Shasta River
Chinook and Coho Salmon Observations in 2012
Siskiyou County, CA

Photo by Bill Chesney

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ABSTRACT

A total of **29,544** fall run Chinook salmon (Chinook**,** *Oncorhynchus tshawytscha*) were estimated to have entered the Shasta River during the 2012 spawning season, the biggest run since the Klamath River Project began monitoring in 1978. 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 21, 2012 until December 20, 2012. The first Chinook was observed on September 2, 2012 and the last Chinook on November 28, 2012. KRP staff also processed a total of 609 Chinook carcasses during spawning ground surveys, and a total of 104 (a systematic 1:10 sample) Chinook carcasses were collected as wash backs against the SRFCF weir during the season.

Chinook carcasses sampled in the spawning ground surveys ranged in fork length (FL) from 40 cm to 88 cm and grilse were determined to be < 60 cm in FL. Carcasses sampled as weir wash backs were checked for marks and clips, scales were taken, and sex and fork length information were collected. The run was comprised of 1,950 grilse (6.6%), and 27,594 adults (93.4%). A net total of 31 adipose-clipped (AD) Chinook were observed passing through the SRFCF during the season, and these fish were assumed to be of hatchery origin. The heads of 7 AD Chinook were recovered, 3 as wash backs on the weir and 4 in the spawning ground surveys. Six of the seven had positive CWT identification, and the seventh tag was unreadable. Tag codes indicated five 3 year old fish and one 4 year old fish. Five of the fish had been tagged at Iron Gate Hatchery and one, a 3 year old, was tagged and released from Trinity River Hatchery. Expansion of the 6 known tag codes and the 25 unknown tag codes based on proportions of coded wire tags (CWTs) recovered at Iron Gate Hatchery resulted in an estimated hatchery contribution of 126 Chinook, or 0.43% of the total run observed in 2012.

A net total of **115** coho salmon (coho, *Oncorhynchus kisutch*) were estimated to have entered the Shasta River during the 2012 season. The first coho of the season was observed passing through the SRFCF on October 10, 2012, and the last coho was observed swimming downstream through the SRFCF on November 29, 2012. The net number of coho to have entered and remained in the Shasta River in 2012 was **115.** Based on PIT tag detections and caudal punch and left maxillary clip observations, an estimated 81, or 70% of the coho salmon entering the Shasta River were of Iron Gate Hatchery origin.

A net total of 186 adult and 187 sub-adult steelhead trout **(***Oncorhynchus mykiss)* were observed passing through the SRFCF during the 2012 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 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 700 feet from the confluence of the Shasta and Klamath Rivers (Klamath River mile 176, Figure 1).

Video equipment was first installed at the SRFCF in 1998 and has been used to describe migration of Chinook into the Shasta River ever since. Although the primary responsibility of the KRP is to enumerate and describe Chinook salmon populations, data are recorded for other salmonid 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 2012.

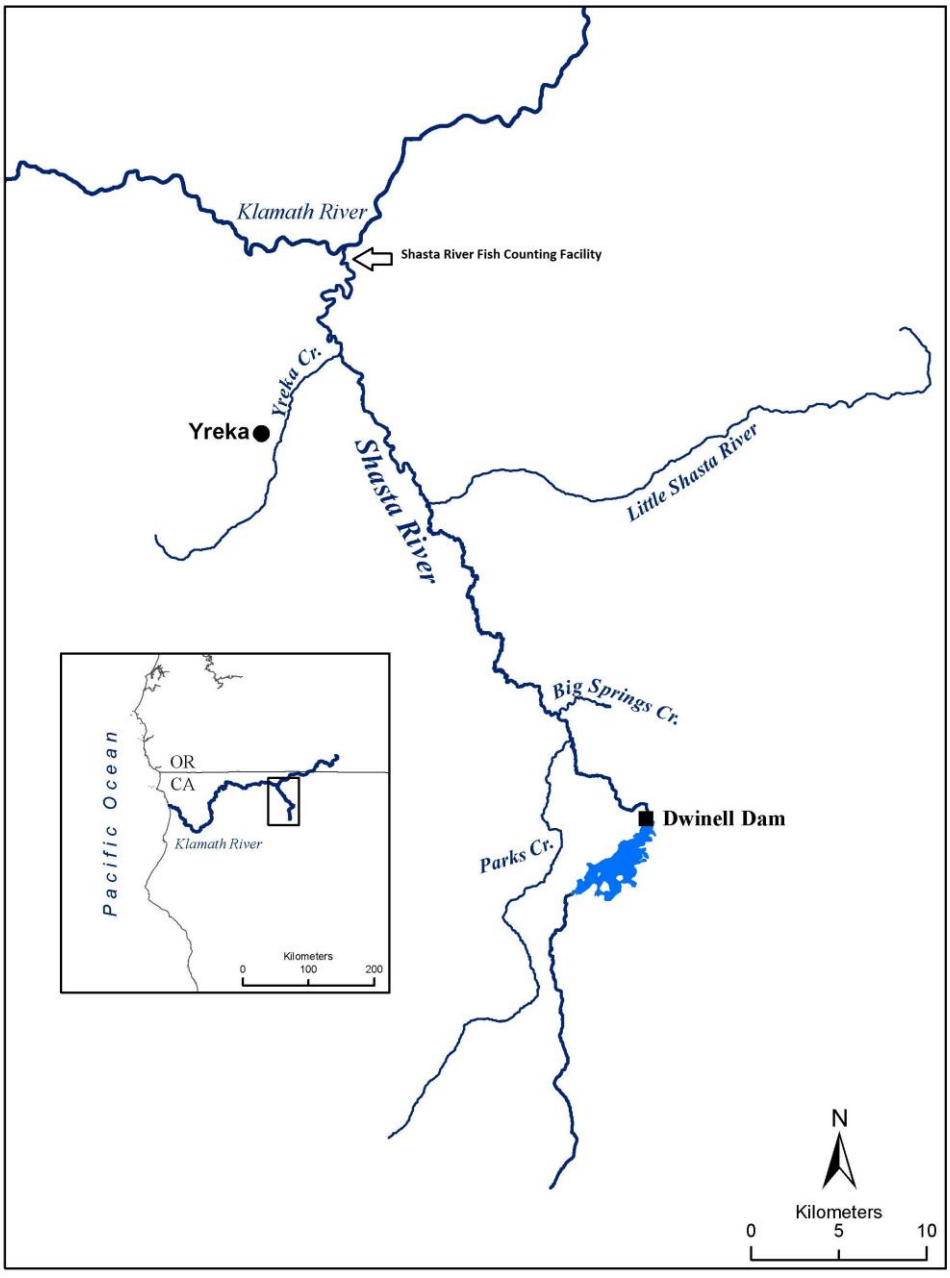

Figure 1. The Shasta River Watershed and location of Shasta River Fish Counting Facility (SRFCF).

METHODS

Monitoring of the salmon run within the Shasta River is 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.

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 (Figure 3). A SplashCam Delta Vision black and white underwater camera with a 3.6 mm wide angle lens was used in 2012 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.

Figure 3. Camera housing and flume, Shasta River Fish Counting Facility.

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

The weir and video camera were installed on August 20, 2012 and began recording on August 21, 2012. KRP staff performed routine daily maintenance of the SRFCF. Staff inspected the video system to ensure that everything was operating correctly, inspected and cleaned the weir panels and made any necessary repairs, and processed any wash-back carcasses present. Twice per week, on Mondays and Thursdays, 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 lampreys or any other distinguishable marks that were visible on the footage. Fish for which positive identification could not be made were recorded as "unknown" species, and were later re-checked by other project personnel. All data were then entered into files on a personal computer and each data file was edited 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 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. 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 17, 2012 and December 12, 2012. 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. 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, 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, tissue and otolith samples were collected when possible. Tissue samples were collected following protocol provided by the National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Science Center, and were provided to NOAA's Salmon Genetics Repository in Santa Cruz for future life history and stock identification purposes. Otoliths were collected following standard protocol and archived for future microchemistry analysis.

RESULTS

Operation of the SRFCF began on August 21, 2012 at approximately 14:01 hours, Pacific Standard Time (P.S.T.). The first Chinook of the season was observed on September 2, 2012 at 14:25 hours and the last Chinook was observed on November 28, 2012 at 16:01 hours (P.S.T.). The weir and recording equipment were removed on December 20, 2012 due to high in-stream flows.

Recording was disrupted between 0700 hours on November 30, 2012 and 1247 hours on December 10, 2012. During this period, conduit on the Alaskan weir was raised to protect weir integrity during high flows from a storm event, and recording was stopped. However, a DIDSON camera was deployed and recorded fish passage continuously for the entire period that the weir was compromised.

Chinook Salmon

A net total of 29,544 Chinook were counted passing upstream through the SRFCF during the 2012 season (Figure 4). This number was derived by subtracting the number of downstream observations (843) from the number of upstream observations (30,387). Fish are counted as downstream migrants if they enter the flume from the upstream end and exit at the downstream end. If fish enter the flume but back down without exiting on the upstream end, they are not counted.

Consistent with previous years' monitoring efforts, the majority of Chinook (96%) passed through the SRFCF during daylight hours between 07:00 and 18:00 hours (Figure 5).

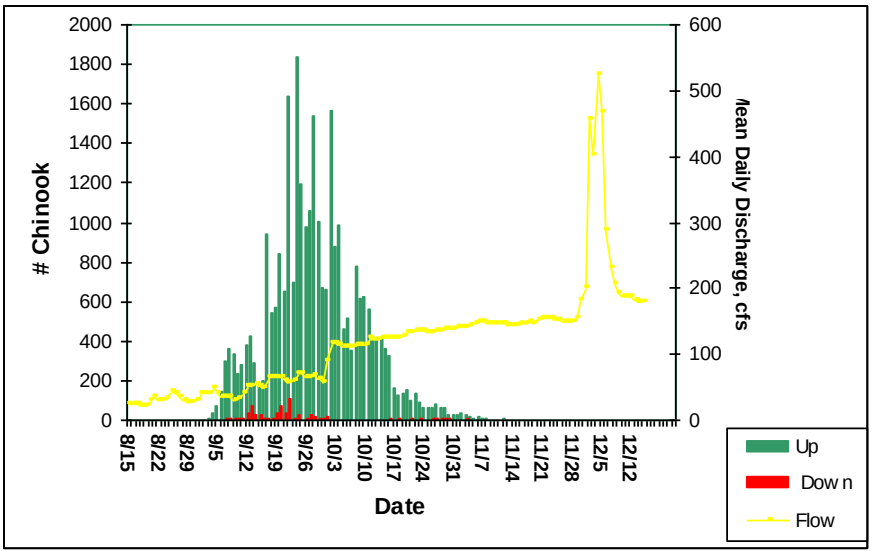

Figure 4. Run timing of and up/down movements of Chinook salmon at the Shasta River Fish Counting Facility in 2012, and flows observed at USGS Gauge No. 11517500

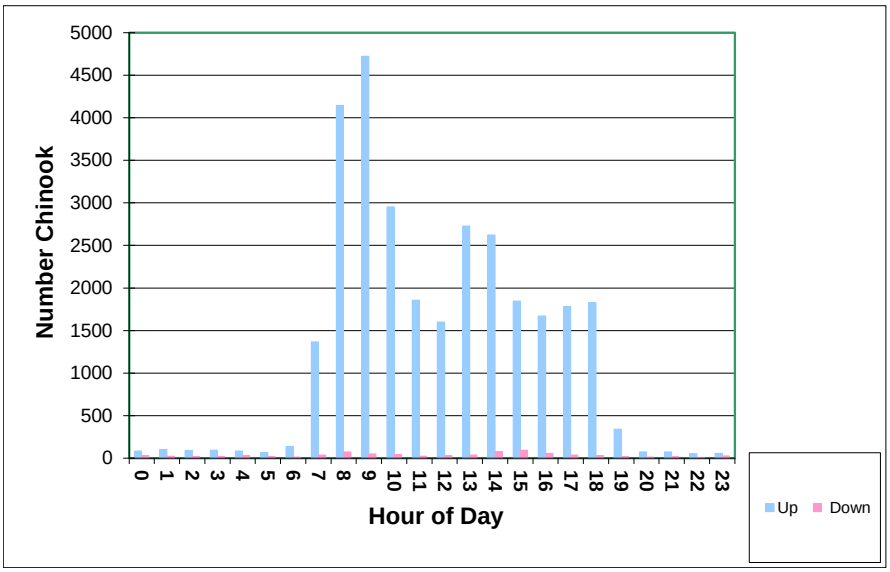

Figure 5. Diel run timing of Chinook salmon movement through the Shasta River Fish Counting Facility during the 2012 season.

A total of 2,709 Chinook (9% of the run) were recorded as having at least one live lamprey attached to their bodies. Of these, 174 Chinook had two lamprey attached, and 11 had three or more. 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. In many cases, lamprey attached to the right side of fish can be seen dangling below, above, or behind, these fish as they pass through the flume. As a result, the estimated number of fish observed with lamprey

attached likely underestimates the actual occurrence of lamprey attachments.

A net total of 31 AD Chinook were observed passing through the SRFCF during the season, and these fish were assumed to be of hatchery origin (Table 1). 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. The heads from seven AD Chinook were recovered from carcasses: 3 in the wash back sample and 4 from the spawning ground surveys. One of the wash back carcasses had an unreadable tag, and the other two originated from Iron Gate Hatchery: one was a four year old fish and the other a three year old fish, both released as fingerlings. Three of the spawning ground survey carcasses originated at Iron Gate Hatchery and were three year old fish released as fingerlings, and the fourth, recovered in the main stem upper Shasta River between Big Springs Creek and Parks Creek, was a three year old fish tagged at Trinity River Hatchery and released as a fingerling.

Expansion of these 6 CWTs by their production multipliers (the inverse of the proportion of each group of juveniles that were tagged) yielded an estimate of 24 hatchery origin Chinook. The remaining 25 AD Chinook were observed in the video flume but not recovered. An estimate of hatchery contribution was derived based on applying the proportion of CWT recoveries observed at Iron Gate Hatchery (IGH) to these 25 AD fish. Using this method a total of 102 additional hatchery origin Chinook were estimated to have entered the Shasta River during the 2012 run. This yields a total estimate of 126 hatchery Chinook, or 0.43% of the total run observed in 2012.

Spawning Ground Surveys

A total of 618 Chinook carcasses were sampled during spawning ground surveys. Of the 610 for which sex determinations were made, 354 (58%) were female and 256 (42%) were male. Fork lengths were determined for 609 of the carcasses recovered and are shown in Figure 6.

A total of 925 redds were observed during spawning ground surveys in 2012 (Table 2). Of these, 444 were seen in the canyon reaches and 481 in the Big Springs complex (Figure 7). The canyon reaches were not surveyed beyond 10/17/12 due to high flows, so canyon redds were not fully documented. Species determinations of the redds were not always possible, but one redd was observed with a live coho on it in the main stem Shasta River between Parks Creek and Hidden Valley Ranch on 12/12/2012.

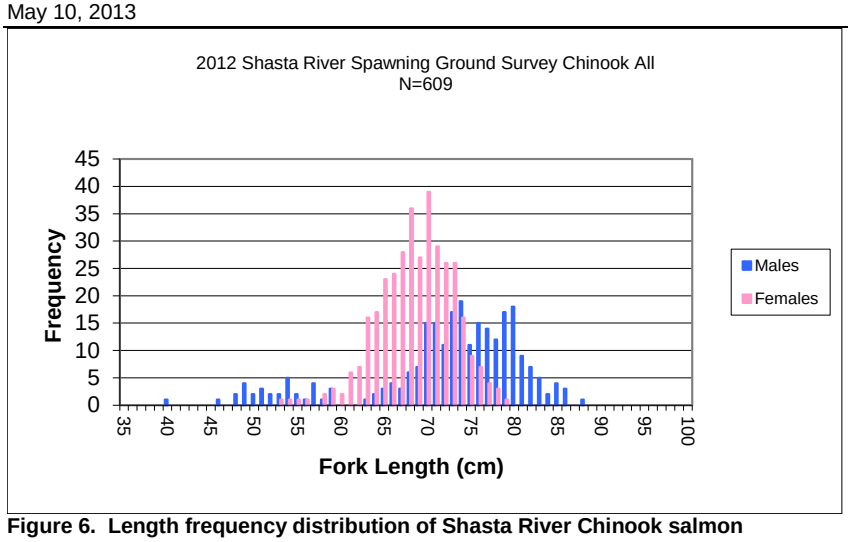

Figure 6. Length frequency distribution of Shasta River Chinook salmon sampled in spawning ground surveys conducted during the 2012 season.

Table 1. Estimated contribution of 31 AD-clipped Chinook salmon observed at the SRFCF in 2012 based on the number of CWT fish observed at IGH in 2012.

CWT	Brood Year	# CWTs Recovered at IGH	Proportion of CWTs recovered at IGH	Estimated Number	Production Multiplier	Expanded Estimate
68642	2008	12	0.001484414	0.03711	4.02	**0**
68643	2008	9	0.001113310	0.02783	4.02	**0**
68644	2008	34	0.004205839	0.10515	4.03	**0**
68645	2008	58	0.007174666	0.17937	4.02	**1**
68646	2008	67	0.008287976	0.20720	4.03	**1**
68647	2008	88	0.010885700	0.27214	4.06	**1**
68648	2008	143	0.017689263	0.44223	4.02	**2**
68661	2008	25	0.003092528	0.07731	4.02	**0**
68662	2008	29	0.003587333	0.08968	4.03	**0**
68818	2008	1	0.000123701	0.00309	4.05	**0**
68710	2009	1639	0.202746165	5.06865	4.02	**20**
68711	2009	1680	0.207817912	5.19545	4.01	**21**
68712	2009	1230	0.152152400	3.80381	4.04	**15**
68713	2009	1081	0.133720930	3.34302	4.17	**14**
68714	2009	901	0.111454725	2.78637	4.01	**11**
68715	2009	612	0.075705096	1.89263	4.04	**8**
68716	2009	260	0.032162296	0.80406	4.01	**3**
68720	2009	6	0.000742207	0.01856	4.29	**0**
68824	2009	1	0.000123701	0.00309	4.09	**0**
68837	2009	3	0.000371103	0.00928	4.03	**0**
68792	2010	54	0.006679861	0.16700	4.03	**1**
68793	2010	51	0.006308758	0.15772	4.17	**1**
68794	2010	45	0.005566551	0.13916	4.02	**1**
68795	2010	48	0.005937655	0.14844	12.17	**2**
68799	2010	7	0.000865908	0.02165	4.03	**0**
Totals		**8,084**	**1.000**	**25**		**102**
	Hatchery contribution of 25 unknown tag codes in Shasta River					**102**
	Expansion of 6 known tag codes in Shasta River					**24**
	Total estimated contribution of hatchery origin Chinook in Shasta River					**126**
Estimated number reduced to reflect percentage of heads recovered at IGH that contained wire						
Unreadable CWTs: 100000=no CWT, 200000=CWT lost, 400000=CWT unreadable						

Table 2. Number of live Chinook and coho salmon and redds observed by date during spawning ground surveys in the upper Shasta River, including the Big Springs area, in 2012.

Reach	Description of Reach	Date	# Live Chinook	# Live Coho	# New Redds	Comments
20	Main stem Shasta River, Parks Creek to Big Springs Creek	10/11/2012	125	0	70	
20		10/17/2012	206	0	24	
20		10/24/2012	86	0	10	
20		10/31/2012	79	0	2	
20		11/7/2012	33	0	24	
20		11/14/2012	27	0	10	
21	Big Springs Creek (upper bridge to mouth)	10/12/2012	95	0	79	
21		10/17/2012	149	0	38	
21		10/24/2012	130	0	33	
21		10/31/2012	60	0	49	
21		11/7/2012	35	0	20	
21		11/14/2012	6	0	18	
21		12/4/2012	6	3*	0	*recorded as possible coho
21		12/12/2012	0	0	0	
22	Main stem Shasta River, Parks Creek to Hidden Valley Ranch	11/21/2012	0	0	13	
22		11/28/2012	0	0	0	
22		12/12/2012	0	1	7	1 coho on redd
23	Lower Parks Creek to 2nd Fence	11/2/2012	12	0	0	
23		11/21/2012	0	0	0	
23		11/28/2012	0	0	0	high turbidity
		12/7/2012	0	0	0	
23		12/12/2012	0	0	0	high flow
24	Upper Parks Creek	11/21/2012	0	0	0	
24		11/28/2012	0	0	0	
24		12/7/2012	0	0	0	
24		12/12/2012	0	0	0	high turbidity

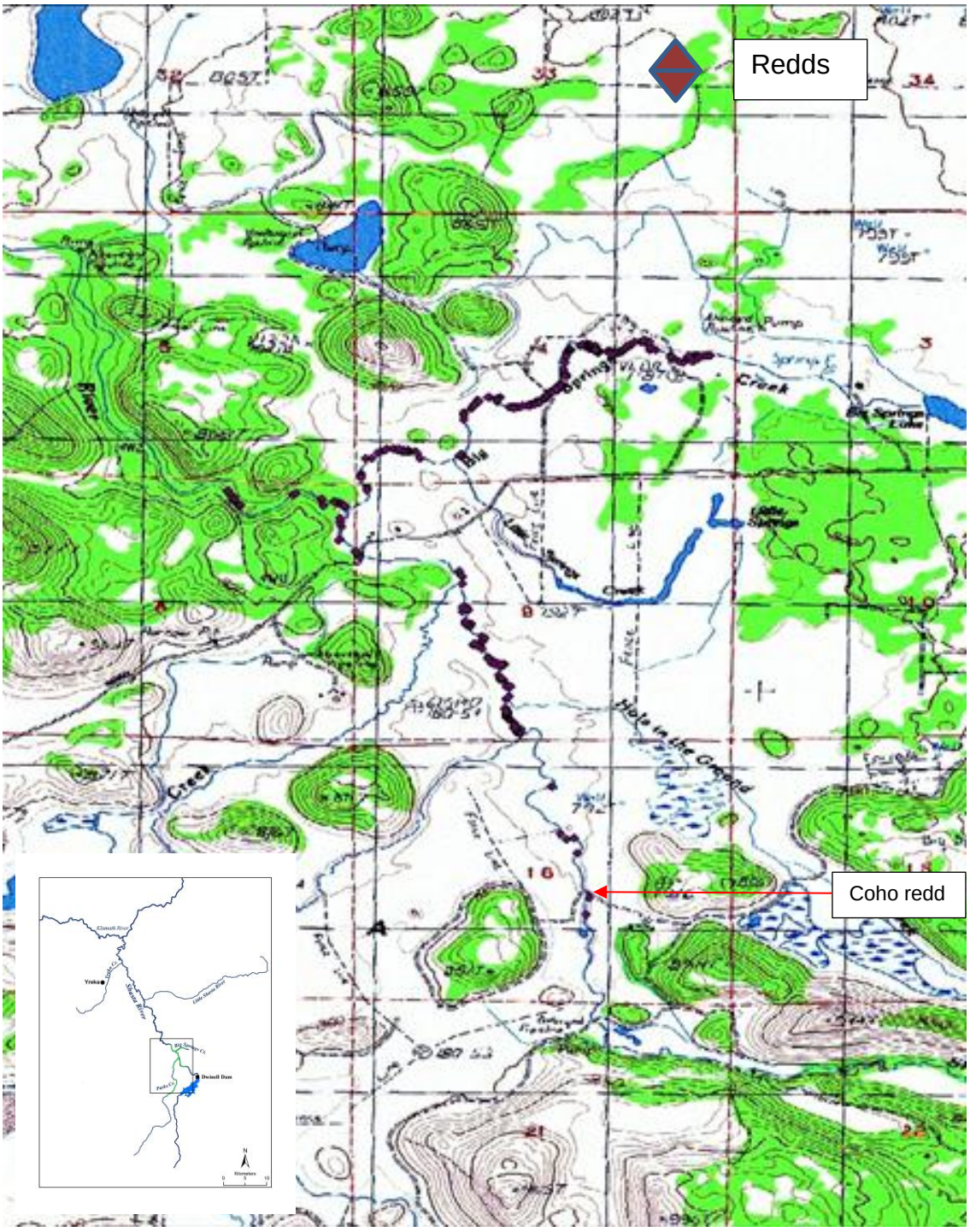

Figure 7. Redds observed in the Big Springs area of the Shasta River, 2012.

Wash backs

In 2012, a total of 1,040 Chinook carcasses were recovered as wash backs onto the weir, of which 104 were sampled (a one in ten systematic sample, plus all AD carcasses). Of the 104 carcasses sampled, 20 (19%) were females and 84 (81%) were male. Length frequency distribution of these samples are presented in figures 8 and 9. The wash back samples collected at the SRFCF have shown a heavy bias toward males (Table 3).

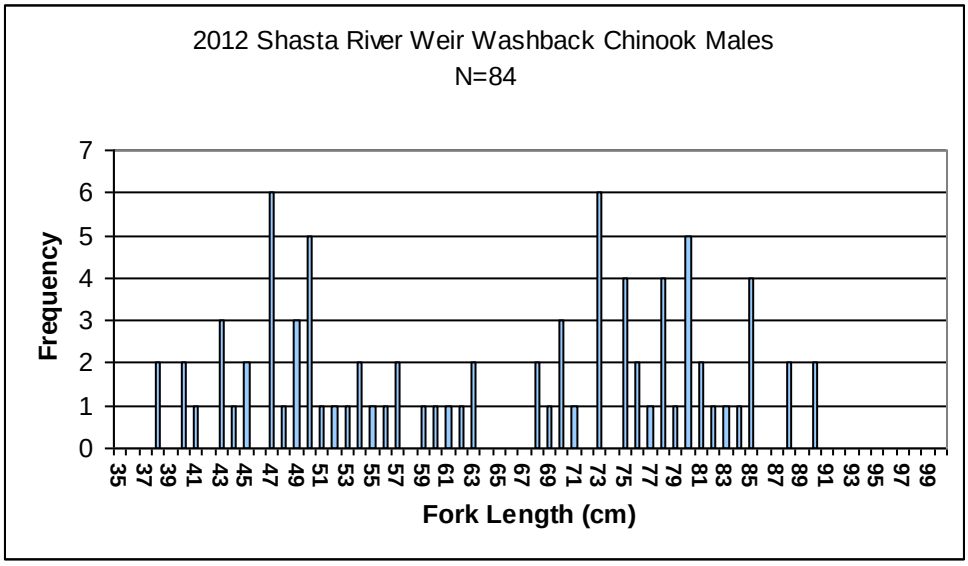

Figure 8. Length frequency distribution of Shasta River male Chinook salmon sampled as weir wash backs during the 2012 season.

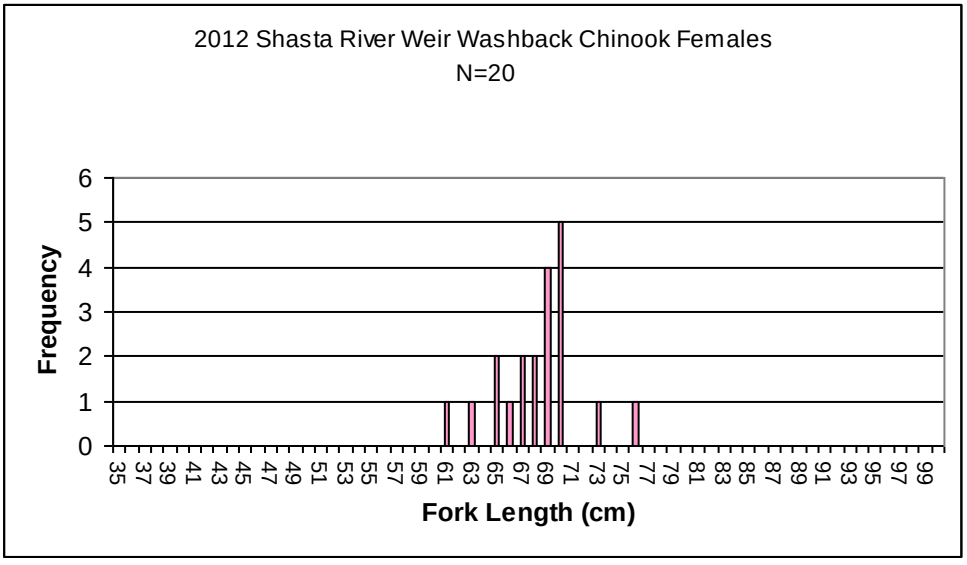

Figure 9. Length frequency distribution of Shasta River female Chinook salmon sampled as weir wash backs during the 2012 season.

Table 3. Sex composition of wash back carcasses sampled at Shasta River Fish Counting Facility, 2005-2012.

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

Grilse Cut-off

In 2012, the grilse cutoff and subsequent grilse/adult proportions of the Shasta River run were determined by scale age analysis. The 2012 run was comprised of 1,950 (6.6%) grilse and 27,594 (93.4%) adults for a total run size of **29,544** Chinook salmon (KRTAT, 2013). The KRP collected and provided a total of 817 scale samples from the Shasta River to the Yurok Tribe for ageing. Due to the sex bias present in the wash back samples only scales collected from spawning ground surveys were used for ageing purposes. Based on length frequency analysis of spawning ground survey carcasses, KRP staff determined that the nadir separating adults and grilse was <60 cm. FL.

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, 2002-2012.

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%
AVERAGE			**8.7%**

Coho Salmon

A total of 124 coho salmon were observed passing upstream and 10 coho were observed passing downstream through the SRFCF from October 10, 2012 to November 29, 2012 (Figure 10). After subtracting the 10 coho observed moving downstream through the SRFCF, and adding one fish estimated to have entered the river during the period of video equipment malfunction, the total number of coho that are known to have remained in the Shasta River is **115**.

In 2012, 342 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 17 and December 6, 2012. Fifty (50) 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 3 to 25 days, with an average of 11 days. Of the 50 pit tagged fish detected, all were detected at the arrays located furthest downstream near the SRFCF at RKM0, two were also detected at RKM12 (RM 7.5) and one at RKM 56 (RM 32.8). The array at RKM 7.5 was not installed, however, until November 18, 2012, and some of the coho released from IGH may have passed by that array undetected.

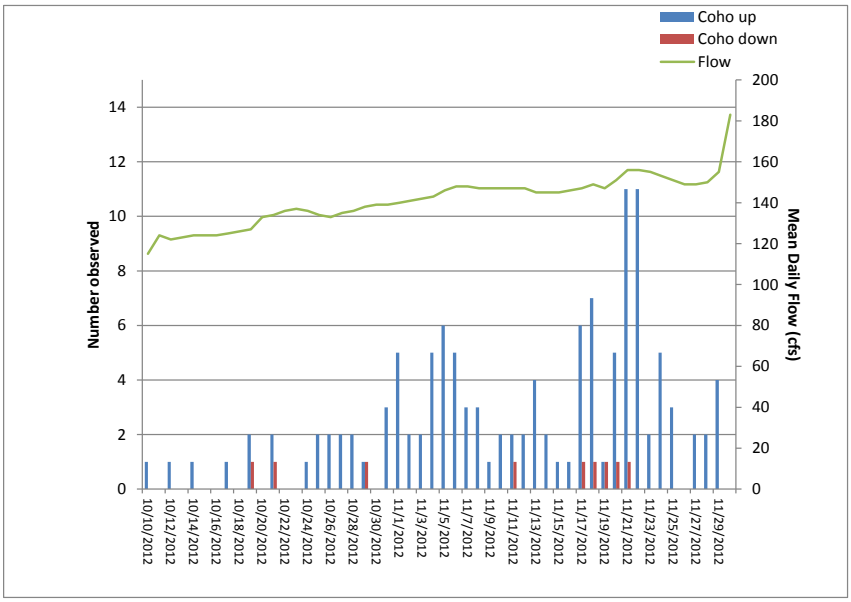

Figure 10. Run timing of coho salmon and mean daily flow measured in cfs near the mouth of the Shasta River during 2012 (USGS gauge 11517500)

Twenty-five observations were made of upstream migrating coho with lamprey attachments as they passed through the SRFCF, and of these, four were observed with at least two lamprey attachments.

Steelhead Trout

In 2012, a net total of 186 adult steelhead (211 upstream, 25 downstream) and 187 sub-adults (217 upstream, 30 downstream) were estimated to have entered and remained in the Shasta River during the video recording season from September 16, 2012 to November 30, 2012 (Figures 11 and 12). Lines on the back of the video flume were set at 16 inches (40.64 cm) to delineate sub-adults versus adults.

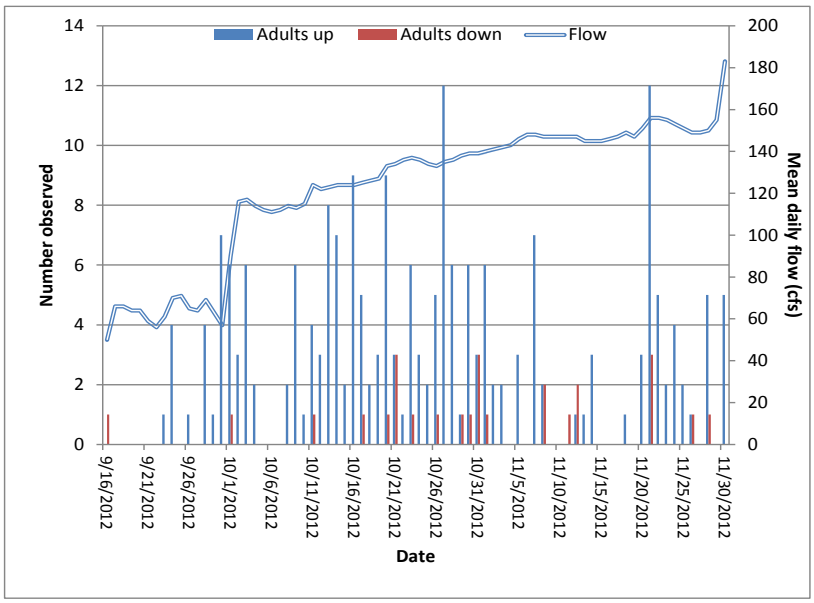

Figure 11. Adult (≥16") steelhead trout observations through the Shasta River Fish Counting Facility and mean daily flow measured in cfs near the mouth of the Shasta River during 2012. (USGS gauge 11517500).

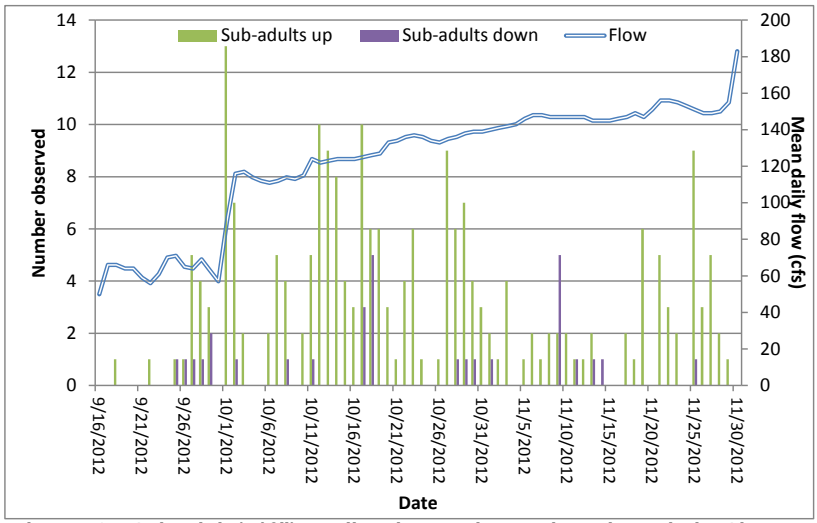

Figure 12. Sub-adult (<16") steelhead trout observations through the Shasta River Fish Counting Facility and mean daily flow measured in cfs near the mouth of the Shasta River during 2012. (USGS gauge 11517500).

DISCUSSION

Chinook Salmon

The 2012 run of Chinook salmon into the Shasta River was the largest since the KRP began monitoring escapement at its current site in 1978. The average run size from this period is 5,956, and has ranged from a low of 533 fish in 1990 to a high of 29,544 fish in 2012 (Figure 13). Prior to 1978, runs of Chinook were monitored at the Shasta Racks (site of the SRFCF) beginning in 1934. This shows that the 2012 run was the largest since 1963 (Figure 14). Returns of Chinook grilse in 2012 were the highest on record for the Klamath Basin (58%), and returns of grilse to the Shasta River were also the highest on record with 11,175, 98 percent of the total run (Figure 15). That strong age class (brood year 2009) was again seen in the large return of age 3 fish in 2012. 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 (KRTAT, 2013).

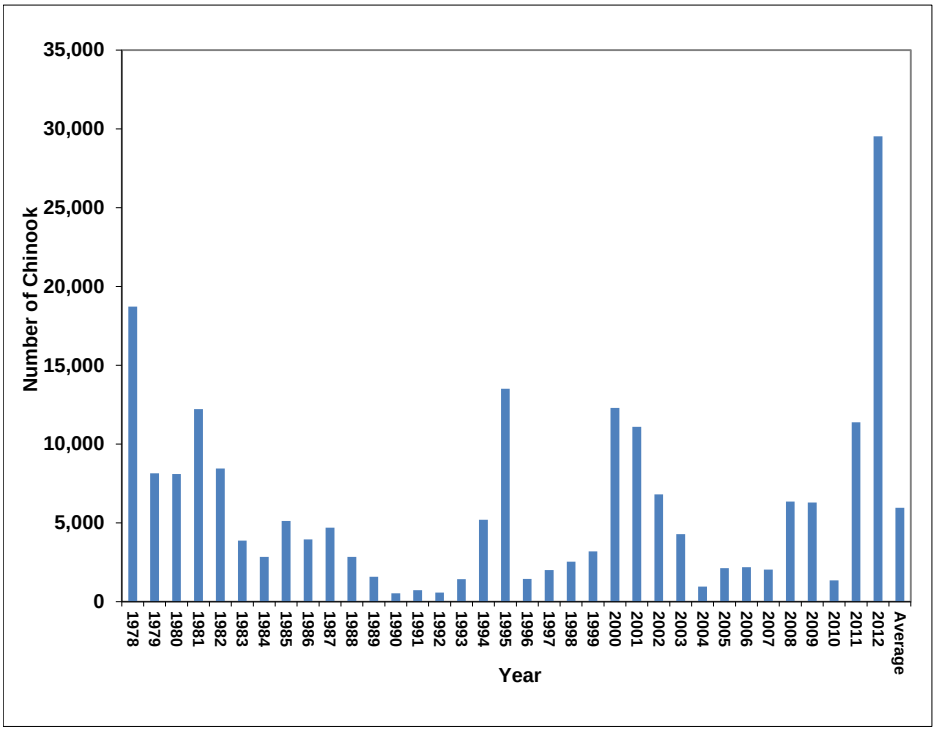

Figure 13. Chinook salmon returns to the Shasta River, 1978-2012.

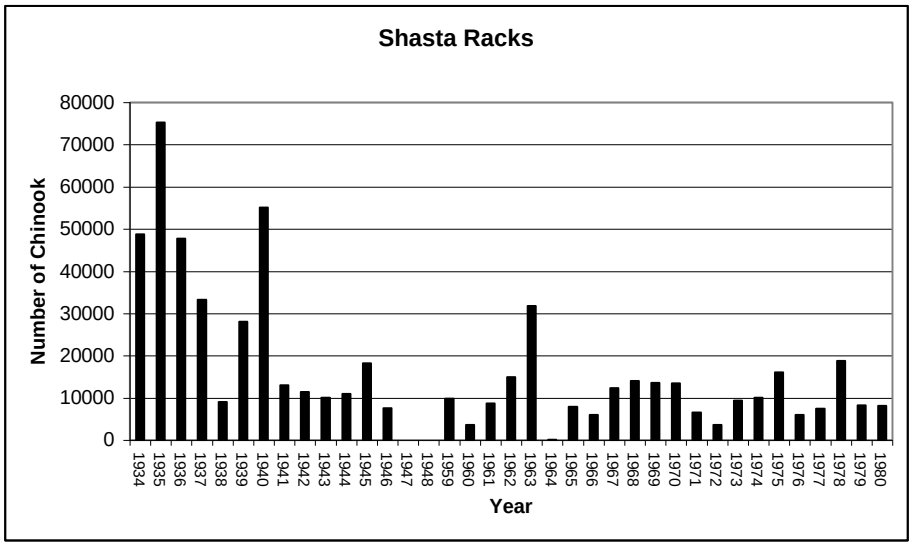

Figure 14. Chinook salmon returns to the Shasta River, 1934-1980

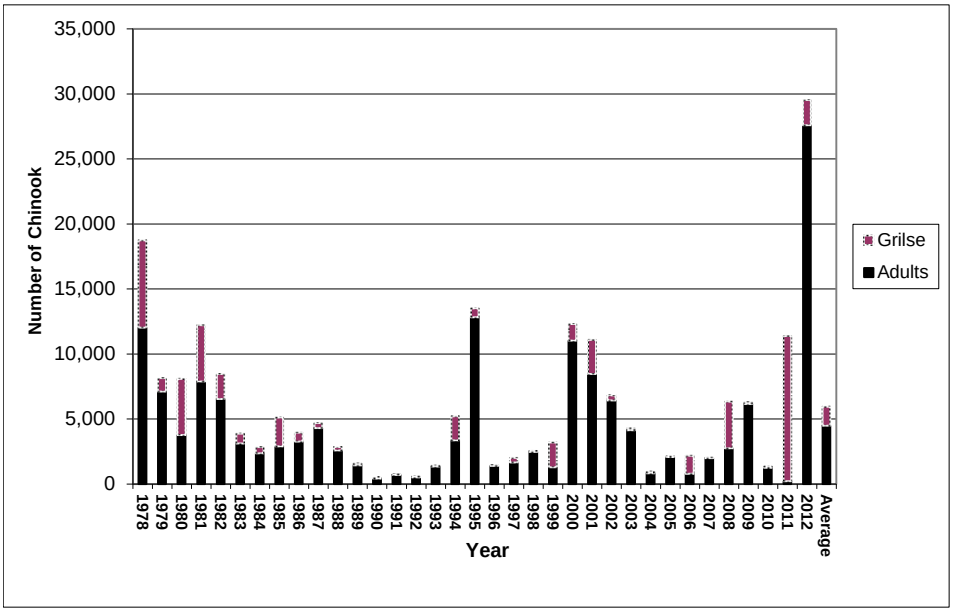

Figure 15. Chinook salmon adult and grilse returns to the Shasta River, 1978-2012.

In 2011, the run of Chinook salmon to the Shasta River was relatively large at 11,388, yet only 110 Chinook redds were detected in the surveyed reaches of the Shasta River. This may be explained by the low abundance of adult females (114) estimated during the 2011 run. In contrast, the number of redds observed in 2012 was 925. This is not a

complete count of redds in the Shasta River, however, but a comparison between the two years in index reaches. Using the 58% female ratio observed in the spawning ground surveys in 2012, the number of adult female Chinook returning to the Shasta River was estimated to be 17,135. After 10/17/2012, survey efforts were restricted to the Big Springs complex, so the number of redds in the canyon were likely underestimated. Historically, more redds are observed in the canyon reaches of the Shasta River than in the upper (Big Springs Complex) reaches.

Exceptionally high survival of brood year 2009 throughout all life stages appears to have contributed to the large return of age three Chinook salmon to the Shasta River in 2012. 2013 rotary trap operations currently underway are reporting record numbers of 0+ Chinook emigrating from the Shasta River (at the end of Julian Week 12, ending March 25, 2013, 0+ Chinook numbers in 2013 were 24 times those of 2012) (Bill Chesney CDFW file, 2013.)

Data from brood years 2000 through 2011 indicate the river's current habitat conditions continue to produce more 0+ Chinook as more adults return, indicating that the watershed may not have not reached a "saturated level" or "carrying capacity" for Chinook salmon (Figure 16). As the estimate of 0+ Chinook produced for brood year 2012 becomes finalized this relationship may be challenged as 2.4 times the number of adults returned in brood year 2012 compared to brood year 2000, the previous adult high for the period of record.

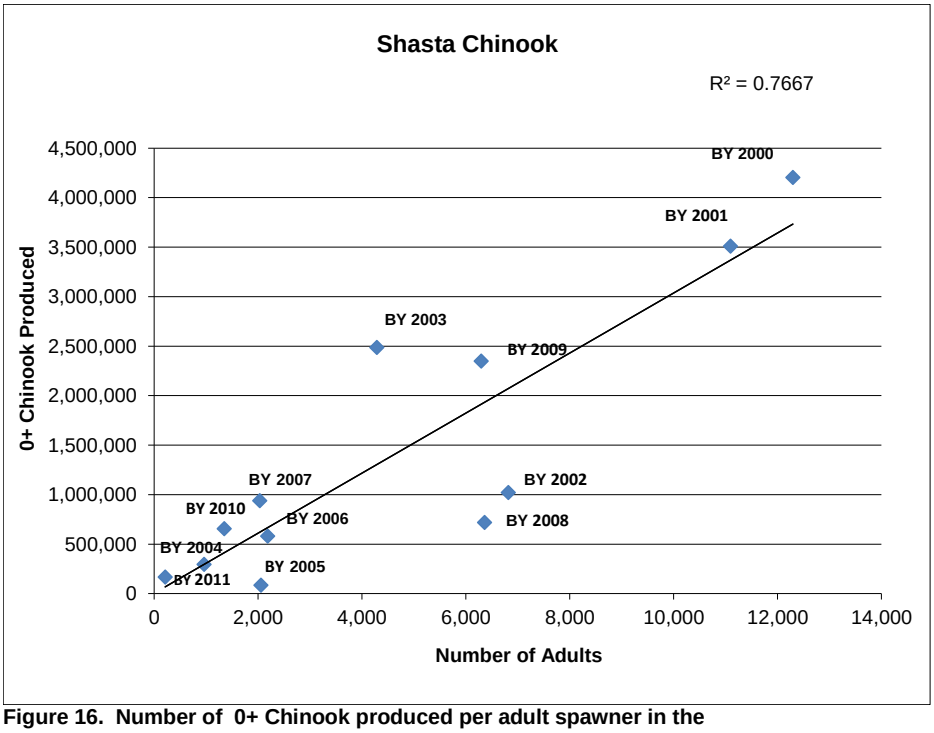

Figure 16. Number of 0+ Chinook produced per adult spawner in the Shasta River, Brood Years 2000-2010.

Each year the Klamath River Technical Advisory Team (KRTAT) determines the age composition for Chinook salmon populations that return to the Klamath River and its tributary streams. These analyses are based on both length frequency distributions and results of scale age analysis conducted for each sub-basin within the Klamath River watershed. The data are used in a Klamath River Ocean Harvest Model to estimate age specific ocean abundance and develop harvest management options for the following season. A summary of the age composition determinations for Shasta River Chinook salmon are provided in Table 5.

Table 5. Age composition of Shasta River Chinook runs as determined by Klamath River Technical Advisory Team, 2002-2012.

	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

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 2012 (Table 6).

Coho Salmon

Since 2001, the KRP has operated the SRFCF beyond the Chinook salmon migration period in an effort to better document coho returns in the Shasta River. Returns of coho to the Shasta River from 1978 to 2012 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 2007-2012 are shown in Table 7. In 2012, 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.

Table 6. Chinook natural spawner escapement to the Klamath Basin and Shasta River, and contribution of Shasta River to Basin escapement, 1978-2012.

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	110,554	11,388	10%
2012	137,723	29,544	21%
Average	**61,975**	**5,956**	**10%**

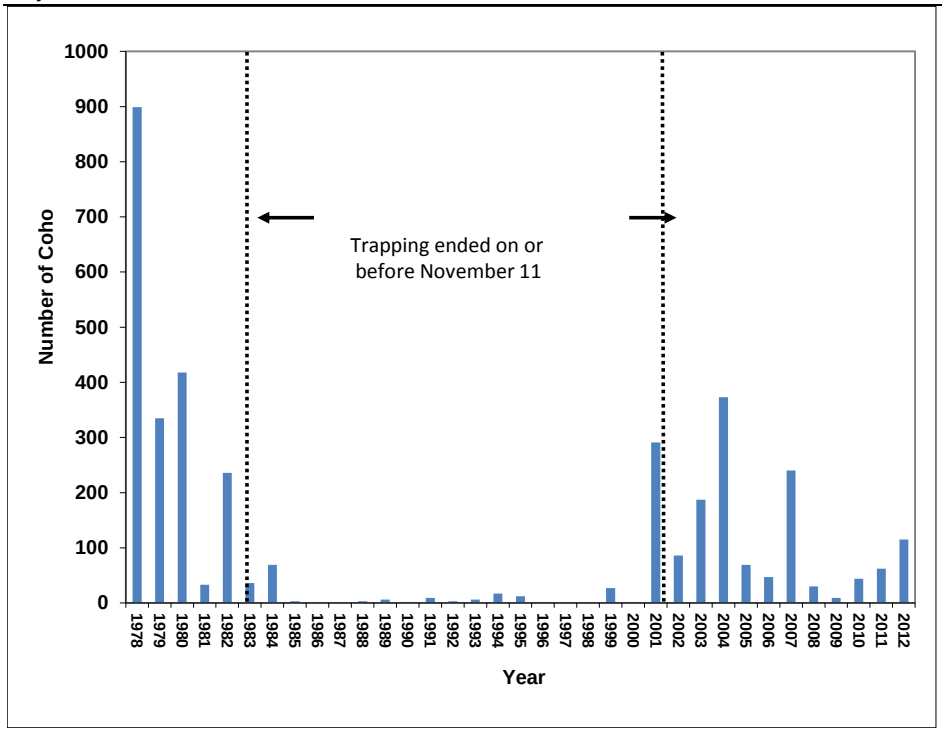

Figure 17. Returns of coho salmon to the Shasta River, 1978-2012.

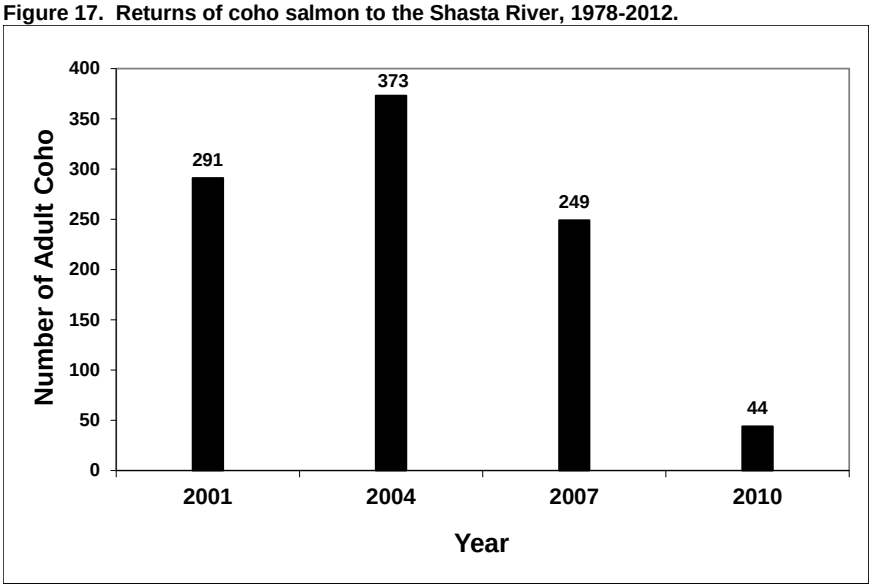

Figure 18. Returns of Shasta River coho cohort 1

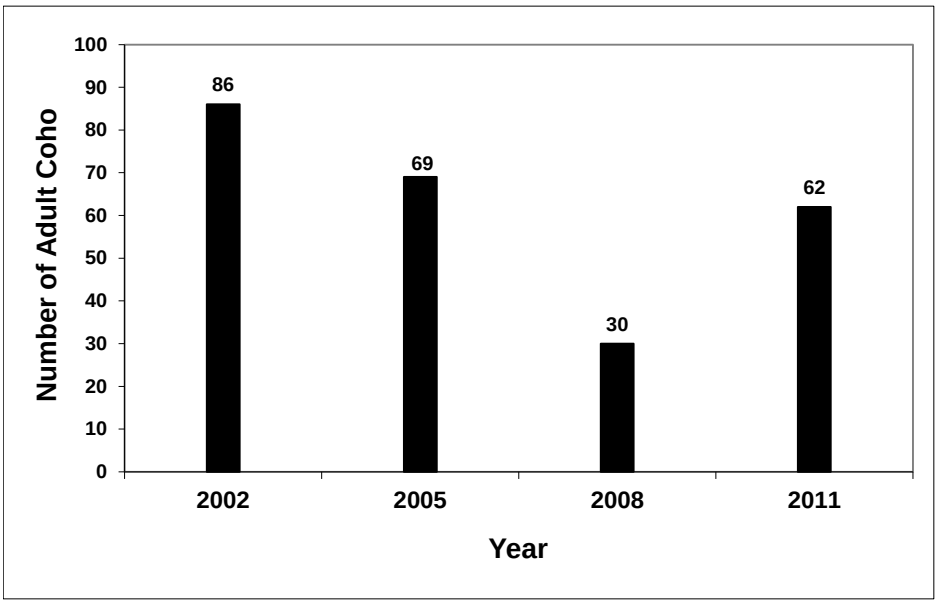

Figure 19. Returns of Shasta River coho cohort 2

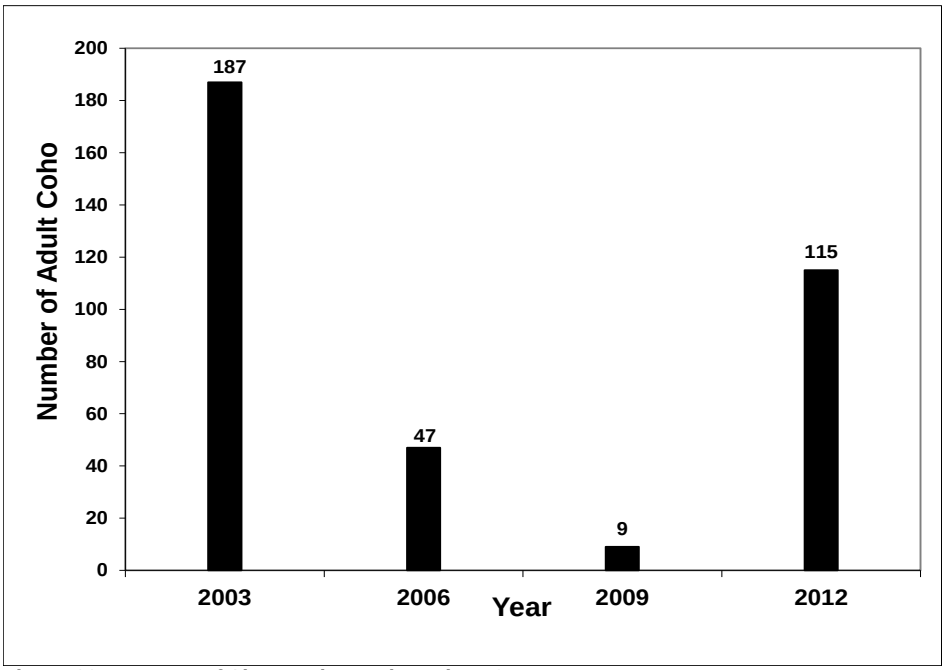

Figure 20. Returns of Shasta River coho cohort 3.

Table 7. Estimates of hatchery strays as percentage of coho entering the Shasta River, 2007-2012.

Year	Total Number of Coho	Hatchery Stray Estimate	Percent Hatchery
2007	249	5	2%
2008	30	22	73%
2009	9	2	20%
2010	44	11	25%
2011*	62	44	71%
2012*	115	81	70%
AVERAGE			**43%**
* In 2011 and 2012, adult coho were pit tagged and released after entering Iron Gate Hatchery			

One of the recommendations of the draft Hatchery and Genetic Management Plan (HGMP) for Iron Gate Hatchery (prepared as part of CDFW's Section 10 application for management of listed species as part of hatchery operations) is that coho in excess of the hatchery's brood stock needs be released alive into the Klamath River at the IGH spawning building. Escapement of these released salmon into the Shasta River may explain the reversal of the downward trajectory of cohorts 2 and 3 (Figures 19 and 20). Cohort 1, the strongest of the year classes, will return in the fall of 2013. It appears that IGH-origin coho salmon have contributed, and continue to contribute significantly to the coho escapement in the Shasta River.

What is not clear at this time is the spawning success of coho salmon that enter IGH, and are released and swim up the Shasta River. During 2012 in Bogus Creek, which is located less than one river mile from IGH, 66% of the recovered female coho that entered the hatchery, and were released died without having spawned (M. Knechtle, pers. comm.) In future years, genetic analysis of juvenile coho leaving the Shasta River may help further the understanding of the contribution of hatchery origin coho to the Shasta River population.

During the 2012 spawning ground surveys, the only live coho observed on a redd occurred in the mainstem Shasta River between Parks Creek (RM 32) and Hidden Valley Ranch (RM 34), the same reach in which two live coho were observed on a redd in 2011. The Department first gained access to the uppermost survey reaches of the Shasta River in 2010, and each subsequent year has furthered the understanding of the spawning distribution of coho salmon.

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.

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 2001-2009.

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%

/1 Adult estimate adjusted for estimated hatchery composition of Adult Years 2007-2012

Analyzing the comparisons of estimated adult coho returns to yearling coho production estimates (Chesney et al 2010) 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 19.5 and ranged from a low of 0.2 to a high of 46.6 for brood years 2001-2010 (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, tissue samples from all sampled coho are being collected at the rotary screw trap located near the SRFCF and will be 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 2001-2010.

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
Average				**19.6**

STEELHEAD TROUT

The objectives of the KRP have traditionally focused on monitoring the escapement of Chinook, and more recently coho salmon. However, in 2011 the project acquired a DIDSON (Dual Frequency Identification Sonar) camera unit which was deployed during periods of high flow when weir integrity was compromised in 2011 and 2012. It is hoped that the data acquired from these units will enable more complete counts of fall and winter-run steelhead in future years, as well as comparison between years in order to better understand the population trends of Shasta River steelhead trout.

ACKNOWLEDGMENTS

KRP staff would like to thank Shasta River landowners for their cooperation in granting access to their properties, and James Adams, Rosa Albanese, Mary Daniels, Seth Daniels, Chris Diviney, Molly Gorman, Donn Rehberg, Kristen Sellmer, Rebecca Swanz, Kirsten Underwood and Karly Wagner for their diligence in conducting spawning ground surveys in 2012. KRP staff would also like to specifically thank 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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