Shasta River
Chinook and Coho Salmon Observations in 2013
Siskiyou County, CA

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Shasta River Fish Counting Facility, Chinook and Coho Salmon Observations in 2013 Siskiyou County, CA

ABSTRACT

A total of **8,021** fall run Chinook salmon (Chinook**,** *Oncorhynchus tshawytscha*) were estimated to have entered the Shasta River during the 2013 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 28, 2013 until December 9, 2013, when the weir sustained structural damage from ice build-up and was removed. The first Chinook was observed on September 9, 2013 and the last Chinook on December 3, 2013. KRP staff also processed a total of 512 Chinook carcasses during spawning ground surveys (of which 469 were used in fork length histograms), 65 Chinook carcasses as wash backs against the SRFCF weir (a systematic 1:10 sample), and 45 live Chinook in a trap immediately upstream of the video flume during the season.

Chinook carcasses sampled in the spawning ground surveys ranged in fork length (FL) from 43 cm to 100 cm and grilse were determined to be < 59 cm in FL. Males ranged in FL from 43 to100 cm. and averaged 80 cm. Females ranged in FL from 54 cm. to 88 cm. and averaged 73 cm. Carcasses sampled as weir wash backs were checked for marks and clips, scales were taken, and sex and fork length information collected. The run was comprised of 1,096 grilse (13.7%), and 6,925 adults (86.3%). Sex composition of the fish processed in spawning ground surveys, wash backs and trap was 56.4% (326) females and 43.6% (252) males. A total of 7 adipose-clipped (AD) Chinook were recovered during the spawning ground surveys (3) and in the weir wash back sample (4). Five of the seven had positive CWT identification. All 5 fish had been tagged at Iron Gate Hatchery. Expansion of the 5 known tag codes resulted in an estimated hatchery contribution of 146 Chinook, or 1.8% of the total run observed in 2013.

A net total of 134 coho salmon (coho, *Oncorhynchus kisutch*) were estimated to have entered the Shasta River prior to removal of the weir on December 9, 2013. The first coho of the season was observed passing through the SRFCF on October 19, 2013, and the last coho was observed swimming upstream through the SRFCF on December 5, 2013. After the video weir was removed, an additional 29 PIT tagged coho (released from IGH) were detected passing through the PIT antenna arrays at the SRFCF site between December 13, 2013 and January 8, 2014, for a total of **163** coho known to have entered the Shasta River during the 2013-2014 season. Based on PIT tag detections and caudal punch and left maxillary clip observations, an estimated 101, or 62% of the coho salmon entering the Shasta River were of Iron Gate Hatchery origin.

A net total of 65 adult and 64 sub-adult steelhead trout **(***Oncorhynchus mykiss)* were observed passing through the SRFCF during the 2013 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 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 2013.

METHODS

Monitoring of the salmon run within the Shasta River during the 2013-14 season was accomplished through four 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), completion of spawning ground surveys upstream of the weir to obtain biological data from salmon carcasses, and operation of a trap just upstream of the video flume, primarily during coho season for the purpose of obtaining biological samples from coho, Chinook and steelhead entering the Shasta River.

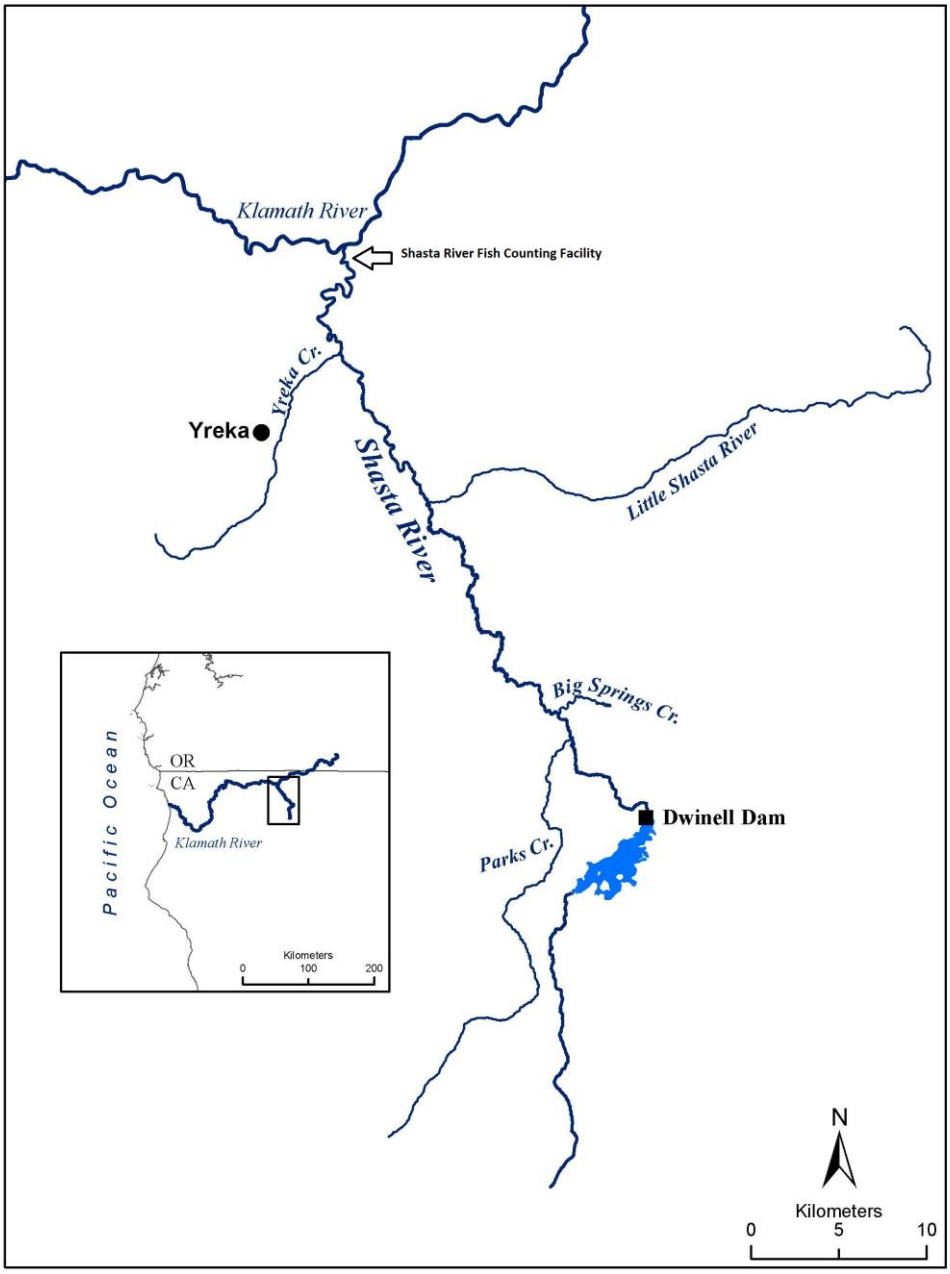

Figure 1. The Shasta River Watershed and location of Shasta River Fish Counting Facility (SRFCF).

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 2013 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 28, 2013. 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.

Hard 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

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

counted. Fish for which positive identification could not be made were recorded as "unknown" species. All data were then entered into files on a personal computer and each data file was edited and corrections made by a second individual prior to commencement of data analysis.

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 carcasses were processed. Coho carcasses with an operculum punch were scanned with a hand-held PIT tag detector, and PIT tag numbers recorded. 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.

SPAWNING GROUND SURVEYS

Spawning ground surveys were conducted between October 10, 2013 and January 29, 2014. 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 (Figures 3 and 4). The purpose of the spawning ground surveys was to gather biological data necessary to describe physical characteristics of the run, and to document spawning distribution. 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 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.

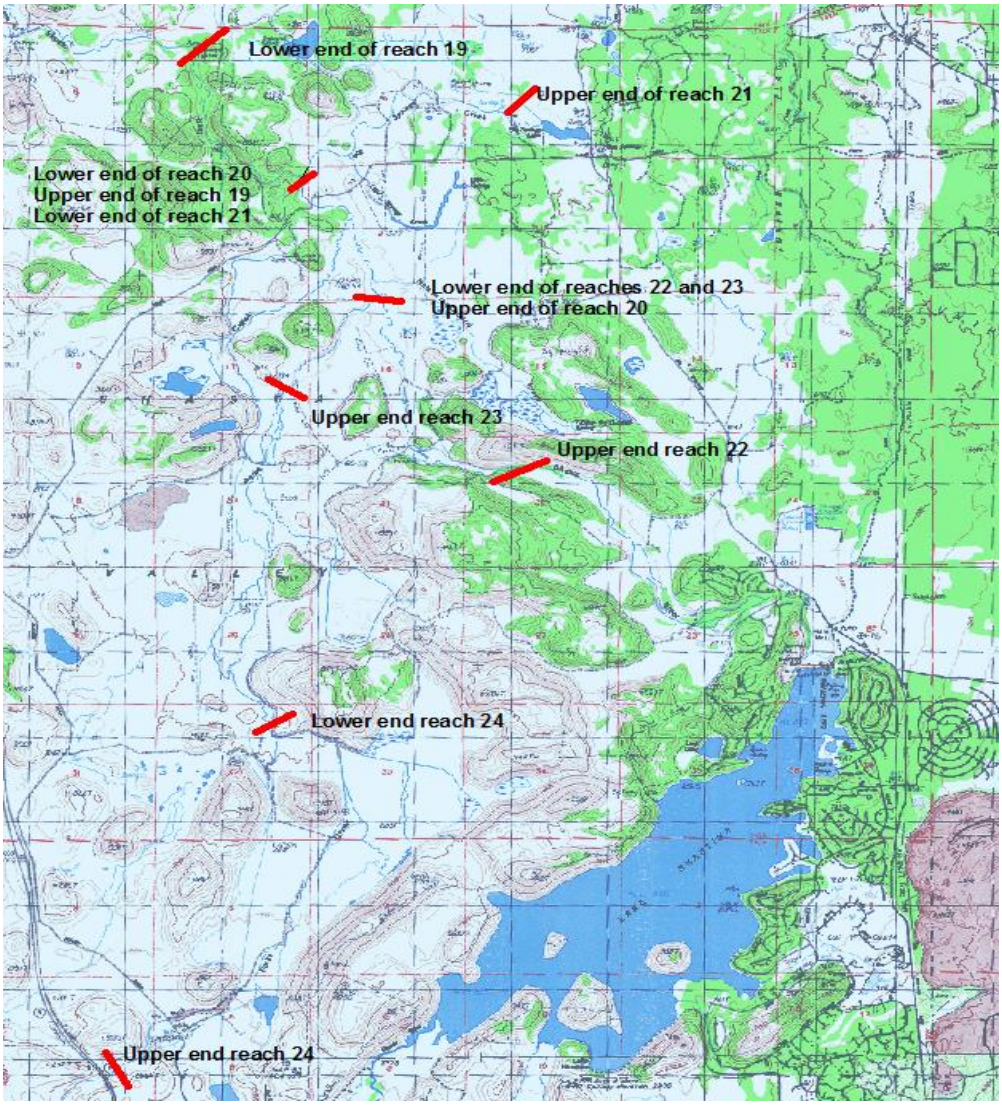

Figure 3. Spawning ground survey reaches in the upper Shasta River, 2013-14.

Table 1. Description of Shasta River Spawning Ground Survey Reaches, 2013-2014

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

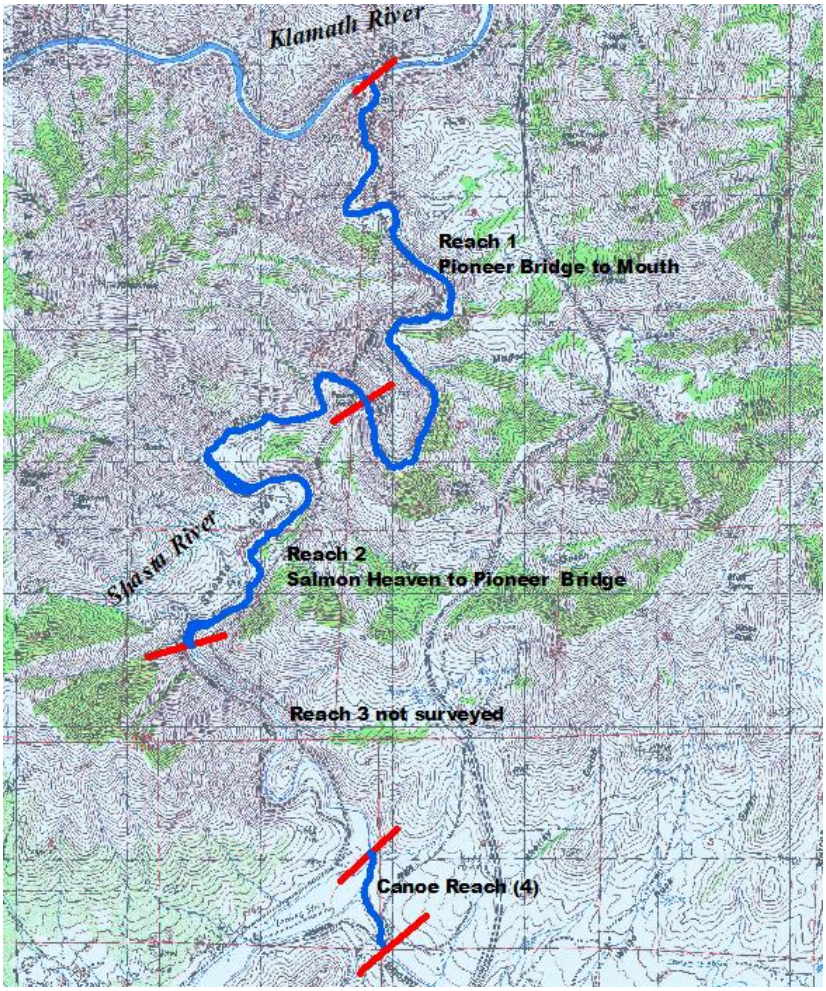

Figure 4. Spawning ground survey reaches in the Shasta River canyon, 2013

RESULTS

Operation of the SRFCF began on August 28, 2013 at 10:44 hours, Pacific Standard Time (P.S.T.). The first Chinook of the season was observed on September 9, 2013 and the last Chinook was observed on December 3, 2013. The weir and recording equipment were removed on December 9, 2013 after four days of sub-freezing temperatures and ice build-up on the weir panels resulted in structural damage which compromised weir integrity.

Recording was disrupted between 020:10:00 hours on September 4 and 06:26 hours on September 5, 2014 (a total of 3.84 hours) and between 19:25:17 hours and 20:36:49 hours on December 6, 2013 (a total of 1:11:32 hours). An average count of salmonid species observed three days before and three days after each recording malfunction event was made, and as a result of this calculation, zero fish were added to the counts.

Chinook Salmon

A net total of 8,021 Chinook were counted passing through the SRFCF during the 2013 season. This number was derived by subtracting the number of downstream observations (170) from the number of upstream observations (8,193). The run peaked between September 21, 2013 and October 16, 2013, during which 84% of the total run was observed (Figure 5). Consistent with previous years' monitoring efforts, the majority of Chinook (94%) passed upstream through the SRFCF during daylight hours between 07:00 and 19:00 hours (Figure 6). A total of 1,211 Chinook (15% 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.

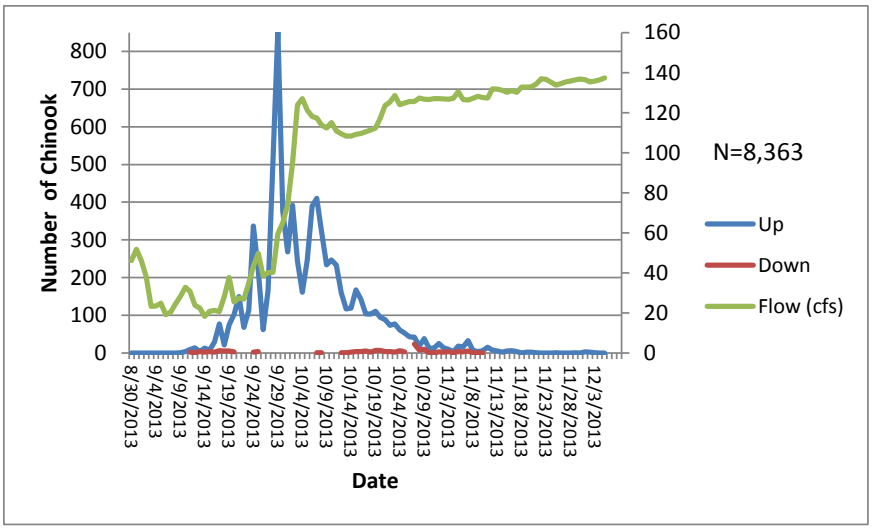

Figure 5. Chinook salmon observed migrating through the Shasta River Fish Counting Facility, 2013 by date.

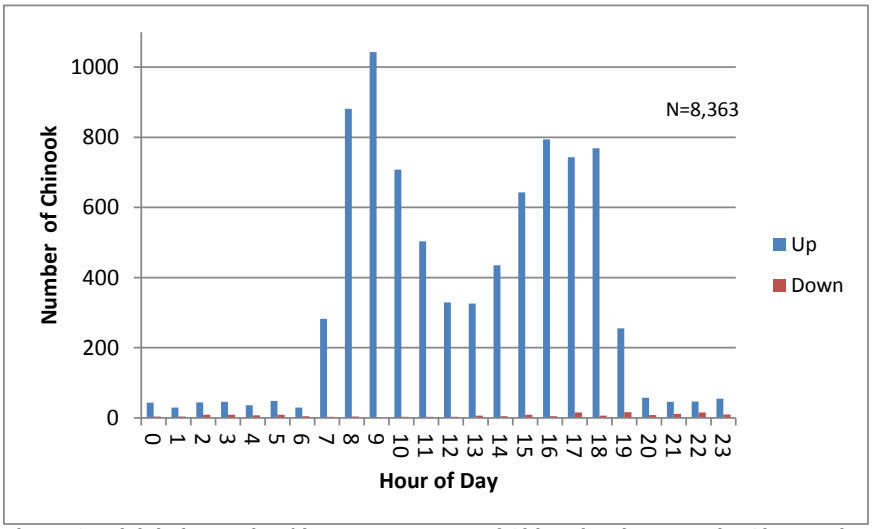

Figure 6. Diel timing and up/down movements of Chinook salmon at the Shasta River Fish Counting Facility in 2013.

A net total of 14 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 sample and not on video observations. The heads from 7 AD Chinook were recovered from carcasses: 4 in the wash back sample and 3 from the spawning ground surveys.

All 4 of the wash back samples had positive reads, and all were of IGH origin. One was an age 4 fish (released as a smolt), one was an age 3 fish (released as a yearling), and 2 were age 2 fish, one released as a smolt and one as a yearling. Two of the 3 heads recovered in the spawning ground surveys contained no tag, and the third was an age 4 fish released from IGH as a smolt.

Expansion of these 5 known CWTs by their production multipliers (the inverse of the proportion of each group of juveniles that were tagged) yielded an estimate of 18 hatchery origin Chinook. An estimate of total hatchery contribution was derived based on multiplying the recovered tags by an expansion factor of 7.23 (video count/ number of carcasses examined in spawning ground surveys and weir wash backs). Using this method a total of 146 hatchery origin Chinook , or 1.8% of the total run, were estimated to have entered the Shasta River during the 2013 run.

Spawning Ground Surveys

A total of 512 Chinook carcasses were sampled during spawning ground surveys. Of the 469 for which both sex and length determinations were made, 304 (64.8%) were female and 165 (35.2%) were male. Of 304 female carcasses examined, 292 (96%) were determined to have spawned successfully, and 12 (4%) were determined to have died prior to spawning. Fork lengths of the recovered carcasses are shown in Figures 7 and 8.

A total of 453 redds were observed during spawning ground surveys in 2013 (Figure 9). Of these, 210 were seen in the canyon reaches and 243 in the Big Springs complex. 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, 47 were identified as coho redds, 3 as unknown and 403 as Chinook redds. Two coho carcasses were recovered and processed during the 2013-2014 season, both in Reach 24 (upper Parks Creek). One was an unmarked male grilse and the other a left-maxillary clipped (IGH origin) adult female which appeared to have successfully spawned.

Wash backs

In 2013, a total of 643 Chinook carcasses were recovered as wash backs onto the weir, of which 64 were sampled (a one in ten systematic sample, plus all AD carcasses). Of the 64 carcasses sampled, 12 (19%) were females and 52 (81%) were male. Length frequency distribution of these samples are presented in Figure 10. As in previous years, the wash back samples collected at the SRFCF show a heavy bias toward males (Table 3).

Table 2. Estimated contribution 5 known coded wire tag (CWT) codes recovered in the Shasta River during the 2013 season.

CWT	Brood Year	Release Type	Number of CWTs recovered in Shasta River	Estimated Number	Production Multiplier	Production Estimate	Sample Expansion	Total Estimate
68713	2009	F	1	1	4.17	**4**	**7.23**	**30**
68716	2009	Y	1	1	4.01	**4**	**7.23**	**29**
68799	2010	Y	1	1	4.03	**4**	**7.23**	**29**
60418	2011	F	1	1	4.01	**4**	**7.23**	**29**
60422	2011	Y	1	1	4.00	**4**	**7.23**	**29**
Totals		**668**	**0.838**	**5**		**18**		**146**
	Expansion of 5 known tag codes in Shasta River					**146**		
	Total estimated contribution of hatchery origin Chinook in Shasta Riv					**146**		

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 survyeys and in the weir wash back sample divided by the video estimate.

Table 3. Sex composition of wash back carcasses sampled at Shasta River Fish Counting Facility, 2005-2013.

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**
AVERAGE		**84**	**16**

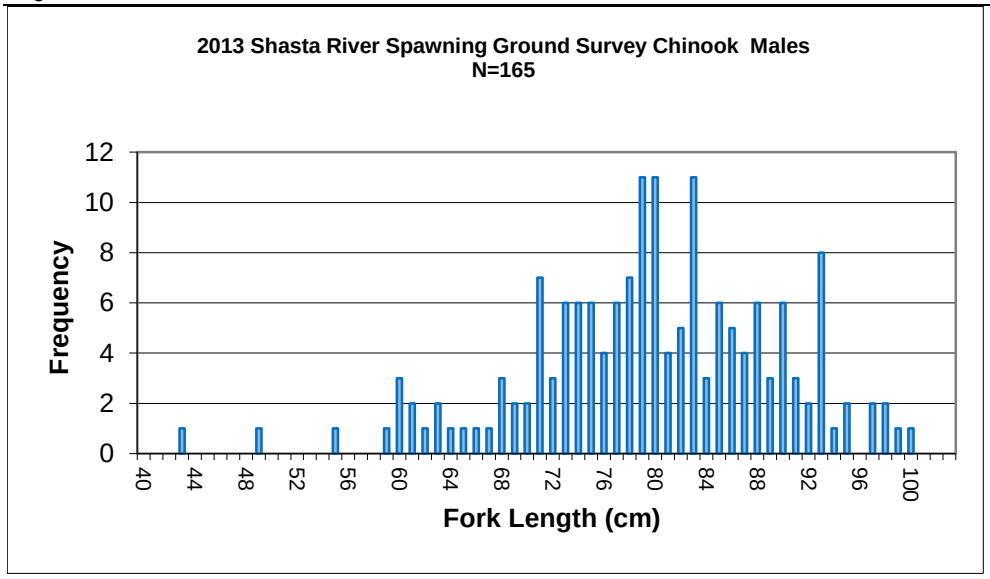

Figure 7. Length frequency distribution of Shasta River Chinook male salmon sampled in spawning ground surveys during the 2013 season.

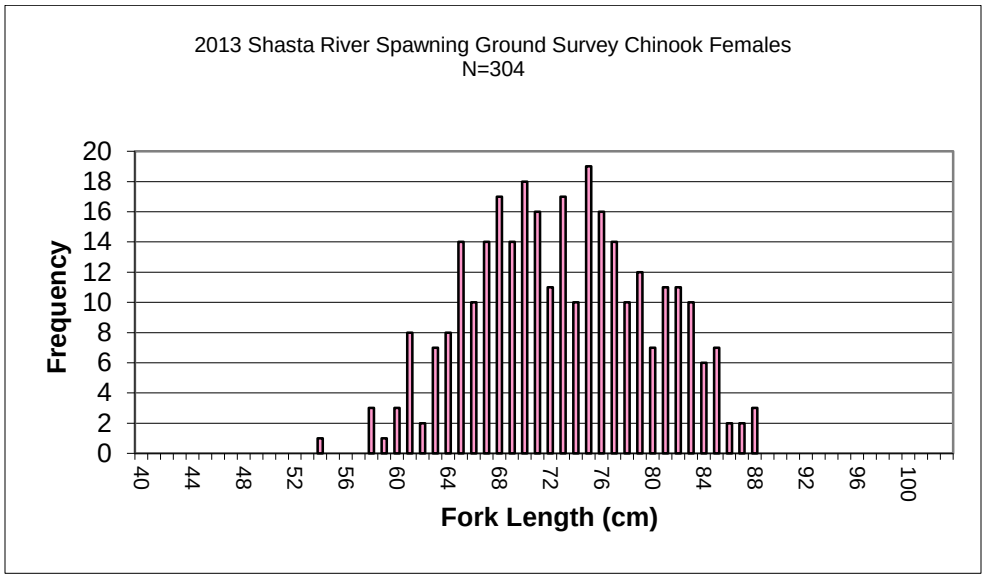

Figure 8. Length frequency distribution of Shasta River Chinook female salmon sampled in spawning ground surveys during the 2013 season.

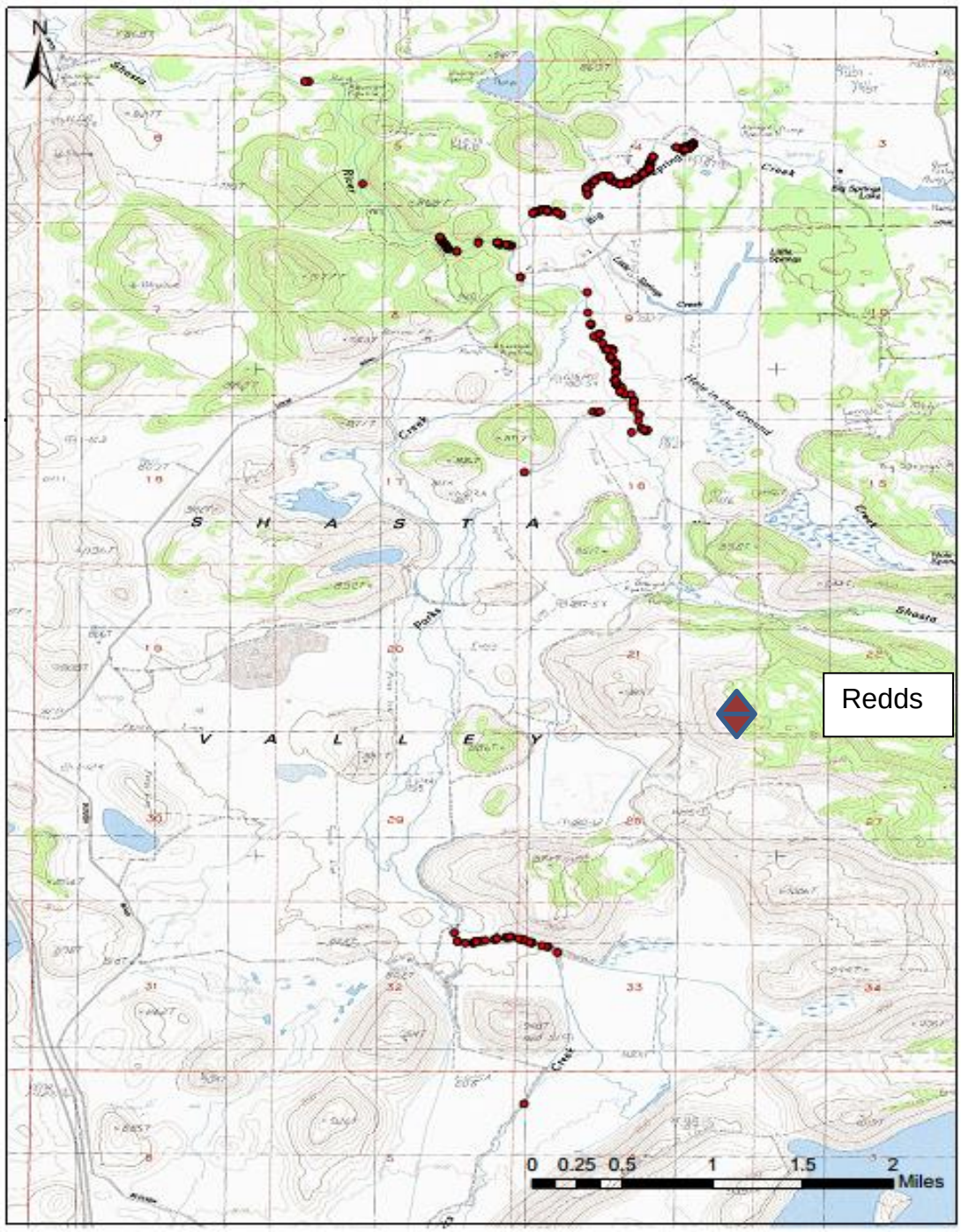

Figure 9. Redds observed in the Big Springs area of the Shasta River, 2013.

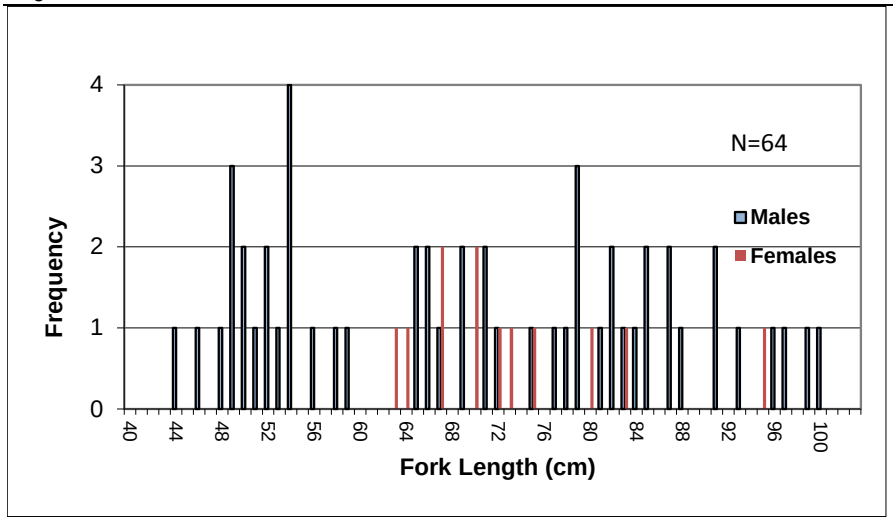

Figure 10. Length frequency distribution of Shasta River Chinook salmon sampled as weir wash backs during the 2013 season.

Grilse Cut-off

Shasta River spawning ground surveys typically yield few jacks (in 2013, 3 out of 469 samples were jacks using a fork length cutoff of < 59 cm). KRP staff believes that this is not representative of the true jack component, and partitioned the 2013 Shasta River Chinook run age structure by utilizing a method which was developed by the KRTAT in 2006, a year in which few carcasses were recovered. The proportion of jacks among males P(J/M) was derived using the trap sample. Eleven of the 35 male Chinook sampled in the trap were determined to be jacks using a < 59 cm cutoff (0.314%). The proportion of males among adults P(M/A) was estimated using the carcass survey data. There were 162 adult males out of 469 samples, 0.345%. Using these proportions, the following method was used:

1. **Estimate the proportion of males P(M) in the run:**

$$P(M) = \frac{P(M/A)}{1-P(J/M)\ [1-P(M/A)]} = \frac{0.345}{1-0.31428\ [\ 1-\ 0.345]} = 0.435$$

Based on the following relationship:

$$P(M/A) = \frac{P(M/A)}{P(A)} = \frac{P(M)-P(J)}{1-P(J)} = \frac{P(M)-P(J/M)P(M)}{1-P(J/M)P(M)}$$

2 . **Estimate the proportion of jacks in the run**:

P(J)=P(M) x P(J/M) = (0.435)(0.314)= 0.137

3. **Estimate the jack run:**

J= N x P(J)= 8,021 x .137= 1,096 jacks

4. **Estimate the adult run**: A=N-J= 8,021-1,096= 6,925 adults

Using a jack cutoff of <59 cm fork length, the Department estimates that the 2013 Chinook run in the Shasta River consisted of 1,096 jacks (13.7%) and 6,925 (86.3%) adults for a total run size of **8,021** Chinook salmon. This was confirmed by scale age analysis (KRTAT, 2014).

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, 2002-2013.

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%
AVERAGE			**8.2%**

Coho Salmon

A total of 147 coho salmon were observed passing upstream and 13 coho were observed passing downstream through the SRFCF from October 19, 2013 to December 8, 2013 (Figure 11). The net number of coho known to have entered and remained in the Shasta River prior to removal of the weir was 134. Because the weir was removed on December 9, 2013 following structural damage due to ice buildup, the video weir did not capture the entire coho migration period. There were an additional 30 PIT tagged coho (surplus coho released from IGH) detected going upstream through the PIT tag antennas located at the SRFCF after the removal of the weir between December 13, 2013 and January 23, 2014, for a season total of 164 coho. It is not known how many untagged coho may have entered the Shasta River following the removal of the weir.

In 2013, 866 surplus adult 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 21, 2013 and January 21, 2014. Fifty-six of these PIT tagged coho were detected by antenna arrays in the Shasta River. The number of days that elapsed between the release from IGH and the date of first detection in the Shasta River ranged from 1 to 53 days, with an average of 17 days. Of the 56 PIT tagged fish detected, all were detected at the arrays located furthest downstream near the SRFCF at RKM 0, 14 were also detected at RKM12 (RM 7.5) 4 at RKM 46 (RM 28.6), and 5 at RKM 51 (RM 31.7). One fish, a 70 cm female, was detected at the Bogus Fish Counting Facility and again, two days later, at the Shasta River RKM 0 antenna.

The proportions of hatchery-origin (HOR) and natural-origin (NOR) coho entering the Shasta River during the 2013-14 season were estimated by applying the observed clip rates from spawning ground survey and trap samples that were not PIT tagged to the unknown portion of the run. It was determined that 101, or 62% of the Shasta River coho run in 2013-14 were of hatchery origin.

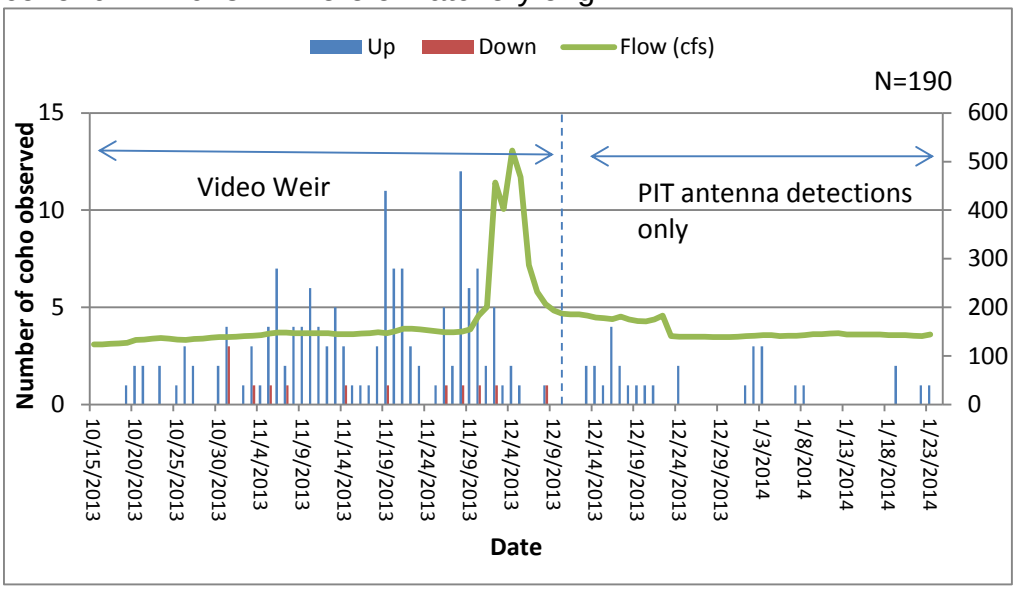

Figure 11. Run timing of coho salmon in the Shasta River during 2013-14 season. Weir was removed on 12/9/13 and subsequent antenna detections were of IGH-released PIT tagged coho.

The majority of redds identified as coho redds occurred on upper Parks Creek and on the main stem Shasta River between Parks Creek and Big Springs . Twenty-seven observations (20%) were made of upstream migrating coho with lamprey attachments as they passed through the SRFCF during the 2013-14 season.

Steelhead Trout

In 2013, a net total of 65 adult steelhead (70 upstream, 5 downstream) and 64 sub-adults or “half-pounders” (72 upstream, 8 downstream) were estimated to have entered and remained in the Shasta River during the video recording season from August 28, 2013 to December 9, 2013 (Figures 12 and 13). Lines on the back of the video flume were set at 16 inches (40.64 cm) to delineate sub-adults (half-pounders) versus adults. 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.

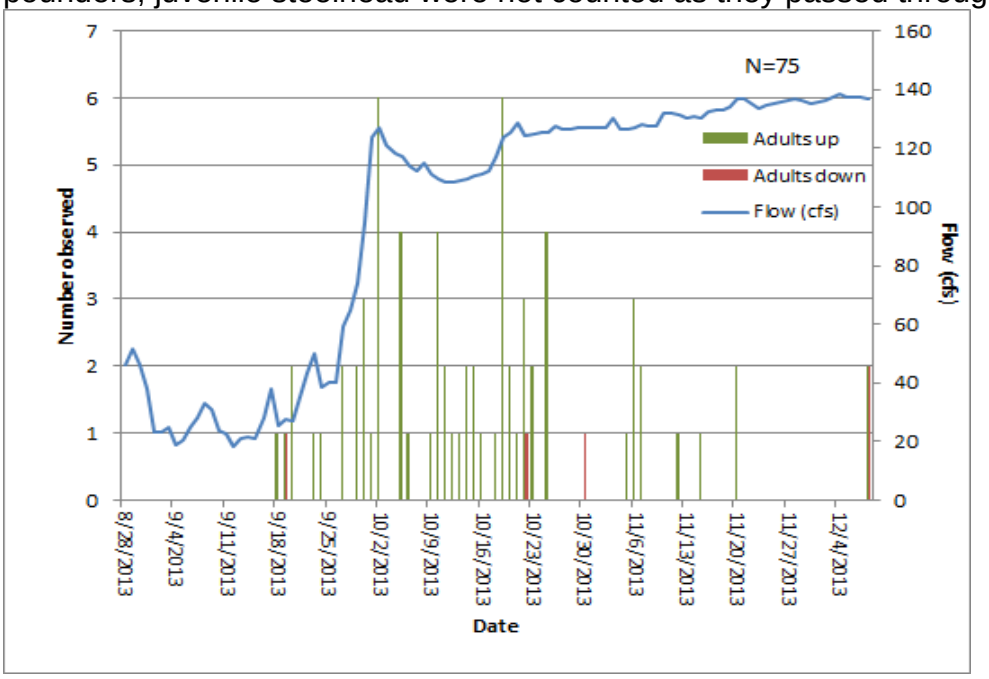

Figure 12. Adult (≥16”) steelhead trout observations through the Shasta River Fish Counting Facility during the 2013 season.

DISCUSSION

Chinook Salmon

The 2013 run of Chinook salmon (8,021) was 2,008 fish above the 36-year average of 6,013 (Figure 14). 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. Returns of Chinook grilse in 2011 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 and age 4 fish in 2013. By contrast, the brood year 2008 age class, which was represented by only 23 age three fish in 2011, was estimated to contribute only two age four fish in 2012 and zero age 5 fish in 2013. (KRTAT, 2014).

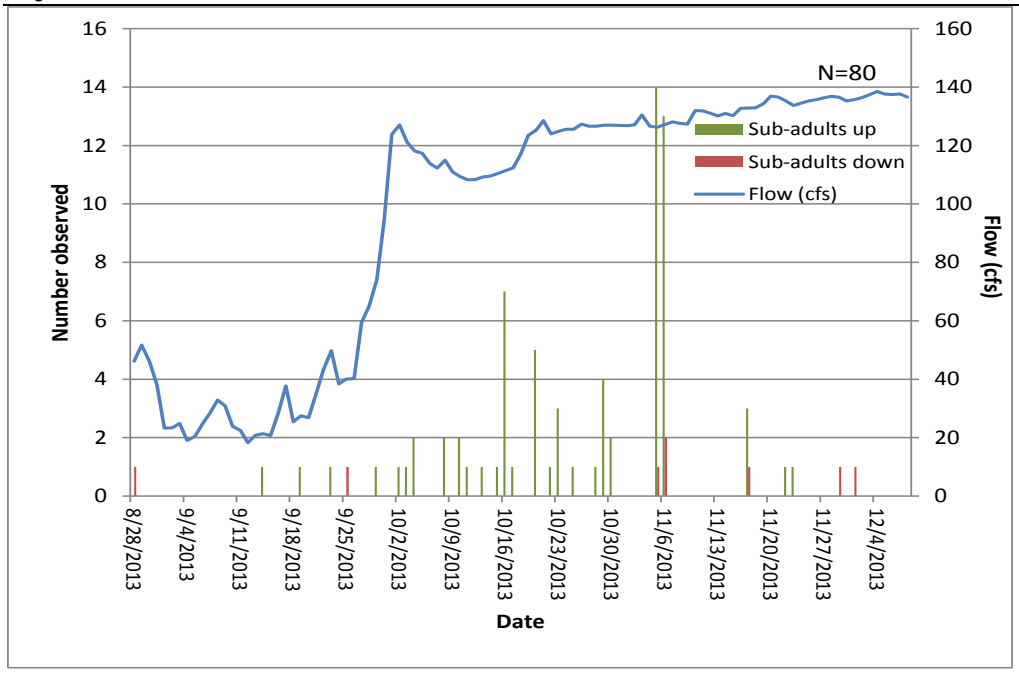

Figure 13. Sub-adult (<16") steelhead trout observations through the Shasta River Fish Counting Facility during the 2013 season.

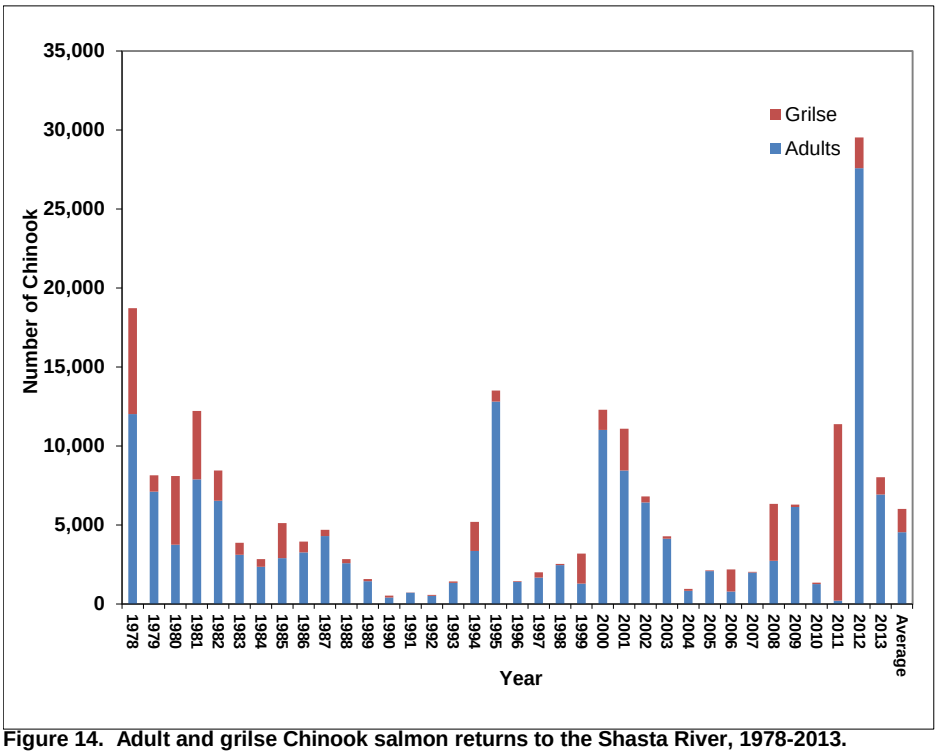

Figure 14. Adult and grilse Chinook salmon returns to the Shasta River, 1978-2013.

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 15), although the rate at which juvenile Chinook were produced from brood year 2012 was reduced when compared to previous seasons. 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 only went up 24% indicating that during 2012 capacity limitations may have been present.

Table 5. Age composition of Shasta River Chinook runs as determined by Klamath River Technical Advisory Team, 2002-2013.

Year	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
Average	1,638	4,113	975	56	5,143	6,781

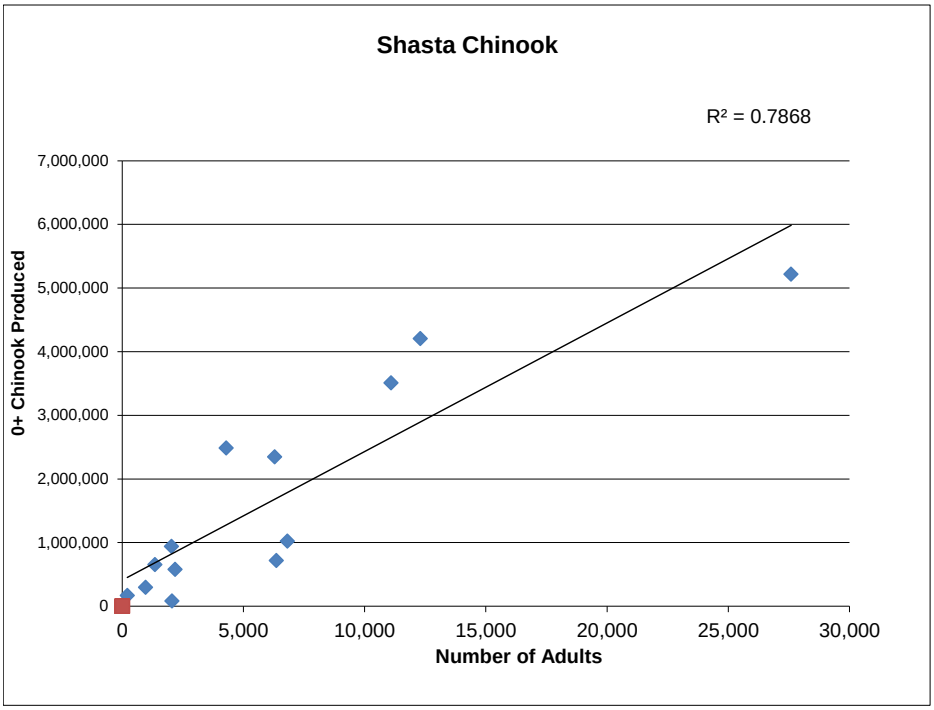

Figure 15. Number of 0+ Chinook produced per adult spawner in th Shasta River, Brood Years 2000-2012.

The Shasta River is an important component of the Klamath Basin Chinook run. The Shasta River has contributed an average of 10 percent of the basin-wide natural spawning escapement during the period from 1978 to 2013 (Table 6). A comparison of Shasta River escapement to Klamath Basin escapement is shown in Figure 16.

Table 6. Chinook natural spawner escapement to the Klamath Basin and Shasta River, and contribution of Shasta River to Basin escapement,1978-2013.

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%
Average	**62,022**	**6,014**	**10%**

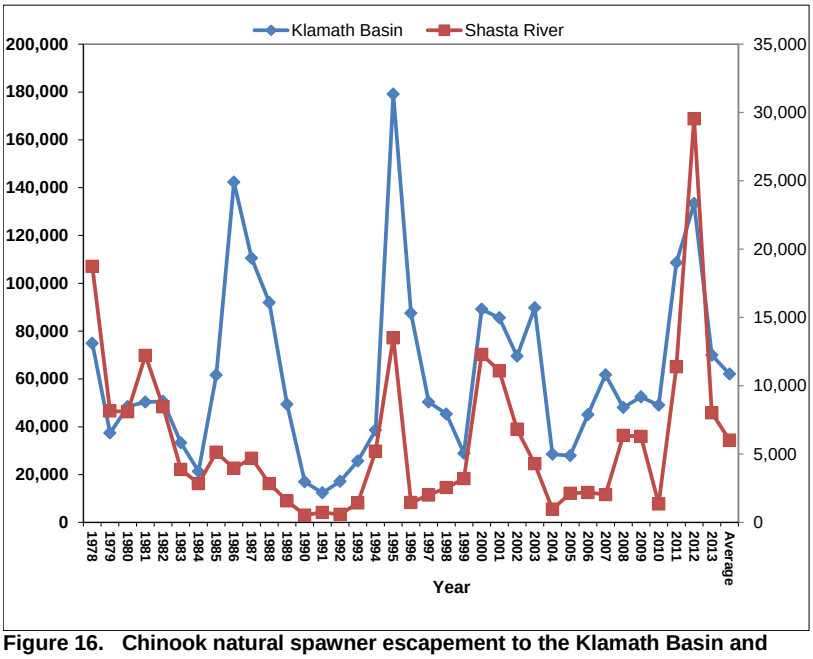

Figure 16. Chinook natural spawner escapement to the Klamath Basin and Shasta River, 1978-2013

Coho Salmon

Returns of coho to the Shasta River from 1978 to 2013 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 2007-2013 are shown in Figures 18-20 and in Table 7. In 2013, 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, in the trap and in the spawning ground survey.

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. Improved, genetically-based brood stock management practices at IGH are also intended to increase the genetic diversity and fitness of IGH coho and their progeny, so that the straying of IGH fish will benefit the Shasta River coho population and its recovery.

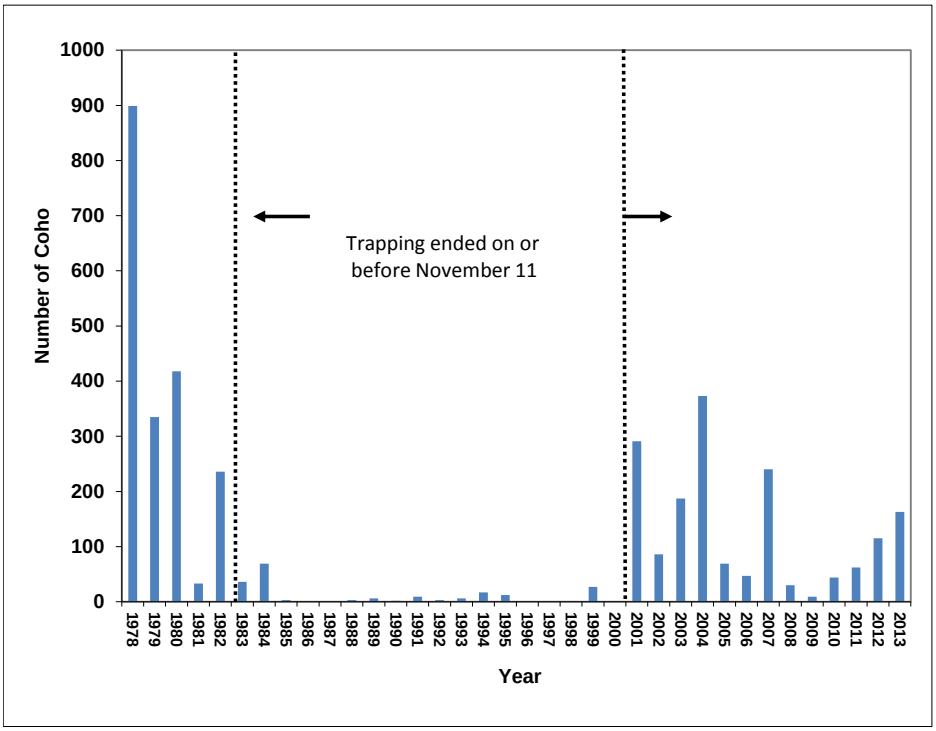

Figure 17. Returns of coho salmon to the Shasta River, 1978-2013.

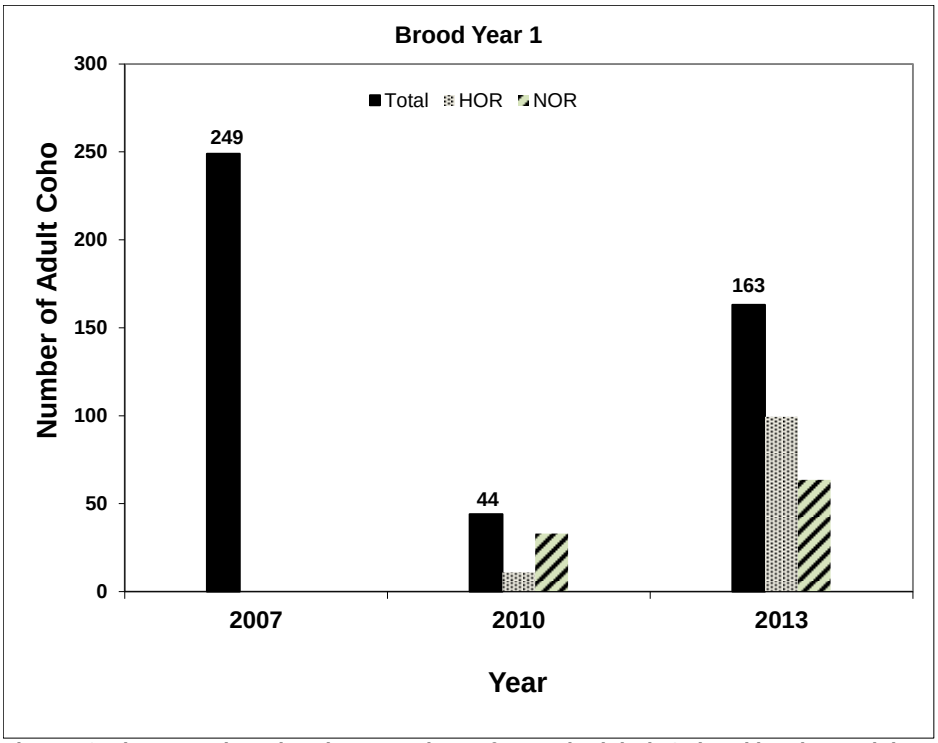

Figure 18. Three year brood cycle comparison of natural origin (NOR) and hatchery origin (HOR) coho salmon returning to the Shasta River from 2007through 2013. Due to low carcass recovery in 2007 hatchery contribution rate was not estimated.

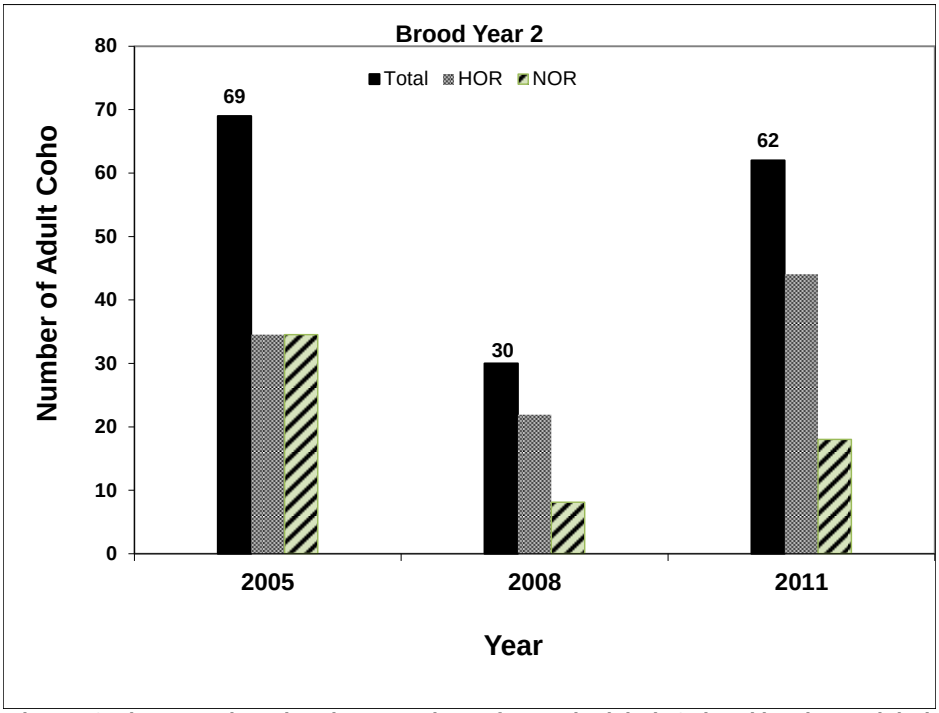

Figure 19. Three year brood cycle comparison of natural origin (NOR) and hatchery origin (HOR) coho salmon returning to the Shasta River from 2005 through 2011.

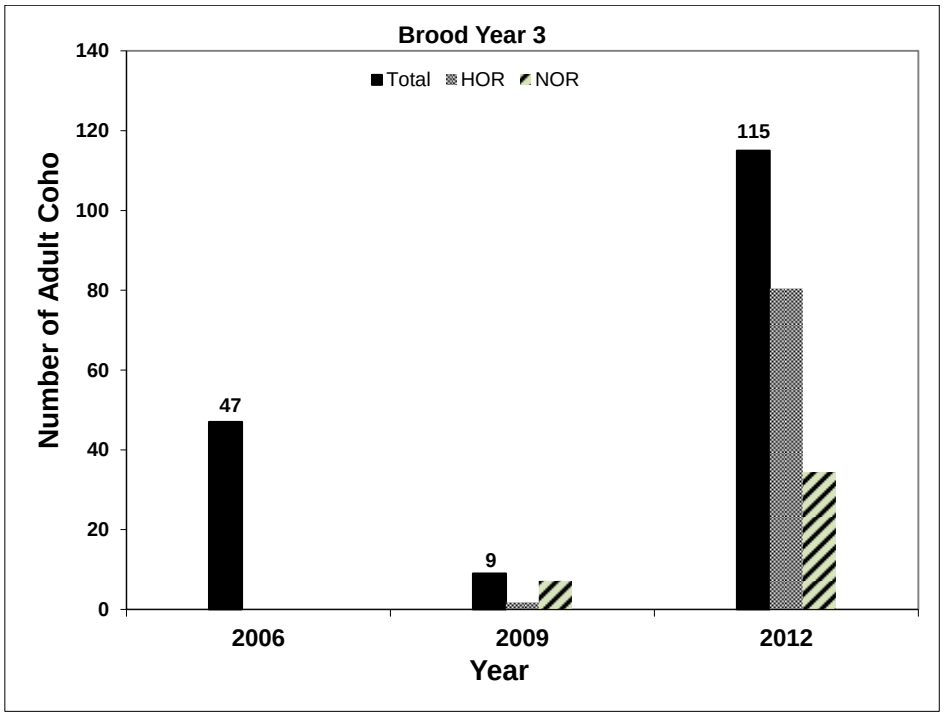

Figure 20. . Three year brood cycle comparison of natural origin (NOR) and hatchery origin (HOR) coho salmon returning to the Shasta River from 2006 through 2012. Due to low carcass recovery in 2006, hatchery contribution rate was not estimated.

Table 7. **Estimates of hatchery strays as percentage of coho entering the Shasta River, 2007-2013.**

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%
AVERAGE			**47%**
* in 2011-2013, surplus adult coho were PIT tagged and released after entering Iron Gate Hatchery			

Ongoing rotary trap operations at the mouth of the Shasta River 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). 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 2001-2010.

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%
/1 Adult estimate adjusted for estimated hatchery composition of Adult Years 2007-2013						

Analyzing the comparisons of estimated adult coho returns to yearling coho production estimates (Daniels et al 2013) 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 18.5 and ranged from a low of 2.1 to a high of 46.6 for

brood years 2001-2011 (Table 9As 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, tissue samples from all sampled coho were collected at the rotary screw trap located near the SRFCF and were 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 2001-2011.

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
Average				**18.5**

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 keep the video weirs, along with DIDSON (Dual Frequency Identification Sonar) camera units, in place in order to obtain a more complete count of steelhead in the Shasta River and other Klamath River tributaries

ACKNOWLEDGMENTS

KRP staff would like to thank Shasta River landowners for their cooperation in granting access to their properties. Special thanks to Bill Chesney for his ongoing efforts working with anadromous salmonids in the Shasta River watershed and graciously making the results of his juvenile monitoring available.

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