

# **BOGUS CREEK SALMON STUDIES 2013**

## **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 and conducted spawning ground surveys (carcass surveys) 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 (Chinook) salmon, coho salmon and steelhead trout into Bogus Creek. Video fish counting operations began on September 4, 2013 and ended on May 1, 2014 at the end of the season. Spawning ground surveys began on October 14, 2013 and were conducted twice a week through January 24, 2014.

The first adult Chinook was observed entering Bogus Creek on September 17, 2013 and the last Chinook salmon was observed on December 3, 2013. The total number of Chinook salmon that entered Bogus Creek during the 2013 season is estimated to be **4,020** 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 1,715 (42.66%) males and 2,305 (57.34%) females. Scale analysis was used to determine the age proportions of the run. Adults comprised approximately 91.6% (3,682 fish) and grilse comprised 8.4% (338 fish) of the run. Males ranged in fork length from 43cm to 99cm and averaged 72.2cm. Females ranged in fork length from 55cm to 89cm and averaged 73.4cm. Based on coded wire tag expansions, KRP staff estimated that 1,765 Chinook salmon (43.9%) were of hatchery origin.

The first adult coho salmon was observed entering Bogus Creek on October 25, 2013 and the last coho salmon was observed on February 18, 2014. A total of 405 coho salmon were observed moving upstream through the Bogus Creek Fish Counting Facility (BCFCF) during the season and 41 additional coho carcasses were observed downstream of the BCFCF yielding an estimated season total of **446** coho salmon. Based on the proportion of male and female coho salmon that were sampled during the spawning ground surveys and known recoveries of released PIT tagged fish from Iron Gate Hatchery (IGH) that returned to Bogus Creek, the run was comprised of approximately 198 (44.5%) males and 248 (55.5%) females. Based on a grilse cut off of  $\leq 54$ cm, age three fish comprised approximately 98.1% (438 fish) and age two fish comprised 1.9% (8 fish) of the run. Males ranged in fork length from 45cm to 81cm and averaged 70.5cm. Females ranged in fork length from 55cm to 79cm and averaged 69.6cm. An estimated 45.3% (202 fish) of the coho salmon returning to Bogus Creek during the 2013 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 359 coho salmon (80.4%) were of hatchery origin.

The first steelhead  $>16''$  was observed entering Bogus Creek on November 8, 2013 and the last steelhead was observed on April 30, 2014 the day prior to removal of the counting station. During this time there were a total of 280 steelhead observations including both upstream (191) and downstream (89) movements. The 191 observed upstream migrating steelhead represents the maximum number of steelhead for the season. The actual number of steelhead for the season is likely lower than 191 as some fish move up and down through the flume multiple times. 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 collected 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.

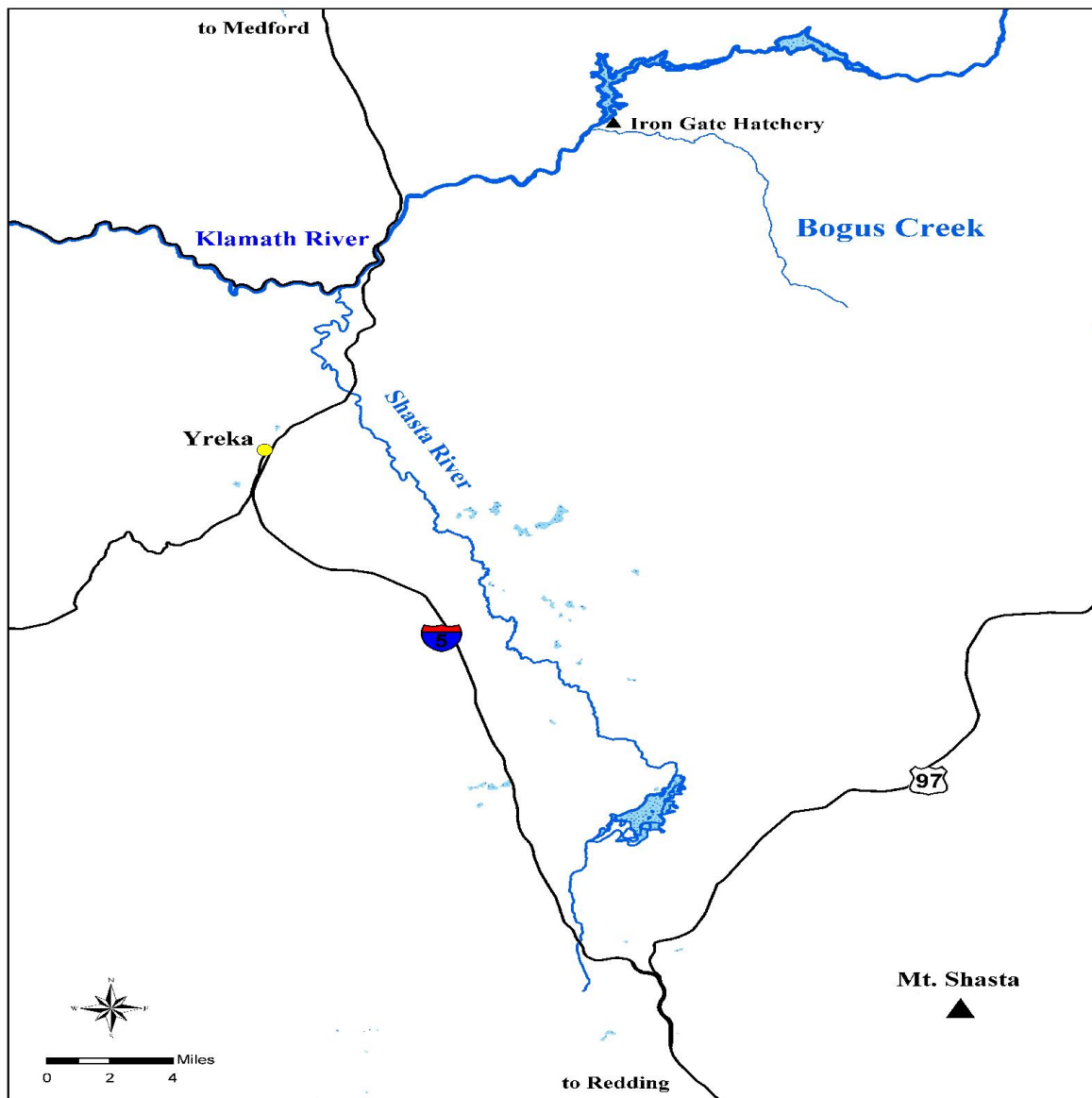


Figure 1. Location of Bogus Creek, tributary to the Klamath River, Siskiyou County.

**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 was 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 which includes collection of fork lengths, determining sexual composition of the run, assessing pre-spawn mortality, and recovery of coded wire tags (CWT) from ad-clipped salmon encountered during the survey.

**KLAMATH RIVER PROJECT AND BOGUS CREEK STUDY**

The Bogus Creek study is one component of the KRP (initiated in 1978). The goals of the KRP include obtaining information on population abundance, 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 and coho salmon 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.
- D) Collect run-timing and biological data for all steelhead observed during the Chinook and coho salmon spawning season.

**METHODS****OPERATION OF THE BOGUS CREEK FISH COUNTING FACILITY**

The video fish counting system was installed at the BCFCF on September 4, 2013 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 May 1, 2014. 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**

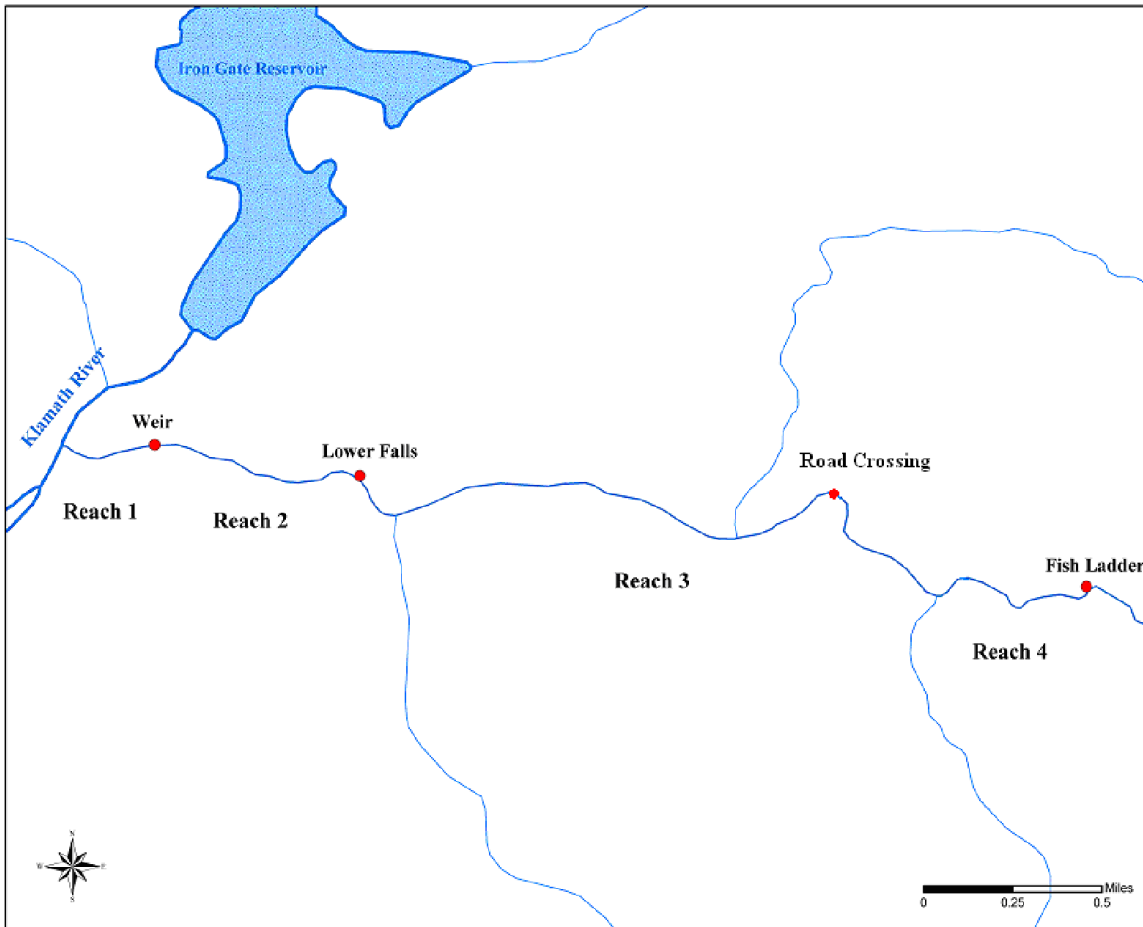
Spawning ground surveys were conducted twice a week on Tuesdays and Fridays throughout the salmon spawning season starting October 14, 2013 and ending January 24, 2014. A total of twenty five surveys were performed during the spawning season. For the purpose of the spawning ground surveys, Bogus Creek was divided into 4 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' high) and fish ladder a distance of approximately 1.1 miles. Each survey was 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 fourth Chinook carcass examined during the survey. A systematic random sampling rate of 1 in 4 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 fourth sample was identified as a Random (R) sample and every ad-clip that was sampled outside of the fourth sample was identified as a Non-Random (NR) sample. Therefore, ad-clip samples could be identified as either Random (if fourth sample) or Non-Random 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 as a Random.

The spawning ground surveys attempt to assign returning adult coho salmon into three groups: Natural origin coho (NOR); Hatchery origin coho (HOR); 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 draft Hatchery Genetics Management Plan (HGMP).

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 45 Chinook salmon and 207 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 45 Chinook salmon and 114 coho salmon throughout the season and cataloged for future microchemistry analysis. All samples were collected following standard protocols.



**Figure 2. Map of spawning ground survey reaches on Bogus Creek used during the 2013 season. The weir denotes the location of the Bogus Creek Fish Counting Facility (BCFCF).**

**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. Currently a mark-recapture study design is not being implemented in reach one 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 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 (KRTAT) using scale age analysis.

## RESULTS

### OPERATION OF THE BOGUS CREEK FISH COUNTING FACILITY

The BCFCF began recording fish movements at 0900 hours on September 4, 2013. The first Chinook salmon was observed at the BCFCF on September 17, 2013 and the last Chinook salmon was observed on December 3, 2013. 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 5, 2013 and October 28, 2013 (Figure 3) when 86.9% of the total run was observed. Seventy three percent of observed Chinook salmon passed through the BCFCF during daylight hours (between 0700 and 1900) and peaked in the afternoon between 1600 and 1800 hours (Figure 4).

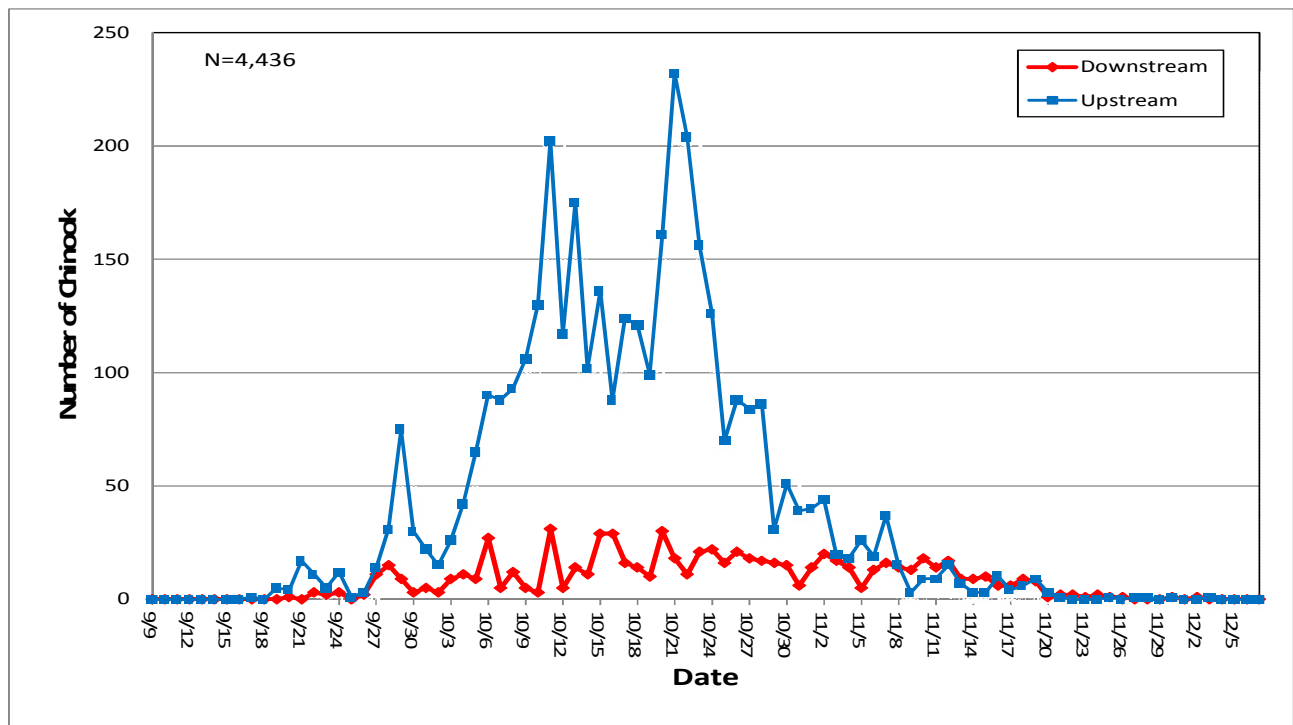
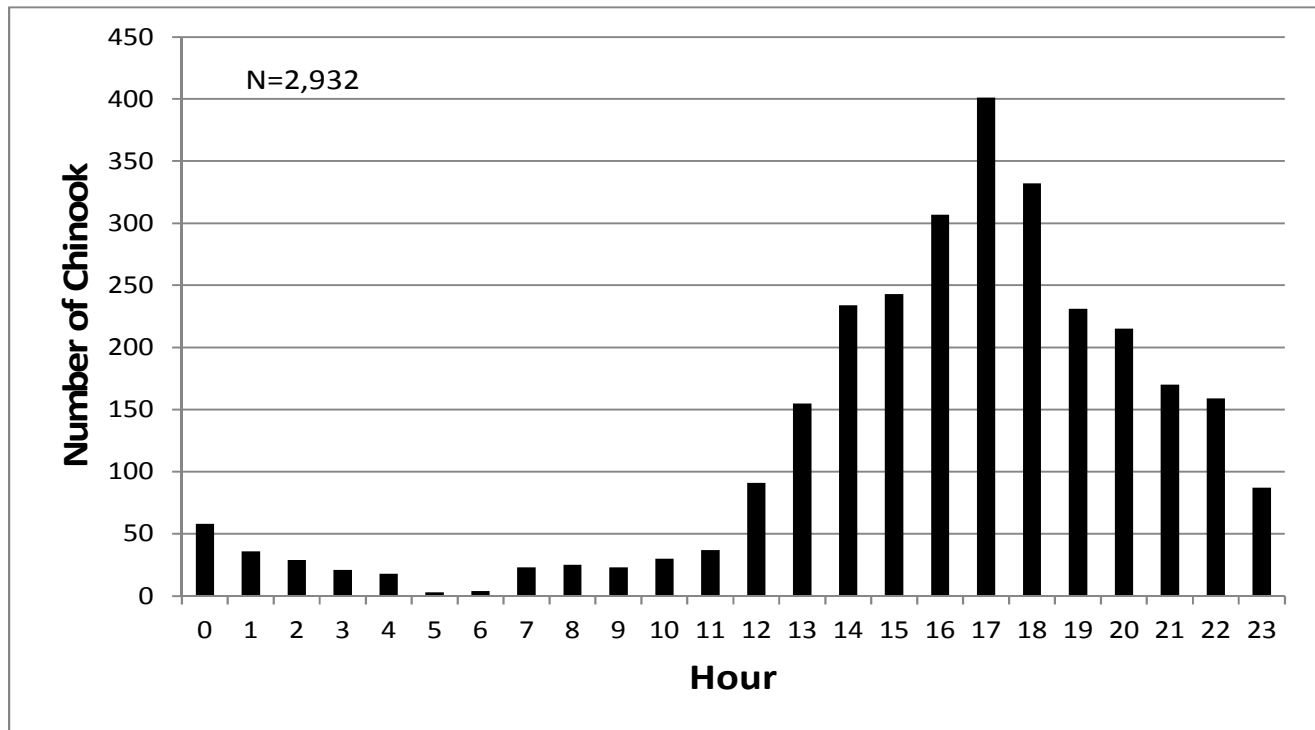


Figure 3. Run timing of Chinook salmon through the BCFCF during the 2013 season. Both upstream and downstream movements through the counting flume are shown (N=4,436).

A total of 2,932 Chinook salmon were estimated to have passed through the BCFCF during the 2013 season. A total of 1,088 Chinook salmon carcasses were counted in Reach 1, downstream of the BCFCF, yielding a total run size estimate of 4,020 Chinook salmon. Based on the proportion of male and female Chinook salmon that were sampled during the spawning ground surveys the run was comprised of approximately 1,715 (42.66%) males and 2,305 (57.34%) females. Based on scale age analysis, adults comprised approximately 91.6% (3,682 fish) and grilse comprised 8.4% (338 fish) of the run (KRTT, 2014).



**Figure 4. Summary of hourly run timing of Chinook salmon observed (N=2,932) at the Bogus Creek Fish Counting Facility during 2013.**

### SPAWNING GROUND SURVEYS

A total of 797 Chinook salmon carcasses were systematically sampled (1 in 4) during the spawning ground survey. Of the 797 Chinook salmon carcasses systematically sampled, 340 (42.66%) were male and 457 (57.34%) were female (two female carcasses without measured fork lengths) and 93 were ad-clipped (an additional 246 non-random ad-clipped Chinook were sampled). Males ranged in fork length from 43cm to 99cm and averaged 72.2cm (Figure 5). Based on the length frequency distribution of male Chinook salmon presented on Figure 5, grilse were determined to be  $\leq 58$ cm in fork length. The grilse determination based on fork length frequency was supported by scale age analysis. Females ranged in fork length from 55cm to 89cm and averaged 73.4cm (Figure 6).

A total of 457 female Chinook salmon carcasses were systematically sampled (1 in 4) 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 457 female Chinook salmon carcasses examined, 441 females (96.5%) were found to have spawned, and 16 females (3.5%) were identified as un-spawned.



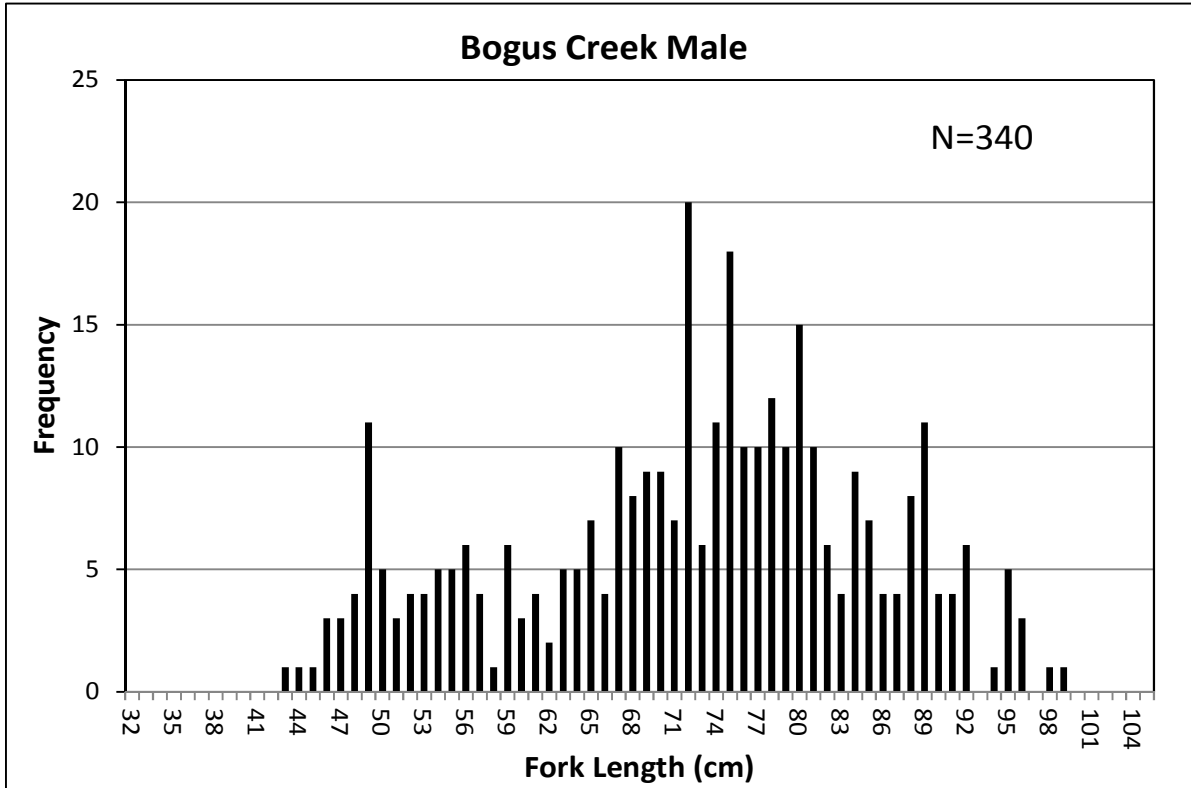


Figure 5. Length Frequency distribution of male Chinook salmon systematically sampled during spawning ground surveys in Bogus Creek, 2013 (N= 340).

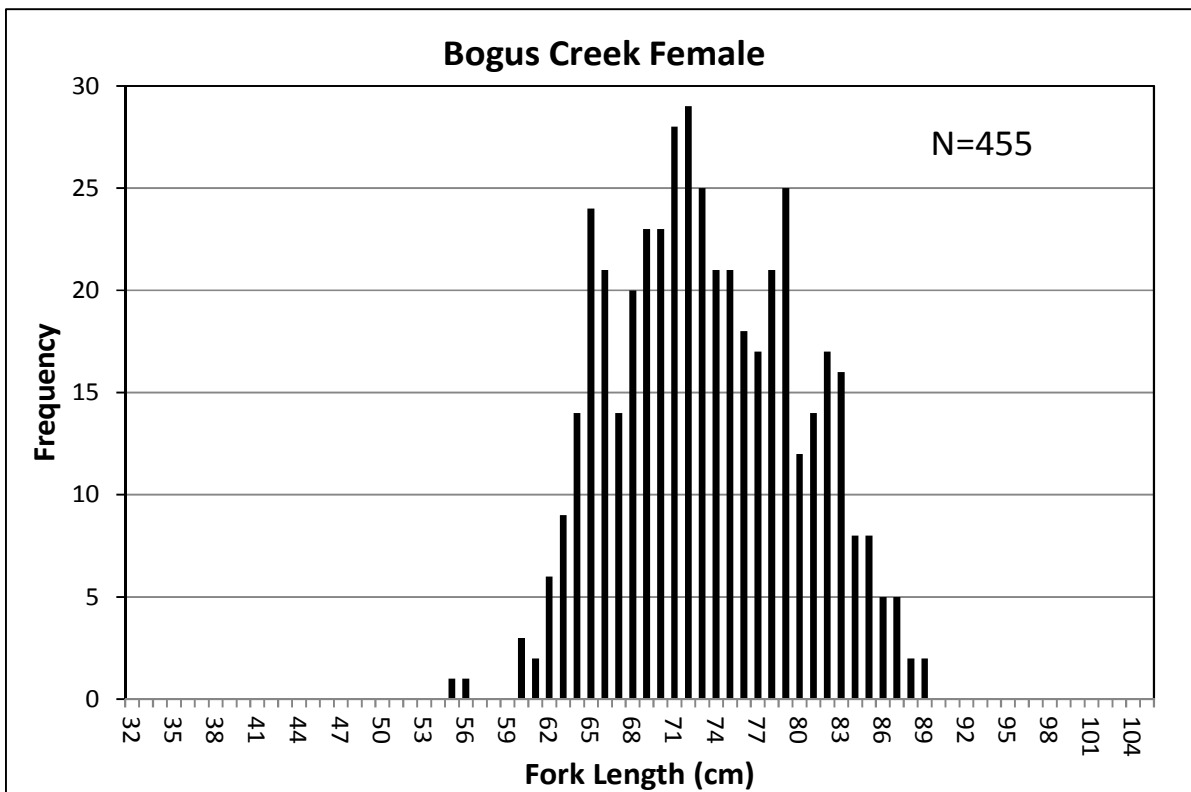


Figure 6. Length frequency distribution of female Chinook salmon systematically sampled during spawning ground surveys in Bogus Creek, 2013 (N= 455).

**HATCHERY CONTRIBUTION ESTIMATE**

A total of 339 heads were collected from ad-clipped Chinook salmon. Positive CWT reads were obtained from 317 heads. Seventeen heads were collected that did not contain a CWT. One tag was lost during extraction and four additional heads contained unreadable CWT's. The five CWT's that were lost during extraction or unreadable were expanded based on the proportion of CWT that returned to Bogus Creek. All of the CWT's recovered were from IGH. 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 surveying all areas of anadromy, a sample expansion (1.33) based on the inverse of the number of carcasses (2,198) examined upstream of BCFCF during spawning ground surveys divided by the total number of Chinook salmon that were observed passing through the BCFCF (2,932), was applied to all CWT recoveries upstream of the BCFCF (Table 1). A sample expansion is not utilized in the reach one hatchery contribution estimate as the entire reach is surveyed. KRP staff estimated that 1,764 (43.9%) of the Chinook salmon in Bogus Creek during the 2013 season were of hatchery origin.

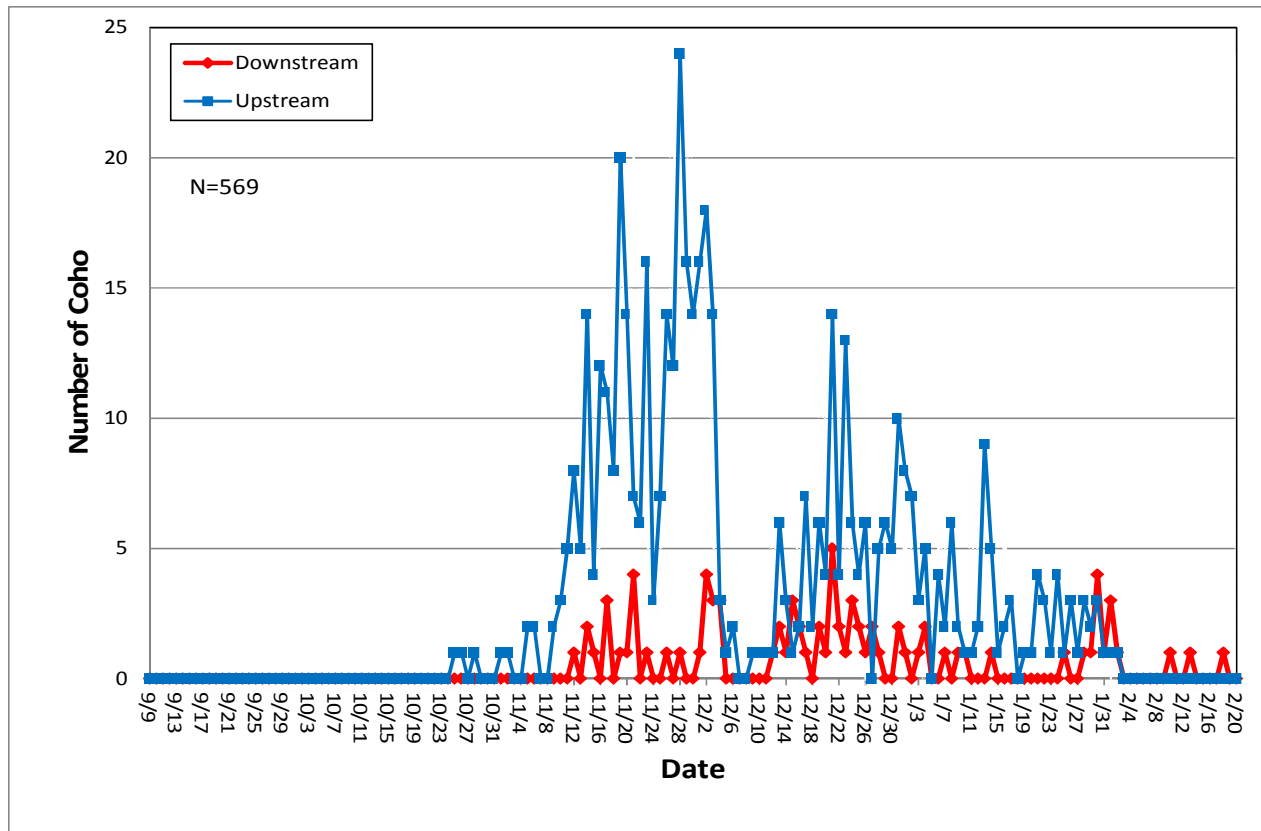
**Table 1. Estimated contribution of hatchery origin fall Chinook salmon in Bogus Creek 2013.**

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
068710	IGH	F	2009	4	18	4.02	72	1	72
068711	IGH	F	2009	4	17	4.01	68	1	68
068712	IGH	F	2009	4	19	4.04	77	1	77
068713	IGH	F	2009	4	20	4.17	83	1	83
068714	IGH	F	2009	4	21	4.01	84	1	84
068715	IGH	F	2009	4	11	4.04	44	1	44
068716	IGH	Y	2009	4	6	4.01	24	1	24
068720	IGH	F	2009	4	3	4.29	13	1	13
068792	IGH	F	2010	3	9	4.03	36	1	36
068793	IGH	F	2010	3	13	4.17	54	1	54
068794	IGH	F	2010	3	17	4.02	68	1	68
068795	IGH	F	2010	3	8	12.17	97	1	97
068799	IGH	Y	2010	3	1	4.03	4	1	4
060416	IGH	F	2011	2	1	4.01	4	1	4
060419	IGH	F	2011	2	1	4.01	4	1	4
060420	IGH	F	2011	2	1	4.01	4	1	4
Sub Total=					166	Sub Total=			739
Estimated contribution of lost or unreadable CWT's					4	Sub Total=			18
								Total=	757
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
068710	IGH	F	2009	4	18	4.02	72	1.33	96
068711	IGH	F	2009	4	12	4.01	48	1.33	64
068712	IGH	F	2009	4	5	4.04	20	1.33	27
068713	IGH	F	2009	4	15	4.17	63	1.33	83
068714	IGH	F	2009	4	10	4.01	40	1.33	53
068715	IGH	F	2009	4	14	4.04	57	1.33	75
068716	IGH	Y	2009	4	4	4.01	16	1.33	21
068720	IGH	F	2009	4	5	4.29	21	1.33	29
068792	IGH	F	2010	3	10	4.03	40	1.33	54
068793	IGH	F	2010	3	20	4.17	83	1.33	111
068794	IGH	F	2010	3	17	4.02	68	1.33	91
068795	IGH	F	2010	3	17	12.17	207	1.33	275
060420	IGH	F	2011	2	3	4.01	12	1.33	16
060421	IGH	F	2011	2	1	4	4	1.33	5
Sub Total=					151	Sub Total=			1,001
Estimated contribution of lost or unreadable CWT's					1	Sub Total=			7
								Sub Total	1,008
								Total Estimated Hatchery Contribution=	1,764

a/ Release type; F=Fall fingerling, Y=Fall Yearling  
 b/ Production Multiplier value is the inverse of the proportion of effectively tagged and total release from IGH  
 c/ Sample expansion is the inverse of the number samples during the carcass surveys in reach 2, 3, and 4 divided by the video estimate.

**COHO SALMON**

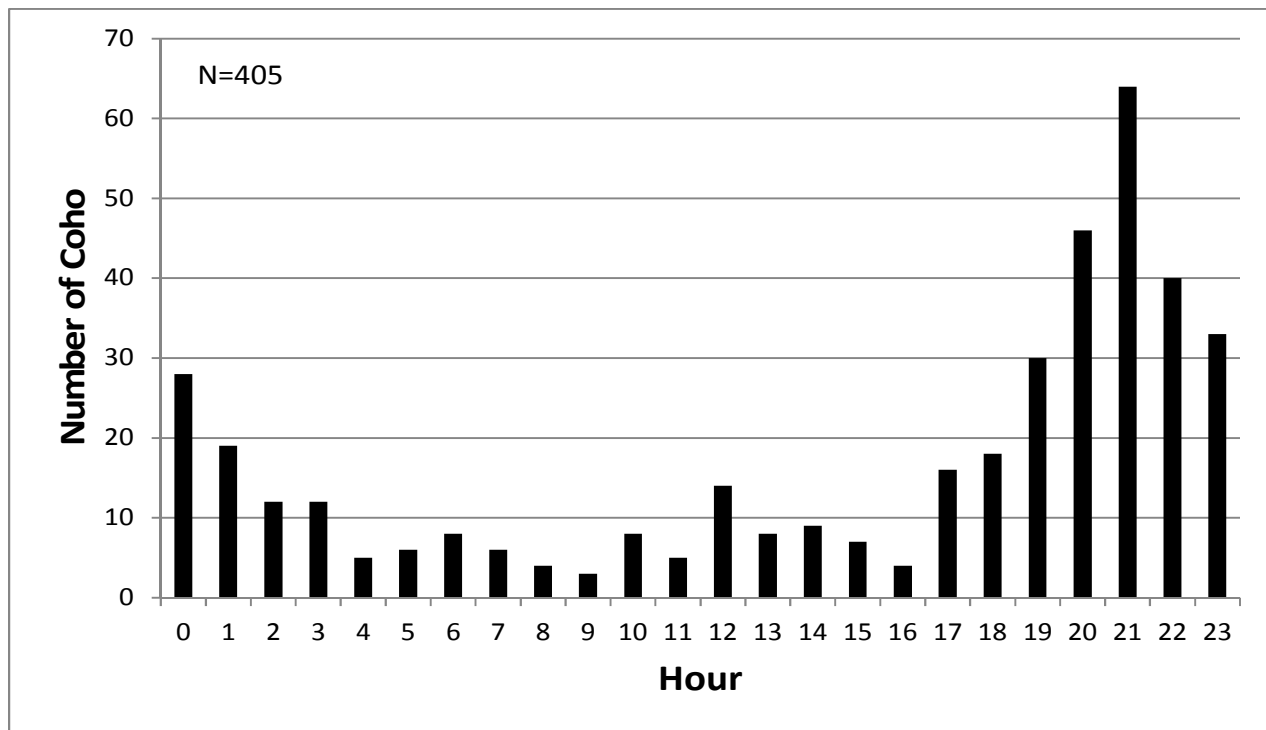
The first adult coho salmon was observed entering Bogus Creek on October 25, 2013 and the last coho salmon was observed on February 18, 2014. A net total of 405 coho salmon were observed moving upstream through the BCFCF during the season (Figure 7). Forty-one additional coho were recovered downstream of the counting station yielding a season total of **446**. Diel movements of coho salmon through the BCFCF were higher in the evening hours and peaked between 1900 and 2300 hours (Figure 8).



**Figure 7. Run timing of coho salmon observed passing through the Bogus Creek Fish Counting Facility during the 2013 season. Both upstream (487) and downstream (82) movements are shown.**

**SPAWNING GROUND SURVEYS**

A total of 215 coho salmon carcasses were sampled during the spawning ground survey. Of these, 128 were females (59.5%) and 87 were males (40.5%). Males ranged in fork length from 45cm to 81cm and averaged 70.5cm (Figure 9). Based on the length frequency distribution of observed male coho salmon, grilse were determined to be  $\leq 54$ cm in fork length. Females ranged in fork length from 55cm to 79cm and averaged 69.6cm (Figure 10). The estimated proportion of grilse in the total population was 1.9% and the proportion of grilse among males was 4.6%.



**Figure 8. Diel migration patterns of coho salmon observed (N=405) moving through (Hourly net movement) the Bogus Creek Fish Counting Facility in 2013.**

All 128 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 128, 109 (85.2%) were found to have spawned, 19 females (14.8%) still contained many eggs in their body cavity and were classified as un-spawned. Ten of the 41 (24.4%) females recovered that were previously caudal punched and released from IGH were un-spawned. For females that had not been caudal punched and released from IGH, the observed un-spawned rate was 10.3% (9 of 87) (Table 2).

**Table 2. Estimated Bogus Creek surplus and non-surplus coho salmon percent prespawn mortalities during the 2004 through 2013 seasons.**

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
Average	45.3	31.4	24.4	32.1

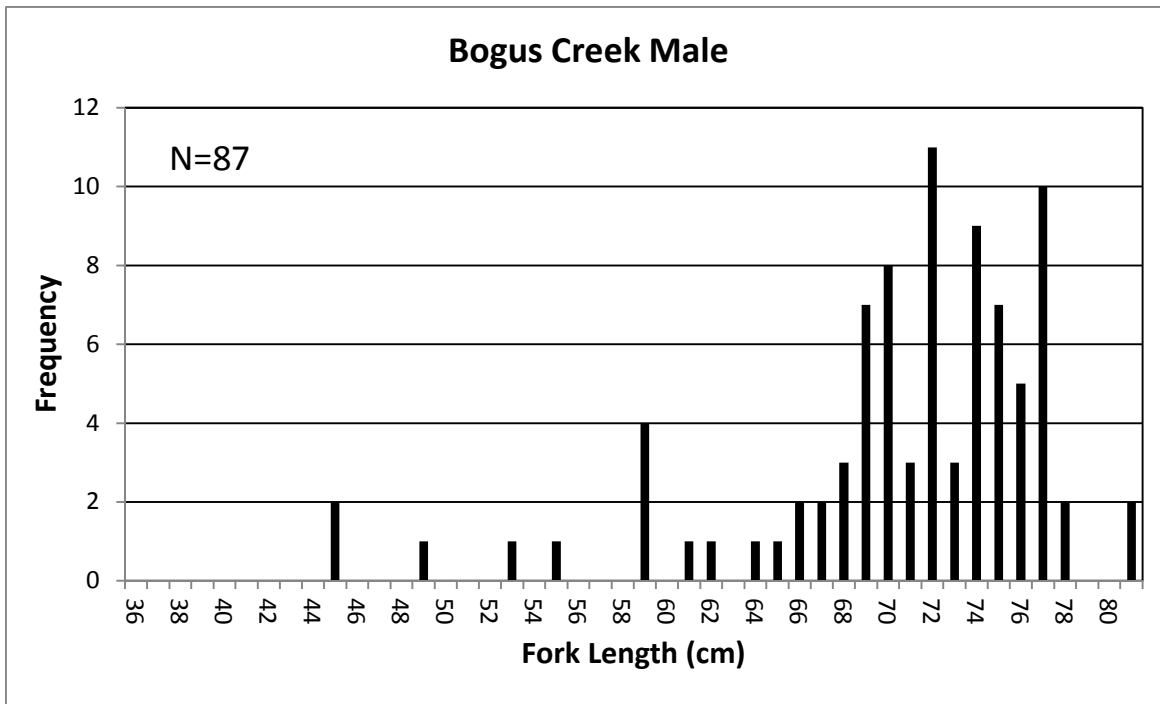


Figure 9. Length frequency distribution of male coho salmon observed during spawning ground surveys in Bogus Creek, 2013 (n = 87).

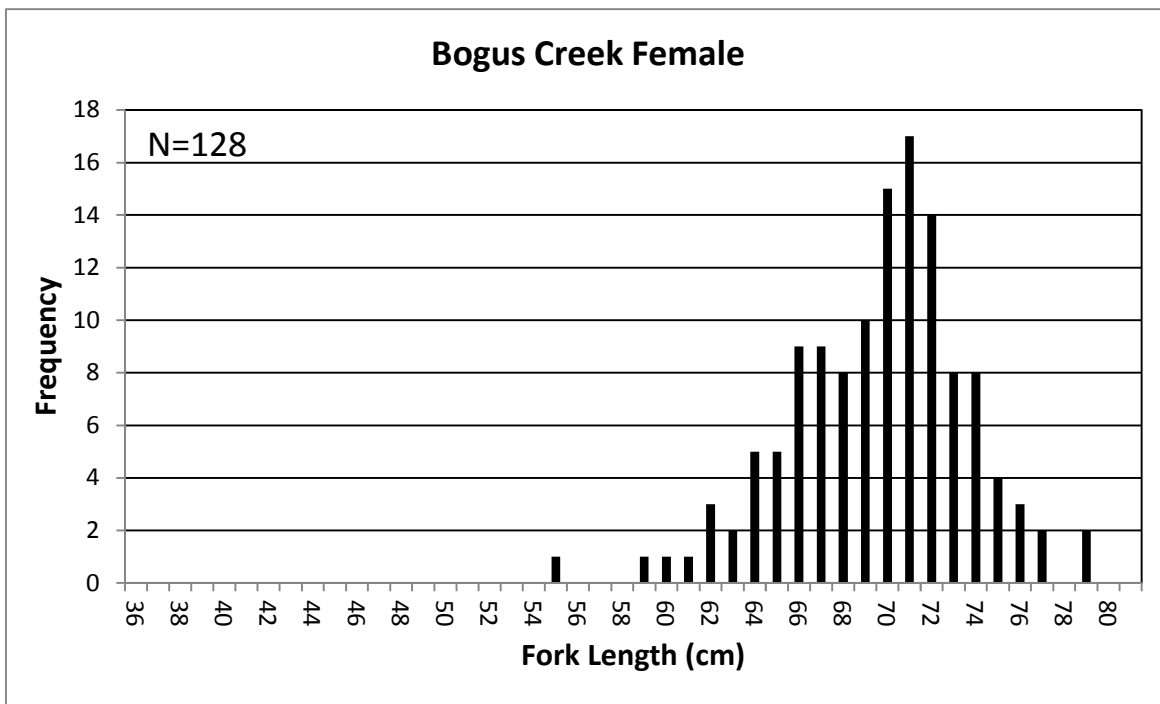
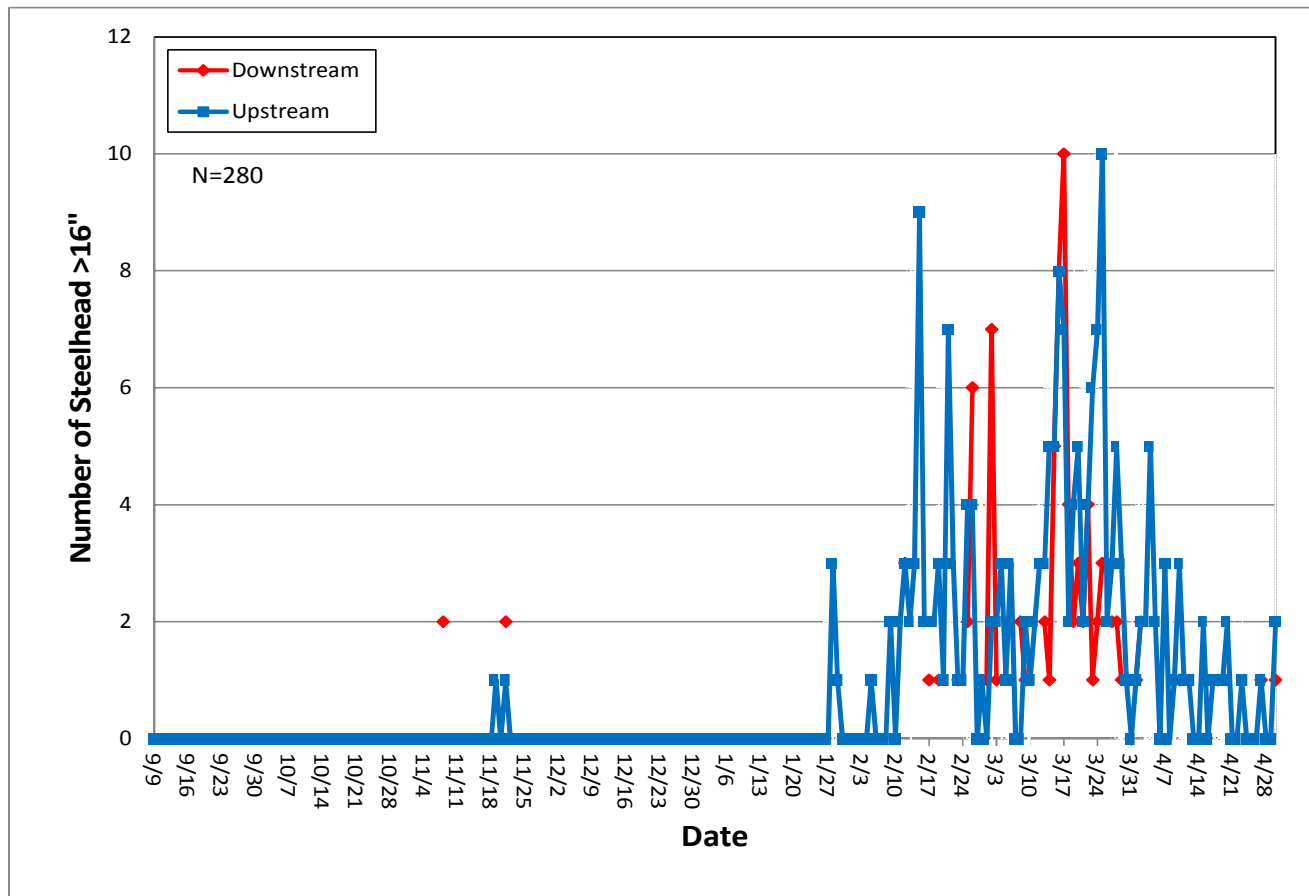


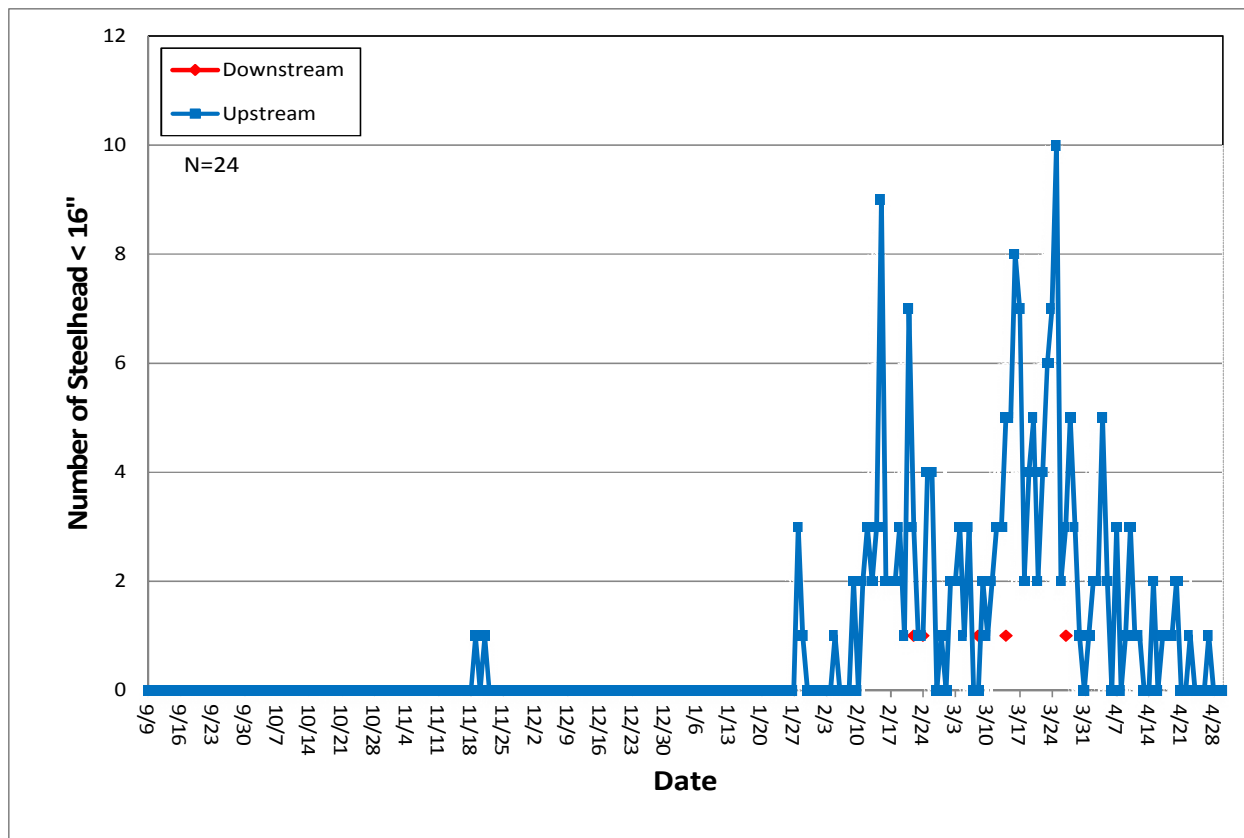
Figure 10. Length frequency distribution of female coho salmon observed during spawning ground surveys in Bogus Creek, 2013 (n = 128).

**STEELHEAD**

In 2013, a net total of 102 adult (>16") steelhead (191 upstream, 89 downstream; Figure 11) and 19 sub-adult (<16") steelhead (24 upstream, 5 downstream; Figure 12) were estimated to have entered and remained in the Bogus Creek during the video recording season from September 4, 2013 to May 1, 2014. One additional steelhead was added to the total to account for a period of time when the camera was not functioning on March 10, 2014. The camera video system malfunctioned on March 10<sup>th</sup> at 0300 and was restored thirty hours later on March 11, 2014 at 0900. Adding the one steelhead estimated during the video malfunction to the 102 net total observed from the videography yields a total of 103 for the season. Peak upstream movement of adult steelhead was observed between February 9, 2014 and April 10, 2014 when 91.3% of the adult steelhead were observed. Lines on the back of the video flume were set at 16 inches (40.64 cm) to delineate sub-adults versus adults. The 2013/2014 season was the third year that lines delineating adult steelhead and sub-adults were used. As additional years of data are collected annual comparisons will be presented. Additionally, the BCFCF was operated through the end of April during the 2013/2014 season to attempt to capture the full migration window of steelhead. The majority of steelhead migration into and out of Bogus Creek during the 2013/2014 season occurred after the normal removal of the counting station (generally the weir is removed on or around January 1<sup>st</sup>). Even with the extended monitoring effort at Bogus Creek during 2014, adult steelhead (>16") were observed on the last day of monitoring on April 30<sup>th</sup> indicating that some migration of adult steelhead was still occurring upon removal of the counting facility.



**Figure 11. Run timing of steelhead trout (>16") observed passing through the Bogus Creek Fish Counting Facility during the 2013/2014 season (N=280) (both upstream and downstream movements are shown).**



**Figure 12. Run timing of steelhead trout (<16") observed passing through the Bogus Creek Fish Counting Facility during the 2013/2014 season (N=24) (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 8,594 fish (Figure 13). The 2013 Chinook salmon run in Bogus Creek ranks twenty-sixth (4,020 fish) out of 36 years of data. During the peak return of Chinook to Bogus Creek in 1995 (46,432) 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 that were 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 in turn reduces the potential interactions between hatchery and natural area produced Chinook salmon populations within the basin.

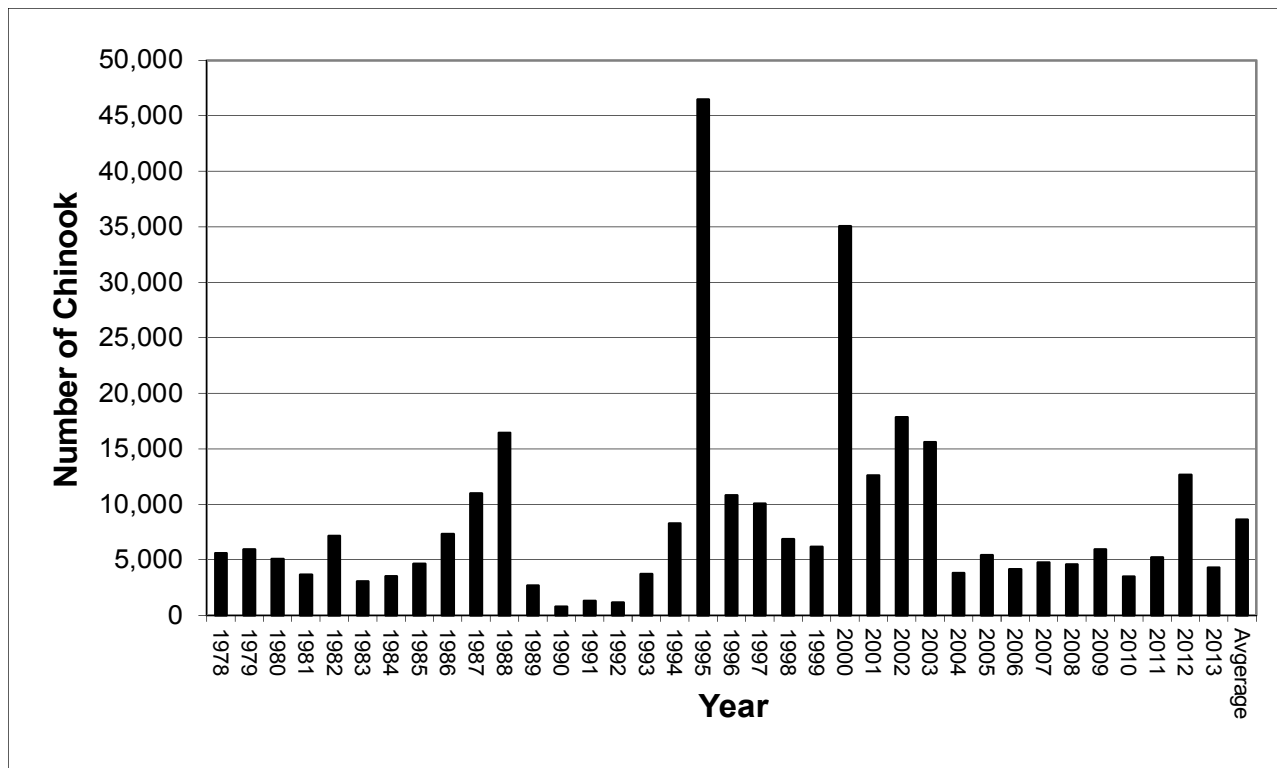


Figure 13. Estimated escapement of adult Chinook salmon returning to Bogus Creek from 1978 to 2013.

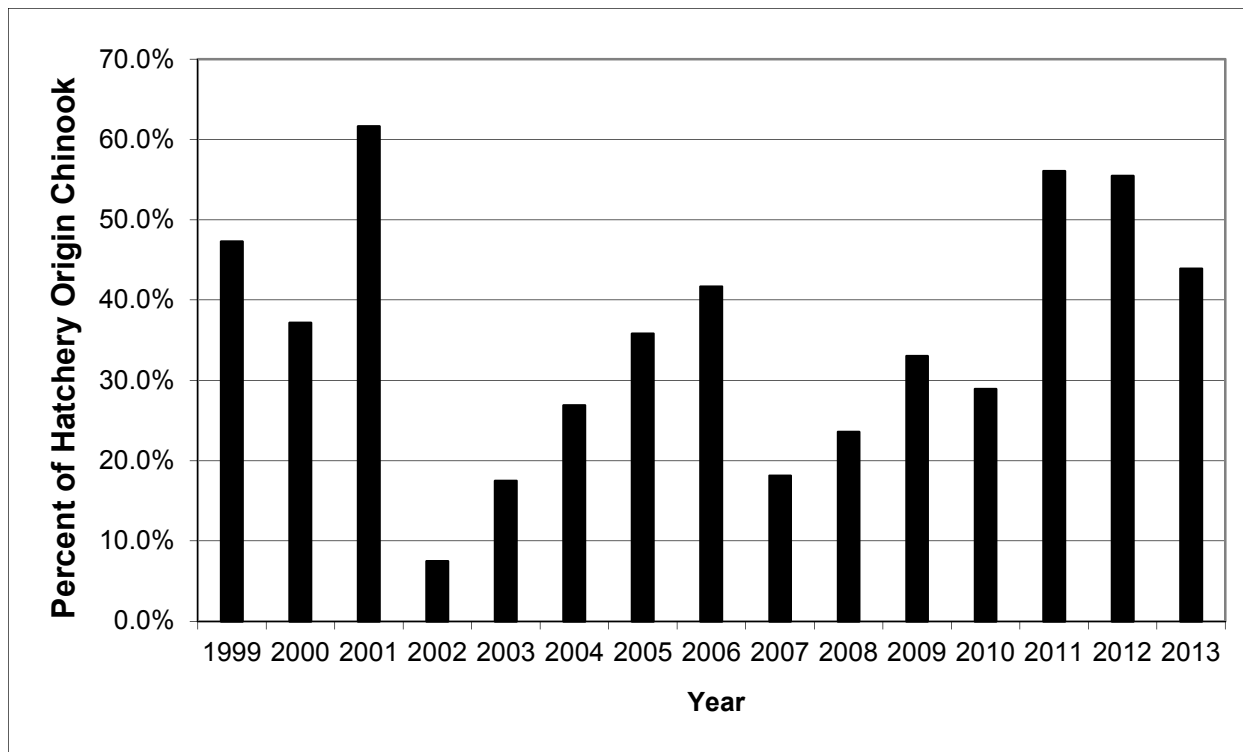
**HATCHERY CHINOOK SALMON CONTRIBUTIONS**

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 greatly ranging from 61.6% to 7.5%. An estimated 43.9% of the Chinook salmon that entered Bogus Creek during 2013 were of hatchery origin (Figure 14).

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, and 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 five 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.

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.





**Figure 14. Estimated contribution of hatchery origin Chinook salmon observed in Bogus Creek from 1999 through 2013.**

## COHO SALMON

Since video operations began in 2004 the estimated escapement of coho salmon in Bogus Creek has averaged 184 fish (Figure 15). The run size of coho salmon during 2013 was estimated to be 446, 142.6% above the ten year average. The run size estimate for the 2005 season is believed to be underestimated due to storms that greatly hindered the Department's ability to effectively monitor the escapement of coho salmon into Bogus Creek that year. Due to the underestimated run size in 2005 there is difficulty when comparing the number of three year olds returning in 2008 to their parental cohort from 2005. The adult abundance in 2013 (446) was greater than when this year class returned last in 2010 (154) and an increase in brood year strength of 1.9 times was observed (Figure 16, Figure 17 and Figure 18). The increase in brood year strength observed in 2013 can largely be attributed to the influence of IGH origin fish. Some adult 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 draft HGMP. Other hatchery origin adult coho stray directly into Bogus Creek without first entering IGH. If the 202 adult coho that entered Bogus Creek as a result of the adult release program at IGH and the 167 IGH-produced strays to Bogus Creek were removed from the abundance estimate only 77 natural origin coho would remain, and a resulting decrease in brood year strength of 50% would have been observed.

In 2013, of the 1,268 coho that arrived at IGH, 896 surplus fish were released back into the Klamath River. Of those adult coho, 866 were PIT tagged and 28 females were also fitted with esophageal radio transmitters. Of the total number of PIT tagged fish 193 (109 females and 84 males) were detected in Bogus Creek at an antenna array located by the video weir (22% of the total number of coho PIT tagged). Of the 28 radio tagged females, 12 entered Bogus Creek (43%) two of the females were recovered and each had spawned prior to mortality (Personal communication Caitlin Bean). Surplus female adult coho were radio tagged between November 6 and November 20, 2013. Correcting the PIT

releases for the same period of time during which the coho were radio tagged resulted in total of 142 surplus coho. Of the 142 surplus coho that were PIT tagged between November 6 and November 20, 2013, 114 were females and 28 were males. Of the 114 PIT tagged females 32 were detected on the Bogus Creek PIT tag antenna array (28%).

## HATCHERY COHO SALMON CONTRIBUTIONS

Three hundred fifty nine of the total 446 (80.4%) coho salmon that returned to Bogus Creek were estimated to be of hatchery origin during the 2013 season.

Four hundred and five coho were observed passing through the BCFCF (RKM 0.3) and, of those fish, 193 were surplus coho from IGH (detected on the PIT tag antenna array) with known origin (183 HOR, 10 NOR). During carcass surveys upstream of the weir, 174 coho salmon were sampled and of those 127 were non-surplus fish (83 HOR, 44 NOR). The proportion of HOR to NOR fish based on the 127 fish sampled (65.3% HOR and 34.6% NOR) was applied to the proportion of the run that were not PIT tagged (212 coho). These proportions when applied to the 212 non-surplus coho known to have entered Bogus Creek through the video weir, estimated that 139 were HOR and 73 were NOR. An additional 41 coho salmon carcasses (37 HOR, 4 NOR) were recovered in Reach 1 downstream of the BCFCF. These groups (recoveries downstream of the BCFCF, known and estimated from above the BCFCF) were added to generate the final hatchery proportion (80.4%) for the Bogus Creek (183 HOR surplus coho + 139 estimated HOR upstream of weir + 37 HOR downstream of weir = 359).

The proportion of HOR coho in Bogus Creek has been estimated since 2004 and has ranged from 24% to 88% and has averaged 51%. As a result of hatchery management changes associated with the draft HGMP since 2010 surplus HOR adults have been released back to the river at the spawning building. During the 2010 season 60 adults were released from IGH but during 2011, 2012 and 2013, 259, 342, 896 were released respectively and this has significantly affected the proportion of HOR returns to Bogus Creek (Figure 19).

Forty seven of the 174 (27.0%) coho salmon observed in the spawning ground survey upstream of the counting station were opercle punched, indicating that they were surplus coho salmon from IGH. Based on the proportion of coho carcasses recovered, an estimated 109 surplus coho would have been predicted to have entered Bogus Creek upstream of the counting station. However, the empirical data shows that a total of 193 surplus coho salmon were detected at the BCFCF PIT tag antenna arrays (personal communication Chris Adams). A comparison of these two results illustrates that information generated from the spawning ground surveys may underestimate 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 47.6% (193/405). There were a total of 41 coho salmon carcasses recovered in Reach 1 downstream of the counting station of which nine were identified as 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 45.3% (202/446).

A total of 896 (866 PIT tagged) adult coho were released from IGH during the 2013 season and an estimated 23.3% (202/866) 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 that they encountered. Crews may have also failed to thoroughly inspect carcasses for operculum punches.

The substitution of an opercle punch for the caudal fin punch has improved this discrepancy but accuracy could still be improved.

Utilizing total escapement, estimated proportion natural origin coho and estimated age structure of returning adult coho salmon to Bogus Creek allows for total spawner (hatchery plus natural origin) to natural origin recruit analysis for years 2004, 2005 and 2007-2010 (Figure 20). The spawner recruit analysis is limited to six years of data, but indicates that the production of NOR coho salmon in Bogus Creek may be limited to roughly 150 adults. If additional years of data support this conclusion, then the draft 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 draft 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 NOR adults, then phase two will never be reached and as a result PNI will not be managed. Prior to 2011 the proportion of hatchery origin spawners on the spawning grounds (pHOS) in Bogus Creek was less than 50%. The higher the pHOS becomes the harder it is to achieve PNI values >0.5.

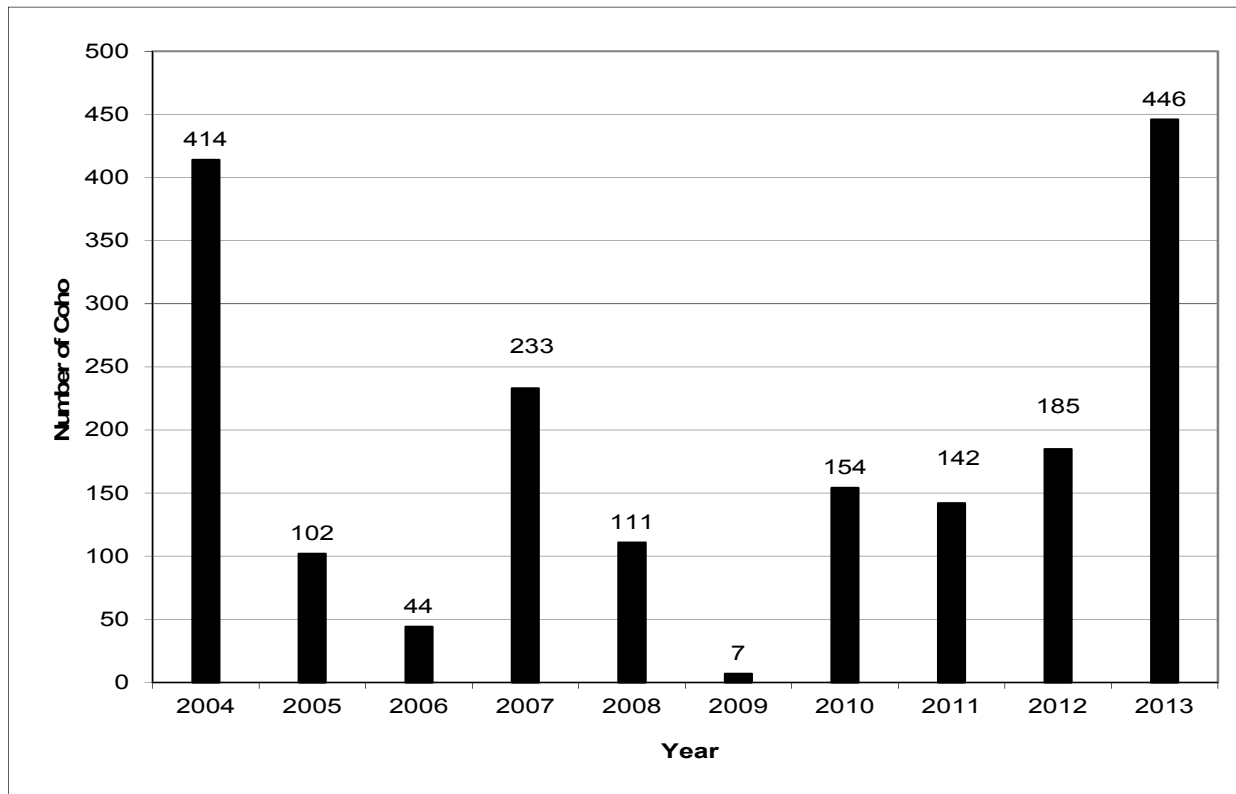


Figure 15. Estimated escapement of adult coho salmon returning to Bogus Creek from 2004 through 2013.

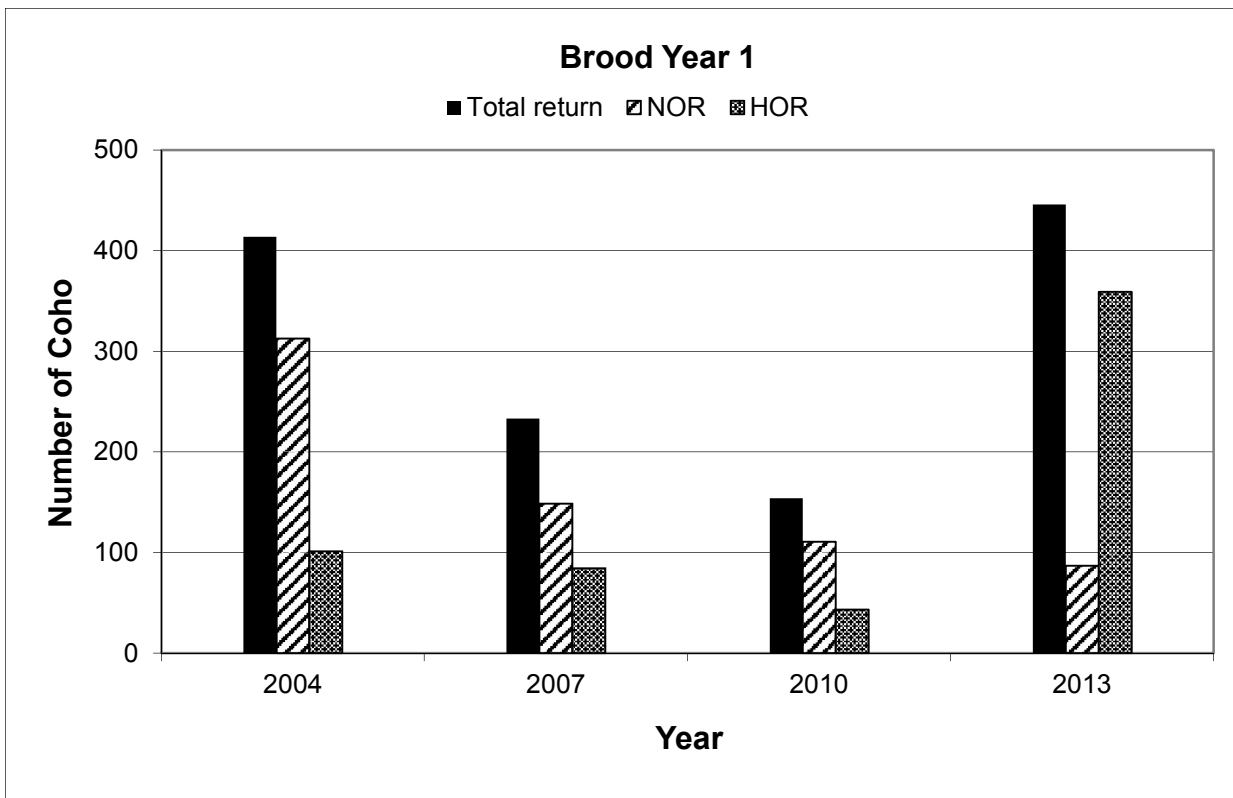


Figure 16. Estimated total return, natural origin return (NOR) and hatchery origin return (HOR) of adult coho salmon (Brood Year 1) returning to Bogus Creek from 2004 through 2013.

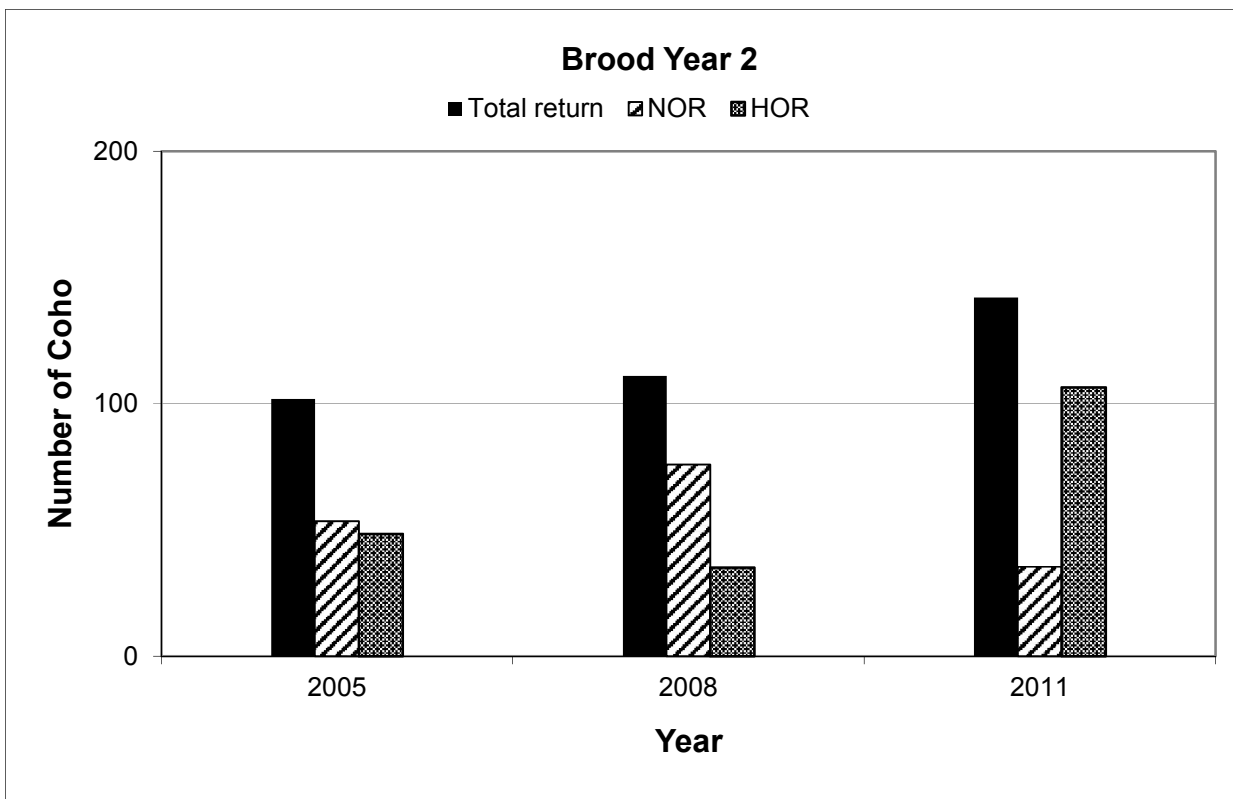


Figure 17. Estimated total return, natural origin return (NOR) and hatchery origin return (HOR) of adult coho salmon (Brood Year 2) returning to Bogus Creek from 2004 through 2013.

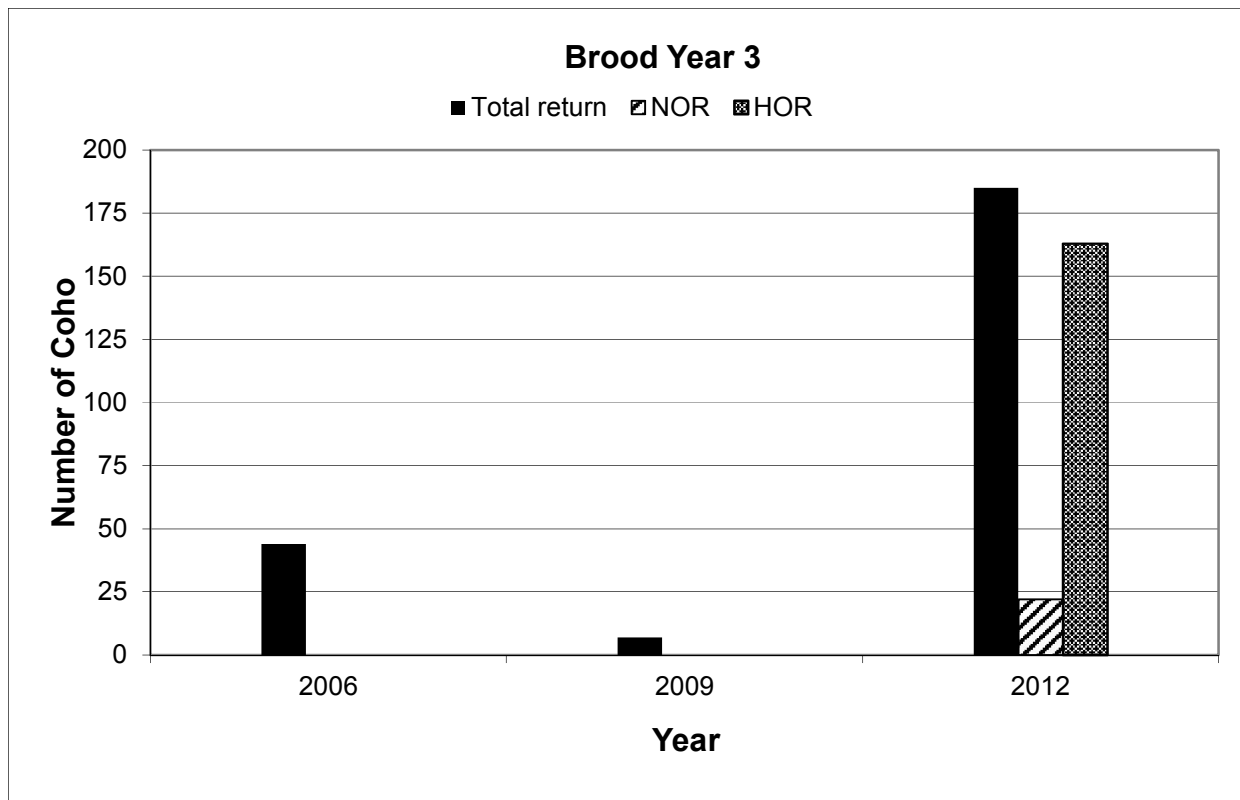


Figure 18. Estimated total return, natural origin return (NOR) and hatchery origin return (HOR) of adult coho salmon (Brood Year 3) returning to Bogus Creek from 2004 through 2013.

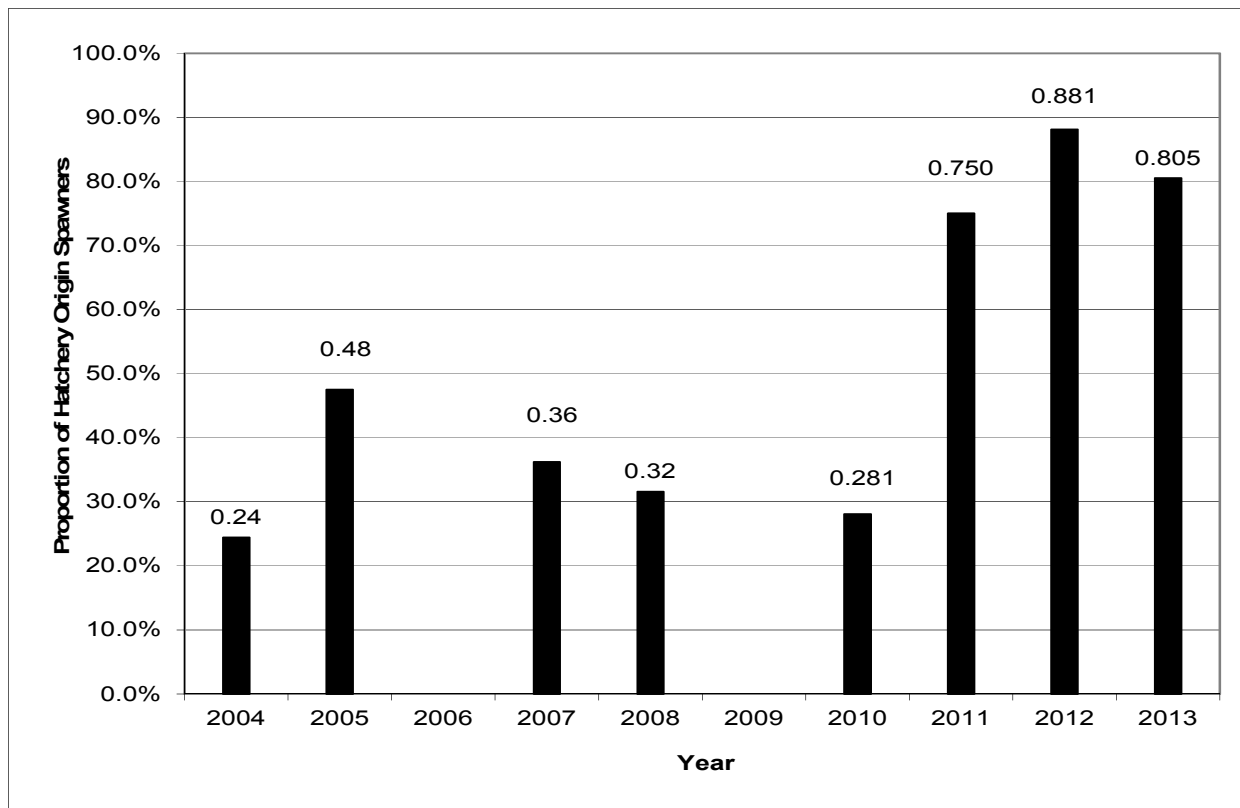
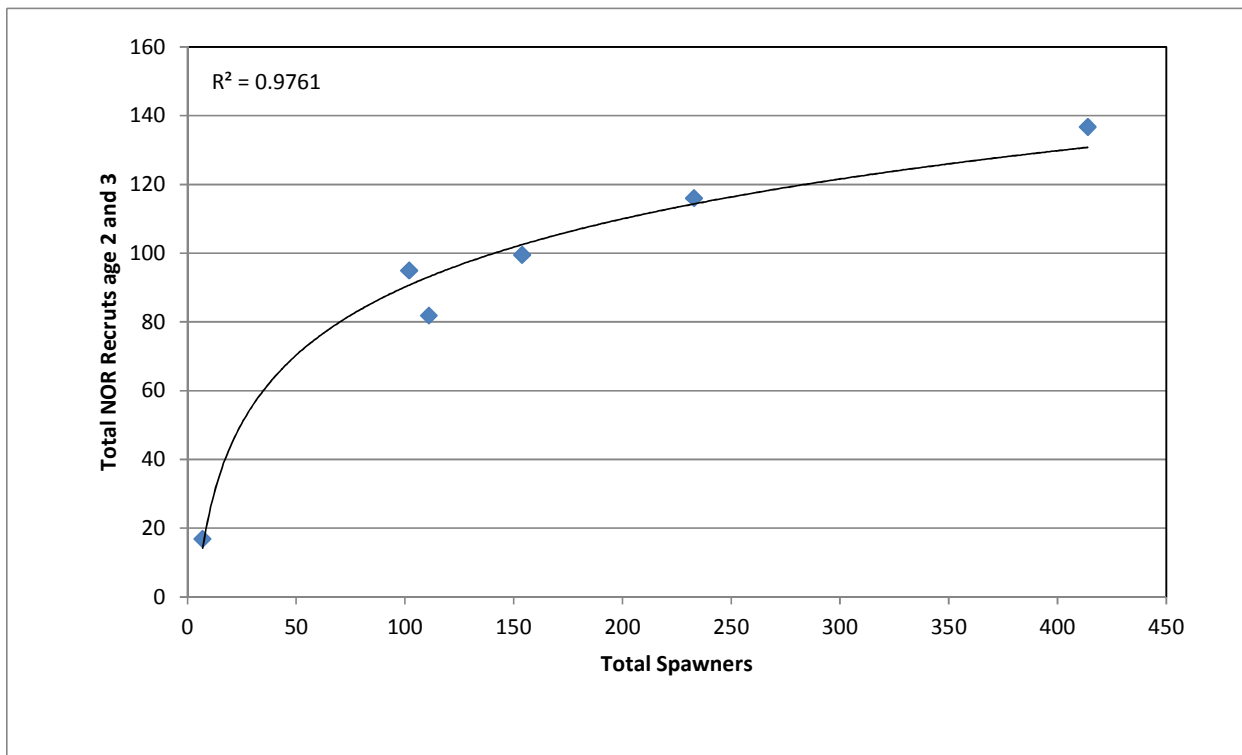


Figure 19. Estimated contribution of hatchery origin coho salmon observed in Bogus Creek from 2004 through 2013. Due to low carcass recovery in 2006 and 2009 hatchery contribution rates were not estimated in those years.



**Figure 20. Spawner to recruit analysis for Bogus Creek coho salmon for spawner years 2004, 2005 and 2007-2010.**

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<http://www.pcouncil.org/salmon/background/document-library/#KlamathRiverSalLib>