Shasta River
Chinook and Coho Salmon Observations in 2014
Siskiyou County, CA

Photo by Bill Chesney, February 7, 2015.

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Shasta River Fish Counting Facility, Chinook and Coho Salmon Observations in 2014 Siskiyou County, CA

ABSTRACT

A total of **18,359** fall run Chinook salmon (Chinook, *Oncorhynchus tshawytscha*) were estimated to have entered the Shasta River during the 2014 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 August 29, 2014 until December 10, 2014. The first Chinook was observed on September 6, 2014 and the last Chinook on December 9, 2014. KRP staff also processed a total of 261 Chinook carcasses during spawning ground surveys, 145 Chinook carcasses as wash backs against the SRFCF weir (a systematic 1:10 sample), and 14 Chinook from a trap immediately upstream of the video flume during the season.

Chinook carcasses sampled in the spawning ground surveys were used to describe characteristics of the run. Carcasses ranged in fork length (FL) from 39 cm. to 102 cm. and grilse were determined to be < 64 cm. in FL. Males ranged in FL from 39 to 102 cm. and averaged 74 cm. Females ranged in FL from 50 cm. to 92 cm. and averaged 75 cm. The run was comprised of 3,945 grilse (21.5%), and 14,414 adults (78.5%). Sex composition of the fish processed in spawning ground surveys, wash backs and trap was 45% (187) females and 55% (230) males. A total of 13 adipose-clipped (AD) Chinook were recovered in the weir wash back sample. Twelve of the 13 had positive CWT identification. All 12 fish had been tagged at Iron Gate Hatchery. Expansion of the 12 known tag codes for production and sampling resulted in an estimated hatchery contribution of 735 Chinook, or 4.0% of the total run observed in 2014.

A net total of 46 coho salmon (coho, *Oncorhynchus kisutch*) were estimated to have entered the Shasta River prior to removal of the weir on December 10, 2014. The first coho of the season was observed passing through the SRFCF on October 10, 2014, and the last coho was observed swimming upstream through the SRFCF on December 9, 2014. Antenna arrays located at the SRFCF and several points upstream detected 31 coho salmon entering the Shasta River which had been PIT tagged (PIT) and released from Iron Gate Hatchery during the 2014 season. At least one antenna array was functional between September 1, 2014 and December 31, 2014, and no detections occurred following the removal of the weir on December 10, 2014. Based on a grilse cut off of <52 cm. fork FL, and using known FLs of PIT, spawning ground survey and wash back samples, 42 two-year old coho (91%) and 4 three -year old coho (9%) entered the Shasta River in 2014. Based on PIT detections and caudal punch and left maxillary clip observations, an estimated 83% of the coho salmon entering the Shasta River were of Iron Gate Hatchery origin.

A net total of 250 adult and 129 sub-adult steelhead trout **(***Oncorhynchus mykiss)* were observed passing through the SRFCF during the 2014 season, although the video weir operation period does not cover the entire migration period for steelhead trout.

INTRODUCTION

The Klamath River Project (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 and coho salmon that return to the Klamath River Basin, excluding the Trinity River Basin, each year. To achieve this task 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. The Shasta River Fish Facility (SRFCF) is located approximately 213 meters (700 feet) from the confluence of the Shasta and Klamath Rivers (Klamath RKM 283, Figure 1).

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 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 ESU 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 run as well as the Chinook run into the Shasta River. This report describes the characteristics of the Chinook, coho and steelhead salmon runs that entered the Shasta River during the fall of 2014.

METHODS

Monitoring of the salmon run within the Shasta River during the 2014 season was accomplished through three primary efforts: operation of a video weir, collection of data from salmon carcasses that become impinged on the weir panels as they float downstream (wash backs), and completion of spawning ground surveys upstream of the weir to obtain biological data from salmon carcasses.

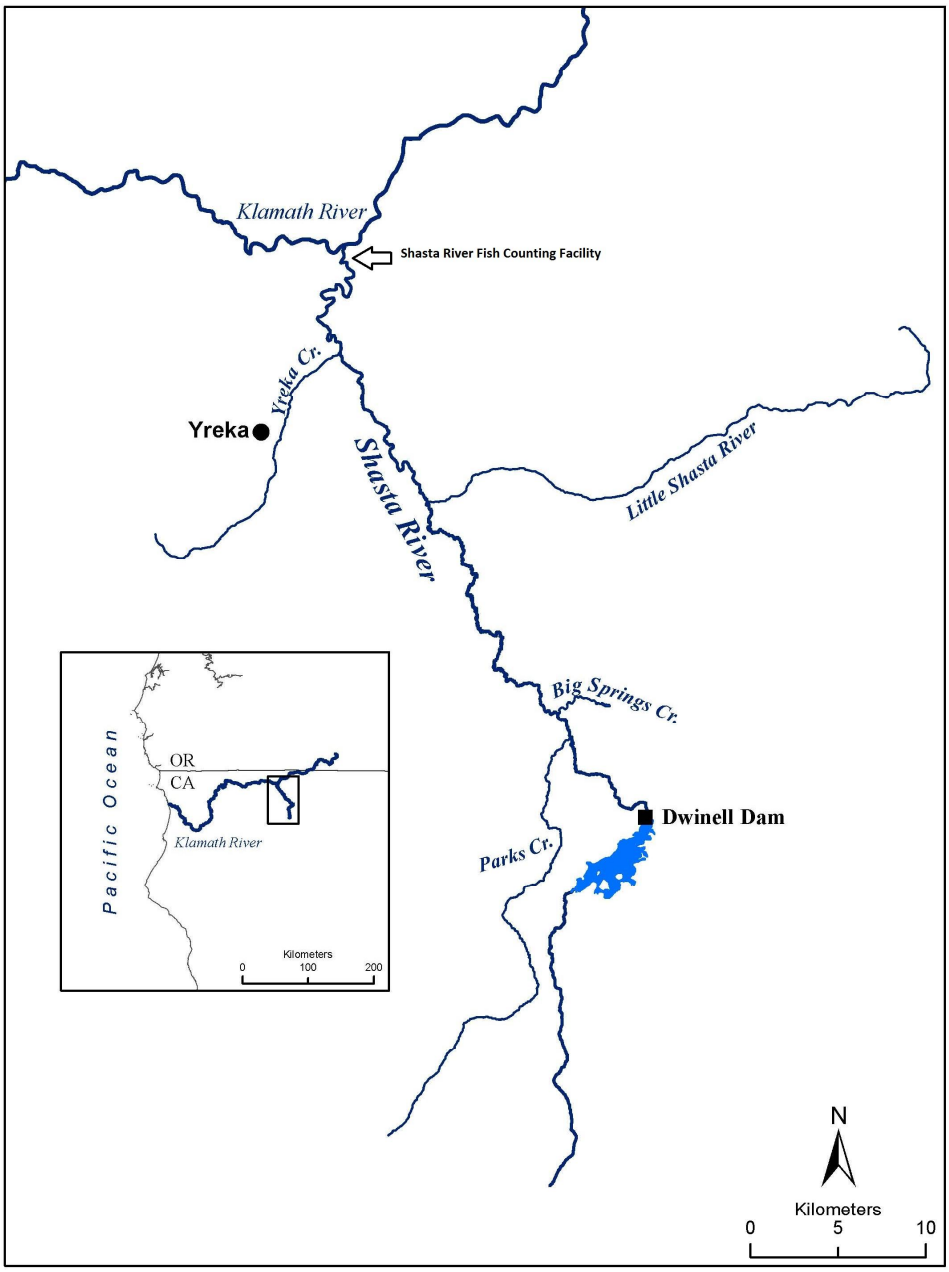

Figure 1. The Shasta River Watershed and location of Shasta River Fish Counting Facility (SRFCF).

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 2). 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 2014 for capturing images, and an ECOR 264 digital video recorder (DVR) with a Western Digital swappable hard drive were used for recording[1].

Figure 2. Alaska-style panels of the Shasta River Fish Counting Facility (SRFCF)

The weir and video camera were installed and recording began on August 29, 2014. 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 an external hard 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 adipose-clipped (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. All data were then entered into files on a

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

personal 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 August 29, 2014 at 10:44 hours, Pacific Standard Time (P.S.T.). The first Chinook of the season was observed on September 6, 2014 and the last Chinook was observed on December 9, 2014. The weir and recording equipment were removed on December 10, 2014 due to high flows. There were no disruptions to recording during the 2014 season.

WASHBACK CARCASSES

All salmon carcasses that drifted downstream and became impinged on the weir panels were recovered, and a systematic sample of one in ten Chinook carcasses were processed. Data collected on these systematically sampled wash back carcasses included fork length (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 carcasses, all carcasses were examined for AD clips, and all AD carcasses and all coho and steelhead carcasses were processed. Heads were collected from each AD fish for later coded wire tag (CWT) recovery and analysis. All carcasses were cut in half to prevent sample duplication and returned to the river downstream of the weir. Coho carcasses with an operculum punch were scanned with a hand-held PIT tag detector, and PIT tag numbers recorded.

SPAWNING GROUND SURVEYS

Spawning ground surveys were conducted between October 8, 2014 and January 7, 2015. Survey reaches included the lower seven miles of the Shasta River, and in the Big Springs area including the main stem Shasta River, Big Springs Creek and Parks Creek on publicly owned lands and on private lands where permission to access was obtained. 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 . 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.

During each survey, crews walked along the river bank 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

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. All samples were collected following standard protocols.

Table 1. Description of Shasta River Spawning Ground Survey Reaches, 2014-15.

Reach Number	Downstream end	Upstream end
1	Confluence with Klamath River	Pioneer Bridge
2	Pioneer Bridge	Salmon Heaven
4	Highway 263	Shelley Bridge
19	Nelson Ranch	Confluence with Big Springs Creek
20	Confluence with Big Springs Creek	Confluence with Parks Creek
21	Mouth of Big Springs Creek	Upper bridge, Big Springs Creek
22	Mouth of Parks Creek	Hidden Valley Ranch
23	Mouth of Parks Creek	2nd Fence
24	Parks Creek, Dukes	Slough Rd. crossing

RESULTS

Chinook Salmon

A net total of 18,359 Chinook were counted passing through the SRFCF during the 2014 season. This number was derived by subtracting the number of downstream observations (988) from the number of upstream observations (19,347). The run peaked during a high flow event on September 25, 2014, during which 8% of the run was observed (Figure 3). Consistent with previous years' monitoring efforts, the majority of Chinook (98%) passed upstream through the SRFCF during daylight hours between 06:00 and 17:00 hours (Figure 4).

A total of 1,544 Chinook (8.4% of the run) were recorded as having at least one live lamprey attached to their bodies. Since the camera captures only the left side of each fish as it migrates upstream, attached lamprey, clips, scars or other abnormalities that may be present on the right side cannot be observed, so the incidence of lamprey attachment is probably higher.

A net total of 57 AD Chinook 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 adipose-clipped Chinook that pass through the weir. For this reason, the hatchery contribution to the Shasta River is based on carcasses examined during spawning ground surveys and the weir wash back sample and not on video observations. The heads from 13 AD Chinook were recovered from carcasses, all from the wash back sample.

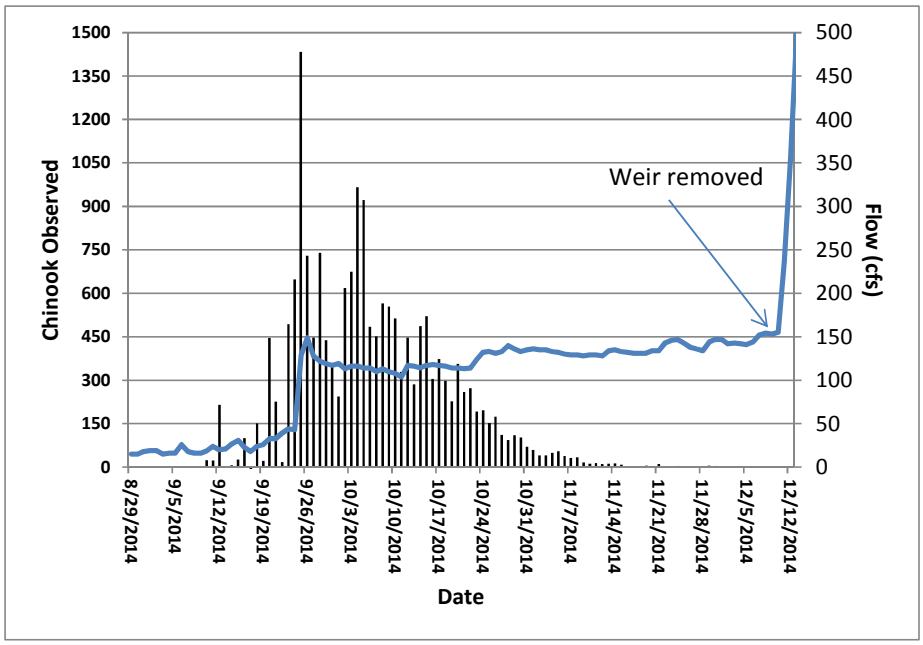

Figure 3. Chinook salmon observed migrating through the Shasta River Fish Counting Facility, 2014 by date, and flows at nearby USGS gauge 11517500.

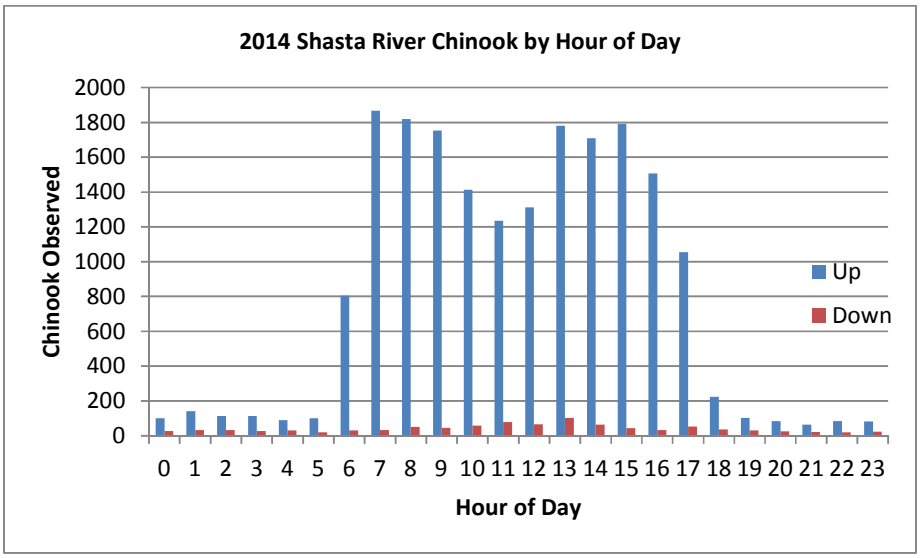

Figure 4. 2014 Shasta River Chinook observed by hour of day.

Twelve of the thirteen AD wash back samples had positive reads for coded wire tags (CWT), and all 12 were of IGH origin. Two were age-5 fish, one released as a smolt and one as a yearling, 4 were age-4 fish, 3 released as fingerlings and one as a

yearling, and 6 were age-3 fish of which one was released as a yearling and 5 as fingerlings. One head contained no tag. Expansion of these 12 known CWTs by their production multipliers (the inverse of the proportion of each group of juveniles that were tagged) yielded an estimate of 65 hatchery origin Chinook. An estimate of total hatchery contribution was derived based on multiplying the recovered tags by an expansion factor of 11.38 (video count/ number of carcasses examined in spawning ground surveys and weir wash backs). Using this method a total of 735 hatchery origin Chinook, or 4.0% of the total run, were estimated to have entered the Shasta River during the 2014 run.

Table 2. Estimated contribution of 12 known coded wire tag (CWT) codes recovered in the Shasta River during the 2014 season.

CWT	Origin	Brood Year	Release Type a/	Number of CWTs recovered	Production Multiplier b/	Production Estimate	Sample Expansion c/	Total Estimate
68713	IGH	2009	F	1	4.17	**4**	**11.38**	**47.45**
68715	IGH	2009	Y	1	4.01	**4**	**11.38**	**45.63**
68794	IGH	2010	F	1	4.02	**4**	**11.38**	**45.75**
68795	IGH	2010	F	2	12.17	**24**	**11.38**	**276.99**
68799	IGH	2010	Y	1	4.03	**4**	**11.38**	**45.86**
60379	IGH	2011	Y	1	4.00	**4**	**11.38**	**45.52**
60418	IGH	2011	F	1	4.01	**4**	**11.38**	**45.63**
60419	IGH	2011	F	1	4.01	**4**	**11.38**	**45.63**
60420	IGH	2011	F	1	4.01	**4**	**11.38**	**45.63**
60422	IGH	2011	Y	2	4.00	**8**	**11.38**	**91.04**
Totals				**12**				
		Expansion of 12 known tag codes and estimated contribution of hatchery origin Chinook in the Shasta River						**735**

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

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

c/ Sample expansion is the inverse of the number samples examined during carcass surveys, trap and in the weir wash back sample divided by the video estimate.

Spawning Ground Surveys

A total of 261 Chinook carcasses were observed during spawning ground surveys and all were sampled. Of the 258 for which both sex and length determinations were made, 140 (54%) were female and 118 (46%) were male. All of the 140 female carcasses examined were determined to have spawned successfully. Fork lengths of the recovered carcasses are shown in Figures 5 and 6.

A total of 557 redds were observed during spawning ground surveys in 2014. Of these, 370 were seen in the canyon reaches and 182 in the Big Springs complex (Figure 8). Redds observed in the canyon reaches were not flagged, and the season estimate was derived from the peak daily redd count. Redds encountered in the upper Shasta River were flagged and marked with a GPS unit, and after the initial survey only new redds were identified. Species determinations of the redds were not always possible; however, one was identified as a steelhead redd, one as a coho redd, and eleven redds were classified as “unknown” as to species., The remaining 546 were believed to be

Chinook redds. Redds were not used for an escapement estimate, but to document spawning distribution within the reaches surveyed. One coho carcass, a 67 cm. unmarked female which had successfully spawned, was recovered and processed during the 2014 season, on Reach 20 (the main stem Shasta River between Parks Creek and Big Springs Creek). Scale, tissue and otolith samples were taken from that fish.

Wash backs

In 2014, a total of 1,450 Chinook carcasses were recovered as wash backs onto the weir, of which 145 were sampled. Of the 145 carcasses sampled, 39 (27%) were females and 106 (73%) were male. Length frequency distribution of these samples are presented in Figure 7. As in previous years, the wash back samples collected at the SRFCF show a heavy bias toward males (Table 3).

Table 3. Sex composition of wash back carcasses sampled at Shasta River Fish Counting Facility, 2005-2014.

Year	Sample Number	% Males	% Females
2005	395	76	24
2006	457	94	6
2007	228	71	29
2008	767	96	4
2009	327	71	29
2010	118	83	17
2011	1,623	99.6	0.4
2012	104	81	19
2013	64	81	19
2014	145	73	27
AVERAGE		83	17

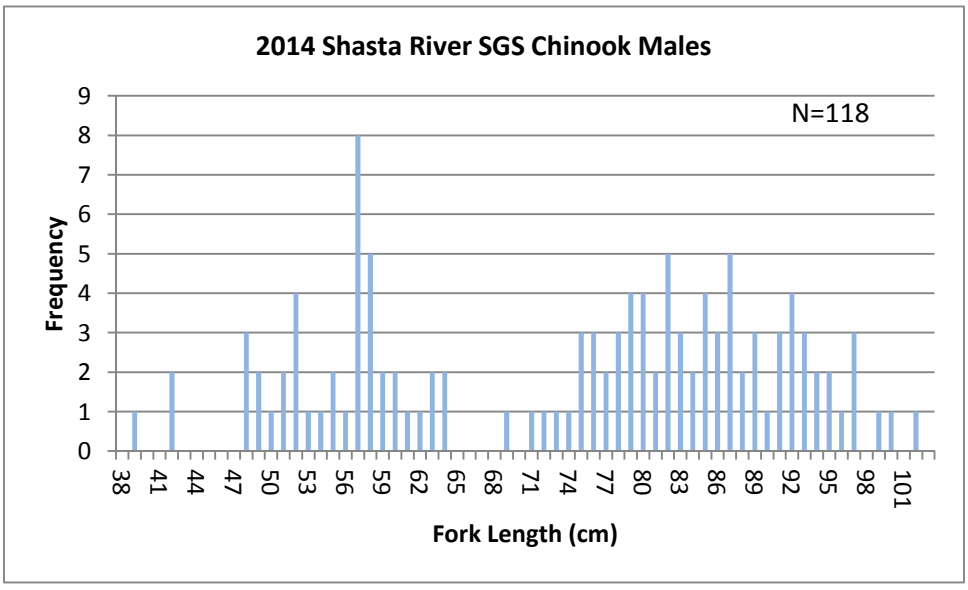

Figure 5. Length frequency distribution of Shasta River Chinook male salmon sampled in spawning ground surveys during the 2014 season.

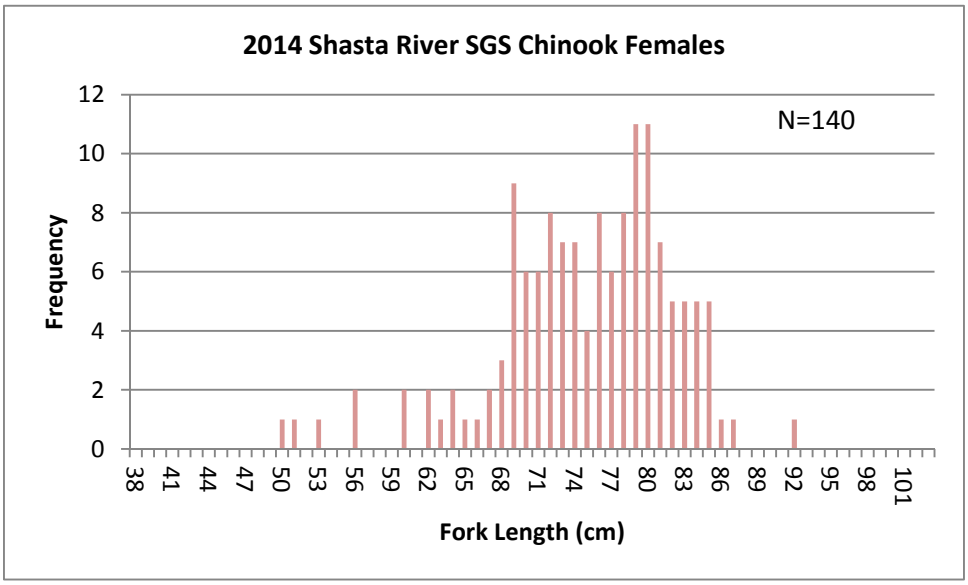

Figure 6. Length frequency distribution of Shasta River Chinook female salmon sampled in spawning ground surveys during the 2014 season.

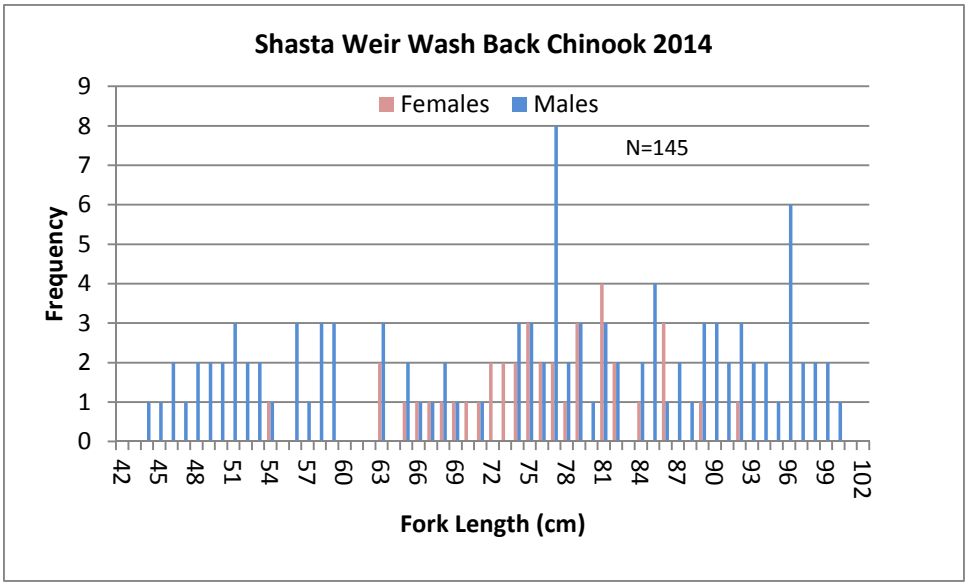

Figure 7. Length frequency distribution of Shasta River Chinook salmon sampled as weir wash backs during the 2014 season.

Grilse Cut-off

The Shasta River spawning ground surveys in 2014 yielded 258 Chinook carcasses for which sex and length could be determined. Scale age analysis of this sample by the Yurok Tribe determined that the 2014 Chinook run in the Shasta River consisted of 3,945 grilse (21.5%) and 14,414 (78.5%) adults for a total run size of **18,359** Chinook salmon (KRTAT, 2015).

Hatchery Straying

Since 2002, the KRP has estimated the number of hatchery origin Chinook that may have strayed into the Shasta River. These estimates have been based on sample expansions from known tag recoveries obtained from the Shasta River, or have been based on the proportional distribution of CWT recoveries observed at IGH and applied to the number of unrecovered ad-clipped Chinook that are observed passing through the SRFCF during the season, or both. 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 38.7% in 2004 (Table 4).

Table 4. Estimates of straying of hatchery origin Chinook salmon as a percentage of total escapement, 2002-2014.

Year	Total Number of Chinook	Hatchery Stray Estimate	Percent Hatchery
2002	6,820	79	1.2%
2003	4,195	436	10.4%
2004	962	372	38.7%
2005	2,129	469	22.0%
2006	2,184	105	4.8%
2007	2,035	69	3.4%
2008	6,362	56	0.9%
2009	6,287	131	2.1%
2010	1,348	157	11.6%
2011	11,388	74	0.6%
2012	29,544	126	0.4%
2013	8,021	146	1.8%
2014	18,359	735	4.0%
AVERAGE			**7.8%**

2014 Shasta River Observed Redds reaches 19 through 24.

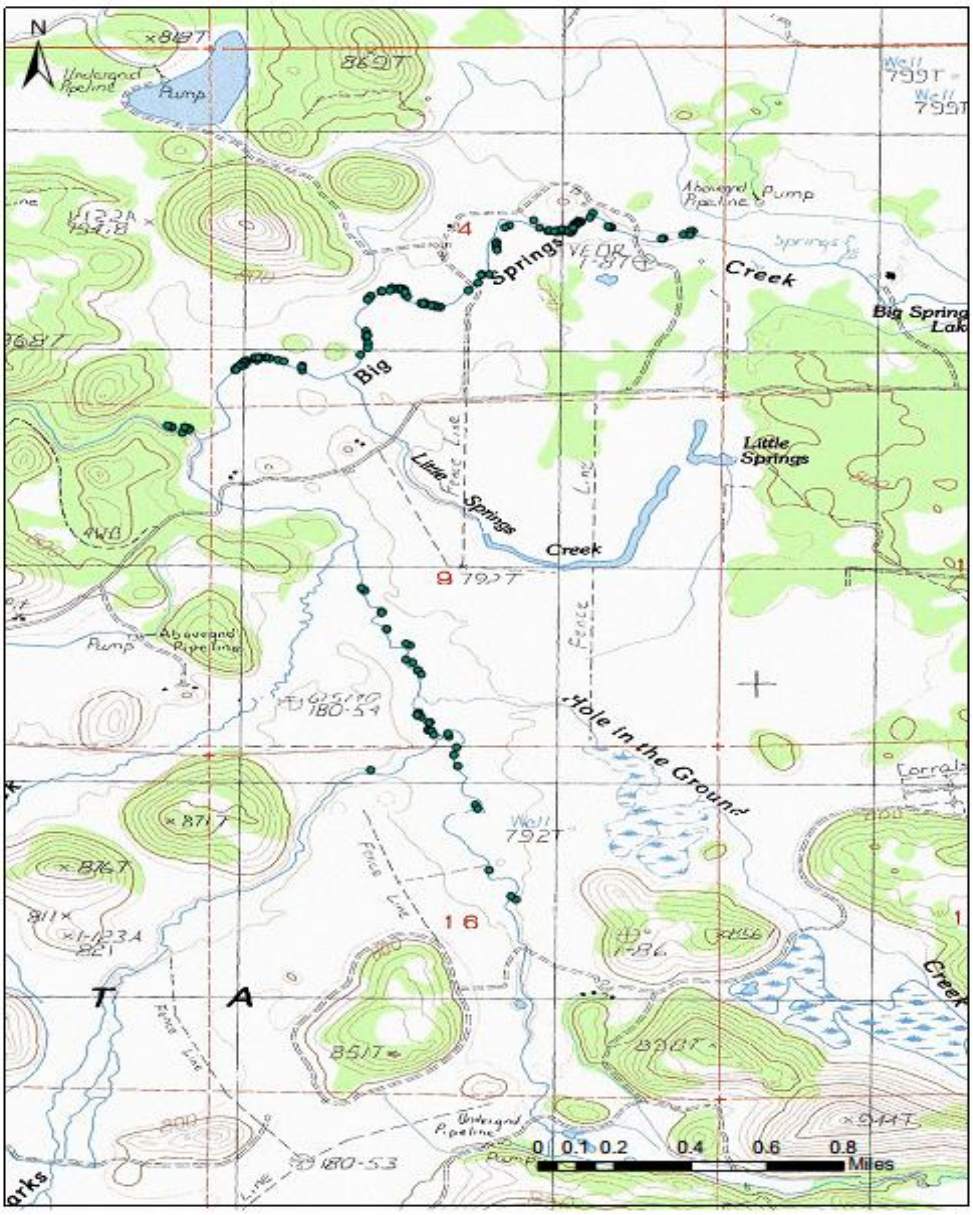

Figure 8. Redds observed in the Big Springs area of the Shasta River, 2014.

Coho Salmon

A total of 61 coho salmon were observed passing upstream and 15 coho were observed passing downstream through the SRFCF from October 10, 2014 to December 9, 2014 (Figure 9). The net number of coho known to have entered and remained in the Shasta River prior to removal of the weir was **46.** Because the weir was removed on December 10, 2014 due to a forecasted high flow event, the video weir did not capture the entire coho migration period. Data from 2001 to 2014 show that during the 14-year period, an average of 89.6% of the coho run entered the Shasta River on or before December 9.

In 2014, 238 coho salmon which entered IGH and were in excess of the hatchery's brood stock needs were tagged with Passive Integrated Transponder (PIT) tags and released from the IGH spawning building between October 20 , 2014 and December 15, 2014. PIT tag antenna arrays were in place at the upstream and downstream ends of the SRFCF as well as at RKMs 12, 46, 51 and 56 and in Big Springs Creek, Little Springs Creek and Parks Creek between September 1, 2014 and December 31, 2014. During the high flows that occurred after the removal of the weir, at least one PIT tag antenna was in continuous operation at RKM 0, and there were no PIT tag detections made after the weir's removal on December 10. Prior to that date, thirty-one (31) detections of Iron Gate PIT tagged coho occurred in the Shasta River.

The proportions of hatchery-origin (HOS) and natural-origin (NOS) coho entering the Shasta River during the fall 2014 season were estimated by applying the observed clip rates from spawning ground survey and weir wash back samples (N=2) that were not PIT tagged to the unknown (video) portion of the run. It was determined that 38, or 83% of the Shasta River coho run in 2014 were of hatchery origin.

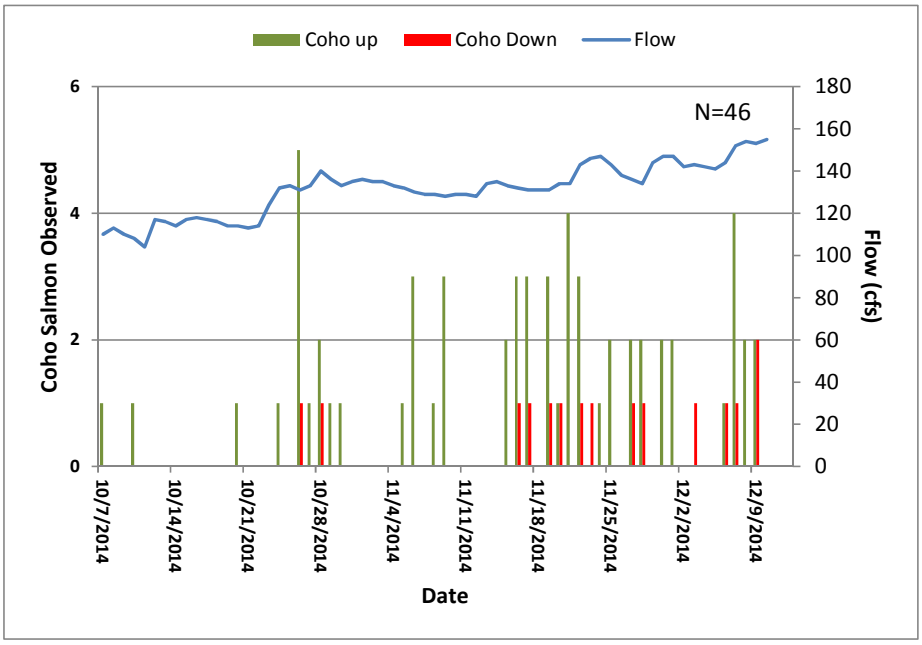

Figure 9. Run timing of coho salmon in the Shasta River during 2014 season.

Only one coho redd was identified in 2014, and it was located on Parks Creek. Since only two coho carcasses were recovered during the 2014 season, one from spawning ground surveys and one as a weir wash back, known fork lengths of PIT detected fish (N=31) were included in the fork length analysis to obtain a more accurate description of the age structure of the Shasta River coho run. Analysis of 33 fork lengths using a grilse cutoff of 52 cm. resulted in an age composition of 42 age two coho (91%) and 4 age 3 coho (4%) for a total of 46 coho entering the Shasta River in 2014. Twenty-seven observations (44%) were made of upstream migrating coho with lamprey attachments as they passed through the SRFCF during the 2013-14 season.

Steelhead Trout

In 2014, a net total of 249 adult steelhead (286 upstream, 37 downstream) and 129 sub-adults or "half-pounders" (135 upstream, 6 downstream) were estimated to have entered and remained in the Shasta River during the video recording season from August 29, 2014 to December 10, 2014 (Figures 10 and 11). Lines on the back of the video flume were set at 16 inches (40.64 cm) to delineate sub-adults (half-pounders) versus adults. Two (2) adult steelhead with adipose fin clips, indicating hatchery origin, were observed, however, it could not be determined whether those fish had a left maxillary clip as well, which would indicate Iron Gate Hatchery origin. Because the Alaskan weir is not impermeable to juvenile fish smaller than half-pounders, juvenile steelhead were not counted as they passed through the video weir.

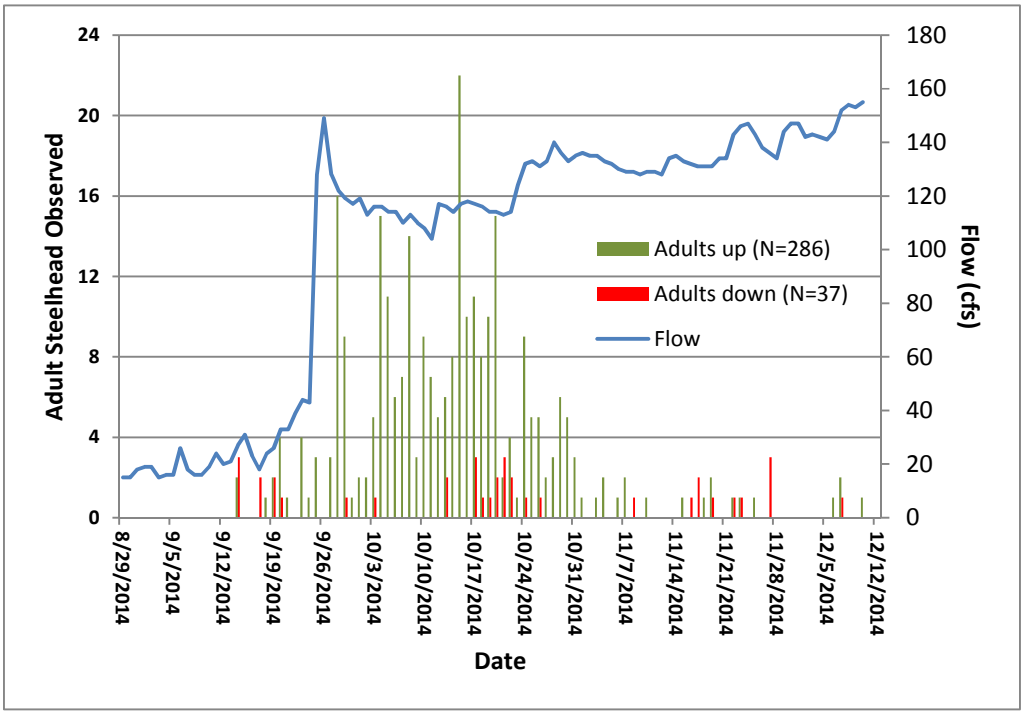

Figure 10. Adult (≥16") steelhead trout observations through the Shasta River Fish Counting Facility during the 2014 season.

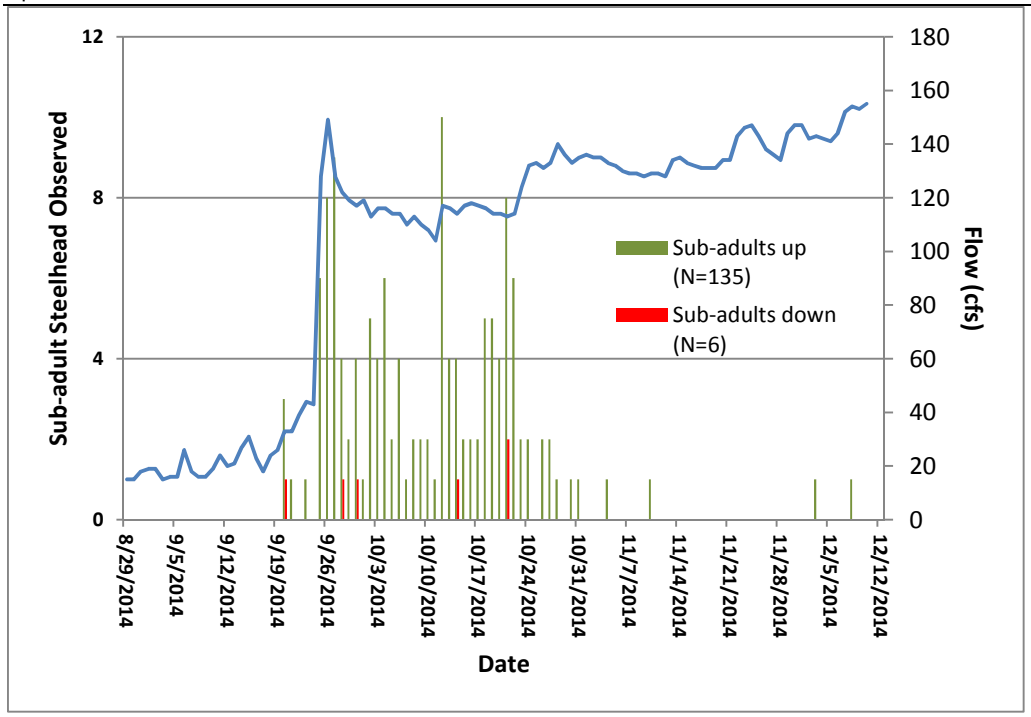

Figure 11. Sub-adult (<16") steelhead trout observations through the Shasta River Fish Counting Facility during the 2014 season.

DISCUSSION

Chinook Salmon

The 2014 run of Chinook salmon was estimated to be 18,359 fish, which is 12,010 fish above the 37-year average of 6,347 (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. In 2011, returns of Chinook grilse were the highest on record for the Klamath Basin. That strong age class (brood year 2009) was again seen in the large return of age 3 fish in 2012, age 4 fish in 2013, and the largest estimate of 5 year olds (83) since 2009 (Table 5).

Data from brood years 2000 through 2012 indicate the river's current habitat conditions continue to produce more 0+ Chinook as more adults return, indicating that the watershed continues to have an increasing ability to produce juvenile Chinook (Figure 13) although the rate at which juvenile Chinook were produced from brood year 2012 was reduced when compared to previous seasons (Debrick et al., 2014) During 2012, 2.4 times the number of adults (27,594) returned compared to brood year 2000 (11,025), the previous adult high for the period of record, yet the number of 0+ produced increased 24% indicating that during 2012 capacity limitations may have been present. However, many other factors affect the survival of Shasta River juvenile Chinook. A weather event in early February of 2015 produced flows (6,400 cfs) in the Shasta River that were the fifth highest in the period of record dating to 1934 (Figure 14). It is likely that these peak flows and resulting streambed mobilization and sediment transport

caused significant damage to redds and emerging fry. Current out-migrant trapping efforts at the mouth of the Shasta River are reporting below average Chinook numbers despite the strong adult run of fall 2014. (B. Chesney, pers. comm.).

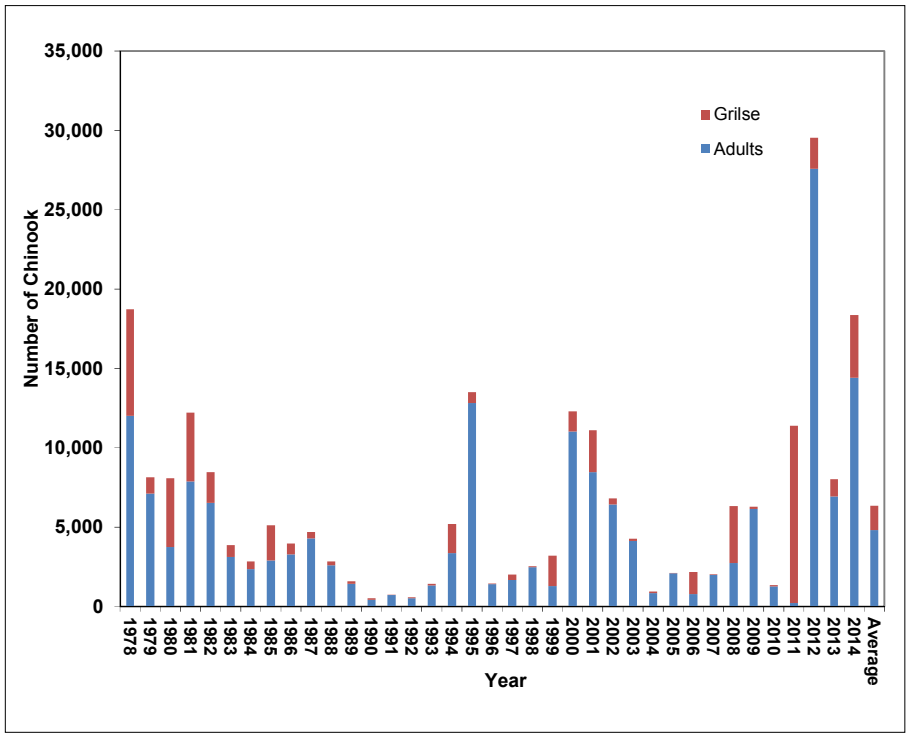

Figure 12. Adult and grilse Chinook salmon returns to the Shasta River, 1978-2014.

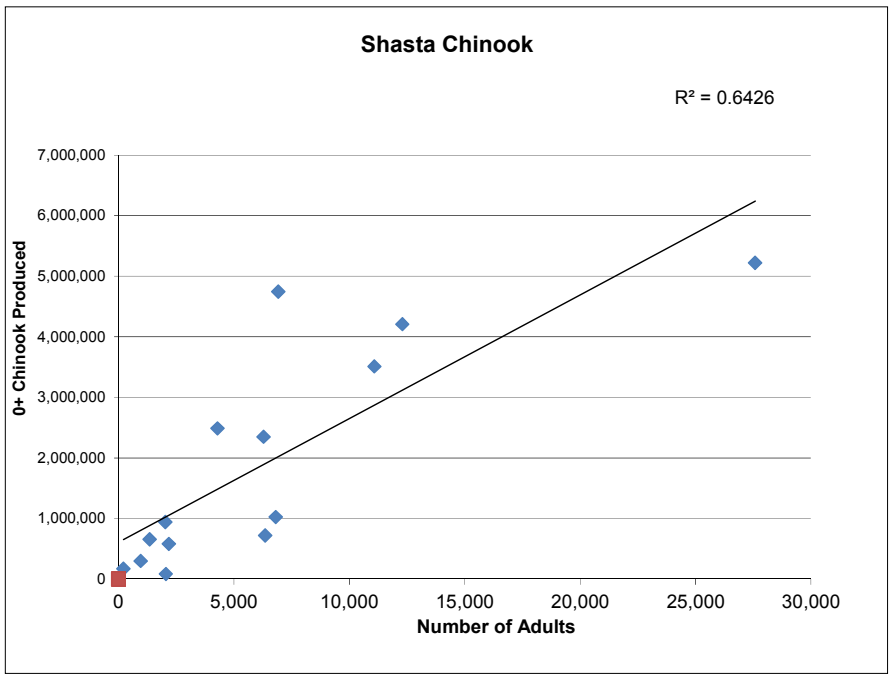

Figure 13. Number of 0+ Chinook produced per adult spawner in the Shasta River, Brood Years 2000-2013.

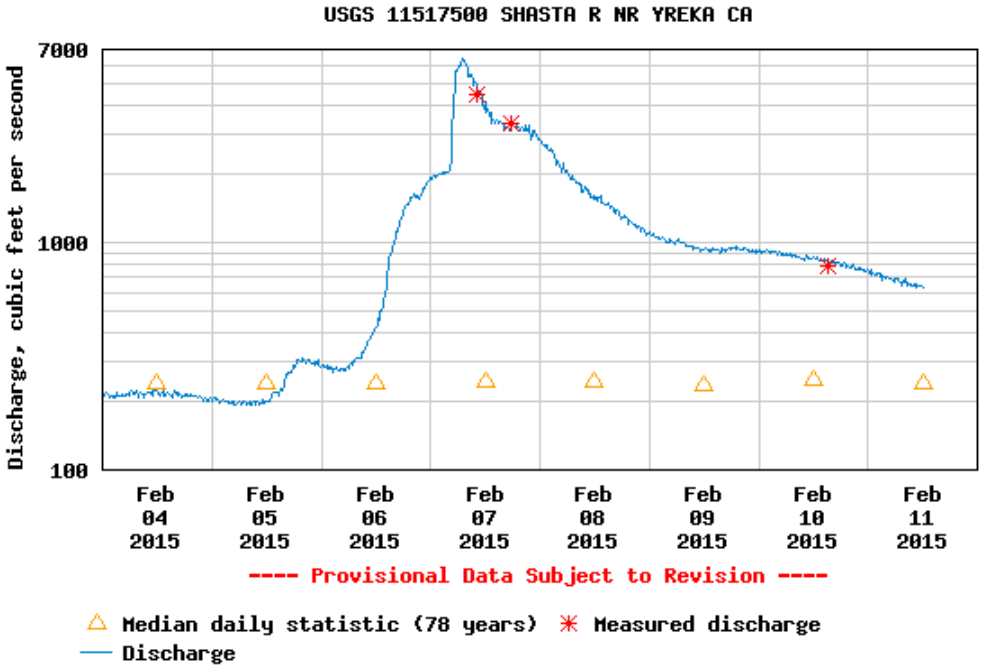

Figure 14. Peak flow of 6,400 cfs on February 7, 2015 is the fifth highest on record at USGS gauge 11517500 near the mouth of the Shasta River.

Table 5. Age composition of Shasta River Chinook runs as determined by Klamath River Technical Advisory Team, 2002-2014.

	Age 2	Age 3	Age 4	Age 5	Total Adults	Total Run
2002	386	4,286	2088	58	6,432	6,818
2003	155	2,798	1325	11	4,134	4,289
2004	129	184	484	166	834	963
2005	38	1,409	600	82	2,091	2,129
2006	863	253	1042	27	1,322	2,185
2007	27	1,855	146	8	2,009	2,036
2008	3,621	1,222	1456	63	2,741	6,362
2009	126	5,595	314	252	6,161	6,287
2010	87	240	1021	0	1,261	1,348
2011	11,175	23	190	0	213	11,388
2012	1,950	27,592	2	0	27,594	29,544
2013	1,096	3,896	3,029	0	6,925	8,021
2014	3,945	4,064	10,265	83	14,412	18,357
Average	1,815	4,109	1,689	58	5,856	7,671

The Shasta River is an important component of the Klamath Basin (including Trinity River) Chinook run and has contributed an average of 10 percent of the basin-wide natural spawning escapement during the period from 1978 to 2014 (Table 6). A comparison of Shasta River escapement to Klamath Basin escapement is shown in

Figure 14. Historically, the Shasta River was documented as a highly productive salmon stream, with a run of over 75,000 Chinook counted at the Shasta Racks (predecessor to the SRFCF) in 1935.

Efforts have been underway in recent years by the Department, the Shasta Resource Conservation District (RCD), and local landowners to coordinate the timing and magnitude of irrigation diversions during critical weeks in September to ensure adequate flows when adult Chinook begin to enter the river and before the irrigation season ends on October 1st.

Coho Salmon

Returns of coho to the Shasta River from 1978 to 2014 are shown in Figure 17. Sampling from 1983 to 2000 cannot be directly compared to other years, as the weir was removed on or before November 11th during those years and sampling does not represent the entire run of coho. Estimates of hatchery origin adult coho salmon entering the Shasta River from 2007-2014 are shown in Figures 18-20 and in Table 7. In 2014, these estimates were derived from PIT tag detections of coho released from IGH as well as positive identification of left-maxillary clipped coho processed as wash backs on the weir and in the spawning ground survey.

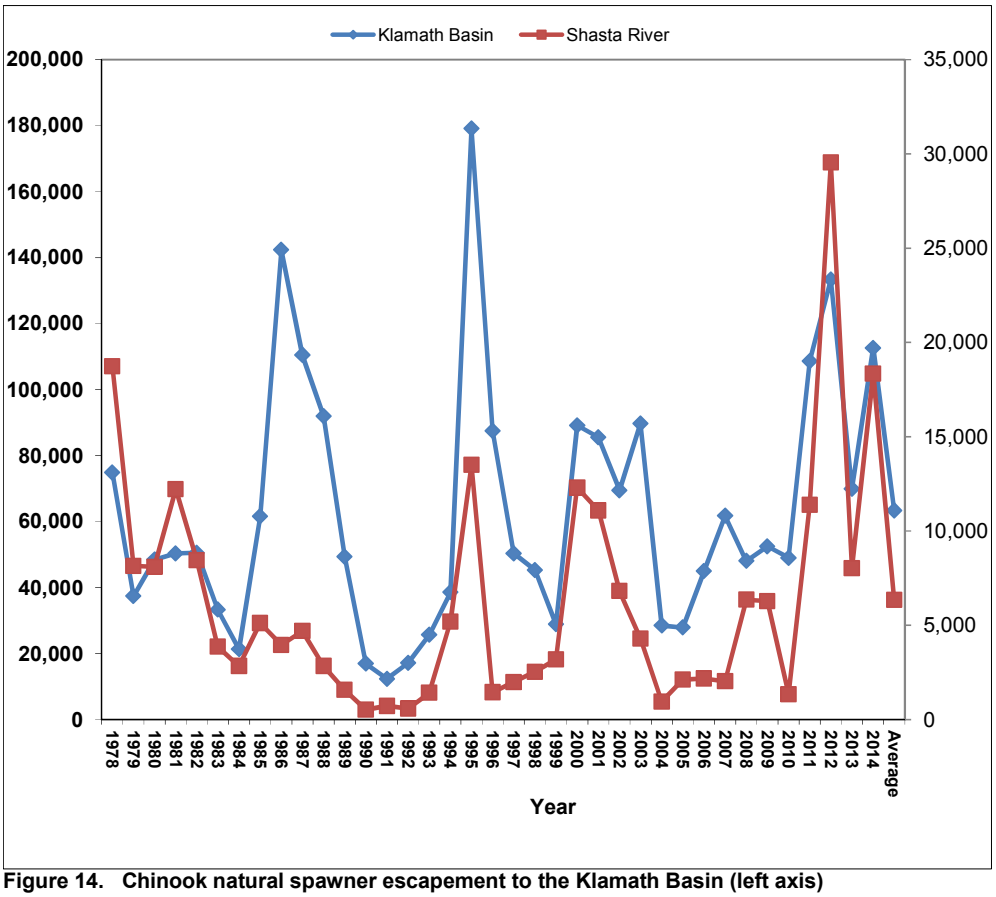

Figure 14. Chinook natural spawner escapement to the Klamath Basin (left axis) and Shasta River (right axis), 1978-2014.

Table 6. Natural Spawner Escapement to Klamath Basin and Shasta River, 1978-2014

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	2,129	8%
2006	45,002	2,184	5%
2007	61,741	2,036	3%
2008	48,073	6,362	13%
2009	52,499	6,287	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	112,599	18,357	16%
Average	**63,389**	**6,347**	**10%**

The decline of coho 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 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 management is that the effects of depensation (inbreeding, difficulty finding mates) outweigh any negative effects of IGH fish straying and spawning in the Shasta River. Current research by Galbreath et al (2014) indicates that domestication effects carried by hatchery-origin coho 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 and their progeny, so that during periods of extreme low abundance of Shasta River coho the straying of IGH fish into the Shasta River will benefit the Shasta River coho population and its recovery.

Ongoing rotary trap operations at the mouth of the Shasta River (Debrick et al, 2014) have produced annual smolt point estimates, which, along with annual adult escapement estimates, can provide a means of predicting the survival of Shasta River coho from outmigration to adult escapement (Table 8).

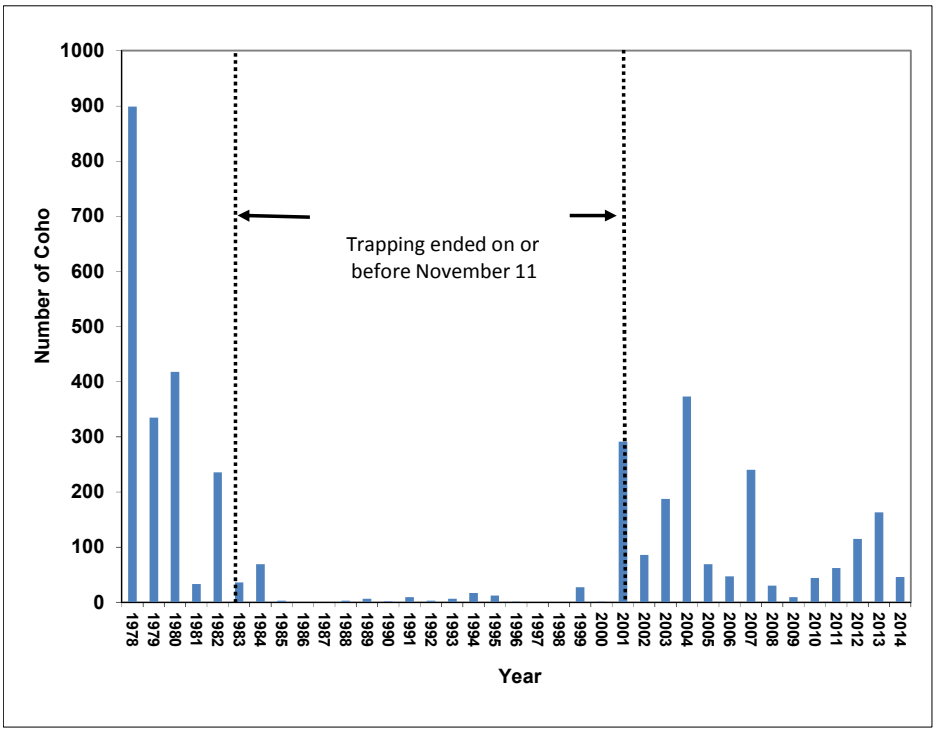

Figure 17. Returns of coho salmon to the Shasta River, 1978-2014.

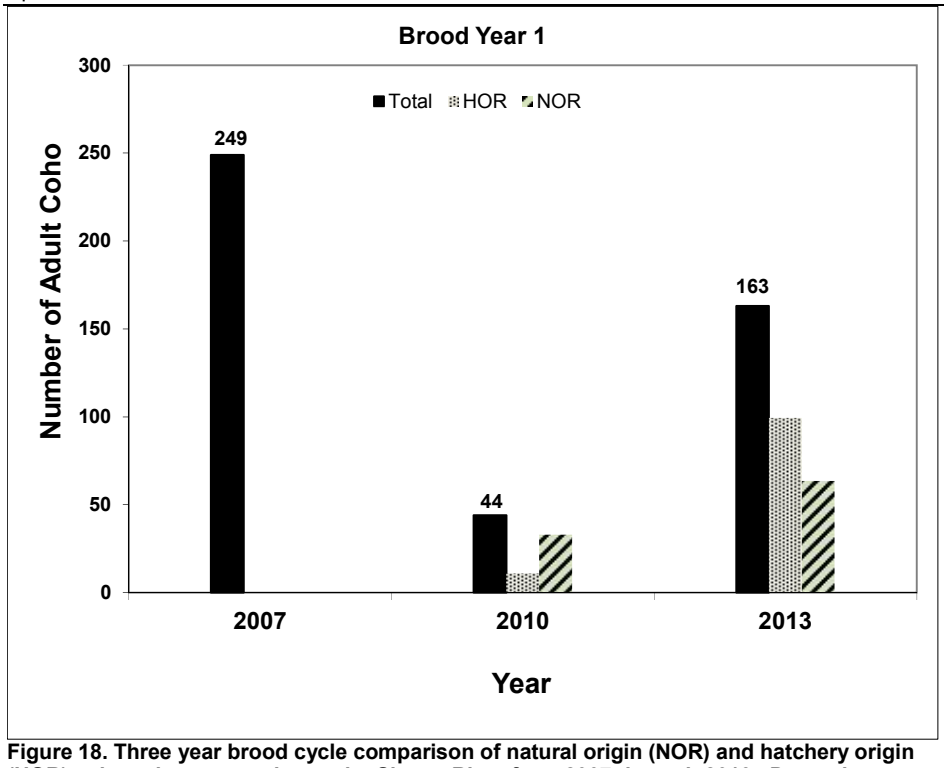

Figure 18. Three year brood cycle comparison of natural origin (NOR) and hatchery origin (HOR) coho salmon returning to the Shasta River from 2007 through 2013. Due to low carcass recovery in 2007 hatchery contribution rate was not estimated.

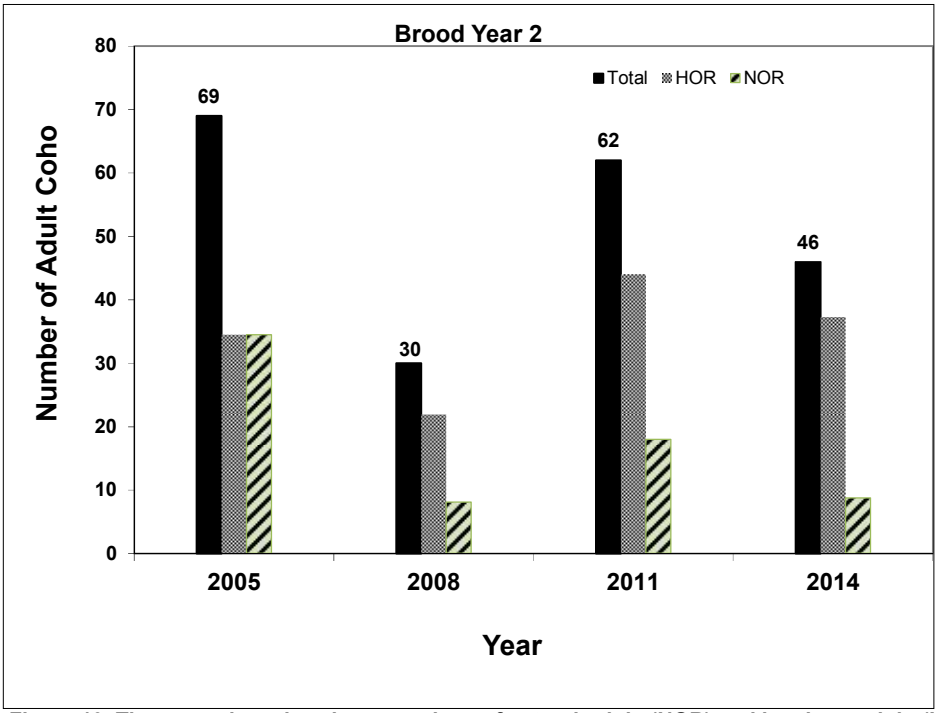

Figure 19. Three year brood cycle comparison of natural origin (NOR) and hatchery origin (HOR) coho salmon returning to the Shasta River from 2005 through 2014.

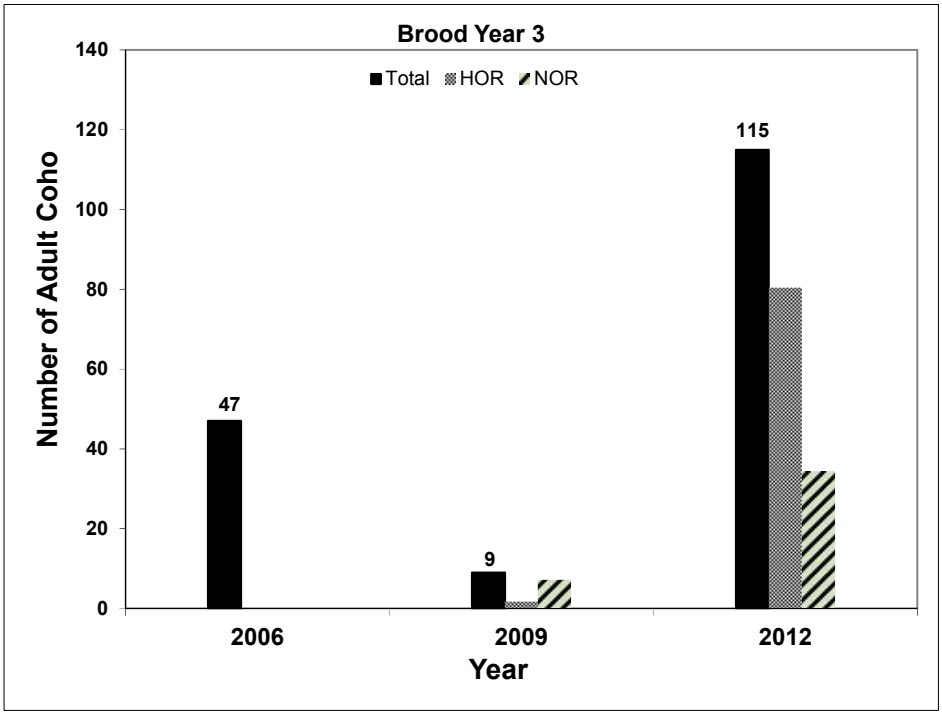

Figure 20. . Three year brood cycle comparison of natural origin (NOR) and hatchery origin (HOR) coho salmon returning to the Shasta River from 2006 through 2012. Due to low carcass recovery in 2006, hatchery contribution rate was not estimated.

Table 7. Estimates of hatchery strays as percentage of coho entering the Shasta River, 2007-2014.

Year	Total Number of Coho	Hatchery Stray Estimate	Percent Hatchery
2007	249	5	2%
2008	30	22	73%
2009	9	2	22%
2010*	44	11	25%
2011*	62	44	71%
2012*	115	81	70%
2013*	163	101	62%
2014*	46	37	83%
AVERAGE			**51%**
* in 2010-2013, surplus adult coho were PIT tagged and released after entering Iron Gate Hatchery			

These relationships are complicated by the difficulty of adequately estimating the contribution of hatchery-origin spawners, as well as the challenges of producing population estimates at extreme low abundance. The brood year 2009 group shows a percent smolt survival of 178.95%. It may be that the 2012 adult return of coho included fish that were not of Shasta River origin, yet were not identified as strays. The smolts observed in 2011 were the product of a very low adult return of 9 coho (7 after adjusted

for hatchery contribution) in 2009, and although trapping effort and efficiency were normal in 2011 (Bill Chesney, pers. comm.), only 19 coho smolts were estimated to have left the Shasta River that year during the rotary trapping season.

Table 8. Coho smolt abundance point estimates, adult coho abundance estimates, ratio of smolts to adult returns and proportion of smolts that returned as adults by brood year for the Shasta River, Brood Years 2001-2011.

Brood Year	Smolt year	Smolt Point Estimate	Adult Year	Adult Estimate /1	Smolts to Adults	Percent Smolt Survival
2001	2003	11052	2004	373	29.63	3.37%
2002	2004	1799	2005	69	26.07	3.84%
2003	2005	2054	2006	47	43.70	2.29%
2004	2006	10833	2007	244	44.40	2.25%
2005	2007	1178	2008	9	130.89	0.76%
2006	2008	208	2009	7	29.71	3.37%
2007	2009	5396	2010	33	163.52	0.61%
2008	2010	169	2011	18	9.39	10.65%
2009	2011	19	2012	34	0.56	178.95%
2010	2012	1930	2013	62	31.13	3.21%
2011	2014	1618	2014	9	179.78	0.56%

/1 Adult estimate adjusted to subtract estimated hatchery composition of Adult Years 2007-2014

Analyzing the comparisons of estimated adult coho returns to yearling coho production estimates (Debrick and Stenhouse, 2014) also produces freshwater survival estimates in the form of yearling coho produced per adult return. The number of yearling coho produced per returning adult has averaged 17.6 and ranged from a low of 2.1 to a high of 46.6 for brood years 2001-2012 (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, and refinements to these estimates will continue to be made in future years.

In addition, increased straying of adult IGH coho due to releases from the IGH spawning building, 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, making it difficult to estimate the juvenile recruitment of natural origin coho. In 2013 and 2014, tissue samples from all sampled coho were collected at the rotary screw trap located near the SRFCF and provided to the NOAA salmon genetics repository for analysis of wild/hatchery composition of Shasta River coho salmon.

Table 9. Adult coho estimates, smolt coho production point estimates and ratio of smolt coho produced per adult return for the Shasta River, Brood Years 2001-2012.

Adult Year Brood Year	Adult Estimate	Yearling year	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	255	2009	5396	21.2
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	115	2014	850	7.4
Average				**17.6**

STEELHEAD TROUT

The objectives of the KRP have traditionally focused on monitoring the escapement of Chinook, and more recently coho salmon. Estimating steelhead trout escapement has proven challenging due to run timing (steelhead migration is usually underway when flow conditions make weir removal necessary) and life history, as individual steelhead are often observed to move repeatedly through the video flume in upstream and downstream directions. However, as flow conditions allow, the goal of KRP is to obtain a more complete count of steelhead in the Shasta River and other Klamath River tributaries.

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