

**Shasta River Fish Counting Facility,
Chinook and Coho Salmon Observations in 2002
Siskiyou County, CA**

ABSTRACT

An underwater video camera was operated in the flume of the Shasta River Fish Counting Facility twenty four hours a day, seven days a week, from 9 September through 17 December of 2002 to monitor fall run Chinook salmon migration into the Shasta River. High flow forced the removal of the SRFCF on 18 December. A total of 6,820 Chinook salmon were observed passing through the SRFCF between 9 September and 23 November. The run peaked on 28 September when 853 Chinook salmon passed through the weir. A total of 613 Chinook salmon carcasses were examined during spawning ground surveys that were conducted primarily on public lands located in the lower 7 miles of the Shasta River. Based on the proportion of the females, males and grilse observed in the spawning ground survey the entire run was comprised of an estimated 3,405 females, 3,185 adult males, and 230 grilse. Female Chinook salmon ranged in fork length from 48 cm to 94 cm and males ranged in fork length from 40 cm to 105 cm. Examination of the male fork length frequency distribution indicated that grilse were likely less than 65 cm in fork length. Only three adipose fin clipped (hatchery origin fish) Chinook salmon were observed and only one of these was recovered during the spawning ground surveys. The coded wire tag that was retrieved from this fish indicated that its origin was from IGH released in the spring of 1998. Assuming that the other two adipose fin clipped Chinook salmon that were observed at the SRFCF, A total of only 79 hatchery origin Chinook salmon entered the Shasta River in 2002. Approximately 1,019 Chinook salmon, or 14.95% of the run, had one or more lamprey attached to them as they passed through the SRFCF. A total of 86 adult coho salmon were observed passing through the SRFCF between 19 October and 17 December.

INTRODUCTION

The Klamath River Project (KRP) of the California Department of Fish and Game (Department) is responsible for estimating the number of fall-run Chinook salmon (*Oncorhynchus tshawytscha*) that return to the Klamath River Basin, excluding the Trinity River Basin, each year. To achieve this task the KRP employs several techniques which include a creel survey of sport fishing efforts, recovery of fish returning to Iron Gate Hatchery (IGH), completion of cooperative spawning ground surveys in major tributary streams and rivers, and operation of a video fish counting weir on the Shasta River near its confluence with the Klamath River.

Video equipment was first installed at the Shasta River Fish Counting Facility (SRFCF) in 1998 and has been used to describe migration of fall-run Chinook salmon into the Shasta River ever since. Although the primary responsibility of the KRP is to enumerate and describe fall-run Chinook salmon populations within the basin to assist harvest managers, data is recorded for other fish species observed at the SRFCF during its normal period of operation from September through the first week of November.

The petition to list coho salmon (*Oncorhynchus kisutch*) under the California Endangered Species Act was received by the California Fish and Game Commission on 28th of July, 2000. Prior to and following receipt of this petition, the Department intensified efforts to document coho salmon presence within the Klamath River Basin and elsewhere. Consistent with this effort, the KRP has elected to continue operating the SRFCF beyond its normal period of operation in an effort to document migration of coho salmon into the Shasta River. The

Southern Oregon Northern California Coastal coho salmon were listed as threatened by the National Marine Fisheries Service under the Federal Endangered Species Act in 1997.

This report describes the characteristics of the Chinook and coho salmon runs that entered the Shasta River during the fall of 2002.

METHODS

Monitoring of the salmon run with in the Shasta River is accomplished through three primary efforts, operation of A video weir, collection of data from salmon carcasses that become impinged on the weir panels as they float downstream (wash backs), and completion of spawning ground surveys to obtain needed biological data from salmon carcasses.

The SRFCF consists of an Alaska Weir strategically placed in a diagonal direction across the river channel. Fish immigrating upstream are directed through a narrow flume, which passes in front of an underwater video camera. The camera was connected to a time lapse video recorder and monitor. A Panasonic Color CCTV Camera Model No.WV-CP150 equipped with a 3.5 – 8mm 1:1.4 Computar lens^{1/} was used throughout the season. A Panasonic time lapse video cassette recorder, model AG-6740, was used to record flume observations and SVHS 120 minute video tapes were used as the recording medium. The weir and video camera was installed on 8 September and began recording on the morning of 9 September at 9:00am. Recording speeds were set at 24 hour mode during the early (September 9 to September 20) and late (November 14 to December 18) portions of the run when numbers of fish passing through the facility were relatively small. The recording speed was increased to record over a 12 hour period during the major portion of the run (September 21 to November 13). The video recorder was set to include both a date and time stamp on every recording to accurately document run timing.

KRP personnel manned the facility 24 hours a day, seven days a week, during the season. Staff conducted hourly inspections of the equipment and weir to ensure that everything was functioning properly. System checks inspected the camera housing, video recorder, picture quality, flume condition, lighting, and weir panels. Water temperatures were also recorded hourly with a handheld thermometer during each system check. Staff maintained the weir panels and cleaned the video flume as needed throughout the season.

Each video tape was reviewed twice during the season. The first review was conducted by staff stationed at the SRFCF and this review provided up to date preliminary information on the numbers and timing of the Chinook salmon run during the season. A more thorough second review was conducted by biological staff in the video laboratory located in the KRP office in Yreka. During the second review staff recorded the date, time (hour:minute:second), and species for each fish observed on each video tape. In addition, staff noted any adipose fin clips (ad-clips) observed, and also recorded the presence of lampreys or any other distinguishable marks that were visible on the tape. All data was then entered into computer files and each data file was subjected to two independent edits prior to commencement of any data analysis.

Any salmon carcasses that drifted downstream and became impinged on the weir panels were recovered and processed. Data collected on these wash back carcasses included species identification, gender, and fork length. Scales were removed from the left side of each carcass at a location posterior to the dorsal fin just above the lateral line whenever possible. Scale samples were then provided to the Yurok Tribal Fisheries Department for analysis. Every carcass was also examined for the presence of any fin clips, marks or tags. Heads were collected from each ad-clipped fish for later coded wire tag recovery and analysis. Each carcass was also examined to determine whether successful spawning had likely occurred. Female salmon with more than 50% of their egg mass still present in their body cavity were identified as pre-spawn mortalities. Carcasses were then cut in half to prevent sample duplication and returned to the river downstream of the weir.

Spawning ground carcass surveys were limited to the lower 7 miles of the Shasta River located in the canyon section, downstream of the Highway 263 Bridge crossing just north of the city of Yreka. The purpose of the spawning ground surveys was to gather biological data necessary to describe the physical characteristics of the run. During each survey crews walked in a downstream direction along the river bank searching for salmon carcasses. As carcasses were located each crew identified them to species and gender, collected a fork length measurement (cm), and a scale sample collected from the left side of each carcass above the lateral line just posterior to the dorsal fin. All of the scale samples that were collected from Chinook salmon were provided to the Yurok Tribal Fisheries Department for age determination. This information is then used to assist the Klamath Fishery Management Council in determining the age composition of Chinook salmon in the Klamath basin for use in harvest management determinations. Each carcass was also examined for the presence of any clips, marks or tags. Heads were collected from any ad-clipped fish for later coded wire tag recovery and analysis. All female carcasses were examined internally to determine spawning success. Females with greater than 50% of their eggs remaining in their body cavity were identified as a pre-spawn mortality. Once examined all carcasses were cut in two to prevent potential recounting during later surveys.

Spawning ground carcass surveys were conducted twice each week, every Tuesday and Friday, throughout the Chinook salmon spawning season. The first survey occurred on 15 October and the last survey occurred on 26 November, 2002. A total of thirteen surveys were conducted during the season.

Flow information was obtained from the USGS gauge (# 11517500) located near the mouth of the river a short distance upstream of the SRFCF. Hourly water temperature measurements were collected at the mouth of the Shasta River, just downstream of the SRFCF, with the use of Onset Computer Corporation Optic Stowaway water temperature device with a recording range from -5 to 37 degrees Celsius. The device recorded water temperatures through 23 October, 2002.

RESULTS

The SRFCF was operated from 9 September through 18 December of 2002. High flows, in excess of 450 cubic feet per second (cfs), forced the Department to cease operation of the SRFCF during the morning hours of 18 December.

Chinook Salmon

A total of 6,820 Chinook salmon were observed at the SRFCF in 2002. The first Chinook salmon was observed passing through the video weir (6 fish) on 9 September and the last Chinook salmon was observed on 23 November. The run peaked on 28 September when 853 Chinook salmon were observed passing through the SRFCF (Figure 2). The numbers of salmon entering the Shasta River declined appreciably during the first two weeks of October. During this time the numbers of Chinook salmon entering the river fluctuated between 68 and 191 fish. On 14 October a second peak of 248 Chinook salmon was observed passing through the weir. The numbers of Chinook salmon entering the weir then declined steadily until 31 October when only 6 fish were observed. Small numbers of Chinook salmon continued to pass through the weir until 23 November when the last Chinook salmon to pass through the weir was observed.

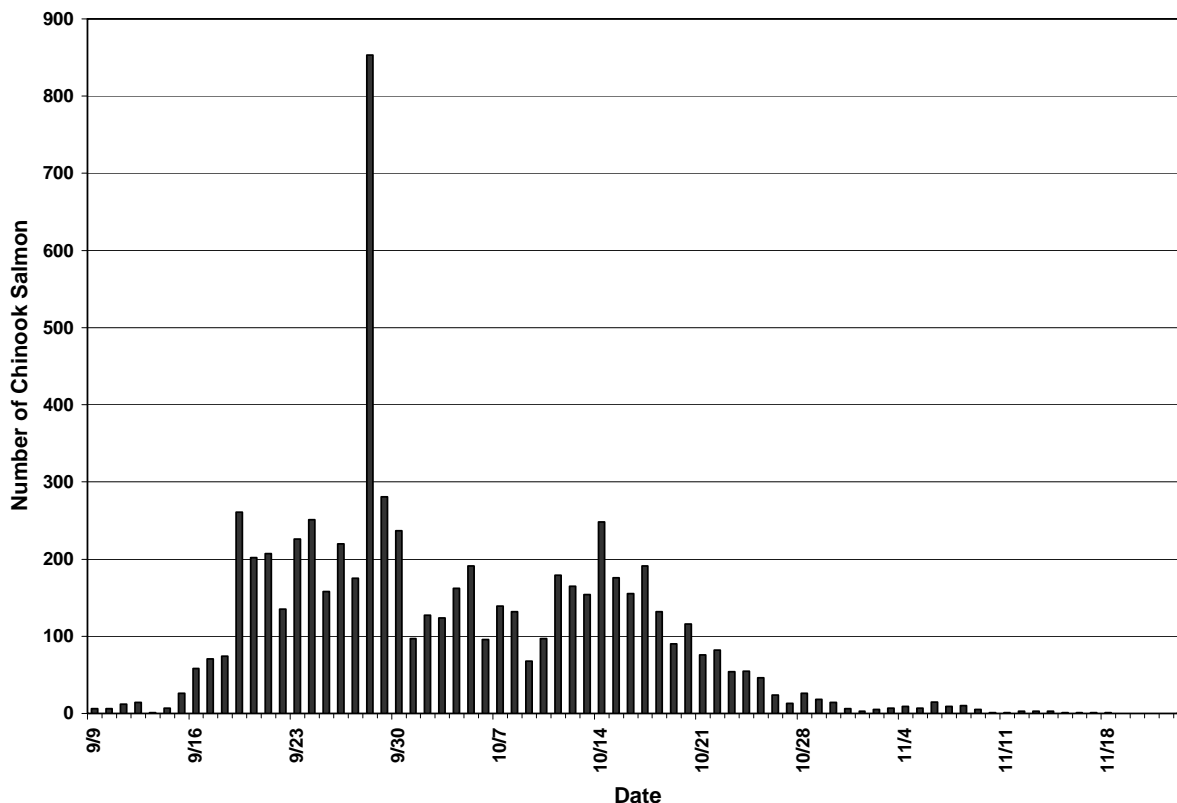


Figure 2. Run timing of fall Chinook salmon (n = 6,820 fish) observed at the Shasta River Fish Counting Facility in 2002.

The vast majority of Chinook salmon (93%) passed through the SRFCF during daylight hours between 0700 hours and 1800 hours (Figure 3). During the day, movement of Chinook salmon through the flume was deliberate in nature. Although the number of Chinook salmon moving into the flume was much less at night, those few fish that did enter the flume appeared to be more hesitant to pass through the flume. It was not uncommon to observe individual fish entering the flume several times over a short period. Some of these fish eventually passed through the flume, while others appeared to have dropped back downstream and probably passed through the flume the following morning. There was never any indication that the weir caused migration delays upstream as large numbers of fish were not observed holding the pool downstream of the weir for prolonged periods of time, several days, during the season.

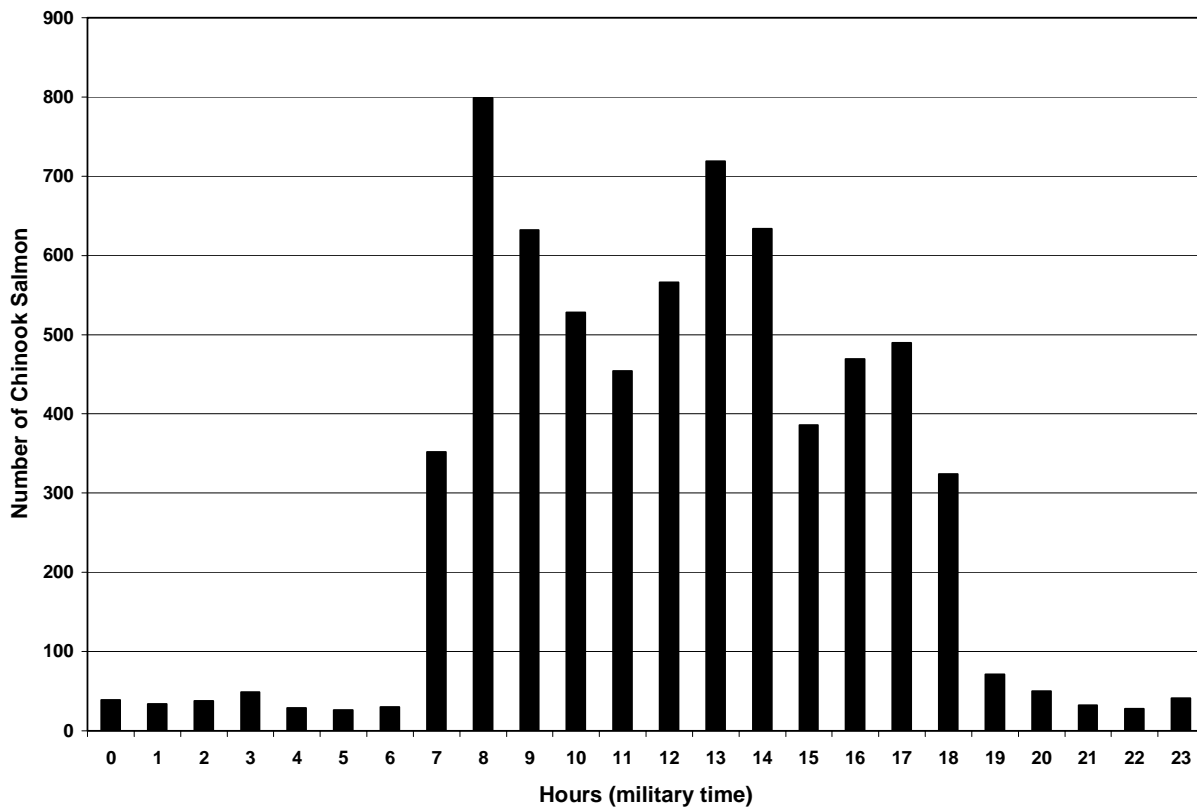


Figure 3. Diurnal timing of Chinook salmon movement through the Shasta River Fish Counting Facility during the 2002 season (n=6,820 fish).

The video camera is positioned on the right side of the flume, facing downstream, and therefore, the left side of each fish is visible to the camera as salmon migrate upstream. As staff reviewed each video tape, information was recorded on the presence of any lamprey, scars, ad-clips, or other abnormalities that are may be present on each fish. Since the right side of each fish cannot be seen during review of video tapes, any scars or abnormalities that may be present on the right side cannot be observed. However, in many cases, lamprey that are attached to the right side of fish can be seen dangling below, above, or behind, these fish as they pass through the flume. Regardless, an unknown number of lamprey that may be attached to the right side of migrating

salmon are not observed by staff as these fish pass through the flume. Figure 4 shows some examples of salmon with lamprey attached at various locations on each fish. A total of 1,019 Chinook salmon (14.95% of the total run) had lamprey attached to them as they passed through the flume. A total of only 25 Chinook salmon were observed with linear marks around the circumference of their bodies, usually anterior to the dorsal fin, that may have been caused by gill nets.

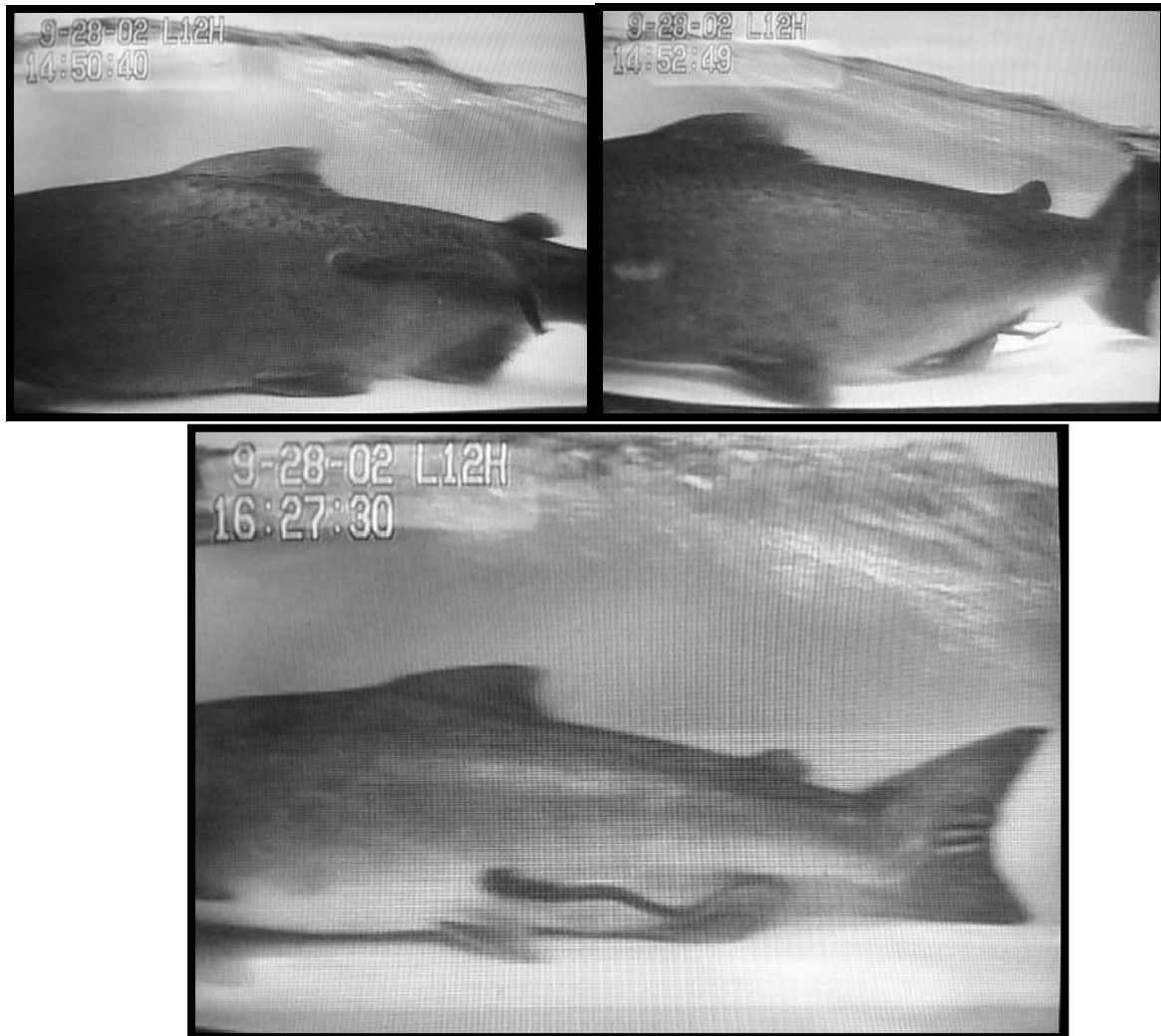


Figure 4. Photographs of Chinook salmon with lamprey attached as they pass through the flume at the Shasta River Fish Counting Facility on 28 September, 2002. The photographs were taken from the SVHS video tape monitor display and were converted to 256 grey scale for presentation purposes. The information in the upper left hand corner of each photograph indicate the date, record speed, and time when each fish passed through the flume.

Three ad-clipped Chinook salmon were observed passing through the video flume during the 2002 season. Of these, one ad-clipped salmon, a 47 cm female, was recovered as a wash back on 5 November. The tag code (#0601020301) that was recovered from the head of the female Chinook salmon recovered at the weir indicated that this fish was released from IGH in 1998 and was a four year fish. Expansion of this single tag recovery by the IGH production multiplier (26.38) would indicate that 26 of the 6,820 Chinook salmon that returned to the Shasta River in 2002 were of hatchery origin. If we assume that the other two ad-clipped fish that were observed at the SRFCF also represent progeny from the same IGH release group, then as many as 79 Chinook salmon for this release group may have returned to the Shasta River.

KRP staff processed a total of 613 carcasses during spawning ground surveys that occurred in the lower seven miles of the Shasta River. Of these, fork length measurements and gender could be determined for 593 fish. The remaining 20 carcasses were either partially eaten, or dismembered to the point where fork length or gender determinations could not be accurately determined. Of the 593 fish that could be positively identified, 296 were female and 297 were male. Pre-spawn mortalities were only observed for 3 of the 296 female Chinook salmon examined. Female Chinook salmon ranged in fork length from 48 cm to 94 cm (Figure 5) and males ranged in size from 40 cm to 105 cm (Figure 6). Examination of the length frequency distribution for fall Chinook salmon males suggests that the cutoff point between grilse and adults in the Shasta River occurs between 64cm and 65cm fork length. Based on this determination and the composition of male and female Chinook salmon observed in the spawning ground survey, the 2002 Chinook salmon run in the Shasta River was comprised of 230 grilse (3.37%), 3,185 adult males (46.7%) and 3,405 females (49.9%). The number of grilse was increased to 386 fish by the Klamath Fishery Management Council's Technical Advisory Team after consideration of age composition data derived from analysis of scales collected from the Shasta River. Therefore, the final Chinook salmon run size estimate for Shasta River is 386 grilse, 3,029 adult males, and 3,405 females for a total run size estimate of 6,820 fall Chinook salmon.

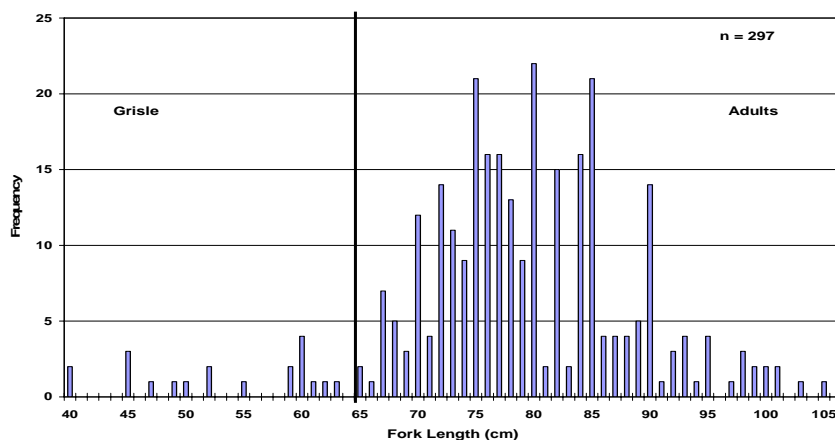


Figure 5. Fork length frequency distribution of male Chinook salmon examined during spawning ground carcass surveys conducted in the lower 7 river miles of the Shasta River, 2002.

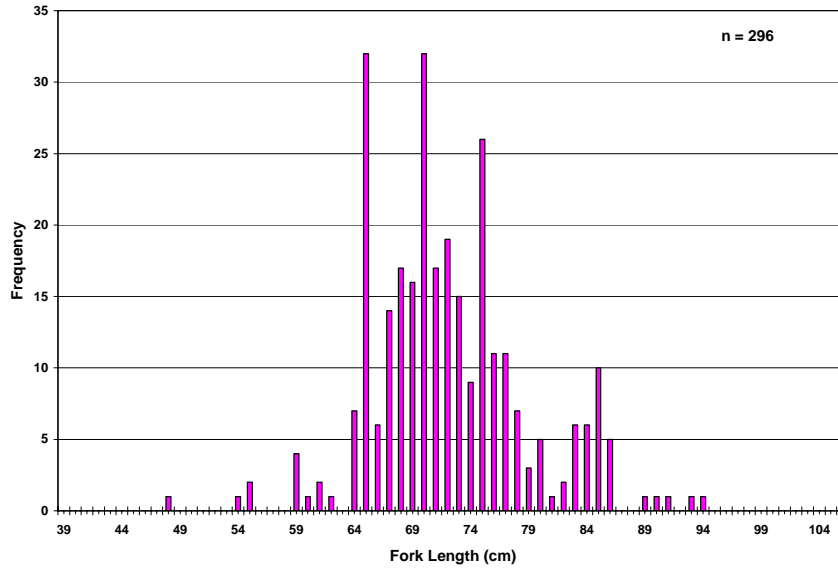


Figure 6. Fork length frequency distribution of female Chinook salmon examined during spawning ground carcass surveys conducted in the lower 7 river miles of the Shasta River, 2002.

Coho Salmon

Coho salmon were first observed passing through the SRFCF on 19 October and a total of 86 adult coho salmon were observed at the SRFCF between 19 October and 17 December, 2002 (Figure 7). The weir ceased operation on 18 December because of high flow, therefore, the numbers of coho salmon that may have entered the Shasta River after 17 December cannot be determined. No coho salmon carcasses were recovered as wash backs against the weir or during the spawning ground surveys which ended on 26 November. Therefore, information regarding individual sizes of fish, gender, or presence of fin clips could not be collected.

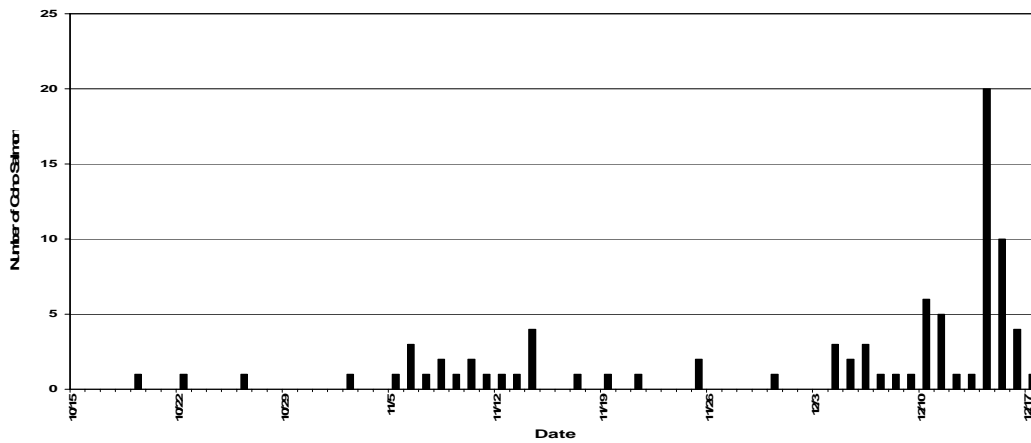


Figure 7. Run timing of adult coho salmon observed at the Shasta River Fish Counting Facility in 2002 (n = 86).

Other Species Observed

In addition to Chinook and coho salmon, the SRFCF also records the presence of other species that are recorded on the video tapes as they pass through the flume. Approximately 1,712 steelhead/rainbow trout (*Oncorhynchus gairdneri*) was observed passing through the SRFCF facility during the season. These were comprised of both juvenile and adult fish. The data collected for steelhead trout was provided to the Department's Steelhead Research and Monitoring Program (SRAMP) office in Yreka for analysis and reporting and is not discussed further in this report.

A total of 17 Centrarchid species were observed moving upstream through the SRFCF from 11 September to 13 October. Four of these fish could be easily identified as largemouth bass (*Micropterus salmoides*) and the remaining 17 fish were likely green sunfish (*Lepomis cyanellus*) or another common sunfish species.

A total of 245 Klamath smallscale sucker (*Catostomus rimiculus*) were observed at the SRFCF moving upstream into the Shasta River from the Klamath River between 9 September and 15 December, 2002. Migration of Klamath smallscale suckers peaked between 28 September and 7 October. Movement of suckers into the Shasta River decreased substantially after 15 October as only an occasional fish was observed moving through the flume for the remainder of the season (Figure 8).

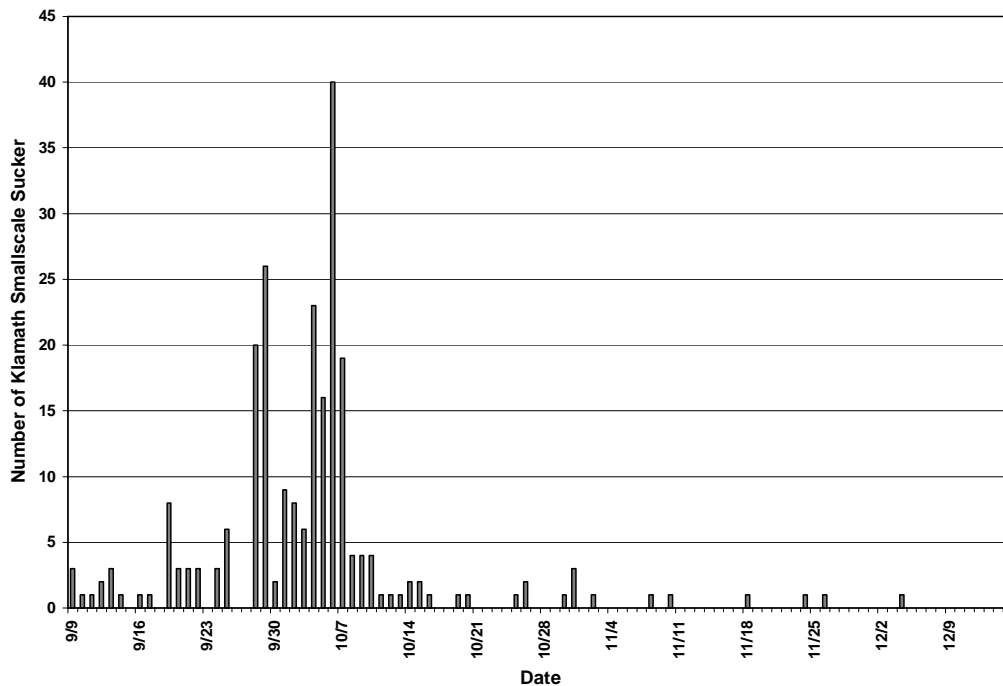


Figure 8. Number and timing of migration of Klamath smallscale sucker observed at the Shasta River Fish Counting Facility during the fall of 2002.

A total of 19 speckled dace (*Rhinichthys osculus*) were observed moving the SRFCF from 9 September to 5 October.

Flow

Flow data for the Shasta River was downloaded from the U.S. Geological Survey (USGS) gauge No. 11517500 located near the mouth of the Shasta River north of Yreka. Complete flow records are available for this gauge for water years 1934 through 1941 and 1946 through 2002. Flow data for the 2002 water year is still provisional at this time and may be subject to revision once these records have been finalized by the USGS. Annual flows in the Shasta River have ranged from a low of 56,299 AF in 1934 to a high of 263,128 AF in 1974 (Figure 9). The 2002 water year was very dry, yielding a total volume of only 89,021 acre-feet (AF).

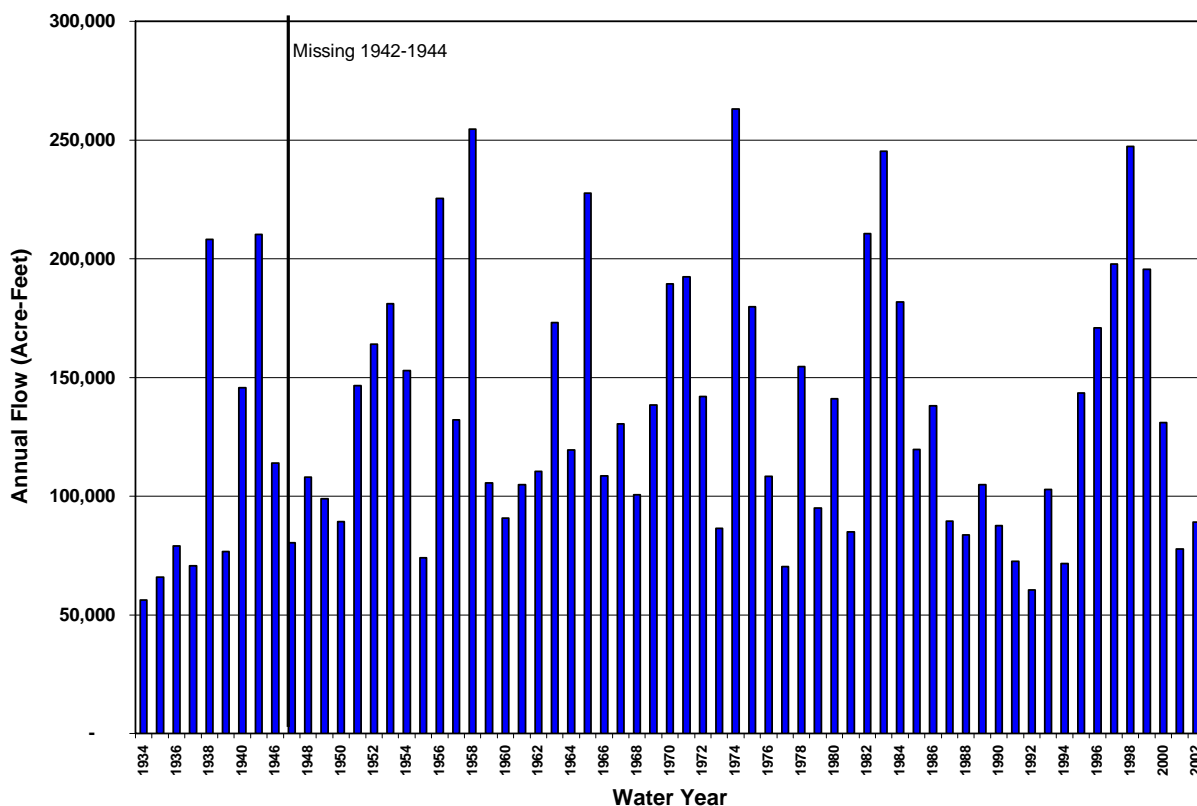


Figure 9. Annual Flows in the Shasta River near Yreka for 1934 to 1941 and 1945 to 2002. Data was obtained from the USGS Gauge No. 11517500. Flow data for the 2002 WY is Provisional at this time.

Agricultural diversions of Shasta River water ends on 1 October of each year. In September average daily flows in the Shasta River, recorded near Yreka, ranged from 15 to 44 cubic feet per second (cfs) and averaged 26 cfs. On 1 October the average daily flow increased to 74 cfs and by 2 October the average daily flow increased further to 118 cfs. In November flows ranged between 143 cfs and 193 cfs with an average daily flow for the month of 157 cfs. Several storm

fronts passed through the Yreka area during November and December which increased Shasta River flows as the ground became saturated. Average daily flows in December reflect the influence of these storms as maximum daily flows increased to 1,500 cfs by the end of the month. On 17 December, the last full day that the SRFCF operated, the average daily flow was 457 cfs. Large amounts of debris, rising water, and safety considerations forced the Department to remove the SRFCF on the morning of 18 December. The average daily flow for 18 December was 461 cfs. Figure 10 shows the average daily flow in the Shasta River from 1 September to 31 December.

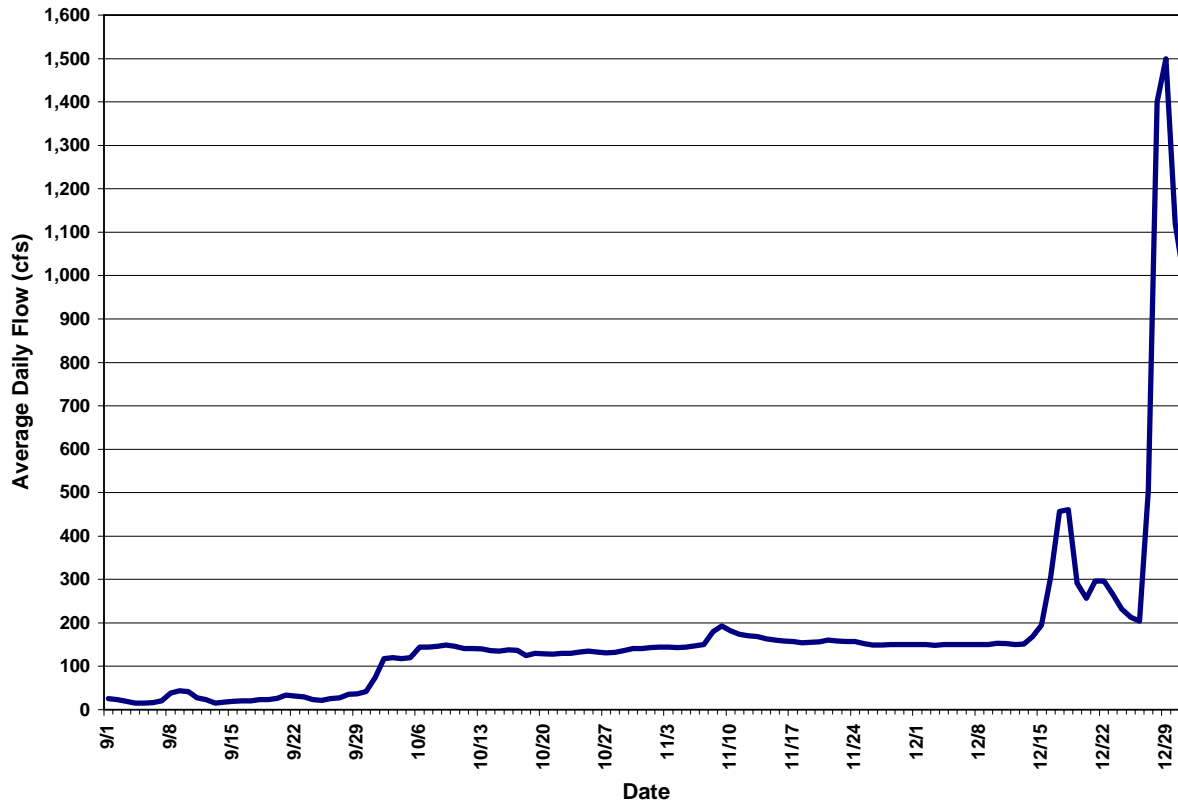


Figure 10. Average daily flows (cfs) in the Shasta River at USGS Gauge No. 11517500 from 1 September to 31 December, 2002. Data are provisional at this time and may be subject to revision.

Water Temperatures

The Department has been monitoring water temperatures at the mouth of the Shasta River, just below the SRFCF, to provide information for water temperature modeling efforts that are currently underway. The KRP was provided with this data for the period from 1 September to 22 October, 2002 (Figure 11). From 9 September through 22 October the average water temperature in the Shasta River ranged from 68°F (20.3°C) to 51°F (10.5 °C). Maximum water temperatures for the same period ranged from 75 °F (23.7 °C) to 54 °F (12.4 °C) and minimum water temperatures ranged from 63°F (17.5 °C) to 47°F (8.6 °C).

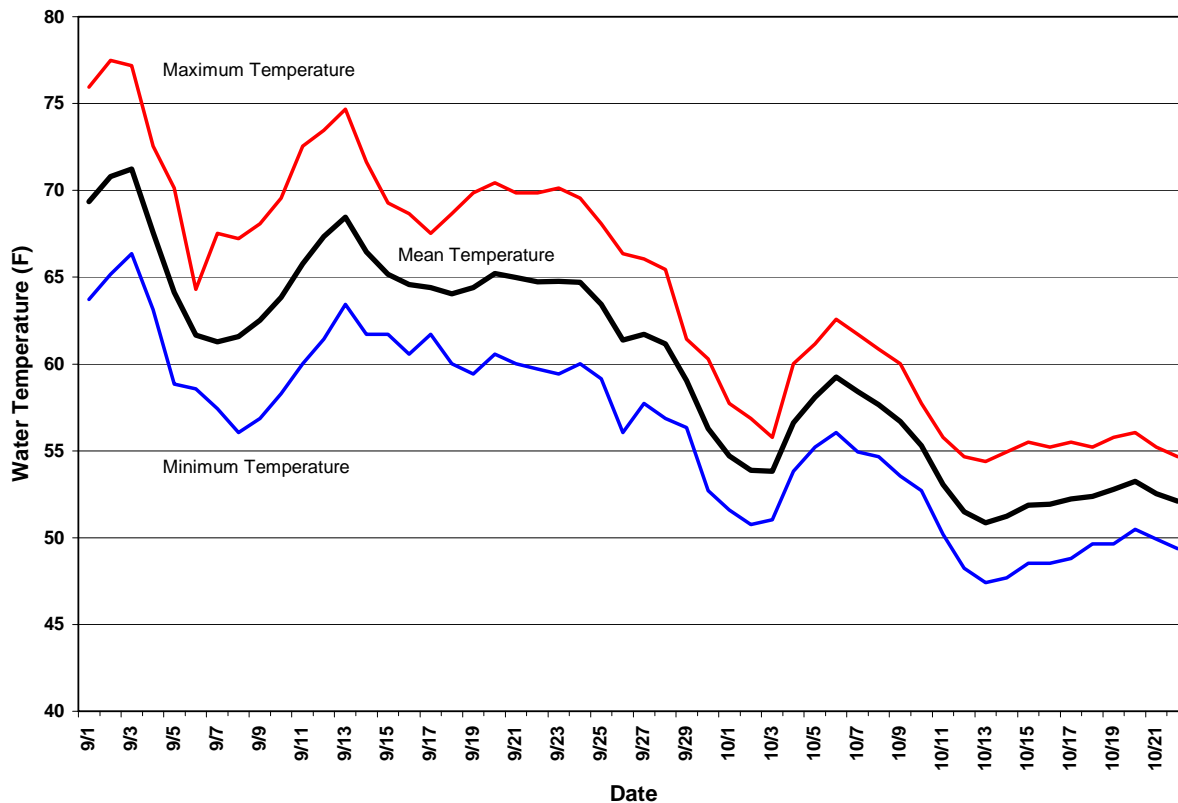


Figure 11. Water temperatures (Minimum, Maximum, and Mean) observed near the mouth of the Shasta River from 1 September to 22 October, 2002.

DISCUSSION

The pre-season estimate for the fall Chinook salmon run in the Klamath Basin was 132,600 fish. The actual run size estimate, as presented in the Department's Mega-Table dated 20 March 2003, was 169,297 fish. This includes a preliminary estimate of approximately 32,553 Chinook salmon that perished in the fish die off that occurred in the Lower Klamath River from 19 September until 27 September, 2002 (Department of Fish and Game 2003). Since 1978, the average annual run size of Chinook salmon in the Shasta River has averaged 5,678 fish. This 2002 run exceeds the average run size by 1,142 fish and ranks as the 9th most abundant run for the period of record from 1978 to 2002 (Figure 12). Shasta River Chinook salmon runs have ranged from a low of only 533 fish in 1990 to a high of 18,731 fish in 1978.

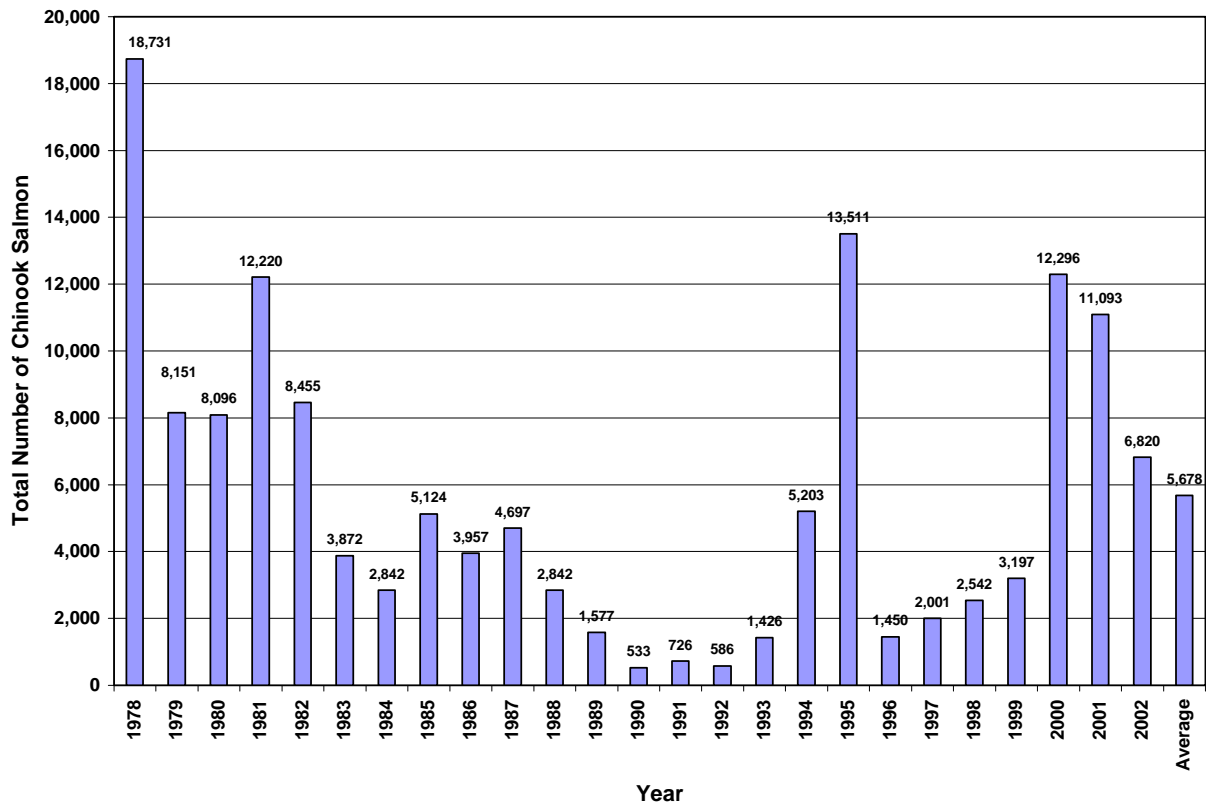


Figure 12. Chinook salmon run size estimates for the Shasta River from 1978 through 2002.

The peak of the Chinook salmon run occurred on September 28 when 853 Chinook salmon were counted at the weir. Up until this point it appeared that the 2002 spawning run would be similar to the 2001 run based on comparison of video run timing records for these two years (Figure 13). However, the numbers of salmon entering the Shasta River in 2002 declined appreciably during the first two weeks of October compared to the run timing observed in 2001. The decline in the numbers of salmon that entered the Shasta River during the first two weeks of October may be related to the large die off of Chinook salmon that was observed in the Lower Klamath River from September 19 to 27. Although it appears likely that many Shasta River Chinook salmon perished in the lower river fish die off, the total number of Chinook salmon that entered the Shasta River to spawn in 2002 exceeded the average annual run-size estimate by 1,142 fish. However, the 2002 Chinook salmon run contained 5,476 fewer fish than was observed in the 2000 run (12,296 fish) and 4,273 fewer fish than was observed in the 2001 run (11,093 fish). Based on these trends, and the similarity in run timing that was observed between the 2001 and 2002 Chinook salmon runs that entered the Shasta River through September 28th, it seems reasonable to assume that as many as 4,000 Shasta River Chinook salmon may have died in the lower river.

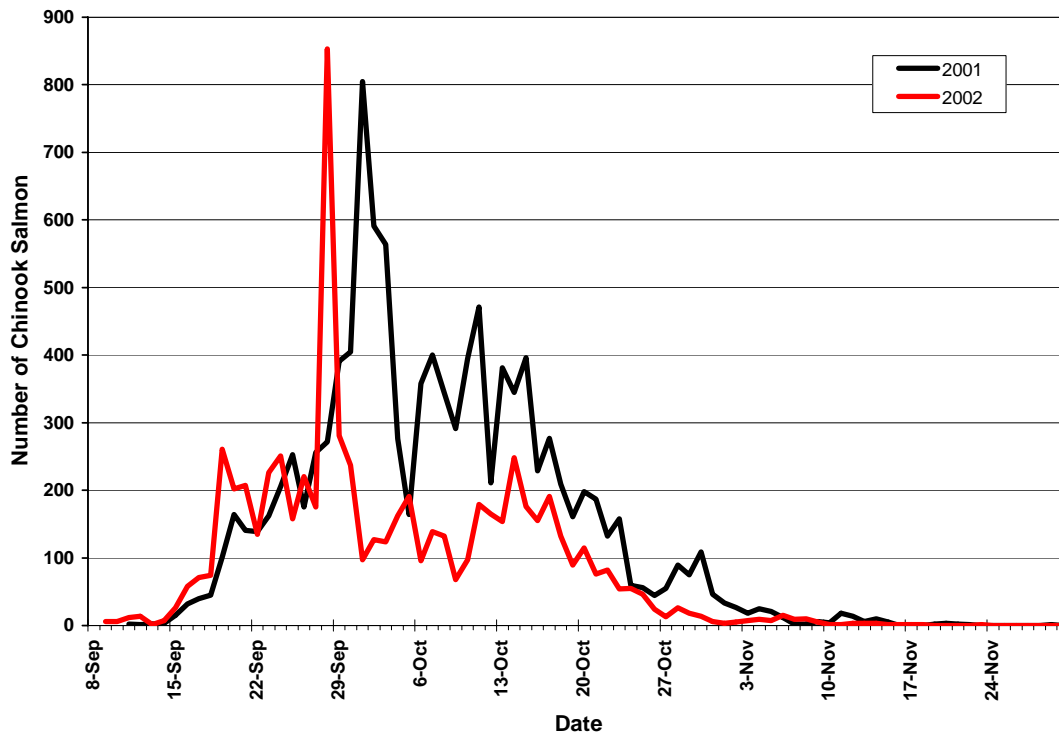


Figure 13. Comparison of the timing and number of Chinook salmon that returned to the Shasta River in 2001 (11,093 fish) and 2002 (6,820 fish).

As was discussed earlier in this report, the irrigation season in the Shasta River officially ends on 1 October of each year. In September, prior to the end of the irrigation season, average daily flows in the Shasta River ranged from a low of 15 cfs to a high of only 44 cfs. On 1 October, when irrigation diversions ceased, the average daily flow increased to 74 cfs and by 2 October flows increased further to 118 cfs. A total of 3,481 Chinook salmon, more than half of the entire run, had already entered the lower Shasta River prior to 1 October (Figure 14). Low flows hindered the ability of these fish to move upstream through the high gradient reaches that are common in the lower canyon. As a result, large numbers of salmon were forced to hold in the lower reaches of the river. Water temperatures during this same period reached as high as 75°F (23.7°C). Under these conditions, there was concern that another epizootic disease outbreak, similar to what occurred in the Lower Klamath River, could be repeated in the lower Shasta River. Fortunately, no signs of disease or pre-spawn mortalities were observed during the season. To reduce this potential threat in the future, additional consideration should be given to increasing flow levels in the lower Shasta River in a way that more closely coincides with Chinook salmon run timing. Additional flows would allow migrating Chinook salmon to disperse into the upper the river where conditions would be more favorable for holding salmon. This would reduce densities of holding Chinook in limited habitats and would reduce the likelihood of horizontal disease transmission that was so prevalent in the lower river fish die off.

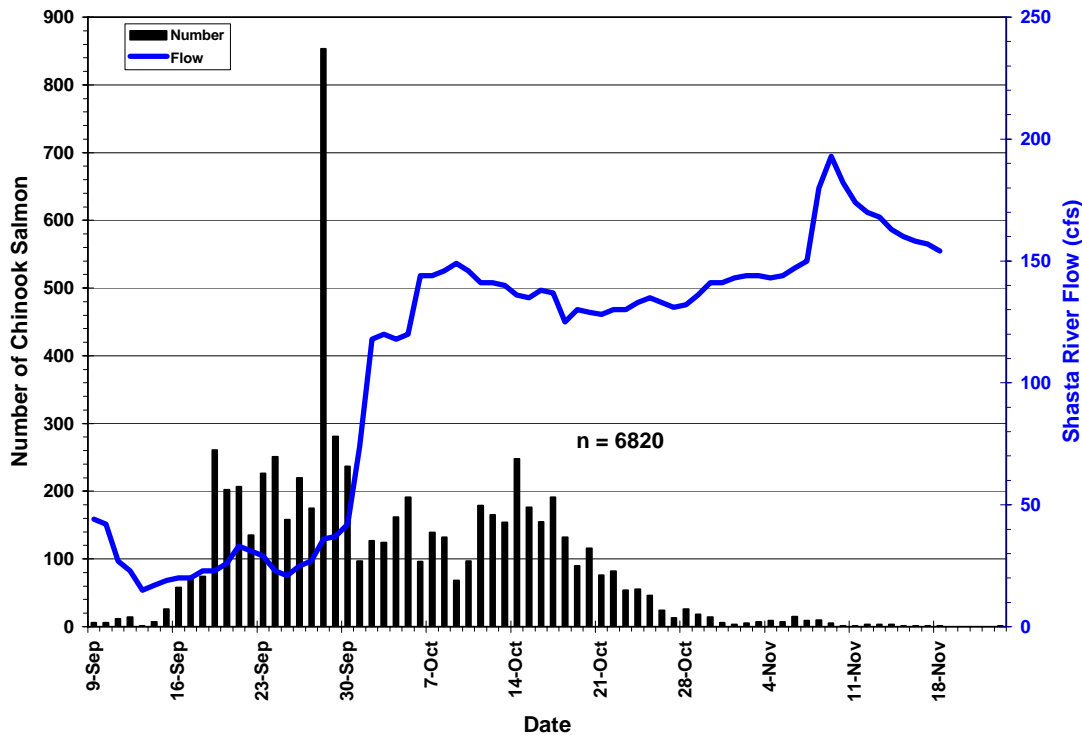


Figure 14. Run timing of Chinook salmon and average daily flows (cfs) that were observed in the Shasta River during 2002.

Since 1979 the KRP has operated the SRFCF with the primary purpose of monitoring the escapement of fall Chinook salmon entering the river. During the course of these efforts coho salmon have been observed passing through the facility on various occasions. Unfortunately, high flows, common during the coho migration period, have greatly compromised the ability to gather consistent data on coho salmon run sizes annually. Since 2001, the KRP has operated the SRFCF beyond the Chinook salmon migration period in an effort to better document coho salmon returns in the Shasta River. However, high flows and large volumes of debris have prevented the SRFCF from operating beyond mid December in both 2001 and 2002. Therefore, information on coho salmon runs in the Shasta River is incomplete and direct comparisons of coho numbers observed between years would not be appropriate. Regardless, the information is valuable and Table 1 provides a summary of coho salmon observations that have been recorded at the SRFCF since 1979.

Table 1. Number of coho salmon that have been observed at the SRFCF from 1979 through 2002.					
Year	# Coho	Last Day of Operations	Year	# Coho	Last Day of Operations
1979	355		1992	3	11/11/92
1981	418	1/6/82	1993	6	11/12/93
1982	263	2/28/83	1994	17	11/6/94
1983	36	1/19/84	1995	12	11/11/95
1984	69	11/19/84	1996	1	11/4/96
1985	3		1997	0	10/28/97
1986	0	11/3/86	1998	0	11/4/98
1987	0	10/12/87	1999	27	11/10/99
1988	3	11/2/88	2000	1	11/7/00
1989	6	10/21/89	2001	291	12/14/01
1990	2	10/28/90	2002	86	12/17/02
1991	9	11/11/91			

In 2002 the SRFCF was operated over a similar time as in 2001, and compared to 2001 the coho salmon run was substantially lower in 2002 than was observed in 2001. Numbers of coho salmon that may have entered the Shasta River after 14 December in 2001 and 17 December in 2002 are unknown however, it is likely that additional coho did enter the Shasta River after operation of the SRFCF ended in each of those years.

Unlike Chinook salmon, whose migration behavior appears more deliberate in nature, coho salmon movement appeared to be more closely associated with increasing flow and water turbidity levels associated with storm runoff. On two occasions during the 2002 season pulses of coho salmon were observed passing through the SRFCF coincident with increasing river flow and water turbidity (Figure 15). The first pulse of coho salmon (17 fish) was observed passing through the SRFCF from 5 November through 14 November. During this same time river flows increased from 147 cfs to 193 cfs and water clarity decreased in response to storm runoff. From 14 November until 3 December only 6 coho salmon were observed at the SRFCF. Movement of coho salmon began to increase on 4 December and on 9 December several storms passed through the area stimulating additional migration of coho salmon through the SRFCF. A total 48 coho salmon moved through the SRFCF between 10 December and 17 December.

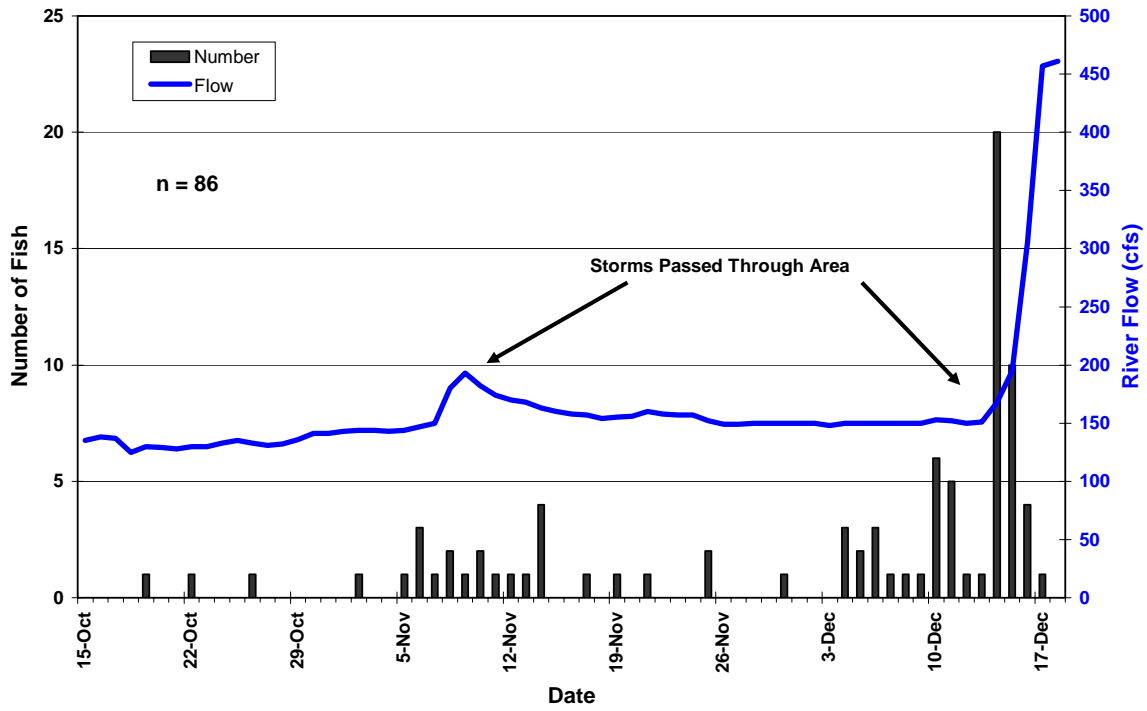


Figure 15. Sbasta River flow (cfs) and timing of coho salmon migration into the Shasta River during the 2002 season.