BOGUS CREEK SALMON STUDIES 2016

FINAL REPORT

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ABSTRACT

The California Department of Fish and Wildlife's (Department), Klamath River Project (KRP) operated a video fish counting facility on Bogus Creek during the Chinook Salmon (*Oncorhynchus tshawytscha*). Coho Salmon (*Oncorhynchus kisutch*) and Steelhead trout (*Oncorhynchus mykiss*) spawning season. The purpose of these surveys is to describe the run characteristics of adult fall-run Chinook Salmon, Coho Salmon and steelhead into Bogus Creek. Video fish counting operations began on September 8, 2016 and ended on May 1, 2017, at the end of the season. In addition, spawning ground surveys began on October 10, 2016 and were conducted twice a week through December 14, 2016 during the salmon season.

The first adult Chinook was observed entering Bogus Creek on September 17, 2016 and the last Chinook Salmon was observed on November 26, 2016. The total number of Chinook Salmon that entered Bogus Creek during the 2016 season is estimated to be **868** fish. Based on the proportion of male and female Chinook Salmon sampled during the spawning ground surveys, the run was comprised of approximately 359 (41.3%) males and 509 (58.7%) females. Scale analysis was used to determine the age proportions of the run. Adults comprised approximately 95.6% (830 fish) and grilse comprised 4.4% (38 fish) of the run. Males ranged in fork length from 55 cm to 93 cm and averaged 75.5 cm. Females ranged in fork length from 56 cm to 82 cm and averaged 69.6 cm. Based on coded wire tag expansions, KRP staff estimated that 209 Chinook Salmon (24.1%) were of hatchery origin.

The first adult Coho Salmon was observed entering Bogus Creek on November 7, 2016, and the last Coho Salmon was observed on January 1, 2017. A total of 85 Coho Salmon were observed moving upstream through the Bogus Creek Fish Counting Facility (BCFCF) during the season and zero additional Coho carcasses were observed downstream of the BCFCF yielding an estimated season total of **85** Coho Salmon. Based on the proportion of male and female Coho Salmon sampled during the spawning ground surveys and known recoveries of released PIT tagged fish from Iron Gate Hatchery (IGH) that entered Bogus Creek, the run was comprised of approximately 52 (61.2%) males and 33 (38.8%) females. Based on a grilse cut off of ≤52 cm, age 3 fish comprised approximately 58.8% (50 fish) and age 2 fish comprised 41.2% (35 fish) of the run. Males ranged in fork length from 44 cm to 72 cm and averaged 58 cm. Additionally 66.7% of the Coho males that returned to Bogus were estimated to be age 2. Females ranged in fork length from 45 cm to 67 cm and averaged 56 cm. An estimated 3.5% (3 fish) of Coho Salmon returning to Bogus Creek during the 2016 season were Coho Salmon that previously entered IGH and were subsequently released (surplus Coho). Based on a combination of fin clip observations and known surplus Coho, KRP staff estimated that 35 Coho Salmon (41.2%) were of hatchery origin.

The first steelhead >40.6 cm was observed entering Bogus Creek on October 9, 2016, and the last steelhead was observed on May 1, 2017. During this time there were a total of 384 steelhead observations including both upstream (234) and downstream (150) movements. The 234 observed upstream migrating steelhead represents the maximum number of steelhead for the season. The

actual number of steelhead for the season is likely much lower than 234 as some fish move up and down through the flume multiple times. The net upstream movement of **84** fish represents a minimum number of steelhead for the season. Zero steelhead were recovered during the spawning ground survey effort.

INTRODUCTION

STUDY LOCATION AND RUN TIMING

Bogus Creek is located on the south east side of the Klamath River just downstream of Iron Gate Hatchery (IGH) (between river mile 189 and 190) in Siskiyou County, near the Oregon border (Figure 1). The mouth of Bogus Creek is roughly 75 feet downstream of the entrance to the axillary ladder used to collect adult salmonid returns at IGH. As a result of the extremely close proximity of Bogus Creek to IGH, there has been significant mixing of hatchery origin and natural origin salmonids from these two locations. Chinook Salmon return to Bogus Creek to spawn from mid-September to early November. The Coho Salmon spawning run typically occurs from late October to early January. Steelhead trout can be observed returning to Bogus Creek from October through April.

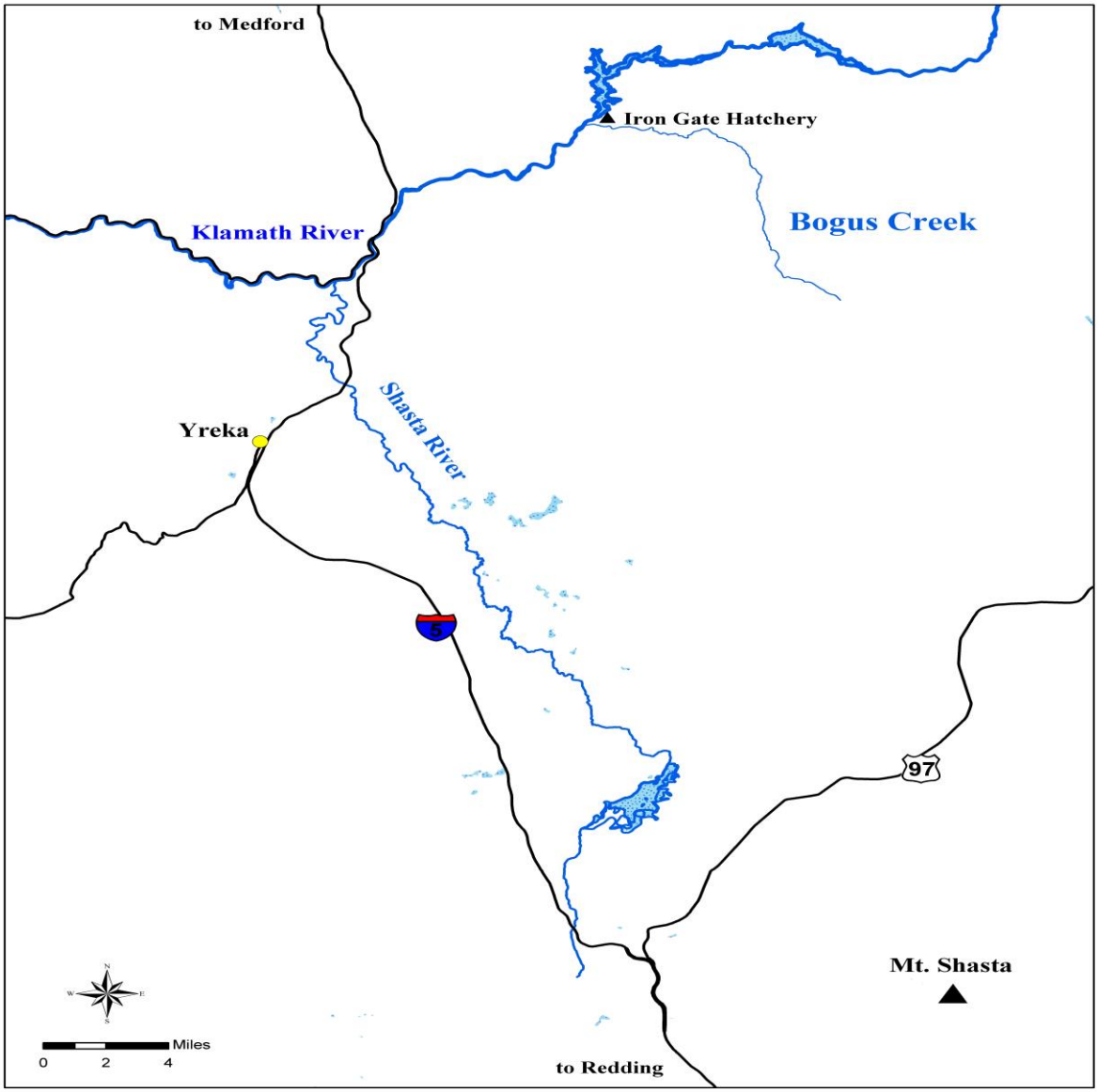

Figure 1. Location of Bogus Creek, tributary to the Klamath River, Siskiyou County.

BOGUS CREEK FISH COUNTING FACILITY

The purpose of the Bogus Creek Fish Counting Facility (BCFCF) is to count the number of adult Chinook and Coho Salmon that enter Bogus Creek each year. Prior to the 2003 spawning run, a fish marking weir and trap were operated on Bogus Creek to collect biological data, recover heads from adipose fin clipped adults (ad-clipped), and mark Chinook Salmon with an opercle punch. The opercle punch was used to generate a Petersen mark and recapture population estimate from recaptures obtained during carcass surveys upstream of the weir. Incorporation of a video counting station in 2003 has improved the accuracy of run size estimates and has eliminated the need to handle migrating salmon during the season. Biological data collection occurs during spawning ground surveys and includes collection of fork lengths, determining sexual composition of the run, assessing pre-spawn mortality, recovery of coded wire tags (CWT) from ad-clipped salmon, and documentation of Coho Salmon released from IGH in excess of broodstock needs that enter Bogus Creek.

KLAMATH RIVER PROJECT AND BOGUS CREEK STUDY

The Bogus Creek study is one component of the KRP (Klamath River Project initiated in 1978). The goals of the KRP include obtaining information on population abundance, hatchery composition, run timing, spawning distribution, fork length frequency, and sex ratios for salmonids (primarily Chinook Salmon) in various tributaries to the Klamath River including the Salmon, Scott, and Shasta rivers, as well as Bogus Creek and a dozen other smaller tributaries. Bogus Creek is particularly important because it is a major salmon spawning tributary, despite its small size. For example, during the 1996-98 spawning seasons, an average of 30.6% (8,914) of the total number of Klamath River Basin Chinook Salmon natural area adult spawners above the Trinity River confluence were estimated to have entered Bogus Creek to spawn. Therefore, a significant portion of natural escapement to the Klamath Basin would be unaccounted for if the Bogus Creek studies were not conducted. In addition to providing valuable escapement estimates to the Pacific Fisheries Management Council for the effective management of Chinook Salmon in the Klamath Basin, the Bogus Creek studies provide an additional opportunity to recover CWTs and collect scale samples (which are used in the final determination of age composition).

BOGUS CREEK STUDY OBJECTIVES SUMMARIZED:

A. Determine the in-river run size (escapement) of Chinook Salmon, Coho Salmon and steelhead trout returning to Bogus Creek.

B. Determine run timing, spawning distribution, length frequency distribution, and sex ratio for Chinook and Coho Salmon in Bogus Creek.

C. Collect scale samples and recover heads (containing coded wire tags) from ad-clipped Chinook Salmon in order to determine age composition and hatchery composition of the run.

METHODS

OPERATION OF THE BOGUS CREEK FISH COUNTING FACILITY

The video fish counting system was installed at the BCFCF on September 8, 2016, at 0900 hours Pacific Standard Time (PST). A temporary Alaskan style weir was installed to direct migrating fish into a flume where they pass in front of the camera. The underwater video system consisted of a digital color 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 throughout the monitoring period which ended on May 1, 2017. A Splash Cam digital color 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.

All hard drives were collected and immediately returned to the office where each was subsequently downloaded and reviewed by staff in the video lab. During each review, staff recorded the date, time (hour:min:sec), and species of each fish observed. If the species could not be determined because of poor visibility or picture quality, staff recorded that observation as fish unknown. Staff also noted any ad-clipped fish observed, and recorded the presence of lamprey scars and any other distinguishable marks that were visible on the fish. All video data were then entered into computer files and each data file was subjected to one independent edit prior to commencement of data analysis.

SPAWNING GROUND SURVEYS

Spawning ground surveys were conducted twice a week on Tuesdays and Fridays throughout the salmon spawning season starting October 10, 2016 and ending December 14, 2016. A total of 15 surveys were performed during the spawning season. For the purpose of the spawning ground surveys, Bogus Creek was divided into four reaches (Figure 2). Reach 1 includes the area from the mouth of Bogus Creek upstream to the BCFCF, a distance of approximately 0.3 miles. Reach 2 extends from the BCFCF upstream to a small waterfall a distance of approximately 0.6 miles. Reach 3 begins at the small waterfall and continues upstream to a road crossing a distance of approximately 1.6 miles and Reach 4 continues from the road crossing upstream to a larger waterfall (about 20 feet high) and fish ladder a distance of approximately 1.1 miles. There is additional spawning habitat upstream of the fish ladder that is not surveyed annually. The goal of the spawning ground survey upstream of the counting station is to collect biological information from salmon carcasses and not estimate abundance. Most surveys were conducted by four crews (one crew per reach), consisting of a minimum of two people for each crew.

Fork length measurements (cm), scale samples, sex determinations, and information regarding female spawning success were systematically collected from every second Chinook carcass examined during the survey. A systematic random sampling rate of 1 in 2 was established and maintained throughout the season. Every carcass, regardless of the sample rate, was inspected for the presence of an ad-clip or any other marks or tags that might be present (jaw tag, radio transmitters, etc.). Every second sample was identified as a random (R) sample and every ad-clip that was sampled outside of the second sample was identified as a non-random

(NR) sample. Therefore, ad-clip samples could be identified as either R (if second sample) or

NR if not part of the systematic sample. All scale samples were provided to the Yurok Tribal Fisheries Department for analysis. Spawning status was evaluated for all female carcasses and was defined as unspawned (many eggs remaining in the body) or spawned (few or no eggs remaining). Heads and scale samples were also collected from all ad-clipped fish (as well as fork length and sex) in order to recover the CWT for subsequent age determination. Once examined, all carcasses were cut in half and returned to the river to prevent potential recounting during later surveys. Every Coho Salmon carcass that was recovered during the survey was sampled.

The spawning ground surveys attempt to assign returning adult Coho Salmon into three groups: natural origin spawners (NOS), hatchery origin spawners (HOS), and surplus hatchery origin Coho (surplus). Surplus hatchery origin Coho are adult Coho that stray into Bogus Creek after first entering IGH and are subsequently released as part of the surplus adult release program. The surplus release program is intended to reduce the demographic risk of extinction to the Upper Klamath Coho Salmon population unit as identified in the Iron Gate Coho Salmon Hatchery Genetics Management Plan (HGMP) and has been implemented since 2010. Prior to release surplus Coho are PIT tagged and opercle punched for future identification during the spawning ground survey effort. Spawning ground survey crews carry PIT scanners and scan all Coho carcasses encountered to identify PIT surplus adults released from IGH or detections of adults that were PIT tagged as juveniles from other tagging projects in the basin.

To assist in developing stock identification baseline information, the KRP collected both genetic tissue and otolith samples during the season. Tissue samples were collected from 26 Chinook Salmon and 5 Coho Salmon for future DNA analysis. All samples were collected following protocols provided by the National Oceanic Atmospheric Administration's (NOAA) Southwest Fisheries Science Center. Tissue samples were sent to the Salmonid Genetic Tissue Repository located at the NOAA Santa Cruz Laboratory for archiving and analysis. Otoliths were collected from 24 Chinook Salmon and 4 Coho Salmon throughout the season and cataloged for future microchemistry analysis. All samples were collected following standard protocols.

POPULATION ESTIMATE

The salmon spawner escapement for the area of Bogus Creek upstream of the BCFCF was derived from a direct count of all salmon observed at the video counting facility (net total =upstream minus downstream movements). To estimate total escapement in Bogus Creek, the number of salmon carcasses observed downstream of the weir was added to the count of all salmon that were observed passing through the video counting facility. The Reach 1 carcass estimate is based on counting and chopping all observed carcasses on each survey day. Due to the sample frequency and small channel, a mark-recapture study design is not being implemented in Reach 1 to estimate carcass abundance.

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). For Reaches 2, 3, and 4, an additional sample expansion (the inverse of the number of fish handled during spawning ground surveys divided by the direct count observed at the video counting facility) was applied.

Preliminary grilse and adult proportions were determined using length frequency analysis of randomly sampled male Chinook, and final grilse and adult proportions and age composition determinations were made by the Klamath River Technical Advisory Team using scale age analysis.

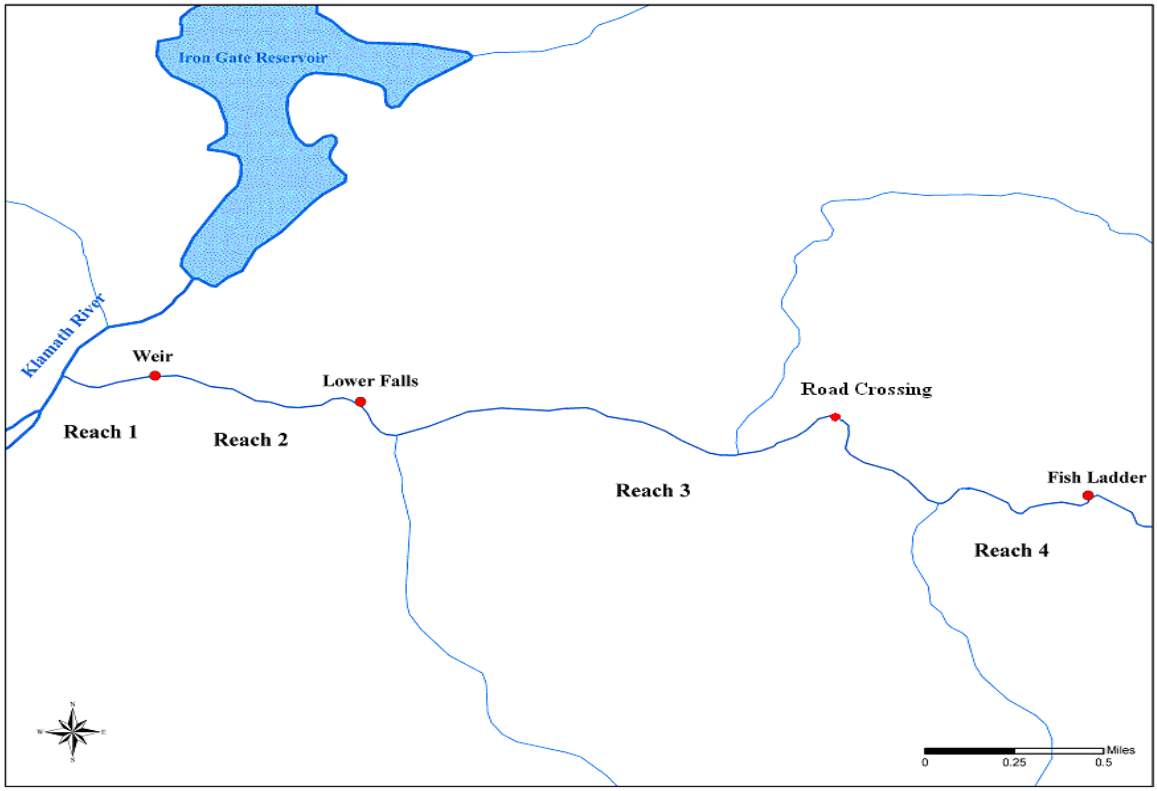

Figure 2. Map of spawning ground survey reaches on Bogus Creek used during the 2016 season. The weir denotes the location of the Bogus Creek Fish Counting Facility.

RESULTS

OPERATION OF THE BOGUS CREEK FISH COUNTING FACILITY

The BCFCF began recording fish movements at 0900 hours on September 8, 2016. The first Chinook Salmon was observed at the BCFCF on September 17, 2016, and the last Chinook Salmon was observed on November 26, 2016. As in prior years, the video flume was blocked to prevent fish from moving upstream until the first Chinook was observed below the counting facility or the first Chinook was observed at IGH. The run peaked between October 1, 2016, and October 20, 2016, (Figure 3) when 85.7% of the total run was observed. Ninety-two percent (92%) of observed Chinook Salmon passed through the BCFCF during daylight hours (between 0700 and 1900) and migration peaked in the afternoon between 1500 and 1700 hours (Figure 4).

A net total of 775 Chinook Salmon were estimated to have passed through the BCFCF during the 2016 season. A total of 93 Chinook Salmon carcasses were counted in Reach 1, downstream of the BCFCF, yielding a total run size estimate of 868 Chinook Salmon. Based

on the proportion of male and female Chinook Salmon sampled during the spawning ground surveys, the run was comprised of approximately 359 (41.3%) males and 509 (58.7%) females. Based on scale age analysis, adults comprised approximately 95.6% (830 fish) and grilse comprised 4.4% (38 fish) of the run (KRTT, 2017).

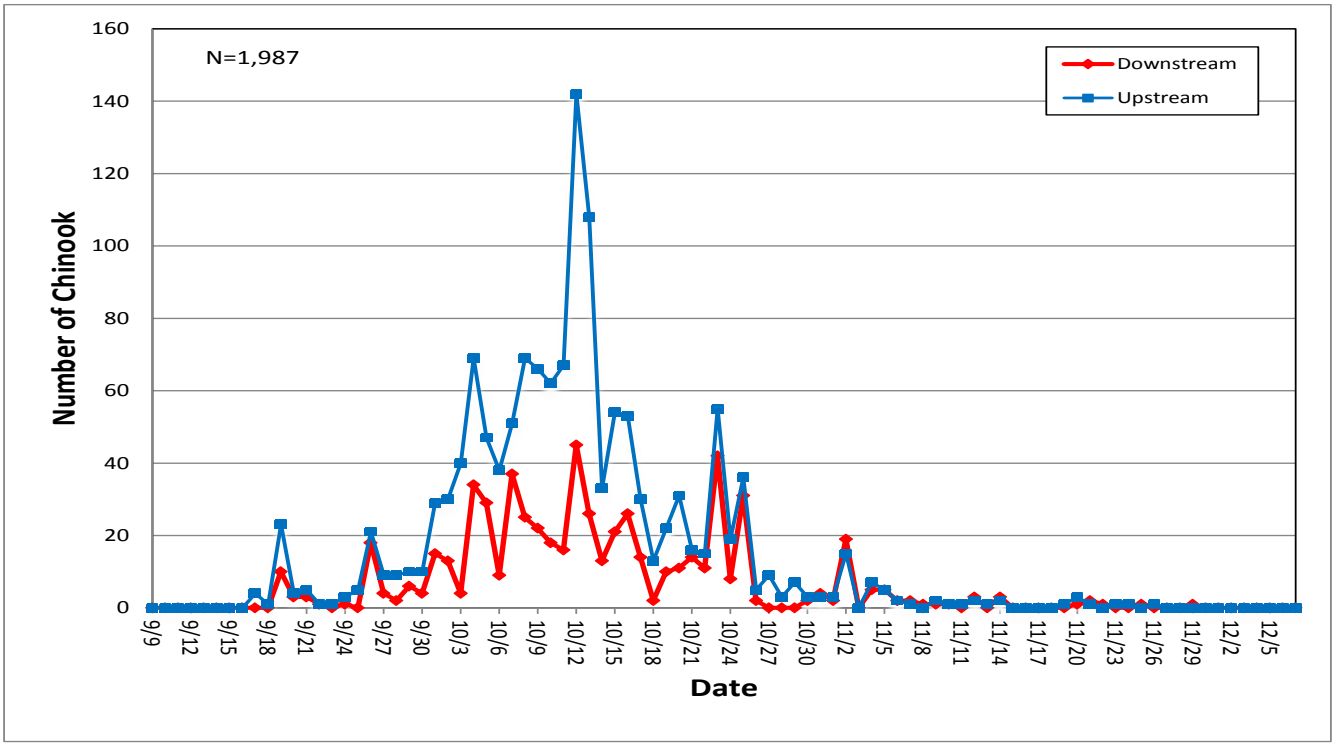

Figure 3. Run timing of Chinook Salmon through the BCFCF during the 2016 season. Both upstream and downstream movements through the counting flume are shown (N=1,987).

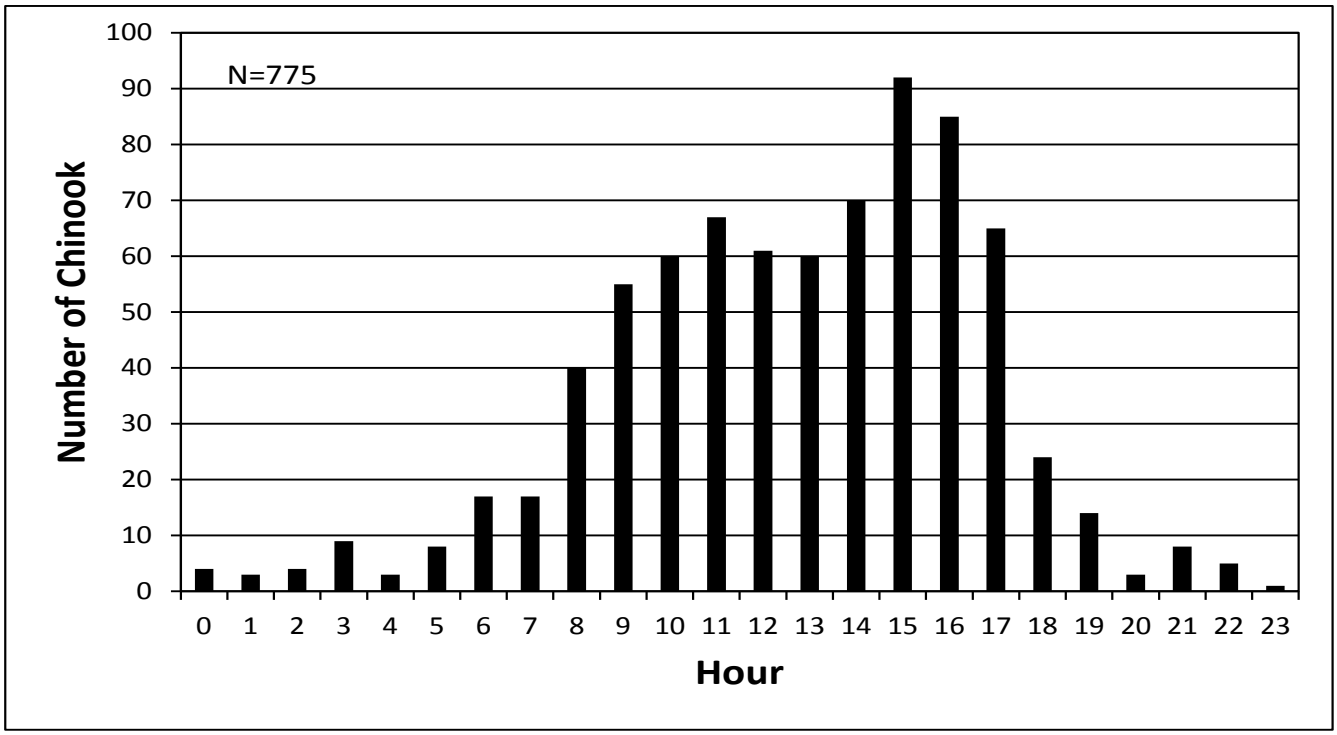

Figure 4. Summary of hourly run timing of Chinook Salmon observed (N=775) at the Bogus Creek Fish Counting Facility during 2016.

SPAWNING GROUND SURVEYS

A total of 121 Chinook Salmon carcasses were systematically sampled (1 in 2) during the spawning ground survey. Of the 121 Chinook Salmon carcasses systematically sampled, 50 (41.3%) were male and 71 (58.7%) were female, and 14 were ad-clipped (an additional 9 non-random ad-clipped Chinook were sampled). Males ranged in fork length from 55 cm to 93 cm and averaged 75.5 cm (Figure 5). Based on the length frequency distribution of male Chinook Salmon presented on Figure 5, grilse were determined to be ≤ 58 cm in fork length. The grilse determination based on fork length frequency was supported by scale age analysis (KRTT). Females ranged in fork length from 56 cm to 82 cm and averaged 69.6 cm (Figure 6).

A total of 71 female Chinook Salmon carcasses were systematically sampled (1 in 2) during the spawning ground survey. Each of these was examined to determine if they had 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 71 female Chinook Salmon carcasses examined, all 71 females (100%) were found to have spawned.

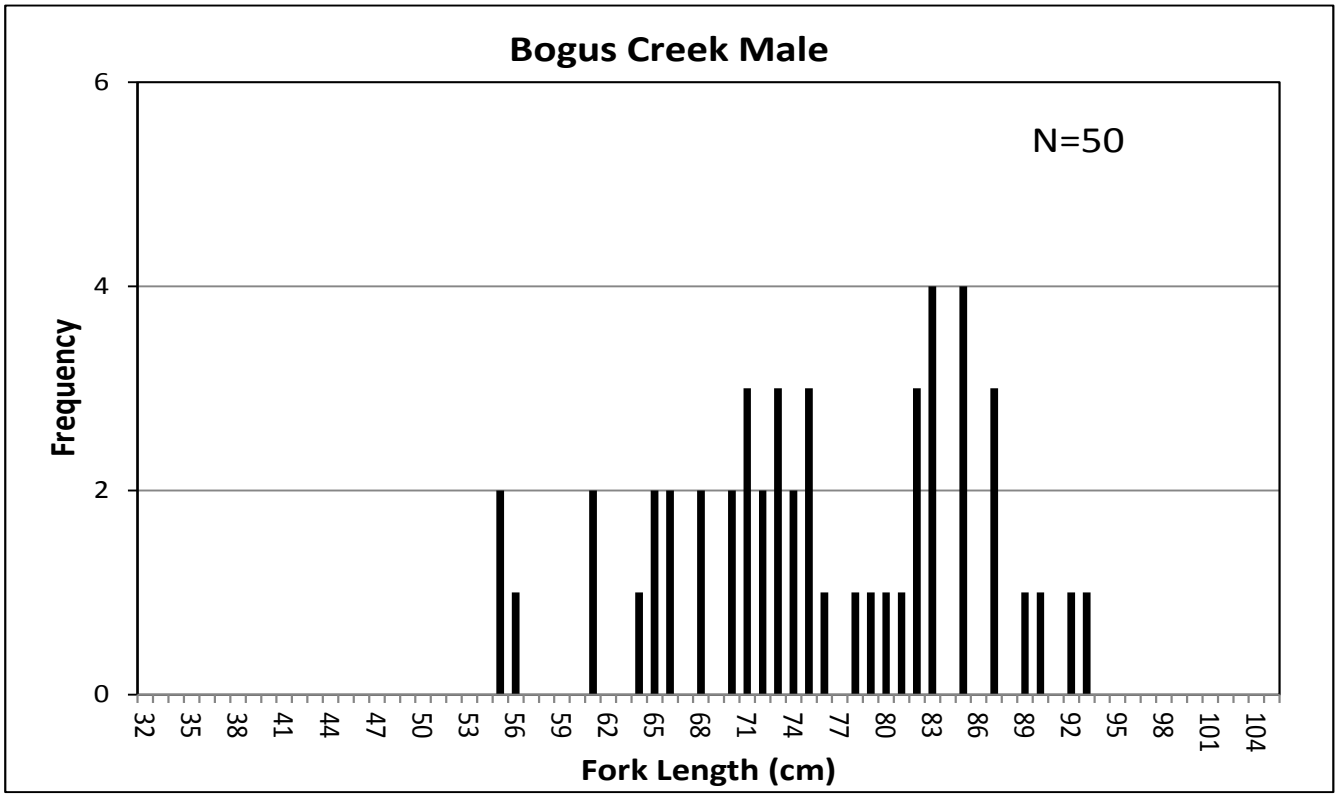

Figure 5. Length Frequency distribution of male Chinook Salmon systematically sampled during spawning ground surveys in Bogus Creek, 2016 (N=50).

HATCHERY CONTRIBUTION ESTIMATE

A total of 23 heads were collected from ad-clipped Chinook Salmon. Positive CWT reads were obtained from 22 heads. One head was collected that did not contain a CWT. No tags were lost during extraction. All of the CWT's recovered were from IGH releases. To estimate the total hatchery contribution, the number of recoveries for each CWT was multiplied by the production multiplier derived at the time of release from IGH. As a result of the carcass survey effort upstream of the BCFCF not including all areas of anadromy, a sample expansion was

applied to all CWT recoveries upstream of the BCFCF (Table 1). The sample expansion (3.74) is based on the inverse of the number of carcasses (207) examined upstream of BCFCF during spawning ground surveys divided by the total number of Chinook Salmon observed passing through the station (775). As a result of the entire reach being surveyed twice a week and the narrow stream channel a sample expansion is not utilized to estimate hatchery contribution in reach one. KRP staff estimated that 209 (24.05%) of the Chinook Salmon in Bogus Creek during the 2016 season were of hatchery origin.

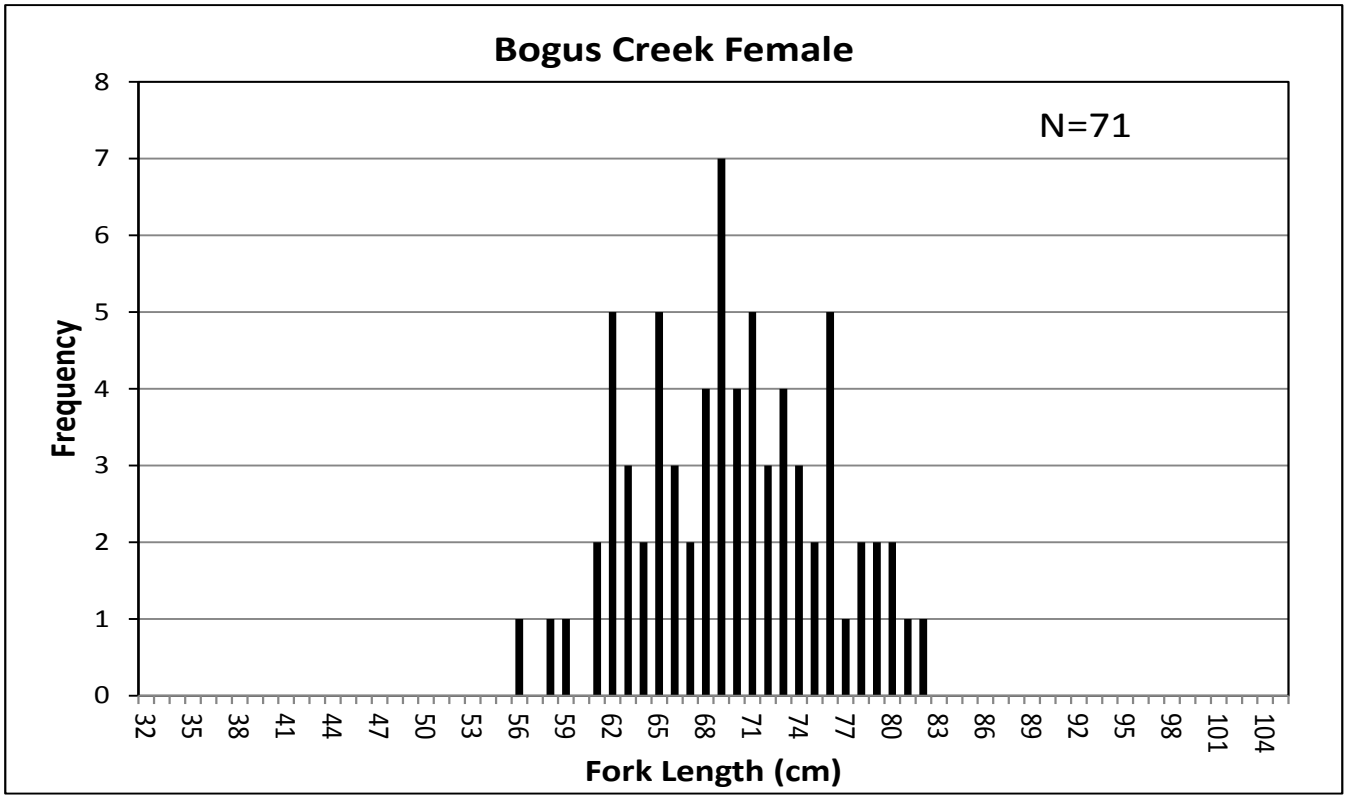

Figure 6. Length frequency distribution of female Chinook Salmon systematically sampled during spawning ground surveys in Bogus Creek, 2016 (N=71).

COHO SALMON

The first adult Coho Salmon was observed entering Bogus Creek on November 7, 2016 and the last Coho Salmon was observed on January 1, 2017. A net total of 81 Coho Salmon were observed moving upstream through the BCFCF during the season (Figure 7). No Coho were recovered downstream of the counting station as carcasses during the season. Four additional Coho were added for periods when the camera was not functioning, yielding a season total of **85**. Diel movements of Coho Salmon through the BCFCF varied but were generally higher during non-daylight hours (Figure 8).

Table 1. Estimated contribution of hatchery origin fall Chinook Salmon in Bogus Creek, 2016.

Spawning Ground Surveys, Reach 1									
Coded Wire Tag	**Location**	**Release Type a/**	**Brood Year**	**Age**	**Sample Number**	**Production Multiplier b/**	**Production Estimate**	**Sample Expansion**	**Total Estimate**
060375	IGH	F	2012	4	1	4.02	4	1	4
068797	IGH	F	2012	4	1	4.00	4	1	4
060501	IGH	F	2012	4	3	4.02	12	1	12
060507	IGH	F	2012	4	1	4.02	4	1	4
060597	IGH	F	2013	3	2	4.05	8	1	8
060604	IGH	Y	2013	3	1	4.01	4	1	4
				Sub Total=	9			Sub Total=	36
Estimated contribution of lost or unreadable CWT's					0			Sub Total=	0
								Total=	36
Spawning Ground Surveys, Reach 2, 3, and 4									
Coded Wire Tag	**Location**	**Release Type**	**Brood Year**	**Age**	**Sample Number**	**Production Multiplier**	**Production Estimate**	**Sample Expansion c/**	**Total Estimate**
068797	IGH	F	2012	4	4	4.00	16	3.74	60
068798	IGH	F	2012	4	3	4.01	12	3.74	45
060501	IGH	F	2012	4	2	4.02	8	3.74	30
060602	IGH	F	2013	3	2	4.02	8	3.74	30
060597	IGH	F	2013	3	2	4.05	2	3.74	7
				Sub Total=	13			Sub Total=	173
Estimated contribution of lost or unreadable CWT's					0			Sub Total=	0
								Sub Total	173
							Total Estimated Hatchery Contribution=		**209**

a/ Release type; F=Fall fingerling, Y=Fall Yearling

b/ Production Multiplier value is the inverse of the proportion of effectivily tagged and total release from IGH

c/ Sample expansion is the inverse of the number samples during the carcass survyeys in reach 2, 3, and 4 divided by the video estimate.

SPAWNING GROUND SURVEYS

A total of 5 Coho Salmon carcasses (2 females and 3 males) were sampled during the spawning ground survey. In an effort to increase the sample size to more accurately describe the age structure of the Coho Salmon run, the information from PIT detected fish with known lengths have been added to the spawning ground survey data. Three males were recovered (PIT) and were 44, 48 and 70 cm respectively. Based on the length frequency distribution of observed male Coho Salmon, grilse were determined to be ≤ 52 cm in fork length (Figure 9). Females ranged in fork length from 45 cm to 67 cm and averaged 56 cm.

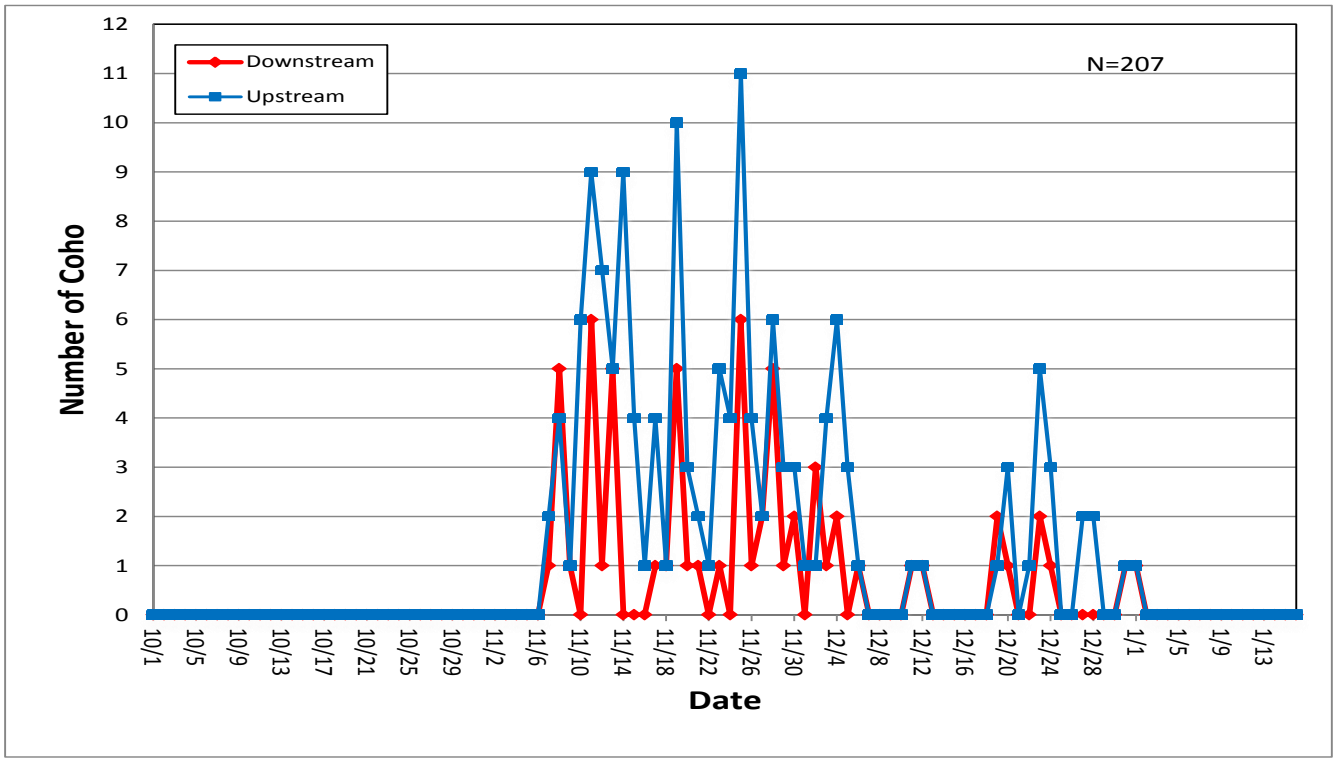

Figure 7. Run timing of Coho Salmon observed passing through the Bogus Creek Fish Counting Facility during the 2017 season. Both upstream and downstream movements through the counting flume are shown (N=207).

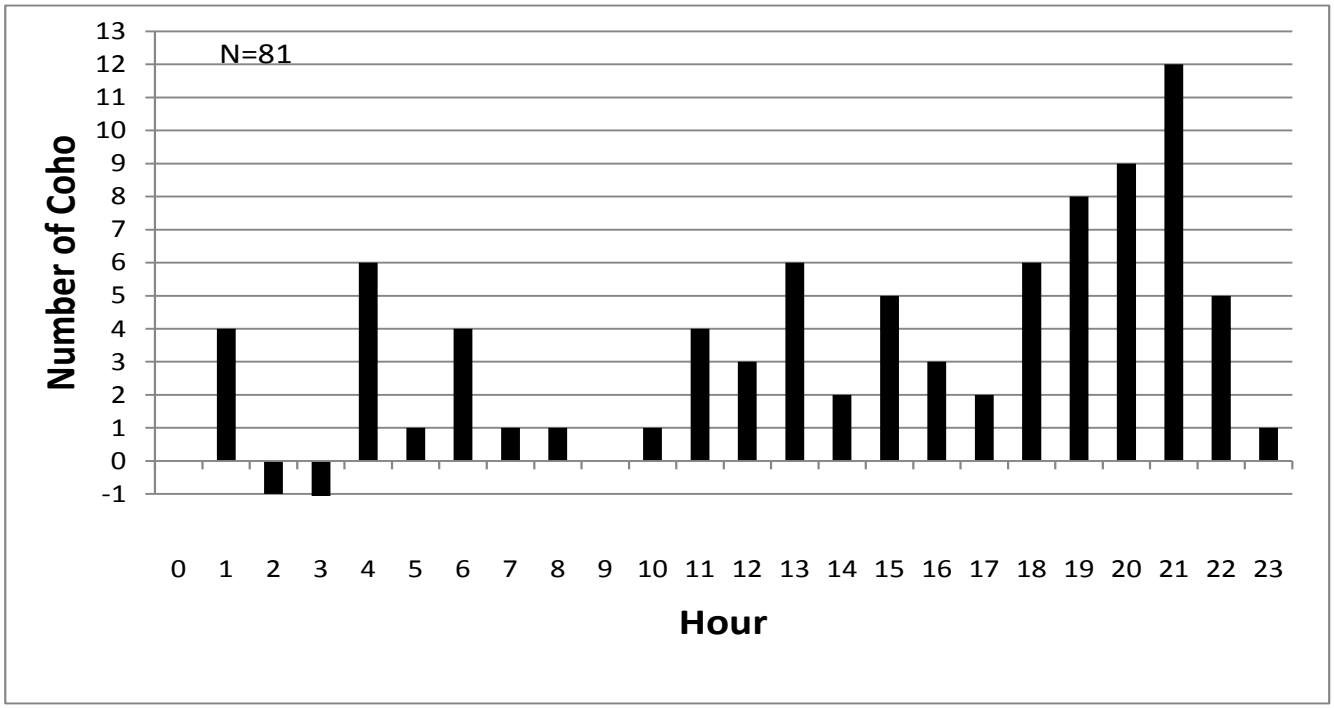

Figure 8. Diel migration patterns of Coho Salmon observed (N=81) moving through (hourly net movement) the Bogus Creek Fish Counting Facility in 2017.

Two female Coho Salmon carcasses were examined to determine if they had 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 two females recovered, both were determined to have spawned. All six of the caudal punched and released Coho from IGH during 2016 were males. As a result, prespawn mortality for IGH released surplus adults was not estimated during 2016. It is unclear why the prespawn mortality is so high for non-surplus adults (Table 2). The high prespawn mortality associated with IGH released surplus adults can in part be attributed to multiple handling events and stress associated with living in captivity for up to 10 days.

Table 2. Estimated Bogus Creek surplus and non-surplus Coho Salmon percent prespawn mortalities during the 2004 through 2016 seasons.

	Percent Prespawn Mortalities			
Year	IGH Released Surplus Adults	Non-Surplus Adults	Aggregate of both IGH released Surplus adults and non-Surplus adults	Average
2004		28.6		28.6
2005			19.6	19.6
2006				
2007			17.2	17.2
2008			36.4	36.4
2009				
2010	40	12.5		26.3
2011	50	62.5		56.3
2012	66.6	42.9		54.8
2013	24.4	10.3		17.4
2014		25		25.0
2015		50		50.0
2016[1]		0		0.0
Average	45.3	29.0	24.4	33.1

/[1] based on two recoveries

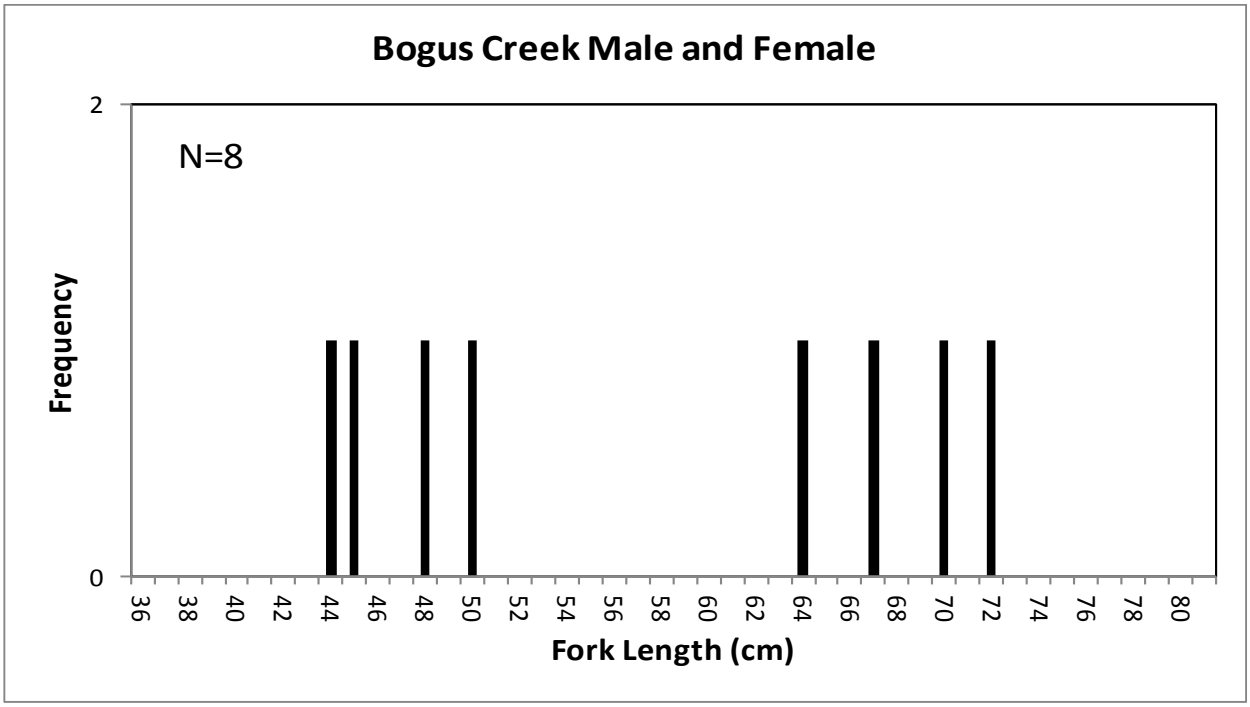

Figure 9. Length frequency distribution of male and female Coho Salmon detected at PIT arrays or observed during spawning ground surveys in Bogus Creek, 2016 (N=8).

STEELHEAD

In 2016, a net total of 84 adult (>40.6cm.) steelhead (234 upstream, 150 downstream; Figure 10) were estimated to have entered and remained in Bogus Creek during the video recording season from September 8, 2016, to May 1, 2017. During this time there were a total of 384 steelhead observations including both upstream (234) and downstream (150) movements. The 234 observed upstream migrating steelhead represents the maximum number of steelhead for the season. The actual number of steelhead for the season is likely much lower than 234 as some fish move up and down through the flume multiple times. The net upstream movement of 84 fish represents a minimum number of steelhead for the season. Peak upstream movement of adult steelhead was observed on March 15, 2016, when a net upstream total of 16 adult steelhead were observed. Lines on the back of the video flume were set at 40.6 cm. to delineate sub-adults versus adults.

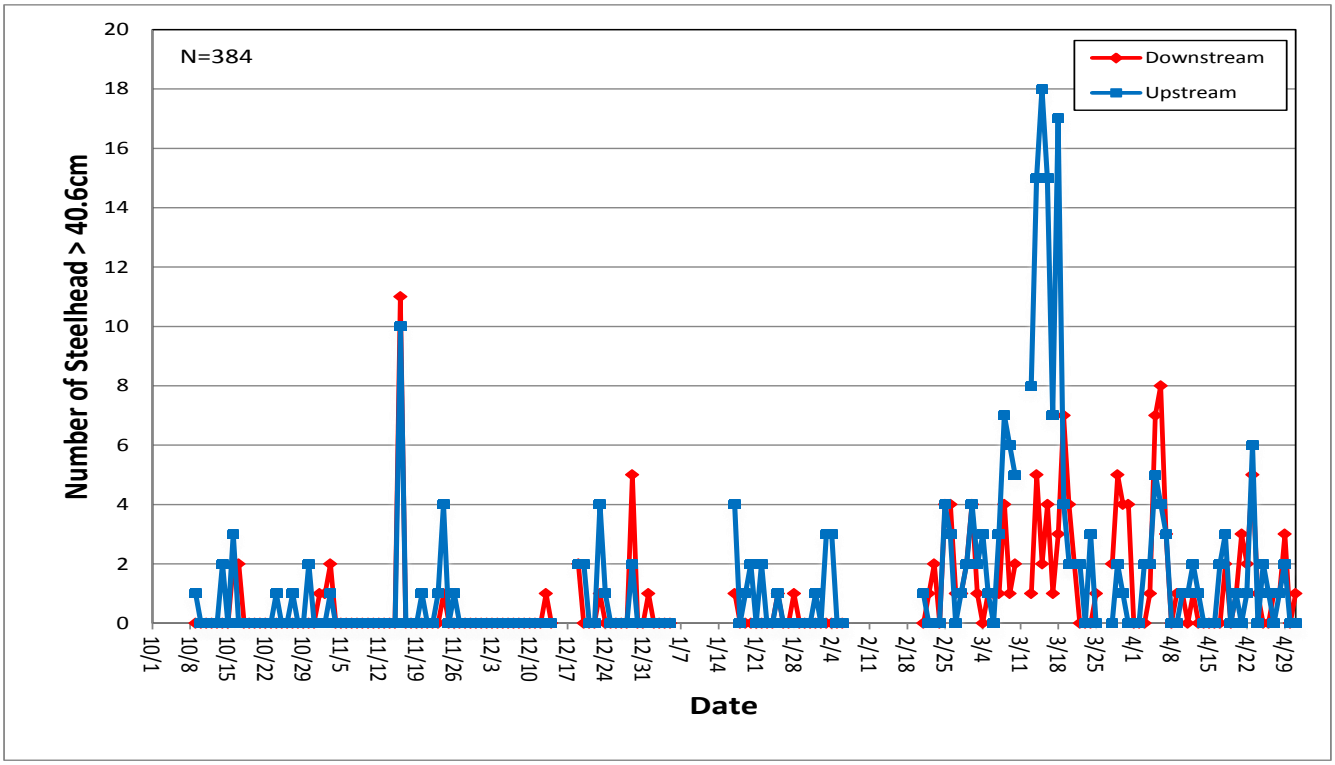

Figure 10. Run timing of steelhead trout (>40.6 cm.) observed passing through the Bogus Creek Fish Counting Facility during the 2016 season (N=384). Both upstream and downstream movements are shown.

DISCUSSION

HISTORIC CHINOOK SALMON RUNS

Since 1978, the Chinook Salmon run in Bogus Creek has ranged from 46,432 fish (1995) to 785 fish (1990) and averaged 8,269 fish (Figure 11). The 2016 Chinook Salmon run in Bogus Creek ranks thirty-eighth (868 fish) out of 39 years of data. During the peak return of Chinook to Bogus Creek in 1995 (46,432 fish), the ladder gates to IGH were closed after the hatchery met its egg production goal. Therefore, a significant portion of the IGH Chinook Salmon that would otherwise have entered the hatchery either spawned in the main stem Klamath River or entered tributaries including Bogus Creek. This would partially account for the large return of Chinook Salmon observed in Bogus Creek during the 1995 season. As a result, the run size estimates for IGH and Bogus Creek during the 1995 season do not accurately describe the run size that would most certainly have occurred if the ladder gates at IGH were left open during that year. Subsequent to 1995, the hatchery policy was modified to allow all Chinook Salmon to enter the hatchery regardless of the numbers of fish that may return. In addition, the current policy reduces the potential for hatchery stocks to spawn in natural areas and as a result reduces the potential interactions between hatchery and natural area produced Chinook Salmon populations within the basin.

HATCHERY CHINOOK SALMON CONTRIBUTIONS

The KRP has estimated the contribution of hatchery origin Chinook Salmon in Bogus Creek since 1999. Over that period of time, the contribution of hatchery Chinook Salmon in relation to the total Chinook Salmon run in Bogus Creek has fluctuated ranging from 61.6% to 7.5%

and averaged 34.9%. An estimated 24.1% of the Chinook Salmon that entered Bogus Creek during 2016 were of hatchery origin (Figure 12).

Yearling Chinook Salmon released from IGH in 1998 (Brood Year 1997) and 1999 (Brood Year 1998) were not tagged prior to release due to budgetary constraints. Without tags, it is impossible to determine contribution rates on these yearling releases; therefore, the hatchery estimates presented for Bogus Creek do not account for potential hatchery returns from these two release groups. Three-year-old returns from these two yearling brood years would have occurred during the 2000 and 2001 seasons. The 2003 return would have been the last year that untagged yearlings from the 1998 brood year would have returned as 5-year-old fish. As a result, the hatchery contribution estimates for Bogus Creek from 1999 to 2003 likely under estimate the total hatchery contribution to Bogus Creek by an unknown number. Even without accounting for these untagged yearling releases, a large proportion of the 2000 (37.2%) and 2001 (61.6%) Chinook Salmon run that returned to Bogus Creek originated from IGH. Additionally, starting in Brood Year 2008 (released in 2009), IGH initiated a 25% constant fractional marking program with the goal of marking and tagging 25% of its Chinook production.

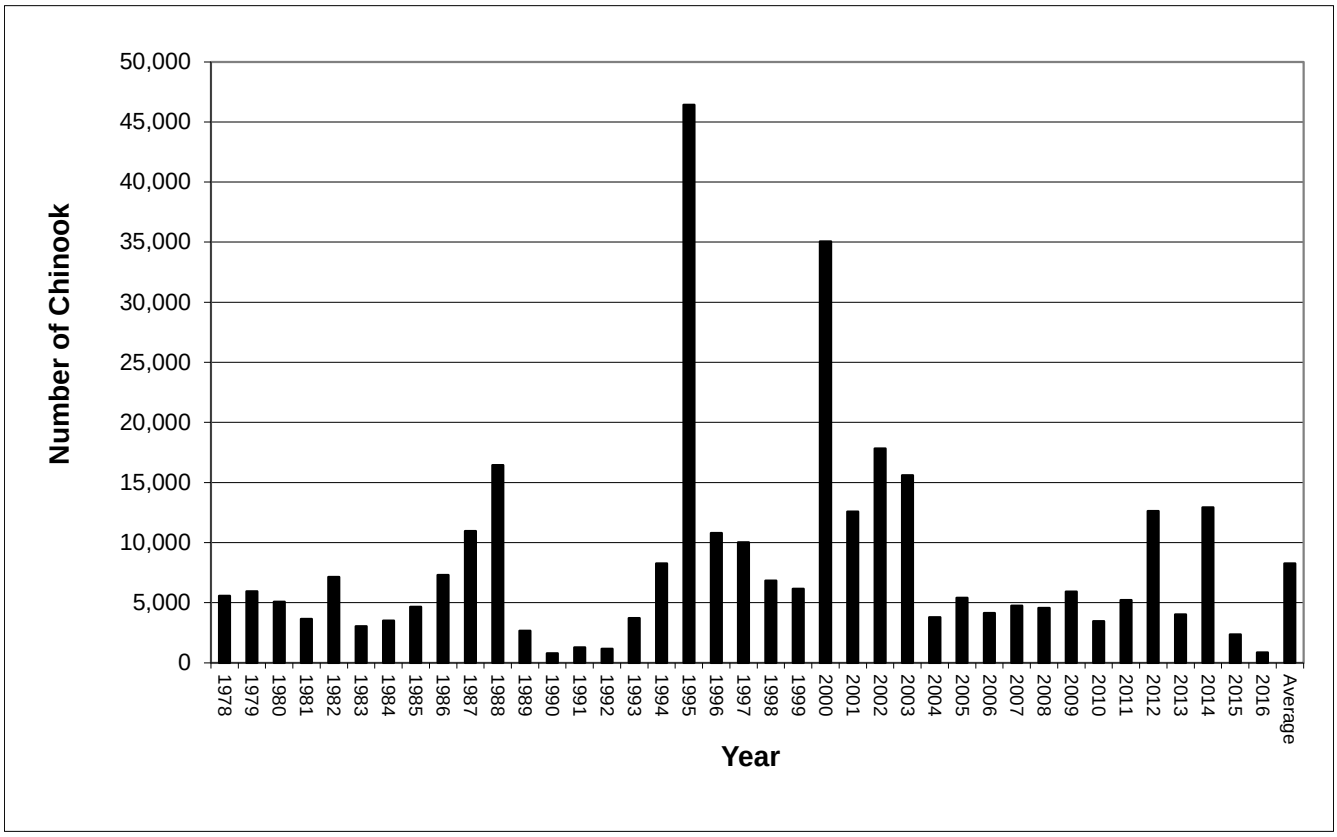

Figure 11. Estimated escapement of adult Chinook Salmon returning to Bogus Creek from 1978 to 2016.

As noted previously, the mouth of Bogus Creek is roughly 75 feet downstream of the entrance to the auxiliary fish ladder used for trapping adult returns to the hatchery. As a result of the extremely close proximity of Bogus Creek to IGH and particularly the axillary fish ladder, there has been significant mixing of salmonids from these two locations.

COHO SALMON

Since video operations began in 2004 the estimated escapement of Coho Salmon in Bogus Creek has averaged 158 fish (Figure 13). The run size of Coho Salmon during 2016 was estimated to be 85 which was 46.1% below the 13-year average. Coho Salmon abundance in 2016 (85) was less than when this year class returned most recently in 2013 (446). A reduction in run size of 80.9% was observed in one generation (Figures 14-16). The decrease in brood year strength observed in 2016 was largely not buffered by the influence of IGH origin fish. Some Coho stray into Bogus Creek after first entering IGH and are subsequently released as part of the surplus adult release program intended to reduce the demographic risk of extinction to the Upper Klamath Coho Salmon population unit as identified in the HGMP. Other hatchery origin

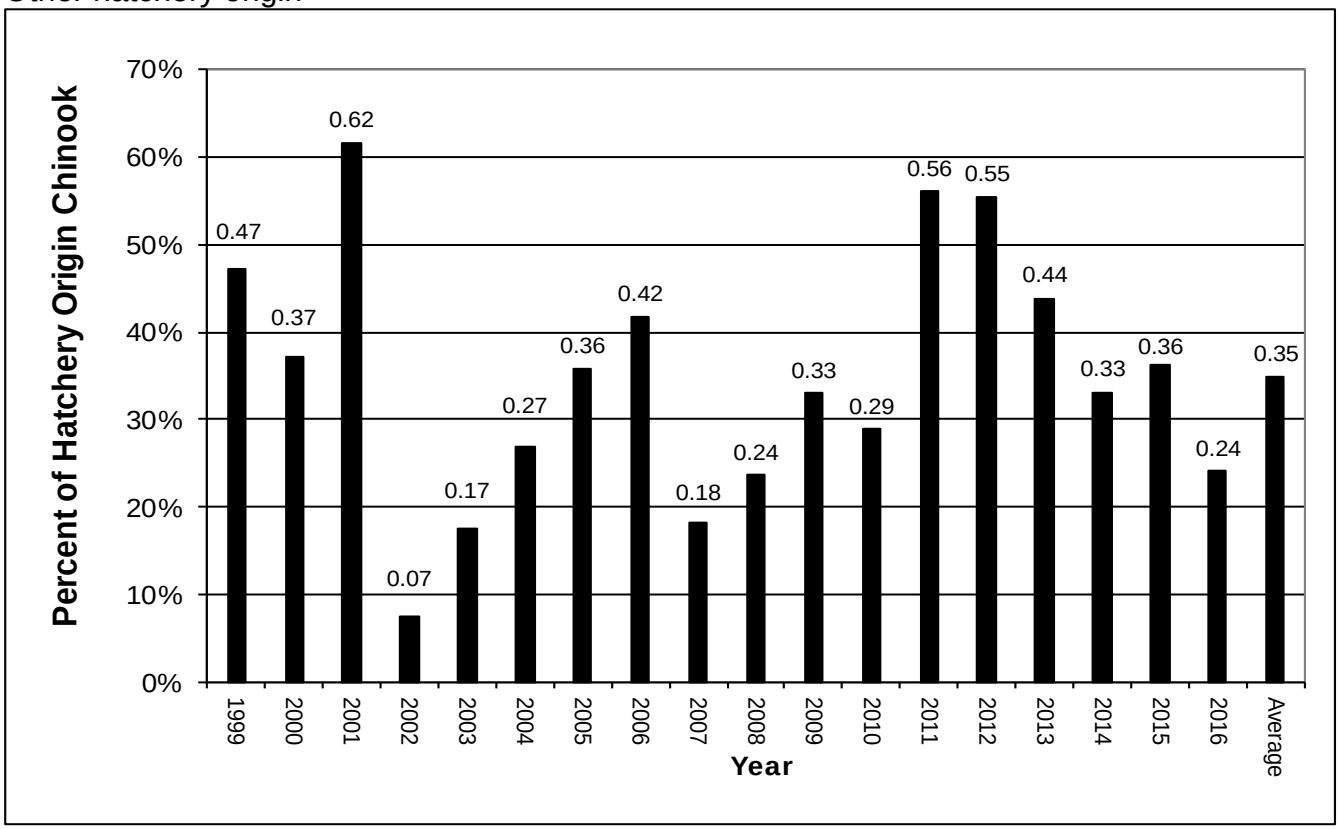

Figure 12. Estimated contribution of hatchery origin Chinook Salmon observed in Bogus Creek from 1999 through 2016.

adult Coho stray directly into Bogus Creek without first entering IGH. If the estimated IGH strays (35) that entered Bogus Creek as a result of the adult release program at IGH and natural staying were removed from the abundance estimate only 50 natural origin Coho would remain, and a resulting decrease in brood year strength of 88.8% would have been observed.

In 2016 86 Coho entered IGH of which 6 surplus fish were PIT tagged and released back into the Klamath River. Fifty percent (3/6) of the surplus Coho were detected in Bogus Creek at an antenna array located at the mouth of Bogus. Due to the low number of surplus Coho releases at IGH during the 2016 season surplus fish influence on sex ratios and age structure in Bogus Creek was lower than during previous seasons in which adult releases occurred.

Eighty-five Coho were observed passing through the BCFCF (RKM 0.3) and, of those fish, 3 were surplus Coho from IGH (detected on the PIT tag antenna array) with known sexes and lengths (3 males). During carcass surveys upstream of the weir, 5 Coho Salmon were sampled and all were non-surplus fish (2 female and 3 male). The proportion of male to female fish based on the 5 fish sampled (60% male and 40% female) was applied to the proportion of the run that were not PIT tagged (82 Coho). These proportions when applied to the 82 non-surplus Coho known to have entered Bogus Creek through the video weir estimated that 49 were male and 33 were female. No Coho Salmon carcasses were recovered in Reach 1 downstream of the BCFCF. These groups (known and estimated from above the BCFCF) were added to generate the final sex composition of 52 male (61.2%) and 33 females (38.8%). Utilizing this same method, a total of 35 grilse (40.1%) and 50 adults (59.1%) have been estimated. Additionally, the proportion of grilse among males was estimated to be a 66.6%.

HATCHERY COHO SALMON CONTRIBUTIONS

Thirty-five of the total 85 (41.2%) Coho Salmon that returned to Bogus Creek were estimated to be of hatchery origin during the 2016 season. Eighty-five Coho were observed passing through the BCFCF (RKM 0.3) and, of those fish, 3 were surplus Coho from IGH (detected on the PIT tag antenna array) with known origin of 2 HOS and 1 NOS. During carcass surveys upstream of the weir, 5 Coho Salmon were sampled. The proportion of HOS to NOS fish based on the 5 fish sampled (40% HOS and 60% NOS) was applied to the proportion of the run that were not PIT tagged (82 Coho). These proportions when applied to the 82 non-surplus Coho known to have entered Bogus Creek through the video weir, estimated that 33 were HOS and 49 were NOS. No additional Coho Salmon carcasses were recovered in Reach 1 downstream of the BCFCF. These groups (known and estimated from above the BCFCF) were added to generate the final hatchery proportion of 41.2% percent for Bogus Creek.

The proportion of HOS Coho in Bogus Creek has been estimated since 2004 and has ranged from 24% to 88% and has averaged 51%. As a result of implementation of the recommendations contained in the HGMP, starting in 2010, Coho Salmon returns in excess of broodstock needs have been released back to the river. During the 2016 season, 6 adults were released from IGH, but during 2010, 2011, 2012, 2013, 2014 and 2015, 60, 259, 342, 896, 239 and 28 were released, respectively, and this has significantly affected the proportion of HOS to Bogus Creek (Figure 17).

None of the 5 (0%) Coho Salmon observed in the spawning ground survey upstream of the counting station were opercle punched (or contained a PIT tag), indicating that they were surplus Coho Salmon from IGH. Based on the proportion of Coho carcasses recovered, zero surplus Coho would have been predicted to have entered Bogus Creek upstream of the counting station. However, the empirical data from PIT detections shows that a total of 3 surplus Coho Salmon were detected at the BCFCF PIT tag antenna arrays (personal communication Steel Sims). During this analysis, it was assumed that if a PIT tagged fish was detected at the array in Bogus Creek (0.3 miles upstream from the confluence with the Klamath River), it was counted towards Bogus Creek returns. There is a possibility that a PIT tagged fish could have approached the array, was detected, but did not swim through the array and swam back downstream and left Bogus Creek. If this occurred, the PIT tag information has been slightly overestimated, although it is assumed this is a rare event. A comparison of

these two results illustrates that information generated from the spawning ground surveys alone underestimates the proportion of surplus Coho that enter Bogus Creek.

The proportion of Coho Salmon in Bogus Creek upstream of the counting station that were surplus fish from IGH was 3.5% (3/85). There were zero Coho Salmon carcasses recovered in Reach 1 downstream of the counting station yielding no additional surplus fish. Utilizing the Reach 1 information as well as the information collected at the counting station, the total estimated contribution of surplus Coho in Bogus Creek was 3.5% (3/85).

A total of 6 (6 PIT tagged) Coho were released from IGH during the 2016 season and an estimated 50% (3/6) of them subsequently entered Bogus Creek. Operculum erosion may have obscured the spawning ground survey crew's ability to observe all of the operculum punched Coho they encountered. The substitution of an opercle punch for the caudal fin punch has improved this discrepancy but accuracy could still be improved. None of the 5 recovered Coho carcasses was PIT tagged.

Utilizing total escapement, estimated proportion natural origin Coho and estimated age structure of returning adult Coho Salmon to Bogus Creek allows for total female spawner (natural origin only) to natural origin recruit analysis for years 2004, 2005, and 2007-2012 (Figure 18). The spawner recruit analysis (logarithmic regression) is limited to nine years of data, but indicates the production of natural origin Coho Salmon in Bogus Creek may be limited to roughly 150 adults. If additional years of data support this conclusion, then the HGMP will need to consider these findings if a Proportionate Natural Influence (PNI) target value of >0.5 is to be achieved in Bogus Creek. Currently, under phase one of the HGMP, hatchery strays will not be controlled until natural origin abundance in Bogus Creek >309. If the capacity for Bogus Creek is limiting production to <150 natural origin adults, then phase two will never be reached, and as a result, PNI will not be managed. Since active supplementation started in 2010, the proportion of hatchery origin spawners on the spawning grounds (pHOS) in Bogus Creek has exceeded 50% four out of seven years. The higher the pHOS becomes, the harder it is to achieve PNI values >0.5.

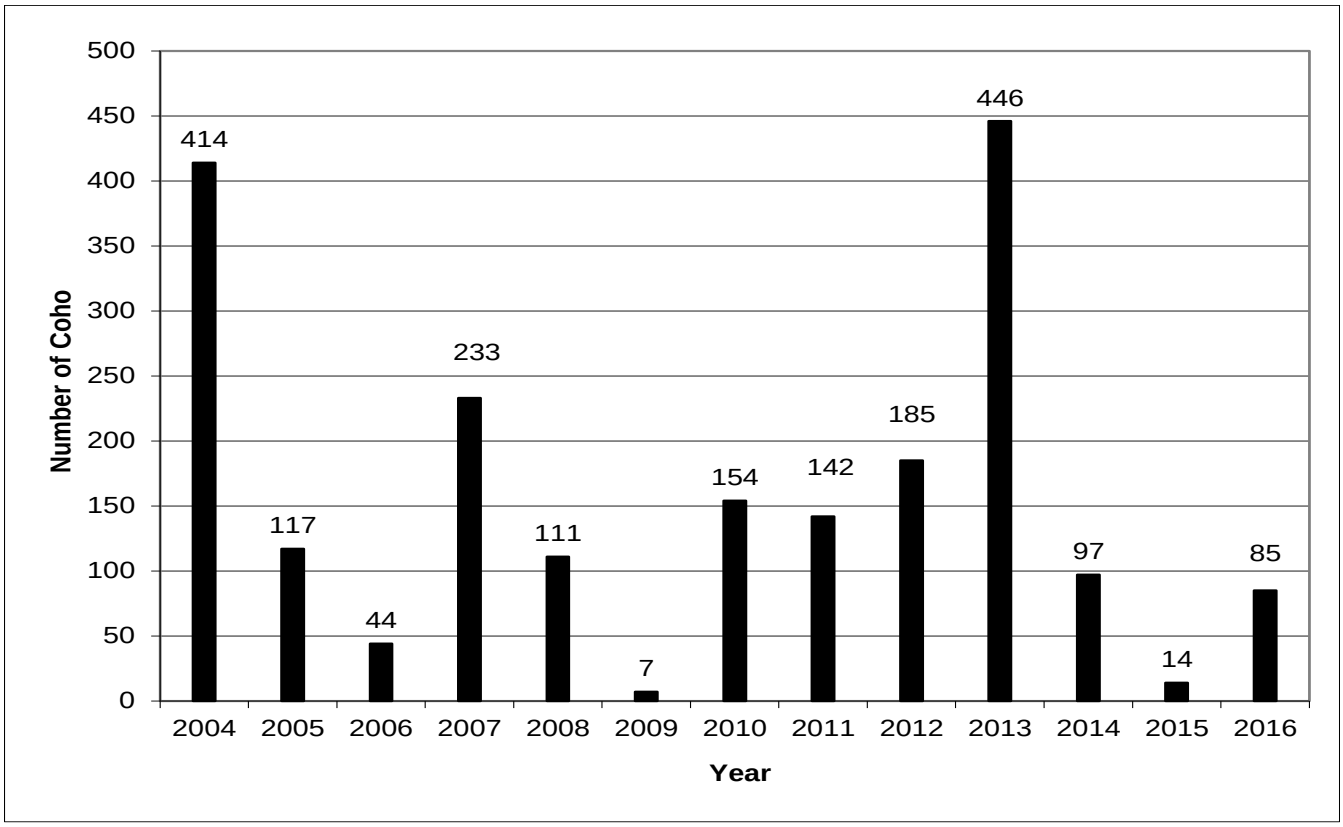

Figure 13. Estimated escapement of adult Coho Salmon returning to Bogus Creek from 2004 through 2016.

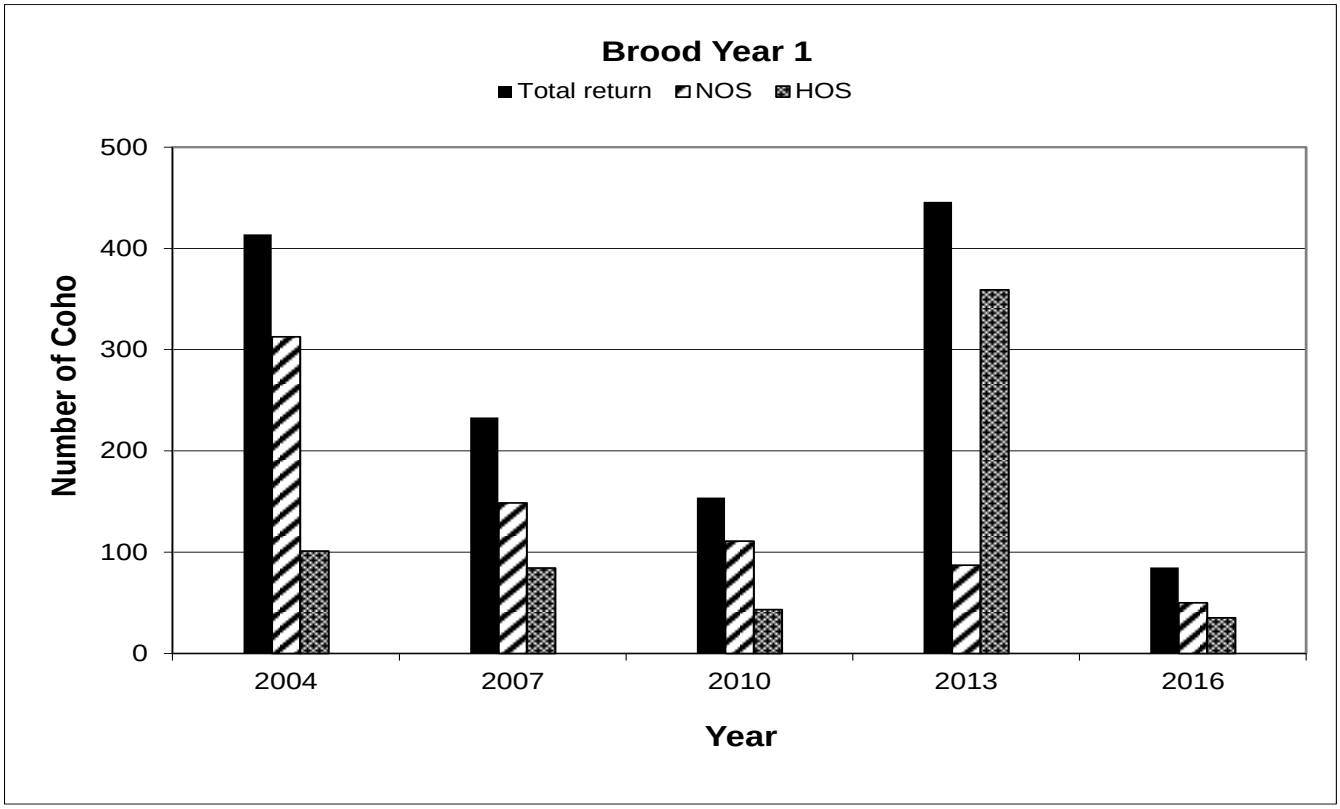

Figure 14. Estimated total return, natural origin spawners (NOS) and hatchery origin spawners (HOS) of adult Coho Salmon (Brood Year 1) returning to Bogus Creek from 2004 through 2016.

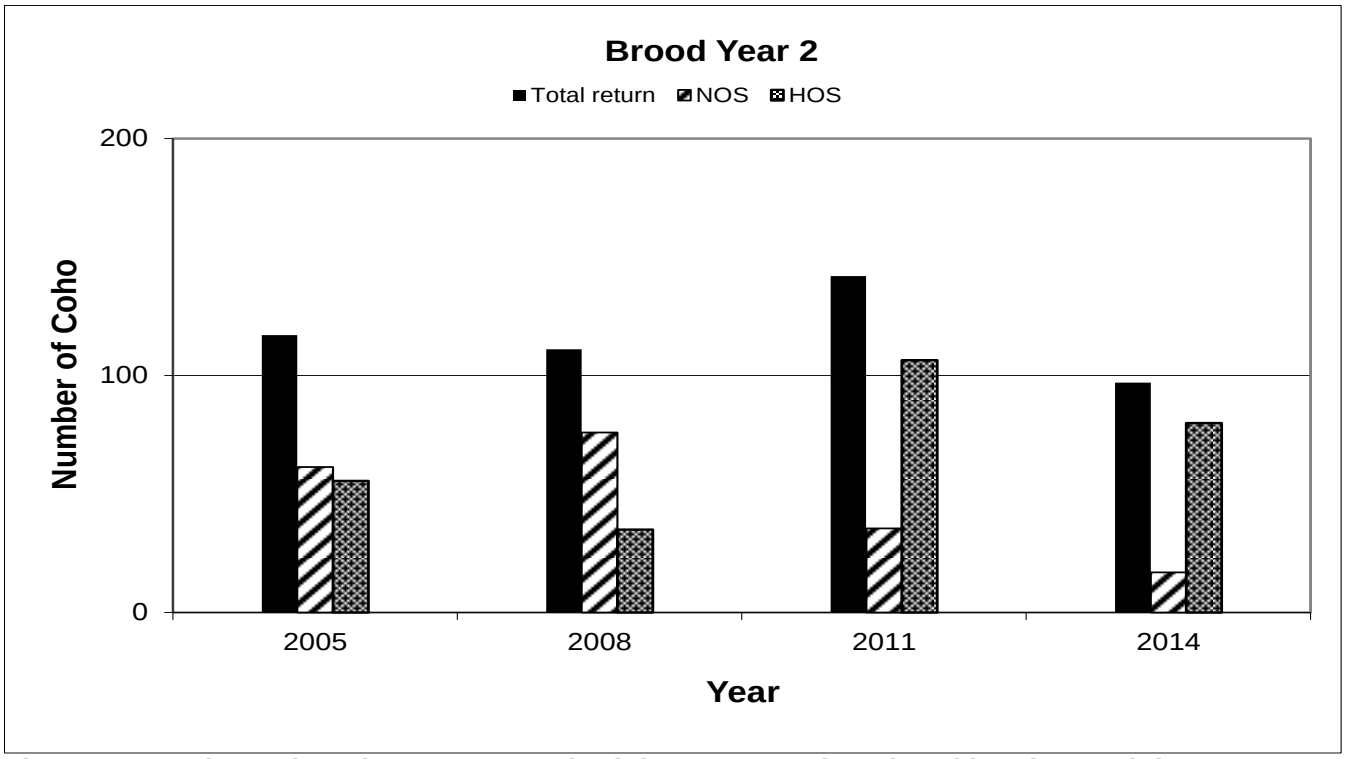

Figure 15. Estimated total return, natural origin spawners (NOS) and hatchery origin spawners (HOS) of adult Coho Salmon (Brood Year 2) returning to Bogus Creek from 2004 through 2014.

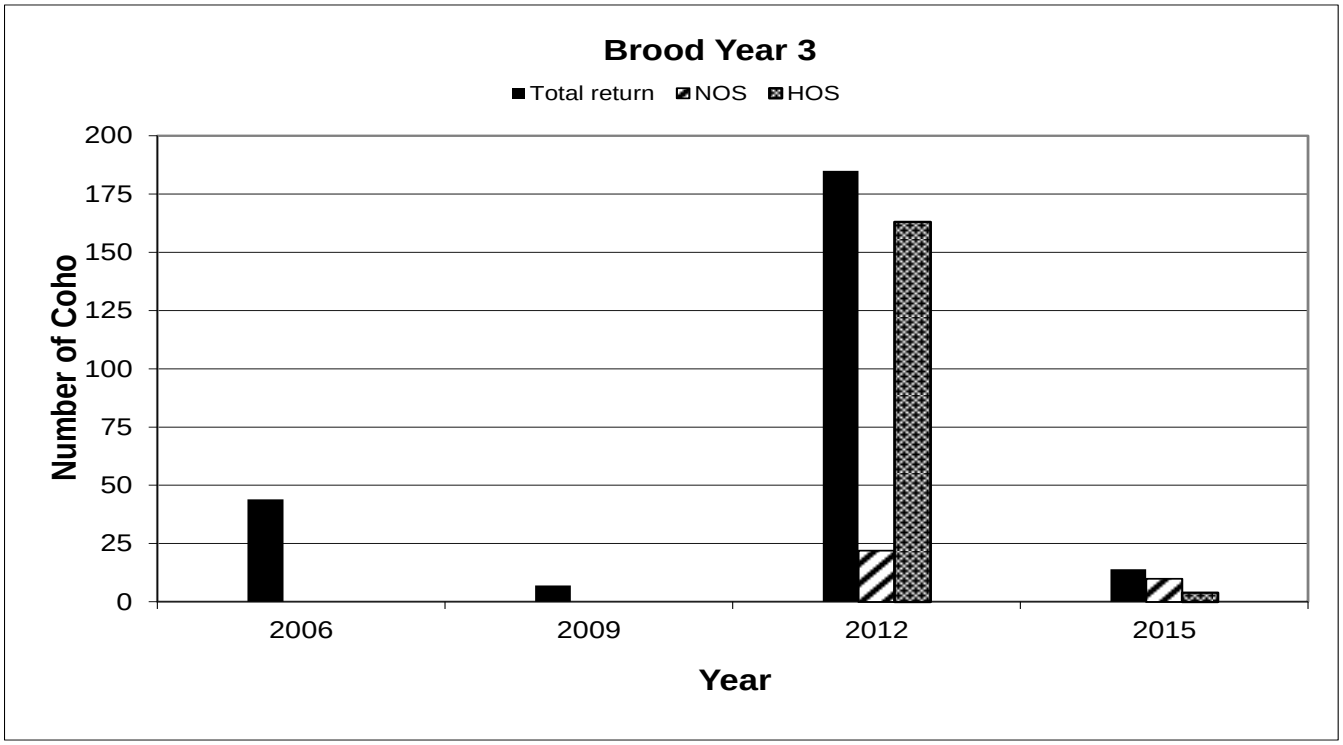

Figure 16. Estimated total return, natural origin spawners (NOS) and hatchery origin spawners (HOS) of adult Coho Salmon (Brood Year 3) returning to Bogus Creek from 2006 through 2015.

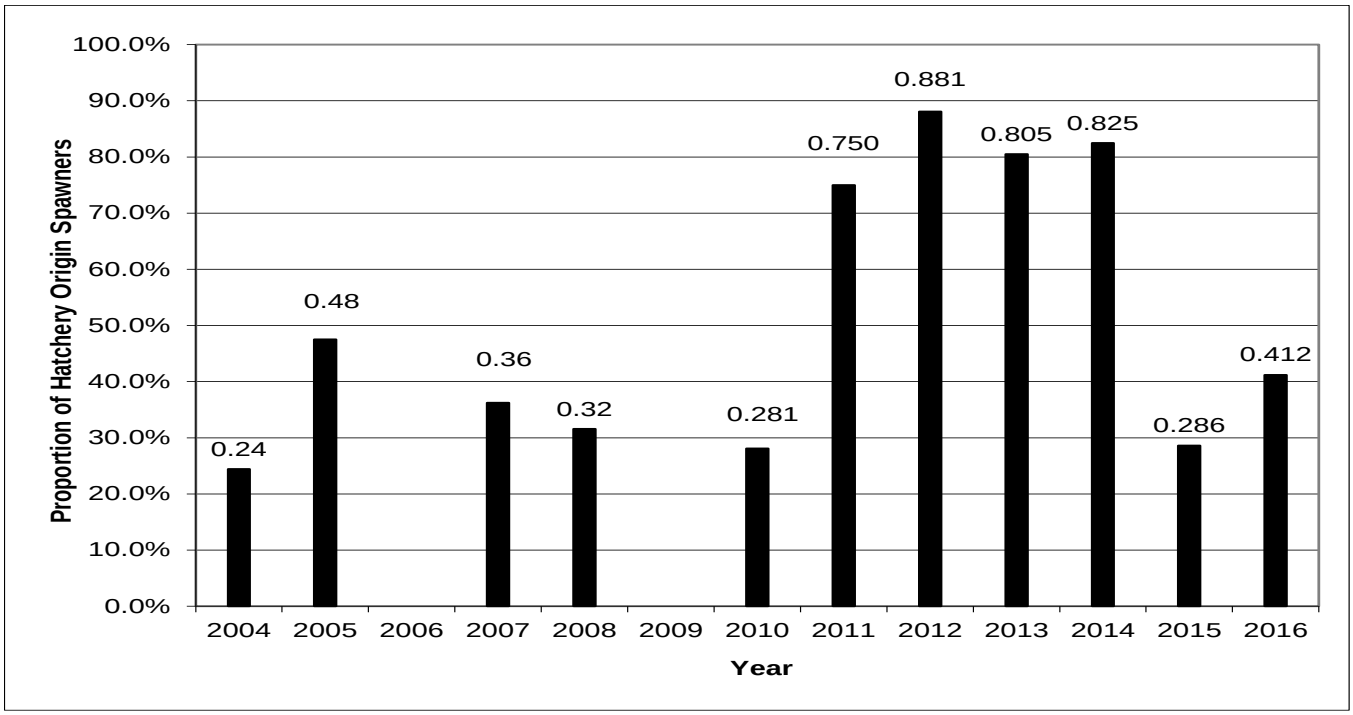

Figure 17. Estimated contribution of hatchery origin Coho Salmon observed in Bogus Creek from 2004 through 2016. Due to low carcass recovery in 2006 and 2009, hatchery contribution rates were not estimated in those years. Starting in 2010, Coho returns in excess of IGH broodstock needs have been released to the river.

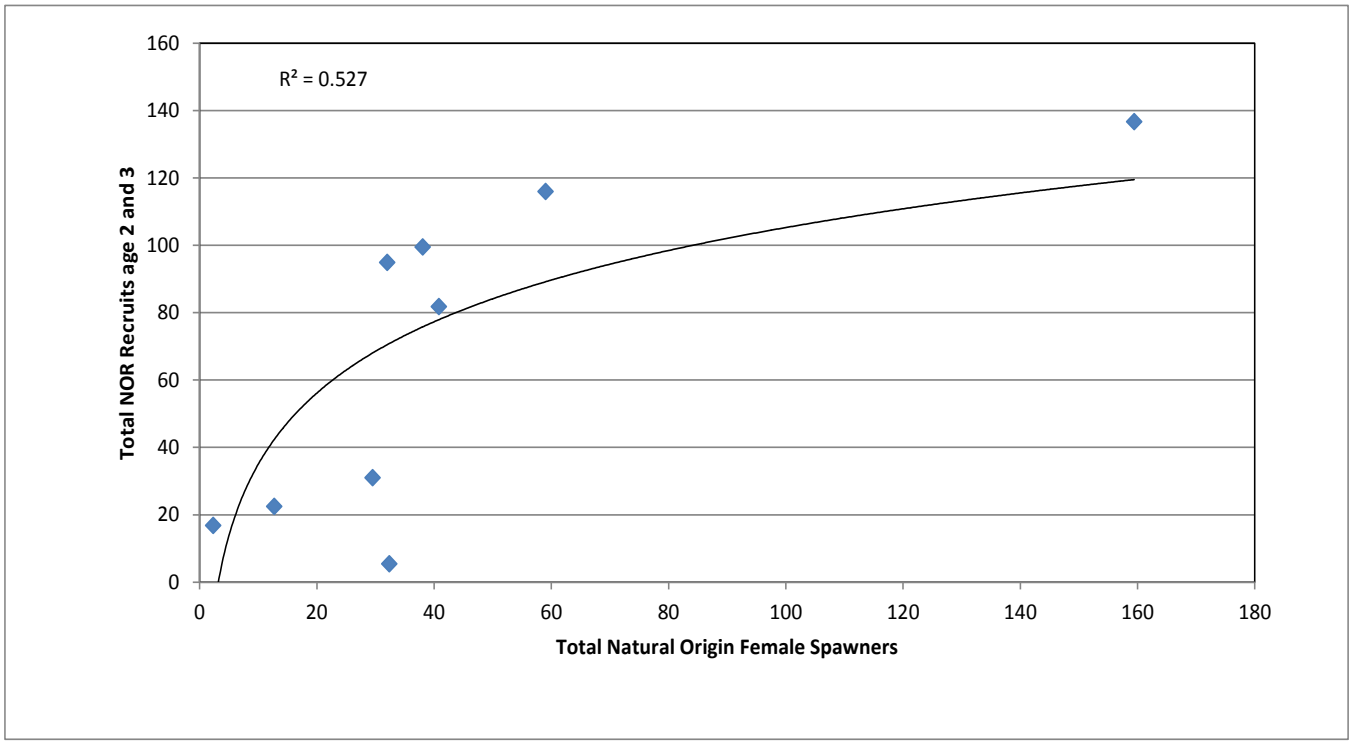

Figure 18. Spawner to recruit analysis (logarithmic regression) for Bogus Creek Natural Origin Coho Salmon for spawner brood years 2004, 2005, and 2007-2013.

STEELHEAD

The BCFCF monitoring extended to May 1, 2017 through the end of the known steelhead migration. The net number of steelhead observed at Bogus Creek has ranged from a low of 24 to a high of 103 and averaged 52.5 for the years 2007 through 2016 (Table 3). During most seasons the monitoring ended prior to the end of the steelhead migration but in both the 2013 and 2016 seasons monitoring extended to May 1st. During the 2013 and 2016 seasons the observed net upstream steelhead counts were 103 and 84 respectively. It is unclear how the resident rainbow trout population in the Klamath River influences the steelhead monitoring in Bogus Creek but there is a concern that the majority of the steelhead observations in March and April are not anadromous forms of *O.mykiss.* An additional concern when monitoring steelhead through the winter and into the spring is our inability to monitor for extended periods of time during the migration due to high flow events. During the 2016 season the Bogus Creek Fish Counting Facility was not operational for 40.25 days during the steelhead migration (Table 4). None of the steelhead observed on the videography had adipose fin clips, indicating that all observations were of natural origin fish.

Table 3. Net upstream steelhead (>40.6 cm) observed at Bogus Creek and the last date of video monitoring for the years 2007 to 2016.

Year	Net Upstream Steelhead >40.6cm	Last date of video monitoring
2007	24	12/31
2008	48	12/22
2009	54	12/15
2010	24	12/14
2011	42	12/23
2012	59	12/7
2013	103	5/1
2014	41	12/1
2015	46	1/16
2016	84	5/1
Average	52.5	

Table 4. Specific dates and times during the 2016 season when filming started and stopped, the number of hours without data for each day 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	12/6/2016	2000	4 : 00	0	1	0
	12/7/2016		24 : 00	0	1	0
	12/8/2016		24 : 00	0	1	0
Filming Started	12/9/2016	925	9 : 25	0	0	0
Filming Stopped	12/14/2016	945	14 : 15	0	0	0
	12/15/2016		24 : 00	0	0	0
	12/16/2016		24 : 00	0	0	0
	12/17/2016		24 : 00	0	0	0
	12/18/2016		24 : 00	0	1	0
Filming Started	12/19/2016	1115	11 : 15	0	0	0
Filming Stopped	1/5/2017	1200	12 : 00	0	0	0
	1/6/2017		24 : 00	0	0	0
	1/7/2017		24 : 00	0	0	0
	1/8/2017		24 : 00	0	0	0
	1/9/2017		24 : 00	0	0	0
	1/10/2017		24 : 00	0	0	0
	1/11/2017		24 : 00	0	0	0
	1/12/2017		24 : 00	0	0	0
	1/13/2017		24 : 00	0	0	0
	1/14/2017		24 : 00	0	0	0
	1/15/2017		24 : 00	0	0	0
	1/16/2017		24 : 00	0	0	0
Filming Started	1/17/2017	1115	11 : 15	0	0	0
Filming Stopped	2/6/2017	1530	8 : 30	0	0	0
	2/7/2017		24 : 00	0	0	0
	2/8/2017		24 : 00	0	0	0
	2/9/2017		24 : 00	0	0	0
	2/10/2017		24 : 00	0	0	0
	2/11/2017		24 : 00	0	0	0
	2/12/2017		24 : 00	0	0	0
	2/13/2017		24 : 00	0	0	0
	2/14/2017		24 : 00	0	0	0
	2/15/2017		24 : 00	0	0	0
	2/16/2017		24 : 00	0	0	0
	2/17/2017		24 : 00	0	0	0
	2/18/2017		24 : 00	0	0	0
	2/19/2017		24 : 00	0	0	0
	2/20/2017		24 : 00	0	0	0
Filming Started	2/21/2017	1430	14 : 00	0	0	0
Filming Stopped	3/10/2017	730	16 : 00	0	0	0
	3/11/2017		24 : 00	0	0	0
	3/12/2017		24 : 00	0	0	0
Filming Started	3/13/2017	1230	12 : 30	0	0	0
Filming Stopped	3/25/2017	1830	5 : 30	0	0	0
	3/26/2017		24 : 00	0	0	0
	3/27/2017		24 : 00	0	0	0
Filming Started	3/28/2017	830	8 : 00	0	0	0
		Totals:	40 : 15	0	4	0

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REFERENCES

Hatchery and Genetic Management Plan for Iron Gate Hatchery Coho Salmon. 2014. California Department of Fish and Wildlife, Northern Region.

KRTT (Klamath River Technical Team). February 2017. Klamath River Fall Chinook Salmon Age-Specific Escapement, River Harvest, and Run Size Estimates, 2016 Run. Available from Pacific Fishery Management Council web address: http://www.pcouncil.org/salmon/background/document-library/#KlamathRiverSalLib