2016 SCOTT RIVER SALMON STUDIES

FINAL REPORT

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ABSTRACT

The California Department of Fish and Wildlife's (Department) Klamath River Project (KRP) operated a video/SONAR fish counting facility and conducted cooperative spawning ground surveys (carcass surveys) on the Scott River during the 2016 fall-run Chinook Salmon (Chinook, *Oncorhynchus tshawytscha*) and Coho Salmon (Coho, *Oncorhynchus kisutch*) spawning season. The purpose of these surveys is to describe the run characteristics of adult Chinook Salmon and Coho Salmon into the Scott River. Fish counting operations began on September 22, 2016, and ended on December 13, 2016, due to high river flows.

The total number of Chinook Salmon that entered the Scott River during the 2016 season is estimated to be **1,515** fish. Based on the proportion of male and female Chinook Salmon that were sampled during the spawning ground surveys, the run was comprised of approximately 602 (39.7%) males and 913 (60.3%) females. Based on scale age analysis, adults comprised approximately 90.9% (1377 fish) and grilse comprised 9.1% (138 fish) of the run. Males ranged in fork length (FL) from 44 cm to 95 cm and averaged 77.2 cm. Females ranged in FL from 49 cm to 91 cm and averaged 74.4 cm. KRP staff estimated that 39 (2.6%) of the Chinook Salmon that returned were of hatchery origin.

The first adult Coho Salmon was observed at the Scott River Fish Counting Facility (SRFCF) on October 22, 2016, and the last Coho Salmon was observed on December 7, 2016. A net total of **226** Coho Salmon were observed moving upstream through the SRFCF during the season. No additional Coho were estimated in the main stem or tributaries downstream of the SRFCF. Based on the proportion of male and female Coho Salmon that were sampled during the season, the run was comprised of approximately 51 (22.7%) males and 175 (77.3%) females. Based on observed carcasses, adults comprised approximately 100% (226 fish) and grilse comprised 0% (0 fish) of the run. Males ranged in FL from 62 cm to 68 cm and averaged 65.0 cm. Females ranged in FL from 60 cm to 69 cm and averaged 64.8 cm. Based on observed carcasses, none of the Coho Salmon were estimated to be of hatchery origin.

INTRODUCTION

STUDY LOCATION AND RUN TIMING

The Scott River is a major tributary of the Klamath River, located in Siskiyou County, and enters the Klamath River at river mile 143 (Figure 1). The Scott River Fish Counting Facility (SRFCF) is located at river mile 18.2 near the downstream edge of Scott Valley between the Indian Scotty Campground and Jones Beach picnic area (041º 38' 10.93" N; 123º 04' 3.08"W). Chinook Salmon typically return to the Scott River to spawn from mid-September to late-December. The Coho Salmon spawning run typically occurs from mid-October to early January, and steelhead run from November to April.

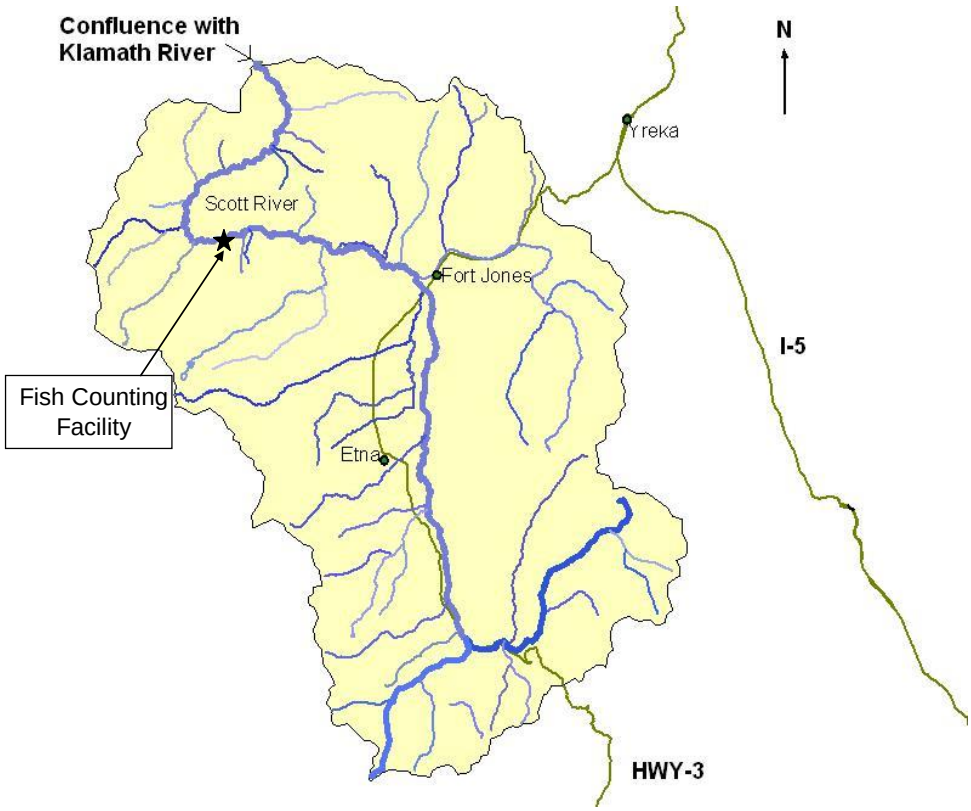


Figure 1. Location of the Scott River, tributary to the Klamath River, Siskiyou County, California.

KLAMATH RIVER PROJECT AND THE SCOTT RIVER STUDY

The Scott River study is one component of the Klamath River Project (KRP) (initiated in 1978). The goals of the KRP include obtaining information on species composition, hatchery composition, run timing, age structure, spawning distribution, fork length (FL) frequency and sex ratios in various tributaries to the Klamath River including the Salmon, Scott, and Shasta rivers, as well as Bogus Creek and 22 other smaller tributaries. The Scott River is particularly important because it is a major salmon spawning tributary. For example, during the 1996-1998 spawning seasons, an average of 30.6% (8,914) of the total number of natural area Klamath

River adult Chinook Salmon spawners above the Trinity River confluence were estimated to have entered the Scott River to spawn. Therefore, a significant portion of natural escapement to the Klamath Basin would be unaccounted for if the Scott River studies were not conducted. In addition to providing valuable escapement estimates to the Pacific Fisheries Management Council for the effective management and allocation of fall Chinook Salmon originating from the Klamath River Basin, the Scott River studies provide an opportunity to monitor an independent population of Coho Salmon (Williams et al. 2008) within the State- and federally listed Southern Oregon/Northern California Coast (SONCC) Coho Salmon range.

In the early years of the KRP, spawning ground surveys were conducted in the major spawning areas of the main stem Scott River which included an approximately 5.5 mile reach near Etna and a 4.75 mile reach downstream of the State Highway 3 Bridge crossing near Fort Jones. From 1989 through 1991 spawning ground surveys were limited to the lower river. In 1985 a temporary fish marking weir was installed on the lower river at river mile 1.6 and was operated during each spawning season until 1991. Operation of the weir was often hampered by high flows, and beginning in 1992, operation of the weir was dropped in favor of conducting more intensive mark recapture spawning ground surveys in cooperation with US Forest Service (USFS) fisheries staff.

In 1994 the California State Legislature passed the Leslie Amendment (SB 779). The passage of SB 779 required Departmental staff to obtain landowner permission prior to accessing private lands to conduct biological investigations. As a result, since 1994, spawning ground surveys have been limited to those areas of the river on private land where landowner permission has been granted. The entire length of the Scott River within the Scott Valley (above river mile 24) passes through private ownership. The level of cooperation from local landowners has varied over the years. Controversies associated with the listing of SONCC coho salmon under the California Endangered Species Act (CESA) and other regulatory actions have reduced the amount of cooperation provided by local landowners to the extent that the Department has been denied permission to survey a large portion of the salmon spawning reaches present in the Scott Valley. As a result of the limited landowner access to the valley reaches, the Department proposed installation of a fish counting facility to be located at the upper end of the canyon reach. The location of the fish counting station allows for monitoring fish abundance into the valley while Cormack-Jolly-Seber mark recapture carcass-based estimates are conducted in the areas downstream of the counting station. The counting facility is also located upstream of several tributaries that can produce significant fall and winter stream flows, thereby reducing the probability of having the counting facility inoperable due to high flow events. Beginning in the 2014 season, the Department has exercised its authority under the navigability statute to access the Scott River adjacent to private lands in the lower 18.2 river miles (downstream of the counting facility).

SCOTT RIVER STUDY OBJECTIVES SUMMARIZED:

A. Determine the in-river run size (escapement) of Chinook Salmon and Coho Salmon returning to the Scott River.

B. Determine run timing, spawning distribution, length frequency (FL) distribution, and sex ratio for Chinook Salmon and Coho Salmon in the Scott River.

C. Collect scale samples from carcasses and look for hatchery marks to determine age composition and hatchery contribution rates of the run.

D. Collect biological data for all steelhead observed during the Chinook Salmon and Coho Salmon spawning seasons.

METHODS

OPERATION OF THE SCOTT RIVER FISH COUNTING FACILITY

The video fish counting system was installed at the Scott River Fish Counting Facility on September 22, 2016, at 1200 hours Pacific Standard Time (PST). A temporary weir (Alaskan weir design) was installed to direct migrating fish into a flume where they pass in front of a video camera (Figure 2). The underwater video system consisted of a digital black and white video camera, water proof camera housing, viewing window, and counting flume which allowed for recording unimpeded fish passage through the facility. The facility was operated 24 hours a day, seven days a week, during the Chinook Salmon and Coho Salmon migration. A Splash Cam digital black and white video camera equipped with a 3.6mm wide angle lens with an auto iris was used to collect the photo image and an Ever Focus Digital Video Recorder (Model ECOR 264) was used to record the image to external hard drives. The time lapse DVR was set to record continuously and drive changes were made at least twice a week.

Figure 2. Scott River Fish Counting Facility located in Siskiyou County, California, 2016.

All hard drives were immediately returned to the office where each was subsequently downloaded and reviewed by project staff in the video lab. During each review staff recorded the date, time (hour:min:sec), and species of each fish observed on each video image. If the species could not be determined due to poor visibility or picture quality, staff recorded that observation as species unknown. Staff also noted any ad-clipped fish observed and recorded the presence of lamprey and any other distinguishable marks that were visible on the image. All data was then entered into computer files and each data file was subjected to one independent review prior to commencement of data analysis. During periods of high flow when the video camera was inoperable, an ARIS SONAR camera was installed to estimate the total number of adult salmonids. The ARIS camera is unable to determine species composition, and as a result, species apportionment was estimated by averaging the known species composition observed from videography three days prior and three days after the ARIS total count was observed.

SPAWNING GROUND SURVEYS

Spawning ground surveys on the Scott River main stem were conducted twice a week on Mondays and Thursdays and opportunistically in main stem tributaries downstream of the counting facilities throughout the salmon spawning season starting October 10, 2016 and ending December 12, 2016. A total of 85 surveys were performed during the spawning season (Appendix 1). Additional surveys were conducted upstream of the counting facility in the main stem and select tributaries during the coho period and are reported by the Siskiyou Resource Conservation District (Magranet 2017). On the morning of each survey, crews of at least two people each were given daily instructions, data sheets, field equipment, vehicle assignments, and each crew was assigned a survey reach. Crews walked their assigned reach in a downstream direction looking for salmon carcasses and spawning redds. All new redds were flagged and mapped on USGS topographic maps, and the information was provided to the Klamath National Forest. All carcasses recovered were identified to species and gender, checked for marks or tags, measured (FL); a scale sample was collected for age composition analysis, and females were examined for spawning success.

For purposes of the mark recapture estimate, each carcass was categorized into one of four pathways (Paths). Fresh carcasses, those with clear eyes and/or firm flesh were designated as Path 1. Individually numbered jaw tags were attached to the lower right jaw of all Path 1 carcasses and returned to the river for potential recapture during later surveys. Older carcasses, those with two cloudy eyes and/or mushy flesh, were categorized as Path 2. All Path 2 carcasses were cut in half and returned to the river after all biological data was collected. Path 3 carcasses included all of the Path 1 carcasses (with jaw tag) that were recaptured during subsequent surveys. Path 3 carcasses were returned to the river for subsequent future recapture. Therefore, Path 3 carcasses could be recaptured multiple times. Path 3 carcasses were returned to the river for future recapture as long as the adipose fin clip determination could still be made with confidence. Once an adipose fin had deteriorated to the point that adipose fin clip determination couldn't be made with confidence, the survey tag was removed and the carcass was chopped in half and removed from the mark recapture experiment. Any carcasses that could be observed by a survey crew but could not be retrieved for data collection because they were located in inaccessible or unsafe locations, were designated as Path 4.

Unfortunately during 2016, extreme low numbers of carcasses were recaptured in the spawning ground survey below the counting facility which prevented the use of the Cormack-Jolly-Seber (CJS) model (Bergman et al. 2012) to estimate total in this area. As a result, the adult Chinook abundance below the counting facility was estimated by multiplying the total number of redds observed during the Chinook period by two. The grilse component from the redd survey was then added back into the total (total run= adults/(1-%grilse). The grilse proportion was estimated from aged scale samples collected during the spawning ground survey.

SURVEY REACHES

Survey reaches have remained fairly consistent since the beginning of the cooperative spawning ground survey in 1992. During the Chinook Salmon spawning season, decisions regarding which reaches should be surveyed were based on the known distribution of the Chinook Salmon run each week, the available labor force present during each survey, and reach specific stream conditions.

A total of 16 survey reaches, covering approximately 53.6 river miles, have been identified on the Scott River (Table 1; Figure 3). Access to private lands along the Scott River is critically important to the survey in those spawning areas that are present in Scott Valley. Historically, the highest observed densities of Chinook salmon spawning areas within Scott Valley were located downstream of the State Highway 3 Bridge crossing (river mile 34.6) to the USGS gauging station located at river mile 21 (Reaches 8, 9, and 10), and in that part of the river located downstream of Young's Dam, (river mile 46 to about river mile 42) located upstream of the Eller Lane Bridge crossing (Reaches 12, 13, and 14).

To assist in developing stock identification baseline information the KRP collected both genetic tissue and otolith samples during the season. Tissue samples were collected for future DNA analysis from 49 Chinook Salmon and 21 Coho Salmon. Tissue was collected from the first Chinook from each reach and each survey date and all Coho Salmon for which samples could be collected. All samples were collected following protocols provided by the National Oceanic Atmospheric Administration's (NOAA) Southwest Fisheries Science Center. Samples were sent to the Salmonid Genetic Tissue Repository located at the NOAA Santa Cruz Laboratory for archiving and analysis. Otoliths were collected from 49 Chinook Salmon and 21 Coho Salmon; otoliths were collected from the first Chinook from each reach and each survey date and all Coho Salmon for which samples could be collected. All otoliths collected were archived for future microchemistry analysis. All otolith samples were collected following standard protocols described by Stevenson (1992).

POPULATION ESTIMATE

The Chinook Salmon spawner escapement for the area of the Scott River upstream of the counting facility was derived from a direct count of all Chinook Salmon observed at the counting facility. To estimate adult escapement in the Scott River downstream of the counting station, the number of Chinook Salmon redds were multiplied by 2 (utilizing data from Reach 1 through Reach 6 only). The grilse component below the counting facility was estimated using the following equation: total run= adults/(1-%grilse). To estimate total Chinook escapement the number of Chinook from downstream and upstream of the counting station were summed.

The Coho Salmon spawner escapement for the area of the Scott River upstream of the counting facility was also derived from a direct count of all Coho Salmon observed at the counting facility. Spawning ground surveys were conducted through December 12, 2016, in the main stem and tributaries (Tompkins Creek, Kelsey Creek, and Canyon Creek) below the counting facility. To estimate total adult Coho Salmon escapement in the Scott River, the number of observed Coho Salmon redds downstream of the counting station (zero in 2016)

Table 1. Description of cooperative spawning ground survey reach locations along the Scott River during the 2016 season.

Reach Number	Downstream Limit	RM	Upstream limit	RM	Length (miles)
1	Mouth	0.00	Mid Point	2.60	2.60
2	Mid Point	2.60	Pat Ford Ck	4.90	2.30
3	Pat Ford Ck	4.90	George Allen Gulch	7.80	2.90
4	George Allen Gulch	7.80	Townsend Gulch	10.50	2.70
5	Townsend Gulch	10.50	Bridge Flat	14.20	3.70
6	Bridge Flat	14.20	Counting Weir	18.20	4.00
7	Counting Weir	18.20	USGS Stream Gage	21.00	2.80
8	USGS Stream Gage	21.00	Meamber Bridge	24.40	3.40
9	Meamber Bridge	24.40	Dunlop	29.50	5.10
10	Dunlop	29.50	Highway 3 Bridge	35.60	6.10
11	Highway 3 Bridge	35.60	Eller Lane	41.10	5.50
12	Eller Lane	41.10	Sweezy Bridge	42.10	1.00
13	Sweezy Bridge	42.10	Horn Lane	43.90	1.80
14	Horn Lane	43.90	Young's Dam	46.00	2.10
15	Young's Dam	46.00	Fay Lane	49.60	3.60
16	Fay Lane	49.60	East Fork Confluence	53.60	4.00

were multiplied by two in order to estimate the number of adult coho (assuming two unique individuals participated in the construction of each redd) and were added to the count of all coho salmon observed passing through the SRFCF. The grilse component below the counting facility was estimated using the following equation: total run= adults/(1-%grilse). No Coho redds were identified downstream of the counting station during 2016 so the number of Coho observed at the counting station represented the total.

HATCHERY CONTRIBUTION RATES

The hatchery contribution rates for Chinook and Coho have been estimated both through the recovery of carcasses and through reviewing fish images observed at the fish counting facility. During the 2016 season, hatchery contribution rates were based on collection of data from observed carcasses for Chinook Salmon and Coho Salmon. The hatchery contribution rate of Chinook Salmon was derived by multiplying the number of CWTs observed for each CWT group by its production multiplier value (the inverse of the proportion of each group of juveniles that were tagged). An additional sample expansion (the inverse of the number of fish handled during spawning ground surveys divided by the total estimated) was applied.

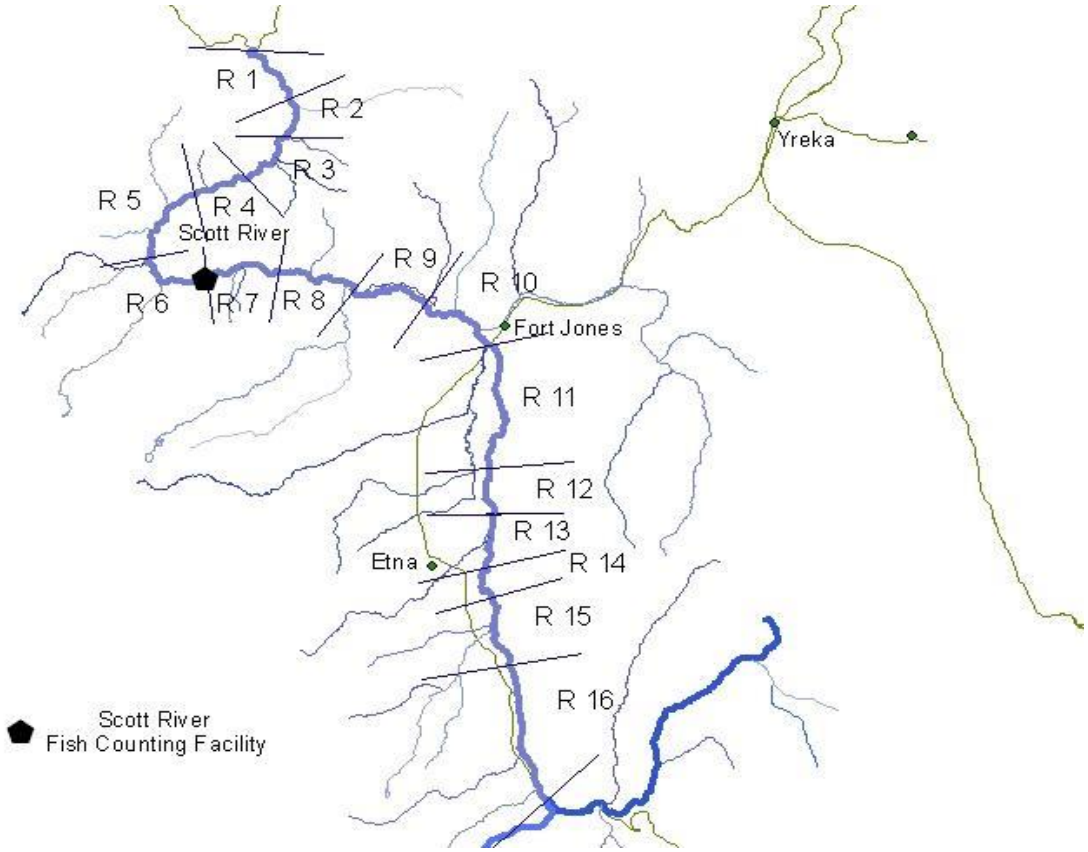


Figure 3. Location of the fish counting facility and spawning ground survey reaches on the Scott River used during the 2016 field season.

RESULTS

OPERATION OF THE SCOTT RIVER FISH COUNTING FACILITY

The Scott River Fish Counting Facility (SRFCF) began recording fish movements on September 22, 2016. The first Chinook Salmon was observed at the SRFCF on October 6, 2016, and the last Chinook Salmon was observed on December 2, 2016. The run peaked between October 10, 2016, and October 22, 2016, when 73.6% of the Chinook migration was observed (Figure 4). About half (57.5%) of Chinook Salmon passed through the SRFCF during daylight hours and peaked in the afternoon between 1600 and 1700 hours (Figure 5).

A net total of 372 Chinook Salmon were estimated to have passed through the SRFCF during the 2016 season (399 upstream and 27 downstream) when videography was employed. During periods of high flows, KRP operated an ARIS (SONAR) camera on three occasions (26 days) during the season and estimated an additional 757 Chinook (Table 2). Twenty-three Chinook were included in the total as an expansion for periods of time (75 hours) on two occasions when neither camera (video or SONAR) was functioning (Table 3).

SPAWNING GROUND SURVEYS

A total of 155 Chinook carcasses were sampled during the spawning ground survey as Path 1 or Path 2 carcasses. Of these, 62 (39.7%) were male and 94 (60.3%) were female. Males ranged in FL from 44 cm to 95 cm and averaged 77.2 cm (Figure 6). Females ranged in FL from 49 cm to 91 cm and averaged 74.4 cm (Figure 7). One ad-clipped Chinook was observed during the spawning ground survey effort and was recovered in Reach 14. This one ad-clipped fish was an age 3 (2013 BY) TRH fall fingerling release. After expanding for production (4.08) and sampling (8.83), this single recovery expanded to 39 fish yielding a total estimated hatchery composition of 2.6% (Table 4). After examination of the length frequency distribution and scale age analysis of Path 1 and Path 2 carcasses, a maximum grilse cut-off of < 58 cm was established for Scott River Chinook. Due to high flows during the spawning season multiple surveys were canceled due to unsafe survey conditions (Appendix 1).

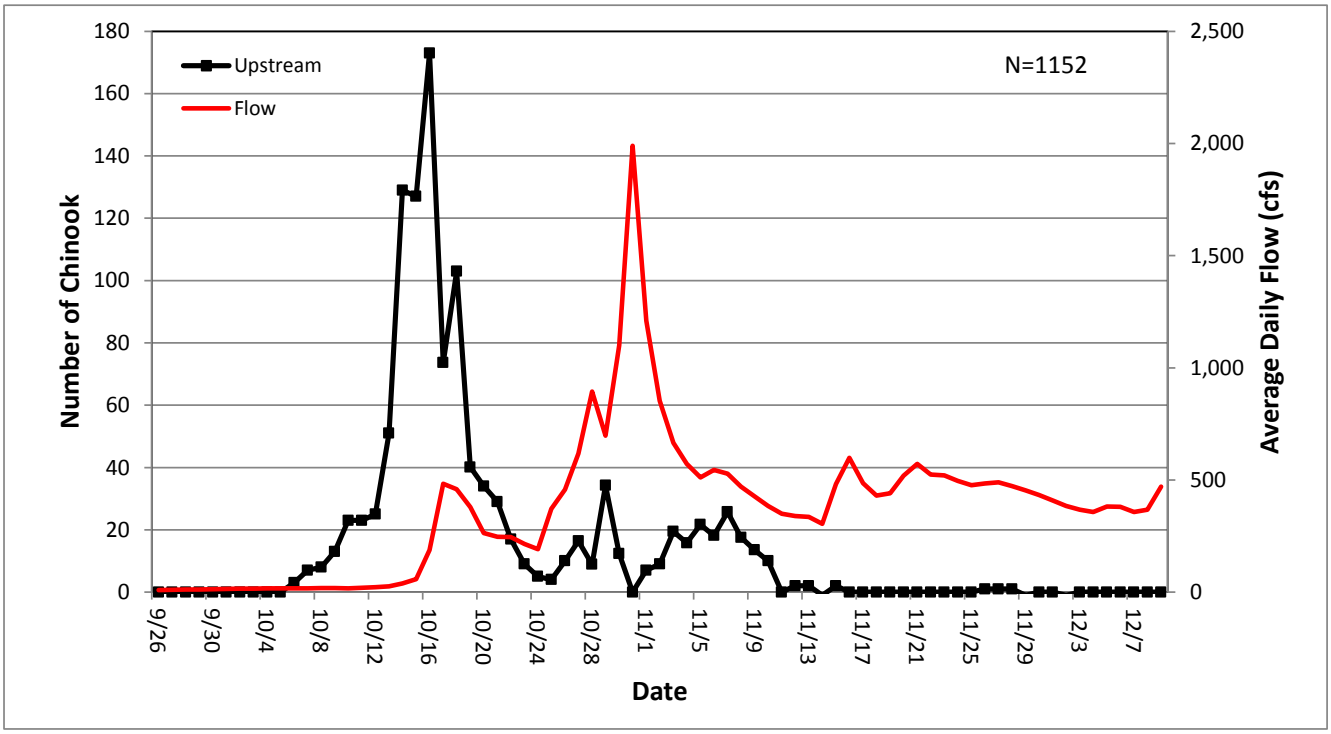


Figure 4. Run timing of Chinook Salmon through the Scott River Fish Counting Facility during the 2016 season (N=1152), and average daily flows observed at USGS Gauge No. 11519500.

A total of 94 Path 1 and Path 2 Chinook Salmon female carcasses were observed during the spawning ground survey. Each female carcass was examined to determine if it had successfully spawned prior to death. Spawning status was defined as un-spawned (many eggs remaining in the body) or spawned (few or no eggs remaining). Of the 94 female Chinook Salmon carcasses examined, 86 females (91.5%) were found to have spawned, and 8 females (8.5%) were identified as un-spawned.

In 2016 the CJS mark recapture data collected during the spawning ground survey was analyzed for Reaches 1-6 only. Due to inconsistent results, a lack of marks and recaptures in the mark recapture study (M=16; C=10; R=1), the use of the CJS mark recapture method to estimate carcass abundance (downstream of the weir) was not possible. Model 3 and Model 6 which were rated equivalent in the analysis resulted in point estimates of 73 and 745,

respectively, a difference in magnitude of 10 times. Therefore, the lower river abundance estimate was derived utilizing data generated from the redd survey. A total of 165 Chinook salmon redds were observed in Reaches 1 through 6 below the counting facility. Multiplying the season total redd count by 2 generates an estimate of 330 adults. Utilizing the formula total run=adults/(1-%grilse) generates a sub area total of 363 Chinook: 330 adults and 33 grilse. The total Chinook Salmon run size estimate of **1,515** Chinook was generated by summing the video estimate (1,152) and the Redd survey estimate (363). Based on scale age analysis, adults comprised approximately 90.9% (1,377 fish) and grilse comprised 9.1% (138 fish) of the run (KRTAT 2017).

Table 2. Specific dates and times during the 2016 season when ARIS filming started and stopped, the number of hours the ARIS was used each day, and the number of Chinook, Coho, and steelhead estimated during that time.

	Date	Time	Number of hours : minutes	Number of Chinook estimated	Number of Coho estimated	Number of Steelhead estimated
ARIS Started	10/14/2016	1030	13 : 30	67	0	0
	10/15/2016		24 : 0	127	0	0
	10/16/2016		24 : 0	172	0	0
	10/17/2016		24 : 0	74	0	14
	10/18/2016		24 : 0	103	0	20
ARIS Stopped	10/19/2016	1100	11 : 0	25	0	5
Sub Total				568	0	39
ARIS Started	10/27/2016	1300	11 : 00	14	0	7
	10/28/2016		24 : 0	9	0	4
	10/29/2016		24 : 0	34	0	16
	10/30/2016		24 : 0	12	0	6
	10/31/2016		24 : 0	0	0	0
ARIS Stopped	11/1/2016	800	8 : 0	0	0	0
	11/2/2016					
ARIS Started	11/3/2016	1100	11 : 0	13	6	4
	11/4/2016		24 : 0	16	7	4
	11/5/2016		24 : 0	22	9	6
	11/6/2016		24 : 0	18	8	5
	11/7/2016		24 : 0	26	10	7
	11/8/2016		24 : 0	18	8	5
ARIS Stopped	11/9/2016	1030	10 : 30	4	2	1
Sub Total				186	50	65
ARIS Started	11/18/2016	1030	13 : 30	0	3	1
	11/19/2016		24 : 0	0	6	2
	11/20/2016		24 : 0	0	8	3
	11/21/2016		24 : 0	0	7	2
	11/22/2016		24 : 0	0	10	3
	11/23/2016		24 : 0	0	11	3
	11/24/2016		24 : 0	0	2	2
	11/25/2016		24 : 0	1	4	4
	11/26/2016		24 : 0	1	4	4
	11/27/2016		24 : 0	1	4	4
ARIS Stopped	11/28/2016	1330	13 : 30	0	1	1
Sub Total				3	60	29
Totals				**757**	**110**	**133**

Table 3. Specific dates and times during the 2016 season when no filming (video or ARIS) occurred the specific time data collection stopped and re-started, the number of hours without data and the number of Chinook, Coho, and steelhead estimated during that time.

	Date	Time	Number of hours : minutes without data	Number of Chinook estimated	Number of Coho estimated	Number of Steelhead estimated
Filming Stopped	11/1/2016	800	16:00	7	2	3
	11/2/2016		24 : 0	9	4	3
Filming Started	11/3/2016	1100	11:00	6	3	2
Filming Stopped	11/15/2016	1200	12:00	1	6	2
Filming Started	11/16/2016	1200	12:00	0	4	2
Totals			75:00	23	19	12

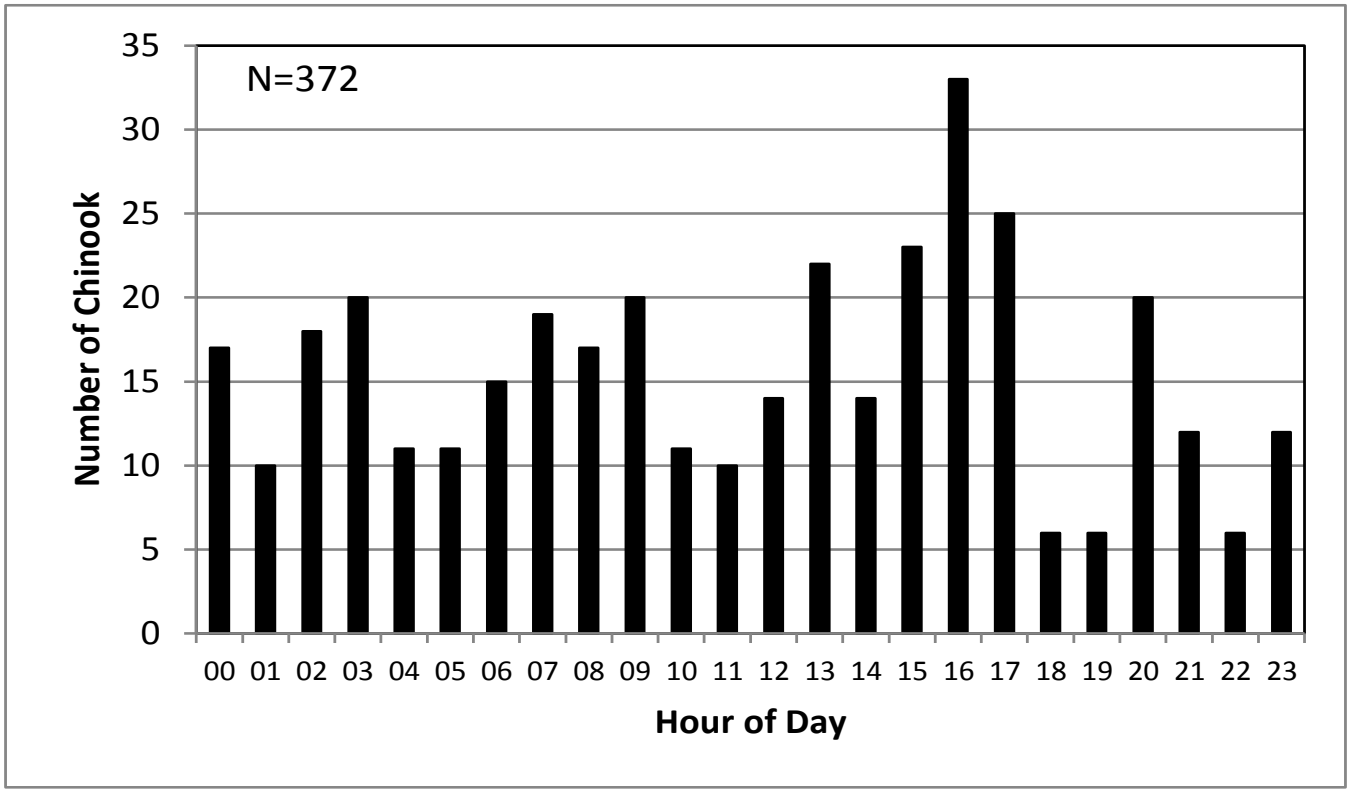


Figure 5. Summary of daily run timing of Chinook Salmon observed at the Scott River Fish Counting Facility during 2016 (N=372).

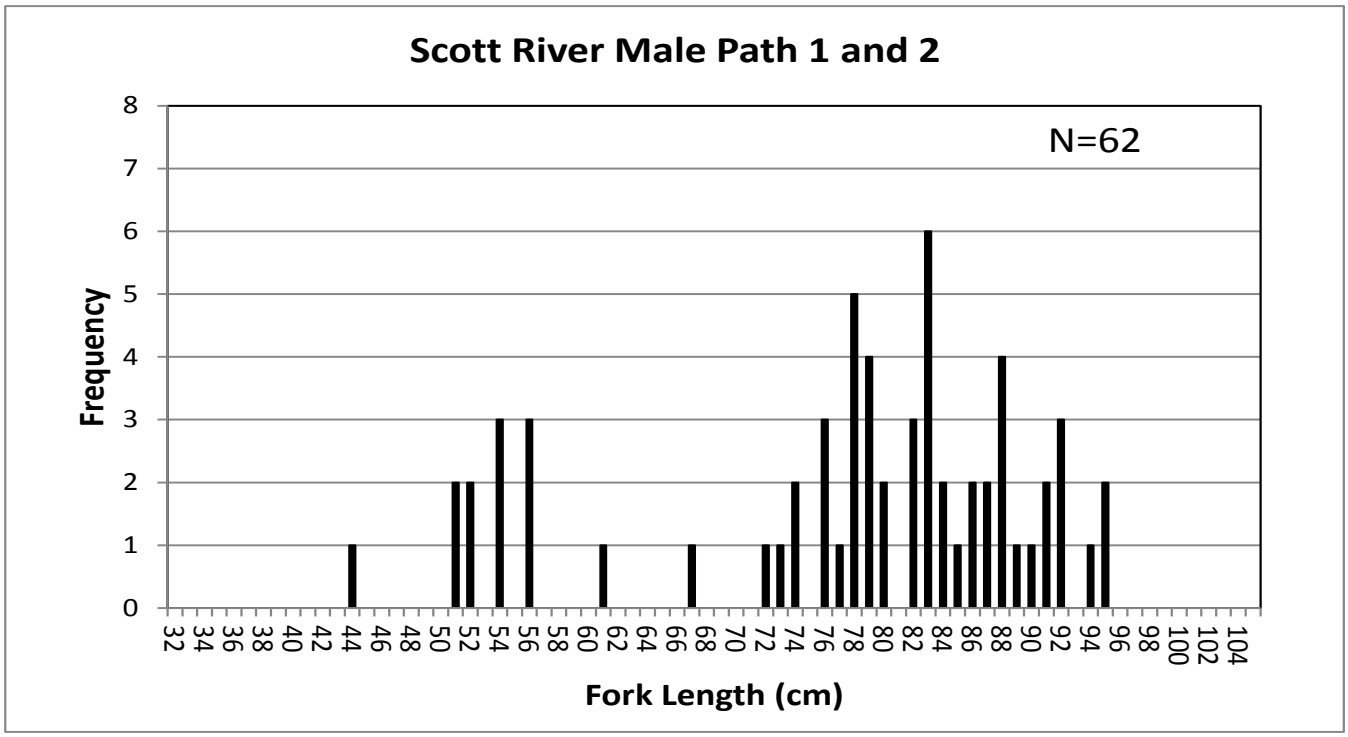


Figure 6. Length Frequency distribution of Path 1 and Path 2 male Chinook Salmon observed during spawning ground surveys in the Scott River, 2016 (N=62).

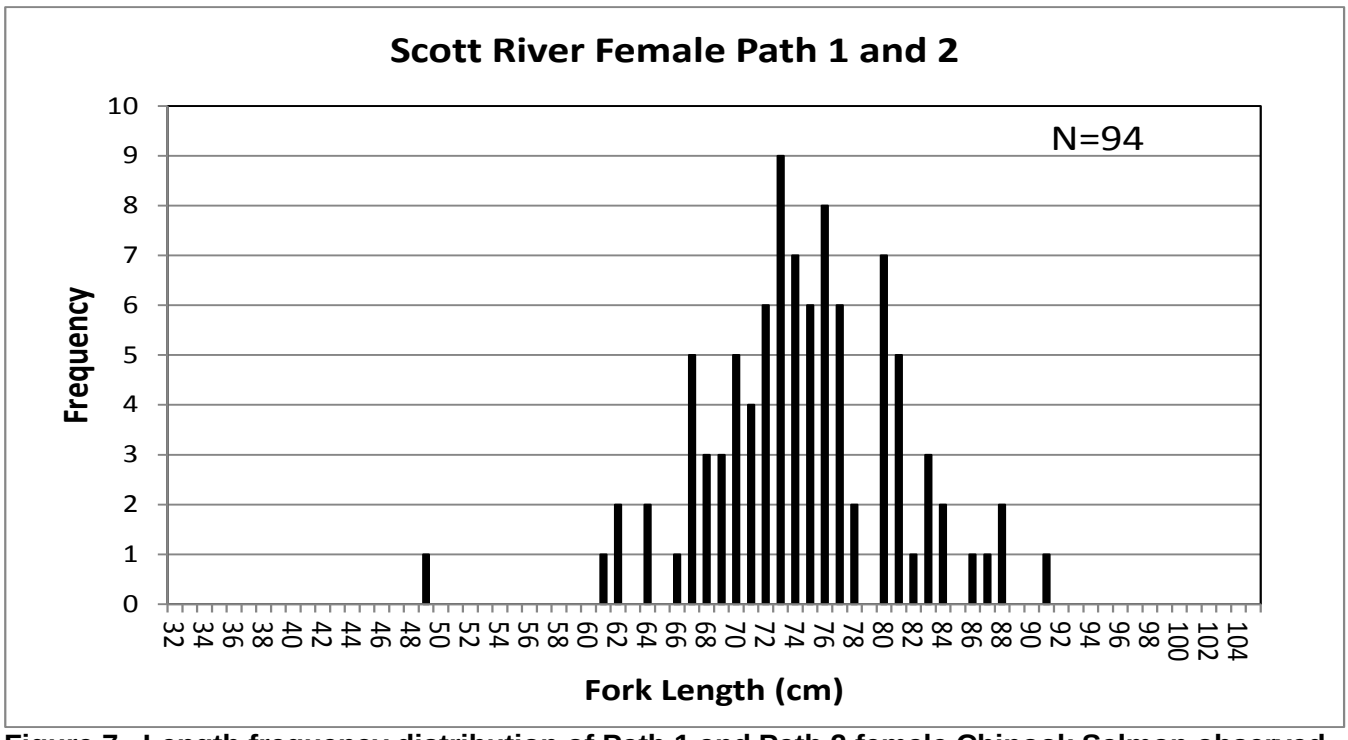


Figure 7. Length frequency distribution of Path 1 and Path 2 female Chinook Salmon observed during spawning ground surveys in the Scott River, 2016 (N=94).

Table 4. Estimated contribution of hatchery origin fall Chinook Salmon in Scott River, 2016.

Spawning Ground Surveys									
Coded Wire Tag	Location	Release Type	Brood Year	Age	Sample Number	Production Multiplier	Production Estimate	Sample Expansion	Total Estimate
60611	TRH	Ff	2013	3	1	4.08	4	9.53	39
				Sub Total=	1			Sub Total=	39
Estimated contribution of lost CWT's					0			Sub Total=	39
							Total Estimated Hatchery Contribution=		**39**

a/ Release type; Ff=Fall fingerling, Fy=Fall Yearling
b/ Production Multiplier value is the inverse of the proportion of effectivily tagged and total release

COHO SALMON

The first adult Coho Salmon was observed at the counting facility on October 22, 2016, and the last Coho Salmon was observed on December 7, 2016 (Figure 8). A net total of 97 Coho Salmon (109 upstream and 12 downstream) were observed moving through the SRFCF when videography was employed. During periods of high flows, KRP operated an ARIS (SONAR) camera on three occasions (26 days) during the season and estimated an additional 110 Coho (Table 2). Nineteen additional Coho were added for periods of time (75 hours) in which neither camera was functioning properly (Table 3). Coho Salmon migration peaked following a 2,000cfs flow event during an October 31, 2016 storm. During a 21-day period from November 2, 2016 through November 23, 2016 76.2% of the coho (172) were observed. During the 2016 season KRP staff attempted to estimate the number of grilse in the Scott River by enumerating the number of coho observed in the video flume that were shorter or longer than 56 cm. Utilizing this method, KRP staff identified 100% adults and 0% grilse (see the discussion for further information on seasonal estimates of age proportions).

Diel movements of Coho Salmon through the SRFCF were higher in the evening hours and peaked between 1900 hours and 0100 hours (Figure 9). Migrations were generally low during the day and increased from the late afternoon through early morning. The hours between 0900 and 1200 were generally the time during the day when the crew was at the weir conducting daily maintenance.

SPAWNING GROUND SURVEYS

Zero Coho carcasses were observed during the cooperative spawning ground survey on the lower mainstem Scott River (Reaches 1-8) and 22 Coho carcasses (21 measured) were observed in upper Scott River main stem (Reaches 12 through 16 and tributary reaches) during surveys coordinated by the Siskiyou Resource Conservation District (SRCD) (Magranet, 2017). No Coho carcasses were collected as wash backs at the counting facility (Figure 10). Applying the sex ratios of recovered Coho carcasses from the SRCD's upper Scott River surveys to the total estimate yielded an estimated 22.7% (51) male and 77.3% (175) female Coho Salmon. None of the 22 Coho carcasses examined had a maxillary clip, resulting in an estimated hatchery composition of zero. Based on the FL frequency distribution of the carcasses measured during the season and previous observations, it was determined that all of the carcasses recovered during 2016 were adults.

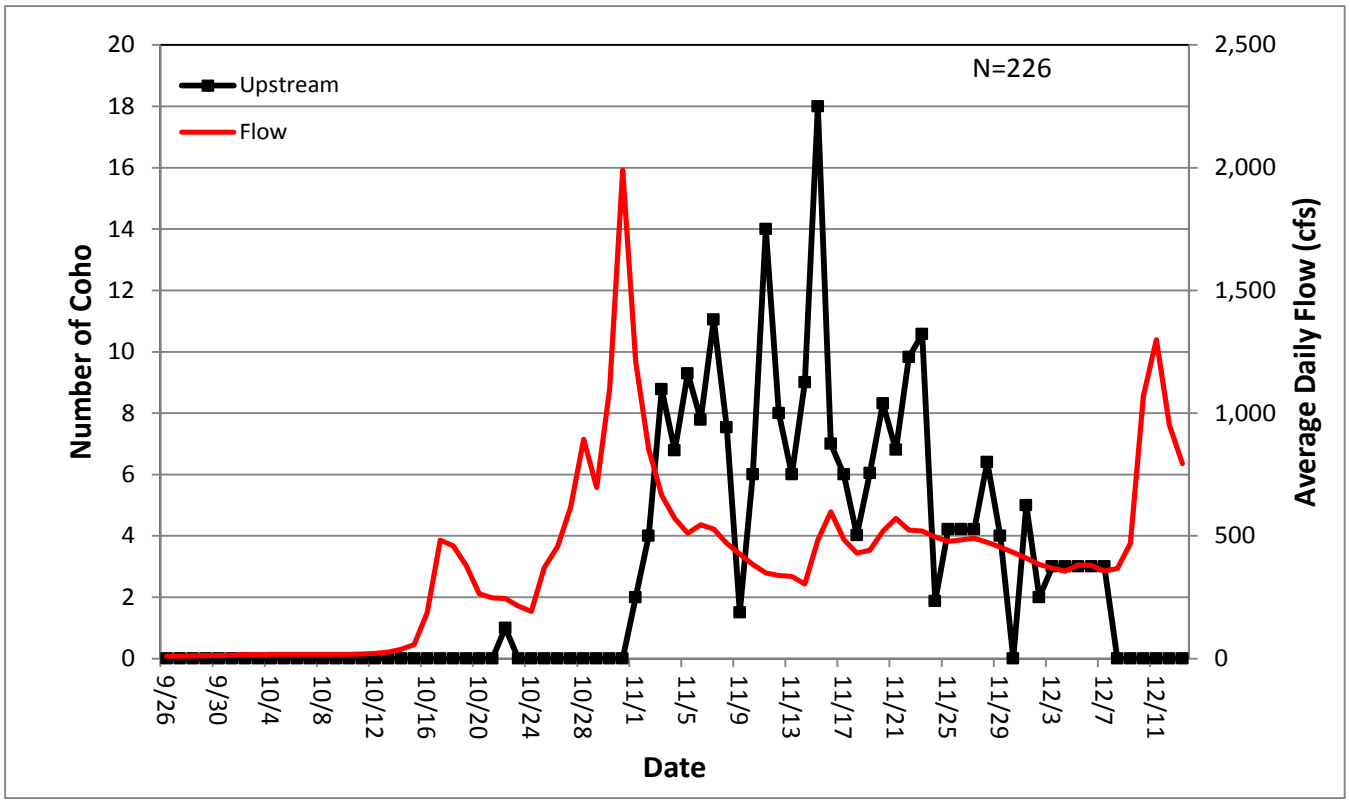


Figure 8. Run timing of Coho Salmon observed passing through the Scott River Fish Counting Facility during the 2016 season (N=226), and average daily flows observed at USGS Gauge No. 11519500.

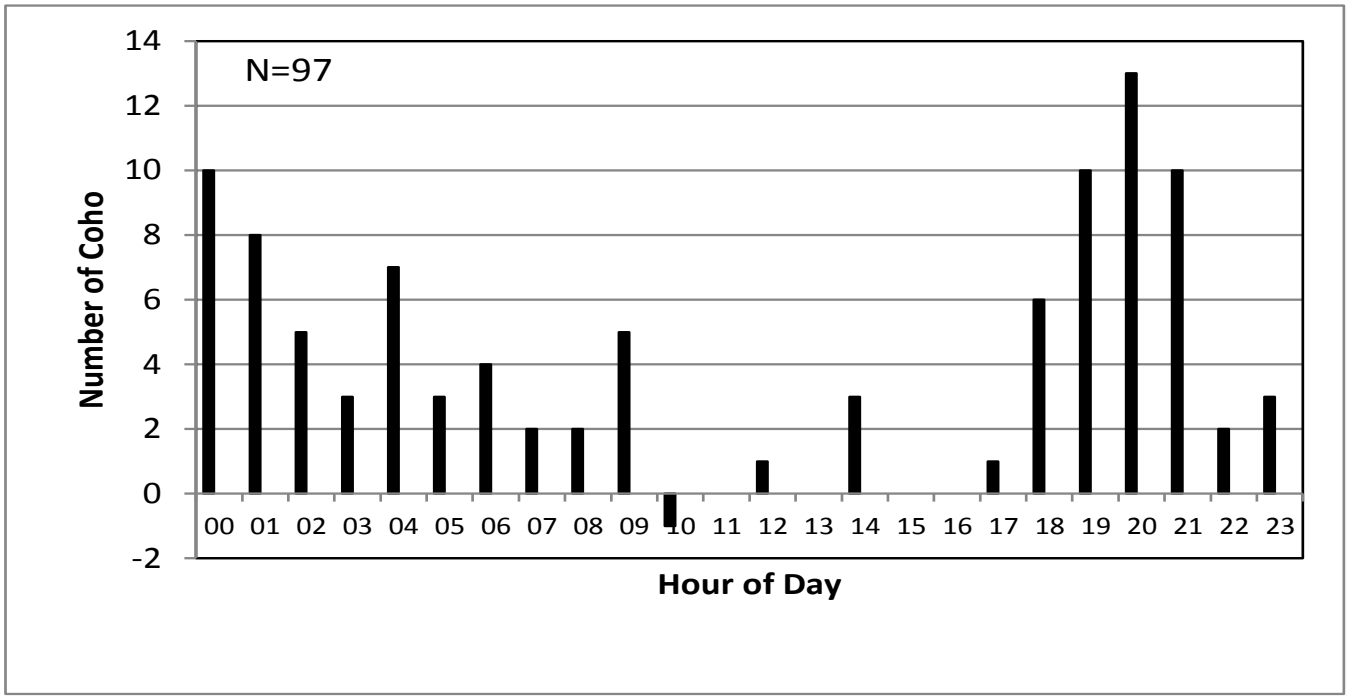


Figure 9. Diel migration patterns of Coho Salmon observed moving through the Scott River Fish Counting Facility in 2016 (N=97).

Applying the maximum grilse FL cutoff to the total number of measured carcass recoveries generated an age two proportion of 0% and an age three proportion of 100%. Twenty-one of the 22 carcasses examined were sampled for tissue, and collected samples were supplied to the NOAA Southwest Fisheries Science Center located in Santa Cruz, California, for stock identification purposes. Additionally, 21 Coho Salmon otolith samples were collected and archived at the Department's Yreka, California, office for future stock identification and life history examination. Coho redds were not observed in Canyon Creek, Kelsey Creek or Tompkins Creek.

A total of 226 Coho Salmon were estimated moving upstream through the SRFCF during the season. Additionally, zero Coho redds were observed in areas below the counting facility resulting in no additional Coho downstream of the counting station. Therefore, the total number of estimated Coho Salmon that entered the Scott River during the 2016-2017 season is **226**. Utilizing the observed age proportions derived from fork length frequency of sampled carcasses, the resulting number of age 2 and age 3 fish are 0 (0%) and 226 (100%), respectively.

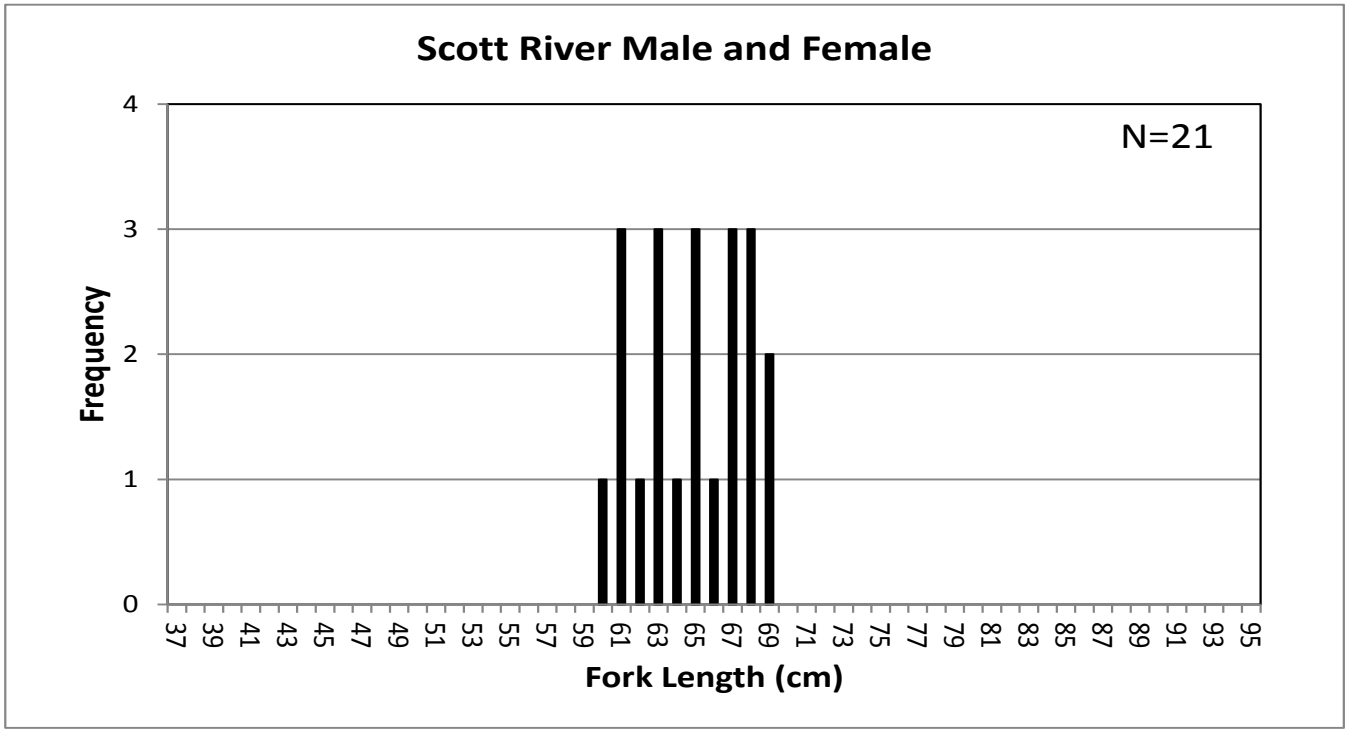


Figure 10. Length frequency distribution of Coho Salmon observed during cooperative spawning ground surveys (0), SRCD spawning ground surveys (21), and as wash backs (0) on the Scott River Fish Counting Facility, during the 2016-2017 spawning season (N=21).

STEELHEAD

In 2016 a net total of 224 adult (>40.64 cm) steelhead (Figure 11) were estimated to have entered and remained in the Scott River during the video recording season from September 22, 2016, to December 13, 2016. Lines on the back of the video flume were set at 40.64 cm (16 inches) to delineate sub-adults versus adults. The 2016 season was the seventh year that lines delineating adult steelhead and sub-adult steelhead were used.

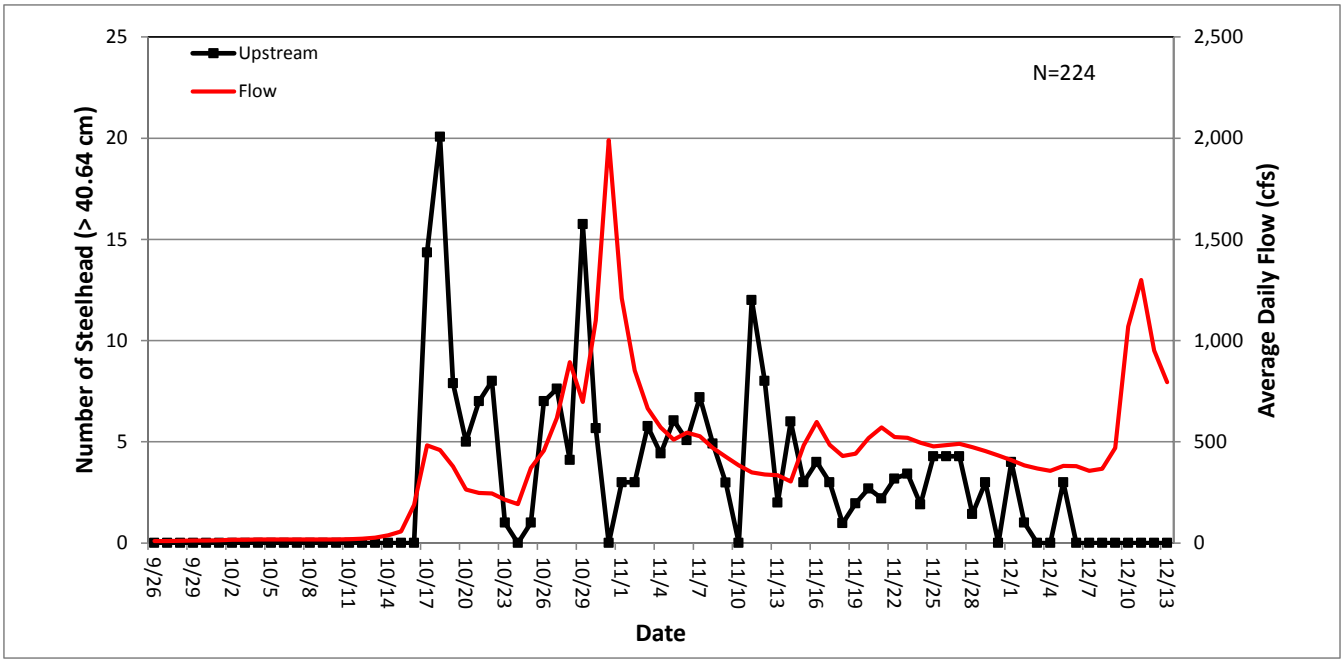


Figure 11. Run timing of steelhead trout (>40.64 cm) observed passing through the Scott River Fish Counting Facility during the 2016 season (N=224), and average daily flows observed at USGS Gauge No. 11519500.

DISCUSSION

CHINOOK SALMON RUNS

Since 1978, the Chinook Salmon run in the Scott River has ranged from 14,477 fish (1995) to 467 fish (2004) and has averaged 5,313 fish (Figure 12). The 2016 Chinook Salmon run in the Scott River ranks 37 (1,515 fish) out of 39 years of monitoring. The 2016 run was 71% lower than the 39-year average. A total of 1,152 Chinook Salmon were estimated to have passed through the SRFCF during the 2016 season. A total of 363 Chinook Salmon were estimated in Reach 1 through Reach 6 yielding a total run size estimate of **1,515** Chinook Salmon. The various sub-basin proportions of the Chinook distribution for years 2008-2016 are detailed in Table 5 and identifies the importance of the entire Scott River watershed to Chinook Salmon. From 2008 through 2016, an average of 69% of the Chinook run spawned upstream of the counting station (Reaches 7 through 16). As a result of the higher flow conditions during the Chinook migration adult fish passage in the lower canyon reaches was not a concern in 2016, and an estimated 76% of the Chinook run was observed passing through the counting station. The addition of the fish counting facility has allowed for an accurate estimation of Chinook migration to areas of spawning habitat in the valley reaches without having to conduct spawning ground surveys in these reaches.

The Scott River is an important component of the Klamath Basin Chinook runs. The Scott River has contributed an average of 9% of the basin-wide (including Trinity River) natural spawning escapement to the Klamath River basin during the period from 1978 to 2016 (Table 6). The Scott River Chinook population tracks very similarly to the total Klamath Basin population ($r=0.7753$ p-value <0.001) indicating that forces outside the Scott River watershed play an important role in influencing abundance of this population of Chinook (Figure 13).

Table 5. Scott River Chinook salmon abundance estimates by area and percentages of the total above and below the Counting Station during the 2008-2016 seasons.

Year	Downstream of Counting Station	Upstream of Counting Station	% Downstream of Counting Station	% Upstream of Counting Station	Total Basin Estimate
2008	1,439	3,234	31%	69%	4,673
2009	1,014	1,197	46%	54%	2,211
2010	280	2,228	11%	89%	2,508
2011	983	4,538	18%	82%	5,521
2012	1,208	8,144	13%	87%	9,352
2013	1,252	3,372	27%	73%	4,624
2014	2,995	9,476	24%	76%	12,471
2015	1,741	372	82%	18%	2,113
2016	363	1,152	24%	76%	1,515
Average	1,253	3,746	31%	69%	4,999

To evaluate freshwater productivity the production of emigrating 0+ Chinook has been estimated in the Scott River since Brood Year 1999 (Jetter et al. 2016). The number of 0+ Chinook produced per adult has been calculated for Brood Years 1999 through 2015 and has ranged from a low of 14.4 to a high of 383.0 and averaged 97.9 (Figure 14). Brood year 2015 recorded an observed 26.8 0+ Chinook produced per adult. The observed 0+ Chinook produced per adult for Brood Year 2015 was 73% less than the 17-year average of 97.9 fish. Due to funding constraints, the Department was unable to operate the Scott River Rotary Screw Trap during the 2017 season preventing this analysis for Brood Year 2016. The Department anticipates conducting Scott River Rotary Screw Trapping in the winter and spring of 2018 and continuing to provide data for this important analysis. As the watershed approaches carrying capacity the number of 0+ Chinook produced per adult is a direct measure of in-river productivity, and as habitat conditions improve or diminish, this measure will reflect those conditions.

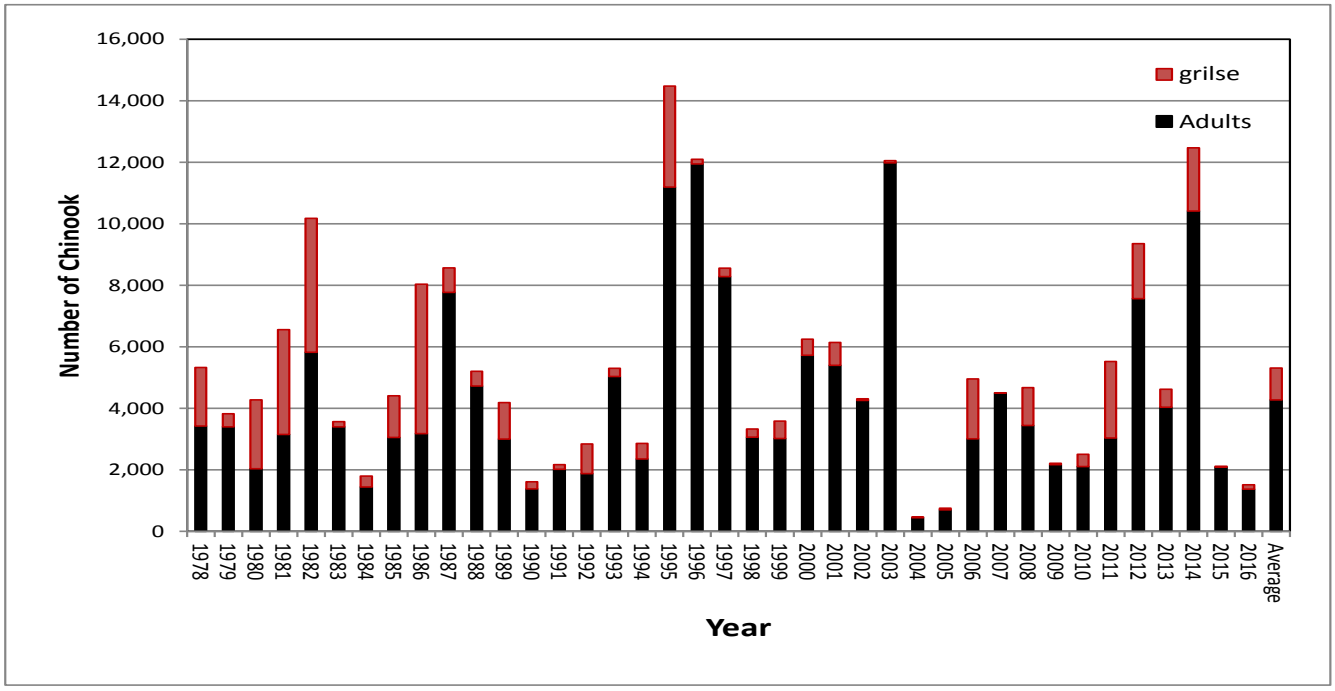


Figure 12. Estimated escapement of Chinook Salmon returning to the Scott River from 1978 to 2016.

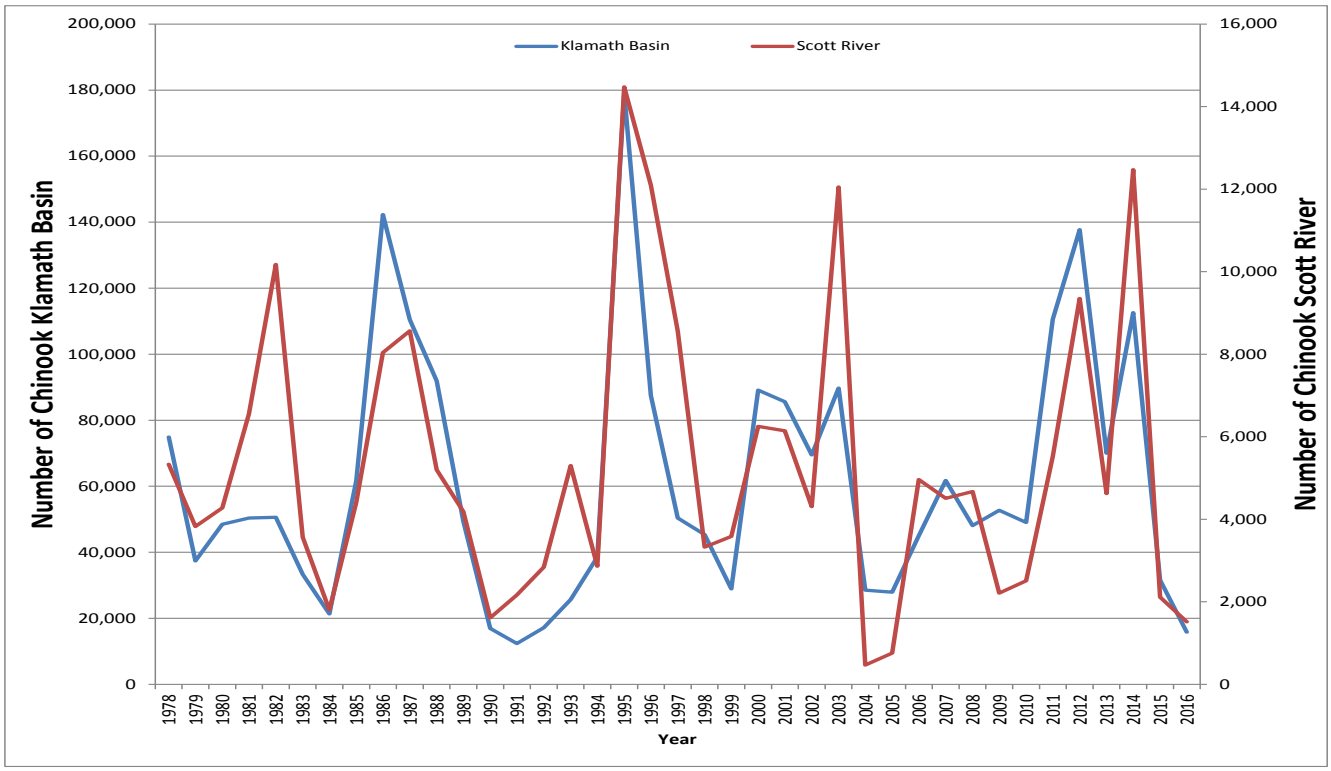


Figure 13. Chinook Salmon Klamath Basin natural spawner escapement (primary y-axis) and the Scott River natural spawner escapement (secondary y-axis) from 1978 through 2016.

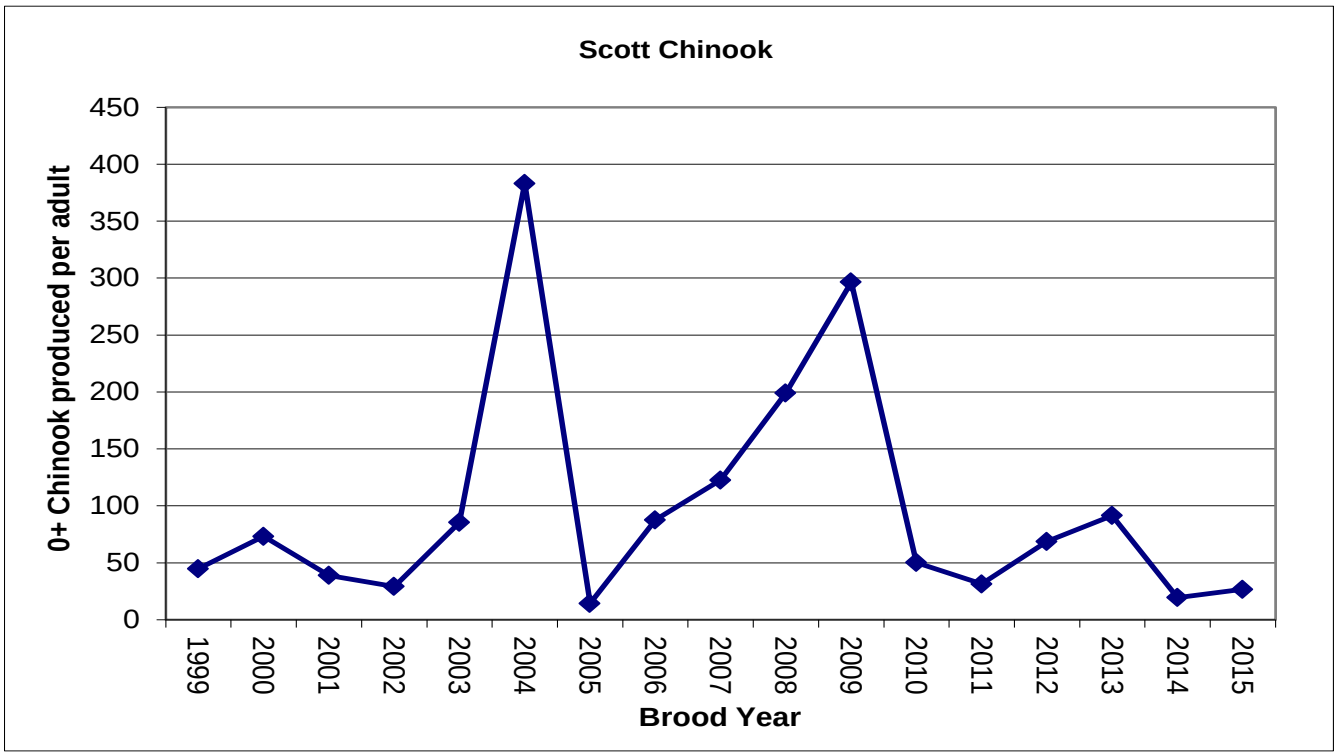


Figure 14. Number of 0+ Chinook produced per adult spawner in the Scott River by brood year, for Brood Years 1999-2015.

COHO SALMON

Since video operations began in 2007, the estimated escapement of Coho Salmon in the Scott River has ranged from a low of 63 to a high of 2,752 and averaged 692 (Figure 15). The adult run size of Coho Salmon prior to 2007 is unknown and with the addition of the counting facility the ability to monitor this ESA listed run has greatly improved. Although recent adult run size data is sparse on the Scott River, monitoring of the yearling juvenile emigration has taken place since 2003. The emigration data generated from 2003 through 2016 indicates significant variation in brood year strength (Jetter et al. 2016). Results of the first ten years of adult monitoring at the SRFCF support this observation. The cohort that returned in 2016 was once the strongest cohort in the Scott River with returns of 2,752 in 2013. In one generation, this strong brood year decreased in total numbers by 2,502 fish, a reduction of 90.9%, from returns in 2013 (Figure 16). This large decline in brood year strength is the first decline observed in the last six seasons.

It should be noted that the 2016 monitoring season ended prior to the end of the Coho migration and the 2016 estimate is believed to underestimate the actual run size. In an effort to evaluate the accuracy of the 2016 Coho run due to the removal of the counting station prior to the end of the adult migration we used the observed average smolt survival of 5.58% (Brood Years 2004-2008 and 2010-2012) and applied it to the yearling point estimate from 2015 of 7,253 which yields a predicted 2016 return of 405. The 250 observed Coho (24 age 2 from 2015 and 226 age 3 from 2016) is less than the predicted returns of 405 using this method. Based on below average returns of both Coho Salmon and Chinook Salmon throughout the Klamath basin, it is reasonable to think that the actual out of basin survival experienced by this brood year was below the observed average. To account for the potential reduced out of basin survival, the yearling point estimate from Brood Year 2015 could have experienced, we applied an out of basin survival rate that was 75% and 50% of the observed average which yielded predicted estimates of 304 and 202 respectively.

An additional way to evaluate the accuracy of the 2016 estimate is to look at the proportion of the total annual run that has been observed by December 13 for the period of record (Figure 16). For the years 2007-2015, an average of 81.5% of the annual Coho run has been observed by December 13. If 81.5% of the age 3 Coho were observed during the 2016 season, then an estimated 301 (24 age 2 from 2015 and 277 age 3 from 2016) Coho Salmon would have been estimated if we were able to monitor through the entire migration. This analysis provides some evidence that if adults were missed at the end of the migratory window due to removing the counting facility, it was likely few (Figure 17). This analysis also provides context to the large decrease observed in this brood year and strongly indicates that this once strong brood year has been reduced significantly and currently has an abundance similar to the other two brood years.

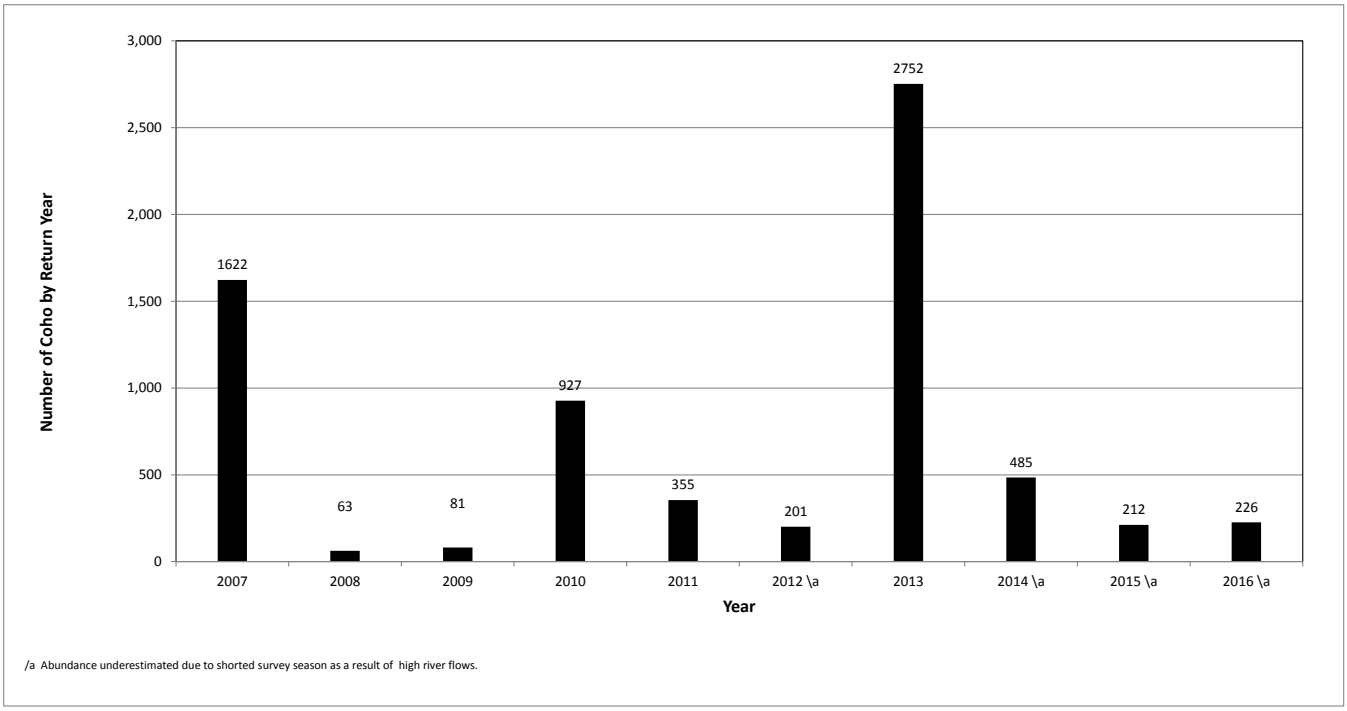


Figure 15. Estimated escapement by return year of adult and grilse Coho Salmon (age 2 and age 3) returning to the Scott River from 2007 to 2016.

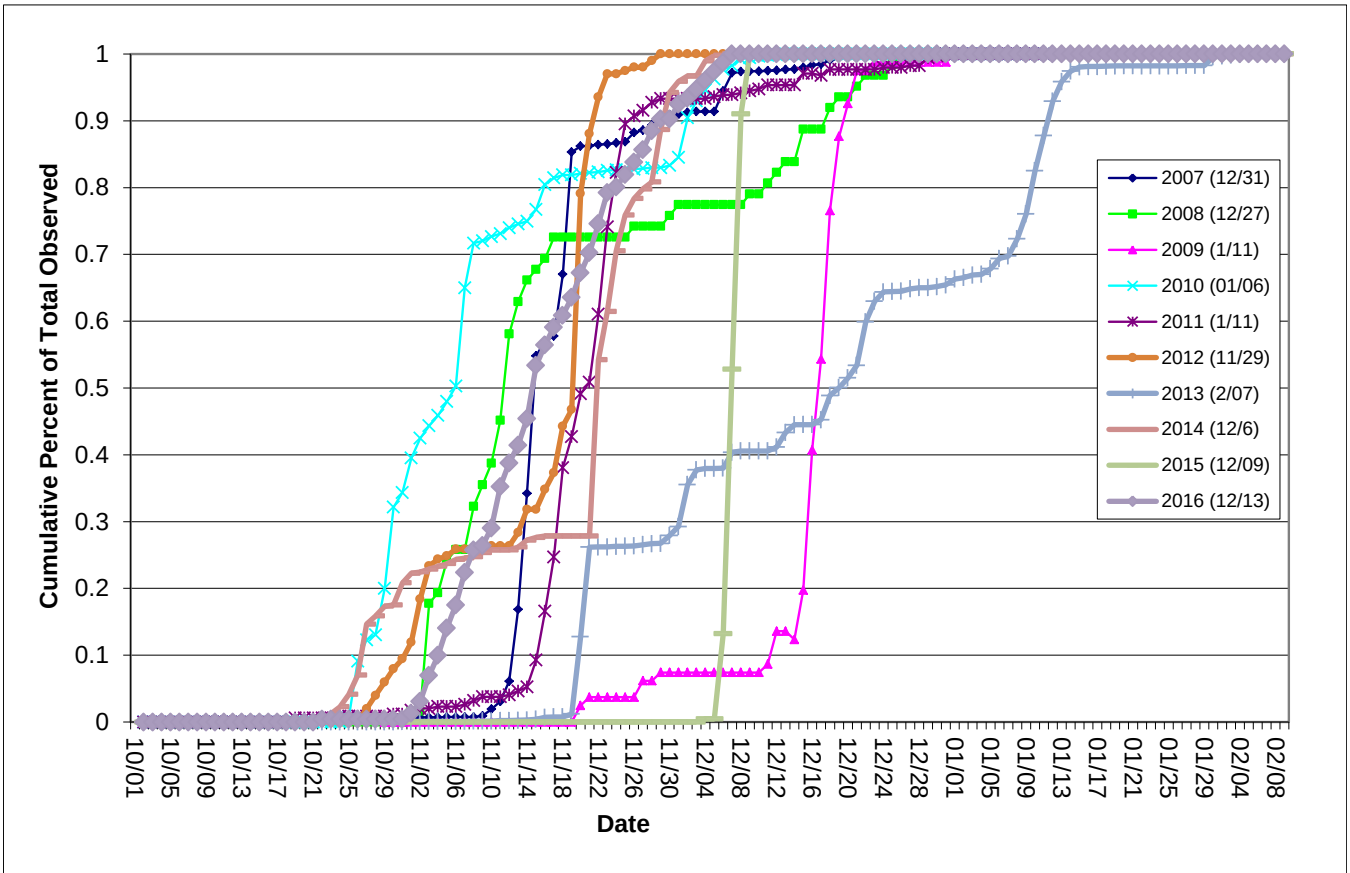


Figure 16. Cumulative percent of total observed Coho Salmon observations by day at the Scott River Fish Counting Facility annually from 2007-2016. The date in parenthesis indicates the last date the fish counting facility was operated for each year.

Table 6. Klamath Basin and Scott River Chinook natural spawner escapements (age 2-5), 1978-2016.

Year	Chinook Natural Spawner Escapement		% Scott
	Klamath Basin	Scott River	
1978	74,906	5,332	7%
1979	37,398	3,824	10%
1980	48,465	4,277	9%
1981	50,364	6,556	13%
1982	50,597	10,176	20%
1983	33,310	3,568	11%
1984	21,349	1,801	8%
1985	61,628	4,408	7%
1986	142,302	8,041	6%
1987	110,489	8,566	8%
1988	91,930	5,200	6%
1989	49,377	4,188	8%
1990	16,946	1,615	10%
1991	12,367	2,165	18%
1992	17,171	2,838	17%
1993	25,683	5,300	21%
1994	38,578	2,863	7%
1995	179,118	14,477	8%
1996	87,500	12,097	14%
1997	50,369	8,561	17%
1998	45,343	3,327	7%
1999	28,904	3,584	12%
2000	89,122	6,253	7%
2001	85,581	6,142	7%
2002	69,502	4,308	6%
2003	89,744	12,053	13%
2004	28,516	467	2%
2005	27,931	756	3%
2006	45,002	4,960	11%
2007	61,741	4,505	7%
2008	48,073	4,673	10%
2009	52,702	2,211	4%
2010	49,027	2,508	5%
2011	110,554	5,521	5%
2012	137,724	9,352	7%
2013	69,986	4,624	7%
2014	112,599	12,470	11%
2015	31,607	2,113	7%
2016	15,818	1,515	10%
Average	**61,521**	**5,313**	**9%**

The estimated proportion of hatchery origin Coho Salmon in the Scott River during 2016 has been estimated two independent ways, first through the recovery of carcasses during spawning ground survey efforts and second through clip identification of images collected at the video weir. Both the spawning ground survey data and video data produced hatchery proportions of zero. The sample sizes that the spawning ground survey and video data relied on were 21 and 97 respectively. Due to the significantly larger sample size available from video data the estimated proportion of hatchery origin Coho in the Scott River during the 2016 season has been estimated using the video data and is estimated to be 0.0%.

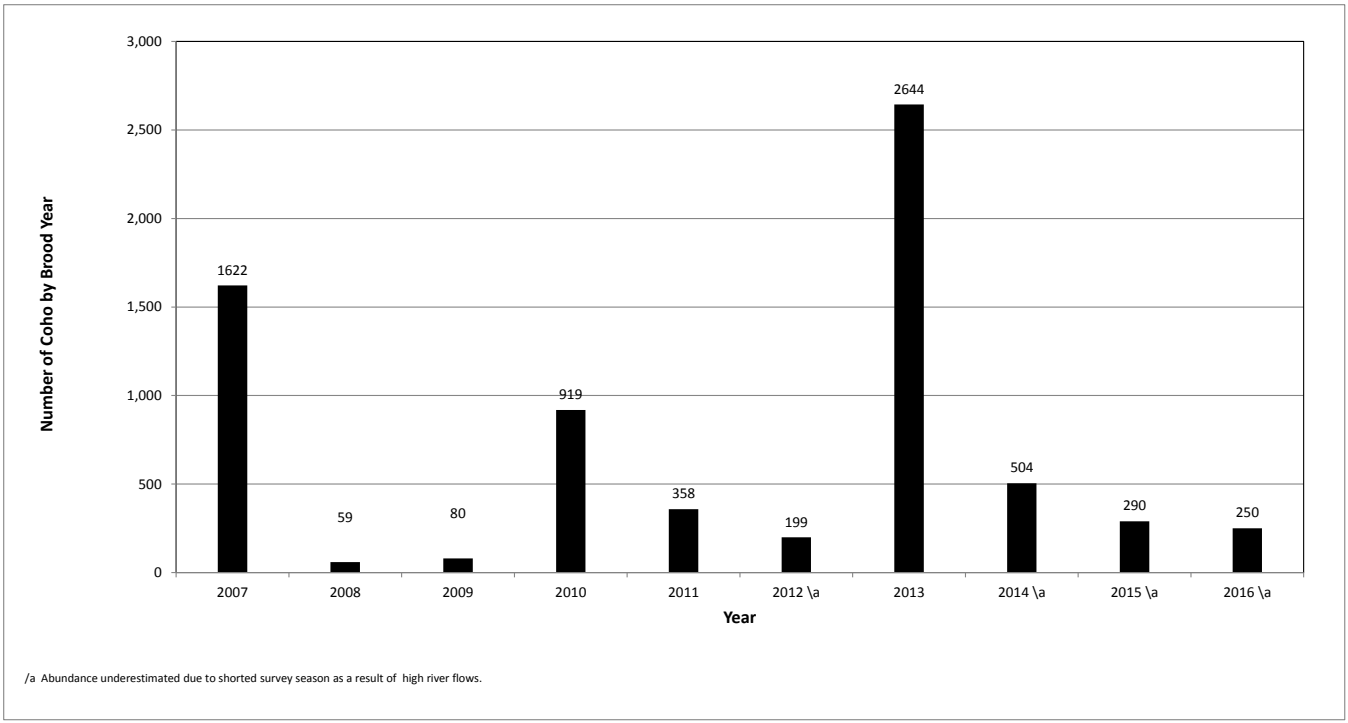


Figure 17. Estimated escapement by Brood Year of adult and grilse Coho Salmon (age 2 and age 3) returning to the Scott River from 2007 to 2016.

Utilizing the number of coho smolts produced in the Scott River (Jetter et al. 2016) and the results of the adult abundance estimates allows for analysis of Scott River freshwater production and out of basin survival by brood year. For Brood Years 2004 to 2008 and 2010 to 2013 the out of basin survival has averaged 5.85 percent and ranged from a low of 1.48 percent to a high of 16.47 percent (Table 7). Due to the extremely high observed percent smolt survival of 71.64 for Brood Year 2009, data from this brood year has been omitted from this analysis. It is possible that the smolt estimate generated for Brood Year 2009 underestimated the actual number of out migrants. Although the proportion of smolts that survive outside the Scott River watershed is largely driven by uncontrollable factors it is important to track this survival metric to accurately evaluate ongoing restoration efforts taking place within the watershed.

Analyzing the comparisons of coho smolt production estimates to estimated female adult Coho Salmon returns produces freshwater survival estimates in the form of coho smolts produced per adult female return. For Brood Years 2007 through 2014 the number of coho smolts produced per returning adult female has ranged from a low of 4.79 to a high of 78.62 and has averaged

Table 7. Coho smolt outmigrant abundance point estimates, age 2 and age 3 coho abundance estimates, and proportion of outmigrant smolts that returned by brood year for the Scott River, Brood Years 2004-2013.

Brood Year	Smolt Year	Smolt point Estimate	Age 3 Return Year	Age 2 Return	Age 3 Return	Age 2 and 3 Return	Percent smolt survival
2004	2006	75097	2007	0	1622	1622	2.16
2005	2007	3931	2008	0	58	58	1.48
2006	2008	941	2009	5	75	80	8.50
2007	2009	62207	2010	6	913	919	1.48
2008	2010	2174	2011	14	344	358	16.47
2009	2011	275	2012	11	186	197	71.64
2010	2012	50315	2013	13	2631	2644	5.25
2011	2013	7927	2014	121	383	504	6.36
2012	2014	5708	2015	102	188	290	5.08
2013	2015	7253	2016	24	226	250	3.45

44.61 (Table 8). Due to the difficulty in estimating abundance of adults and out-migrants at low abundance levels it is unclear if the smolts produced per adult female ratio generated for Brood Year 2009 is a result of decreased freshwater productivity or a result of sampling difficulty. As additional years of data become available the freshwater production of coho salmon in the Scott River can be further evaluated. The number of smolts produced per returning adult female by brood year is a direct measure of freshwater survival. For levels below carrying capacity, it can be stated that as the number of smolts produced per returning adult female increases it can be inferred that in-river conditions for coho salmon are improving. Conversely as the number of smolts produced per returning adult female decreases it can be inferred that in-river conditions for coho salmon are getting worse. The number of smolts produced per returning adult is influenced by inter-annual variation in sex ratios and age structure, and these variables have been accounted for in this analysis.

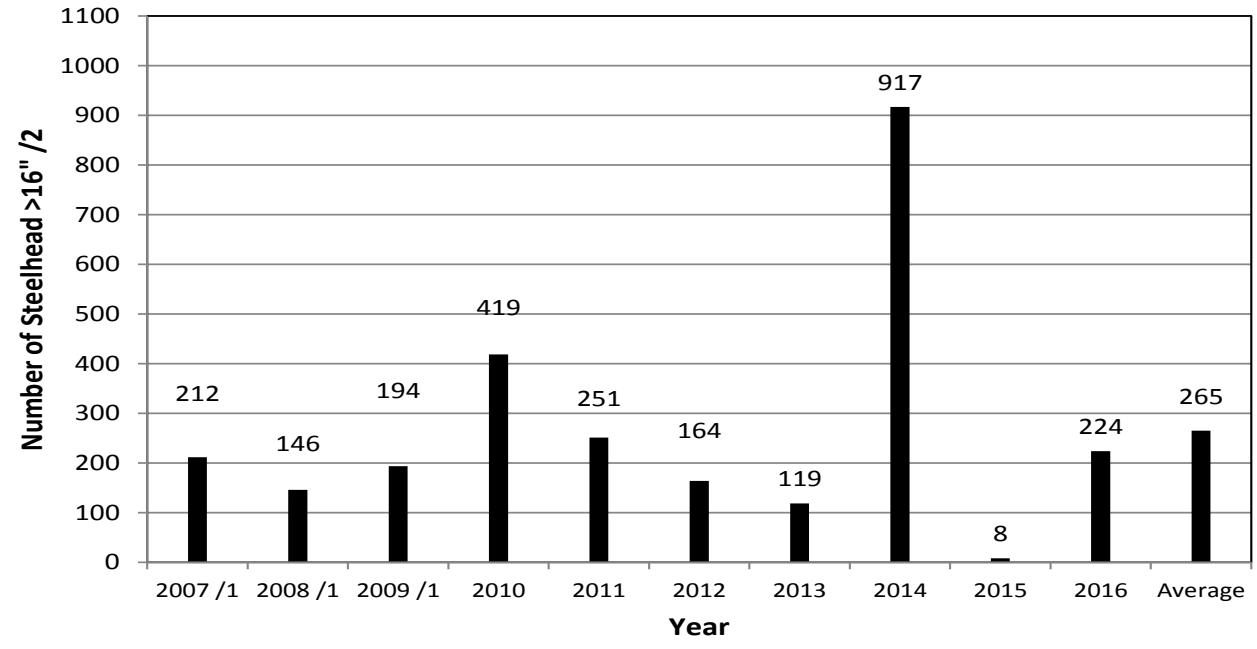
Table 8. Adult Coho Salmon estimate, Coho smolt production point estimate and ratio of Coho smolts produced per adult female return for the Scott River, Brood Years 2007 through 2014.

Adult Year Brood Year	Adult Estimate	Adult Female Estimate	Smolt Year	Smolt point Estimate	Smolts produced per Female
2007	1622	860	2009	62207	72.33
2008	63	32	2010	2174	67.94
2009	81	41	2011	275	6.71
2010	927	640	2012	50315	78.62
2011	355	170	2013	7927	46.63
2012	201	86	2014	5708	66.37
2013	2752	1514	2015	7253	4.79
2014	485	179	2016	2411	13.47
				Average	**44.61**

STEELHEAD

The number of returning adult steelhead has been monitored at the SRFCF beginning in 2007. During the 2007 through 2009 seasons an unknown number of sub-adult steelhead may have been counted as adults. Starting in 2010, lines on the back of the video flume were set 16 inches (40.64 cm) apart to delineate sub-adults versus adults. Since this time, the number of steelhead >16" observed in the Scott River has been 419, 251, 164, 119, 917, 8, and 224 for

2010, 2011, 2012, 2013, 2014, 2015, and 2016, respectively (Figure 18). From 2007 to present, the number of observed adult steelhead has ranged from a high of 917 to a low of 8 with an average of 224. The run size of adult steelhead prior to 2007 is unknown and with the addition of the counting facility the ability to monitor this run has greatly improved. Although recent adult run size data is sparse on the Scott River, monitoring of the juvenile emigration has taken place since 2003. It is believed that the majority of adult steelhead migration occurs outside the operational window of the SRFCF. Therefore, the number of observed steelhead should be considered minimum number of returns and not basin estimates. The use of a SONAR camera in the Scott River after the end of the Coho migration may add in the Department's ability to monitor the steelhead migration.



/1 Data may include an unknown number of sub-adult steelhead.
/2 Due to shifts in effort and timing of the run the number of steelhead observed represents an unknown proportion of the total annual return.

Figure 18. Number of observed Steelhead >16" at the Scott River Fish Counting Facility from 2007 to 2016.

ACKNOWLEDGEMENTS

The California Department of Fish and Wildlife would like to thank Sport Fish Restoration Fund for their financial assistance in the operation of the SRFCF during 2016. The cooperative spawning ground surveys would not be possible without the assistance of the U.S. Fish and Wildlife Service Yreka office and the USFS. Additionally, this work would not be possible without the cooperation and participation of the SRCD, Karuk Tribe, Quartz Valley Tribe, USFS, Northern California Resource Center, Americorps, and Etna High School who assisted in completing spawning ground surveys on the Scott River. We would also like to express our appreciation to the various landowners who have provided permission to access the Scott River through their property. Additionally, we thank the SRCD for making their data available for this report.

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Appendix 1. Summary of surveys conducted in the Scott River watershed during the 2016 spawning season by date and reach.

	Reach																
Survey lead	CDFW	CDFW	CDFW	CDFW	CDFW	CDFW	CDFW	CDFW	SRCD	SRCD	SRCD	SRCD	SRCD	SRCD	CDFW	CDFW	CDFW
Survey Date	1	2	3	4	5	6	7	8	9	12	13	14	15	16	Tompkins Creek	Canyon Creek	Kelsey Creek
10/10/2016	1	1	1	1	1	1											
10/12/2016									1								
10/13/2016	1	1	1	1		1											
10/18/2016																1	1
10/20/2016	1	1	1	1			1	1									
10/24/2016	1	1	1	1	1							1					
10/27/2016												1					
11/3/2016						1										1	1
11/4/2016												1	1				
11/7/2016	1	1	1		1		1	1		1	1	1	1				
11/9/2016									1								
11/10/2016			1	1	1	1		1			1	1	1				
11/14/2016	1	1	1				1	1		1	1	1	1				
11/16/2016									1								
11/17/2016												1					
11/18/2016								1			1						
11/21/2016											1	1			1		
11/22/2016														1			
11/28/2016					1		1	1									
12/1/2016	1	1	1					1									
12/5/2016				1		1							1	1			
12/8/2016								1									
12/9/2016						1											
12/12/2016								1									