

BOGUS CREEK SALMON STUDIES 2017

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 11, 2017 and ended on June 8, 2018. In addition, spawning ground surveys began on October 20, 2017 and were conducted twice a week through January 12, 2018 during the salmon season.

The first adult Chinook was observed entering Bogus Creek on September 12, 2017 and the last Chinook Salmon was observed on November 28, 2017. The total number of Chinook Salmon that entered Bogus Creek during the 2017 season is estimated to be **2,722** fish. Based on the proportion of male and female Chinook Salmon sampled during the spawning ground surveys, the run was comprised of approximately 1,435 (52.7%) males and 1,287 (47.3%) females. Scale analysis was used to determine the age proportions of the run. Adults comprised approximately 68.9% (1,874 fish) and grilse comprised 31.1% (848 fish) of the run. Males ranged in fork length from 41 cm to 92 cm and averaged 61.6 cm. Females ranged in fork length from 44 cm to 81 cm and averaged 65.1 cm. Based on coded wire tag expansions, KRP staff estimated that 515 Chinook Salmon (18.9%) were of hatchery origin.

The first adult Coho Salmon was observed entering Bogus Creek on November 10, 2017, and the last Coho Salmon was observed on February 7, 2018. A total of 44 Coho Salmon were observed moving upstream through the Bogus Creek Fish Counting Facility (BCFCF) during the season. Two additional Coho carcasses and one Coho redd was observed downstream of the BCFCF yielding an estimated season total of **48** Coho Salmon. Based on the proportion of male and female Coho Salmon observed in the Bogus Creek videography, the sex composition of the run was estimated at 18 (38%) males and 30 (62%) females. Based on a grilse cut off of ≤ 56 cm (observed during video monitoring), age 3 fish comprised approximately 77.3% (37 fish) and age 2 fish comprised 22.7% (11 fish) of the run. A single male coho salmon was recovered and it measured 68 cm fork length. Females ranged in fork length from 56 cm to 69 cm and averaged 63 cm. Twenty-two Coho salmon were released from Iron Gate Hatchery as surplus broodstock (surplus Coho) and none were recovered straying into Bogus Creek. Based on fin clip observations during the video monitoring, KRP staff estimated that 11 Coho Salmon (22.0%) were of hatchery origin.

The first steelhead >40.6 cm was observed entering Bogus Creek on September 14, 2017, and the last steelhead was observed on May 9, 2018. During this time there were a total of 607 steelhead observations including both upstream (406) and downstream (201) movements. The 406 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 406 as some fish move up and down through the flume multiple times. The net upstream movement of **205** 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 auxiliary 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 typically return to Bogus Creek to spawn from mid-September through November. The Coho Salmon spawning run typically occurs from late October to early January. Steelhead trout can be observed returning to Bogus Creek from September through May.

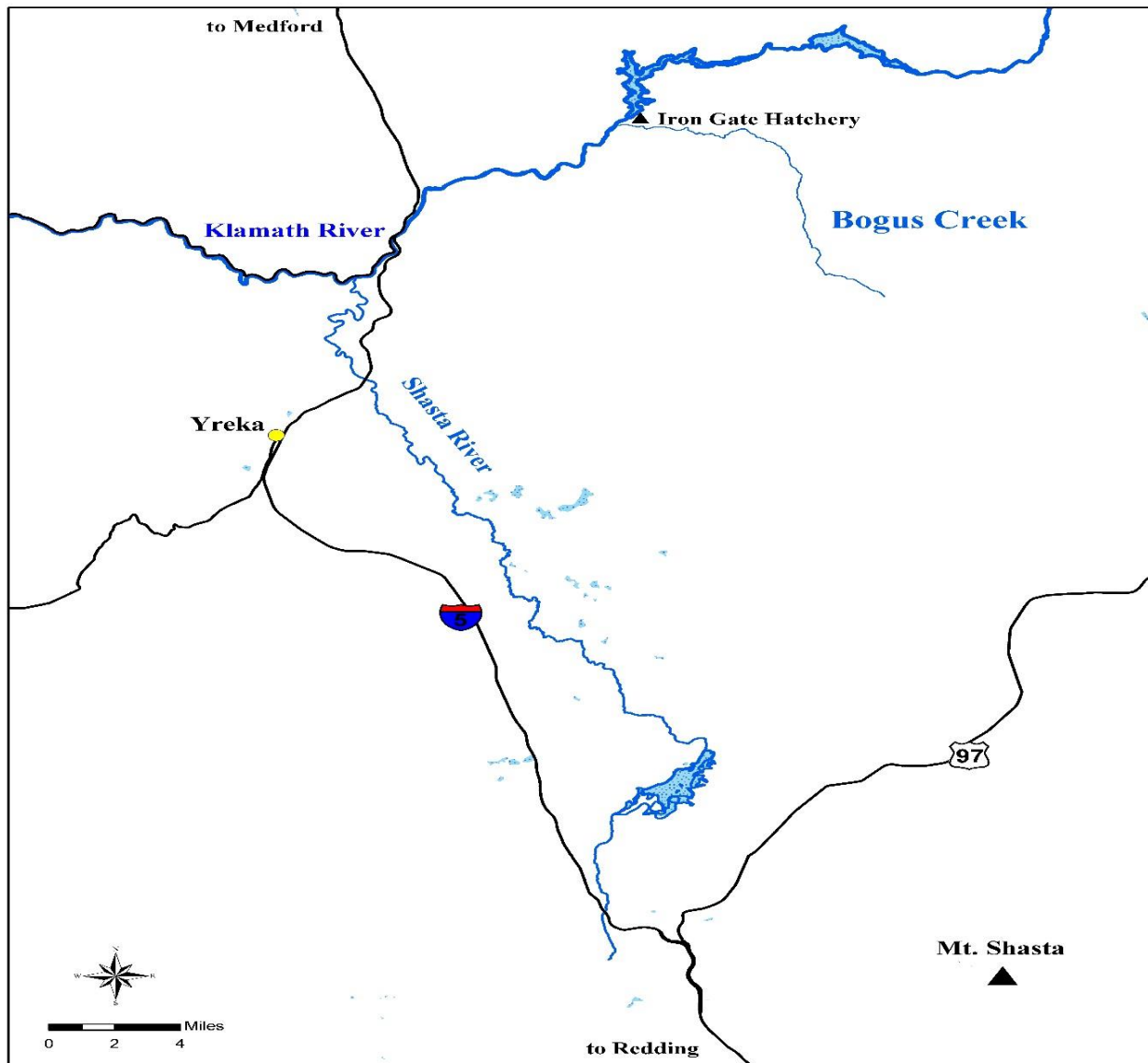


Figure 1. Location of Bogus Creek, tributary to the Klamath River, Siskiyou County.

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 11, 2017, at 0900 hours Pacific Standard Time (PST). A temporary Alaskan style weir was installed to direct migrating fish into a fish ladder and 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 June 8, 2018. 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. During spring time operations the temporary weir was removed to minimize maintenance during the low flow period of the monitoring season. During low flow operation fish are physically unable to jump the dam structure and must swim upstream and downstream through the fish ladder and counting flume.

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 unknown species. All unknown species due to poor visibility were assigned species based on the proportion of known species migrating on the specific day for which the unknown observations were made. To estimate the number of fish passing through the counting station during periods of time when the video equipment was not operational fish were accounted for by averaging known fish migrations from 3 days prior and 3 days after the specific hours for which the camera was not functioning. 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 20, 2017 and ending January 12, 2018. A total of 18 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 31 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 30 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 independently for the areas downstream (Reach 1) and upstream (Reach 2-4) of the counting station. Reach 1 recoveries were simply expanded by their production multiplier (estimated at the time of juvenile release, obtained from hatchery records). Reach 2-4 hatchery composition was estimated upstream of the counting station using carcasses handled during the spawning ground surveys. The hatchery composition for upstream of the counting facility was calculated as follows:

- 1) The sampling fraction for fish examined for adipose fin clips (carcasses on spawning grounds) is estimated by dividing the number of carcasses examined for adipose clips by the number of fish migrating upstream of the counting station (from video counts);
- 2) Each coded-wire tag recovered during spawning ground surveys above the counting facility is expanded by the hatchery production multiplier (estimated at the time of juvenile release, obtained from hatchery records), to yield an estimate of the number of hatchery fish among observed carcasses; and
- 3) The expanded CWT recoveries from step 2 are multiplied by the reciprocal of the sampling fraction from step 1 to estimate the total number of hatchery Chinook escaping to spawning grounds upstream the counting station.

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.

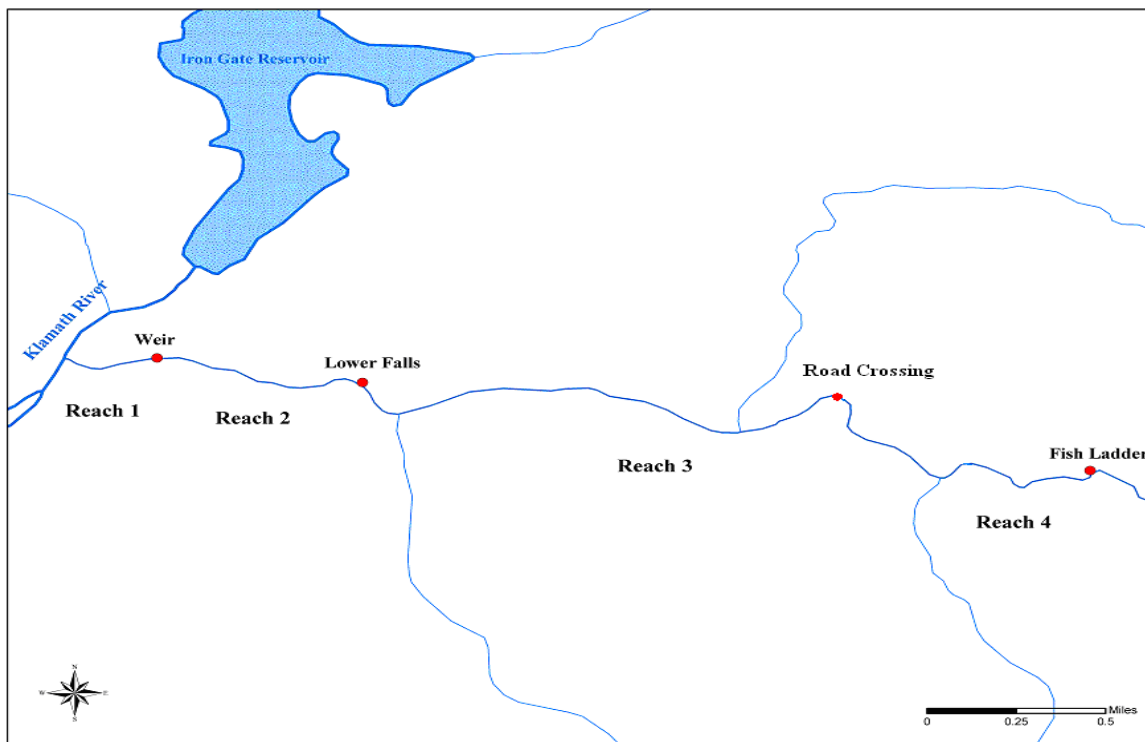


Figure 2. Map of spawning ground survey reaches on Bogus Creek used during the 2017 season. The weir denotes the location of the Bogus Creek Fish Counting Facility.

RESULTS

OPERATION OF THE BOGUS CREEK FISH COUNTING FACILITY

The BCFCF began recording fish movements at 0900 hours on September 11, 2017. The first Chinook Salmon was observed at the BCFCF on September 12, 2017, and the last Chinook Salmon was observed on November 28, 2017. 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 8, 2017, and October 22, 2017, (Figure 3) when 72.6% of the total run was observed. One hundred percent (100%) of Chinook Salmon passed (net upstream movement) through the BCFCF during daylight hours (between 0700 and 1900) and net upstream migration peaked in the afternoon between 1500 and 1600 hours (Figure 4).

A net total of 2,224 Chinook Salmon were estimated to have passed through the BCFCF during the 2017 season. A total of 498 Chinook Salmon carcasses were counted in Reach 1, downstream of the BCFCF, yielding a total run size estimate of 2,722 Chinook Salmon. Based on the proportion of male and female Chinook Salmon sampled during the spawning ground surveys, the run was comprised of approximately 1,435 (52.7%) males and 1,287 (47.3%) females. Based on scale age analysis, adults comprised approximately 68.8% (1,874 fish) and grilse comprised 31.2% (848 fish) of the run (KRTT, 2018).

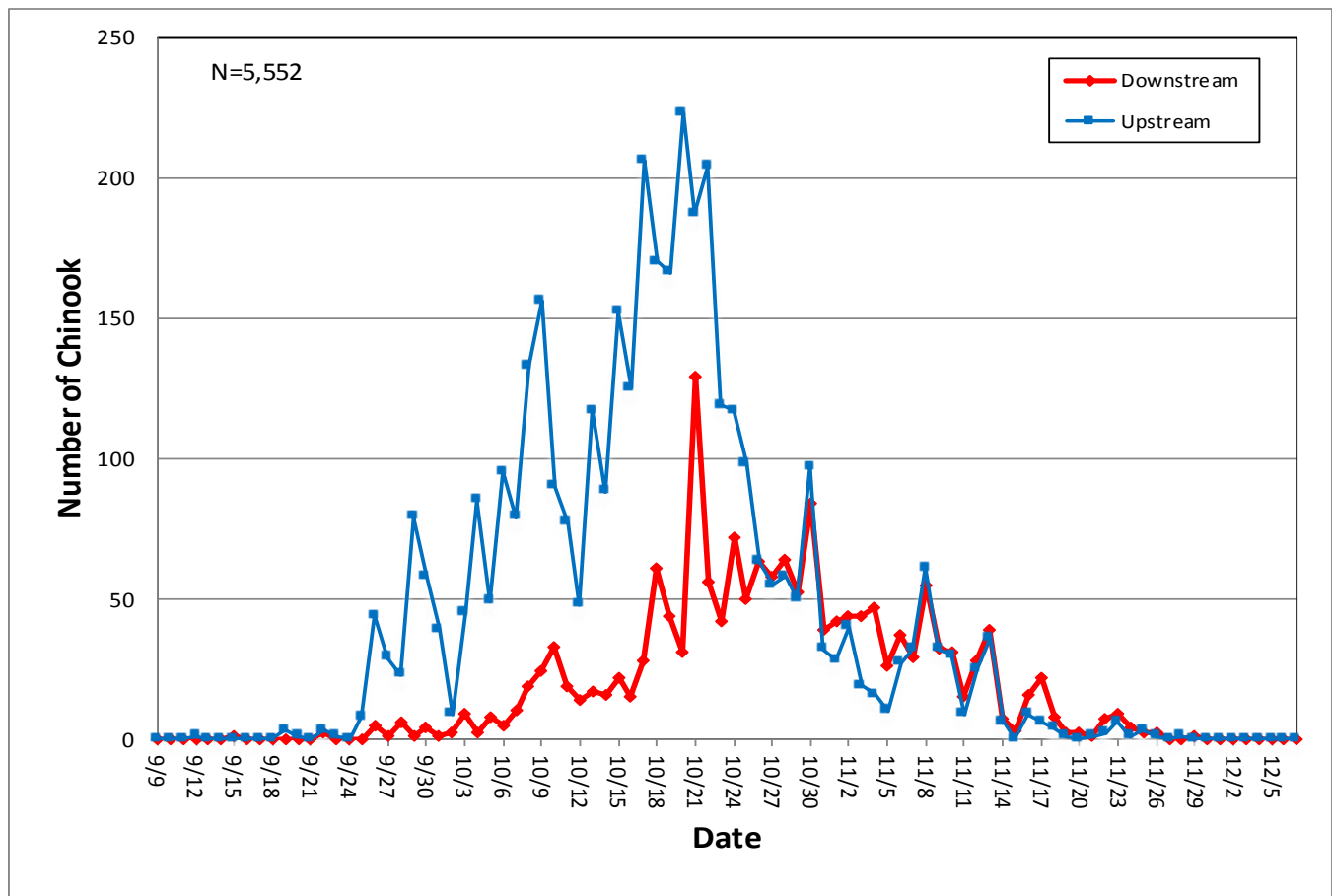


Figure 3. Run timing of Chinook Salmon through the BCFCF during the 2017 season. Both upstream and downstream movements through the counting flume are shown (N=5,552).

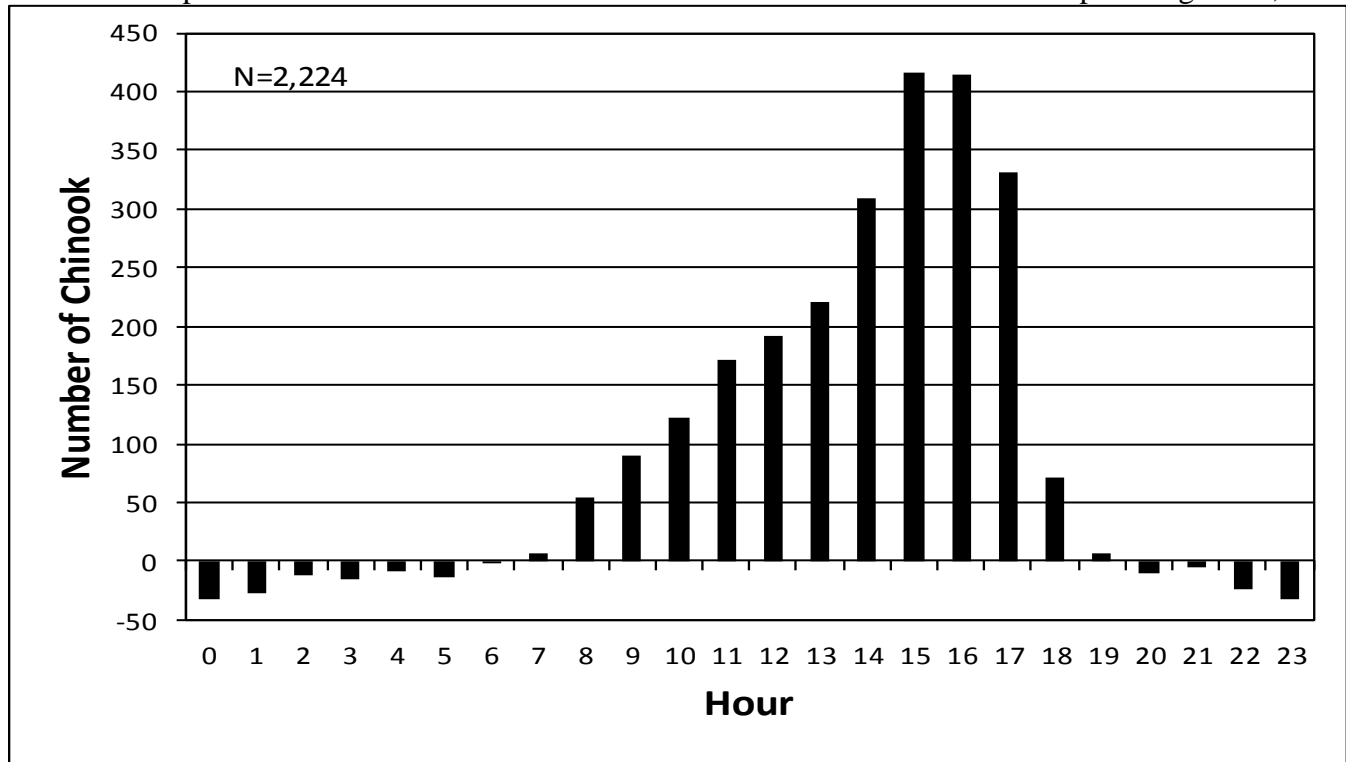


Figure 4. Summary of hourly run timing of Chinook Salmon observed (N=2,224) at the Bogus Creek Fish Counting Facility during 2017.

SPAWNING GROUND SURVEYS

A total of 757 Chinook Salmon carcasses were systematically sampled (1 in 2) during the spawning ground survey. Of the 757 Chinook Salmon carcasses systematically sampled, 399 (52.7%) were male and 358 (47.3%) were female, and 19 were ad-clipped (an additional 65 non-random ad-clipped Chinook were sampled). Males ranged in fork length from 41 cm to 92 cm and averaged 61.6 cm (Figure 5). Based on the length frequency distribution of male Chinook Salmon presented on Figure 5, grilse were preliminarily determined to be ≤ 55 cm in fork length. The grilse determination based on fork length frequency was supported by scale age analysis (KRTT) but was refined to ≤ 58 cm in fork length. Females ranged in fork length from 44 cm to 81 cm and averaged 65.1 cm (Figure 6).

A total of 358 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 358 female Chinook Salmon carcasses examined, 25 females (6.9%) were found to have been un-spawned.

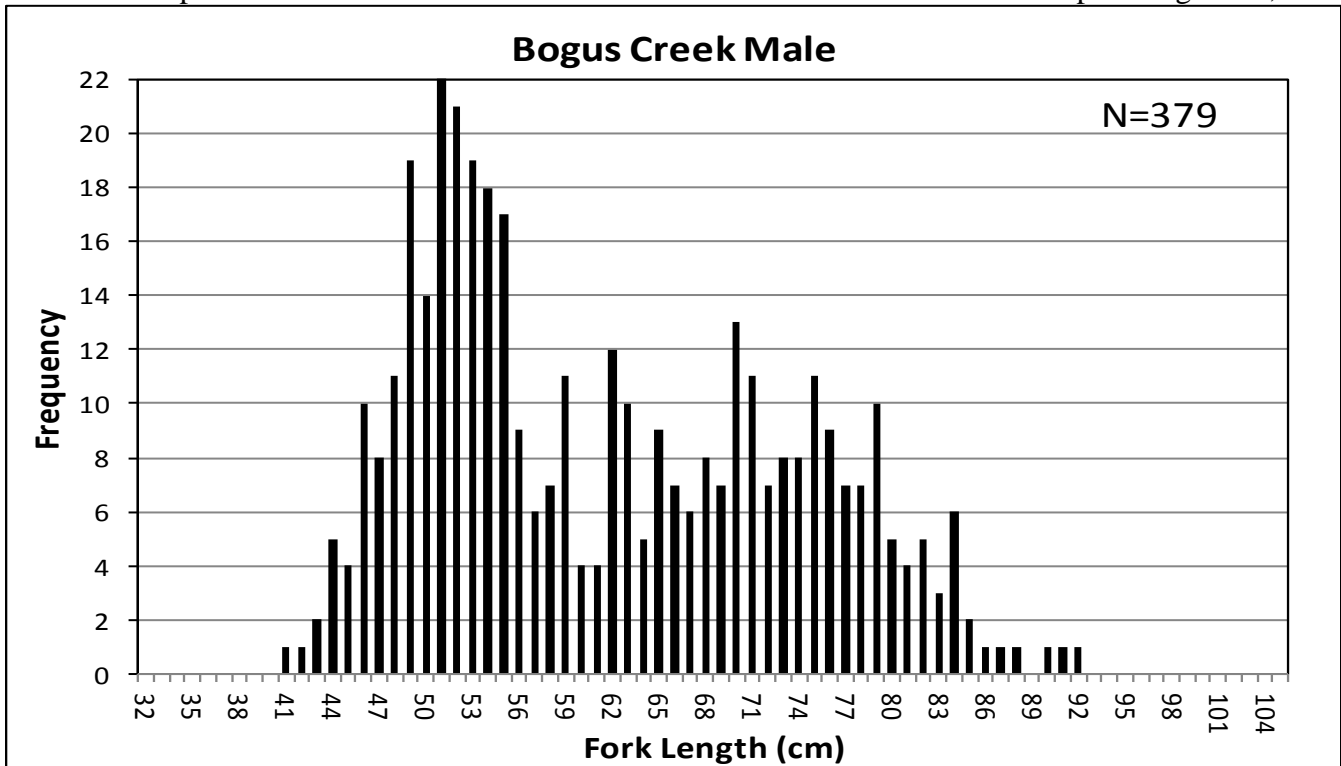


Figure 5. Length Frequency distribution of male Chinook Salmon systematically sampled during spawning ground surveys in Bogus Creek, 2017 (N=379).

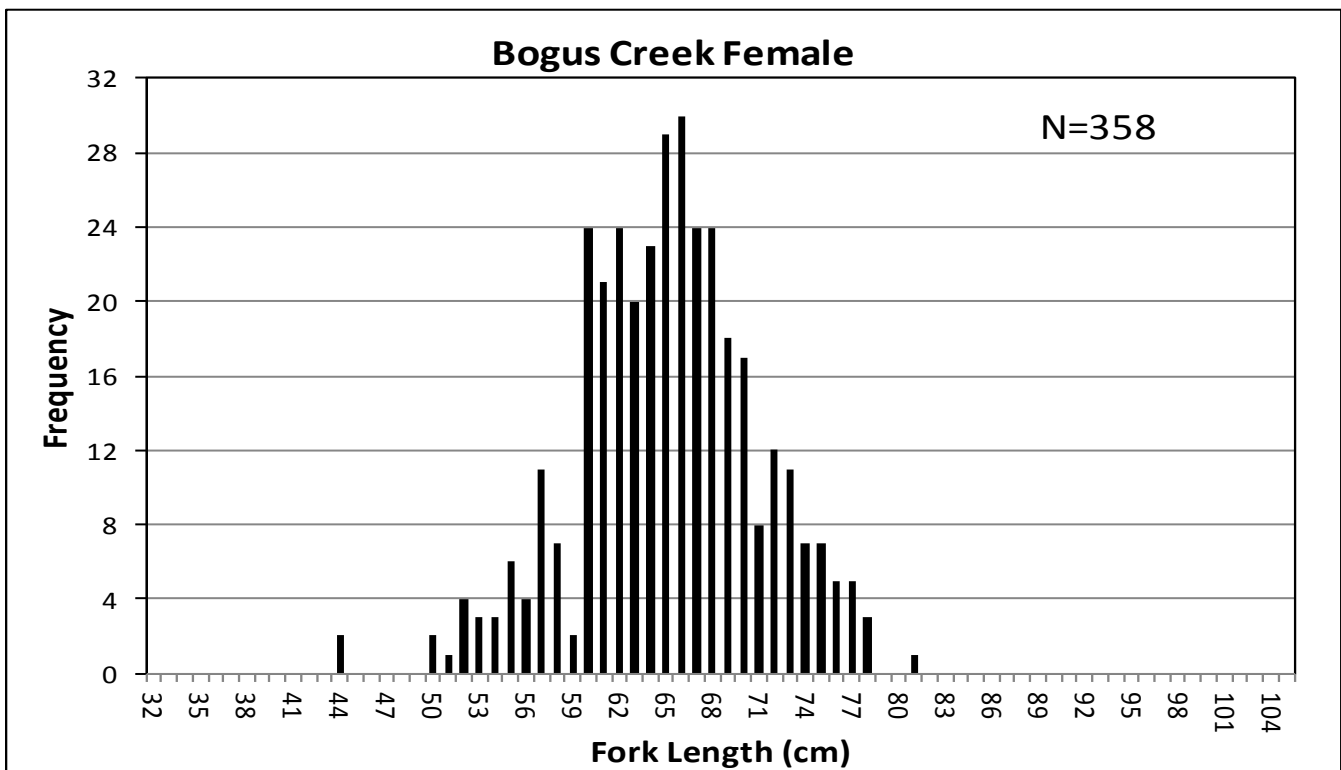


Figure 6. Length frequency distribution of female Chinook Salmon systematically sampled during spawning ground surveys in Bogus Creek, 2017 (N=358).

HATCHERY CONTRIBUTION ESTIMATE

A total of 90 heads were collected from ad-clipped Chinook Salmon. Positive CWT reads were obtained from 82 heads. Six heads were collected that did not contain a CWT. Two 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 (2.24) is based on the inverse of the number of carcasses (992) examined upstream of BCFCF during spawning ground surveys divided by the total number of Chinook Salmon observed passing through the station (2,224). 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 515 (18.9%) of the Chinook Salmon in Bogus Creek during the 2017 season were of hatchery origin.

COHO SALMON

The first adult Coho Salmon was observed entering Bogus Creek on November 10, 2017 and the last Coho Salmon was observed on February 7, 2018. A net total of 44 Coho Salmon were observed moving upstream through the BCFCF during the season (Figure 7). Two Coho were recovered as carcasses and one coho redd was observed downstream of the counting station during the season. No additional Coho were added for periods when the camera was not functioning. Assuming two fish were associated with the observed redd and adding the two observed carcasses to the video estimate yields a season total Coho salmon run-size estimate of **48**. Diel movements of Coho Salmon through the BCFCF varied but were generally higher during non-daylight hours (Figure 8). Based on the number of Coho Salmon observed greater than and less than 56 cm fork length during the videography effort age proportions were estimated to be 22.7 percent grilse and 77.3 percent adults.

SPAWNING GROUND SURVEYS

A total of 5 Coho Salmon carcasses (4 females and 1 male) were sampled during the spawning ground survey. Only a single 68 cm fork length male coho was recovered during the spawning ground survey effort. Females ranged in fork length from 56 cm to 69 cm and averaged 63 cm (Figure 9).

Four 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 four females recovered, all were determined to have spawned (Table 2). Seventeen of the 22 of the caudal punched and released Coho from IGH during 2017 were males. None of these 22 fish were recovered as carcasses in Bogus Creek during 2017 to further evaluate pre-spawn mortality differences in these two groups. The high pre-spawn mortality associated with IGH released surplus adults in prior seasons can in part be attributed to multiple handling events and stress associated with living in captivity for up to 14 days prior to release.

Table 1. Estimated contribution of hatchery origin fall Chinook Salmon in Bogus Creek, 2017.

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
068797	IGH	F	2012	5	1	4.00	4	1	4
068798	IGH	F	2012	5	1	4.01	4	1	4
060417	IGH	F	2013	4	1	4.01	4	1	4
060597	IGH	F	2013	4	4	4.05	16	1	16
060601	IGH	F	2013	4	2	4.04	8	1	8
060604	IGH	Y	2013	4	7	4.01	28	1	28
060684	IGH	F	2014	3	12	4.04	49	1	49
060685	IGH	F	2014	3	2	4.00	8	1	8
060686	IGH	F	2014	3	2	4.02	8	1	8
060688	IGH	Y	2014	3	9	4.02	36	1	36
060784	IGH	F	2015	2	3	4.01	12	1	12
060785	IGH	F	2015	2	1	4.01	4	1	4
Sub Total=					45	Sub Total=			181
Estimated contribution of lost tag (1) or unreadable CWT's					1	Sub Total=			4
								Total=	185
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
060597	IGH	F	2013	4	1	4.05	4	2.24	9
060601	IGH	F	2013	4	1	4.04	4	2.24	9
060604	IGH	Y	2013	4	6	4.01	24	2.24	54
060684	IGH	F	2014	3	12	4.04	49	2.24	109
060685	IGH	F	2014	3	2	4.00	8	2.24	18
060686	IGH	F	2014	3	1	4.02	4	2.24	9
060688	IGH	Y	2014	3	7	4.02	28	2.24	63
060784	IGH	F	2015	2	3	4.01	12	2.24	27
060785	IGH	F	2015	2	2	4.01	8	2.24	18
060786	IGH	F	2015	2	2	4.02	2	2.24	4
Sub Total=					37	Sub Total=			320
Estimated contribution of lost head (0) or unreadable CWT's (1)					1	Sub Total=			9
								Sub Total	329
Grand Total Estimated Hatchery Contribution=									515

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.

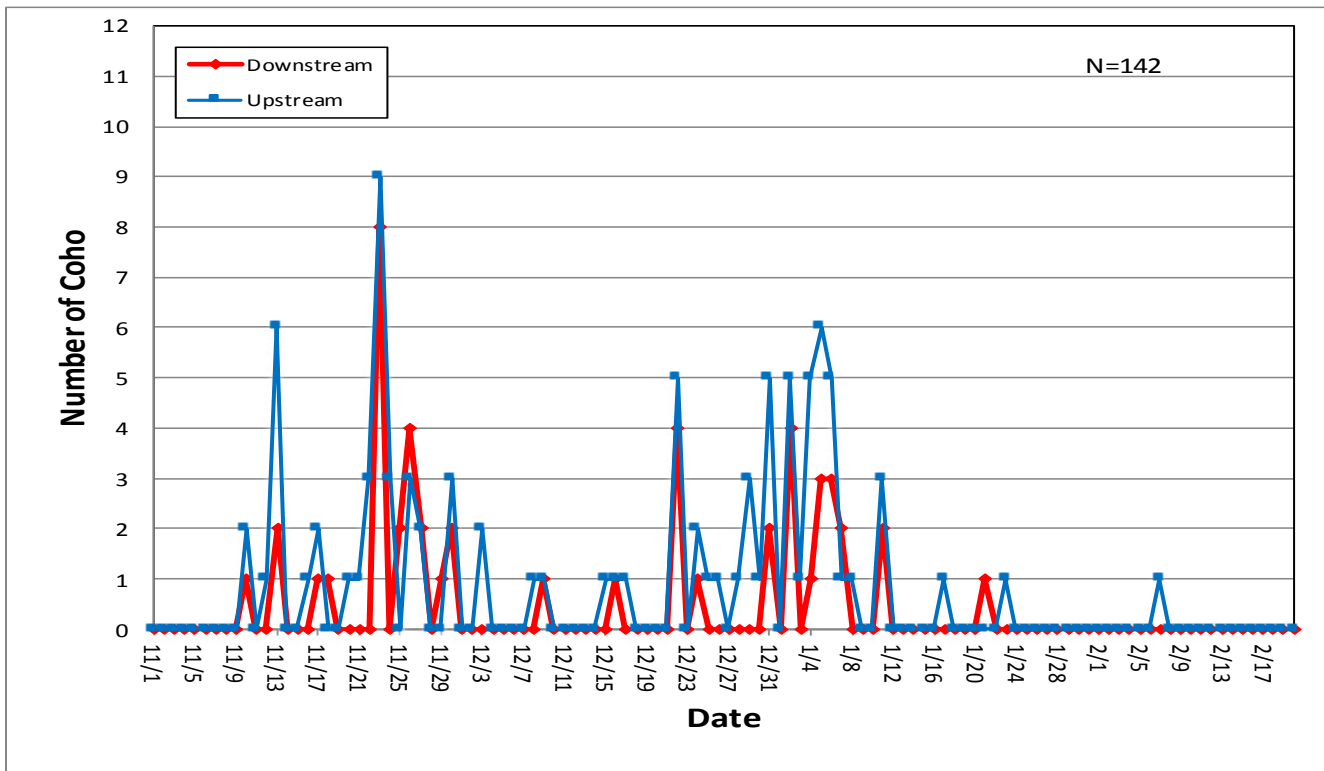


Figure 7. Run timing of Coho Salmon observed passing through the Bogus Creek Fish Counting Facility during the 2017 season. Both upstream and downstream movements through the counting flume are shown (N=142).

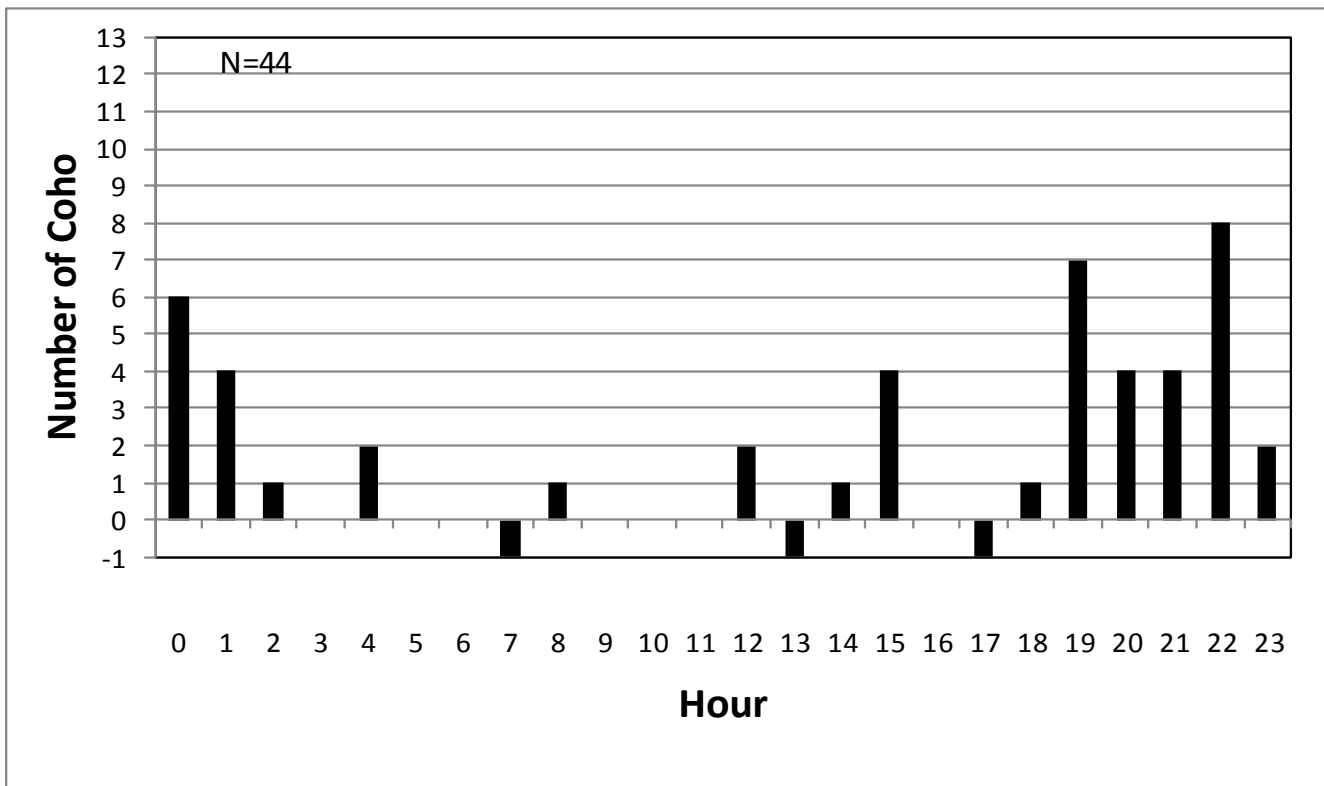


Figure 8. Diel migration patterns of Coho Salmon observed (N=44) moving through (hourly net movement) the Bogus Creek Fish Counting Facility in 2017 season.

Table 2. Estimated Bogus Creek surplus and non-surplus Coho Salmon percent pre-spawn mortalities during the 2004 through 2017 seasons.

Year	Percent Prespawn Mortalities			
	IGH Released Surplus Adults	Non-Surplus Adults	Aggregate of both IGH released Surplus adults and non-Surplus adults	Average
2004	-	28.6	-	-
2005	-	-	19.6	19.6
2006	-	-	-	-
2007	-	-	17.2	17.2
2008	-	-	36.4	36.4
2009	-	-	-	-
2010	40.0	12.5	-	26.3
2011	50.0	62.5	-	56.3
2012	66.6	42.9	-	54.8
2013	24.4	10.3	-	17.4
2014	-	25.0	-	-
2015	-	50.0	-	-
2016 ¹	-	0	-	-
2017 ¹	-	0	-	-
Average	45.3	25.8	24.4	32.5

¹ based on two recoveries in 2016 and 4 recoveries in 2017

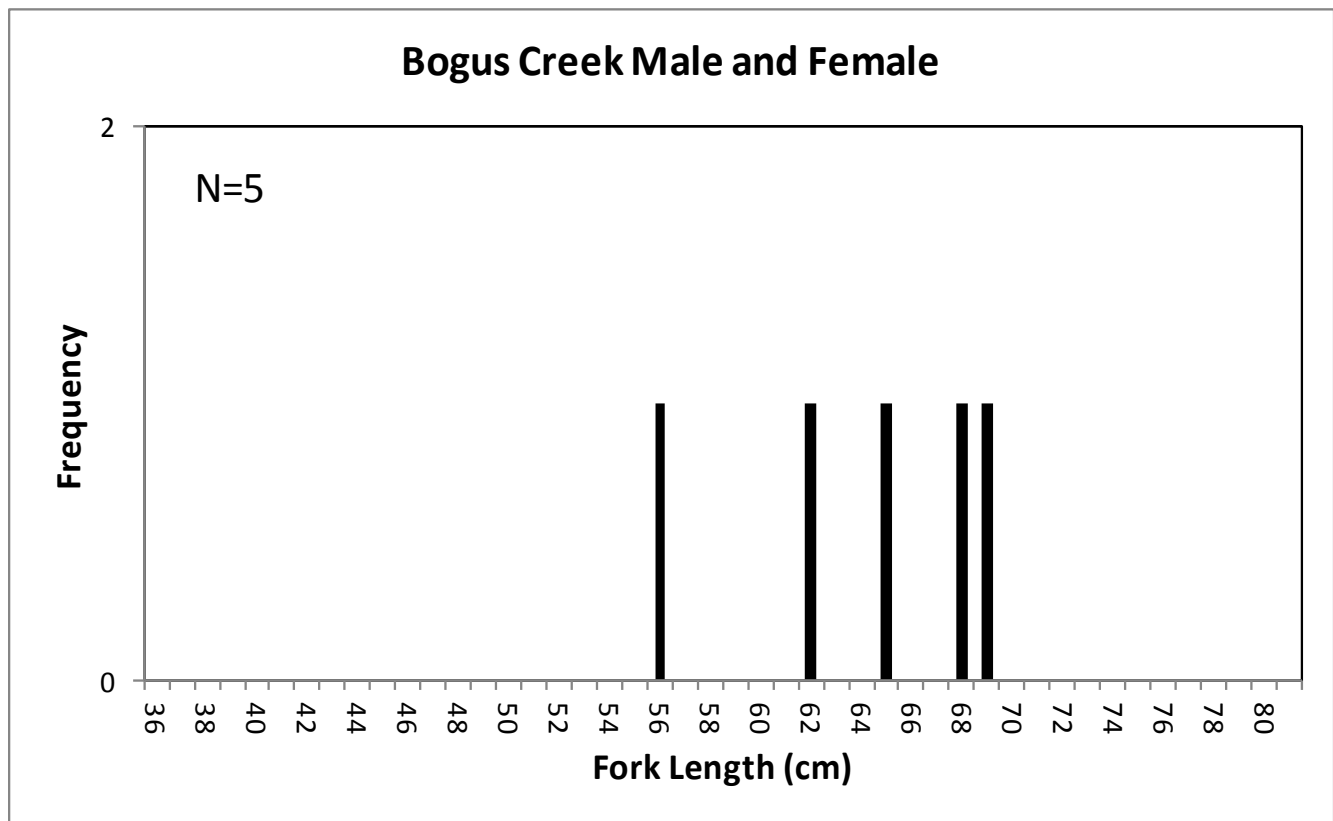


Figure 9. Length frequency distribution of male and female Coho Salmon observed during spawning ground surveys in Bogus Creek, 2017 (N=5).

STEELHEAD

In 2017, a net total of 205 adult (>40.6cm.) steelhead (406 upstream, 201 downstream; Figure 10) were estimated to have entered and remained in Bogus Creek during the video recording season from September 11, 2017, to June 8, 2018. During this time there were a total of 595 steelhead observations including both upstream (394) and downstream (201) movements. An additional 12 steelhead were added during periods of time when the camera visibility was too poor to determine species (8) or during periods of time when the camera was not functioning (4). The 406 estimated 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 406 as some fish move up and down through the flume multiple times. The net upstream movement of 205 fish represents a minimum number of steelhead for the season. Upstream movement of adult steelhead was observed throughout the season but was generally bimodal with migration periods in the fall during September through November and during the winter/spring from mid-January through April. Very few steelhead were observed during the month of December. Lines on the back of the video flume were set at 40.6 cm. to delineate sub-adults versus adults.

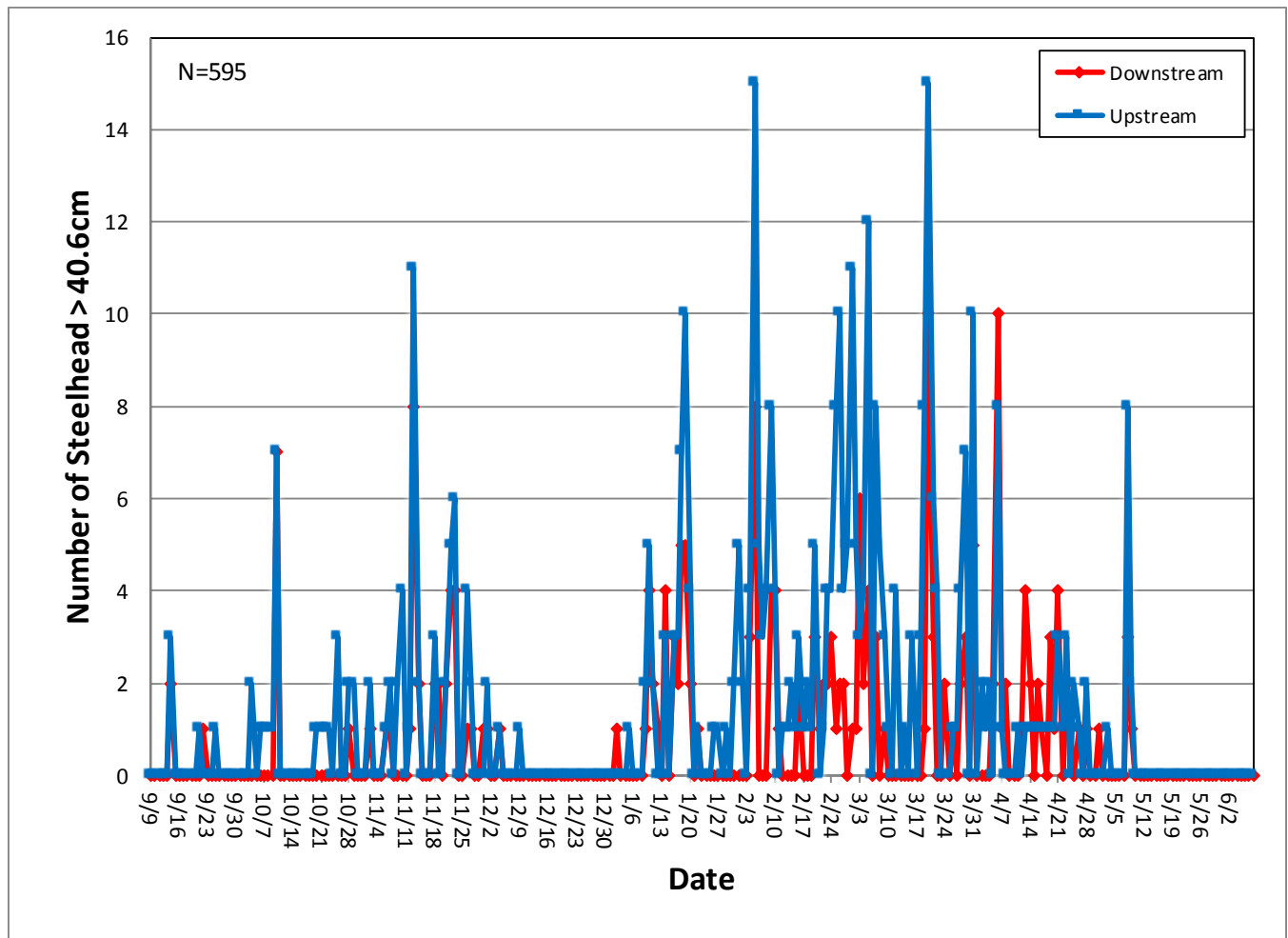


Figure 10. Run timing of steelhead trout (>40.6 cm.) observed passing through the Bogus Creek Fish Counting Facility during the 2017 season (N=595). Both upstream and downstream movements are shown.

DISCUSSION

CHINOOK SALMON

Since 1978, the Chinook Salmon run in Bogus Creek has ranged from 46,432 fish (1995) to 785 fish (1990) and averaged 8,131 fish (Figure 11). The 2017 Chinook Salmon run in Bogus Creek ranks thirty-fourth (2,722 fish) out of 40 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 ranged from 61.6% to 7.5% and averaged 34.0%. An estimated 18.9% of the Chinook Salmon that entered Bogus Creek during 2017 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 underestimate 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 auxiliary fish ladder, there has been significant mixing of salmonids from these two locations.

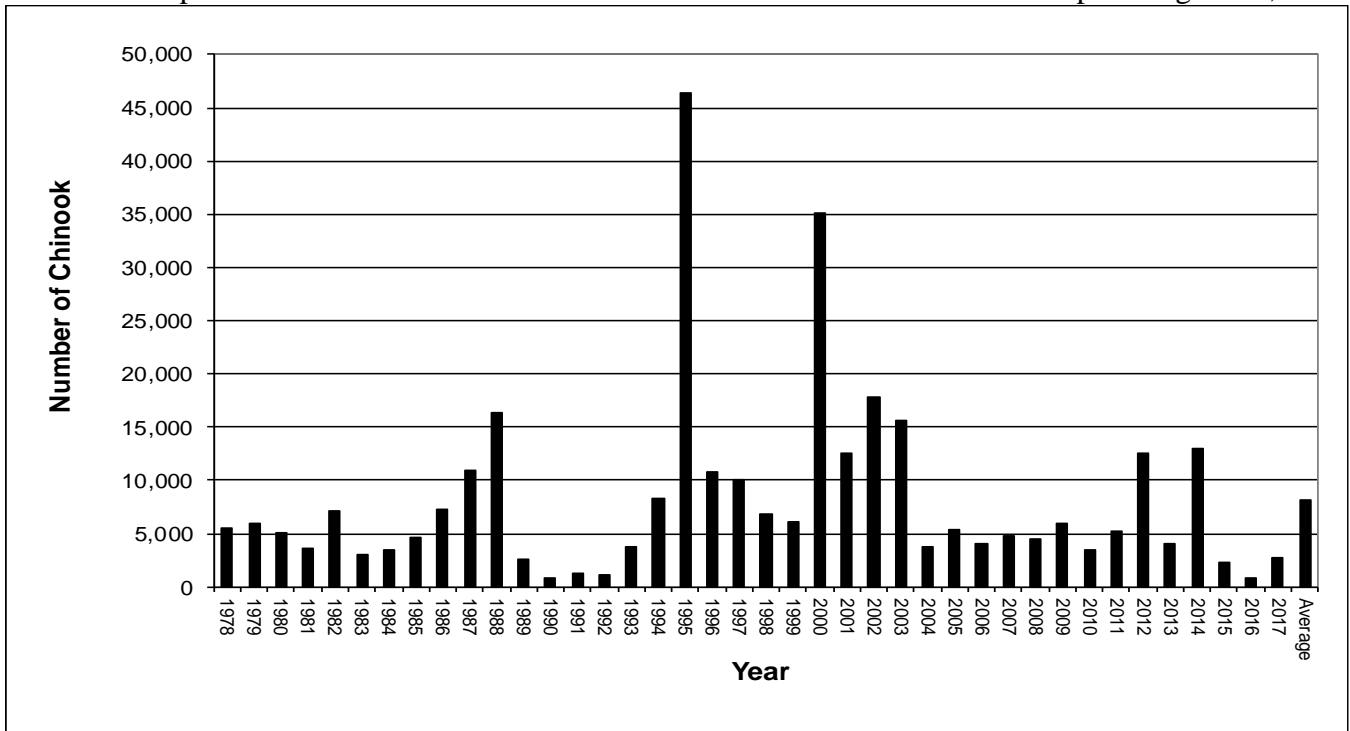


Figure 11. Estimated escapement of adult Chinook Salmon returning to Bogus Creek from 1978 to 2017.

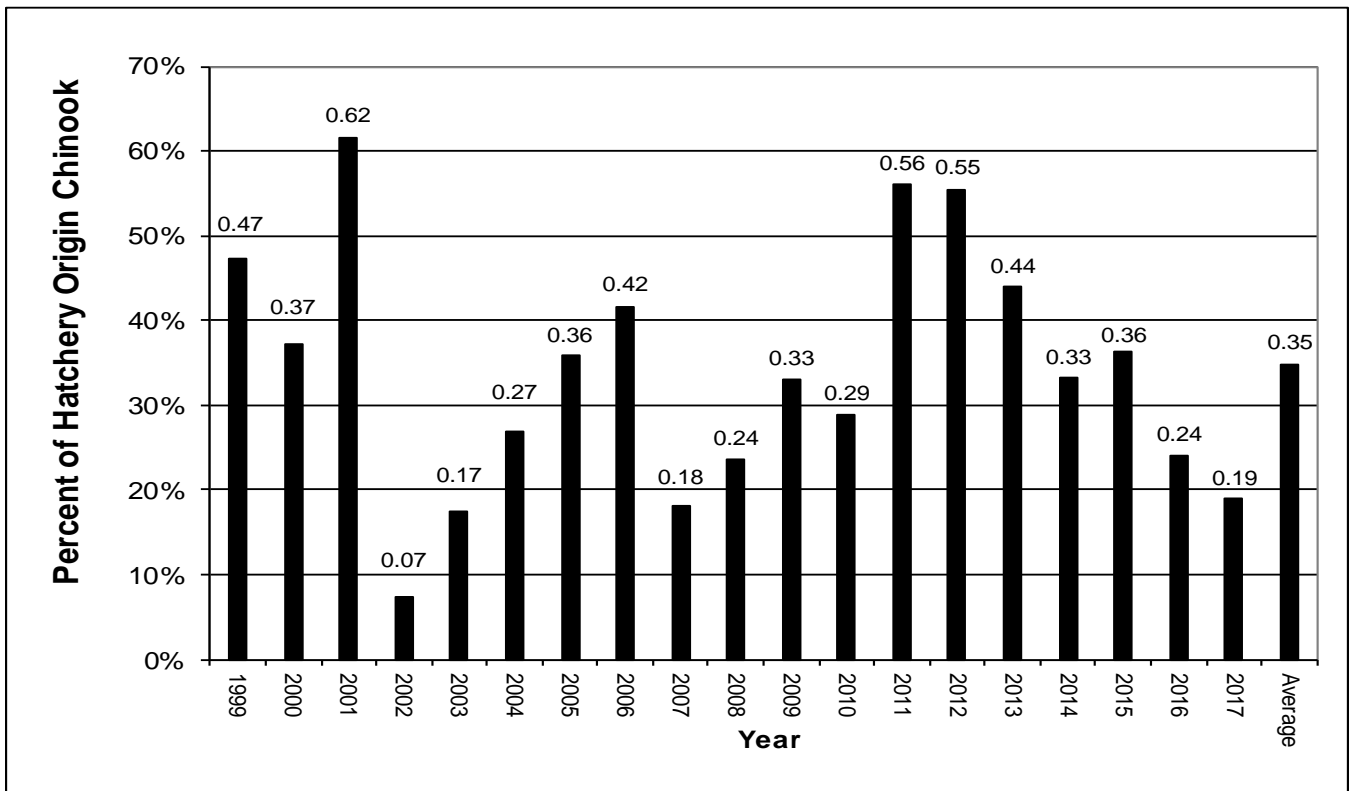


Figure 12. Estimated contribution of hatchery origin Chinook Salmon observed in Bogus Creek from 1999 through 2017.

COHO SALMON

Since video operations began in 2004 the estimated escapement by return year (hatchery origin, natural origin, age 2 and age 3) of Coho Salmon in Bogus Creek has averaged 150 fish (Figure 13). The escapement of Coho Salmon during 2017 was estimated to be 48, which was 67.9% below the 14-year average. Coho Salmon escapement in 2017 (48) was less than observed escapement in 2014 (97), a reduction in run size of 50.5%. The decrease in run size observed in 2017 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 adult Coho stray directly into Bogus Creek without first entering IGH. If the estimated IGH strays (11) that entered Bogus Creek were removed from the abundance estimate only 37 natural origin Coho would remain, and a resulting decrease in run size of 61.8% would have been observed.

HATCHERY COHO SALMON CONTRIBUTIONS

During carcass surveys, 5 Coho Salmon were sampled. The proportion of hatchery and natural origin fish based on the 5 fish sampled was 20% HOS and 80% NOS. In an effort to increase the sample size to more accurately describe the hatchery contribution all 48 Coho Salmon video images were evaluated for the presence of left maxillary clips. Forty-one of the images were clear enough for max clip determination with high confidence. The final 2017 hatchery origin proportion was estimated from videography and was determined to be 22.0% which was applied to the run-size of 48 Coho generating an estimated 11 HOS and 37 NOS.

The proportion of HOS Coho in Bogus Creek has been estimated since 2004 and has ranged from 22% to 88% and has averaged 49%. As a result of implementation of the recommendations contained in the HGMP, starting in 2010, Coho Salmon IGH returns in excess of broodstock needs have been released back to the river. During the 2017 season, 22 adults were released from IGH, but during 2010, 2011, 2012, 2013, 2014, 2015 and 2016, 60, 259, 342, 896, 239, 28 and 6 were released, respectively, and this has significantly affected the proportion of HOS to Bogus Creek (Figure 14).

None of the 5 (0%) Coho Salmon observed in the spawning ground survey were operculum punched (or contained a PIT tag), which would have indicated that they were surplus Coho Salmon from IGH. Based on the proportion of Coho carcasses recovered, zero surplus Coho have been predicted to have entered Bogus Creek. There is a possibility that IGH surplus PIT tagged Coho may have entered Bogus Creek and went undetected as a result of the PIT antenna not operating during the 2017 season. In recent years PIT antennas have detected IGH surplus fish that the spawning ground survey did not. A total of 22 Coho were released from IGH during the 2017 season and none were observed during spawning ground surveys on 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 our ability to detect IGH surplus fish on spawning grounds but accuracy could still be improved.

In an effort to evaluate the natural origin abundance of Coho salmon in Bogus Creek the estimated hatchery influence has been removed and the returns of age 2 and age 3 have been pooled by cohort. The natural origin returns of coho salmon by cohort have ranged from a low

of 4 to a high of 131 for the years 2005 to 2017 (Figure 15). The 2014 brood year cohort that returned in 2017 (age 3 in 2017 and age 2 in 2016) in one generation increased in total numbers by 24, from 5 to 29 an increase or 4.28 times. It should be noted that the 2017 cohort return of 29 was 35% lower than this specific cohorts five year average of 44 fish. The three natural origin cohorts average returns are 19 (cohort 1 returning as age 3 in 2015), 92 (cohort 2 returning as age 3 in 2016), 44 (cohort 3 returning as age 3 in 2017) respectively.

Utilizing total escapement, estimated proportion of natural origin Coho and estimated age structure of returning adult Coho Salmon to Bogus Creek allows for total female spawner (natural origin plus hatchery origin) to natural origin recruit analysis for years 2004, 2005, and 2007-2014 (Figure 16). The spawner recruit analysis is limited to ten 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 passive supplementation started in 2010, the proportion of hatchery origin spawners on the spawning grounds (pHOS) in Bogus Creek has exceeded 50% four out of eight years. The higher the pHOS, the harder it is to achieve PNI values >0.5.

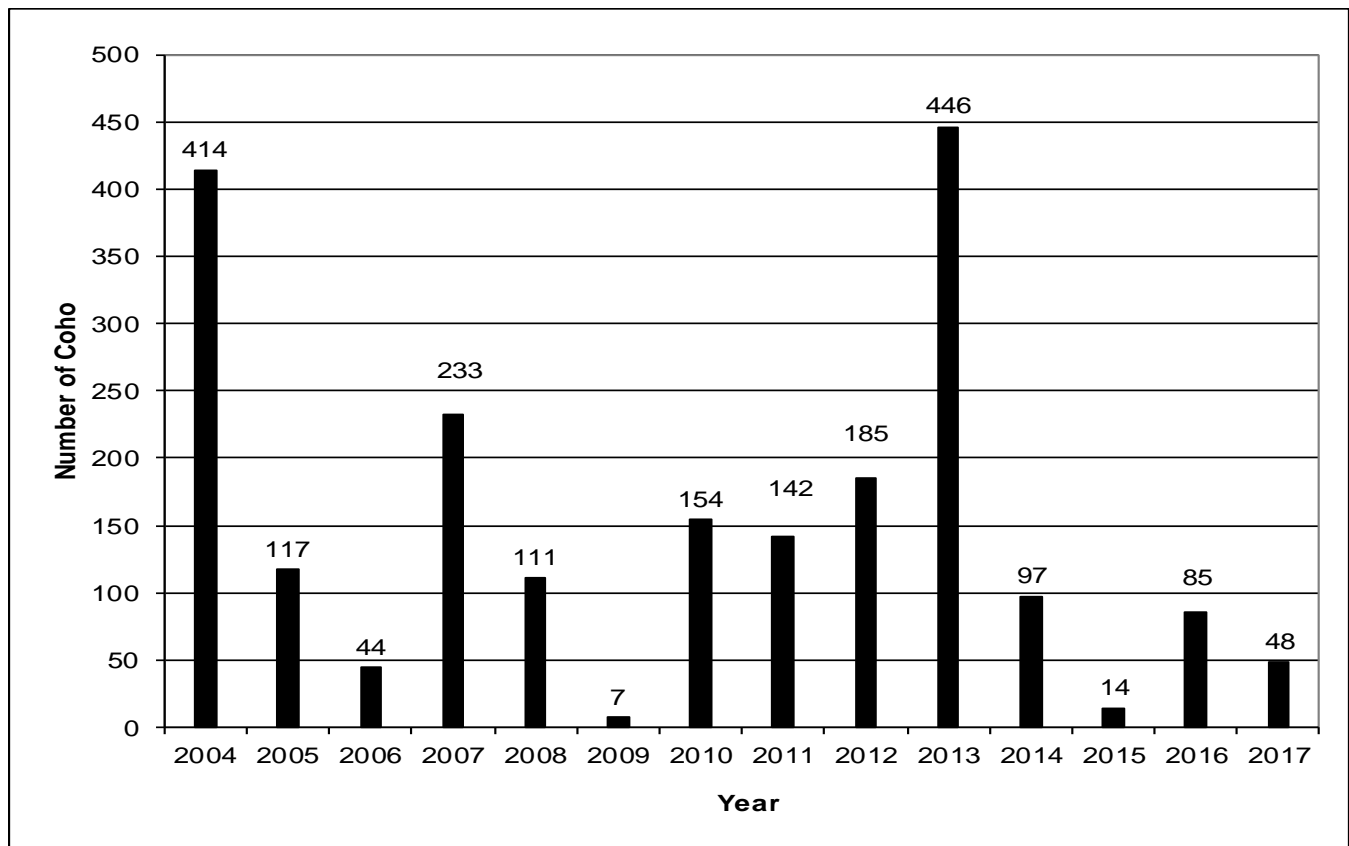


Figure 13. Estimated escapement by Return Year of hatchery and natural origin adult and grilse Coho Salmon (age 2 and age 3; different cohorts) returning to Bogus Creek from 2004 through 2017.

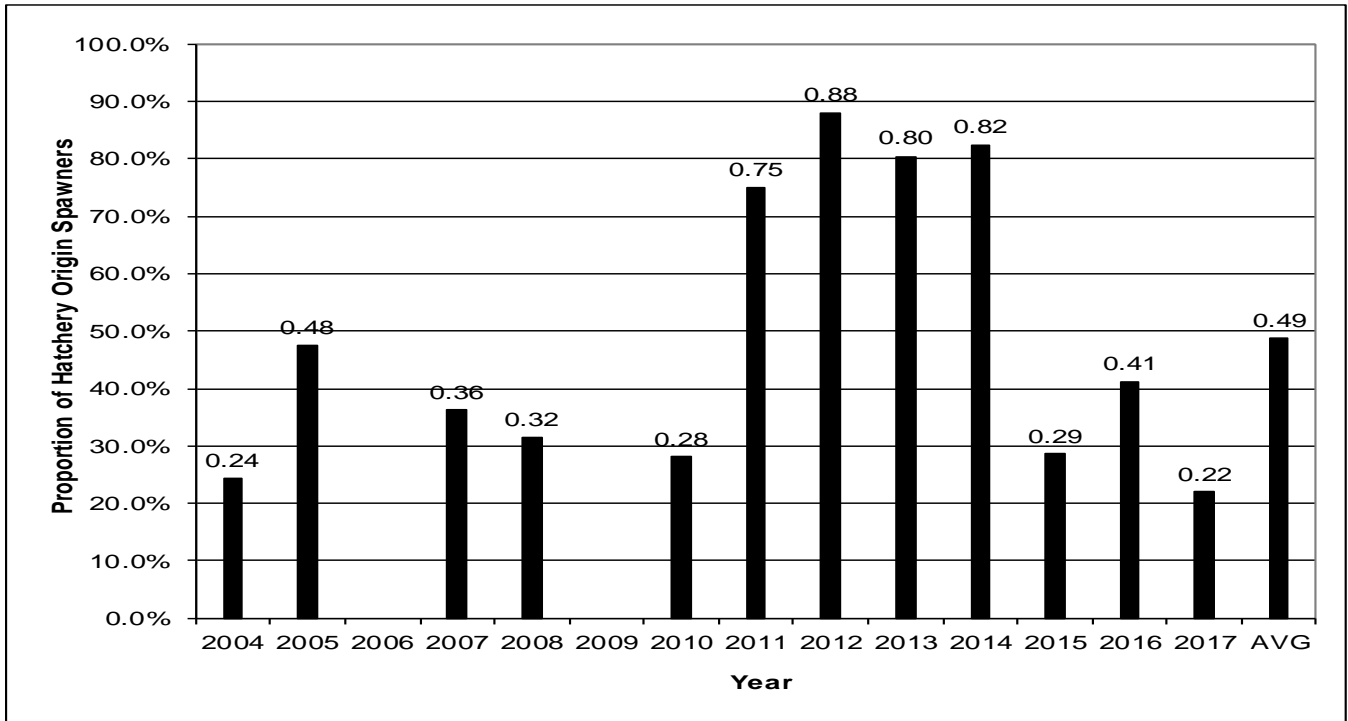


Figure 14. Estimated contribution of hatchery origin Coho Salmon observed in Bogus Creek from 2004 through 2017. Due to low carcass recovery in 2006 and 2009, hatchery contribution rates were not estimated in these years. Starting in 2010, Coho returns in excess of IGH broodstock needs have been released to the river.

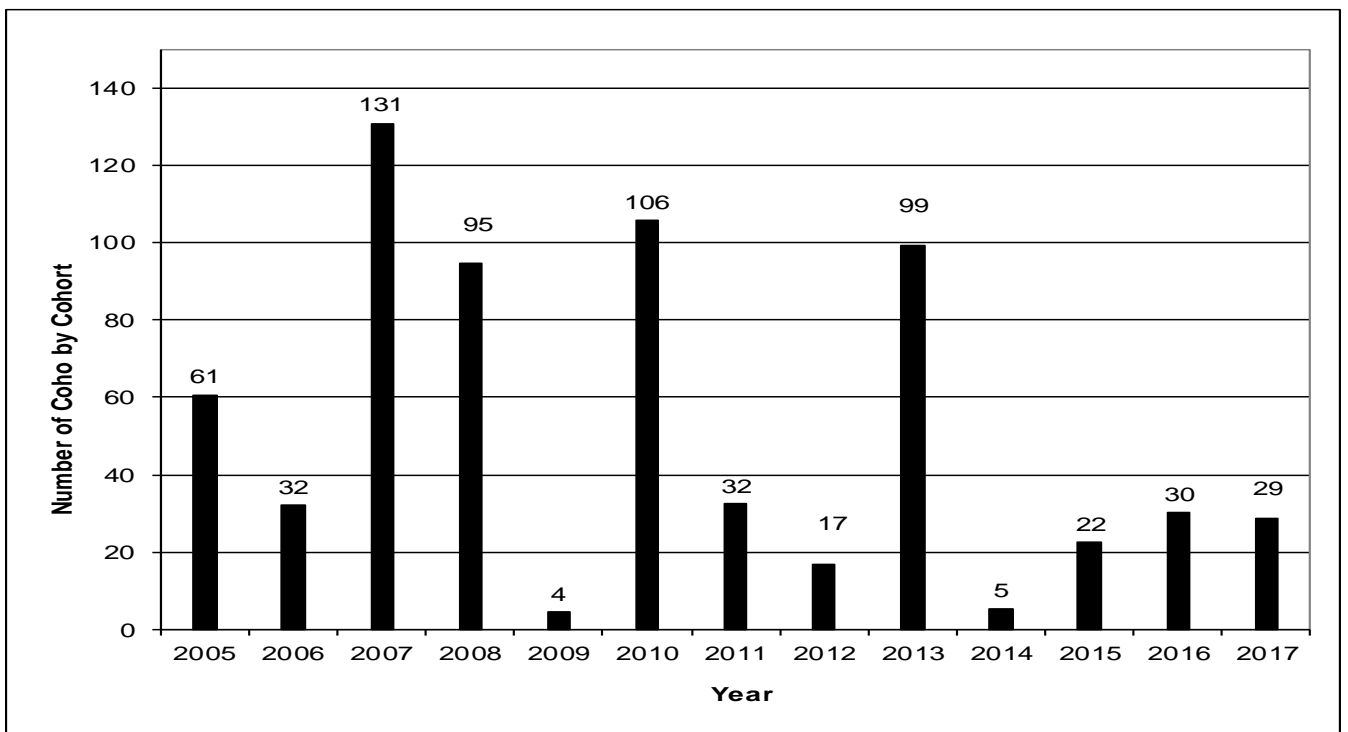


Figure 15. Estimated escapement by Cohort of natural origin adult and grilse Coho Salmon (age 2 and age 3; same cohort) returning to Bogus Creek from 2004 through 2017. Year indicates when a cohort returned at age 3.

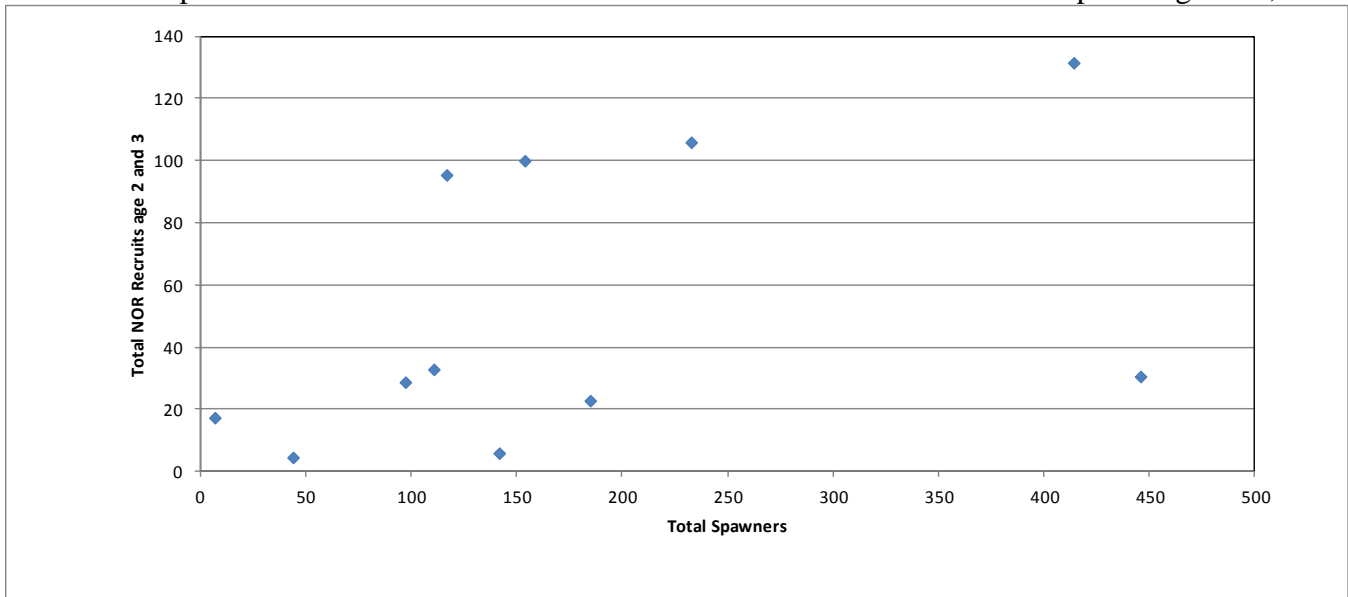


Figure 16. Total Spawner (natural plus hatchery origin) to natural origin recruit analysis for Bogus Creek Coho Salmon for spawner brood years 2004, 2005, and 2007-2014.

STEELHEAD

The BCFCF monitoring extended to June 8, 2018 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 205 and averaged 83 for the years 2007 through 2017 (Table 3). During most seasons the monitoring ended prior to the end of the steelhead migration but in the 2013, 2016 and 2017 seasons monitoring extended to or beyond May 1st. During the 2013, 2016 and 2017 seasons the observed net upstream steelhead counts were 103, 84 and 205 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 February, March and April are not anadromous forms of *O.mykiss*. The 2017 season was the first year for which a bi-modal return timing was observed with two distinct pulses for fish migrating into Bogus Creek. The first group of fish was observed from September through November and the second group observed from January through May. It is possible that both fall and winter anadromous forms as well as resident Klamath River steelhead are utilizing Bogus Creek.

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). Flow conditions during the 2017 season were much more stable with 4.05 monitoring days lost due to high flows. 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 2017.

Year	Net Upstream Steelhead >40.6 cm	Last date of 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
2017	205	6/8
Average	83	

Table 4. Specific dates and times during the 2017 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	1/23/2018	945	14 : 25	0	0	1
	1/24/2018		24 : 00	0	0	1
	1/25/2018		24 : 00	0	0	1
Filming Started	1/26/2018	1300	11 : 00	0	0	1
Filming Stopped	5/22/2018	815	16 : 45	0	0	0
Filming Started	5/23/2018	715	7 : 25	0	0	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 2018. Klamath River Fall Chinook Salmon Age-Specific Escapement, River Harvest, and Run Size Estimates, 2017 Run. Available from Pacific Fishery Management Council web address: <http://www.pcouncil.org/salmon/background/document-library/#KlamathRiverSalLib>