Shasta River
Chinook and Coho Salmon Observations in 2010-2011
Siskiyou County, CA

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Shasta River Fish Counting Facility, Chinook and Coho Salmon Observations in 2010 Siskiyou County, CA

ABSTRACT

A total of **1,348** Chinook salmon (Chinook, *Oncorhynchus tshawytscha*) were estimated to have entered the Shasta River during the 2010 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 31, 2010 until December 17, 2010. The first Chinook was observed on September 5, 2010 and the last Chinook on December 6, 2010. KRP staff also processed a total of 25 Chinook carcasses during spawning ground surveys, and a total of 122 Chinook carcasses were collected as wash backs against the SRFCF weir during the season.

Sampled Chinook carcasses ranged in FL from 34 cm to 98 cm and grilse were determined to be < 62 cm in FL. The run was comprised of 78 grilse (5.8%), and 1,270 adults (94.2%). A net total of 14 adipose-clipped (AD) Chinook were observed passing through the SRFCF during the season, and these fish were assumed to be of hatchery origin. The head of one AD Chinook was recovered in the wash back sample, and the coded wire tag indicated the fish was a three-year old (BY 2007) tagged at Iron Gate Hatchery (IGH) and released as a smolt. Expansion of the known tag code and the 13 unknown tag codes based on proportions of coded wire tags (CWTs) recovered at Iron Gate Hatchery resulted in an estimated hatchery contribution of 157 Chinook, or 11.6% of the total run observed in 2010.

A net total of **44** coho salmon (coho, *Oncorhynchus kisutch*) were estimated to have entered the Shasta River during the 2010-11 season. The first coho of the season was observed passing through the SRFCF on October 26, 2010, and the last coho was observed swimming upstream through the SRFCF on December 16, 2010. A total of 48 coho were observed passing upstream through the SRFCF and 5 coho were observed passing downstream, for a net of 43 coho known to have remained in the Shasta River. In addition, one coho was added for a period of time during which the video camera was not functioning, using an average of coho observed 2 days prior to and 2 days following the camera down time. The net number of coho to have entered and remained in the Shasta River in 2010 was **44.**

A net total of **131** adult steelhead (144 upstream, 13 downstream) and 259 half- pounders (293 upstream, 34 downstream) were estimated to have entered and remained in the Shasta River during the video recording season of 2010.

INTRODUCTION

The Klamath River Project (KRP) of the California Department of Fish and Game (Department) is responsible for estimating the number of fall-run 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.

Video equipment was first installed at the Shasta River Fish Counting Facility (SRFCF) in 1998 and has been used to describe migration of fall-run Chinook into the Shasta River ever since. Although the primary responsibility of the KRP is to enumerate and describe fall-run Chinook salmon populations, data is recorded for other salmonid species observed at the SRFCF during its period of operation as well.

In 2004 the California Fish and Game Commission proposed to add coho populations between San Francisco and Punta Gorda (Central California Coast ESU) to the state's list of Endangered Species and those between Punta Gorda and the northern border of California, including the Klamath River, (Southern Oregon/Northern California Coast ESU) to the list of Threatened Species (Walsh and Hampton, 2007). Since that time, the KRP has operated its SRFCF video system through December, 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 and coho salmon runs that entered the Shasta River during the fall of 2010.

METHODS

Monitoring of the salmon run within the Shasta River is accomplished through four primary efforts: operation of a video weir, operation of a trap connected to the upstream end of the video flume, 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 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 1). Fish immigrating upstream are directed through a narrow flume, which passes in front of an underwater video camera. The camera is connected to a time lapse video recorder and monitor. A JVC digital color video camera (Model No TK-C92OU) equipped with a 5 – 50mm 1:1.3 Computar lens was used at the SRFCF until mid-December, when it was exchanged for a Delta Vision Color Underwater SplashCam camera in anticipation of high flows. This submersible camera can continue to record even if the camera box is flooded by high water. An Everfocus EDSR 100H digital video recorder (DVR) with a Seagate 250 hard drive in a swappable Everfocus DTLA 250F tray were used for recording.[1]

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

Figure 1. Alaska-style panels of the Shasta River Fish Counting Facility.

The weir and video camera were installed during the last week of August and began recording on August 31, 2010. KRP staff performed routine daily maintenance of the SRFCF. Staff inspected the video system to insure 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 a blank 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 a one terra-bite (TB) 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 recorded as “unknown” as to species were reviewed by project biologists. 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.

TRAP

A temporary trap was installed immediately upstream of, and connected to the SRFCF on October 29, 2010, in collaboration with the Department's Shasta/Scott Resource Assessment Program. The objective of the trap was to capture and radio-tag coho salmon for migration investigations. The trap was operated three days per week between 0800 and 1200 hours and between 1200 and 1600 hours and was checked and processed twice daily. All Chinook and coho salmon were sampled for FL, sex, and presence/absence of marks or clips. Healthy, unmarked coho salmon were fitted with a radio tag and released. Each sampled Chinook was marked with a left operculum punch to prevent duplicate sampling should the fish be recovered as a carcass on spawning ground surveys or as a wash back on the weir. The trap was removed on December 6, 2010.

WASHBACK CARCASSES

All salmon carcasses that drifted downstream and became impinged on the weir panels were recovered and processed. Data collected on these wash back carcasses included species, gender, and FL. 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.

Every carcass was also examined for the presence of fin clips, marks or tags. Carcasses encountered in the wash back or spawning ground survey sample which had an operculum punch were cut in half and not sampled, as the punch indicated the fish had been sampled earlier in the trap located at the SRFCF. Heads were collected from each AD fish for later CWT recovery and analysis. Each female carcass was also examined to determine whether successful spawning had occurred. Female salmon with more than 50% of their egg mass still present in their body cavity were identified as pre-spawn mortalities. Carcasses were then cut in half to prevent sample duplication and returned to the river downstream of the weir.

SPAWNING GROUND SURVEYS

Spawning ground surveys were conducted on the lower seven miles of the Shasta River, on publicly owned lands and on private lands where permission to access was obtained, and on the upper Shasta River, Big Springs Creek, and, when access was granted, Parks Creek in the Big Springs area. 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 in areas previously inaccessible to Department personnel. Surveys were conducted once per week 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 and tissue samples, otolith samples were collected when possible. Otoliths collected were archived for future life history and stock identification purposes. Otoliths were collected following standard protocols as described by Stevenson, 1992.

GRILSE CUT-OFF

Because of the small spawning ground survey sample (N=28), small trap sample (N=3) and the bias toward males (83%) in the wash back sample, the grilse cut-off and subsequent grilse/adult proportions were derived using the following equations. This method was used for the 2006 Shasta run, for which the wash back and SGS samples were also felt to be biased. The proportion of males among adults P(M/A) was estimated using the carcass survey data. There were 6 males out of 25 samples, 24%, and no jacks were recovered in the SGS sample. The proportion of jacks among males, P(J/M) was derived from the wash back sample, 20 jacks out of 98 males (.20408).

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

$$P(M) = \frac{P(M/A)}{1-P(J/M)\ [1-P(M/A)]} = \frac{0.24}{1-0.204\ [\ 1-\ 0.24]} = 0.284$$

Based on the following relationship:

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

1. Estimate the proportion of jacks in the run:

   P(J)=P(M) x P(J/M) = (0.284)(0.204)= 0.0579

2. Estimate the jack run:

   J= N x P(J)= 1,348 x .0.0579= 78 jacks

4. Estimate the adult run:

   A=N-J= 1,348-78= 1,270 adults

RESULTS

Operation of the SRFCF began the morning of August 31, 2010 at approximately 11:44 hours, Pacific Standard Time (P.S.T.). The first Chinook of the season was observed on September 5, 2010 at 18:17 hours and the last Chinook was observed on December 6, 2010 at 11:58 hours, P.S.T.. The weir and recording equipment were removed on December 17, 2010 due to anticipated high in-stream flows.

Recording was disrupted on one occasion: from 16:06 hrs on December 14, 2010 until 07:36 hrs on December 15, 2010, a total of 15 hours and 30 minutes, due to operator error.

Chinook Salmon

A net total of 1,348 Chinook were counted passing upstream through the SRFCF during the 2010 season (Figure 2). This number was derived by subtracting the number of downstream observations (47) from the number of upstream observations (1,395). The number of Chinook which may have passed through the SRFCF during periods of video malfunctions was estimated by averaging Chinook movements during the same time period two days prior to and two days after each video malfunction. No additional Chinook were estimated to have entered the Shasta River during the period of equipment malfunction. The Department estimates that the Chinook salmon run in the Shasta River during 2010 was comprised of 78 (5.8%) grilse and 1,270 (94.2%) adults for a total run size of **1,348** Chinook salmon.

Consistent with previous years' monitoring efforts, the majority of Chinook (95%) passed through the SRFCF during day light hours between 06:00 and 17:00 hours (Figure 3).

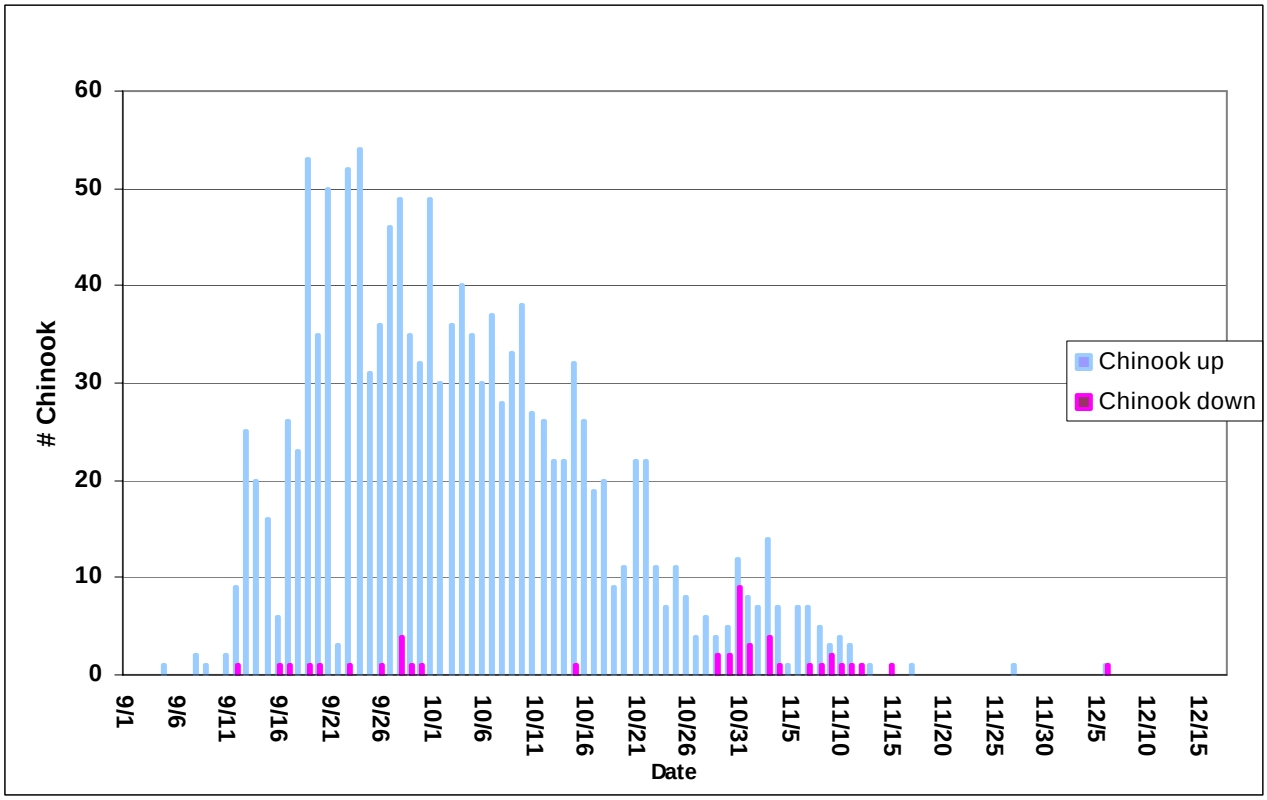

Figure 2. Run timing of and up/down movements fall Chinook salmon observed at the Shasta River Fish Counting Facility in 2010.

The video camera is positioned on the right side of the flume, facing downstream, and therefore, only the left side of each fish is visible to the camera as salmon migrate upstream. As staff reviewed each video tape, information was recorded on the presence of lamprey, fin clips, scars or other abnormalities that may be present on each fish. A total of 521 Chinook (39% of the run) were recorded as having at least one live lamprey attached to their bodies. Of these, 330 Chinook had 1 lamprey, 150 had 2 attached, 39 had 3 and 2 had 4 lamprey attached. Since the right side of each fish cannot be seen during review of video tapes, any of these 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 by a small portion.

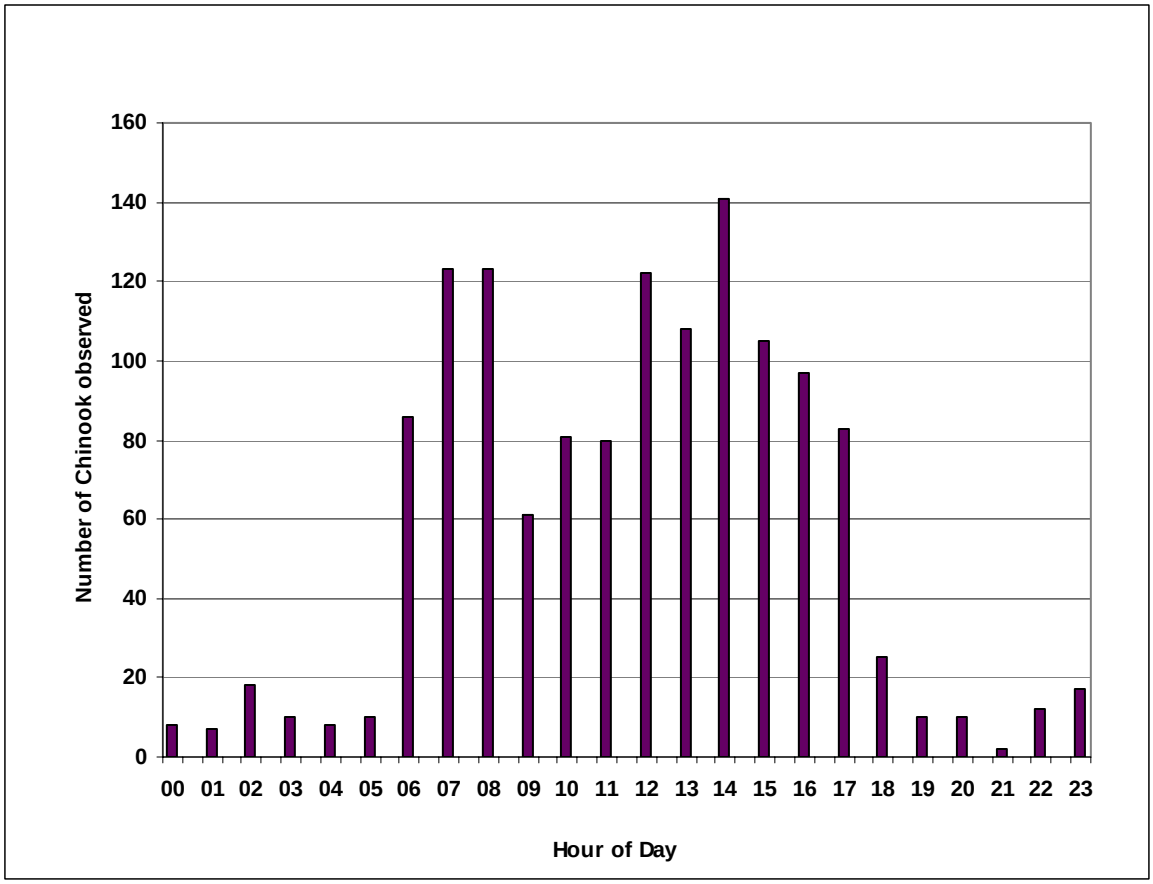

Figure 3. Diel run timing of Chinook salmon movement through the Shasta River Fish Counting Facility during the 2010 season.

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 (Table 1). The head from one AD Chinook was recovered from a carcass examined in the wash back sample, and it contained a coded wire tag (CWT). Analysis of the tag recovered indicated that this was a brood year 2007 fish released from Iron Gate Hatchery (IGH) as a smolt in 2008. Expansion of this CWT by the production multiplier yielded an estimate of 9 hatchery origin Chinook. The remaining 13 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 13 AD fish. Using this method a total of 148 additional hatchery origin Chinook were estimated to have entered the Shasta River during the 2010 run. This yields a total estimate of 157 hatchery Chinook, or 11.6% of the total run observed in 2010.

Table 1. Estimated contribution of 14 AD-clipped Chinook salmon observed at the SRFCF in 2010 based on the number of CWT fish observed at IGH and expanded based on the production multiplier for each CWT release code.

CWT	BY	# CWTs Recovered	Proportion of CWTs recovered	Estimated Number	Production Multiplier	Expanded Estimate
601020607	2005	1	0.001138952	0.01481	9.22	**0**
601020608	2006	11	0.012528474	0.16287	20.81	**3**
601020609	2006	18	0.020501139	0.26651	15.93	**4**
601020700	2006	7	0.007972665	0.10364	16.61	**2**
601020701	2006	13	0.014806378	0.19248	16.54	**3**
601020702	2006	15	0.017084282	0.22210	16.65	**4**
601020703	2006	14	0.015945330	0.20729	18.23	**4**
601020704	2006	212	0.241457859	3.13895	9.58	**30**
608020000	2007	32	0.036446469	0.47380	19.84	**9**
608020001	2007	52	0.059225513	0.76993	18.10	**14**
608020002	2007	20	0.022779043	0.29613	15.93	**5**
608020003	2007	39	0.044419134	0.57745	16.26	**9**
608020004	2007	49	0.055808656	0.72551	16.66	**12**
608020005	2007	47	0.053530752	0.69590	17.59	**12**
608020006	2007	152	0.173120729	2.25057	10.64	**24**
065353	2006	1	0.001138952	0.01481	3.99	**0**
065361	2006	1	0.001138952	0.01481	4.05	**0**
68809	2007	1	0.001138952	0.01481	4.07	**0**
068642	2008	9	0.010250569	0.13326	4.02	**1**
068643	2008	10	0.011389522	0.14806	4.02	**1**
068644	2008	25	0.028473804	0.37016	4.03	**1**
068645	2008	48	0.054669704	0.71071	4.02	**3**
068646	2008	45	0.051252847	0.66629	4.03	**3**
068647	2008	49	0.055808656	0.72551	4.06	**3**
068648	2008	5	0.005694761	0.07403	4.02	**0**
068661	2008	1	0.001138952	0.01481	4.02	**0**
068662	2008	1	0.001138952	0.01481	4.03	**0**
Totals		**878**	**1.0000**	**13**		**148**

Hatchery contribution of 13 unknown tag codes	**148**
Expansion of one known tag code	**9**
Total estimated contribution of hatchery origin Chinook	**157**

Unreadable CWTs: 200000=CWT lost, 400000=CWT unreadable

Spawning Ground Surveys

A total of 291 redds were observed during spawning ground surveys in 2010. Of these, 202 were seen in the canyon reaches and 89 in the Big Springs complex. The redds were not measured nor defined as to species. Table 2 shows live Chinook and coho salmon and new redds observed during spawning ground surveys in 2010.

A total of 25 Chinook carcasses were sampled during spawning ground surveys. Of these, 19 (76%) were female and 6 (24%) were male. Fork lengths of the 25 carcasses recovered are shown in Figure 4.

Table 2. Number of live Chinook and coho salmon and new redds observed by date during Shasta River spawning ground surveys, 2010.

Reach	Description of Reach	Date	# Live Chinook	# Live Coho	# New Redds
1	Mouth to Pioneer Bridge	10/13/2010	33		41
1		10/20/2010	44		31
2	Pioneer Bridge to Salmon Heaven	10/7/2010	12		11
2		10/13/2010	0		3
2		10/19/2010	19		0
2		10/20/2010	13		7
2		11/10/2010	2		44
2		11/16/2010	1		16
19	Big Springs Creek confluence to Nelson Ranch	10/20/2010	2		23
19		10/27/2010	1		20
19		11/3/2010	1		20
20	Main stem Shasta River, Parks Creek to Big Springs Creek	10/27/2010	2		5
20		11/3/2010	1		0
20		11/10/2010	0		3
20		12/1/2010	0	1	0
20		12/8/2010	0	2	0
20		12/29/2010	0		35
21	Big Springs Creek (upper bridge to mouth)	10/20/2010	4		0
21		10/27/2010	1		0
21		12/21/2010	0	2	0
21		12/29/2010	0		31
22	Main stem Shasta River, Parks Creek to Hidden Valley Ranch	12/8/2010	0		1
24	Upper Parks Creek	12/8/2010	0	2	0
24		12/15/2010	0	3	0
24		12/22/2010	0	1	0

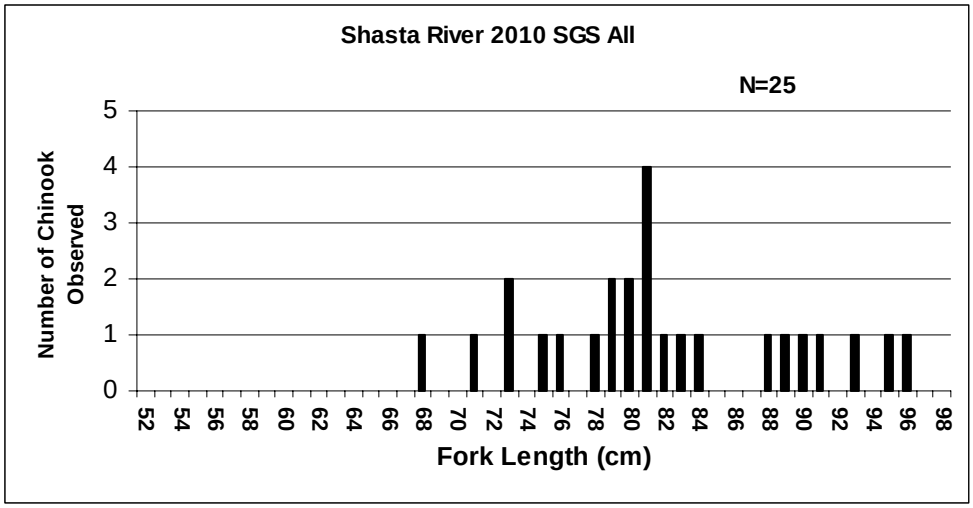

Figure 4. Length frequency distributions of Shasta River Chinook salmon sampled in spawning ground surveys conducted during the 2010 season.

In 2010, the Department was allowed access to limited reaches of the the upper Shasta River and its tributaries, including Parks Creek. Figures 5 through 8 show the distribution of redds by date first observed for the Big Springs complex. Redds were not measured or identified as to species. Observations of live coho are also noted in figures 5 and 8.

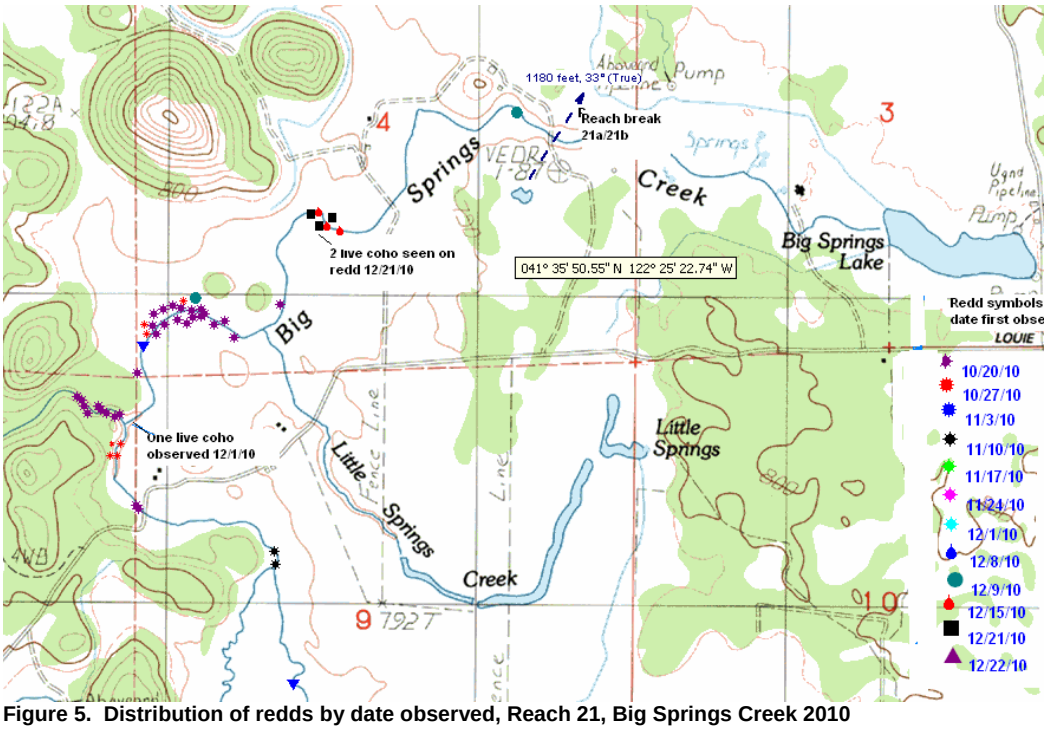

Figure 5. Distribution of redds by date observed, Reach 21, Big Springs Creek 2010

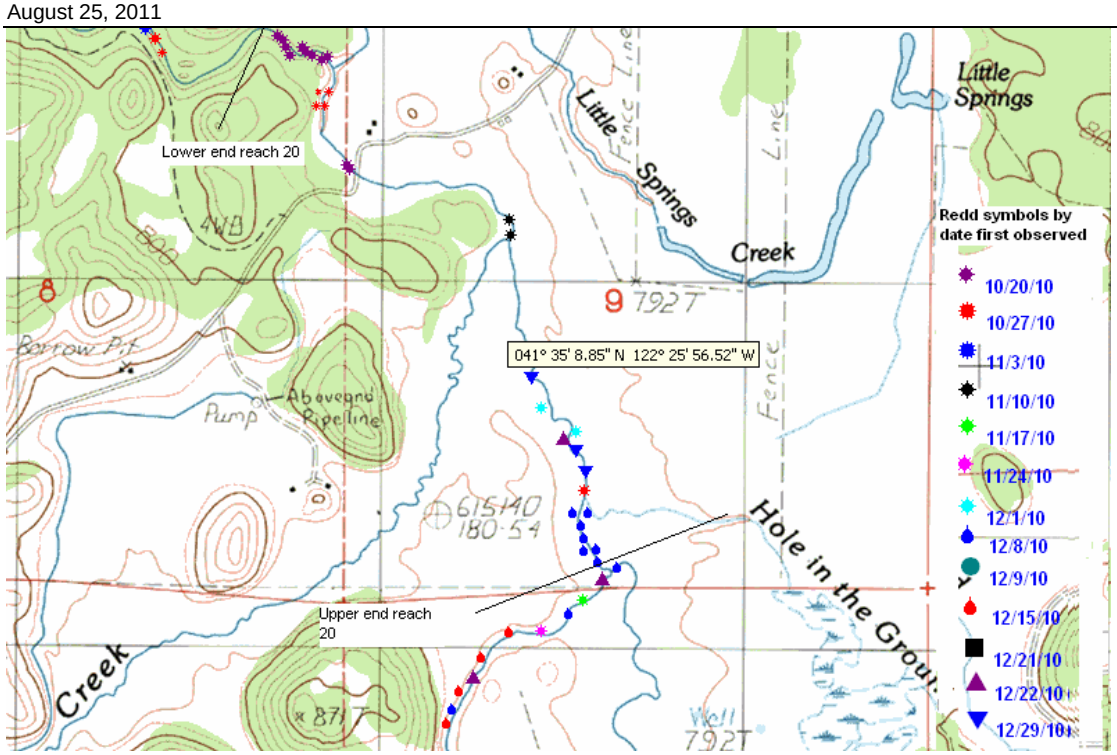

Figure 6. Distribution of redds by date observed, Reach 20, mainstem Shasta River from Parks Creek confluence to below Big Springs Creek confluence.

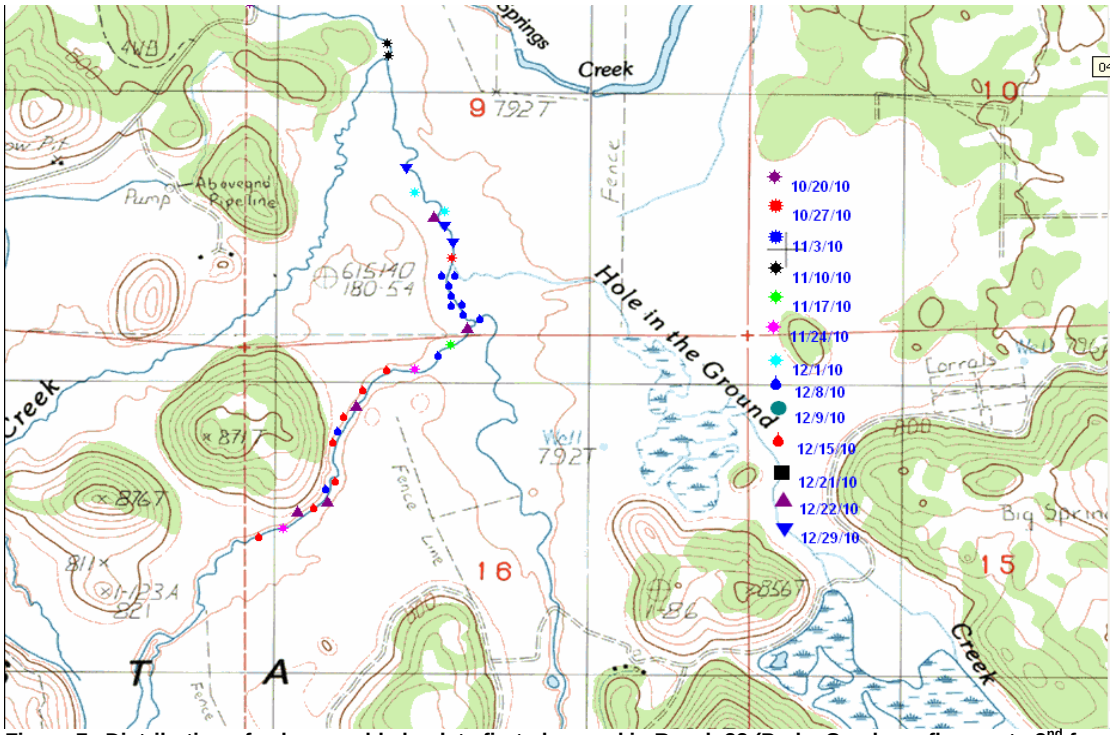

Figure 7. Distribution of salmon redds by date first observed in Reach 23 (Parks Creek confluence to 2nd fence crossing), mainstem upper Shasta River, 2010

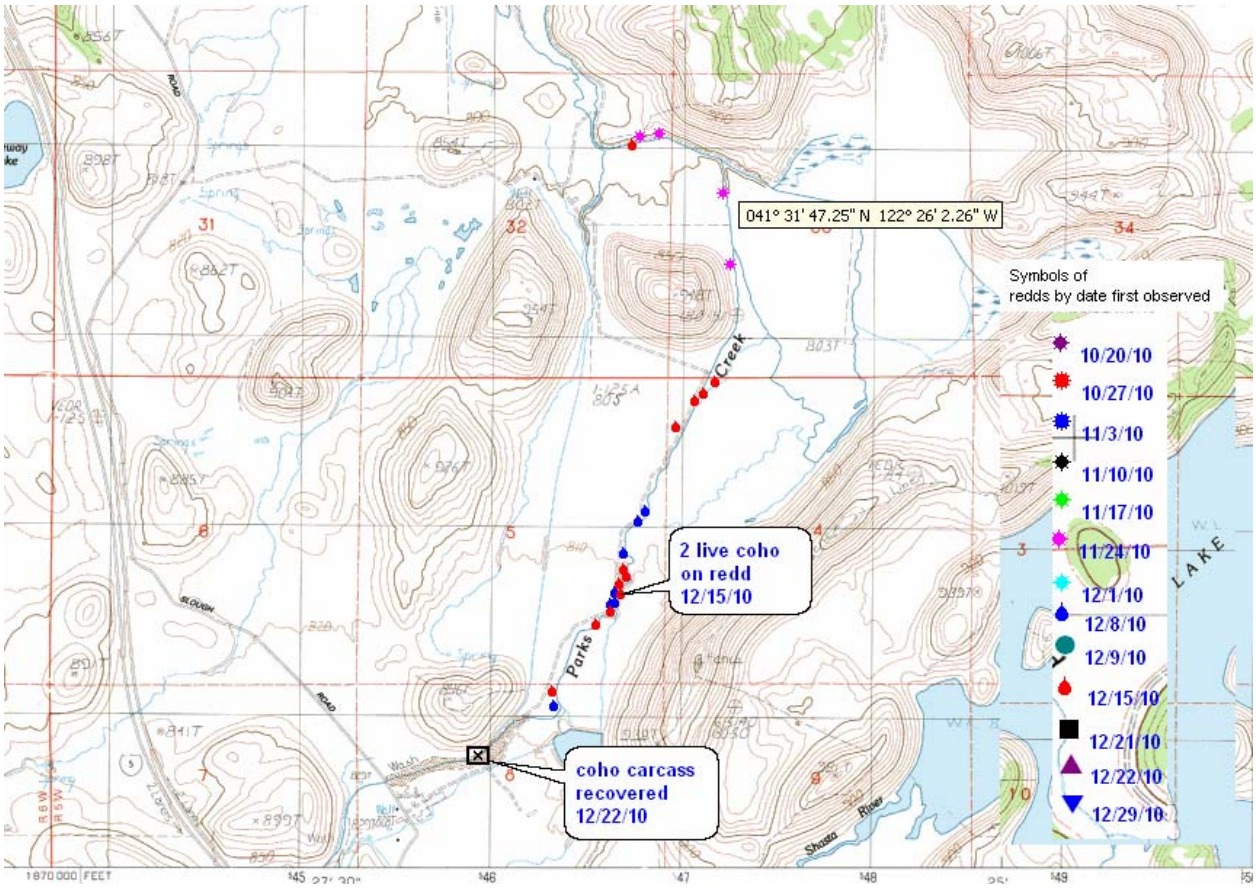

Figure 8. Distribution of salmon redds by date first observed in Reach 24 (Parks Creek, I-5 to Duke's) 2010

Wash backs

A total of 118 Chinook carcasses were recovered and sampled as wash backs on the weir. Of the 118, 20 (17%) were female and 98 (83%) were male. Figures 9 and 10 show the length frequency distribution of these samples. Since 2004, the wash back samples at the SRFCF have shown a heavy bias toward males (Table 3).

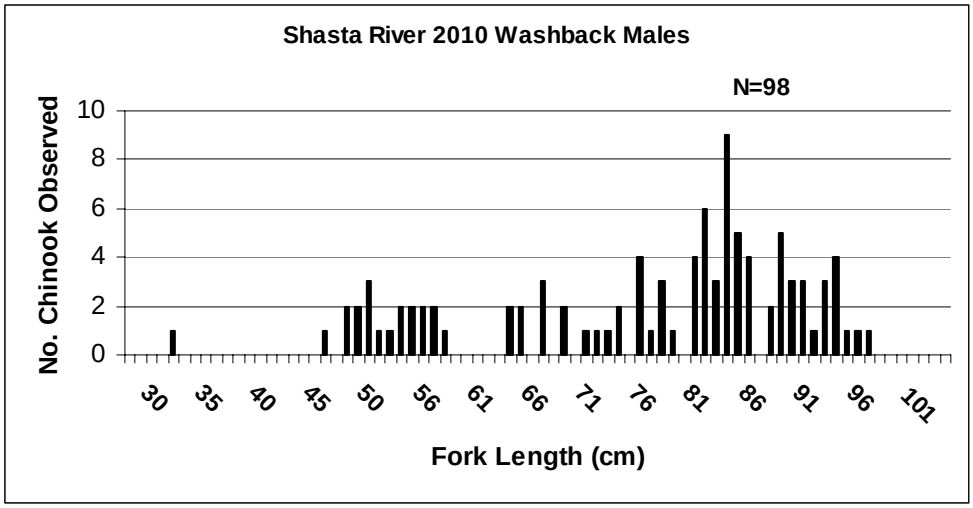

Figure 9. Length frequency distributions of Shasta River male Chinook salmon sampled as weir wash backs during the 2010 season.

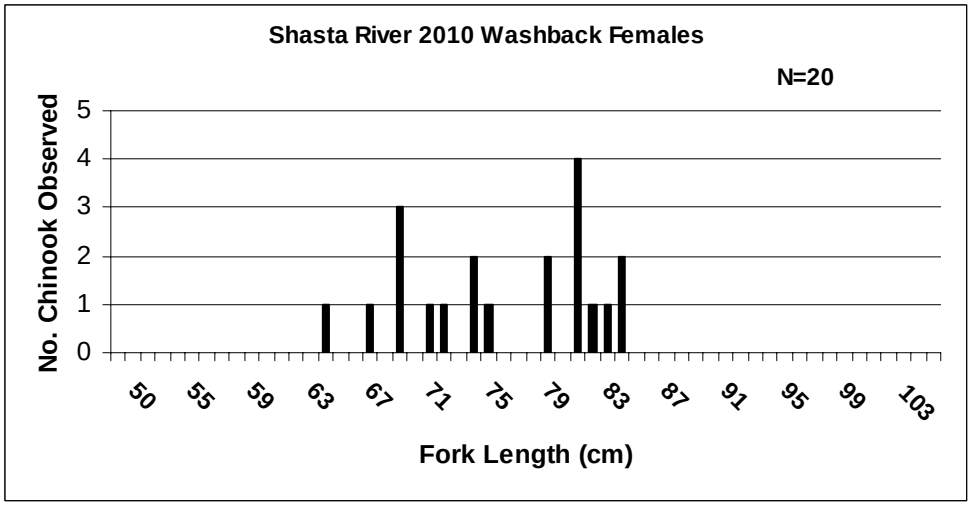

Figure 10. Length frequency distributions of Shasta River female Chinook salmon sampled as weir wash backs during the 2010 season

Table 3. Sex compositions of wash back carcasses sampled at Shasta River Fish Counting Facility, 2005-2010.

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
AVERAGE		82	18

Trap

In 2010, the trap at the SRFCF was not used to obtain biological samples from the Chinook run as it was in 2009, but rather for the purpose of trapping and radio-tagging coho salmon. It was operated three days a week between 10/30/10 and 12/6/10 from 0800 to 1200 hours and from 1200 to 1600 hours, with two checks per day. A total of 4 coho (only 2 of which met the criteria for radio tagging), 3 Chinook and one steelhead were sampled for FL, sex, presence/absence of marks or tags, scales and tissue.

Coho Salmon

A total of 48 coho salmon were observed passing upstream and 5 coho were observed passing downstream through the SRFCF from October 26, 2010 to December 16, 2010 (Figure 12). After subtracting the 5 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 **44**.

Beginning in 1996, all coho released from IGH (75,000 yearlings) receive a left maxillary clip and all coho released from Trinity River Hatchery (500,000 yearlings) receive a right maxillary clip. Unfortunately, the picture quality of the video footage does not allow for accurate determination of the presence of a maxillary clip. Therefore, the potential contribution of hatchery origin coho cannot be accurately determined from video review.

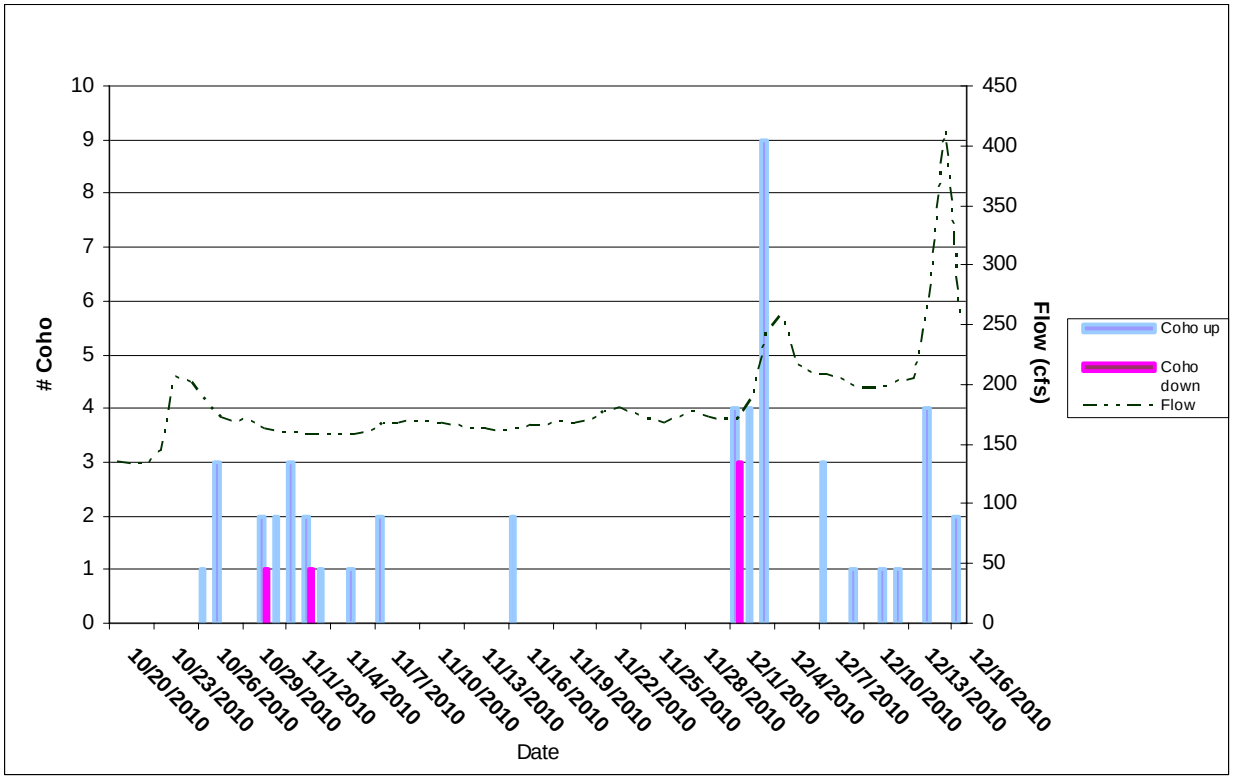

Figure 12. Run timing of coho salmon and flow measured in cfs at the mouth (USGS gauge 11517500) of the Shasta River in 2010.

Four observations were made of upstream migrating coho with lamprey attachments as they passed through the SRFCF, and 1 of these was observed with at least two lamprey attachments.

Two adult female coho salmon were radio-tagged using an esophageal implant radio transmitter by the Department's Shasta/Scott Resource Assessment program in 2010. Tracking of these fish was done by truck in the canyon area, where roads border the river for seven miles, by aerial surveys and by a stationary receiver at the mouth of Parks Creek. One coho tagged on 11/3/10 remained in the canyon until 11/9/10, then was detected at the Parks Creek base station (RM 35) six days later. The fish spent 23.75 hours in Parks Creek, then migrated back to the Shasta River and was detected by aerial survey near Grenada on 11/24/10 and 1/2/11. On 2/1/10, the tag was tracked on foot to Shasta RM 19 and was detected, but not retrieved, in deep vegetation near a redd.

The second radio-tagged coho spent five days near the SRFCF after tagging, then was detected at RM 5 at 13:45 hours, RM 8 at 16:50 hours and later at the Parks Creek

base station (RM 35) at 21:35 the following day, having covered 30 river miles in one and one half days. The fish spent the next several days ascending and descending Parks Creek and eventually swam downstream in the main stem Shasta River, where it was last detected by aerial survey downstream of Yreka Ager Rd crossing, RM 8.3. The tag was not recovered. (Olswang, 2011).

Steelhead Trout

In 2010, a net total of 131 adult steelhead (144 upstream, 13 downstream) and 259 half-pounders (293 upstream, 34 downstream) were estimated to have entered and remained in the Shasta River during the video recording season from August 31 to December 17, 2010. Lines on the back of the video flume were set at 16 inches (40.64 cm) to delineate half-pounders versus adults. The total number of upstream and downstream observations (484) was lower than the 814 observed in 2009 and the 1,130 observed in 2008.

Flow

In-stream flow data for the Shasta River was downloaded from the U.S. Geological Survey (USGS) gauge no. 11517500 located near the mouth of the Shasta River north of Yreka.

Flow data for the SRFCF 2010 season are shown in Figure 13. Recording was not disrupted due to high flows in 2010, however, a peak flow of 412 c.f.s. on December 15, 2010 required that the weir be cleared of debris several times per day to maintain structural integrity.

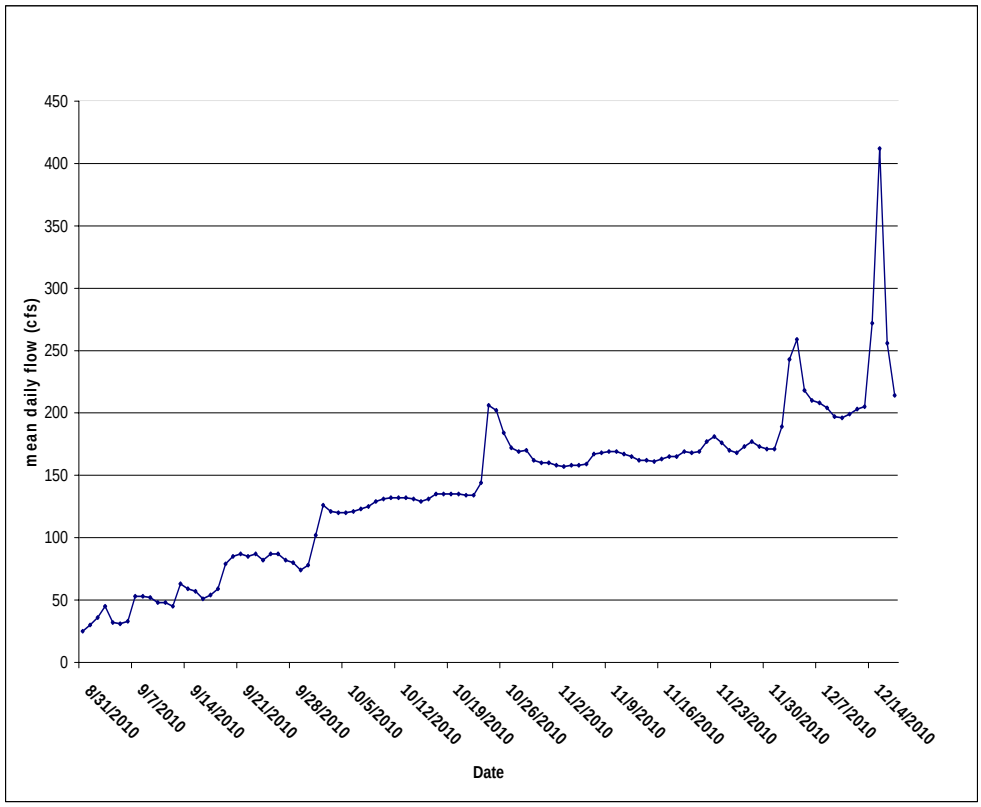

Figure 13. Average daily flows (cfs) in the Shasta River at USGS Gauge No. 11517500 from August 31, 2010 to December 17, 2010

DISCUSSION

Chinook Salmon

Since 1978 the run size of fall Chinook in the Shasta River has averaged 5,077 fish, and has ranged from a low of 533 fish in 1990 to a high of 18,731 fish in 1978. The 2010 fall Chinook run totaled 1,348 fish, and ranks as the 5th lowest run recorded since 1978 (Figure 14).

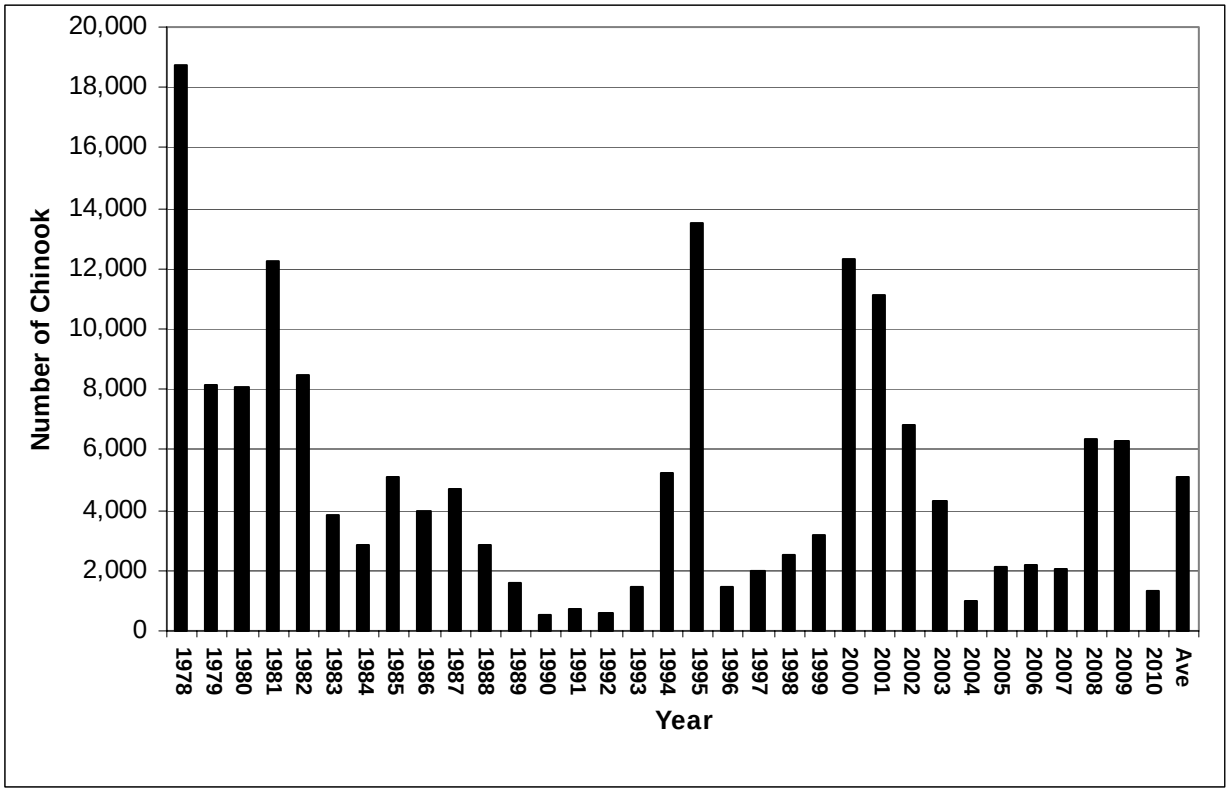

Figure 14. Chinook salmon run size estimates for the Shasta River from 1978 through 2010

Hatchery Straying

Since 2002, the KRP has estimated the number of hatchery origin fall Chinook that may have strayed into the Shasta River. These estimates have been based on sample expansions from 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 ad-clipped Chinook that were observed passing through the SRFCF during the season, or both. Since 2001 the percent estimated contribution of hatchery strays to the Shasta River has ranged from a low of 1.2% in 2002 to a high of 38.7% in 2004 (Table 5). The percentage of hatchery strays into the Shasta River was 11.6% in 2010.

Table 5. Estimates of hatchery strays as percentage of Chinook entering the Shasta River, 2002-2010.

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%
AVERAGE			**10.6%**

Each year the Klamath River Technical Advisory Team determines the age composition for fall 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 Stock Projection Model which estimates age specific ocean abundance and is used to develop harvest management recommendations for the following season. A summary of the age composition determinations for Shasta River fall Chinook salmon are provided in Table 6.

Table 6. Age composition of Shasta River fall Chinook salmon from 2002 through 2010 as determined by the Klamath River Technical Advisory Team.

Year	Age 2	Age 3	Age 4	Age 5	Total Adults	Total Run
2002	**386**	**4,286**	**2,088**	**58**	**6,432**	**6,818**
2003	**155**	**2,798**	**1,325**	**11**	**4,134**	**4,289**
2004	**129**	**184**	**484**	**166**	**833**	**962**
2005	**38**	**1,409**	**600**	**82**	**2,091**	**2,129**
2006	**863**	**253**	**1,042**	**27**	**1,321**	**2,184**
2007	**27**	**1,855**	**146**	**8**	**2,008**	**2,035**
2008	**3,621**	**1,222**	**1,456**	**63**	**2,741**	**6,362**
2009	**126**	**5,595**	**314**	**252**	**6,161**	**6,287**
2010	**87**	**240**	**1,021**	**0**	**1,261**	**1,348**

The Shasta River is an important component of the Klamath Basin Chinook runs. Table 7 shows that the Shasta River has contributed an average of 9 percent of the basin-wide natural spawning escapement during the period from 1978 to 2010. As habitat conditions improve in the Shasta River watershed the ability of the watershed to produce fish will hopefully improve. The river's current habitat conditions continue to produce more 0+ Chinook as more adults return, indicating that the watershed has not reached a "saturated level" or "carrying capacity" for Chinook salmon (Figure 15). The Shasta River has been known for its extremely productive conditions and at the current levels of fish abundance the Shasta River is considered spawner limited.

Figure 15. Number of 0+ Chinook produced per adult spawner in the Shasta River, Brood Years 2000-2009.

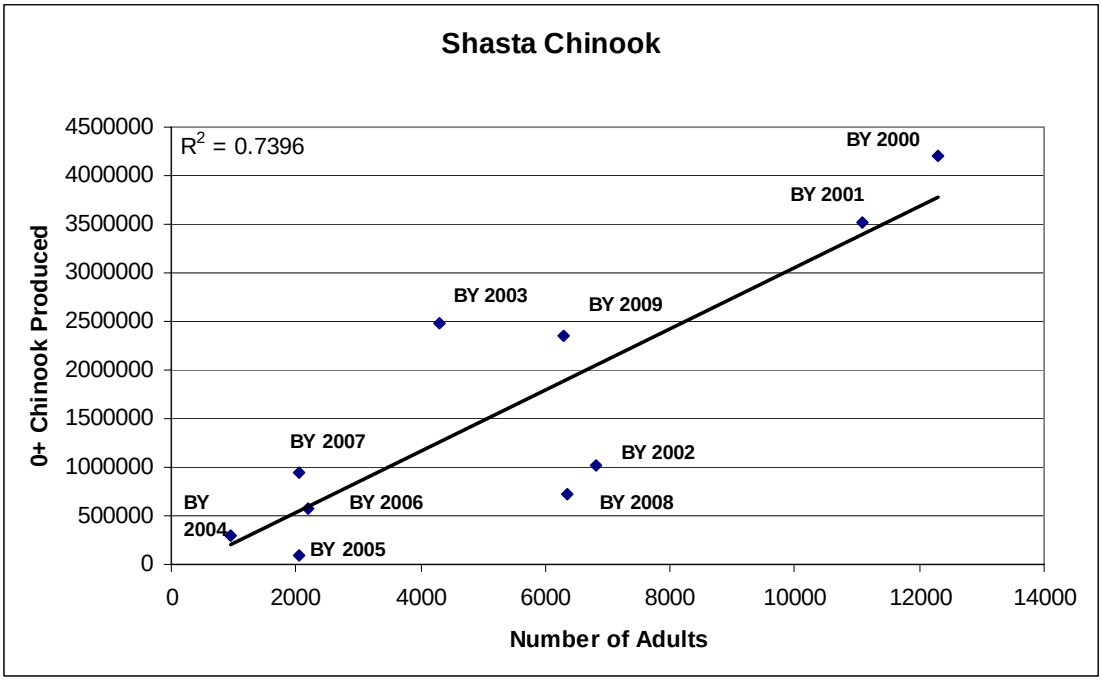

Table 7. Klamath Basin and Shasta River Chinook natural spawner escapements (age 2-5), 1978-2010.

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	52,702	6,287	12%
2010	52,499	1,348	3%
Average	**58,318**	**5,077**	**9%**

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. Figure 16 shows returns of coho to the Shasta River from 1978 to 2010. Sampling from 1983 to 2000 cannot be directly compared to other years, as the weir was removed on or before November 11 during those years and sampling does not represent the entire run of coho.

The cohort of coho salmon which returned to the Shasta River in 2010 was the

strongest of the three cohorts, but showed a marked downward trend (Figure 16).

Of the 4 coho caught in the trap at the SRFCF in 2010, one (25%) was marked with a left maxillary clip indicating that this fish was of hatchery origin, most likely IGH. Based on a sub-sample of coho handled at the trap the proportion of hatchery origin fish has been estimated from 2007-2010 (Table 8).

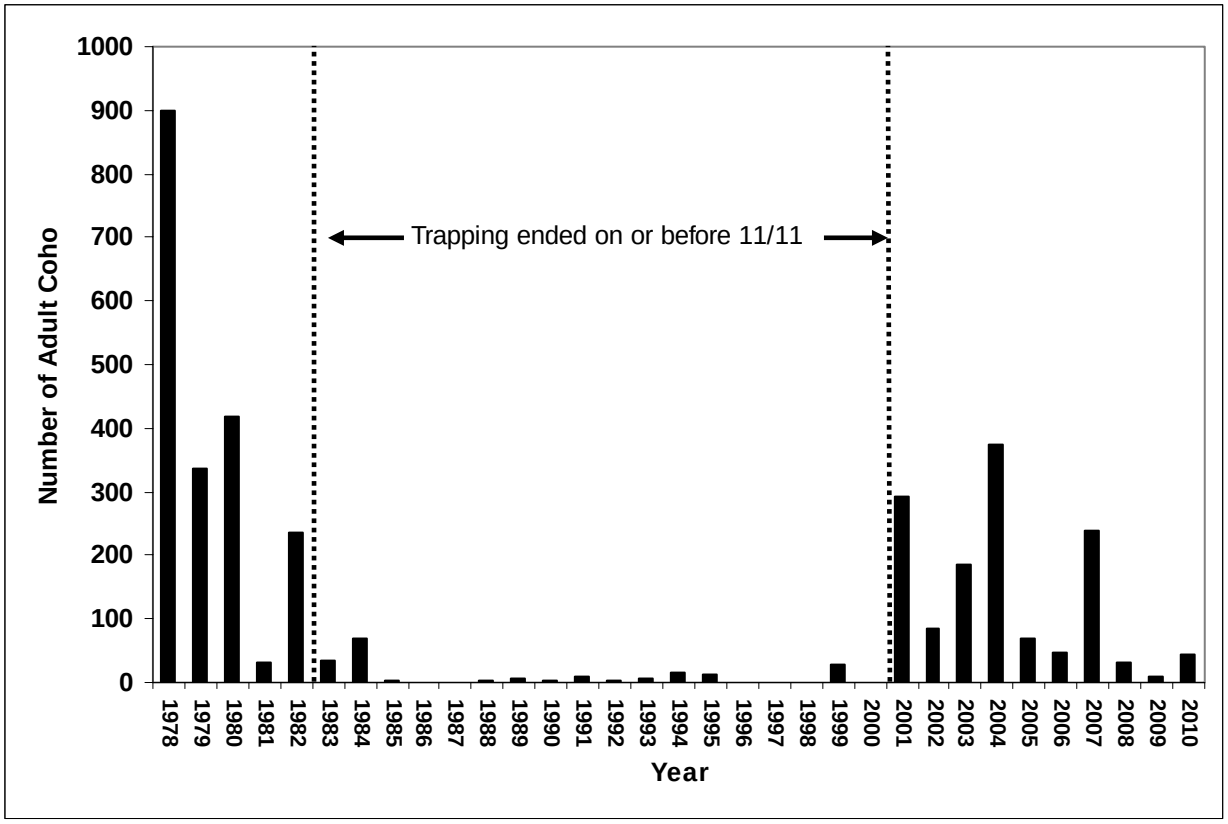

Figure 16. Returns of coho salmon to the Shasta River, 1978-2010.

Table 8. Estimates of hatchery strays as percentage of coho entering the Shasta River, 2007-2010, based on a sub -sample of coho trapped at the SRFCF.

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%

Radio tagging studies conducted in 2004 through 2009 identified two main spawning areas in the Shasta River: the lower six miles of canyon and the upstream area known

as the Big Spring Complex. (Littleton and Pisano, 2006; Olswang, 2007, 2008 and 2009). In 2010 the Department was granted, for the first time, limited access to Parks Creek for the purpose of conducting salmon migration studies. Both of the coho salmon radio-tagged at the SRFCF in 2010 swam up to and entered Parks Creek, although they both eventually re-entered the main stem Shasta River and swam downstream. It was speculated by the Department's Shasta/Scott Resource Assessment program that coho behavior and migrations may be experiencing effects associated with depensation and that observations may have been the result of salmon's inability to find mates. (Olswang, 2011).

Rotary screw trapping studies at the mouth of the Shasta River from 2003 to 2009 have documented the emigration of coho fry or parr in response to low flows and high water temperatures which typically occur after the start of the agricultural irrigation season on April 1st (Chesney et al, 2010). These studies concluded that high summer temperatures, low flows and barriers to juvenile migration out of the canyon make it unlikely that the progeny of canyon-spawning coho are able to find over- summer rearing habitat in the Shasta River. Non natal rearing of juvenile coho salmon has been documented in the Klamath River and it is unclear how these juvenile fish contribute to the Shasta River population in future years (Hillemeier et al, 2009).

In the Big Springs complex, during the summers of 2008, 2009 and 2010 direct observations as well as pit tagging studies identified several cold water spring areas where coho were rearing over the summer. Pit tagged coho were observed to move upstream into these thermal refugia when water temperatures rose elsewhere in the river. Chesney et al 2010 concluded that conservation of these areas were essential to the survival of juvenile coho. In 2010, the Department continued its efforts to secure adequate flows in critical springs providing coho rearing habitat.

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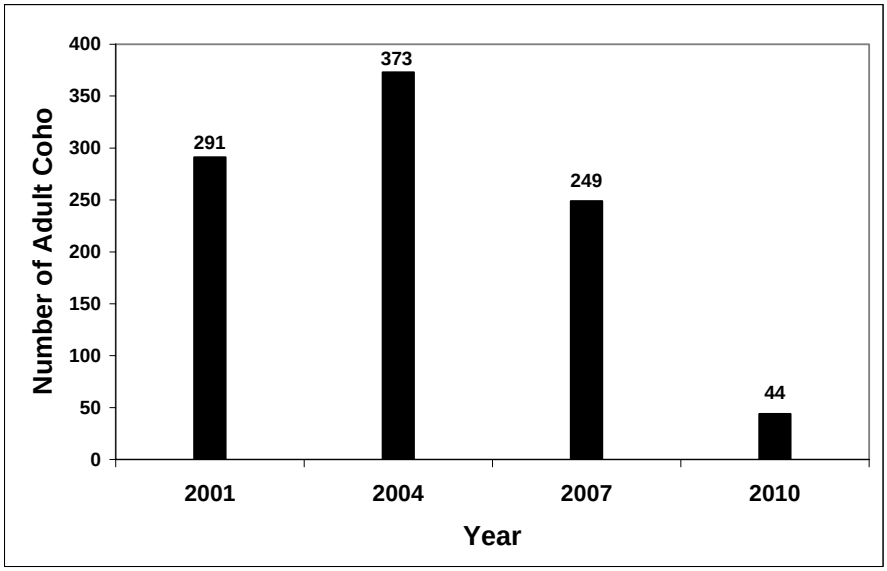

Figure 17. Returns of Shasta coho cohort 1.

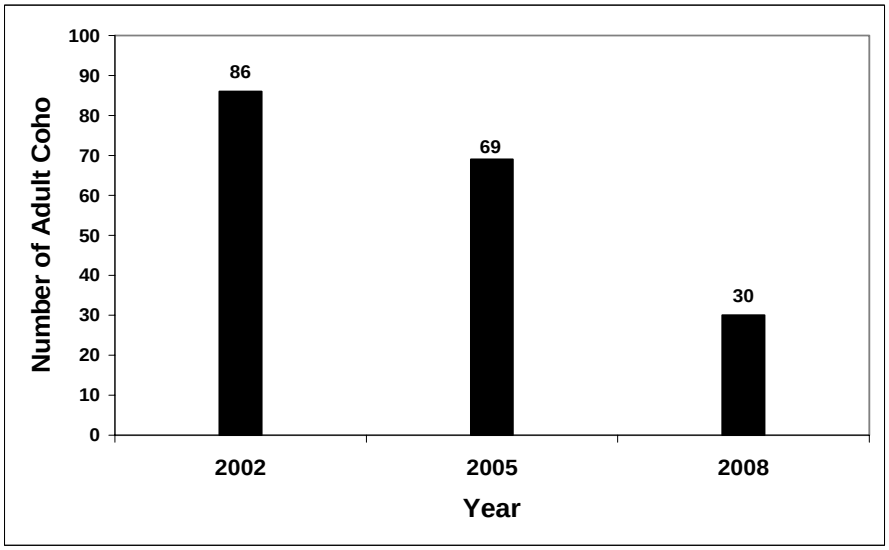

Figure 18. Returns of Shasta coho cohort 2.

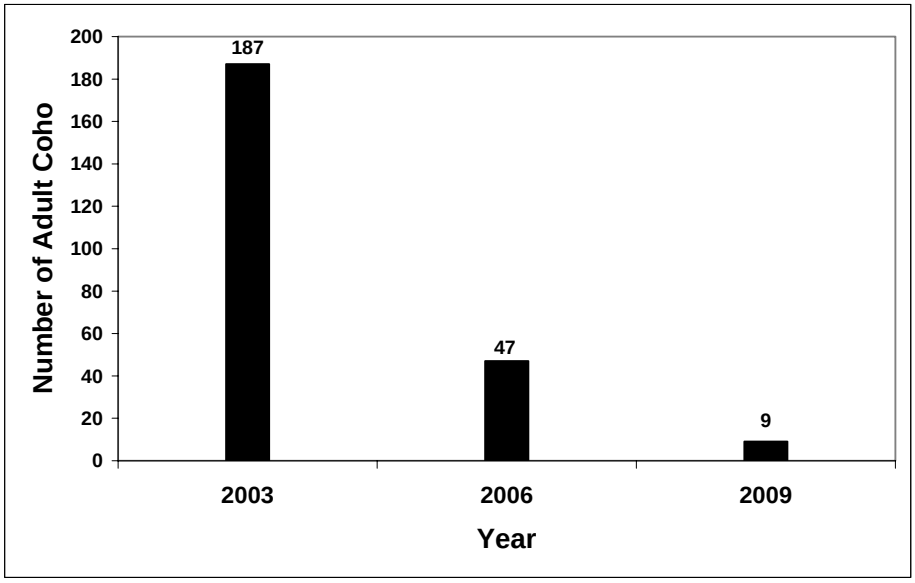

Figure 19. Returns of Shasta coho cohort 3.

Figures 17, 18 and 19 show declines of 3 Shasta River coho cohorts. Given the extremely poor returns of all three cohorts, enhancement of the Shasta River coho runs is being considered by the Department and other management agencies. Options under consideration include a captive broodstock program, injection of eyed eggs into suitable spawning gravel and the release of juvenile or adult coho into suitable habitat.

Utilizing the number of yearling coho produced in the Shasta River (Chesney et al, 2011) and the results of the adult abundance estimates allows for analysis of freshwater production and out of basin survival by brood year. The number of yearling coho that are required to produce a single adult coho has averaged 46.5 and ranged from a low of 23.11 to a high of 122.6 for brood years 2001-2007. The corresponding out of basin survival has averaged 2.8 percent and ranged from a low of 0.82 percent to a high of 4.33 percent (Table 9). Although the proportion of yearlings that survive outside the Shasta River watershed is largely driven by factors uncontrollable it is important to track this survival metric to accurately evaluate ongoing restoration efforts taking place within the watershed.

Table 9. Yearling coho outmigrant abundance point estimates, adult coho abundance estimates, ratio of outmigrant yearlings to adult returns and proportion of outmigrant yearlings that returned as adults by brood year for the Shasta River, Brood Years 2001-2007.

Brood Year	Yearling Year	Yearling point estimate	Adult Year	Adult Estimate	Yearlings to Adults	Percent yearling 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	255	42.48	2.35%
2005	2007	1178	2008	31	38.00	2.63%
2006	2008	208	2009	9	23.11	4.33%
2007	2009	5396	2010	44	122.64	0.82%
Average						**2.80%**

Analyzing the comparisons of estimated adult coho returns to yearling coho production estimates (Chesney et al 2011) 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 18.4 and ranged from a low of 4.4 to a high of 38.0 for brood years 2001-2008 (Table 10). 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.

Table 10. Adult coho estimates, yearling coho production point estimates and ratio of yearling coho produced per adult return for the Shasta River, Brood Years 2001-2008.

Adult Year Brood Year	Adult Estimate	Yearling year	Yearling point estimate	Yearlings produced per adult
2001	291	2003	11052	38
2002	86	2004	1799	20.9
2003	187	2005	2054	11
2004	373	2006	10833	29
2005	69	2007	1178	17.1
2006	47	2008	208	4.4
2007	255	2009	5396	21.2
2008	31	2010	169	5.5
Average				**18.4**

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