Shasta River
Salmonid Monitoring 2020
Siskiyou County, CA

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ABSTRACT

A total of **4,168** fall run Chinook Salmon (*Oncorhynchus tshawytscha*) were estimated to have entered the Shasta River during the 2020 spawning season. An underwater video camera was operated in the flume of the Shasta River Fish Counting Facility (SRFCF) twenty-four hours a day, seven days a week, from September 2, 2020 until January 11, 2021. The first Chinook Salmon was observed on September 5, 2020 and the last Chinook Salmon on December 9, 2020. Klamath River Project (KRP) staff sampled 434 carcasses to collect biological metrics and to determine the presence of Iron Gate Hatchery produced fish.

Chinook Salmon carcasses sampled in the spawning ground surveys (SGS), weir washbacks (WB) and adult trap were used to describe characteristics of the run. We processed 434 carcasses which ranged in fork length (FL) from 39 cm. to 97 cm. Males ranged in FL from 39 cm. to 97 cm. and averaged 61 cm. Females ranged in FL from 45 cm. to 82 cm. and averaged 63 cm. Grilse were determined by scale-based aging. The run was comprised of 393 grilse (9.4%), and 3,775 adults (90.6%). The sex composition of the run, based on 20 SGS fish sampled, was 60% (2,501) female and 40% (1,667) male. No hatchery origin fishes, as denoted by adipose clipped (ad) carcasses, were encountered during SGS sampling, however an estimate of 34 (0.81%) ad fish entered the Shasta River based on video observations. Coded-wire tag (CWT) proportions from Iron Gate Hatchery (IGH) were used to estimate the age classes and release types of IGH Chinook Salmon observed by video in the Shasta River this year.

A net total of **37** Coho Salmon (*Oncorhynchus kisutch*) were estimated to have entered the Shasta River prior to removal of the weir on January 9, 2020. The first Coho Salmon of the season was observed swimming upstream through the SRFCF on November 14, 2020 and the last Coho Salmon was observed swimming upstream through the SRFCF on January 6, 2021. Seven Coho Salmon carcasses were recovered as WB samples. Six (86%) of the Coho Salmon WB were male and ranged in FL from 45-72 cm. One (14%) female Coho Salmon WB was recovered and was 52 cm. long. No Coho Salmon were recorded as pre spawn mortalities. Three (43%) of Coho Salmon WB had left maxillary clips indicating IGH origin, this was expanded to the video estimate of 37 and we estimate that 16 Coho Salmon in the Shasta River were of IGH origin.

A net total of **240** steelhead trout (*Oncorhynchus mykiss*) with a fork length greater than or equal to 16 inches were observed passing through the SRFCF during the 2020 season, prior to the removal of the SRFCF on January 11, 2021.

Introduction

The KRP of the California Department of Fish and Wildlife (Department) is responsible, in cooperation with other state, federal and tribal partners, for estimating the number of Chinook Salmon (*Oncorhynchus tshawytscha*) and Coho Salmon (*Oncorhynchus kisutch*) that return to the Klamath River Basin, excluding the Trinity River Basin, each year. In addition to escapement, objectives include the determination of run timing, spawning distribution, length frequency (FL) distribution, sex ratio, and spawn condition for Chinook Salmon and Coho Salmon in the Shasta River. Scales and coded-wire tags are collected to determine the age composition and hatchery contribution to each annual run.

To achieve these tasks the KRP employs several techniques which include a creel survey of sport fishing effort and harvest, recovery of fish returning to Iron Gate Hatchery (IGH), completion of cooperative spawning ground surveys in major tributary streams and rivers, and operation of video fish counting weirs on the Shasta River, Scott River and Bogus Creek. This report summarizes observations of salmonids in the Shasta River. The SRFCF is located approximately 213 meters (700 feet) from the confluence of the Shasta and Klamath Rivers (Klamath RM 176.6, RKM 283, Figure 1 and Figure 2). Coordinates for the facility are 041º 49' 46.38" N, 122º 35' 35.38" W.

Video equipment was first installed at the SRFCF in 1998 and has been used to describe migration of salmonids into the Shasta River ever since. Although the primary responsibility of the KRP is to enumerate and describe Chinook Salmon and Coho Salmon populations, data are recorded for steelhead trout (*Oncorhynchus mykiss*) and other species observed at the SRFCF during its period of operation as well.

Since 2004, when the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon was listed as a Threatened Species by the California Fish and Game Commission, the KRP has operated its SRFCF video system through December, and into January when possible, in order to enumerate the Coho Salmon run as well as the Chinook Salmon run. This report describes the characteristics of the Chinook Salmon, Coho Salmon and steelhead troutruns that entered the Shasta River during the 2020-2021 season.

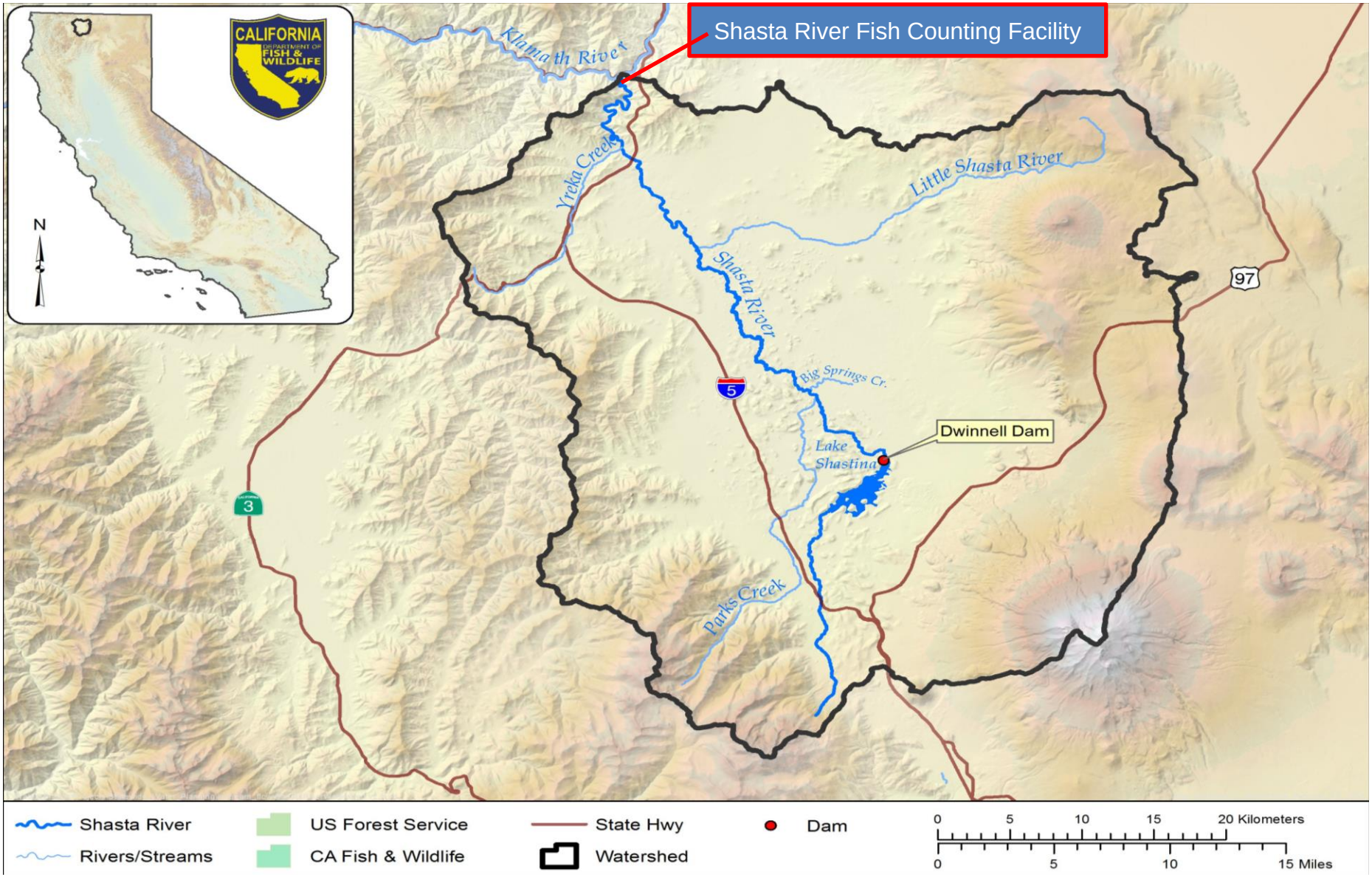

Figure 1: The Shasta River Watershed and location of the Shasta River Fish Counting Facility

Figure 2: Google Earth Image Looking South at the Shasta and Klamath Confluence

Methods

Monitoring of the salmon run within the Shasta River during the 2020 season was accomplished through four primary efforts: operation of a video weir, operation of an upstream migrant trap, collection of data from salmon carcasses that become impinged on the weir panels as they float downstream (WB), and completion of spawning ground surveys upstream of the weir to obtain biological data from salmon carcasses.

VIDEO WEIR

The SRFCF consists of a video camera, counting flume and an Alaska style weir strategically placed in a diagonal across the river channel (Figure 3). Fish immigrating upstream are directed through a narrow flume, which passes in front of an underwater video camera. A SplashCam Delta Vision* black and white underwater camera with a 3.6 mm wide angle lens was used in 2020 for capturing images, and an ECOR 264* digital video recorder (DVR) with a swappable hard drive were used for recording video footage.

*Use of product names in this report does not imply endorsement by the California Department of Fish and Wildlife.

Figure 3: Alaska-style panels of the Shasta River Fish Counting Facility (SRFCF)

The weir and video camera were installed, and recording began on September 2, 2020. KRP staff performed routine daily maintenance of the SRFCF. This included inspecting the video system to ensure that everything was operating correctly, inspecting and cleaning weir panels and making any necessary repairs, and processing any wash-back carcasses present. Twice per week the hard drive was removed from the DVR and replaced with another drive. All recording equipment was secured in locked enclosures and access to the site was controlled through a locked gate located on private property.

Swappable drives with stored video data were immediately returned to the office where each was subsequently downloaded onto a shared network drive for storage and review by staff in the video lab. During each review, staff recorded the date, time (hour:min:sec), and species of each fish observed. In addition, staff noted the presence of ad fish, and recorded the presence of lamprey or any other distinguishable marks that were visible on the footage. Fish were counted as downstream migrants if they entered the flume from the upstream end and exited at the downstream end. If fish entered the flume but backed down without exiting on the upstream end, they were not counted. Fish for which positive identification could not be made were recorded as “unknown” species. These fish were later reviewed and if identification could not be determined the fish were assigned a species based on average passage in the outage time frame from the 2 days before and after the event. All data were then entered into files on a

computer and each data file was edited and corrections made by a second individual prior to commencement of data analysis. Operation of the SRFCF began on September 2, 2020. The first Chinook Salmon of the season was observed on September 5, 2020 and the last Chinook Salmon was observed on December 9, 2020.

WASHBACK CARCASSES

All salmon carcasses that drifted downstream and became impinged on the weir panels were recovered. A systematic sample of one in five Chinook Salmon carcasses were processed. Data collected on these systematically sampled WB carcasses included FL, gender, marks, tags and the presence of fin clips. Scales were removed from the left side of each carcass at a location posterior to the dorsal fin just above the lateral line whenever possible. Each female carcass was also examined to determine whether successful spawning had occurred. Spawning status was defined as un-spawned (many eggs remaining in the body) or spawned (few or no eggs remaining). In addition to the systematically sampled Chinook Salmon carcasses, all carcasses were examined for ad clips, and all ad carcasses and Coho Salmon and steelhead trout carcasses were processed. Heads were collected from each ad fish for later CWT recovery and analysis. All carcasses were cut in half to prevent sample duplication and returned to the river downstream of the weir.

ADULT TRAP

During the 2020 season an 8’ by 8’ trap was constructed on the upstream side of the video flume at the SRFCF to facilitate biological sampling of the fall Chinook Salmon run. Fish entered the trap by swimming upstream through the video flume through a steel fyke which led into the trap. The trap is constructed of evenly spaced bars to allow water to constantly flow into and out of the trap to keep fish in good condition. The trap was set up with two removable panels on the upstream side, when these panels were removed fish could easily continue to swim upstream and exit the trap. Once the panels were lowered into place the trap was actively fishing and fish were held in the trap. This allowed the trap to be fished for short durations (3-6 hours). The trap was typically set in the morning and checked around noon. A crew of two would process fish and empty the trap, all fish were speciated, sexed, measured, and opercula punched to prevent duplicate samples. Chinook Salmon were sampled for scales and genetic tissue. The primary purpose of the trap was to provide an unbiased scale sample collection from Chinook Salmon to increase the number of fish that can be aged to provide a more accurate age estimate.

SPAWNING GROUND SURVEYS

Survey reaches included the lower seven miles of the Shasta River (canyon reaches), several reaches of the upper Shasta River main stem, and on two tributaries: Big Springs Creek, and Parks Creek. Survey reaches are described in Table 1. Together, these surveys cover approximately 15 percent of the Shasta River basin, and their purpose is to gather biological data necessary to describe physical characteristics of the run, and to document spawning distribution in the reaches surveyed. Total escapement numbers are derived from the video weir. Surveys were conducted once per week, usually on Wednesdays, and were limited to areas historically used, or believed to be used, by spawning salmon. Landowners’ willingness to allow access also limited sampling locations.

Table 1: Description of Shasta River Spawning Ground Survey Reaches, 2020

Location	Reach Number	Downstream Point	Upstream Point	Length (miles)	Length (km)
Shasta River	1	Shasta River Fish Counting Facility	Pioneer Bridge	2.97	4.78
Shasta River	2	Pioneer Bridge	Highway 263	2.47	3.98
Shasta River	3	Highway 263	Shelly Bridge (canoe reach)	0.37	0.59
Shasta River	19	Nelson Ranch	Confluence w/Big Springs Creek	1.84	2.96
Shasta River	20	Confluence w/Big Springs Creek	Confluence w/ Parks Creek	0.93	1.49
Big Springs Creek	21	Mouth of Big Springs Creek	Upper Bridge, Big Springs Creek	0.87	1.4
Shasta River	22	Mouth of Parks Creek	Hidden Valley Ranch	2.53	4.07
Parks Creek	23	Mouth of Parks Creek	2nd Fence	0.99	1.59
Parks Creek	24	Parks Creek, Dukes	Slough Road Crossing	1.89	3.04
Totals:				14.9	23.9

During each survey, crews walked along the riverbank or in the channel searching for salmon carcasses. As carcasses were located, crews processed each as previously described for weir wash backs. In addition to scale samples, a tissue and otolith sample was collected from the first carcass sampled from each reach on each survey day. All tissue samples were collected following protocols provided by the National Oceanic and 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 throughout the season and cataloged for future microchemistry analysis. Otolith samples were collected following standard protocols.

CHINOOK SALMON HATCHERY INFLUENCE

Since no ad carcasses were collected, hatchery influence was calculating by using the video net upstream ad Chinook Salmon passage estimate and applying the proportion of CWT codes recovered from IGH to the total estimated ads in the Shasta River video count to estimate hatchery influence.

RESULTS

CHINOOK SALMON VIDEO DATA

A net total of **4,168** Chinook Salmon were estimated to have migrated through the SRFCF during the 2020 season, this includes 10 Chinook Salmon that were estimated during times of video outage (Appendix A). The estimate (4,168) was derived by subtracting the number of downstream observations (268) from the number of upstream observations (4,426). Most of the run (58%) was observed between September 2, 2020 and October 3, 2020, and the peak day of the run was October 3, 2020 with a net passage of 354 (8.49%) Chinook Salmon in addition migration rates increased once flows began to increase in late September (Figure 4). Consistent with previous years' monitoring efforts, the majority of Chinook Salmon (92%) passed upstream through the SRFCF during daylight hours between 06:00 and 17:00 hours (Figure 5).

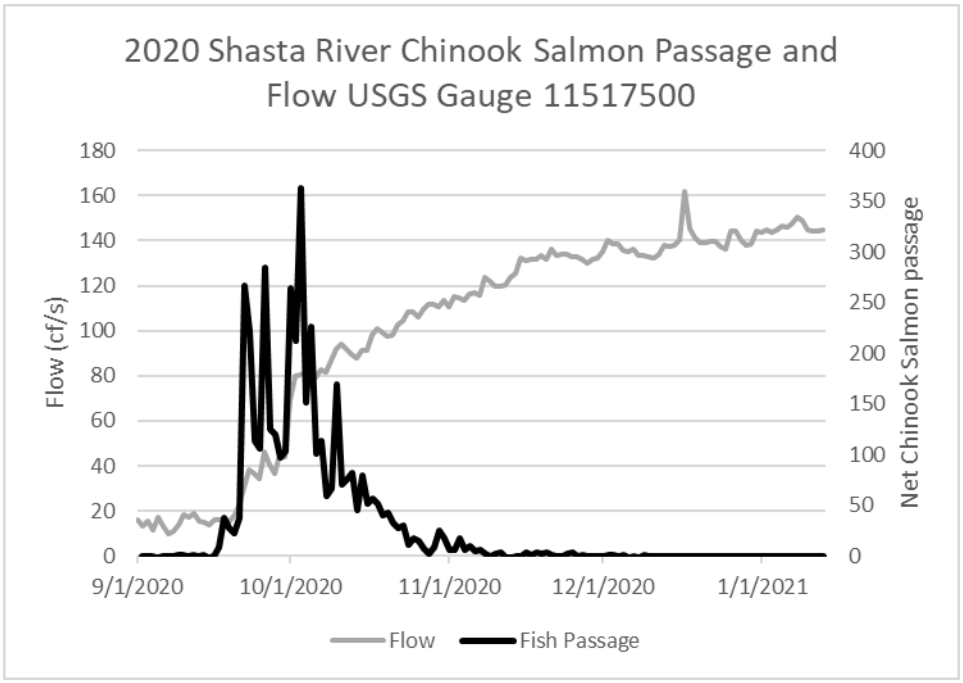

Figure 4: 2020 Shasta Chinook Salmon passage by date and flow (from Yreka gauge #11517500)

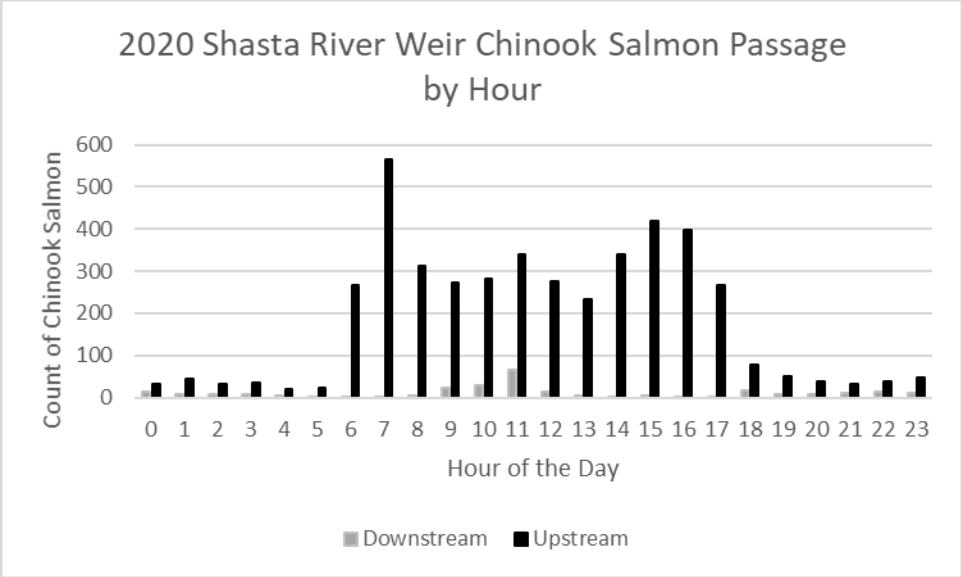

Figure 4: 2020 Shasta River Chinook Salmon observed by hour of day

CHINOOK SALMON WEIR WASH BACK CARCASSES

A total of 395 Chinook Salmon carcasses washed back on the SRFCF weir, of which 36 were sampled as part of a systematic sample (one in five, plus all ad clips) for biologic samples. All 36 carcasses had successful sex and FL determinations made. Of the 36 carcasses sampled, 33 (92%) were males and 3 (8%) were females (Table 2). As in previous years, the WB samples collected at the SRFCF show a heavy bias toward males (Table 2 and Figure 6).

Year	Total Chinook	Total Wash Back	# Sampled	% Males	% Females
2005	2,129	395	395	76	24
2006	2185	457	457	94	6
2007	2,036	228	228	71	29
2008	6362	767	767	96	4
2009	6,287	330	327	71	29
2010	1348	118	118	83	17
2011	11,388	1,623	1,623	99.6	0.4
2012	29544	1040	104	81	19
2013	8,021	643	64	81	19
2014	18357	1450	145	73	27
2015	6,745	82	7	71	29
2016	2889	90	15	80	20
2017	9,905	940	174	94	6
2018	20692	406	69	72	28
2019	6,003	410	85	73	27
2020	4,168	395	36	92	8
Average:				81.725	18.275

Table 2: Sex composition of wash backs from Shasta River Fish Counting Facility, 2005-2020.

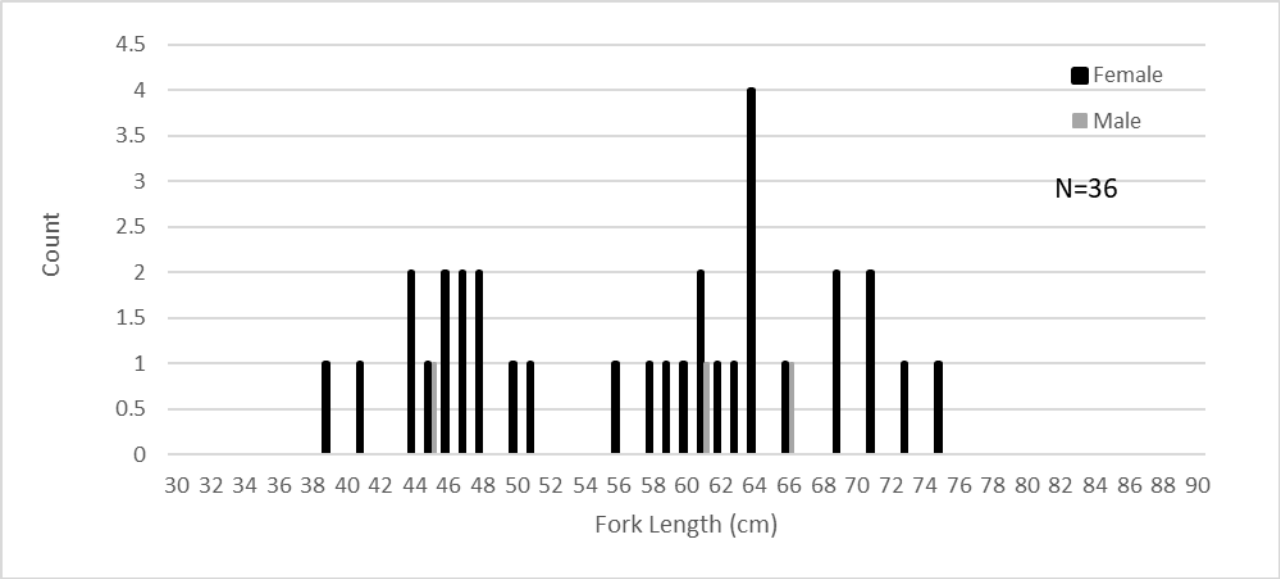

Figure 5: Length frequency of Shasta River Chinook Salmon wash backs during 2020.

ADULT TRAP

The trap was installed on September 15, 2020 and was removed on October 22, 2020 to avoid potential impacts to the Coho Salmon run. The trap was operated for short durations a few times a week, the trap was fished for a seasonal total of 73 hours. In that time 219 Chinook Salmon were caught and sampled. Of the 219 fish, 80 were male (37%) and 139 were female 63%). Male fork lengths ranged from 47 to 87 cm. with an average fork length of 62 cm. Female fork lengths ranged from 46 to 81 cm. with an average Fl of 63 cm., see figures 7 and 8.

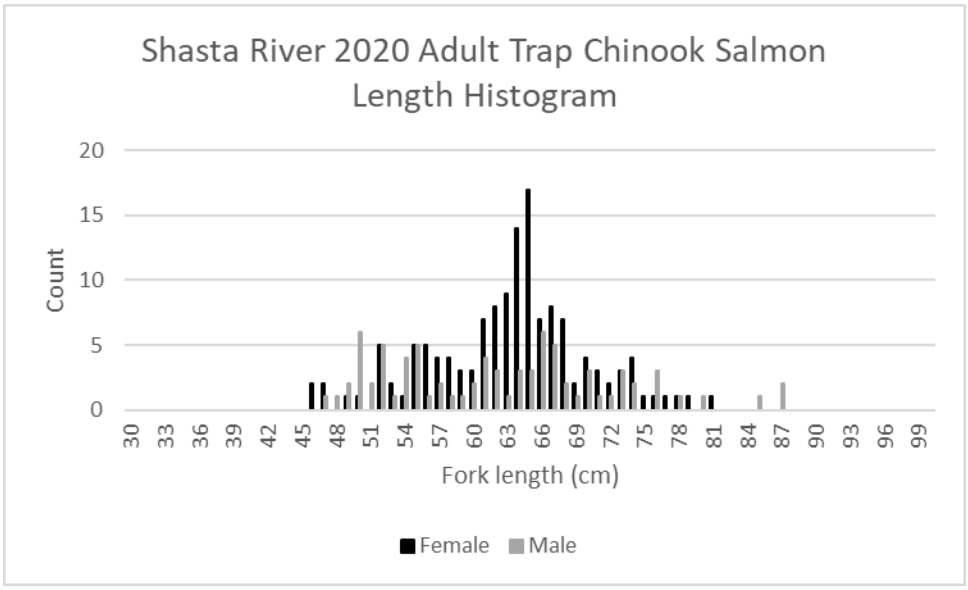

Figure 6: Shasta 2020 trap Chinook Salmon fork length histogram

CHINOOK SALMON SPAWNING GROUND SURVEYS

A total of 20 Chinook Salmon carcasses were observed and sampled during spawning ground surveys. 12 (60%) were female and 8 (40%) were male. Of the 12 female carcasses examined, all 12 (100%) were determined to have spawned successfully (zero or few eggs observed). Fork length frequencies indicate a low proportion of jacks (Figure 8 and Figure 9).

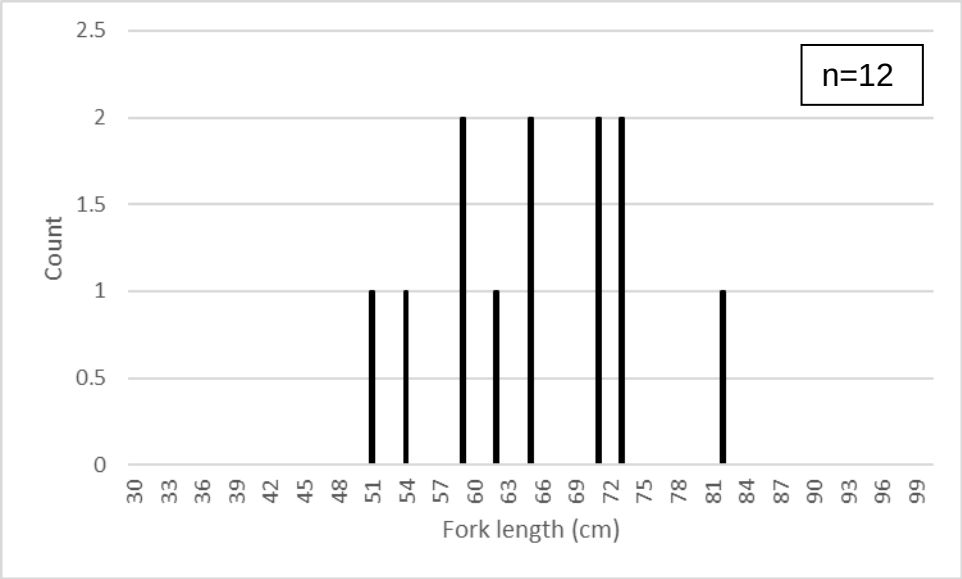

Figure 7: Length frequency of Shasta River Chinook Salmon females from 2020 spawning ground surveys

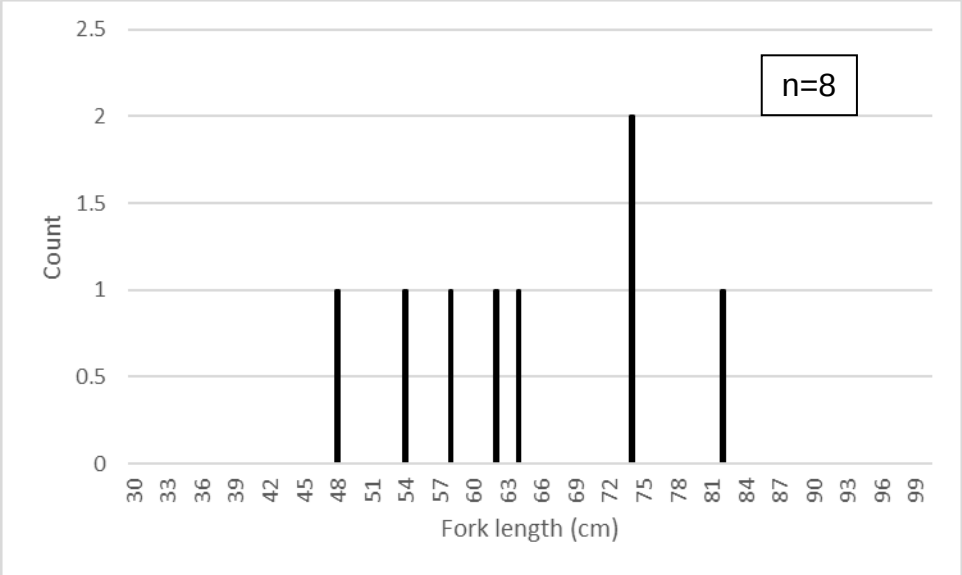

Figure 8: Length frequency of Shasta River Chinook Salmon males from 2020 spawning ground surveys

CHINOOK SALMON AGE COMPOSITION

A preliminary length cutoff separating grilse from adults was estimated to be 56 cm., all Chinook Salmon less than 56 cm. were considered to be grilse and yielded a preliminary estimate of 514 (12%) jacks and 3,654 (88%) adults. Final estimates of the age composition of the 2020 run in the Shasta River were finalized by the Klamath River Technical Advisory Team (KRTAT, 2021) using scale age analysis conducted by the Yurok Tribe and U.S. Fish and Wildlife Service (Table 3). The final estimate was 393 (9%) jacks and 3,775 (91%) adults.

Table 3: Age composition of the Chinook Salmon run to the Shasta River, 2002-2020

	Age 2	Age 3	Age 4	Age 5	Total Adults	Total Run
2002	386	4286	2088	58	6432	6818
2003	155	2798	1325	11	4134	4289
2004	129	184	484	166	834	963
2005	37	1361	579	79	2019	2056
2006	1395	151	625	13	789	2184
2007	27	1855	146	8	2009	2036
2008	3621	1222	1456	63	2741	6362
2009	151	5587	315	243	6145	6296
2010	87	240	1021	0	1261	1348
2011	11175	23	190	0	213	11388
2012	1944	27598	2	0	27600	29544
2013	1096	3896	3029	0	6925	8021
2014	3945	4064	10265	83	14412	18357
2015	133	5752	658	202	6612	6745
2016	135	536	2218	0	2754	2889
2017	6618	782	2022	483	3287	9905
2018	2016	17716	960	0	18676	20692
2019	78	5341	585	0	5926	6004
2020	393	2946	829	0	3775	4168
Average	1764.26	4544.11	1515.63	74.16	6133.89	7898.16

REDDS

A total of 27 redds were observed during spawning ground surveys in 2020. These observations were not intended to represent a comprehensive description of spawning distribution in the Shasta River or to produce an escapement estimate, as spawning ground surveys only cover approximately 15 percent of the watershed. The data is helpful because it illustrates the timing and distribution of salmon spawning in the Shasta River. Of the 27 redds observed, 6 (22%) were observed in the canyon reaches and 21 redds (78%) were observed in the valley reaches or tributaries. Redds observed in the canyon reaches were not flagged, and the season estimate was derived from the peak daily redd count from all areas surveyed. Redds encountered in the upper Shasta River were marked with a Global Positioning System (GPS) unit and flagged using bright flagging tape so each redd would only be counted and marked on the GPS once.

CHINOOK SALMON HATCHERY INFLUENCE

A net total of 8 ad Chinook Salmon were observed passing through the SRFCF during the season, and these fish were assumed to be of hatchery origin. Because of turbulence, the position of the fish in the flume or poor visibility due to water quality, the adipose fin is not always visible during video review, so the observed number is likely less than the number of ad Chinook Salmon that pass through the weir. In typical years hatchery contribution to the Shasta River is based on carcasses examined and the number of ad fish that passed through the flume. In 2020, no ad fish were recovered as washbacks, in the spawning ground surveys, or in the trap so hatchery influence was calculated using the 8 video ads and the tag info from Iron Gate Hatchery in 2020.

Hatchery composition was calculated by applying known CWT tag code proportions that were recovered from Chinook Salmon at IGH in 2020 to the 8 ad fish observed on video. For 2020, the expanded CWT estimate was 34 fish or 0.81% of the run. Since 2001 the estimated contribution of hatchery strays to the Shasta River has ranged from a low of 0.4% in 2012 to a high of 38.6% in 2004 (Table 5).

Table 4: Estimated Hatchery Contribution in the Shasta River during the 2020 season

2020 Shasta Estimated Contribution of the 8 Ad Clipped Chinook Observed in Video Footage Using Proportional Distribution of 2020 IGH CWT's						
CWT	**Brood Year**	**# of CWTs recovered from IGH**	**Proportion of CWT's Recovered from IGH**	**Shasta River Estimated Number**	**Production Multiplier**	**Shasta River Expanded Estimate**
60786	2015	1	0.001414427	0.011315417	4.020709775	0.045496009
60683	2016	50	0.070721358	0.565770863	4.00742145	2.267282291
60994	2016	20	0.028288543	0.226308345	4.001913095	0.90566633
68045	2016	12	0.016973126	0.135785007	4.002684006	0.543504476
68784	2016	5	0.007072136	0.056577086	3.99815965	0.226204223
61210	2017	4	0.005657709	0.045261669	4.059198253	0.183726088
61299	2017	10	0.014144272	0.113154173	4.035821429	0.456670034
61404	2017	16	0.022630835	0.181046676	4.080423665	0.738747142
61430	2017	3	0.004243281	0.033946252	3.945687531	0.133941302
61501	2017	35	0.04950495	0.396039604	4.016867455	1.590838596
61502	2017	29	0.041018388	0.3281471	4.030221469	1.322505489
61503	2017	29	0.041018388	0.3281471	4.03222933	1.323164363
61504	2017	23	0.032531825	0.260254597	4.066817002	1.058407819
61505	2017	28	0.03960396	0.316831683	4.072081327	1.290164381
61506	2017	410	0.579915134	4.639321075	4.102888042	19.03461496
61583	2018	14	0.01980198	0.158415842	4.096865718	0.649008431
62009	2018	6	0.008486563	0.067892504	4.038761155	0.274201606
62010	2018	4	0.005657709	0.045261669	4.049285149	0.183277404
62011	2018	8	0.011315417	0.090523338	16.05881413	1.453697461
Totals:		**707**	**1**	**8**	**Estimated # of hatchery fish**	**33.68111841**
Total Run:	**4168**				**% hatchery**	**0.81%**
Cells shaded in grey=IGH 2020 Data						

Table 5: Contribution of hatchery origin Chinook Salmon straying to the Shasta River, 2002-2020

Year	Total # Chinook	Hatchery Stray Estimate	Percent Hatchery
2002	6,818	79	1.16%
2003	4,289	436	10.17%
2004	963	372	38.63%
2005	2,055	469	22.82%
2006	2,184	105	4.81%
2007	2,036	69	3.39%
2008	6,362	56	0.88%
2009	6,296	131	2.08%
2010	1,348	157	11.65%
2011	11,388	74	0.65%
2012	29,544	126	0.43%
2013	8,021	146	1.82%
2014	18,357	735	4.00%
2015	6,745	89	1.32%
2016	2,889	91	3.15%
2017	9,905	117	1.18%
2018	20,692	1,883	9.10%
2019	6,004	32	0.53%
2020	4,168	34	0.81%
AVERAGE			6.76%

COHO SALMON

A total of 42 Coho Salmon were observed passing upstream and 5 Coho Salmon were observed passing downstream through the SRFCF from September 2, 2020 through January 11, 2021 (Figure 10). The net number of Coho Salmon known to have entered and remained in the Shasta River prior to removal of the weir was **37**. The migration peaked on November 17, 2020 immediately following an increase in flows from storm runoff. Six (86%) of the Coho Salmon washbacks were male and ranged in FL from 45-72 cm. One (14%) female Coho Salmon WB was recovered and was 52 cm. long. No Coho Salmon were recorded as pre spawn mortalities. Three (43%) of Coho Salmon washbacks had left maxillary clips indicating IGH origin, this was expanded to the video estimate of 37 and we estimate that 16 Coho Salmon in the Shasta River were of IGH origin.

Historically, the proportions of hatchery-origin (HOR) and natural-origin (NOR) Coho Salmon entering the Shasta River have been estimated by applying the observed clip rates from spawning ground survey and weir wash back samples that did not have passive integrated tags (PIT) to the unknown (video) portion of the run. In 2020 three (43%) of the seven Coho Salmon carcasses had left maxillary clips. This was expanded with he video estimate (37) and there were 16 estimated Coho Salmon of IGH origin. No PIT tagged fish were detected in the Shasta River, and it was not possible to determine with certainty whether Coho Salmon passing through the video weir had maxillary clips. One Coho Salmon was observed that was smaller than 53 cm which is used as a surrogate jack cutoff when no carcass data is available.

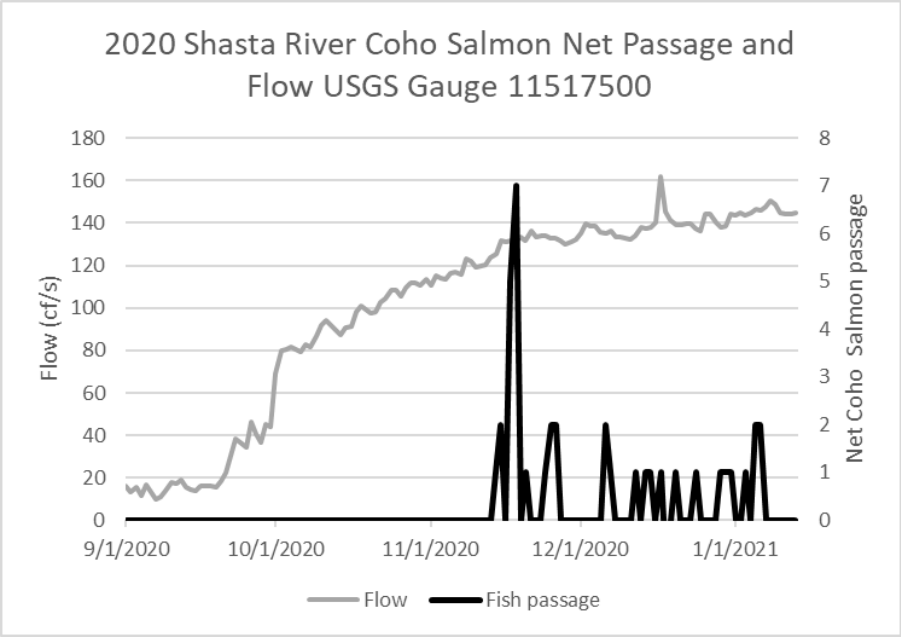

Figure 9: 2020 Shasta River Coho Salmon observed by date and flow (from USGS Yreka gauge #11517500)

STEELHEAD

In 2020, a net total of **240** adult steelhead trout were estimated to have entered and remained in the Shasta River during the video recording season from September 2, 2020 to January 1, 2021 (Figure 11). Two of these steelhead trout were estimated during times of video outage (Appendix A). No observations were made of steelhead trout with ad clips, which would indicate hatchery origin. Because the Alaskan weir is not impermeable to juvenile fish, including “half pounders”, sub-adult or juvenile steelhead trout were counted but excluded from this analysis, so all *Oncorhynchus mykiss* included in this analysis were greater than 40.64 cm (16 inches).

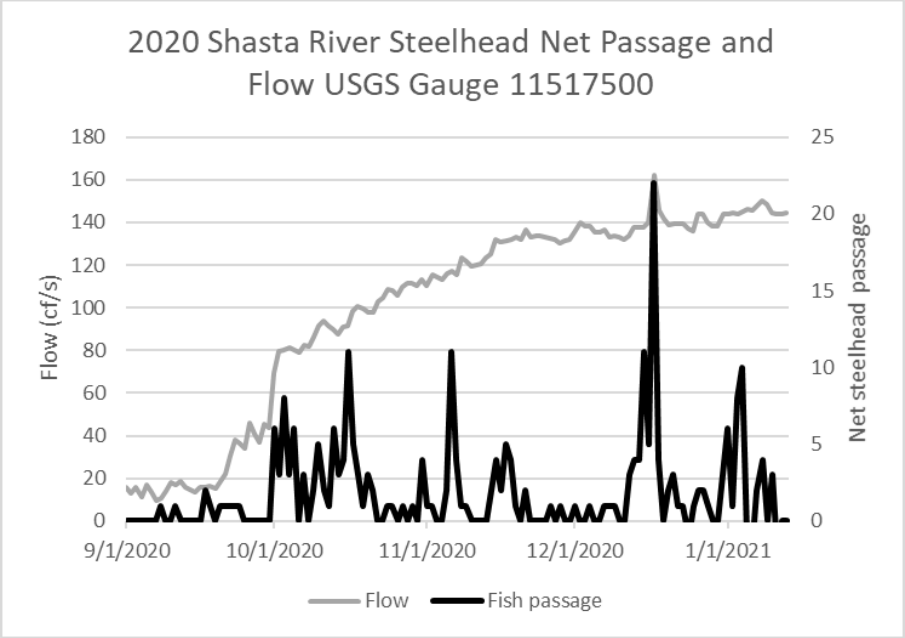

Figure 10: 2020 Shasta River Steelhead observed by date and flow (from USGS Yreka gauge #11517500)

CHINOOK SALMON

The 2020 run of Chinook Salmon of 4,168 was 2,464 fish below the 43-year average of 6,632 (Figure 12). At the current monitoring site, run sizes have ranged from a low of 533 fish in 1990 to a high of 29,544 fish in 2012. Data from 2020 represents the second consecutive year that the Shasta River Chinook Salmon populations have fallen below the average.

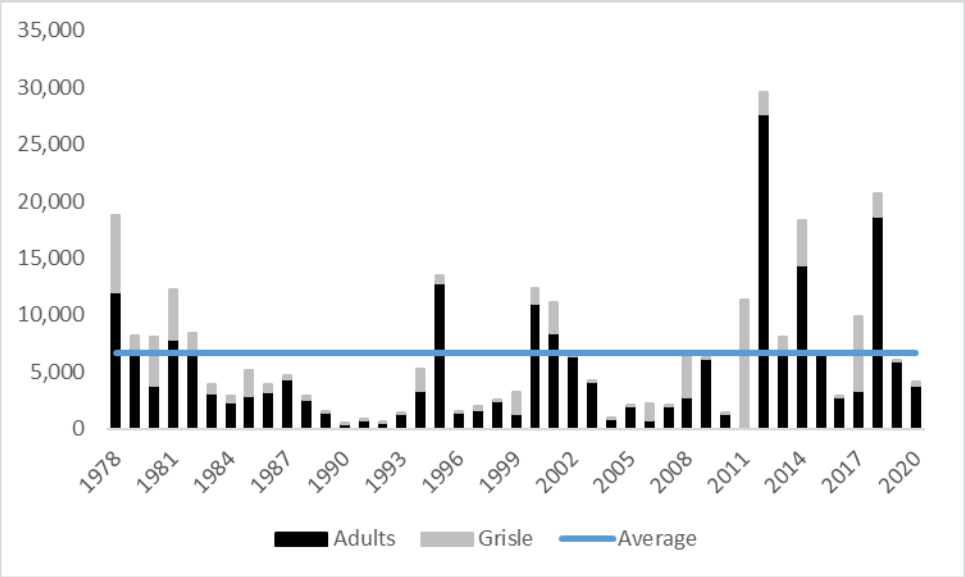

Figure 11: Shasta River annual adult and grilse Chinook Salmon population

The Shasta River is an important component of the Klamath Basin Chinook Salmon run (including Trinity River) and has contributed an average of 12 percent of the basin-wide natural spawning escapement during the period from 1978 to 2020 (Table 6).

Table 6: Escapement of Chinook Salmon to the Klamath Basin and Shasta River, 1978-2020.

Year	Chinook Natural Spawner Escapement		% Shasta
	Klamath Basin	Shasta River	
1978	74,906	18,731	25%
1979	37,398	8,151	22%
1980	48,465	8,096	17%
1981	50,364	12,220	24%
1982	50,597	8,455	17%
1983	33,310	3,872	12%
1984	21,349	2,842	13%
1985	61,628	5,124	8%
1986	142,302	3,957	3%
1987	110,489	4,697	4%
1988	91,930	2,842	3%
1989	49,377	1,577	3%
1990	16,946	533	3%
1991	12,367	726	6%
1992	17,171	586	3%
1993	25,683	1,426	6%
1994	38,578	5,203	13%
1995	179,118	13,511	8%
1996	87,500	1,450	2%
1997	50,369	2,001	4%
1998	45,343	2,542	6%
1999	28,904	3,197	11%
2000	89,122	12,296	14%
2001	85,581	11,093	13%
2002	69,502	6,818	10%
2003	89,744	4,289	5%
2004	28,516	962	3%
2005	27,931	2,055	7%
2006	45,002	2,184	5%
2007	61,741	2,036	3%
2008	48,073	6,362	13%
2009	52,499	6,296	12%
2010	49,031	1,348	3%
2011	108,612	11,388	10%
2012	133,361	29,544	22%
2013	69,986	8,021	11%
2014	112,343	18,357	16%
2015	31,596	6,745	21%
2016	15,818	2,889	18%
2017	35,036	9,905	28%
2018	61,561	20,692	34%
2019	26,412	6,004	23%
2020	31,138	4,168	13%
Average	**59,226**	**6,632**	**12%**

A comparison of Shasta River escapement to Klamath Basin escapement is shown in Figure 13. Historically, the Shasta River was documented as a highly productive salmon stream, with a run of over 75,000 Chinook Salmon counted at the Shasta Racks (predecessor to the SRFCF) in 1935. In most cases the Shasta River follows the trend of the basin indicating similar survival rates, however in the 1980's the Shasta River does not reflect that trend.

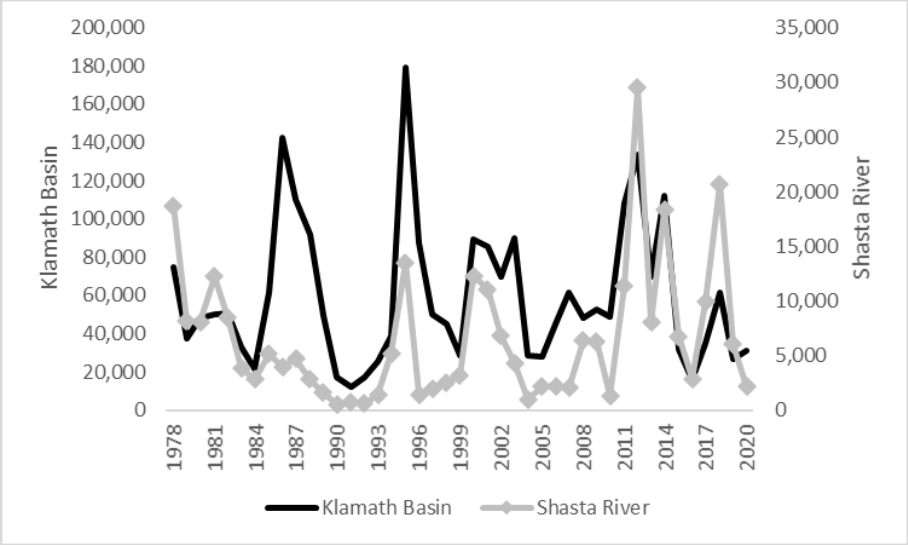

Figure 12: Chinook Salmon spawner escapement to the Klamath Basin and Shasta River from 1978-2020.

Because the Shasta River fall Chinook Salmon run typically enters the river in early September, earlier then runs to other upper Klamath tributaries, fishery managers have, in recent years been concerned with flow and temperature conditions in the river during the early weeks of the fall migration. Observations of fish migration through the SRFCF and real time temperature monitoring have been the basis for coordination between resource agencies and local landowners to ensure adequate flows during the critical month of September. The Nature Conservancy, the Department, the Shasta Resource Conservation District (RCD), the Shasta Valley Watermaster and local landowners coordinate closely during this period to manage the timing and magnitude of irrigation diversions prior to the end of the irrigation season on October 1st.

During the 2020-2021 spawning season the Shasta River experienced low and stable flows. Juvenile (brood year 2020) salmonids leaving the Klamath River tributaries, including the Shasta River in 2020/2021 may encounter low flows and high water temperatures in the main stem Klamath River and exposure to *Ceratonova shasta* and other pathogens is likely, although the extent of exposure is unknown at this time. These pathogens are known sources of mortality in juvenile Chinook Salmon, Coho Salmon and steelhead trout (True et al, 2016). This exposure, along with ocean conditions, play a key role in survival and subsequent adult returns.

Juvenile Chinook Salmon emigration estimates obtained during the following spring/summer of escapement (Morrow 2020) for brood years 2000 through 2019 indicate the Shasta River's current habitat conditions continue to produce more 0+ Chinook Salmon as more adults return, indicating that the watershed continues to have an increasing ability to produce juvenile Chinook Salmon (Figure 13) although the rate at which juvenile Chinook Salmon that were produced from brood year 2012 was reduced when compared to previous seasons (Debrick et al., 2015). In addition, factors such as high flow events which result in streambed mobilization and sediment transport can cause significant damage to redds and emerging fry, and the age and sex composition of the Chinook Salmon run may also affect 0+ Chinook Salmon production.

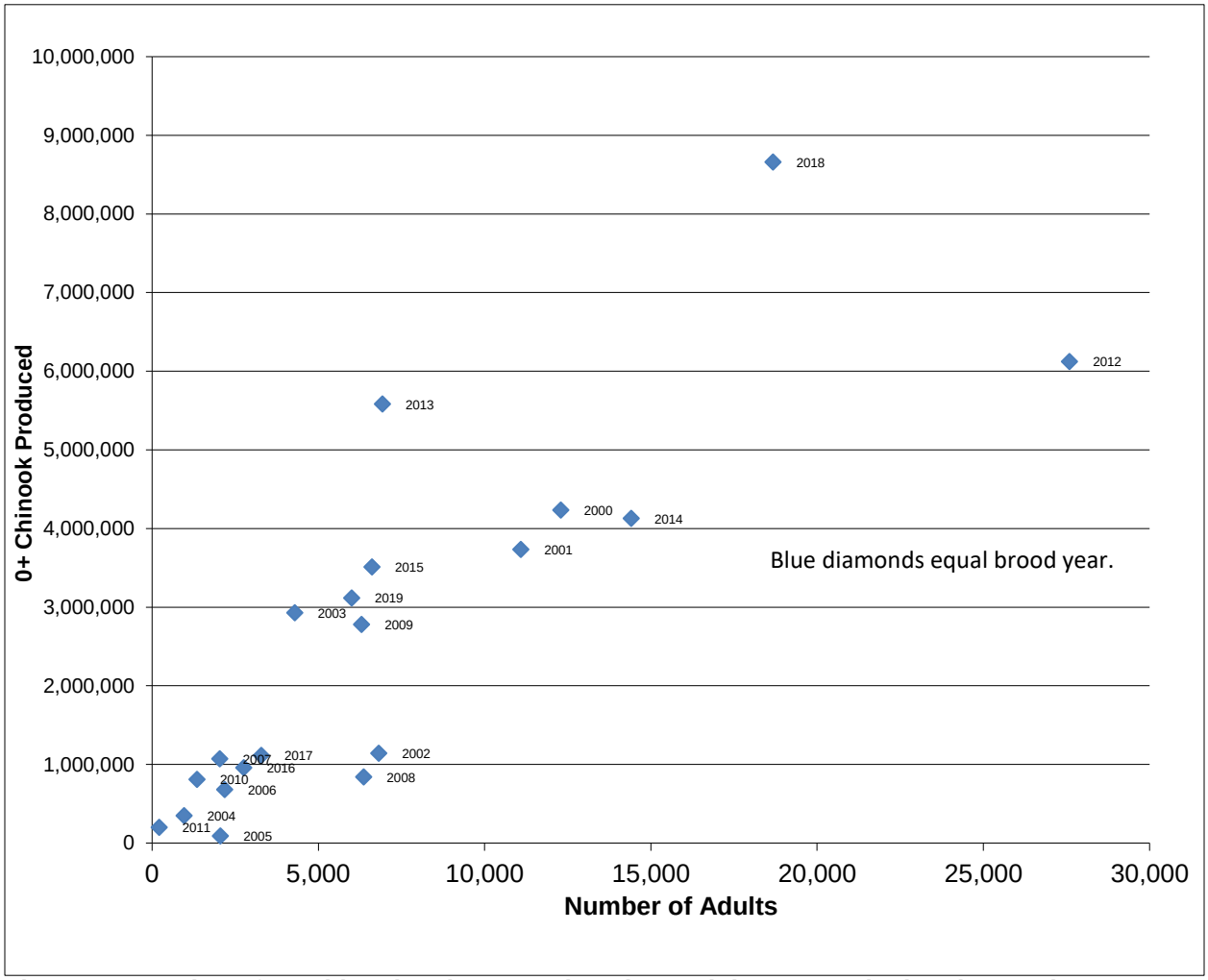

Figure 13: Number of 0+ Chinook Salmon produced per adult spawner in the Shasta River 2000-2020.

Coho Salmon

Coho Salmon returns to the Shasta River from 1978 to 2020 are shown in Figure 15. Sampling from 1983 to 2001 cannot be directly compared to other years, as the weir was removed before November 12th during those years and sampling does not represent the entire run of Coho Salmon. Estimates of hatchery origin adult Coho Salmon entering the Shasta River from 2007-2020 are shown in Figures 16-18.

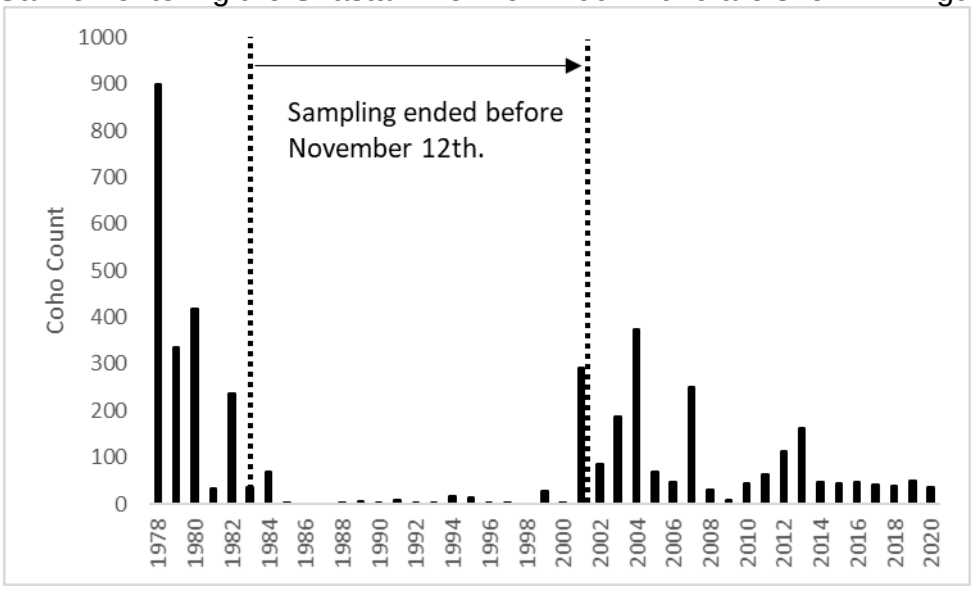

Figure 14: Shasta River Coho Salmon counts by year. In the years 1982-2001 sampling ended before November 12th and likely missed the bulk of the Coho Salmon population.

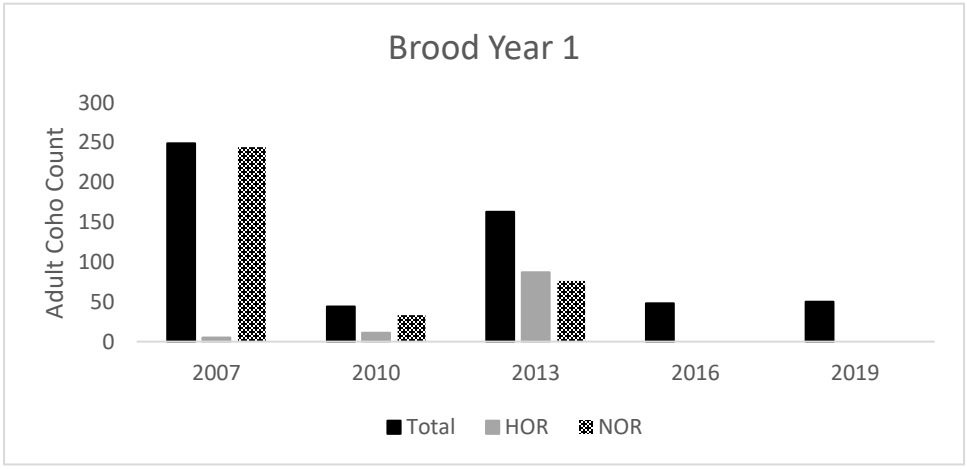

Figure 15: Brood cycle 1 comparison of natural origin (NOR) and hatchery origin (HOR) adult Coho Salmon returning to the Shasta River. Hatchery contribution not calculated for 2016 or 2019 due to no carcass recoveries.

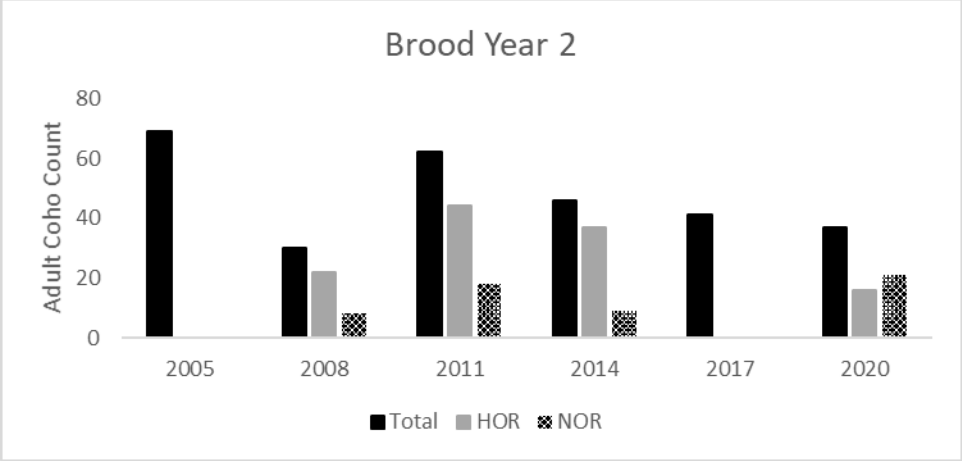

Figure 16: Brood cycle 2 comparison of natural origin (NOR) and hatchery origin (HOR) adult Coho Salmon returning to the Shasta River. Hatchery contribution not calculated for 2005 and 2017 because no carcasses were recovered.

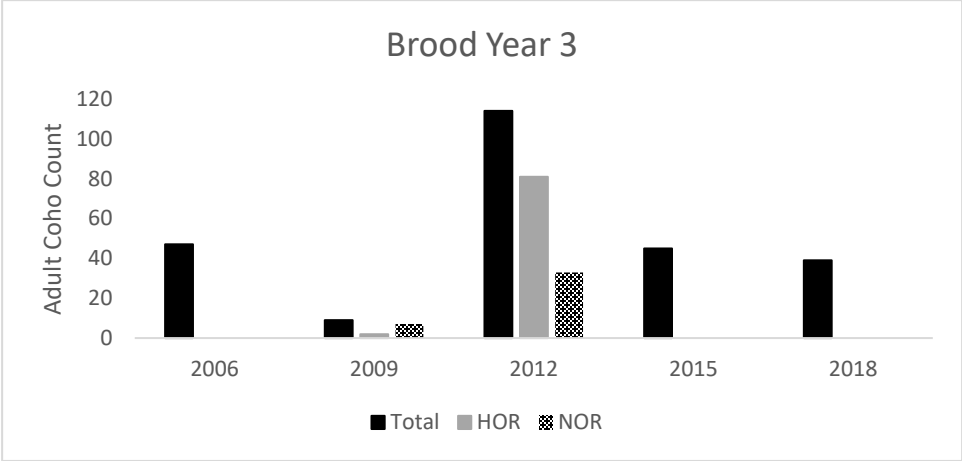

Figure 17: Brood cycle 3 comparison of natural origin (NOR) and hatchery origin (HOR) adult Coho Salmon returning to the Shasta River. Hatchery contribution not calculated for 2006 because there is no data available on hatchery composition and for 2015 and 2018 due to no carcass recoveries.

The decline of Coho Salmon populations in the Klamath Basin, and the Shasta River in particular, has led to much discussion on the cost and benefits of different recovery strategies. The Hatchery Genetic Management Plan (HGMP) recently adopted for Iron Gate Hatchery identifies the IGH Coho Salmon program as an integrated recovery program. This type of program is designed to aid in the recovery and conservation of a natural population, and the fish produced are intended to spawn in the wild or be genetically integrated with the targeted natural population (HGMP, 2013). The consensus among salmon geneticists involved in Shasta River Coho Salmon management is that risk of extinction (due to inbreeding and difficulty finding mates) outweighs any negative effects of IGH fish straying and spawning in the Shasta River. Research by Galbreath et al (2014) indicates that domestication effects carried by hatchery-origin Coho Salmon that spawn in natural areas are moderated within as few as two generations by selection pressures encountered in the natural environment.

Improved, genetically-based brood stock management practices at IGH are intended to increase the genetic diversity and fitness of IGH Coho Salmon and their progeny, so that when IGH fish stray into natural areas it will benefit the Shasta River Coho Salmon population and its recovery.

In 2020 three (43%) of the seven carcasses had left maxillary clips indicating these fish are of IGH origin. This was expanded using the video estimate (37) and an estimated 16 Coho Salmon were of IGH origin (Table 7). Use of the adult trap to collect samples in future years may aid in the calculation of hatchery influence in the Shasta River. Increased straying of adult IGH Coho Salmon due to releases from IGH, as well as hatchery juveniles entering the Shasta River during their downstream migration (Bill Chesney, pers comm) and possibly imprinting on Shasta River water, have been observed in recent years.

Table 7: Estimates of hatchery strays as percentage of Coho Salmon entering the Shasta River, 2007-2020

Year	Total # of Coho	Hatchery Stray Estimate	% Hatchery
2007	249	5	2%
2008	30	22	73%
2009	9	2	22%
2010*	44	11	25%
2011*	62	44	71%
2012*	114	81	71%
2013*	163	62	38%
2014*	46	37	80%
2015*	45	NA	NA
2016*	48	NA	NA
2017*	41	NA	NA
2018*	39	NA	NA
2019*	50	NA	NA
2020*	37	16	43%
Average			47%
* in 2010-2020, surplus adult Coho were PIT tagged and released after entering Iron Gate Hatchery.			
Hatchery composition was not estimated for 2015-2020 as no Coho carcasses were recovered.			

Ongoing rotary trap operations at the mouth of the Shasta River (Morrow 2020) have resulted in reports documenting annual smolt point estimates, which, along with annual adult escapement estimates, can provide a means of estimating the survival of Shasta River Coho Salmon from outmigration to adult escapement (Table 8). These relationships are complicated by the difficulty of adequately estimating the contribution of hatchery-origin spawners, estimating age structure, as well as the challenges of producing population estimates at extreme low abundance. Since 2001 (excluding brood years 2009 and 2015) Coho Salmon smolt to adult survival has ranged from 0.34% to 14.93% and has averaged 3.42% (table 8).

Analyzing the comparisons of estimated adult Coho Salmon returns to yearling Coho Salmon production estimates (Morrow 2020) also produces freshwater survival estimates in the form of yearling Coho Salmon produced per adult return. The number of yearling Coho Salmon produced per returning adult has averaged 18.2 and ranged from a low of 2.1 to a high of 46.6 for brood years 2001-2018 (Table 9). As the number of yearlings produced per returning adult increases it can be inferred that in-river conditions for Coho Salmon are improving. Conversely, as the number of yearlings produced per returning adult decreases it can be inferred that in river conditions for Coho Salmon are getting worse. Production is subject to variability in sex ratios of returning adults, as well as depensation effects that can occur at low population sizes. Refinements to these estimates will continue to be made in future years.

Table 8: Shasta River natural origin Coho Salmon smolt and adult abundance, production, and survival.

Brood Year	Smolt Year	NOR Smolt Point Estimate	Age 2 Return Year	Age 3 Return Year	Age 2 return	Age 3 return	Age 2&3 return	Percent smolt survival
2001	2003	12735	2003	2004		373	373	2.93%
2002	2004	2090	2004	2005		69	69	3.30%
2003	2005	2554	2005	2006		47	47	1.84%
2004	2006	11077	2006	2007		244	244	2.20%
2005	2007	1374	2007	2008		8	8	0.58%
2006	2008	208	2008	2009		7	7	3.37%
2007	2009	6295	2009	2010		33	33	0.52%
2008	2010	215	2010	2011		17	17	7.91%
2009**	2011	9	2011	2012	1	22	23	255.56%
2010	2012	2049	2012	2013	11	61	72	3.51%
2011	2013	586	2013	2014	1	1	2	0.34%
2012	2014	991	2014	2015	8	37	45	4.54%
2013	2015	7326	2015	2016	2	46	48	0.66%
2014	2016	268	2016	2017	2	38	40	14.93%
2015**	2017	33	2017	2018	3	36	39	118.18%
2016	2018	4236	2018	2019	3	50	53	1.25%
2017	2019	69	2019	2020	0	36	36	52.17%
2018	2020	291	2020	2021	1			
* Grilse information not available for 2001-2010								
** BY 2009 & 2015: Inherent error in this years data may be due to underestimating juvenile fish or overestimation or age structure classification of adult coho.								

Table 9: Adult Coho Salmon estimates, yearling Coho Salmon production point estimates and ratio of yearling Coho Salmon produced per adult from 2001-2020

Adult Brood Year	Adult Estimate	Yearling Year	NOR Yearling Point Estimate	Yearlings Produced Per Adult
2001	291	2003	11052	38.0
2002	86	2004	1799	20.9
2003	187	2005	2054	11.0
2004	373	2006	10833	29.0
2005	69	2007	1178	17.1
2006	47	2008	208	4.4
2007	249	2009	5396	21.7
2008	30	2010	169	5.6
2009	9	2011	19	2.1
2010	44	2012	2049	46.6
2011	62	2013	494	8.0
2012	114	2014	850	7.5
2013	163	2015	6279	38.5
2014	46	2016	229	5.0
2015	45	2017	28	0.6
2016	48	2018	3697	77.0
2017	41	2019	69	1.7
2018	39	2020	291	7.5
2019	50	2021	NA	NA
2020	37	2022		
Average				19.7

STEELHEAD TROUT

The objectives of the KRP have traditionally focused on monitoring the escapement of Chinook Salmon, and more recently Coho Salmon. In recent years efforts have been made to extend the monitoring time frame to generate an estimate of adult steelhead trout returning to the Shasta River. In 2020 the video monitoring station was run until January 11, 2021. Steelhead escapement has proven challenging due to run timing (steelhead trout migration is usually underway when flow conditions make weir removal necessary) and life history (as individual steelhead trout are often observed to move repeatedly through the video flume in upstream and downstream directions). A net total of 240 steelhead trout swam upstream past the Shasta video site. Returns of adult steelhead trout to the Shasta River from 2005 to 2020 are shown in Figure 19.

Declines of steelhead trout populations throughout California have been documented in recent decades and have been mainly attributed to habitat degradation. In the Shasta River, construction of the Dwinnell Dam in 1928 at River Mile 40 has blocked access to over 18 miles of high-quality steelhead trout habitat since that time. The dam, along with other downstream diversions, has changed the Shasta River hydrograph and has contributed to an increase in summer water temperatures, limiting the availability of high-quality habitat for steelhead trout(Moyle et al, 2008). As with Coho Salmon, another species with an extended freshwater period in its life history, steelhead trout have been impacted by the recent, severe California multi-year drought. Ongoing land and water management projects in the upper Shasta River, targeted for the recovery of Coho Salmon, will undoubtedly benefit steelhead trout as well.

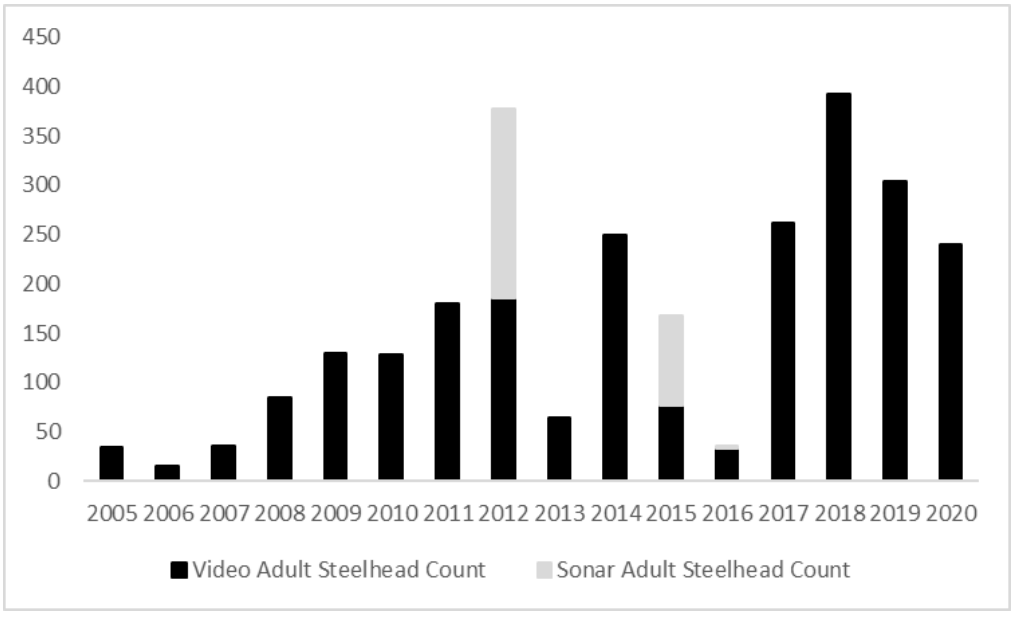

Figure 18: Adult steelhead Returning to the Shasta River, 2005-2020

Appendix A Estimates during video outages:

Date	Time off	Time back on	Outage length	Estimated # of Chinook (jacks & adults)	Estimated # of coho (jacks & adults)	Estimated # of steelhead
10/17/2020	17:24	22:28	5h 4m	6	0	2
10/29/2020	0:32	10:30	9h 58m	4	0	0
11/10/2020	0:00	12:02	12h 2m	0	0	0
Total:			**27 h 4 m**	**10**	**0**	**2**

ACKNOWLEDGMENTS

KRP staff would like to thank Shasta River landowners for their cooperation in granting access to their properties. We would also like to thank KRP crew members as well as AmeriCorps Watershed Stewards members for their exemplary teamwork and diligence in collecting data under challenging conditions. The KRP would also like to extend their gratitude to the Yreka Fisheries Program for sharing the rotary trapping data.

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