BONNEVILLE POWER ADMINISTRATION

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

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MONITORING AND EVALUATION OF YEARLING FALL CHINOOK SALMON RELEASED FROM ACCLIMATION FACILITIES UPSTREAM OF LOWER GRANITE DAM

ANNUAL REPORT 1998

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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 (Snake River stock) yearling fall chinook salmon 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 1998. The three fall chinook acclimation facilities are operated by the Nez Perce Tribe and located at Pittsburg Landing and Captain John Rapids on the Snake River and at Big Canyon Creek on the Clearwater River. Yearlings at the Big Canyon facility consisted of two size classes that are referred to in this report as 9.5 fish per pound (fpp) and 30 fpp. The Big Canyon 9.5 fpp were comparable to the yearlings at Pittsburg Landing, Captain John Rapids and Lyons Ferry Hatchery.

A total of 9,942 yearlings were PIT tagged and released at Pittsburg Landing. PIT tagged yearlings had a mean fork length of 159.9 mm and mean condition factor of 1.19. Of the 9,942 PIT tagged fish released, a total of 6,836 unique tags were detected at mainstem Snake and Columbia River dams (Lower Granite, Little Goose, Lower Monumental and McNary).

A total of 4,926 9.5 fpp and 2,532 30 fpp yearlings were PIT tagged and released at Big Canyon. PIT tagged 9.5 fpp yearlings had a mean fork length of 156.9 mm and mean condition factor of 1.13. PIT tagged 30 fpp yearlings had a mean fork length of 113.1 mm and mean condition factor of 1.18. Of the 4,926 PIT tagged 9.5 fpp yearlings released, a total of 3,042 unique tags were detected at mainstem Snake and Columbia River dams. Of the 2,532 PIT tagged 30 fpp yearlings released, a total of 1,130 unique tags were detected at mainstem Snake and Columbia River dams.

A total of 1,253 yearlings were PIT tagged and released at Captain John Rapids. PIT tagged yearlings had a mean fork length of 147.5 mm and mean condition factor of 1.09. Of the 1,253 PIT tagged fish released, a total of 719 unique tags were detected at mainstem Snake and Columbia River dams.

A total of 2,420 yearlings were PIT tagged and released at Lyons Ferry Hatchery. PIT tagged yearlings had a mean fork length of 159.0 mm and mean condition factor of 1.10. Of the 2,420 PIT tagged fish released, a total of 979 unique tags were detected at mainstem Snake and Columbia River dams (Lower Monumental and McNary).

Median travel times, based on all detections, of PIT tagged fish released from Pittsburg Landing were 10.5 days to Lower Granite Dam, 21.7 days to McNary Dam and 29.8 days to Bonneville Dam. Median migration rates were 16.4 rkm/d to Lower Granite Dam, 18.3 rkm/d to McNary Dam and 18.9 rkm/d to Bonneville Dam. The median arrival dates were April 25 at Lower Granite Dam, May 6 at McNary Dam and May 14 at Bonneville Dam. The 90% passage dates were May 5 at Lower Granite Dam, May 20 at McNary Dam and May 25 at Bonneville Dam.

Median travel times, based on all detections, of PIT tagged 9.5 fpp yearlings released from Big Canyon were 13.3 days to Lower Granite Dam, 26.0 days to McNary Dam and 30.8 days to Bonneville Dam. Median migration rates were 13.0 rkm/d to Lower Granite Dam, 15.3 rkm/d to

McNary Dam and 18.3 rkm/d to Bonneville Dam. The median arrival dates were April 27 at Lower Granite Dam, May 11 at McNary Dam and May 15 at Bonneville Dam. The 90% passage dates were May 9 at Lower Granite Dam, May 24 at McNary Dam and May 25 at Bonneville Dam.

Median travel times, based on all detections, of PIT tagged 30 fpp yearlings released from Big Canyon were 20.8 days to Lower Granite Dam, 37.6 days to McNary Dam and 43.5 days to Bonneville Dam. Median migration rates were 8.3 rkm/d to Lower Granite Dam, 10.6 rkm/d to McNary Dam and 12.9 rkm/d to Bonneville Dam. The median arrival dates were May 5 at Lower Granite Dam, May 23 at McNary Dam and May 28 at Bonneville Dam. The 90% passage dates were May 22 at Lower Granite Dam, May 31 at McNary Dam and June 5 at Bonneville Dam.

Median arrival dates, based on all detections, of PIT tagged yearlings released from Captain John Rapids were April 26 at Lower Granite Dam, May 8 at McNary Dam and May 14 at Bonneville Dam. The 90% passage dates were May 8 at Lower Granite Dam, May 23 at McNary Dam and May 26 at Bonneville Dam.

Median travel times, based on all detections, of PIT tagged fish released from Lyons Ferry Hatchery were 16.9 days to Lower Monumental Dam, 20.9 days to McNary Dam and 30.3 days to Bonneville Dam. Median migration rates were 1.7 rkm/d to Lower Monumental Dam, 7.0 rkm/d to McNary Dam and 12.6 rkm/d to Bonneville Dam. The median arrival dates were April 27 at Lower Monumental Dam, May 1 at McNary Dam and May 8 at Bonneville Dam. The 90% passage dates were May 13 at Lower Monumental Dam, May 16 at McNary Dam and May 24 at Bonneville Dam.

Estimated survival (Survival Under Proportional Hazards Model) of PIT tagged yearlings from Pittsburg Landing was 88.6% to Lower Granite Dam and 55.7% to McNary Dam. Estimated survival of PIT tagged 9.5 fpp yearlings from Big Canyon was 84.7% to Lower Granite Dam and 51.7% to McNary Dam. Estimated survival of PIT tagged 30 fpp yearlings from Big Canyon was 62.2% to Lower Granite Dam and 25.2% to McNary Dam. Estimated survival of PIT tagged yearlings from Captain John Rapids was 77.0% to Lower Granite Dam and 50.5% to McNary Dam. Estimated survival of PIT tagged yearlings from Lyons Ferry Hatchery to Lower Monumental Dam was 93.7% to Lower Monumental Dam and 81.9% to McNary Dam.

A total of 3,911 adult fall chinook salmon returned to Lower Granite Dam in 1998. Of these, 28.5% consisted of fish that were released as yearlings from the FCAP facilities.

ACKNOWLEDGEMENTS

We would like to thank the Bonneville Power Administration for the funding and administrative support, particularly Deborah Docherty our Contracting Officer's Technical Representative, to make this project possible. The Nez Perce Tribe also extended administrative support necessary to carry out this project.

We would like to thank the staff and crew at the U.S. Geological Survey – Biological Resources Division for collecting and providing yearling radio telemetry data from Lower Granite Dam.

Additional thanks go to our colleagues at the Washington Department of Fish and Wildlife – Snake River Laboratory and the U.S. Fish and Wildlife Service – Idaho Fishery Resource Office for their cooperation and assistance.

We would like to extend our appreciation to the following employees of the Nez Perce Tribe who assisted in the field to make this project successful: Bill Arnsberg, Scott Kellar, Mark Pishl and Sean Cross.

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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 resulted in extirpation of chinook salmon from the Clearwater River subbasin 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 and declined to an average of 29,000 adults from 1950-1959 (Bjornn and Horner 1980). Even as late as 1968, fall chinook 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 counts decreased to an average of 600 fish between 1975 and 1980. Natural fall chinook returns fell to a record low of 78 in 1990 increasing to 318 in 1991, 533 in 1992 (WDF 1993), and 742 in 1993 (WDF 1994). Counts decreased again in 1994 and 1995 to 406 and 350, respectively. Since 1995 there has been an upward trend in the number of fall chinook adults counted at Lower Granite Dam. The National Marine Fisheries Service (NMFS) listed Snake River fall 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, the Columbia River Inter-Tribal Fish Commission reached an agreement with state and federal agencies to release yearling fall chinook salmon beginning in 1996 as replacement of lost production from adults trapped at Lower Granite Dam (LGR) and taken back to the hatchery. The agreement stipulated the release of 450,000 yearlings annually on-station from Lyons Ferry Hatchery (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 3 facilities along the Snake and Clearwater Rivers to acclimate yearling release groups with the intent of effectively enhancing population size and distributing natural fall chinook 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 U.S. Fish and Wildlife Service (USFWS) and Washington Department of Fish and Wildlife (WDFW), conducted monitoring and evaluation studies on yearling fall chinook salmon that were acclimated and released from the FCAP facilities and Lyons Ferry Hatchery in 1998. This was the third 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 number and composition of yearlings at the FCAP facilities was atypical in 1998. Shipments of yearlings to all three FCAP facilities were short of the 150,000 fish quota, particularly so at Big Canyon. The Big Canyon yearlings also consisted of two size classes, which will be referred to in this report as 9.5 fish per pound (fpp) and 30 fpp. The Big Canyon 9.5 fpp yearlings were comparable in size to the yearlings at Pittsburg Landing and Captain John Rapids. Yearlings were released from Pittsburg Landing and Big Canyon from April 13-16, Captain John Rapids from April 9-16 and Lyons Ferry Hatchery from April 3-16.

The role of this project in the fall chinook supplementation program is to monitor and evaluate yearling fall chinook pre- and post-release from the FCAP facilities. We primarily monitor yearling size, condition, and post-release emigration characteristics through passive integrated transponder (PIT) tagging. In this report, we present a summary of the activities and data collection in 1998. We are also in the second year of a radio telemetry study to monitor post-release juvenile movement patterns. In addition, we assist the USFWS in monitoring adult fall chinook migration and spawning distribution, which is conducted and reported by the USFWS under BPA Project number 199801003. For a detailed discussion of monitoring and evaluation activities, procedures and analyses for on-station yearling fall chinook releases from Lyons Ferry Hatchery in 1998 please reference Wargo et al. (1999).

PROJECT OBJECTIVES

The objectives of this project are to monitor and evaluate pre-release fish health, condition and mark retention as well as post-release movement patterns, migration timing, travel times, juvenile emigration survival and adult returns of fall chinook salmon from supplementation (acclimated releases) of Snake River stock yearling fall chinook from Lyons Ferry Hatchery. Yearling post-release movement patterns are being examined through a multi-year radio telemetry study, the results of which will be reported in a separate comprehensive report upon conclusion of the study.

METHODS

Study Area Description

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). Our study area continues downstream from the FCAP acclimation facilities to Bonneville Dam (rkm 234) on the Columbia River.

Fish Handling and Anesthetization

Yearlings at Pittsburg Landing and Big Canyon were acclimated in 16 tanks (6 m diameter). Pittsburg Landing releases occurred over four consecutive days while Big Canyon releases occurred on two days. Yearlings at Captain John Rapids were acclimated in a single earthen pond and released volitionally with any fish remaining by the final release date forced out by draining the pond. Yearlings from Lyons Ferry Hatchery were also released volitionally. 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/cgi-bin/ws.exe/websql.dir/FW/PUBLICATIONS/QueryPublications.pl

Fish sampled for PIT tagging at Pittsburg Landing and Big Canyon were captured from acclimation tanks with dip nets. A screen was used to crowd fish in the tanks to improve capture efficiency. PIT tagging at Pittsburg Landing and Big Canyon took place one week prior to release. Fish for PIT tagging at Lyons Ferry Hatchery were captured as they were leaving the facility, tagged, allowed to recover and released into the exit flume to the river. For a detailed description of fall chinook salmon broodstock collection, incubation, rearing, and marking procedures at Lyons Ferry Hatchery please reference Wargo et al. (1999). At the request of WDFW for comparison purposes with Lyons Ferry Hatchery, fish at Captain John Rapids were captured for PIT tagging from an exit flume while actively leaving the facility using dip nets and released back into the exit flume after recovering from the tagging process. We found this method to be ineffective at the Captain John Rapids facility and moved to capture fish directly from the pond using cast nets. Fish captured for PIT tagging were anesthetized in an MS-222 bath consisting of 3 ml stock solution (100 g/L) per 19 L of water buffered with sodium bicarbonate solution.

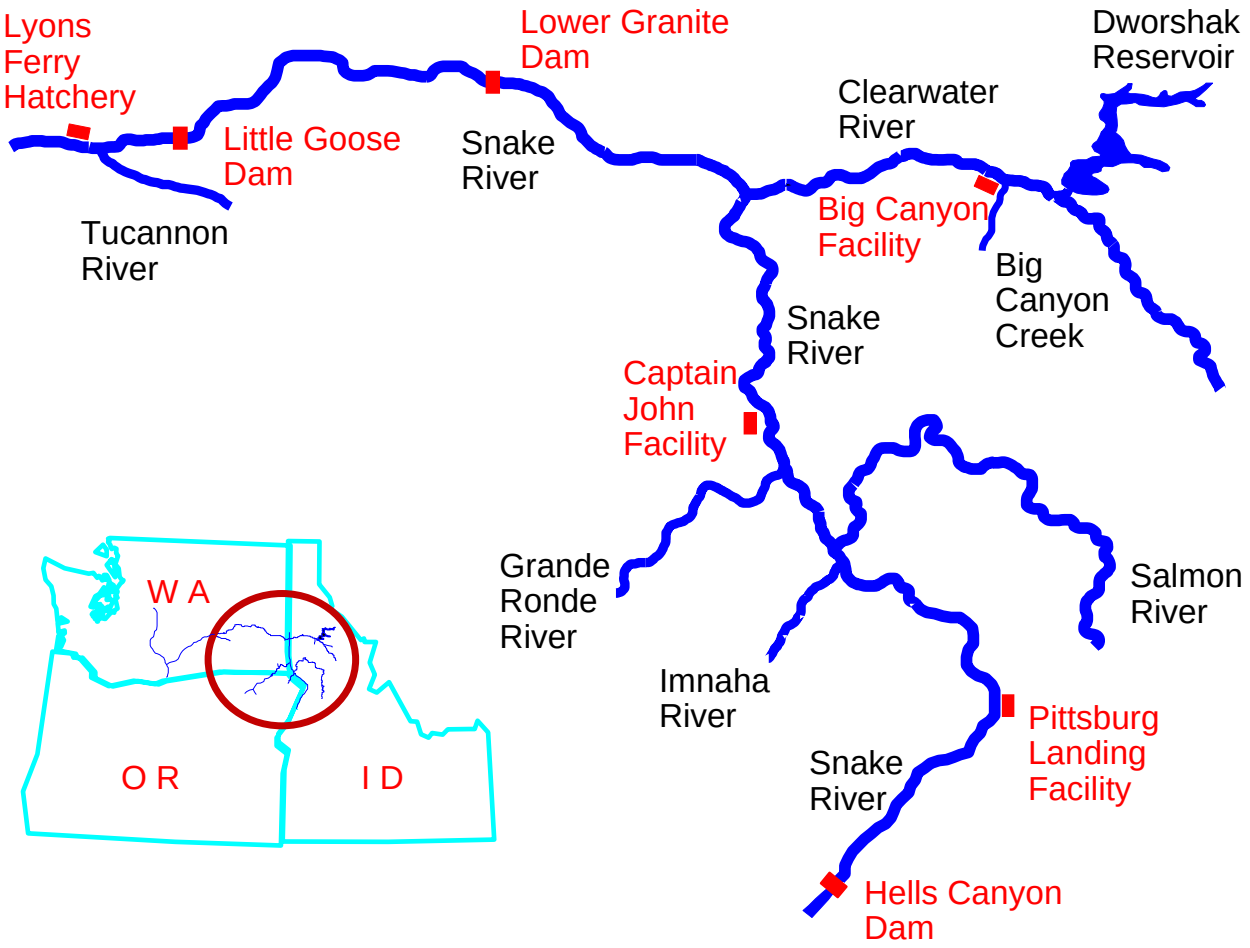

Figure 1. Map of primary study area highlighting FCAP acclimation facilities, Lyons Ferry Hatchery and Lower Granite and Little Goose Dams.

Fish Health

To monitor fish health, USFWS personnel from the Idaho Fish Health Center sampled yearlings at Lyons Ferry Hatchery and the FCAP facilities 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 Field Health Index (QHAI), which converts the index values into one number for each individual fish, with zero being the best possible value (Adams et al. 1993). The overall QHAI for a group is the mean 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 the U.S. Fish and Wildlife Service National Wild Fish Health Survey Laboratory Procedure Manual (True 2000) to determine the level of Bacterial Kidney Disease (BKD) 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).

Flow and Temperature

River 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 and river temperature data for these sites (except for Hell's Canyon Dam where a continuous temperature is not monitored) was 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 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.

PIT Tagging

PIT tagging goals for the Pittsburg Landing and Big Canyon acclimation facilities were 2,500 yearlings for each of four release groups at each facility. 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 several distinct groups. NPT personnel, assisted by WDFW personnel, conducted tagging activities at Big Canyon and Captain John Rapids. USFWS personnel from the Dworshak Fishery Resource Office conducted tagging operations at Pittsburg Landing.

All fish selected for PIT tagging were examined for existing PIT tags and general condition prior to tagging. A subsample was also examined for presence of coded wire tag (CWT) prior to PIT tagging. The fish were then PIT tagged, measured, examined for general condition and a subsample was 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). Fish were PIT tagged 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 scale during PIT tagging operations prior to release. Weights were collected to the nearest 0.1 g using an Ohaus FY-3000 balance. Condition factor was calculated using Fulton's condition factor (Bagenal and Tesch 1978):

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

Mark Retention

All yearlings at the FCAP facilities and Lyons Ferry Hatchery were marked with CWT, AD clips and VIE tags by WDFW personnel. FCAP yearlings were marked prior to transfer from Lyons Ferry Hatchery. 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 green a 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 Lyons Ferry Hatchery.

We sampled for CWTs using a Northwest Marine Technologies Field Sampling Detector model FSD-I. We visually determined retention of AD clips and VIE tags.

PIT Tag Observation

There are five main PIT tag observation locations in the study area, Lower Granite (LGR), Little Goose (LGO), Lower Monumental (LMO), McNary (MCN) and Bonneville (BON) Dams. John Day Dam is not a main site although PIT tag observation data was collected there. And although Bonneville Dam was listed as a main observation site, it was not functioning effectively as a main observation site for the purposes of first observation data (Dave Marvin, Pacific States Marine Fisheries Commission, personal communication). Accordingly, we excluded observation data at John Day and Bonneville Dams from first observation analysis.

PIT tag observation data was downloaded from the PTAGIS database. Arrival timing, cumulative observations, survival estimates, travel times, and migration rates to Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville Dams were calculated from this data. Travel times and migration rates are not reported for fish released from Captain John Rapids due to the volitional release strategy employed there and the resulting inability to accurately identify the precise date and time a given fish left the facility. Although yearlings from Lyons Ferry Hatchery were also released volitionally, they were captured during exit from the facility, PIT tagged and released to the river. As a result, precise release times are known for these fish, unlike those from Captain John Rapids. Fish with single coil detections or negative travel times were removed from analyses where applicable.

Cumulative observation counts and rates, travel times, migration rates and arrival timing were compiled using two methods. PIT tag observations were analyzed by first detection only of individual fish regardless of location (referred to as first detections) and by detections of individual fish at each dam (referred to as all detections). There are advantages to both methods. Under the first detections 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. This method excludes fish that pass a given dam through the collection and bypass facility from analysis at any other downstream dams where it may be observed thereby 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. Using the first detections method, data collected at each dam is essentially being

recorded for completely different groups of fish with no single fish being recorded at more than one dam. Under the all detections method a fish that is detected at multiple dams will be included in the observation record at each dam where it is detected. By including all fish observed at each dam, this method provides a different level of comparability because the observation data at one dam includes some of the same fish as observation data from other dams. Using all detections in such analyses also provides a more comprehensive assessment of the overall release group because it includes all dam passage routes including the collection and bypass facilities.

Non-PIT tagged fish that enter the collection and bypass facilities of dams are typically loaded to barges rather than diverted back to the river. Consequently, the all detections method should not be considered representative of travel times, migration rates and arrival dates for non-PIT tagged fish to dams further downstream. However, it is useful in estimating the effect on timing of passage through the collection and bypass facility for fish that are diverted back to the river. It is important to note that, by definition, all observations at Lower Granite Dam are first detections and therefore all analyses for fish detected at Lower Granite Dam using either method will provide identical results. This also applies to observations of fish from Lyons Ferry Hatchery at Lower Monumental Dam.

The primary differences in river reaches between PIT tag observation sites are the river characteristics and distance 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 10 rkm, respectively. The reaches from Lower Monumental Dam to McNary Dam and John Day Dam to Bonneville Dam include two reservoirs between observation sites, which should be kept in mind when considering analyses for these reaches. All dams equipped with juvenile observation facilities have only one monitoring location except Bonneville Dam, which has three primary monitoring locations.

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 Using Proportional Hazards (SURPH) computer modeling program (Lady et al. 2002) as described in Statistical Survival Analysis of Fish and Wildlife Tagging Studies (Smith et. al. 1994).

Adult Returns

Fish passage numbers for fall chinook adults and jacks at Lower Granite Dam were downloaded from the Fish Passage Center website at www.fpc.org. Data for FCAP adult returns to Lower Granite Dam and Lyons Ferry Hatchery were provided by WDFW. Numbers of FCAP adult returns include fish passed above Lower Granite Dam, collected at Lower Granite Dam then hauled back to Lyons Ferry and volunteers directly into Lyons Ferry. We acknowledge that it is inconsistent to include FCAP volunteers to Lyons Ferry in with the FCAP component of the total return to Lower Granite Dam, however, these fish are few in number and were not broken out in the run reconstruction; therefore the impact to the results we present here is minimal.

Table 1. Important sites within the study area and associated river kilometer.

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

RESULTS AND DISCUSSION

The size composition of the overall Big Canyon yearling group was atypical in 1998. Not only was the release group exceptionally low in numbers, the yearlings consisted of two size classes. One group was about 9.5 fpp and comparable to the yearlings released from Pittsburg Landing, Captain John Rapids and Lyons Ferry Hatchery. The other group consisted of yearlings that were considerably smaller in size, about 30 fpp. Due to the size difference, each group from Big Canyon was analyzed and discussed as a distinct group. All three FCAP facilities were short of the 150,000 yearling release quotas in 1998. A total of 141,814 yearlings were released April 13-16 from Pittsburg Landing, 42,707 of 9.5 fpp and 18,465 of 30 fpp (61,172 total) April 13 and 16 from Big Canyon, 133,205 April 9-16 from Captain John Rapids and 418,992 April 3-16 from Lyons Ferry Hatchery in 1998.

The FCAP project experienced a problem at the Big Canyon acclimation facility in 1998 that resulted in on-site mortality of about 4,295 of the 9.5 fpp of yearlings. On March 13 the water supply pumps shut down during the night. As there was no alarm system in place at the time, the problem went unnoticed for several hours and resulted in depletion of dissolved oxygen levels in one tank. This incident occurred shortly after transfer to the facility and we did not PIT tag fish out of the affected tank, but this incident may have compromised the long-term survivability of the yearlings from that tank.

In 1998 we also conducted the second year of our radio telemetry study on yearlings released from the FCAP facilities. As this is a short-term study intended to last 5 years, in this report we are only describing the general activities we performed in 1998. A comprehensive report

detailing activities and results for the entire study will be submitted upon completion of the study.

In 1998 we radio tagged and released a total of 150 yearling fall chinook salmon from the FCAP facilities (50 yearlings 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 (at Pittsburg and Big Canyon) for capture. The yearlings were radio tagged one day prior to release at the Pittsburg Landing and Big Canyon facilities. Yearlings at Captain John Rapids were captured from the exit flume as they were leaving the facility, tagged, and allowed to recover in tubs before being released back into the exit flume to the river. Only yearlings of the 9.5 fpp size class at Big Canyon were outfitted with radio tags.

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 the memory capability of the receivers was not over capacity. We also tracked radio tagged yearlings by fixed-wing aircraft and boat. We conducted 8 fixed-wing aircraft tracking flights ranging in distance from the FCAP facilities downstream as far as McNary Dam. We tracked by boat for 6 days on Lower Granite Reservoir and 7 days on Little Goose Reservoir.

Fish Health

USFWS personnel from the Idaho Fish Health Center collected yearlings at the FCAP facilities and Lyons Ferry Hatchery from April 6-9, 1998 for health analysis. Table 2 summarizes the QHAI and ELISA results for all groups during pre-release exam. Both Lyons Ferry and Big Canyon have higher QHAI's than the other two groups, due primarily to abnormalities in the spleen, kidney, and liver, which are consistent with infection by *Renibacterium salmoninarum*, the causative agent of Bacterial Kidney Disease (BKD).

Overall, based on ELISA values, 1998 can be considered a year of medium to high levels of BKD in yearling fall chinook salmon from Lyons Ferry Hatchery. Overall BKD levels appeared to increase after transport from Lyons Ferry Hatchery to the FCAP facilities. Yearlings at Pittsburg Landing exhibited slightly lower levels of BKD than did yearlings from the other FCAP facilities, reasons for which are not known. No other pathogenic agents were found on the fish during acclimation.

Table 2. Quantitative Field Health Index mean values and individual ELISA levels for yearlings pre-release at the FCAP facilities and Lyons Ferry Hatchery in 1998.

Release Group	Mean QHAI	ELISA			
		Not Detected	Low	Medium	High
Pittsburg Landing	11.3	0	7	42	11
Big Canyon - 9.5 fpp	25.7	0	2	32	25
Captain John Rapids	10.7	0	3	40	17
Lyons Ferry Hatchery	31.5	2	21	19	18

Flow and Temperature

The daily average discharge in the Snake River near Hell's Canyon Dam from May through July was higher than the 37-year average from 1965 to 2002. Flows peaked at 93,400 cfs on May 27 and 29. Flows began to increase rapidly on May 11 rising from 31,800 cfs on May 10 to 93,400 cfs by May 27 (Figure 2). Flows at this location are exclusively affected by operations at the Hell's Canyon complex of dams.

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 from May through July were higher than the 43-year average from 1958 to 2001, peaking at 166,000 cfs on May 27 (Figure 3). However, the flow at Anatone began to rise on April 23, almost 3 weeks earlier than at Hell's Canyon Dam. This was due to the increased flows of the three major tributaries. At both Hell's Canyon Dam and Anatone peak flows in 1998 were more than twice the average historical peak flows at each respective location.

The average daily discharge in the Clearwater River at Peck was lower than the 38-year average from 1964 to 2002 for almost all of 1998 (Figure 4). Discharge peaked at 48,700 cfs on May 27. Flows in the Clearwater displayed something of a double-crest with the first crest on May 8 followed by a dip and rising again to the highest level on May 27. The higher than normal flows seen at Peck from July 10 through August 23 are due to water releases from Dworshak Reservoir on the North Fork Clearwater River.

The high flows in the Snake River upstream of the Clearwater confluence occurred after the yearlings from the FCAP facilities had left the free-flowing reach of the Snake River as 90% arrival dates of yearlings from Pittsburg Landing and Captain John Rapids to Lower Granite Dam were May 5 and 8, respectively (Figures 2 and 3). In contrast, flows in the Clearwater River at Peck increased rapidly within days of the yearling releases from Big Canyon cresting on May 8. The 9.5 fpp group from Big Canyon moved to Lower Granite Dam in conjunction with these rising flows (Figure 4).

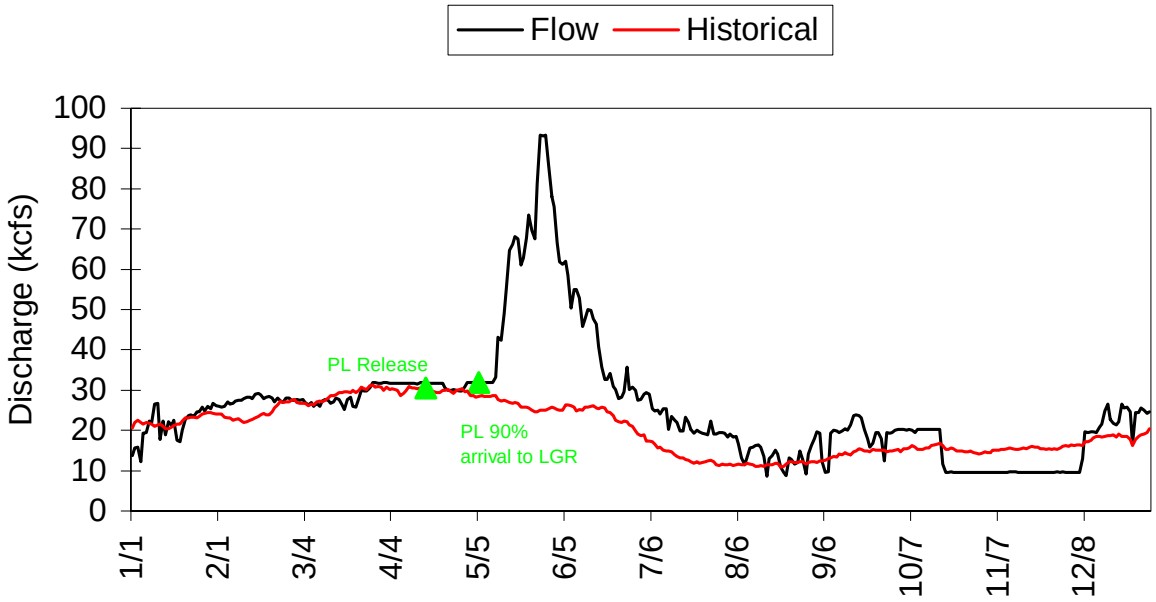

Figure 2. Mean daily flow in 1998 and historical mean flow from 1965-2002 for the Snake River as measured at USGS gauge 13290450 at Hell's Canyon Dam.

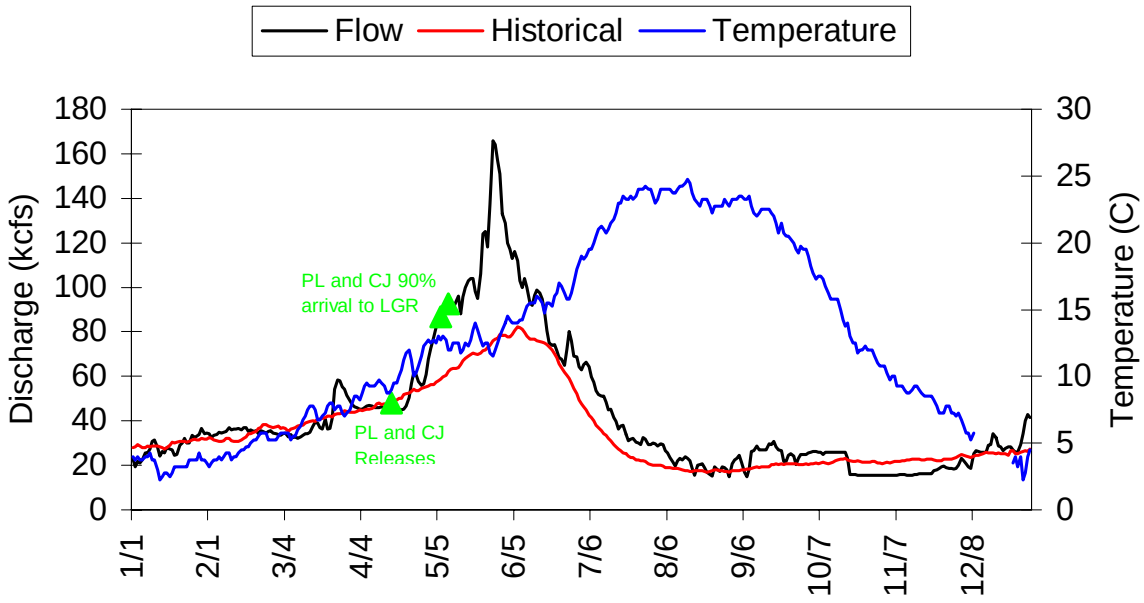

Figure 3. Mean daily flow and temperature in 1998 and historical mean flow from 1958-2001 for the Snake River as measured at USGS gauge 13334300 near Anatone, Washington.

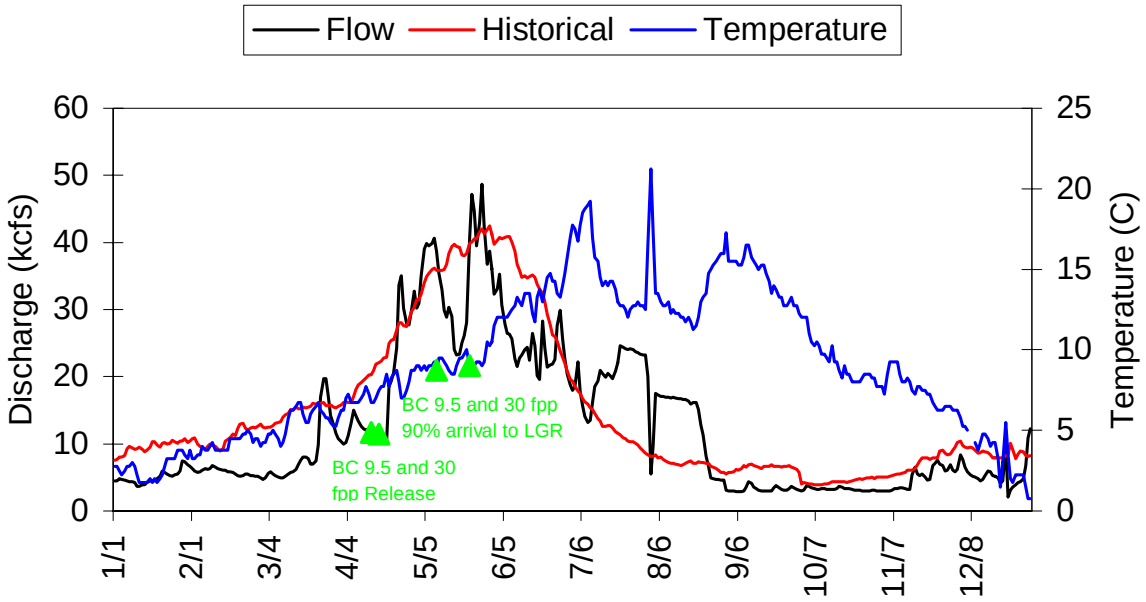

Figure 4. Mean daily flow and temperature in 1998 and historical mean flow from 1964-2002 for the Clearwater River as measured at USGS gauge 13341050 near Peck, Idaho.

Average daily outflows as measured in the tailrace at Lower Granite Dam began increasing with spring runoff from 44.4 kcfs on March 22 peaking at 213.3 kcfs on May 27 (Figure 5). The main period of spill was from April 6 through June 20 with daily spill averaging 34.8 kcfs and peaking at 109.4 kcfs on May 27. Yearlings from the FCAP sites achieved 90% arrival to Lower Granite Dam a few weeks prior to the peak flows at the dam (Figure 5).

Average daily outflows as measured in the tailrace at McNary Dam began increasing with spring runoff from 129.3 kcfs on April 18 peaking at 413.3 kcfs on May 30 (Figure 6). The main period of spill was from April 20 through June 30 with daily spill averaging 102.1 kcfs and peaking at 251.0 kcfs on May 29. Yearlings from the FCAP sites achieved 90% arrival to McNary Dam about one week prior to peak flows at the dam (Figure 6).

Overall, flow patterns do not appear to greatly affect migration timing of yearling fall chinook released from the FCAP facilities as arrival dates to dams are similar for yearlings from each location. The fish appear to be well into the smoltification process and ready to migrate immediately upon release from the FCAP facilities. We currently do not have enough years of data to determine if overall flow levels during a given year affect migration rates and timing. These analyses will be reported as the required data are gathered in future years.

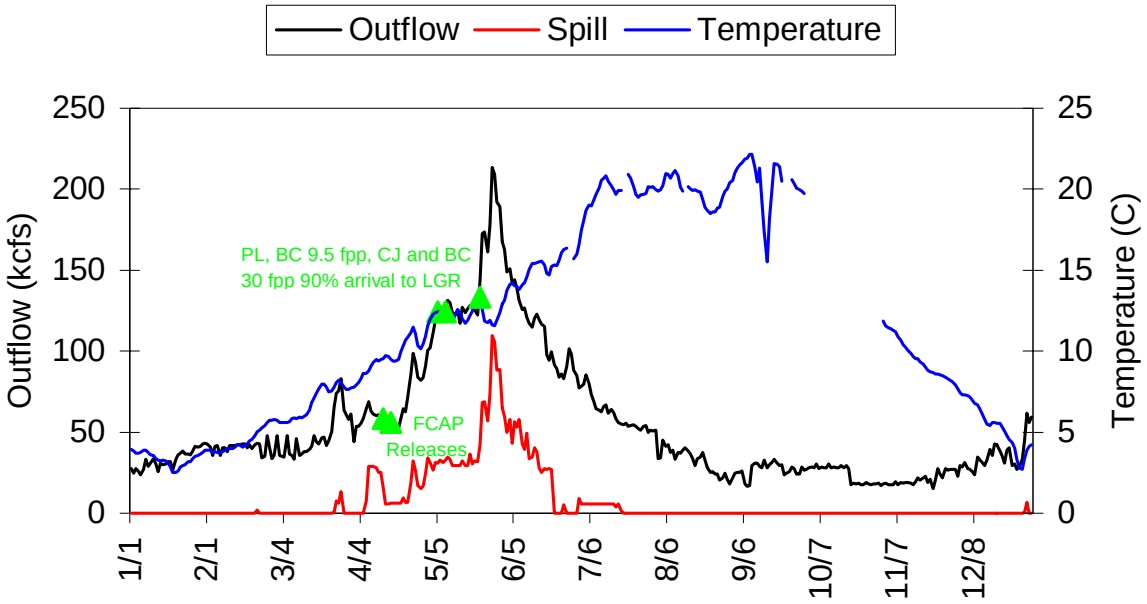

Figure 5. Mean daily flow, spill, and temperature for the Snake River in 1998 as measured by the USACE at Lower Granite Dam.

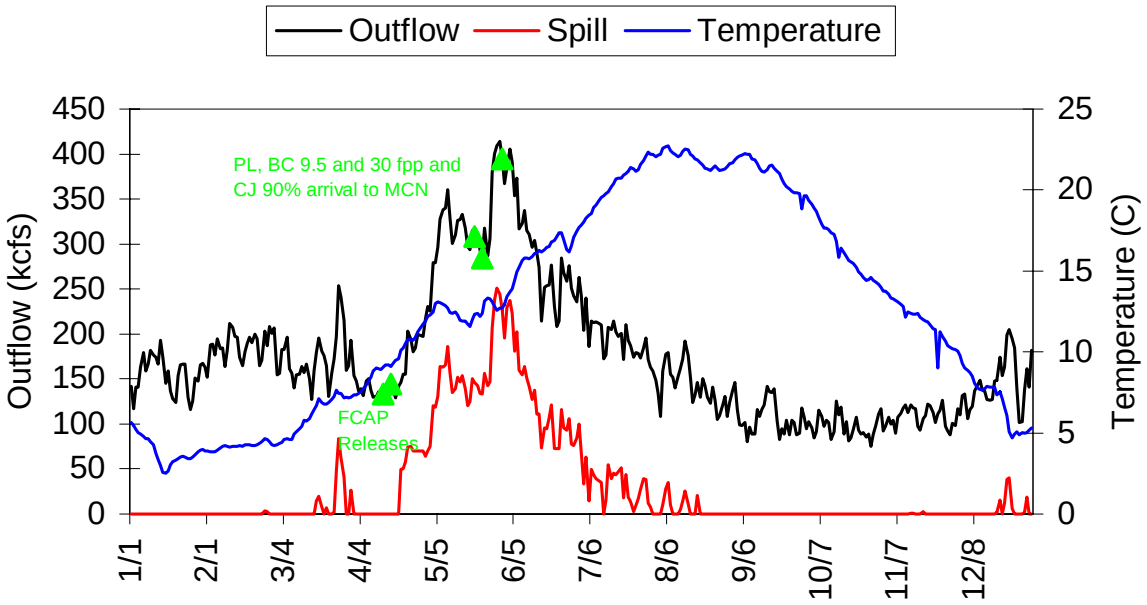

Figure 6. Mean daily flow, spill, and temperature for the Columbia River in 1998 as measured by the USACE at McNary Dam.

PIT Tagging

A total of 9,942 yearling fall chinook were PIT tagged and released from the Pittsburg Landing facility. The fish were released in four groups, one group per day for four days (Table 3). The Big Canyon facility released a total of 7,458 PIT tagged fish on two days, April 13 and 16. A total of 4,926 9.5 fpp and 2,532 30 fpp yearlings were PIT tagged and released from Big Canyon. A total of 1,253 yearlings were PIT tagged and released at the Captain John Rapids Facility and 2,420 were PIT tagged and released from Lyons Ferry Hatchery (Table 3).

Table 3. Number of yearling fall chinook PIT tagged and released from the FCAP facilities and Lyons Ferry Hatchery in 1998.

Release Group	Date Tagged	Number Tagged	Date Released
Pittsburg Landing	4/6	2,469	4/13
	4/7	2,479	4/14
	4/8	2,467	4/15
	4/9	2,527	4/16
	Total	9,942	
Big Canyon - 9.5 fpp	4/7	2,459	4/13
	4/8	2,467	4/16
	Total	4,926	
Big Canyon - 30 fpp	4/7	1,283	4/13
	4/8	1,249	4/16
	Total	2,532	
Captain John Rapids	4/6	98	4/9-16
	4/13	152	
	4/15	503	
	4/15	500	
	Total	1,253	
Lyons Ferry Hatchery	4/6	4/21	4/3-16
	4/14	4/27	
	Total	2,420	

Biological Characteristics

Mean fork lengths of PIT tagged yearlings at Pittsburg Landing, Big Canyon 9.5 fpp and Lyons Ferry were 159.9, 156.9 and 159.0 mm respectively, which were somewhat larger than the 147.5 mm average for the fish at Captain John Rapids. The Big Canyon 30 fpp fish were considerably smaller than all other yearling groups, averaging 113.1 mm fork length (Table 4). The mean condition factor of 1.19 for Pittsburg Landing yearlings was higher than all groups except the Big Canyon 30 fpp group, which was 1.18. Mean condition factor was 1.13 for Big Canyon 9.5 fpp fish, 1.09 for Captain John Rapids and 1.10 for Lyons Ferry Hatchery (Table 4).

Fork length frequency distributions of PIT tagged fish at Pittsburg Landing, Big Canyon 9.5 fpp and Lyons Ferry Hatchery were similar to each other, but dissimilar to the length distribution of the fish from Captain John Rapids (Figure 7). The length distribution of fish from Captain John Rapids differs from those at Pittsburg Landing and Big Canyon 9.5 fpp by having a heavier left tail, indicating a higher proportion of smaller fish, rather than having a similar distribution, which would indicate simply a smaller average fork length (as seen with the Big Canyon 30 fpp fish).

Table 4. Fork length, weight and condition factor of yearling fall chinook salmon PIT tagged and released from the FCAP facilities and Lyons Ferry Hatchery in 1998.

Release Group	Variable	Number Sampled	Mean	Standard Deviation	95% C.I. (+/- mean)	Median	Range
Pittsburg Landing	Fork Length (mm)	9,942	159.9	18.8	0.4	162	84 - 344
	Weight (g)	992	46.1	14.7	0.9	47.3	6.7 - 89.4
	Condition Factor	992	1.19	0.15	0.01	1.19	0.12 - 1.96
Big Canyon - 9.5 fpp	Fork Length (mm)	4,914	156.9	21.0	0.6	161	84 - 210
	Weight (g)	585	47.9	16.8	1.4	48.7	6.0 - 112.6
	Condition Factor	585	1.13	0.09	0.01	1.14	0.87 - 1.33
Big Canyon - 30 fpp	Fork Length (mm)	2,528	113.1	16.6	0.6	113	69 - 190
	Weight (g)	237	15.5	6.6	0.8	14.6	4.5 - 51.2
	Condition Factor	237	1.18	0.12	0.02	1.19	0.82 - 1.70
Captain John Rapids	Fork Length (mm)	1,252	147.5	25.3	1.4	152	74 - 213
	Weight (g)	490	34.2	16.8	1.5	34.2	5.0 - 83.2
	Condition Factor	490	1.09	0.08	0.01	1.09	0.65 - 1.32
Lyons Ferry Hatchery	Fork Length (mm)	2,420	159.0	15.2	0.6	159	113 - 298
	Weight (g)	567	44.8	12.1	1.0	43.5	15.4 - 100.8
	Condition Factor	567	1.10	0.06	0.01	1.09	0.91 - 1.39

The development of a difference in fork length distribution during acclimation was possible for several reasons. 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 or feed distribution technique 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 Lyons Ferry Hatchery. Differences in water temperature could account for the differences in growth rate as well; however this should not cause a change in the length frequency 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 one week prior to release so all the fish were available for the possibility of capture. At Captain John Rapids, the fish were released volitionally and captured from the pond using a cast net after the release had begun. Sampling occurred after the volitional release had begun because of the request by WDFW to sample from the exit flume. The only way all fish would be available for capture is if the flume were monitored and sampled 24 hours a day. As we found this to be ineffective, we decided to capture fish directly from the pond using a cast net. If differences in "desire" to leave the facility exist between fish based on size for any reason or if a block of fish leaves unsampled, then a sampling bias may have occurred. As this is the first year of operations for the Captain John Rapids facility, there is no way to compare this situation with previous years. This question will be looked at further in future years. In future years we will only capture fish for PIT tagging directly from the pond prior to the start of the volitional release.

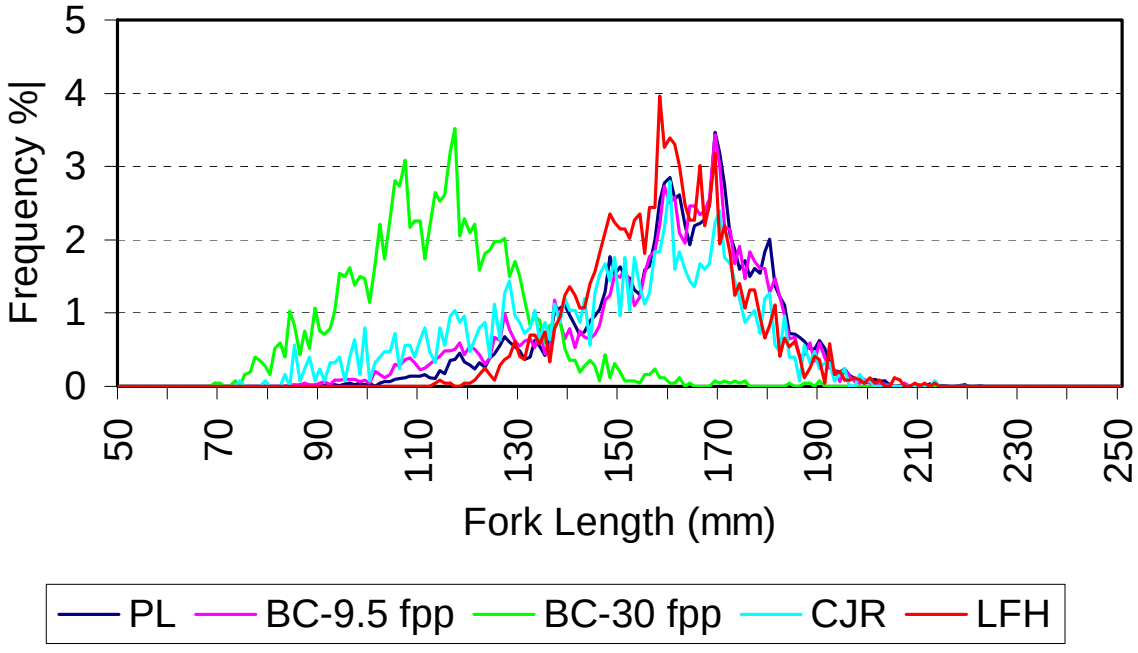

Figure 7. Fork length frequency distributions of yearling fall chinook salmon PIT tagged at the FCAP facilities and Lyons Ferry Hatchery in 1998.

Mark Retention

Coded wire tag retention ranged from 97.1% for yearlings at Captain John Rapids to 99.5% for 30 fpp yearlings from Big Canyon (Table 5). Adipose fin clip retention ranged from 97.0% for Pittsburg Landing yearlings to 99.6% for Big Canyon 30 fpp. Retention of VIE marks was lower and more variable than for adipose fin clips and coded wire tags, ranging from 79.0% at Pittsburg Landing to 90.0% for Big Canyon 30 fpp.

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 Lyons Ferry Hatchery in 1998.

Release Group	Number Sampled	% Retention		
		CWT	AD	VIE
Pittsburg Landing	992	98.9	97.0	79.0
Big Canyon - 9.5 fpp	1,632	98.7	98.7	85.9
Big Canyon - 30 fpp	1,909	99.5	99.6	90.0
Captain John Rapids	519	97.1	99.4	80.2
Lyons Ferry Hatchery	2,420	98.4	99.1	84.3

PIT Tag Observation

PIT tagged yearlings from Pittsburg Landing were observed at Lower Granite Dam at a higher rate than those from Big Canyon or Captain John Rapids (Figure 8). Cumulative observations, based on first detections, at Lower Granite, Little Goose, Lower Monumental and McNary Dams totaled 6,836 for Pittsburg Landing fish, 3,042 for Big Canyon 9.5 fpp, 1,130 for Big Canyon 30 fpp, 719 for Captain John Rapids and 979 for Lyons Ferry Hatchery fish which were 68.8%, 61.8%, 44.6%, 57.4% and 40.5%, respectively, of the total number of PIT tagged fish released from each facility (Table 6). The lower cumulative observation rate for Lyons Ferry yearlings is almost certainly due to the fact that they are released from the hatchery and do not encounter Lower Granite and Little Goose Dams during emigration resulting in reduced opportunity for observation relative to yearlings from the FCAP facilities. The lower observation rates of the Big Canyon 30 fpp fish could result from either a lower survival rate or a disposition to pass dams by routes other than through the bypass and collection facilities, where all PIT tag detection systems are located at the dams.

The total number of PIT tags observed at each dam, by release group, is shown in Table 7. Advantages to using all detections at each dam are that John Day and Bonneville Dams were not properly equipped to serve effectively as main observation sites in 1998, therefore using all detections allows for analysis at those dams. Also, any differences seen in travel times, migration rates and arrival dates between first observation data and all observation data should

be more readily apparent at downstream dams as the proportion of all detections at a dam that are first observations typically decreases at each successive dam downstream. For example, for yearlings from Pittsburg Landing, the percentage of all detections that are first observations is 52.0% at Little Goose Dam, 36.8% at Lower Monumental Dam and 26.9% at McNary Dam. Because John Day and Bonneville Dams were not main observation sites, analyzing data for all detections at those dams allows for such analyses as travel time, migration rate and arrival date which would otherwise not be possible with only first detections.

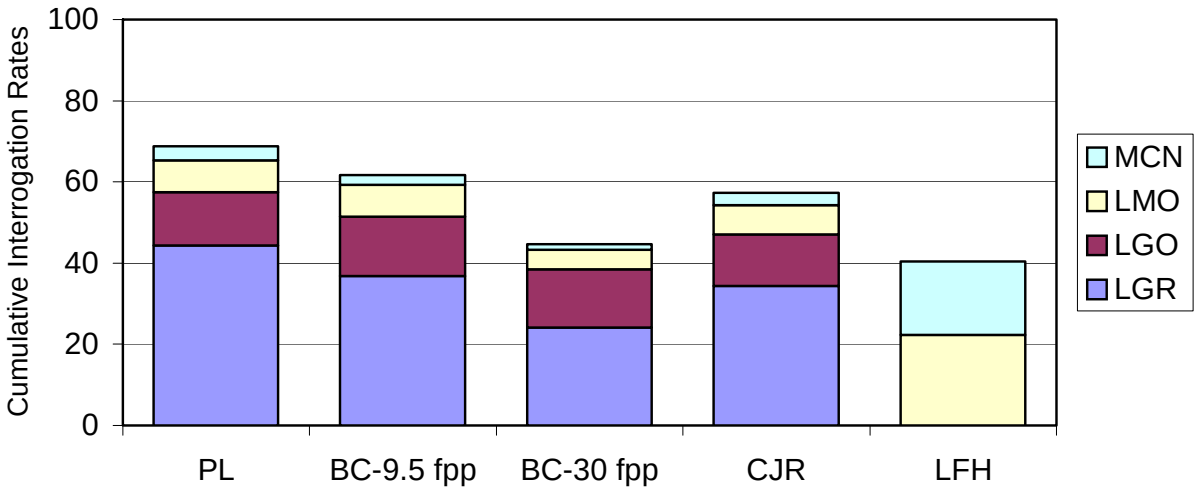

Figure 8. Cumulative observation rates of PIT tagged yearling fall chinook salmon released from the FCAP facilities and Lyons Ferry Hatchery in 1998.

Table 6. Observation rates, based on first detections, of PIT tagged yearling fall chinook salmon released from the FCAP facilities and Lyons Ferry Hatchery at Lower Granite, Little Goose, Lower Monumental and McNary Dams in 1998.

Release Group	LGR	LGO	LMO	MCN	Cumulative Observations	Observation Rate (%)
Pittsburg Landing	4,406	1,303	779	348	6,836	68.8
Big Canyon - 9.5 fpp	1,811	723	383	125	3,042	61.8
Big Canyon - 30 fpp	610	363	122	35	1,130	44.6
Captain John Rapids	431	158	92	38	719	57.4
Lyons Ferry	n/a	n/a	540	439	979	40.5

Table 7. Total observations, based on all detections, of PIT tagged yearling fall chinook salmon released from the FCAP facilities and Lyons Ferry Hatchery at Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville Dams in 1998.

Release Group	LGR	LGO	LMO	MCN	JDA	BON	Total Observations
Pittsburg Landing	4,406	2,508	2,115	1,294	571	405	11,299
Big Canyon - 9.5 fpp	1,811	1,199	999	467	285	155	4,916
Big Canyon - 30 fpp	610	568	366	144	108	20	1,816
Captain John Rapids	431	285	218	128	55	44	1,161
Lyons Ferry	n/a	n/a	541	557	207	118	1,423

Travel Time and Migration Rate

For a study such as this, which compares fish released from and observed at multiple locations, travel time from release to a given point is of limited significance because of differences in distance between release points to a given observation site as well as in distance between observations sites. As would be expected, travel time typically increases from point of release to each successive observation point downstream (Figures 9 and 10). Converting travel time to migration rate is much more meaningful when analyzing groups from release sites with differing distances to one observation site or through reaches with differing distances between observation sites.

Median travel times for yearlings from Pittsburg Landing, Big Canyon and Lyons Ferry, based on first detections and all detections, are shown in Tables 8 and 9, respectively. Travel times based on all detections are typically longer than for those based on first detections, which translates into lower migration rates. This indicates that the collection and bypass facilities delay passage at dams relative to other passage routes such as spillways.

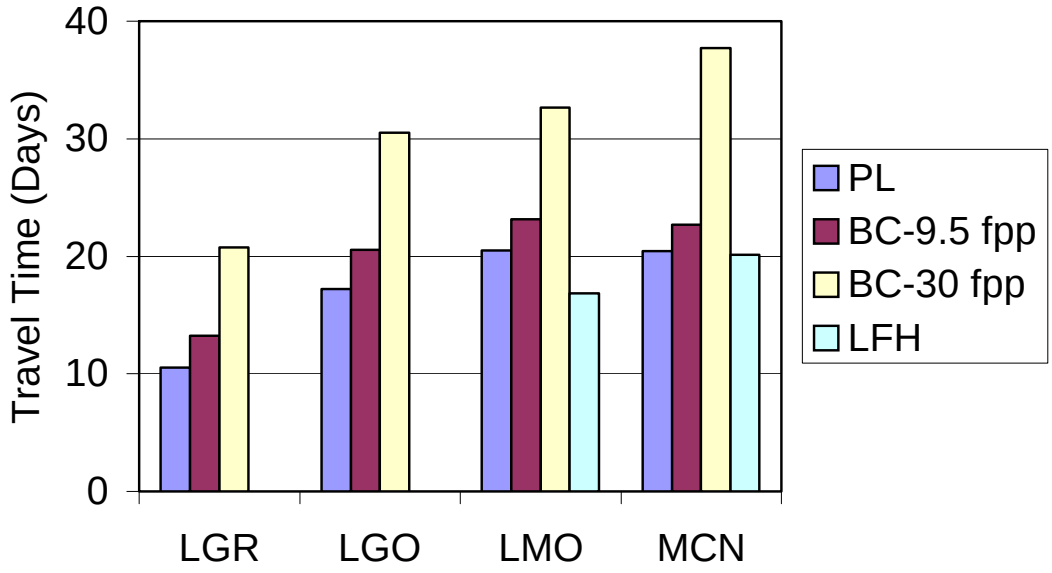

Figure 9. Travel time (days), based on first detections, of PIT tagged yearling fall chinook salmon released from Pittsburg Landing, Big Canyon and Lyons Ferry Hatchery to Lower Snake and Columbia River dams in 1998.

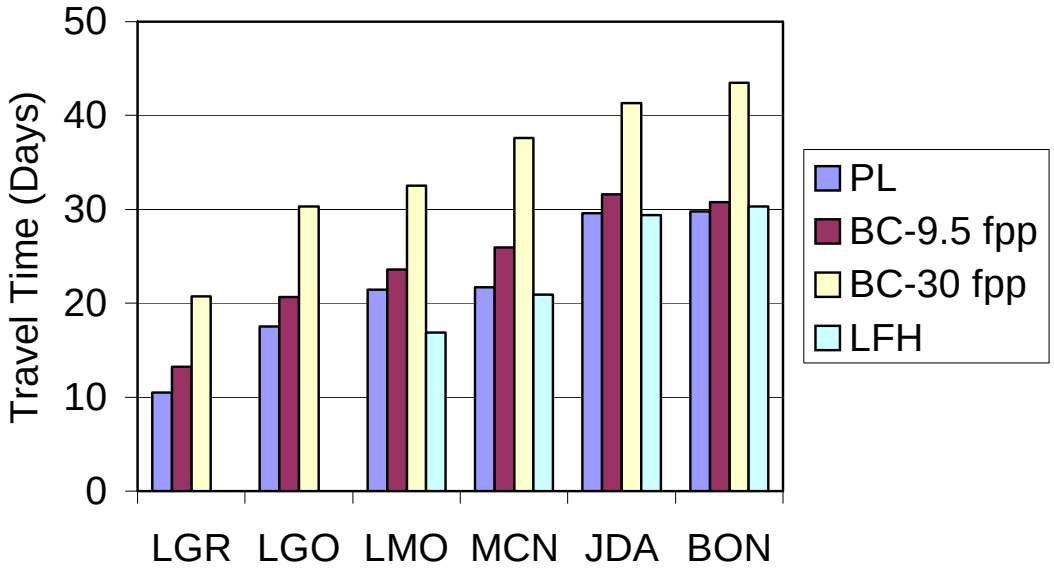

Figure 10. Travel time (days), based on all detections, of PIT tagged yearling fall chinook salmon released from Pittsburg Landing, Big Canyon and Lyons Ferry Hatchery to Lower Snake and Columbia River dams in 1998.

Table 8. Travel time (in days), based on first detections, of yearling fall chinook PIT tagged and released from Pittsburg Landing, Big Canyon and Lyons Ferry Hatchery to Lower Granite, Little Goose, Lower Monumental and McNary Dams in 1998.

Release Group	Release to:	Number Sampled	Mean	Standard Deviation	95% C.I. (+/- mean)	Median	Range
	LGR	4,406	12.4	6.1	0.2	10.5	3.2 - 69.0
Pittsburg	LGO	1,303	18.3	7.4	0.4	17.2	5.9 - 49.7
Landing	LMO	779	21.1	20.5	0.5	20.5	7.6 - 53.4
	MCN	348	22.4	6.8	0.7	20.4	10.7 - 48.8
	LGR	1,811	15.0	7.5	0.3	13.3	3.3 - 64.7
Big Canyon -	LGO	723	22.5	9.4	0.7	20.6	6.7 - 87.9
9.5 fpp	LMO	383	24.8	23.2	0.8	23.2	10.4 - 55.5
	MCN	125	25.1	8.1	1.4	22.7	12.7 - 49.4
	LGR	610	21.6	10.4	0.8	20.8	3.7 - 64.5
Big Canyon -	LGO	363	30.7	10.1	1.0	30.5	8.5 - 77.3
30 fpp	LMO	122	34.0	32.6	1.7	32.6	13.3 - 57.3
	MCN	35	37.7	6.5	2.2	37.7	22.5 - 49.9
Lyons Ferry	LMO	540	18.5	16.9	0.8	16.9	3.7 - 50.3
Hatchery	MCN	439	21.8	8.1	0.8	20.1	9.3 - 52.2

Table 9. Travel time (in days), based on all detections, of yearling fall chinook PIT tagged and released from Pittsburg Landing, Big Canyon and Lyons Ferry Hatchery to Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville Dams in 1998.

Release Group	Release to:	Number Sampled	Mean	Standard Deviation	95% C.I. (+/- mean)	Median	Range
	LGR	4,406	12.4	6.1	0.2	10.5	3.2 - 69.0
	LGO	2,508	18.6	7.4	0.3	17.5	5.9 - 50.3
Pittsburg	LMO	2,115	22.3	21.5	0.3	21.5	7.6 - 53.4
Landing	MCN	1,294	24.0	7.5	0.4	21.7	10.3 - 48.8
	JDA	571	30.8	8.3	0.7	29.6	14.9 - 53.8
	BON	405	30.8	7.2	0.7	29.8	16.3 - 53.7
	LGR	1,811	15.0	7.5	0.3	13.3	3.3 - 64.7
	LGO	1,199	22.8	9.0	0.5	20.7	6.7 - 87.9
Big Canyon -	LMO	999	25.5	23.6	0.5	23.6	10.4 - 55.5
9.5 fpp	MCN	467	27.5	8.5	0.8	26.0	12.7 - 51.8
	JDA	285	33.6	8.9	1.0	31.6	17.7 - 58.7
	BON	155	31.3	6.9	1.1	30.8	19.2 - 52.6
	LGR	610	21.6	10.4	0.8	20.8	3.7 - 64.5
	LGO	568	30.4	10.2	0.8	30.3	6.6 - 77.3
Big Canyon -	LMO	366	33.2	32.5	1.0	32.5	8.4 - 58.0
30 fpp	MCN	144	37.5	7.0	1.2	37.6	19.2 - 51.3
	JDA	108	40.8	7.9	1.5	41.3	22.5 - 59.3
	BON	20	42.9	7.8	3.6	43.5	32.6 - 62.3
	LMO	541	18.6	16.9	0.8	16.9	3.7 - 50.3
Lyons Ferry	MCN	577	22.7	8.4	0.7	20.9	8.5 - 52.2
Hatchery	JDA	207	30.7	10.1	1.4	29.4	12.7 - 54.5
	BON	118	31.0	10.3	1.9	30.3	16.2 - 91.4

There tends to be an increase in migration rate of PIT tagged yearlings as they move downstream (Figures 11 and 12). Median migration rates for yearlings from Pittsburg Landing, Big Canyon and Lyons Ferry, based on first detections and all detections, are shown in Tables 10 and 11, respectively. Migration rates from release to Lower Granite Dam are higher than migration rates between Lower Granite and Little Goose Dams. However, when considering migration rates from Pittsburg Landing, Captain John Rapids and Big Canyon to Lower Granite Dam it is important to take into account that yearling emigration includes about 110, 29 and 50 rkm, respectively, through free-flowing river above the reservoir. Current PIT tag technology is such that effectively segregating the free-flowing reach of the Snake River from the upper reach of Lower Granite pool is not possible. The increased migration rates in downstream reaches may be due to the fact that these fish have been actively migrating for almost a month by the time they reach McNary Dam on the Columbia River. It is possible that migration rates increase further downstream because the fish are at an advanced stage of smoltification and still have another 470 Rkm to reach the ocean.

In contrast to yearlings from the FCAP facilities, the migration rate of yearlings from Lyons Ferry Hatchery was very low from release to Lower Monumental Dam with dramatic increases as they move downstream (Figure 12). It is possible that yearlings from Lyons Ferry Hatchery exhibit slower initial post-release migration rates because they are released directly into an impounded reach whereas the fish from the FCAP facilities were released directly into free-flowing river where the water velocity is much higher.

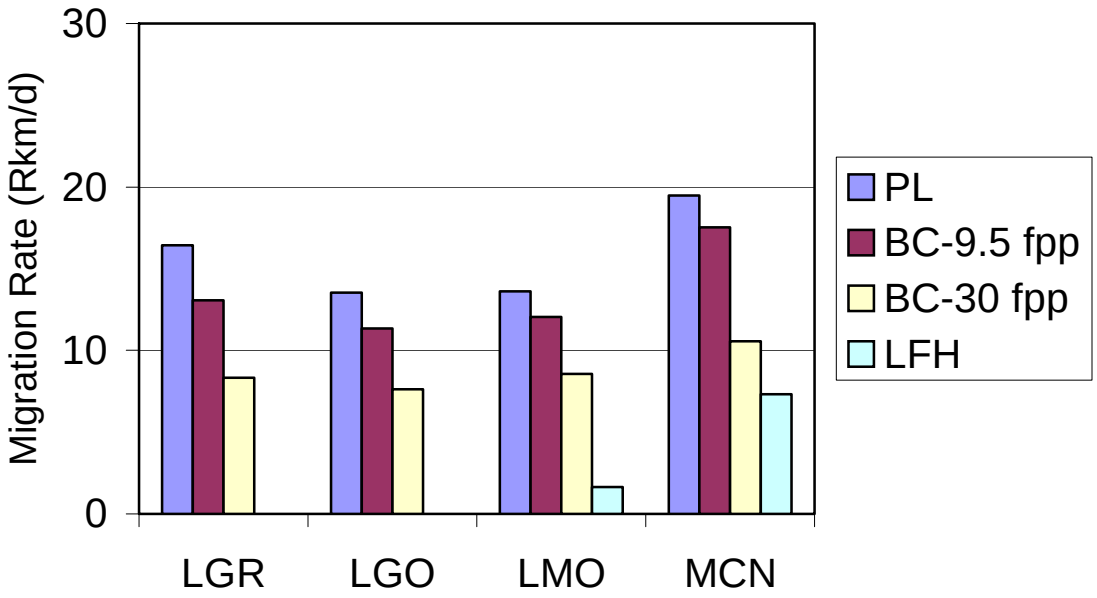

Figure 11. Migration rate (rkm/d), based on first detections, of PIT tagged yearling fall chinook salmon released from Pittsburg Landing, Big Canyon and Lyons Ferry Hatchery to Lower Snake and Columbia River dams in 1998.

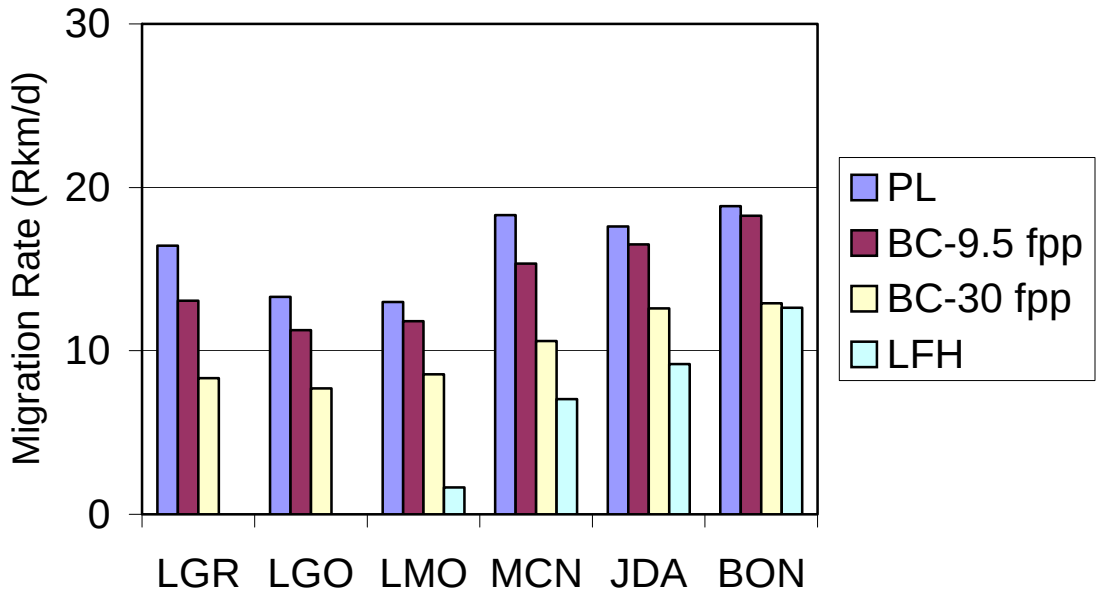

Figure 12. Migration rate (rkm/d), based on all detections, of PIT tagged yearling fall chinook salmon released from Pittsburg Landing, Big Canyon and Lyons Ferry Hatchery to Lower Snake and Columbia River dams in 1998.

Table 10. Migration rate (Rkm/d), based on first detections, of yearling fall chinook PIT tagged and released from Pittsburg Landing, Big Canyon and Lyons Ferry Hatchery to Lower Granite, Little Goose, Lower Monumental and McNary Dams in 1998.

Release Group	Release to:	Number Sampled	Mean	Median	Range
Pittsburg Landing	LGR	4,406	14.0	16.4	2.5 - 54.9
	LGO	1,303	12.7	13.5	4.7 - 39.8
	LMO	779	13.2	13.6	5.2 - 36.7
	MCN	348	17.8	19.5	8.2 - 37.1
Big Canyon - 9.5 fpp	LGR	1,811	11.5	13.0	2.7 - 53.2
	LGO	723	10.4	11.3	2.6 - 34.9
	LMO	383	11.3	12.0	5.0 - 26.8
	MCN	125	15.8	17.5	8.1 - 31.3
Big Canyon - 30 fpp	LGR	610	8.0	8.3	2.7 - 47.2
	LGO	363	7.6	7.6	3.0 - 27.3
	LMO	122	8.2	8.6	4.9 - 21.1
	MCN	35	10.6	10.6	8.0 - 17.7
Lyons Ferry Hatchery	LMO	540	1.5	1.7	0.6 - 7.7
	MCN	439	6.8	7.3	2.8 - 15.8

Table 11. Migration rate (Rkm/d), based on all detections, of yearling fall chinook PIT tagged and released from Pittsburg Landing, Big Canyon and Lyons Ferry Hatchery to Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville Dams in 1998.

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Pittsburg Landing	LGR	4,406	14.0	16.4	2.5 - 54.9
	LGO	2,508	12.5	13.3	4.6 - 39.8
	LMO	2,115	12.5	13.0	5.2 - 36.7
	MCN	1,294	16.6	18.3	8.2 - 38.6
	JDA	571	16.9	17.6	9.7 - 34.9
	BON	405	18.3	18.9	10.5 - 34.4
Big Canyon - 9.5 fpp	LGR	1,811	11.5	13.0	2.7 - 53.2
	LGO	1,199	10.2	11.3	2.6 - 34.9
	LMO	999	11.0	11.8	5.0 - 26.8
	MCN	467	14.5	15.3	7.7 - 31.3
	JDA	285	15.5	16.5	8.9 - 29.4
	BON	155	17.9	18.3	10.7 - 29.3
Big Canyon - 30 fpp	LGR	610	8.0	8.3	2.7 - 47.2
	LGO	568	7.7	7.7	3.0 - 35.3
	LMO	366	8.4	8.6	4.8 - 33.4
	MCN	144	10.6	10.6	7.8 - 20.7
	JDA	108	12.8	12.6	8.8 - 23.1
	BON	20	13.1	12.9	9.0 - 17.2
Lyons Ferry Hatchery	LMO	541	1.5	1.7	0.6 - 7.7
	MCN	577	6.5	7.0	2.8 - 17.3
	JDA	207	8.8	9.2	5.0 - 21.3
	BON	118	12.3	12.6	4.2 - 23.7

Arrival Timing

Median arrival dates of all FCAP and Lyons Ferry Hatchery yearling release groups to Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville Dams are shown in Tables 12 and 13 for first detections and all detections, respectively. The median arrival date, based on all detections, to Lower Granite Dam for the Big Canyon 30 fpp group ranged from 8 to 10 days later than all other yearlings released from the FCAP facilities with the differential increasing at downstream dams. Yearlings from Pittsburg Landing achieved 90% arrival to every dam except Bonneville earlier than Big Canyon 9.5 fpp and Captain John Rapids yearlings. The Big Canyon 30 fpp group typically achieved 90% arrival to the dams 1-2 weeks later than all other groups.

Table 12. Arrival date, based on first detections, of PIT tagged yearling fall chinook released from the FCAP facilities and Lyons Ferry Hatchery to Lower Granite, Little Goose, Lower Monumental and McNary Dams in 1998.

Release Group	Release to:	Number Sampled	Mean	Median	90% Arrival Date
Pittsburg Landing	LGR	4,406	4/27	4/25	5/5
	LGO	1,303	5/3	5/2	5/13
	LMO	779	5/6	5/5	5/15
	MCN	348	5/7	5/5	5/18
Big Canyon - 9.5 fpp	LGR	1,811	4/30	4/27	5/9
	LGO	723	5/7	5/5	5/21
	LMO	383	5/9	5/8	5/20
	MCN	125	5/10	5/7	5/21
Big Canyon - 30 fpp	LGR	610	5/6	5/5	5/22
	LGO	363	5/15	5/16	5/27
	LMO	122	5/19	5/18	5/30
	MCN	35	5/22	5/23	5/30
Captain John Rapids	LGR	431	4/28	4/26	5/8
	LGO	158	5/6	5/4	5/20
	LMO	92	5/8	5/6	5/20
	MCN	38	5/8	5/5	5/21
Lyons Ferry Hatchery	LMO	540	4/29	4/27	5/12
	MCN	439	5/2	4/30	5/14

Table 13. Arrival date, based on all detections, of PIT tagged yearling fall chinook released from the FCAP facilities and Lyons Ferry Hatchery to Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville Dams in 1998.

Release Group	Release to:	Number Sampled	Mean	Median	90% Arrival Date
Pittsburg Landing	LGR	4,406	4/27	4/25	5/5
	LGO	2,508	5/3	5/3	5/14
	LMO	2,115	5/7	5/6	5/17
	MCN	1,294	5/9	5/6	5/20
	JDA	571	5/15	5/14	5/28
	BON	405	5/15	5/14	5/25
Big Canyon - 9.5 fpp	LGR	1,811	4/30	4/27	5/9
	LGO	1,199	5/7	5/5	5/21
	LMO	999	5/10	5/9	5/22
	MCN	467	5/12	5/11	5/24
	JDA	285	5/18	5/16	6/1
	BON	155	5/16	5/15	5/25
Big Canyon - 30 fpp	LGR	610	5/6	5/5	5/22
	LGO	568	5/15	5/15	5/27
	LMO	366	5/18	5/18	5/29
	MCN	144	5/22	5/23	5/31
	JDA	108	5/26	5/27	6/4
	BON	20	5/28	5/28	6/5
Captain John Rapids	LGR	431	4/28	4/26	5/8
	LGO	285	5/6	5/5	5/19
	LMO	218	5/8	5/7	5/19
	MCN	128	5/10	5/8	5/23
	JDA	55	5/17	5/17	5/28
	BON	44	5/15	5/14	5/26
Lyons Ferry Hatchery	LMO	541	4/29	4/27	5/13
	MCN	577	5/3	5/1	5/16
	JDA	207	5/11	5/9	5/26
	BON	118	5/12	5/8	5/24

Survival

Estimated survival of yearlings from release to McNary Dam was 55.7% for Pittsburg Landing, 51.7% for Big Canyon 9.5 fpp, 25.2% for Big Canyon 30 fpp, 50.5% for Captain John Rapids and 81.9% for Lyons Ferry (Table 14). It is interesting to note that survival estimates from FCAP facilities (excluding Big Canyon 30 fpp) were highest for yearlings released from Pittsburg Landing because Pittsburg Landing is the FCAP facility farthest upstream. Yearlings

from Big Canyon and Captain John Rapids had similar survival rates to each other. Reasons for the higher survival from Pittsburg Landing are not readily evident.

Based on the survival estimates for the two size classes from Big Canyon, larger size at release may be an advantage for survival. Several possibilities exist that may affect the survival estimates of Big Canyon 30 fpp fish to make them lower than other groups. First, there were serious health concerns related to the smaller size class fish (B. McLeod, NPT, personal communication), though we cannot make any solid health-based conclusions because health monitoring was not done on that group (K. Clemens, USFWS, personal communication). Also, if the Big Canyon 30 fpp fish were somehow disposed to follow dam passage routes alternate to the bypass and collection facilities, then capture probabilities may have been affected, possibly resulting in lower survival estimates. This is a possibility with the operation of the surface collector at Lower Granite Dam in 1998. Survival estimates of yearlings from the FCAP facilities to Lower Granite and McNary Dams from 1996-1998 are shown in Appendix A.

Table 14. Estimated survival, using the SURPH Model, of yearling fall chinook salmon PIT tagged and released from the FCAP facilities and Lyons Ferry Hatchery to Lower Granite, Lower Monumental and McNary Dams in 1998.

Release Group	Release to:	Estimated Survival	Standard Error
Pittsburg Landing	LGR	0.9878	0.0140
	MCN	0.5568	0.0394
Big Canyon - 9.5 fpp	LGR	0.8472	0.0146
	MCN	0.5168	0.0658
Big Canyon - 30 fpp	LGR	0.6217	0.0203
	MCN	0.2518	0.0445
Captain John Rapids	LGR	0.7698	0.0274
	MCN	0.5049	0.1168
Lyons Ferry Hatchery	LMO	0.9373	0.0496
	MCN	0.8189	0.0847

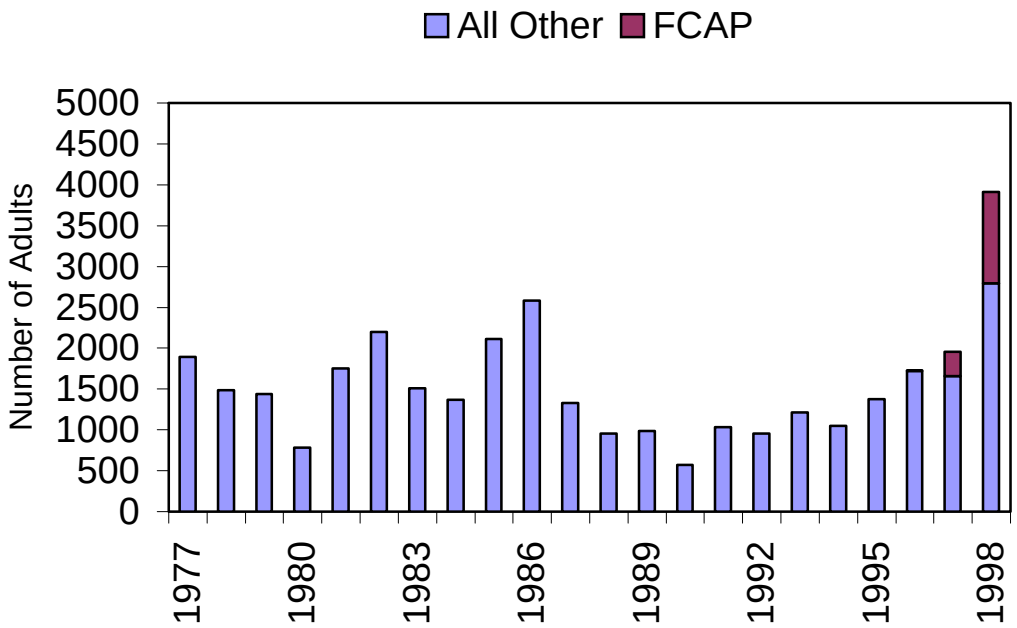
Adult Returns

From 1977 through 1998 returns of adult (adults + jacks) fall chinook salmon to Lower Granite Dam averaged 1,442 fish (Table 15). A total of 3,911 adult fall chinook salmon returned to Lower Granite Dam in 1998. There has been a trend of increasing returns since 1990 with 1998 having the highest return of fall chinook salmon to Lower Granite Dam in that period (Figure 13). From 1996 through 1998 adults from FCAP yearling releases comprised 0.58%, 15.2% and 28.5% of the total return to Lower Granite Dam, respectively. The FCAP returns for 1996 and 1997 consisted exclusively of mini-jacks and jacks, respectively (Table 16). While it is too early

to draw solid conclusions, it appears that the yearling fall chinook supplementation program is a positive factor in the increasing adult fall chinook returns to Lower Granite Dam.

Table 15. Numbers of adult and jack fall chinook salmon, with FCAP contribution, returning to Lower Granite Dam, 1977-1998.

Year	Total Adults	Total Jacks	FCAP Adults	FCAP Jacks
1977	609	1,284	n/a	n/a
1978	641	843	n/a	n/a
1979	497	941	n/a	n/a
1980	453	328	n/a	n/a
1981	337	1,414	n/a	n/a
1982	724	1,478	n/a	n/a
1983	536	977	n/a	n/a
1984	637	731	n/a	n/a
1985	668	1,446	n/a	n/a
1986	782	1,802	n/a	n/a
1987	944	390	n/a	n/a
1988	629	327	n/a	n/a
1989	707	276	n/a	n/a
1990	383	189	n/a	n/a
1991	633	399	n/a	n/a
1992	855	102	n/a	n/a
1993	1,170	39	n/a	n/a
1994	791	255	n/a	n/a
1995	1,067	308	n/a	n/a
1996	1,308	424	n/a	10
1997	1,451	504	n/a	297
1998	1,909	2,002	118	998



Note: FCAP returns include adults that were captured at Lower Granite Dam and hauled to LFH along with a very small number of adults that volunteered directly to LFH.

Figure 13. Total numbers, with FCAP composition, of adult fall chinook salmon returning to Lower Granite Dam, 1977-1998.

Table 16. Number of FCAP adult and jack fall chinook returning to Lower Granite Dam, 1996-1998.

	Adult			Jack		
Year	PL	BC	CJ	PL	BC	CJ
1996	n/a	n/a	n/a	10	n/a	n/a
1997	n/a	n/a	n/a	167	130	n/a
1998	118	n/a	n/a	483	458	57

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.

Bagenal, T. B. and F. W. Tesch. 1978. Age and Growth. Pages 101-136 in T. B. Bagenal, editor. Methods for assessment of fish production in fresh waters, 3rd Edition. Blackwell Scientific Publications, Oxford, England.

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.

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.

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. Elliiott, 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.

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

Wargo, L., D. Milks and G. Mendel. 1999. Lyons Ferry Hatchery Evaluation, Fall Chinook Salmon, Annual Report: 1996 and 1997. Washington Department of Fish and Wildlife Hatcheries Report # FPA 99-06 to U.S. Fish and Wildlife Service, Lower Snake River Compensation Plan Office, Boise, ID.

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.

Appendix A. SURPH survival estimates, standard errors and 95% bounds (at Lower Granite Dam) for yearling fall chinook salmon from release at FCAP facilities to Lower Snake and Columbia River dams from 1996 through 1998. In figures, years are indicated by color. Like colors indicate the same year across multiple figures. For instance, yellow indicates 1998 in all figures containing data for 1998.

Table A.1. SURPH survival estimates, standard errors and 95% bounds for yearling fall chinook salmon released from Pittsburg Landing, Big Canyon and Captain John Rapids to lower Snake and Columbia River Dams, 1996-1998.

	Release to Lower Granite Dam				
Release Group	Year	CJS Estimate	S.E.	95% Lower	95% Upper
PL	1996	0.9878	0.0140	0.9612	1.0161
	1997	0.9224	0.0119	0.8997	0.9463
	1998	0.8857	0.0087	0.8689	0.9030
BC	1997	0.9359	0.0147	0.9080	0.9656
BC - 9.5 fpp	1998	0.8472	0.0146	0.8194	0.8768
BC - 30 fpp	1998	0.6217	0.0203	0.5840	0.6637
BC-Surplus	1997	0.9325	0.0429	0.8551	1.0246
CJ	1998	0.7698	0.0274	0.7188	0.8271

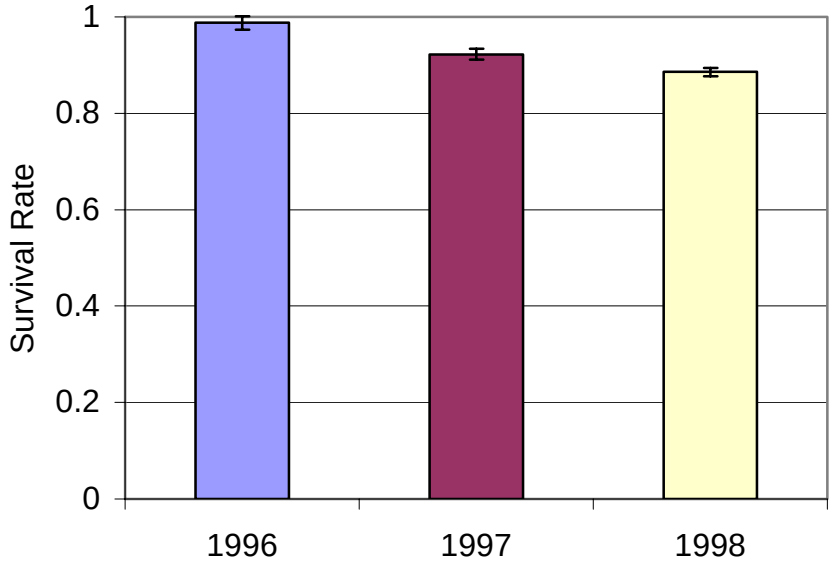


Figure A.1. Estimated survival (+/- s.e.) of yearling fall chinook salmon from Pittsburg Landing to Lower Granite Dam, 1996-1998.

Appendix A (continued).

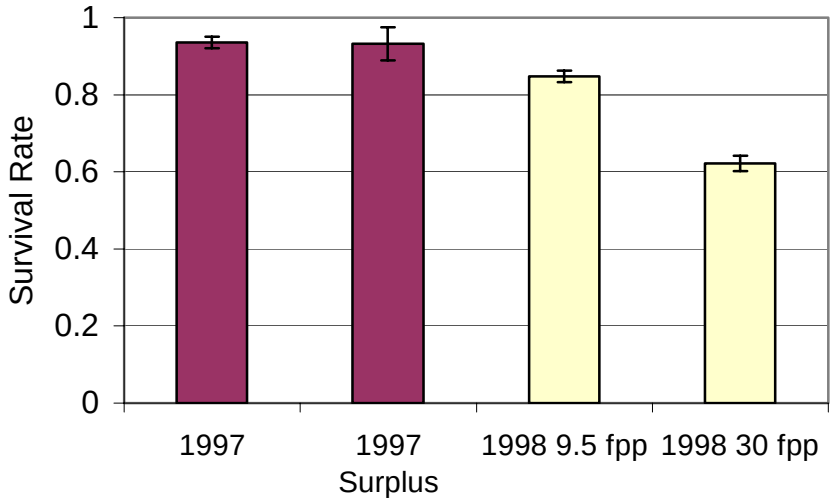


Figure A.2. Estimated survival (+/- s.e.) of yearling fall chinook salmon from Big Canyon to Lower Granite Dam, 1997-1998.

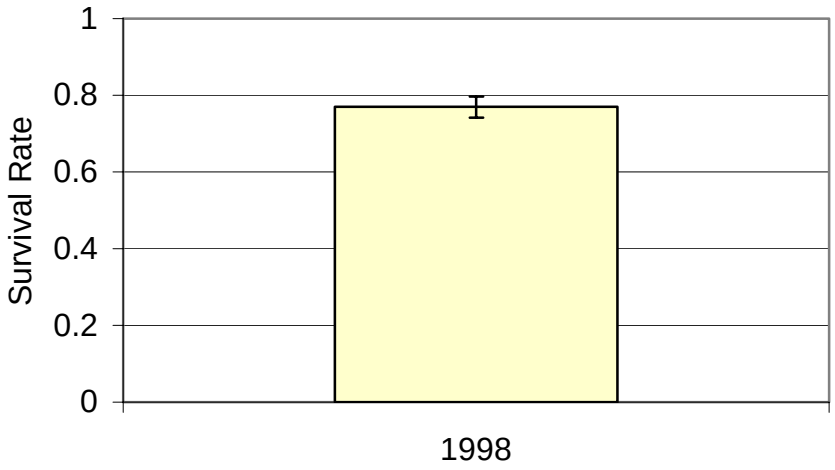


Figure A.3. Estimated survival (+/- s.e.) of yearling fall chinook salmon from Captain John Rapids to Lower Granite Dam, 1998.

Appendix A (continued).

Table A.2. SURPH survival estimates and standard errors for yearling fall chinook salmon released from Pittsburg Landing, Big Canyon, Captain John Rapids and Lyons Ferry Hatchery to McNary Dam, 1996-1998.

Release to McNary Dam			
Release Group	Year	CJS Estimate	S.E.
PL	1996	0.4131	0.0738
	1997	0.8176	0.1593
	1998	0.5568	0.0394
BC	1997	0.8328	0.1792
BC - 9.5 fpp	1998	0.5168	0.0658
BC - 30 fpp	1998	0.2518	0.0445
BC-Surplus	1997	0.7382	0.713
CJ	1998	0.5049	0.1168
LFH	1996	0.8755	0.3955
	1997	1.3479	0.418
	1998	0.8189	0.0847

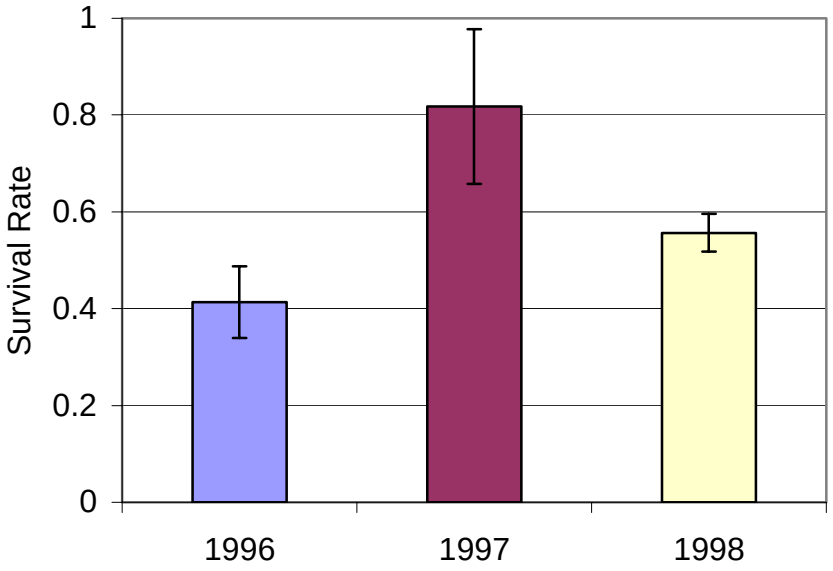


Figure A.4. Estimated survival (+/- s.e.) of yearling fall chinook salmon from Pittsburg Landing to McNary Dam, 1996-1998.

Appendix A (continued).

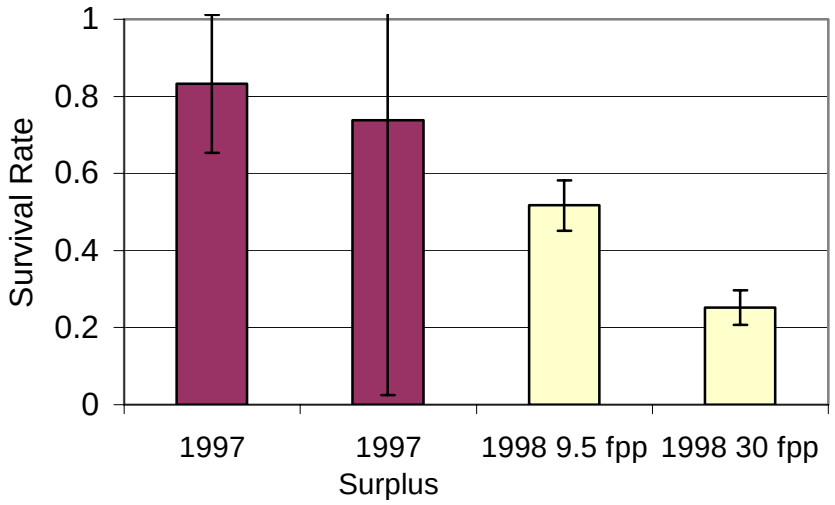


Figure A.5. Estimated survival (+/- s.e.) of yearling fall chinook salmon from Big Canyon to McNary Dam, 1997-1998.

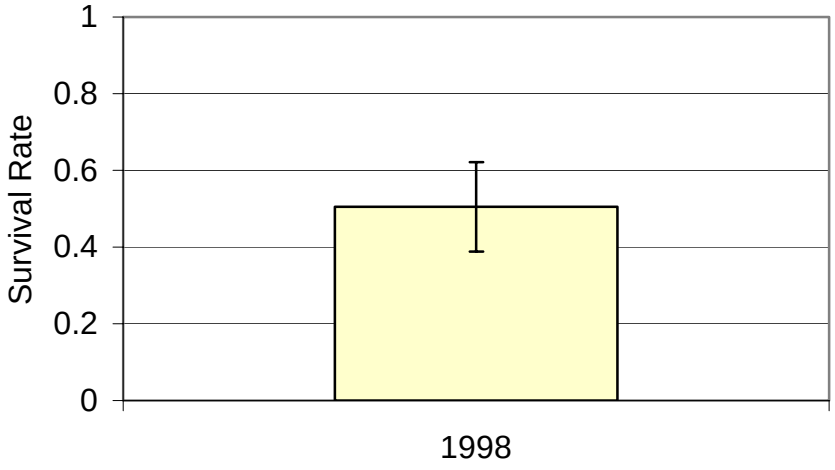


Figure A.6. Estimated survival (+/- s.e.) of yearling fall chinook salmon from Captain John Rapids to McNary Dam, 1998.

Appendix A (continued).

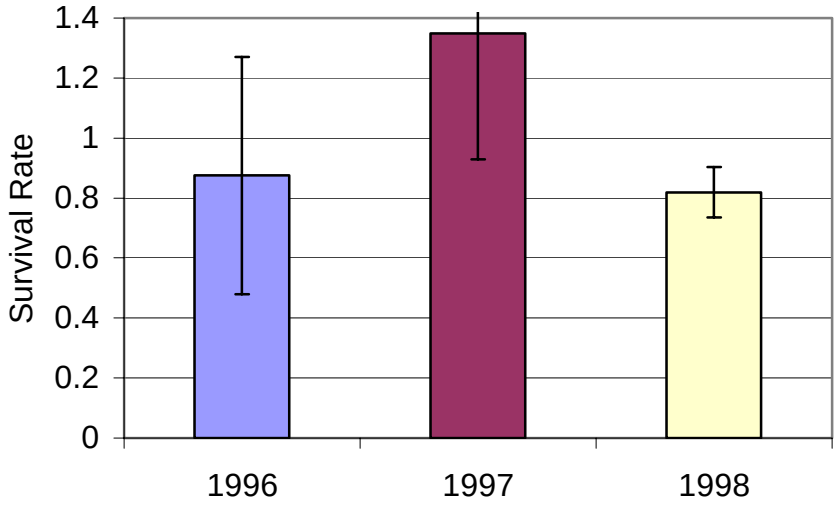


Figure A.7. Estimated survival (+/- s.e.) of yearling fall chinook salmon from Lyons Ferry Hatchery to McNary Dam, 1996-1998.