548 | 21.2 | 22.7 | 9.3 - 43.9 |
| | Bonneville | 389 | 21.4 | 22.8 | 11.8 - 39.4 |
| Big Canyon | Lower Granite | 2,275 | 9.3 | 10.5 | 1.6 - 52.6 |
| | Little Goose | 2,118 | 9.6 | 10.0 | 2.8 - 40.3 |
| | Lower Monumental | 1,360 | 11.2 | 11.5 | 2.9 - 33.8 |
| | McNary | 732 | 13.1 | 13.5 | 4.9 - 31.5 |
| | John Day | 533 | 17.1 | 17.8 | 7.1 - 37.8 |
| | Bonneville | 423 | 18.6 | 19.2 | 9.9 - 48.9 |
| Captain John Rapids | Lower Granite | 987 | 9.1 | 10.1 | 1.7 - 65.2 |
| | Little Goose | 746 | 9.7 | 10.2 | 3.2 - 32.2 |
| | Lower Monumental | 579 | 11.0 | 11.3 | 4.3 - 26.1 |
| | McNary | 276 | 13.5 | 13.9 | 5.6 - 28.7 |
| | John Day | 247 | 18.1 | 19.0 | 7.5 - 35.2 |
| | Bonneville | 191 | 19.3 | 19.7 | 10.9 - 31.0 |
| Lyons Ferry Hatchery | Lower Monumental | 246 | 1.9 | 1.8 | 0.7 - 13.9 |
| | McNary | 152 | 6.0 | 6.0 | 2.6 - 17.4 |
| | John Day | 127 | 9.3 | 9.0 | 5.1 - 21.4 |
| | Bonneville | 71 | 12.3 | 12.8 | 6.9 - 23.5 |

**Appendix E.** Arrival date frequency distributions and cumulative frequencies for PIT tagged yearling fall Chinook from the FCAP sites and LFH based on first and all obs at Lower Snake and Columbia River dams in 2000.

**BASED ON FIRST OBS - Individual release groups at multiple dams**

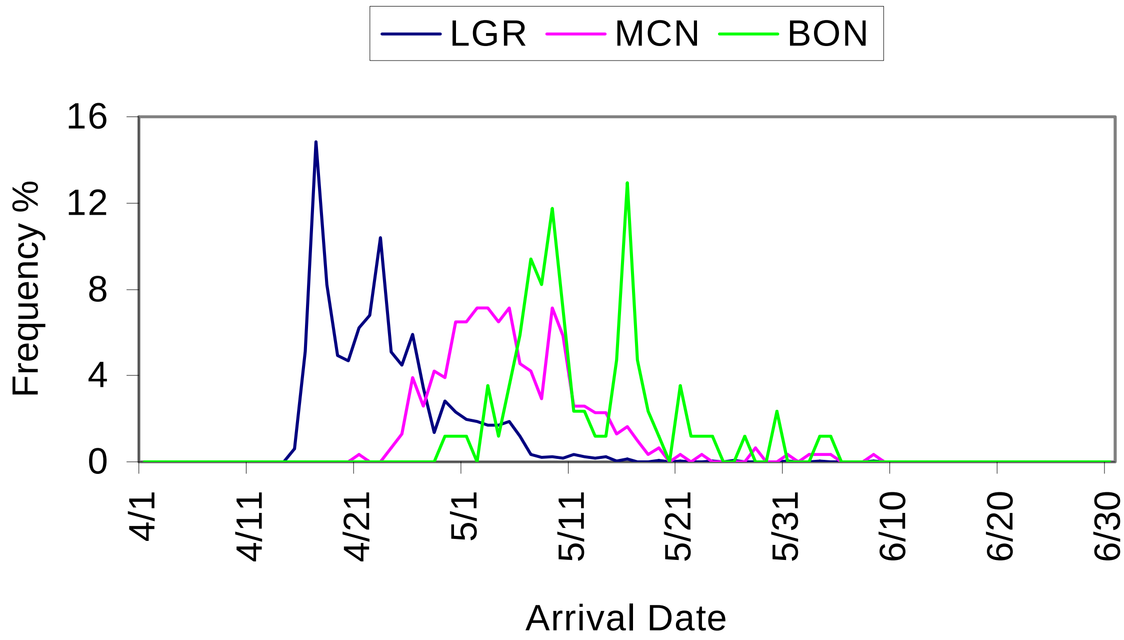


Figure E.1.—First obs arrival date frequency distribution of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2000.

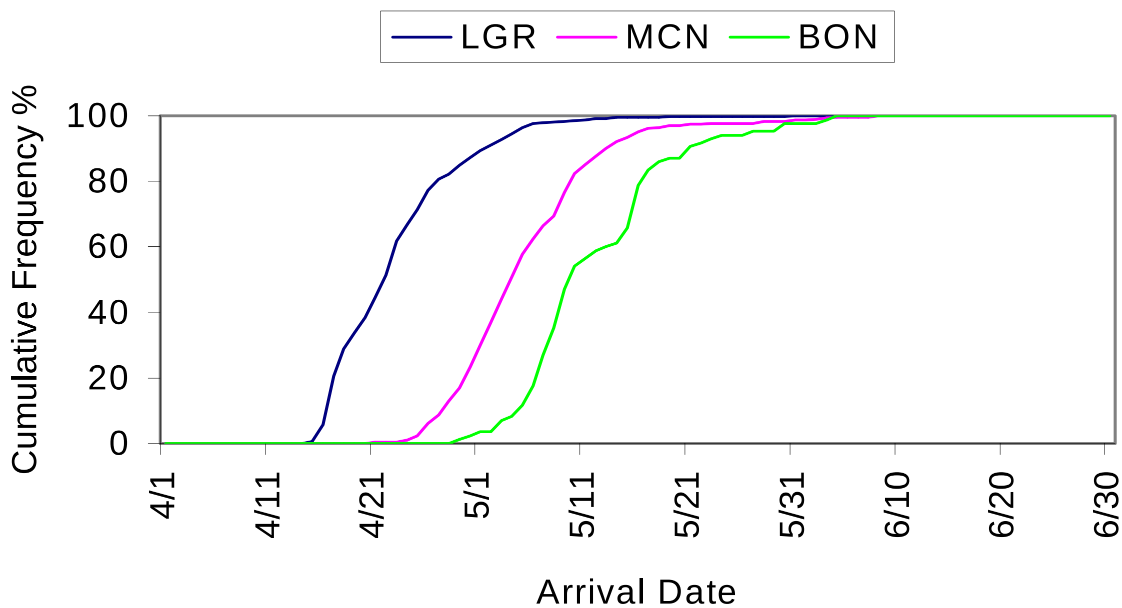


Figure E.2.—First obs arrival date cumulative frequency of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2000.

Appendix E (continued).

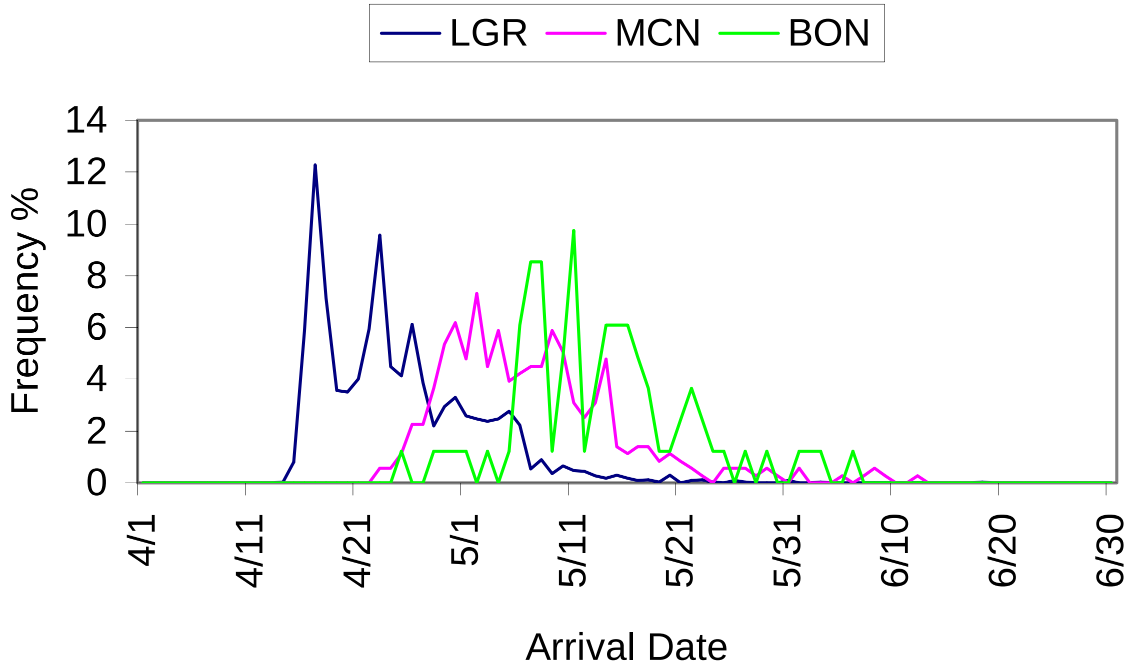


Figure E.3.—First obs arrival date frequency distribution of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2000.

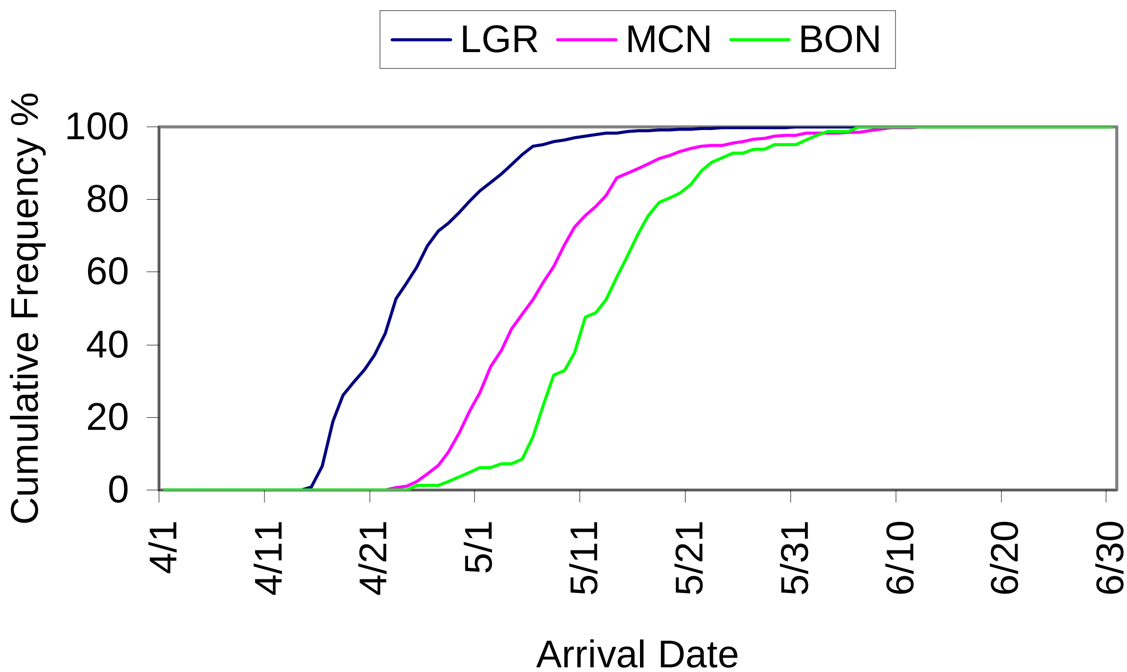


Figure E.4.—First obs arrival date cumulative frequency of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2000.

Appendix E (continued).

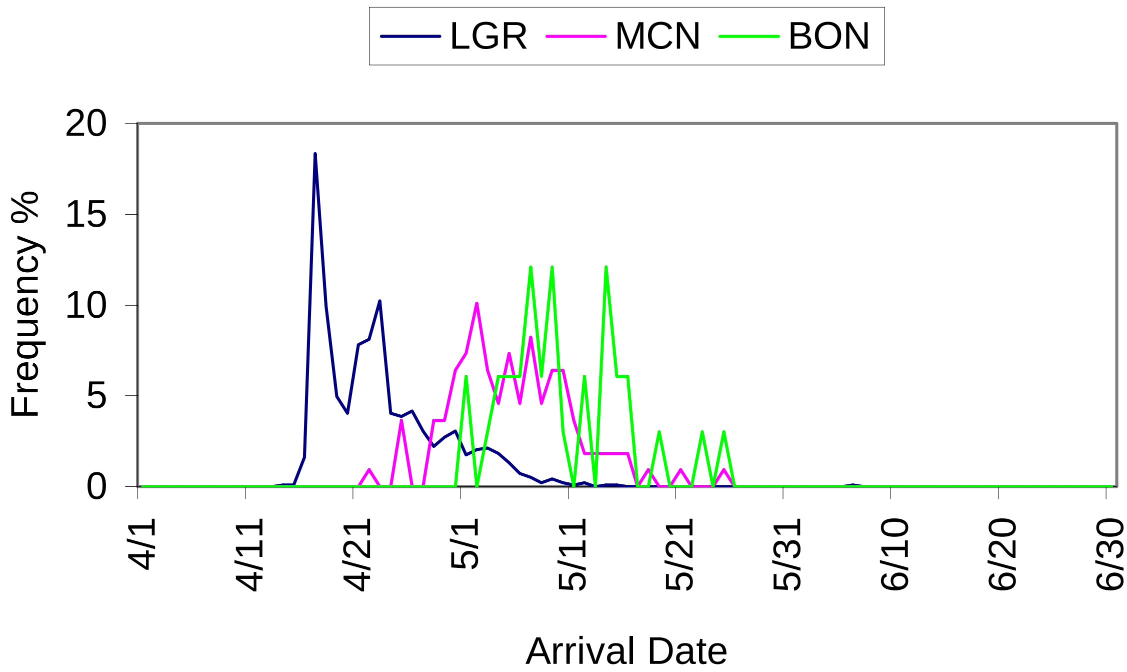


Figure E.5.—First obs arrival date frequency distribution of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2000.

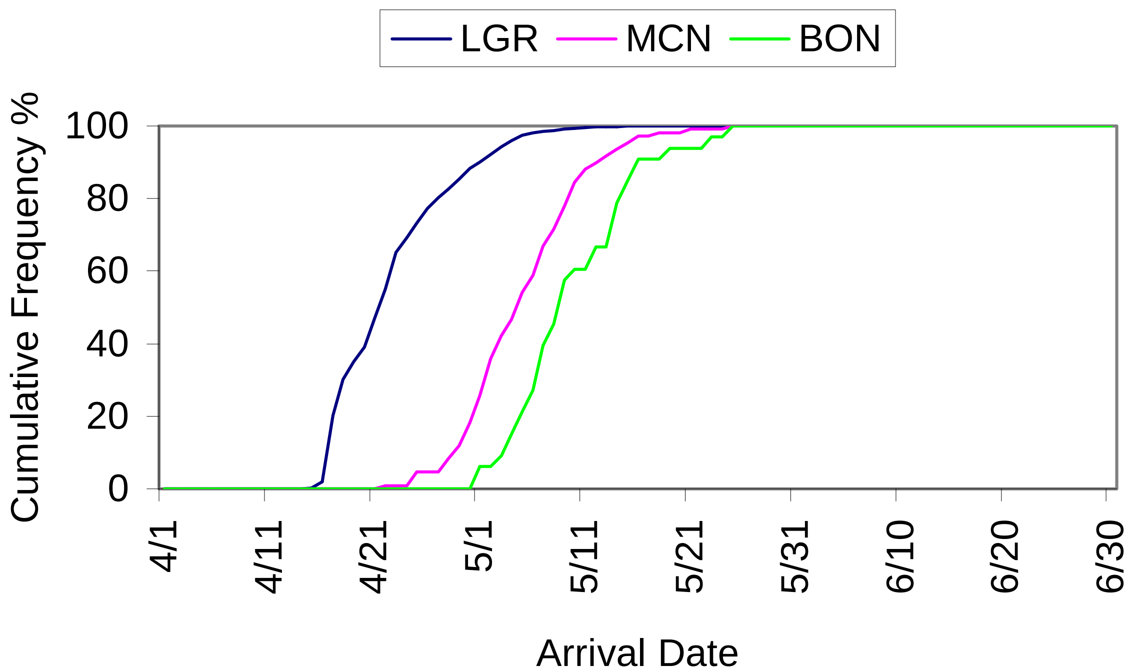


Figure E.6.—First obs arrival date cumulative frequency of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2000.

Appendix E (continued).

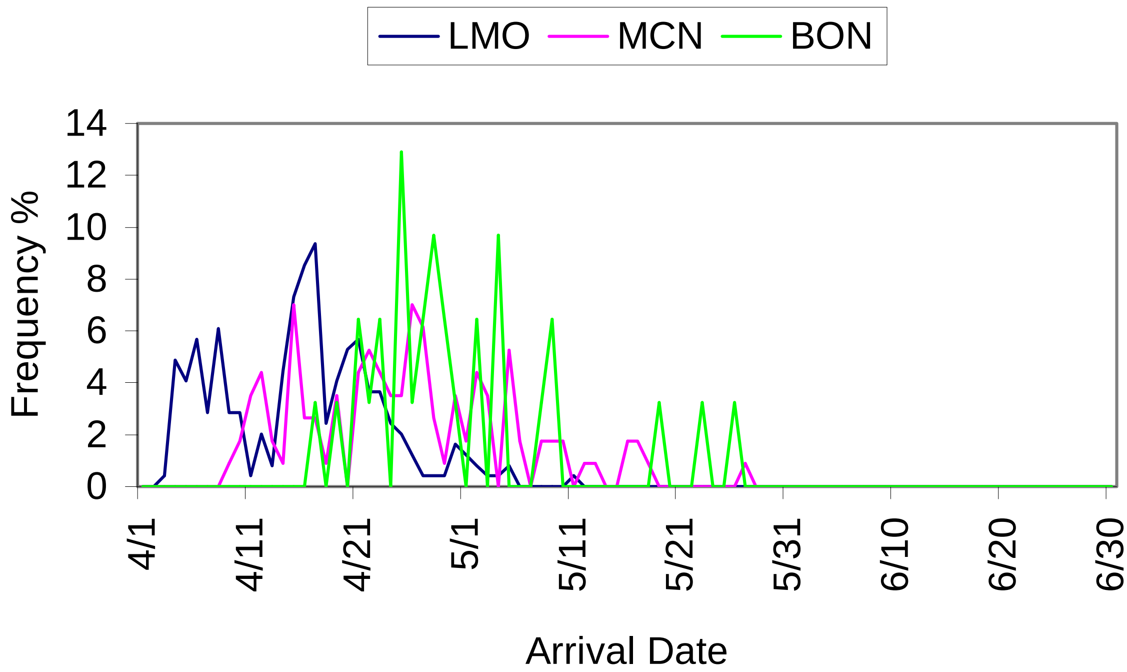


Figure E.7.—First obs arrival date frequency distribution of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 2000.

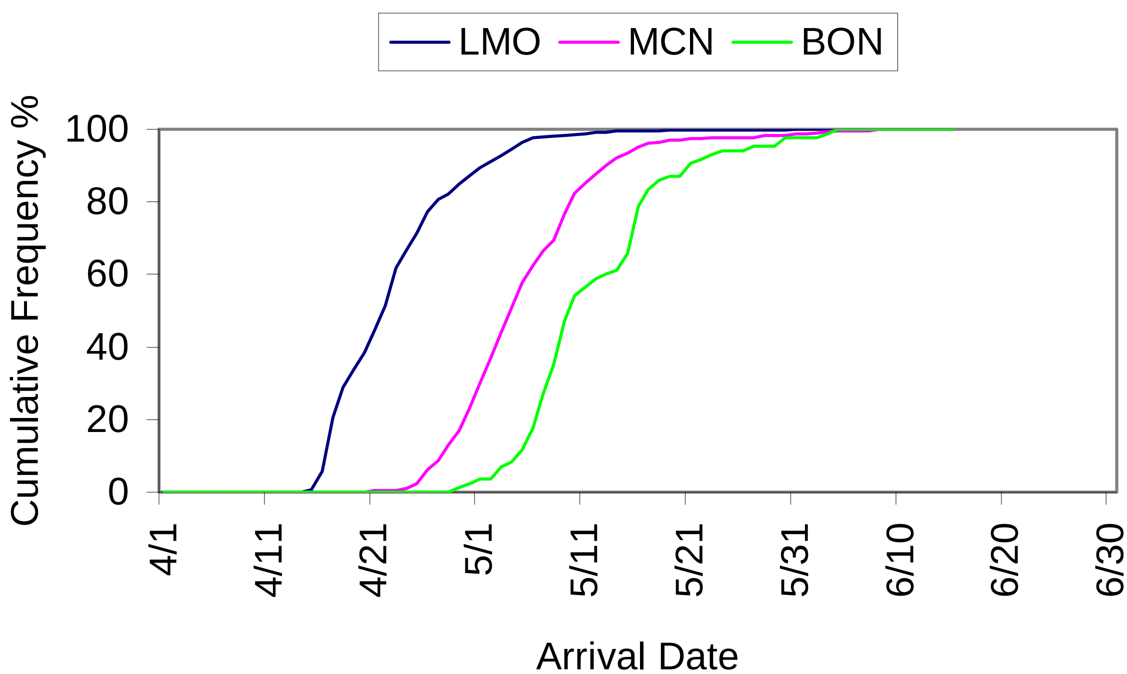


Figure E.8.—First obs arrival date cumulative frequency of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 2000.

Appendix E (continued).

**BASED ON FIRST OBS - Multiple release groups at individual dams**

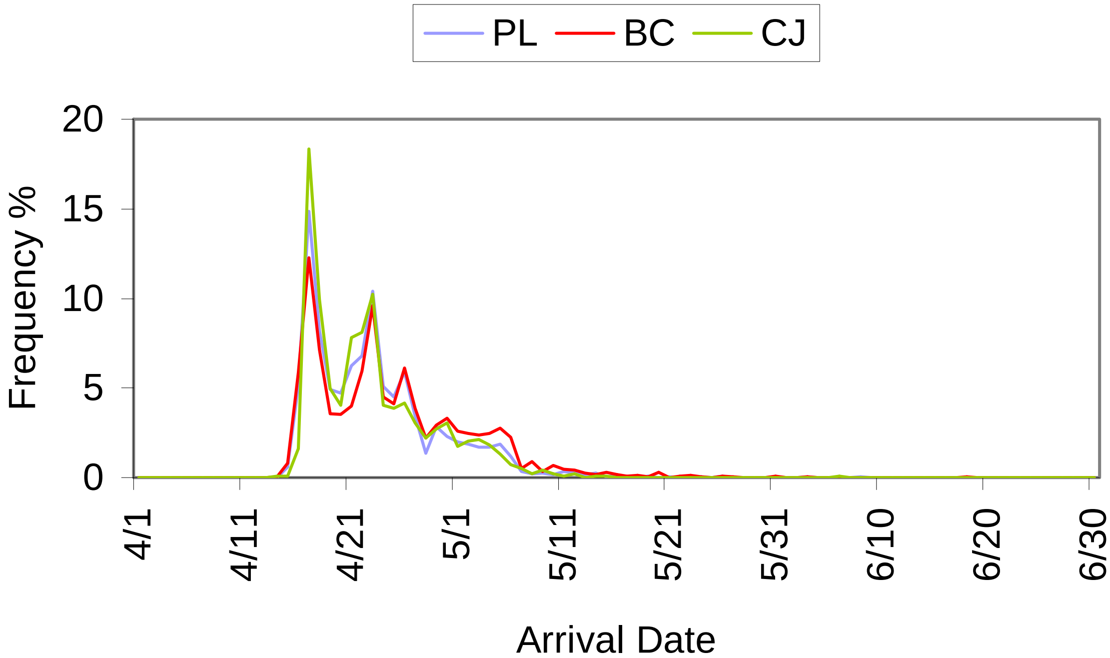


Figure E.9.—First obs arrival date frequency distribution of FCAP yearlings at Lower Granite Dam in 2000.

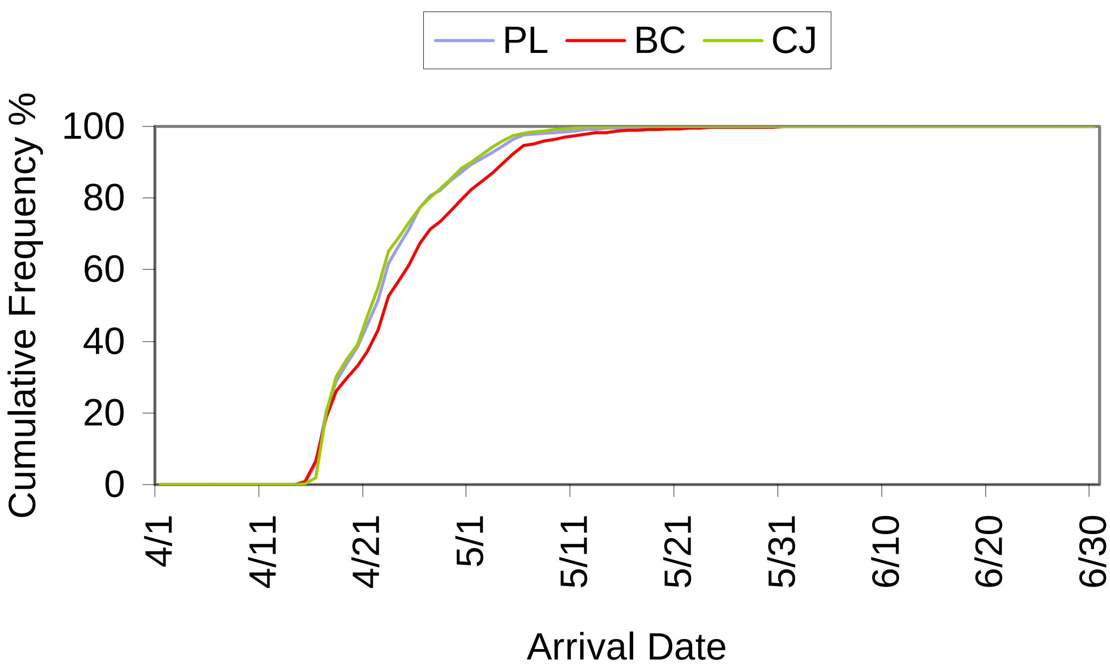


Figure E.10.—First obs arrival date cumulative frequency of FCAP yearlings at Lower Granite Dam in 2000.

Appendix E (continued).

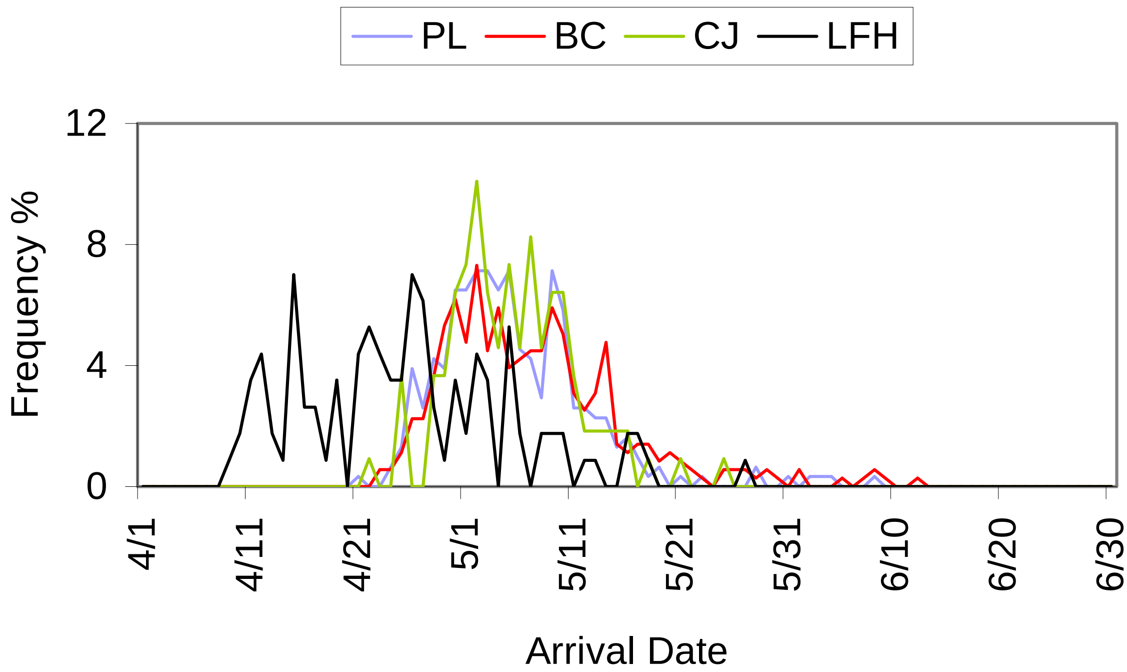


Figure E.11.—First obs arrival date frequency distribution of FCAP and LFH yearlings at McNary Dam in 2000.

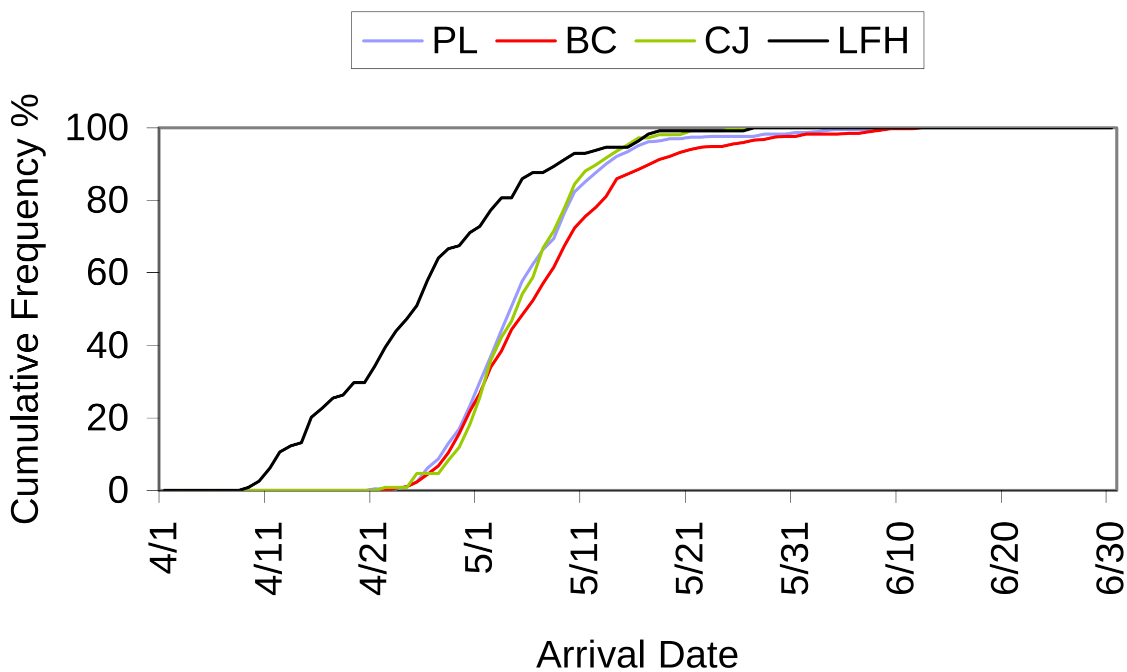


Figure E.12.—First obs arrival date cumulative frequency of FCAP and LFH yearlings at McNary Dam in 2000.

Appendix E (continued).

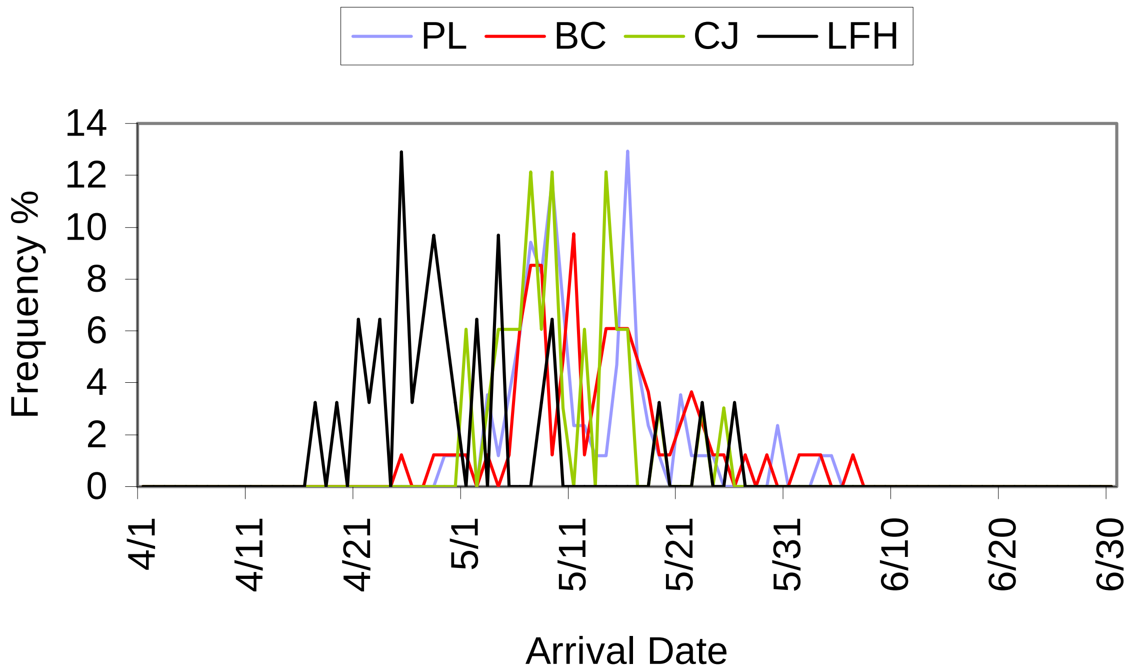


Figure E.13.—First obs arrival date frequency distribution of FCAP and LFH yearlings at Bonneville Dam in 2000.

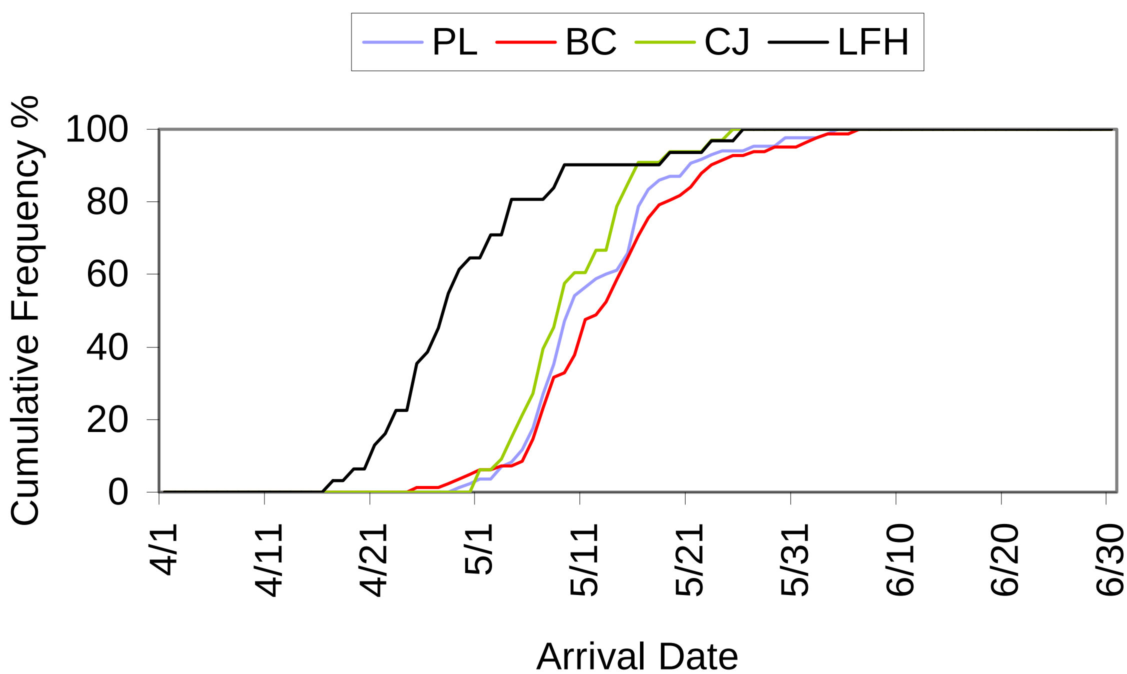


Figure E.14.—First obs arrival date cumulative frequency of FCAP and LFH yearlings at Bonneville Dam in 2000.

Appendix E (continued).

**BASED ON ALL OBS - Individual release groups at multiple dams**

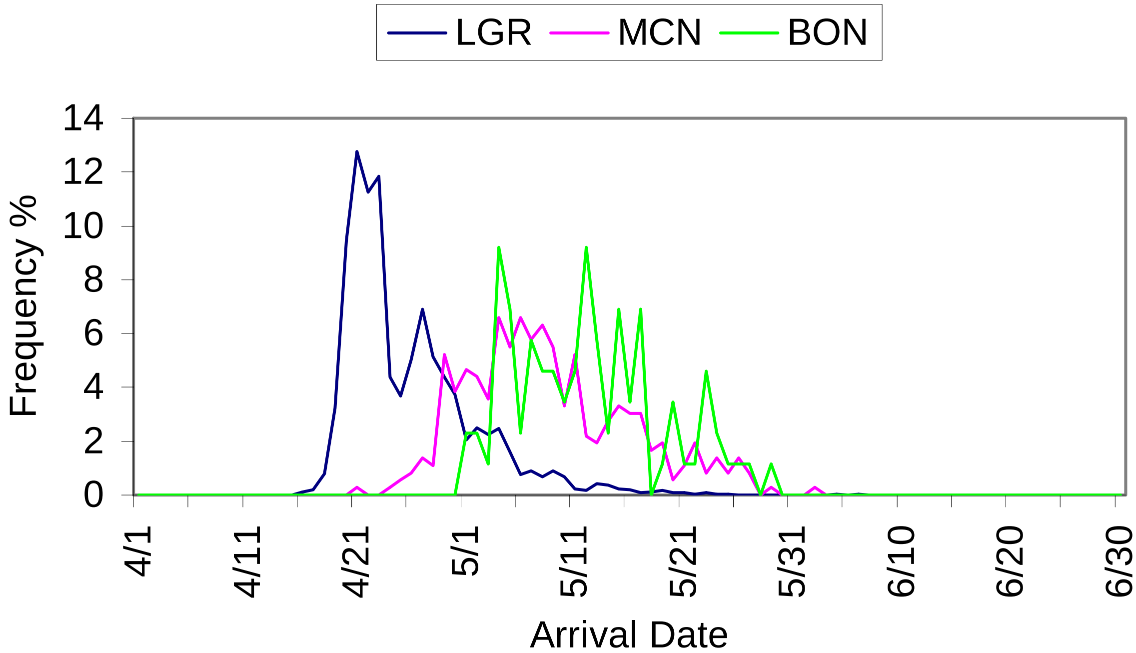


Figure E.15.—All obs arrival date frequency distribution of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2000.

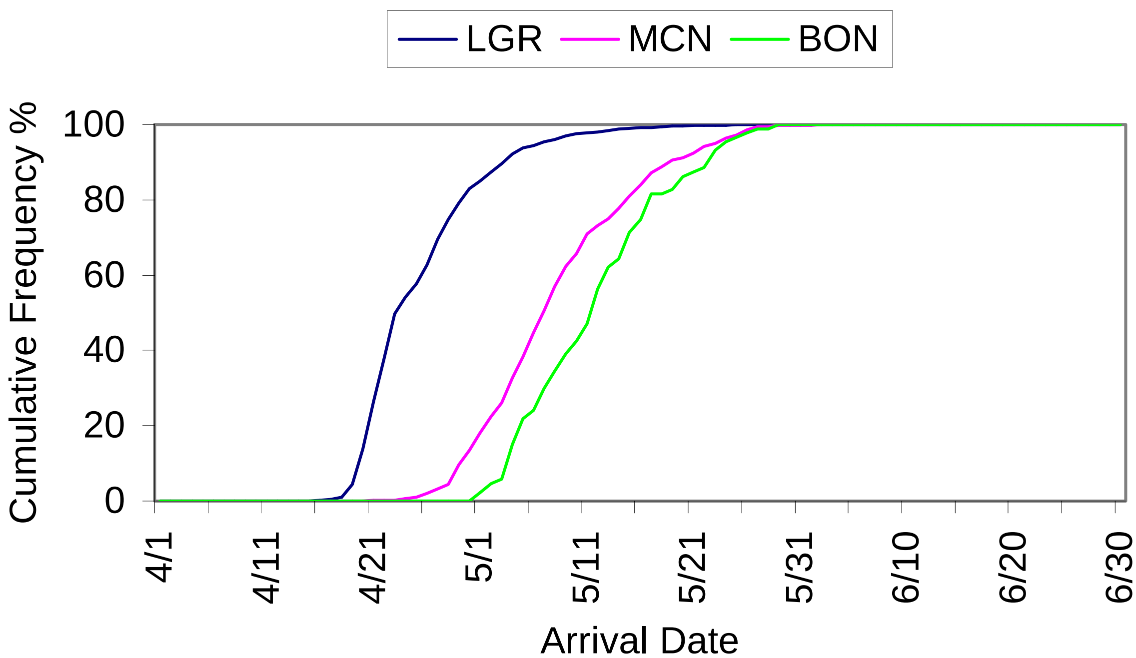


Figure E.16.—All obs arrival date cumulative frequency of Pittsburg Landing yearlings at Lower Granite, McNary and Bonneville dams in 2000.

Appendix E (continued).

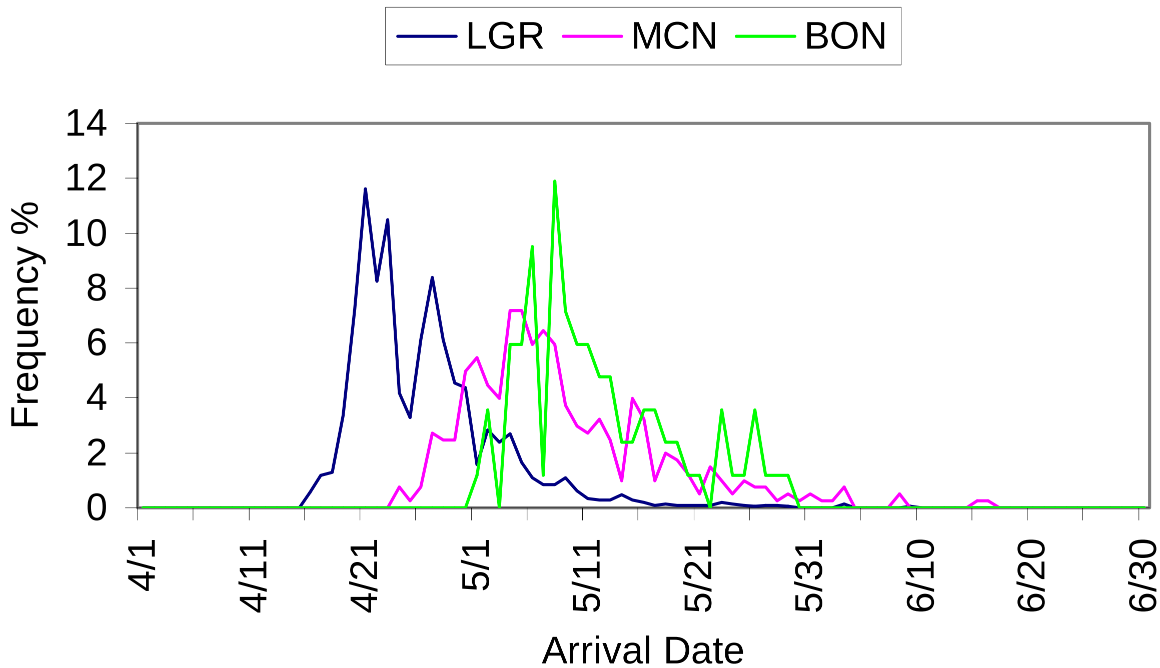


Figure E.17.—All obs arrival date frequency distribution of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2000.

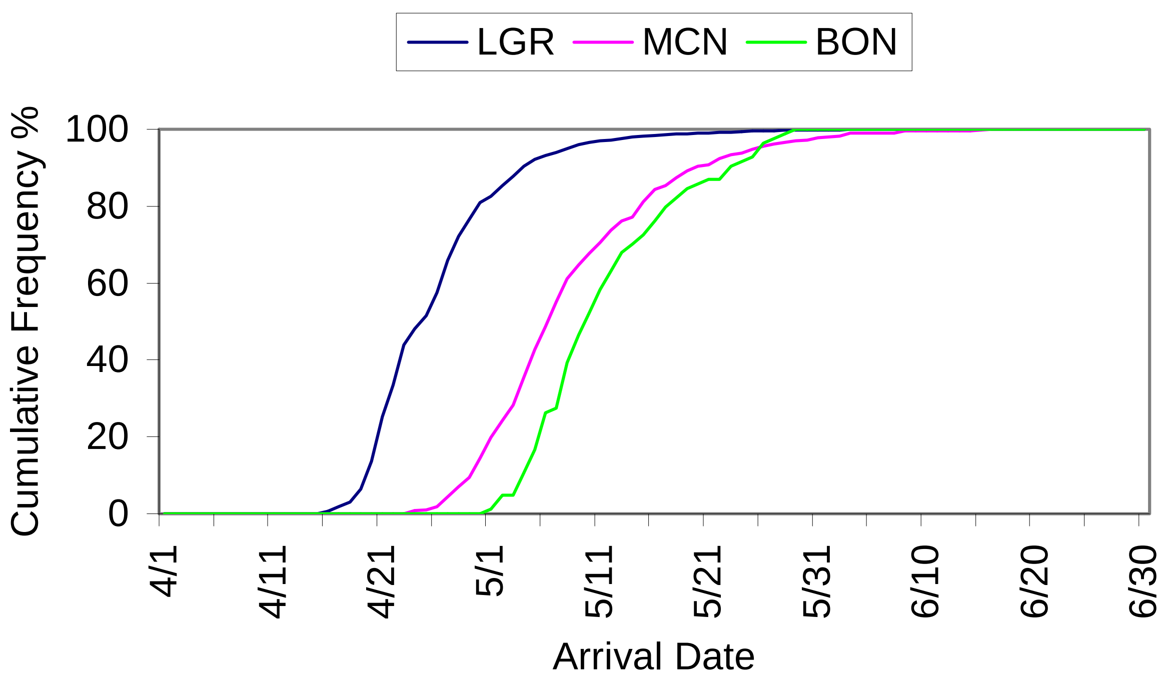


Figure E.18.—All obs arrival date cumulative frequency of Big Canyon yearlings at Lower Granite, McNary and Bonneville dams in 2000.

Appendix E (continued).

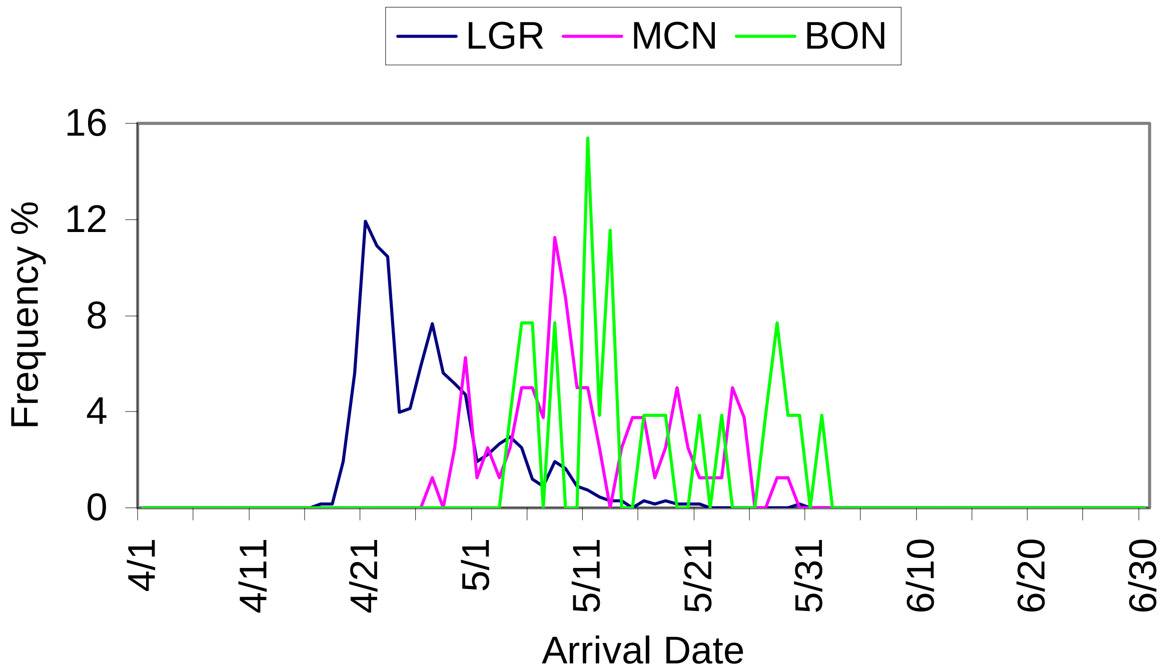


Figure E.19.—All obs arrival date frequency distribution of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2000.

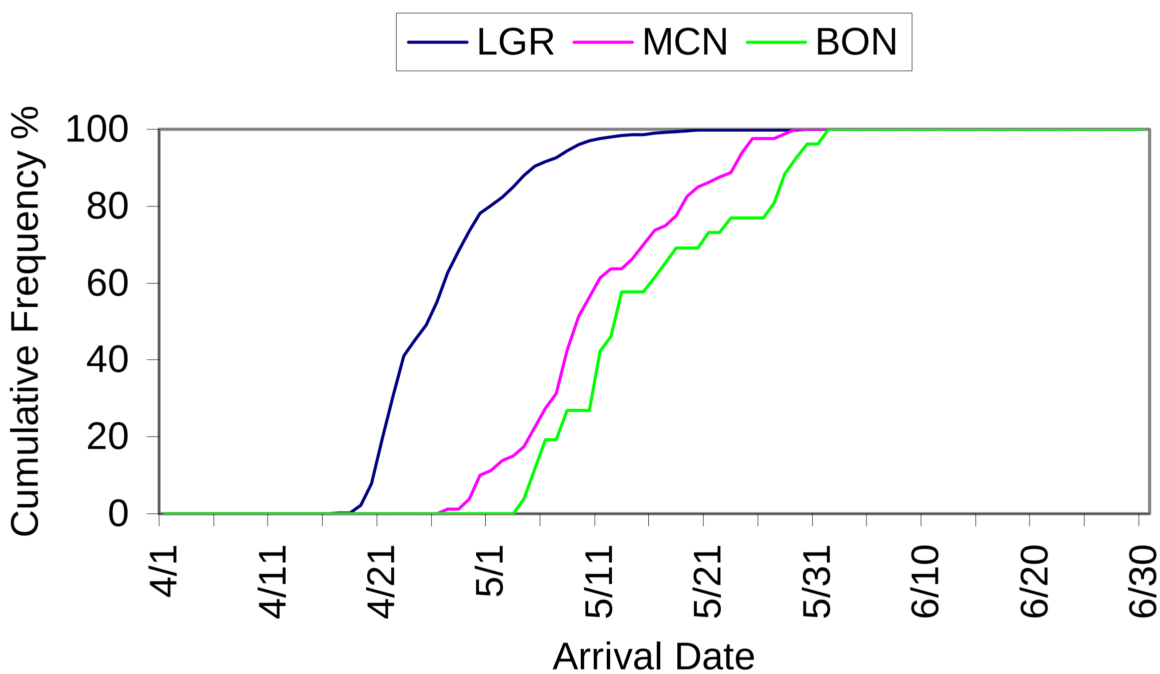


Figure E.20.—All obs arrival date cumulative frequency of Captain John Rapids yearlings at Lower Granite, McNary and Bonneville dams in 2000.

Appendix E (continued).

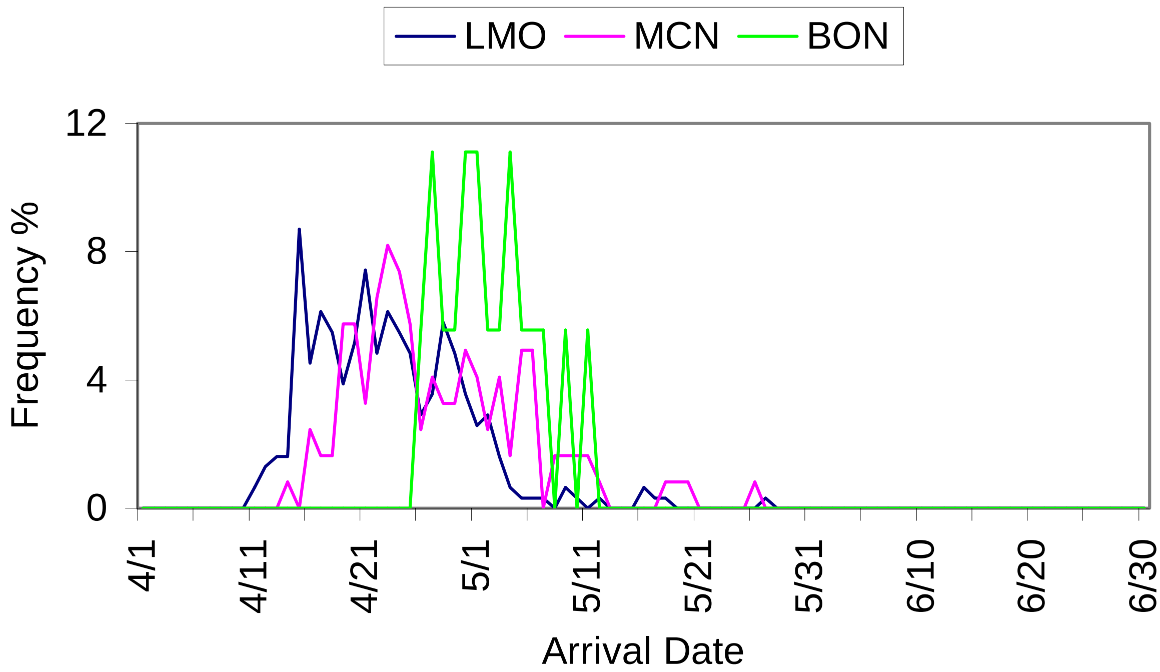


Figure E.21.—All obs arrival date frequency distribution of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 2000.

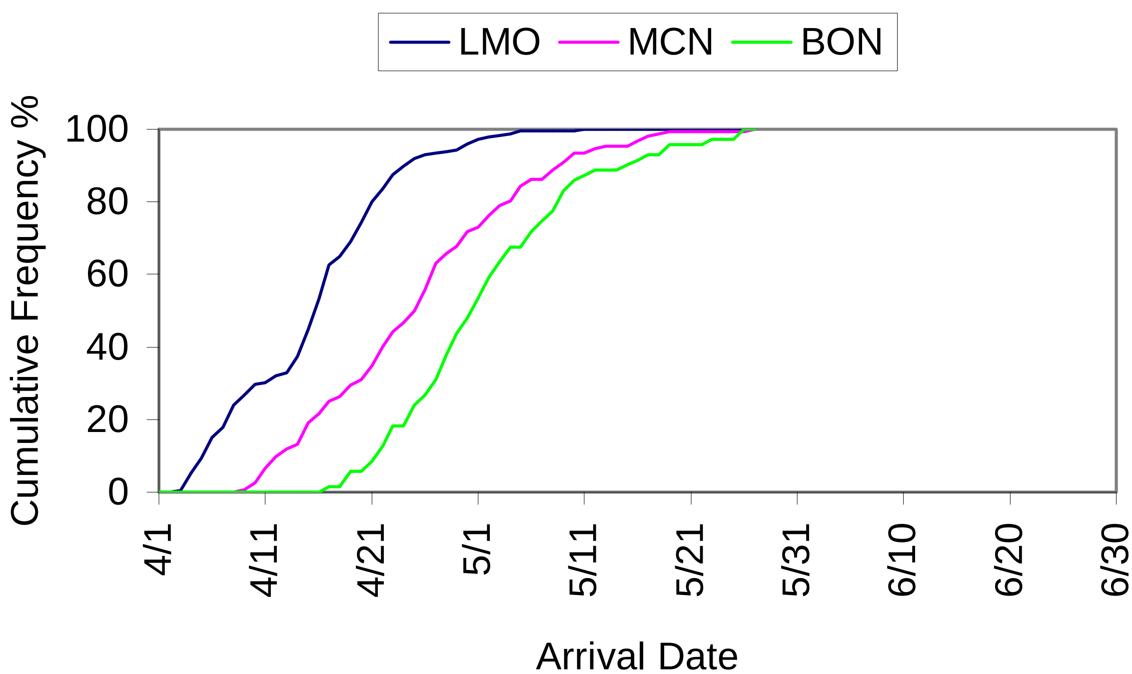


Figure E.22.—All obs arrival date cumulative frequency of LFH yearlings at Lower Monumental, McNary and Bonneville dams in 2000.

Appendix E (continued).

**BASED ON ALL OBS - Multiple release groups at individual dams**

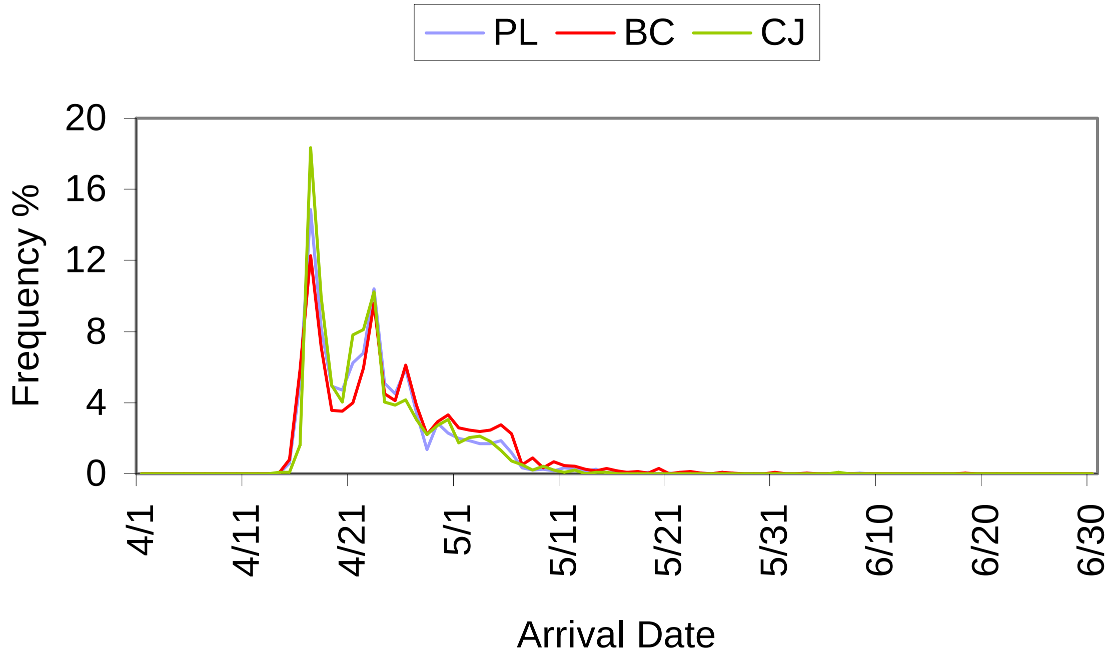


Figure E.23.—All obs arrival date frequency distribution of FCAP yearlings at Lower Granite Dam in 2000.

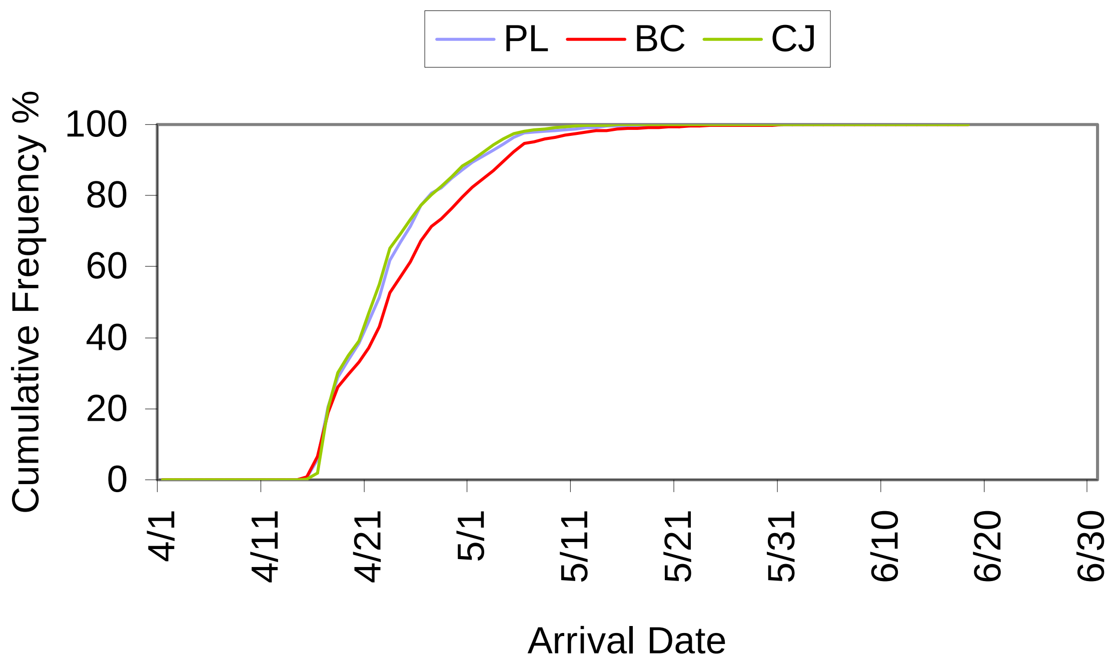


Figure E.24.—All obs arrival date cumulative frequency of FCAP yearlings at Lower Granite Dam in 2000.

Appendix E (continued).

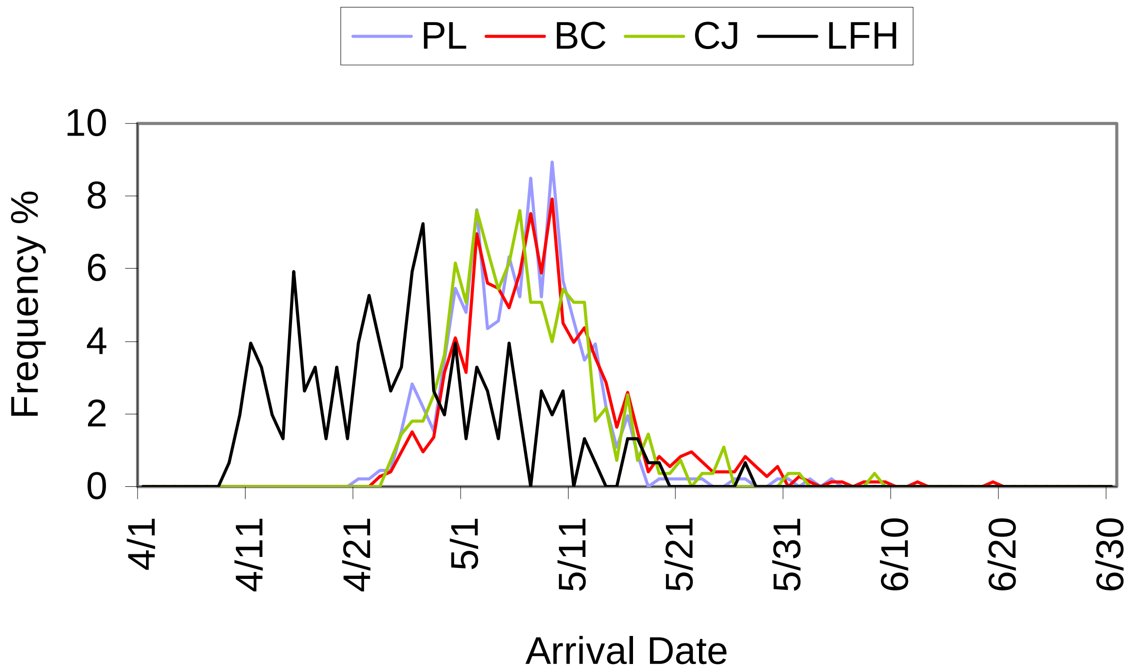


Figure E.25.—All obs arrival date frequency distribution of FCAP and LFH yearlings at McNary Dam in 2000.

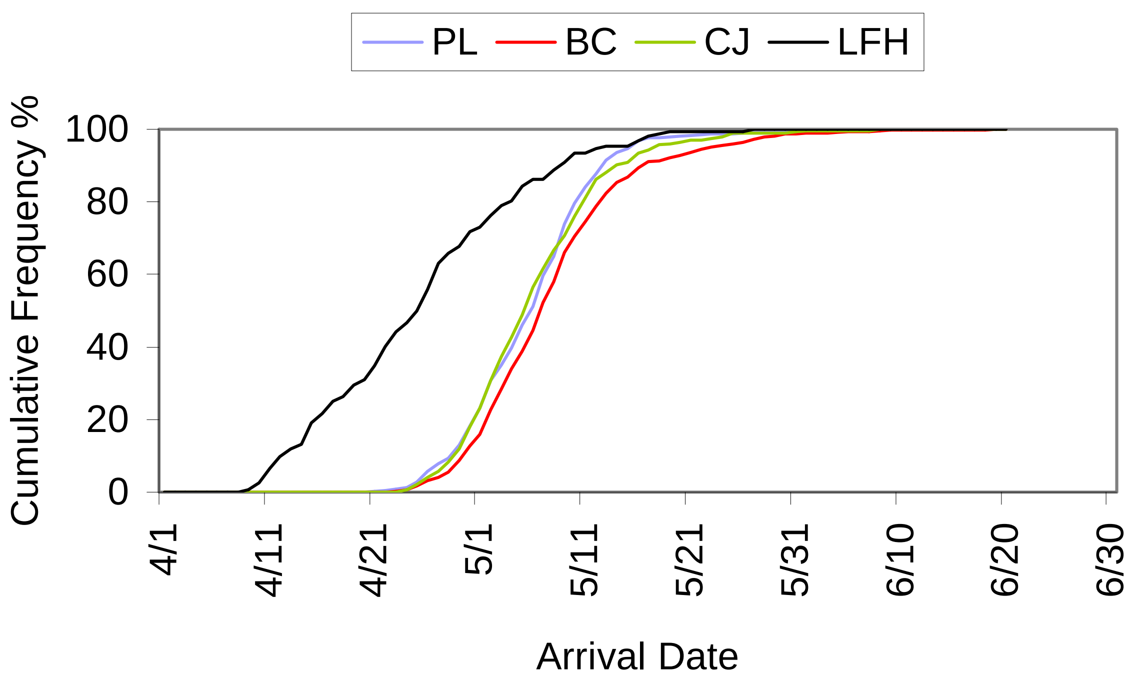


Figure E.26.—All obs arrival date cumulative frequency of FCAP and LFH yearlings at McNary Dam in 2000.

Appendix E (continued).

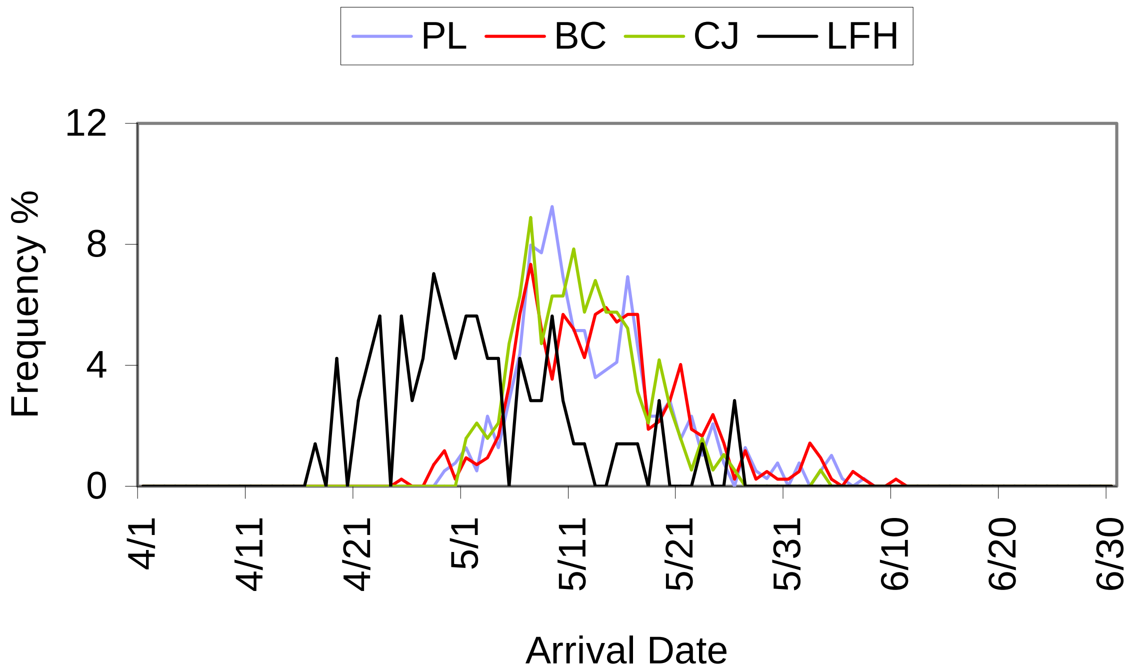


Figure E.27.—All obs arrival date frequency distribution of FCAP and LFH yearlings at Bonneville Dam in 2000.

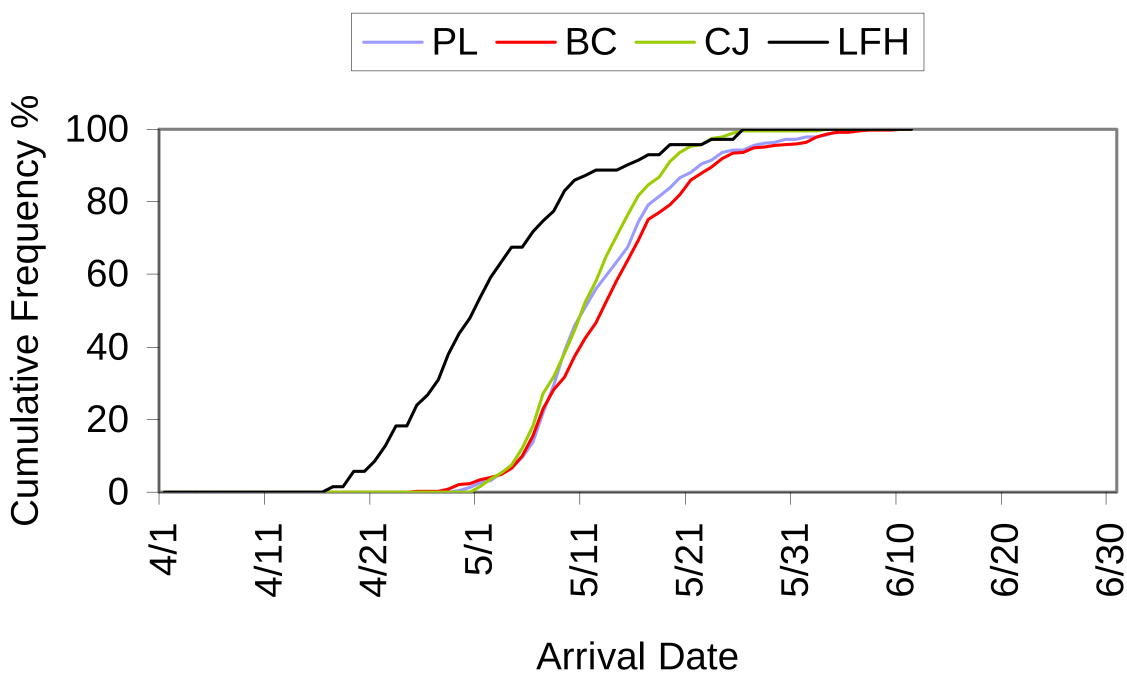


Figure E.28.—All obs arrival date cumulative frequency of FCAP and LFH yearlings at Bonneville Dam in 2000.