Shasta River
Chinook and Coho Salmon Observations in 2009-2010
Siskiyou County, CA

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Shasta River Fish Counting Facility, Chinook and Coho Salmon Observations in 2009 Siskiyou County, CA

ABSTRACT

A total of **6,287** Chinook salmon (Chinook**,** *Oncorhynchus tshawytscha*) were estimated to have entered the Shasta River during the 2009 spawning season. An underwater video camera was operated in the flume of the Shasta River Fish Counting Facility (SRFCF) twenty four hours a day, seven days a week, from September 1, 2009 until December 31, 2009. The first Chinook was observed on September 5, 2009 and the last Chinook on December 19, 2009. Klamath River Project (KRP) staff installed a trap immediately upstream of, and connected to the video flume, and a total of 388 Chinook were trapped and sampled for fork length, sex and presence/absence of marks or tags between September 15, 2009 and December 24, 2009. KRP staff also processed a total of 189 carcasses during spawning ground surveys, and a total of 330 Chinook carcasses were collected as wash backs against the SRFCF weir during the season.

Chinook ranged in fork length (FL) from 38 cm to 100 cm and grilse were determined to be < 60 cm in fork length. The run was comprised of 292 grilse (4.6%), and 5,995 adults (95.4%). A net total of 9 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 from two AD Chinook were recovered from carcasses examined in the wash back sample, but only one contained a coded wire tag (CWT). Analysis of the tag recovered from this head indicated that this was a brood year 2004 fish released from Iron Gate Hatchery (IGH) as a yearling in 2005. Expansion of this CWT by the production multiplier yielded an estimate of 8 hatchery origin Chinook. The remaining 7 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 7 ad-clipped fish. Using this method, a total of 123 additional hatchery origin Chinook were estimated to have entered the Shasta River during the 2009 run. This yields a total estimate of 131 hatchery Chinook, or 2.1% of the total run observed in 2009.

A net total of 9 coho salmon (coho, *Oncorhynchus kisutch*) were estimated to have entered the Shasta River during the 2009-10 season. The first coho of the season was observed passing through the SRFCF on November 2, 2009 and the last coho was observed swimming downstream through the SRFCF on December 21, 2009. All coho observed in the video review and in the trap appeared to be males. A total of 22 coho were observed passing upstream through the SRFCF and 14 coho were observed passing downstream from November 2, 2009 to December 21, 2009. Since it cannot be assumed that the 13 coho observed moving downstream through the SRFCF remained in the Shasta River, the net number of coho that are known to have remained in the Shasta River is **9.**

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 (Chinook, *Oncorhynchus tshawytscha*) 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.

Since 2004, the KRP has elected to continue operating the SRFCF beyond the end of the Chinook run in an effort to document migration of coho salmon (coho, *Oncorhynchus kisutch*) into the Shasta River. On August 5, 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).

This report describes the characteristics of the Chinook and coho salmon runs that entered the Shasta River during the fall of 2009.

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 direction 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. An Everfocus EDSR 100H digital video recorder (DVR) with a Seagate 250 hard drive in a swappable Everfocus DTLA 250F tray were used as for recording.

[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 September 1, 2009. During the 2009 season, staff of the KRP 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. Each day's recording was backed up on a 1 TB swappable drive. 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 September 15, 2009 for the purpose of collecting biological data on upstream migrating Chinook and coho salmon, and also in collaboration with CDFG's Shasta/Scott Resource Assessment Program whose objective was to radio-tag Chinook and coho for migration investigations. The trap was set by the KRP weir crews on Monday, Wednesday and Friday mornings by 0800 hours and checked and processed between 1100 and 1200 hours. All Chinook and coho salmon were sampled for fork length, sex, and presence/absence of marks or clips. Scale and tissue samples were collected from every 5th Chinook. 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 washback on the weir. The trap was removed on December 24, 2009.

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 fork length. 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. Any carcass encountered in the washback or spawning ground survey sample which had an operculum punch was 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 and Big Springs 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, one otolith sample was collected per reach on each survey day. All otoliths collected were supplied to Rebecca Quinones at the United States Forest Service/University of California at Davis for microchemistry analysis, and were collected following protocols provided by Rebecca Quinones.

In 2009, weekly spawning ground surveys were conducted on the Shasta Big Springs Ranch, a 4000+ acre ranch property purchased in 2008 by the Nature Conservancy (TNC). This property includes Big Springs Creek and 2.9 miles of the mainstem Shasta River (RM 31.98 to 34.88). Because this property has not historically been accessible to the CDFG, one of the objectives of the 2009 spawning ground surveys was to map the location of salmon redds. The first spawning ground survey occurred on October 14, 2009 and the last survey occurred on December 2, 2009.

RESULTS

Operation of the SRFCF began the morning of September 1, 2009 at approximately 10:48 hours, Pacific Standard Time (P.S.T.). The first Chinook of the season was observed on September 5, 2009 at 04:11 hours and the last Chinook was observed on December 19, 2009 at 14:06 hours, P.S.T. The weir and recording equipment were removed on December 31, 2009 due to anticipated high flows.

Recording was disrupted on two occasions: the first on October 13, 2009 when a power outage disrupted recording for four hours and 20 minutes, and on December 9, 2009 when a buildup of ice on the weir resulted in the partial collapse of one of the tripods supporting the weir panels. Following this event, the SRFCF facility was not fish tight for four days and one hour. Weir crews attempted to break up the ice twice per day during this period. The weir was repaired and recording resumed on December 13, 2009 after air and water temperatures increased and the ice buildup ceased.

Chinook Salmon

The first Chinook was observed passing through the SRFCF on September 5, 2009 and the last Chinook was observed on December 19, 2009 (Figure 2). A net total of 6,275 Chinook were counted passing upstream through the SRFCF during the 2009 season. This number was derived by subtracting the number of downstream observations

(1,380) from the number of upstream observations (7,655). 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. An additional 12 Chinook were estimated to have entered the Shasta River during periods of equipment malfunctions, for a total estimate of **6,287** Chinook.

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

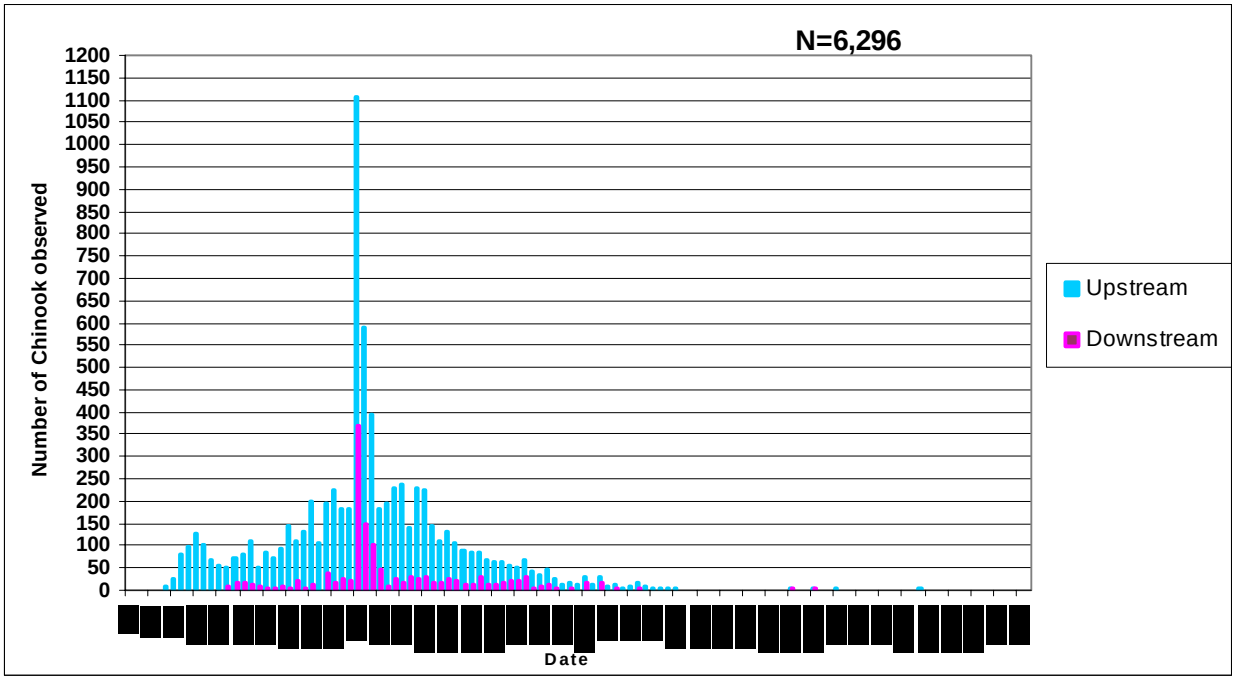

Figure 2. Run timing of fall Chinook salmon observed at the Shasta River Fish Counting Facility in 2009.

The video camera is positioned on the right side of the flume, facing downstream, and therefore, 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 1,080 Chinook, 14% of the Chinook observed swimming upstream at the SRFCF, had live lamprey attached to their bodies. 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.

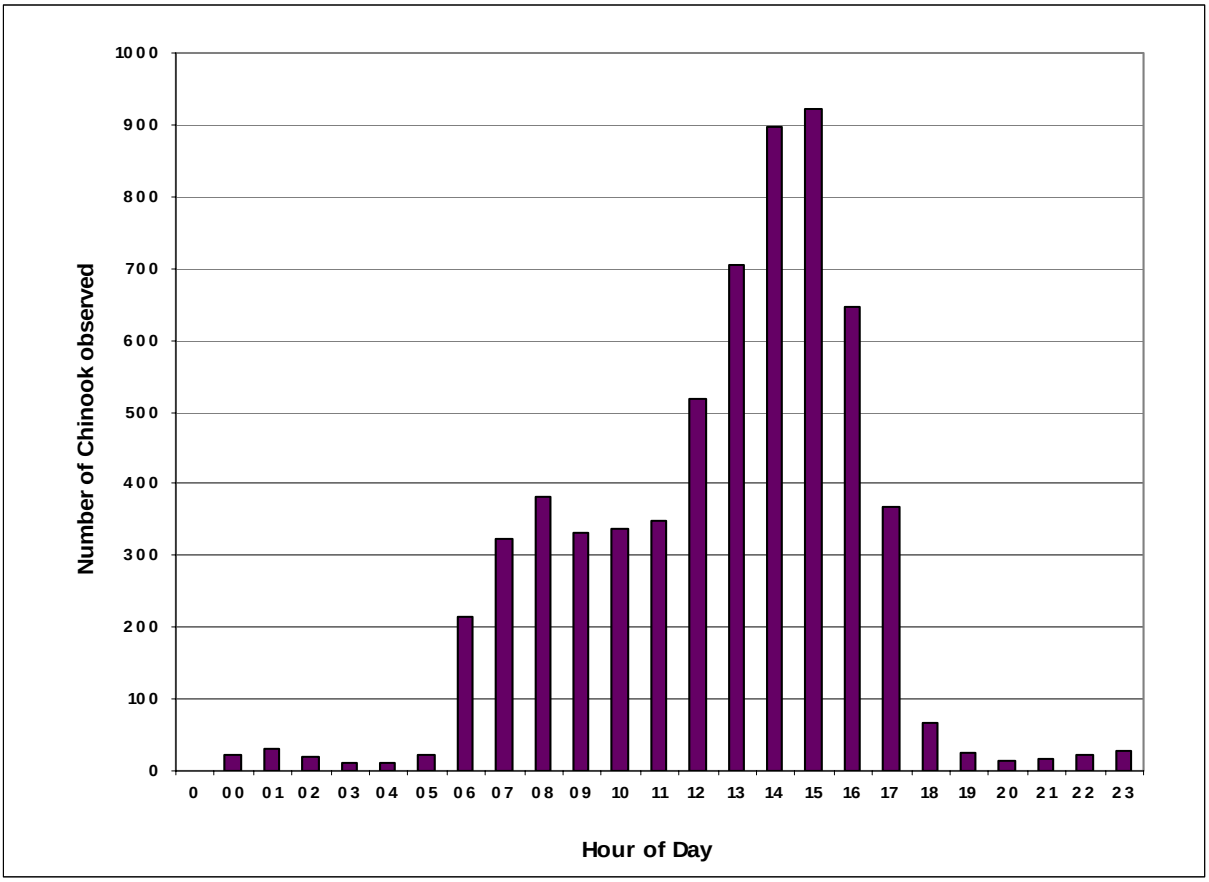

Figure 3. Diel run timing of Chinook salmon movement through the Shasta River Fish Counting Facility during the 2009 season.

A net total of 9 AD Chinook were observed passing through the SRFCF during the season, and these fish were assumed to be of hatchery origin (Table 1). The heads from two AD Chinook were recovered from carcasses examined in the wash back sample, but only one contained a coded wire tag (CWT). Analysis of the tag recovered from this head indicated that this was a brood year 2004 fish released from Iron Gate Hatchery (IGH) as a yearling in 2005. Expansion of this CWT by the production multiplier yielded an estimate of 8 hatchery origin Chinook. The remaining 7 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 7 AD fish. Using this method a total of 123 additional hatchery origin Chinook were estimated to have entered the Shasta River during the 2009 run. This yields a total estimate of 131 hatchery Chinook, or 2.1% of the total run observed in 2009.

Table 1. Estimated contribution of 9 AD-clipped Chinook salmon observed at the SRFCF in 2009 based on the number of CWT fish actually observed at IGH and expanded based on the production multiplier for each CWT release code.

Coded Wire Tag	Brood Year	Age	Release Type	Number of CWT's observed at IGH	IGH CWT Proportion	Estimated Number of CWT's	Production Multiplier	Estimated Hatchery Contribution
601020504	2004	**5**	F	2	0.0025	0.0174	17.12	**0**
601020505	2004	**5**	F	0	0.0000	0.0000	16.61	**-**
601020506	2004	**5**	F	2	0.0025	0.0174	34.04	**1**
601020507	2004	**5**	F	1	0.0012	0.0087	37.42	**0**
601020508	2004	**5**	Y	1	0.0012	0.0087	9.09	**0**
601020509	2004	**5**	Y	0	0.0000	0.0000	8.01	**-**
601020602	2005	**4**	F	24	0.0298	0.2084	18.01	**4**
601020603	2005	**4**	F	17	0.0211	0.1476	18.67	**3**
601020604	2005	**4**	F	13	0.0161	0.1129	37.01	**4**
601020605	2005	**4**	F	4	0.0050	0.0347	46.33	**2**
601020606	2005	**4**	Y	55	0.0050	0.0347	9.24	**0**
601020607	2005	**4**	Y	118	0.0682	0.4777	9.22	**4**
601020608	2006	**3**	F	64	0.1464	1.0248	20.82	**21**
601020609	2006	**3**	F	98	0.0794	0.5558	15.93	**9**
601020700	2006	**3**	F	57	0.1216	0.8511	16.61	**14**
601020701	2006	**3**	F	45	0.0707	0.4950	16.54	**8**
601020702	2006	**3**	F	42	0.0558	0.3908	16.65	**7**
601020703	2006	**3**	F	44	0.0521	0.3648	18.11	**7**
601020704	2006	**3**	Y	174	0.0546	0.3821	9.57	**4**
608020000	2007	**2**	Ff	8	0.2159	1.5112	19.84	**30**
608020001	2007	**2**	Ff	10	0.0099	0.0695	18.10	**1**
608020002	2007	**2**	Ff	2	0.0124	0.0868	15.93	**1**
608020003	2007	**2**	Ff	6	0.0025	0.0174	16.26	**0**
608020004	2007	**2**	Ff	6	0.0074	0.0521	16.66	**1**
608020005	2007	**2**	Ff	8	0.0074	0.0521	17.59	**1**
608020006	2007	**2**	Fy	5	0.0099	0.0695	10.64	**1**
			Subtotal	**806**		**7**		**123**
							Hatchery contribution of 7 unknown ad-clipped Chinook Salmon=	**123**
							Expansions of one known CWT=	**8**
							Total estimated contribution of hatchery origin Chinook =	**131**

Spawning Ground Surveys

A total of 670 redds were observed in two reaches of the Shasta Big Springs Ranch in 2009 (Figure 4,Table 2).

A total of 186 Chinook carcasses were sampled during spawning ground surveys. Of the 181 carcasses for which sex determinations were made 129 (71%) were female and 52 (29%) were male. Fork length measurements were collected from 179 of the 186 carcasses recovered (Figure 5) during the spawning ground survey.

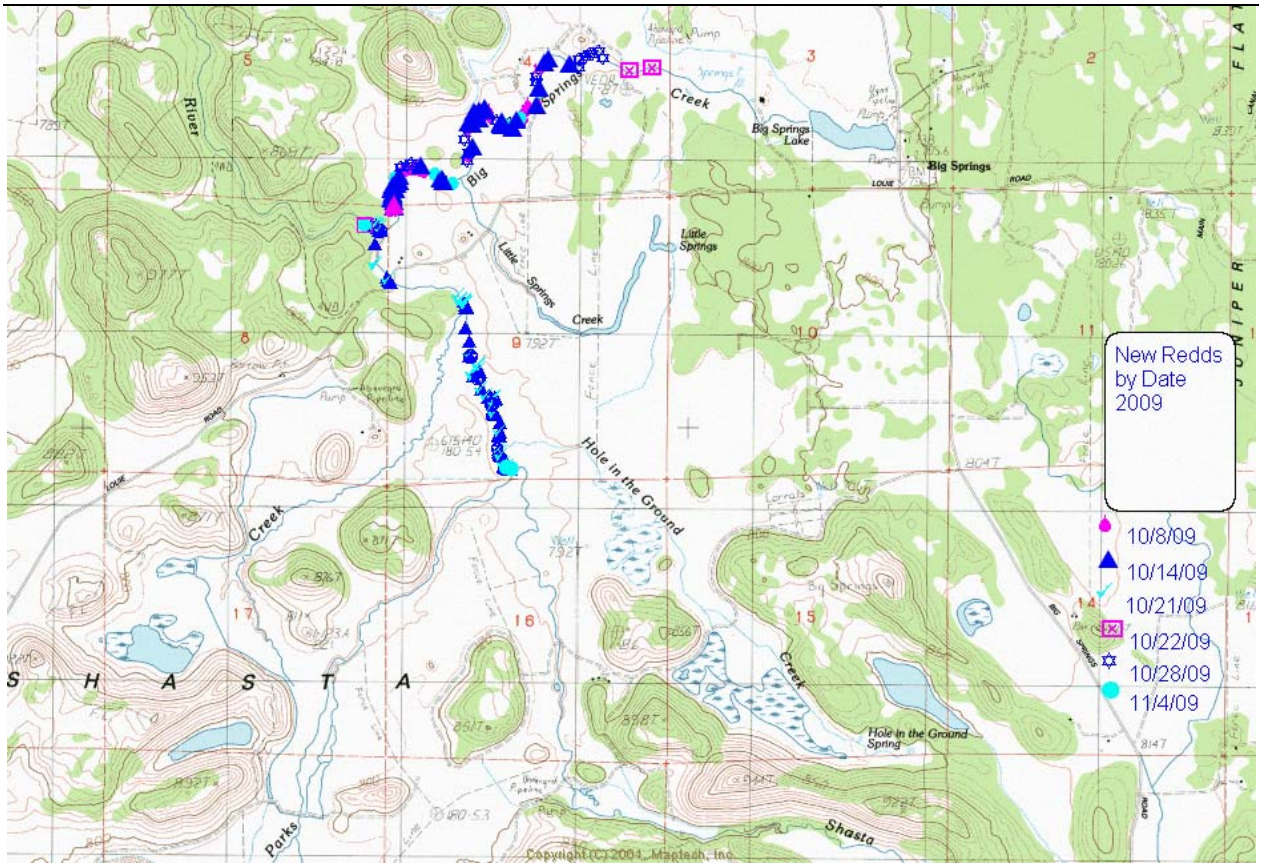

Figure 4. Redds located in Big Springs Creek and the main stem Shasta River above Big Springs Creek, 2009.

Table 2. Number of live Chinook salmon and new redds observed by date on two reaches on the Shasta Big Springs Ranch during 2009.

Reach	Date	# Lives	# New Redds
Mainstem (Parks Creek to Big Springs Creek)	10/7/2009	21	15
	10/14/2009	65	89
	10/21/2009	144	134
	10/28/2009	0	7
	11/4/2009	5	107
	11/18/2009	0	0
	Total	**235**	**352**
Big Springs Creek	10/8/2009	31	24
	10/14/2009	80	64
	10/21/2009	0	101
	10/22/2009	6	3
	10/28/2009	37	116
	11/4/2009	23	0
	11/18/2009	0	10
	12/2/2009	0	0
	Total	**177**	**318**

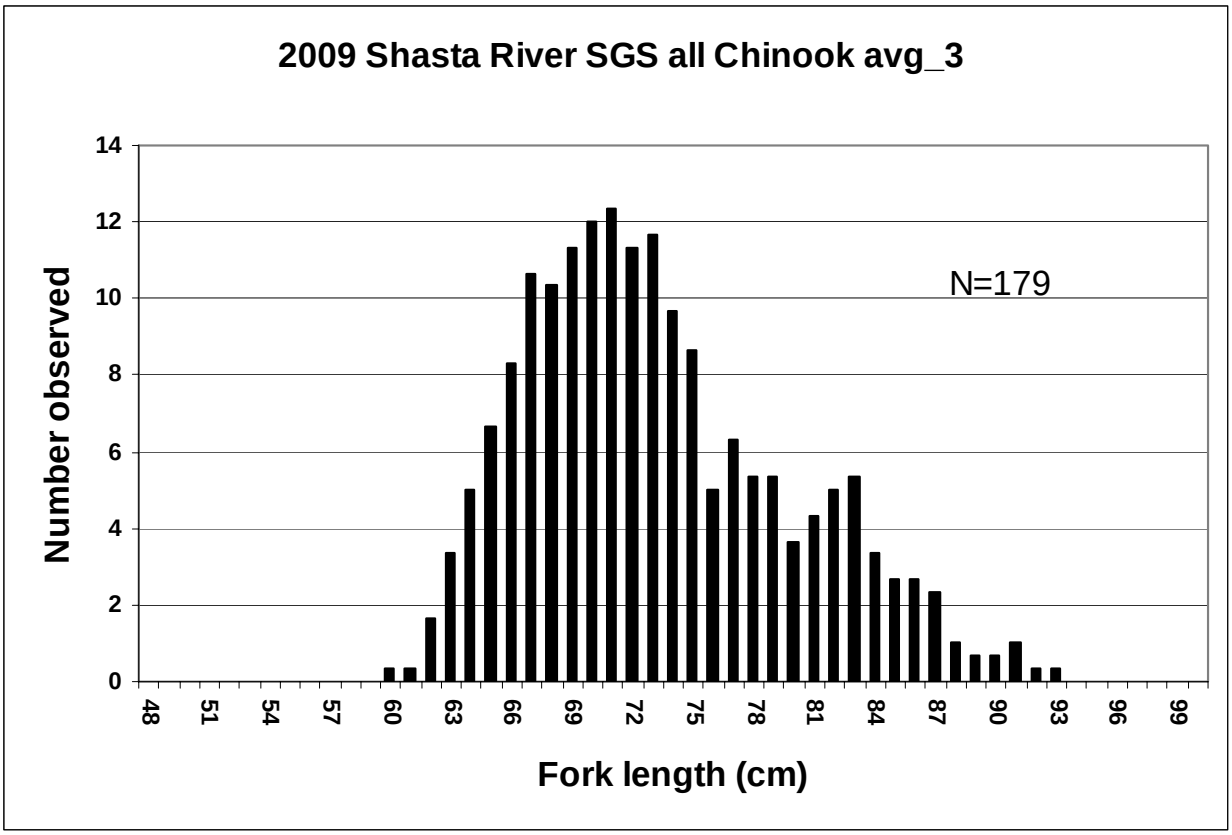

Figure 5. Length frequency distributions of 2009 Shasta River Chinook salmon sampled in spawning ground surveys conducted during the 2009 season.

Wash backs

A total of 331 Chinook carcasses were recovered and sampled as wash backs on the weir. Of the 327 for which sex was determined, 94 (29%) were female and 233 (71%) were male. Since 2004, the wash back samples at the SRFCF have shown a heavy bias toward males (Table 3).

Table 3. Sex composition of wash back carcasses sampled at Shasta River Fish Counting Facility, 2005-2009.

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

Trap

Between September 15, 2009 and December 24, 2009 a total of 388 Chinook were trapped and sampled for fork length, sex, presence/absence of marks or tags, scale and tissue samples. Figure 6 shows the fork length distribution of the Chinook sampled in the trap.

KRP staff elected to determine the grilse fork length cut-off for the 2009 Shasta River Chinook run based on fork length data obtained at the trap, as it eliminated the apparent bias toward males in the wash back sample and the apparent bias toward adult fish seen in the spawning ground survey sample, where no Chinook under 60 cm. in fork length were found in a sample of 179 carcasses. Using the fork length distribution of 388 Chinook sampled in the trap, KRP staff determined that grilse salmon were < 60 cm in FL. Based on this determination, the Department estimates that the Chinook run in the Shasta River during 2009 was comprised of 292 (4.6%) grilse and 5,995 (95.4%) adults.

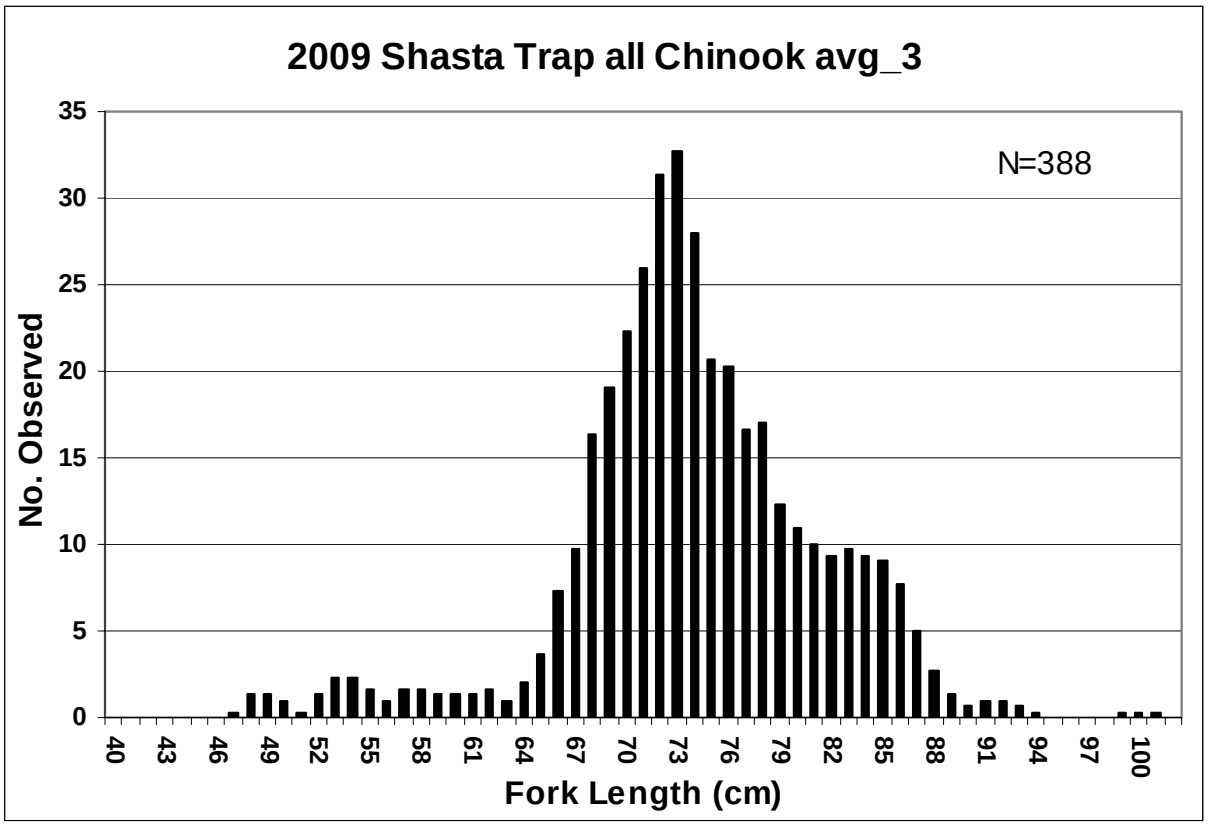

Figure 6. Length frequency distribution of Chinook salmon sampled at SRFCF trap during the 2009 season.

Coho Salmon

A total of 22 coho salmon (coho, *Oncorhynchus kisutch*) were observed passing upstream and 13 coho were observed passing downstream through the SRFCF from November 2, 2009 to December 21, 2009 (Figure 7). After subtracting the 14 coho observed moving downstream through the SRFCF, the total number of coho that are known to have remained in the Shasta River is **nine (9)** fish.

Beginning in 1996, all coho released from IGH (75,000 yearlings) receive a left maxillary clip and all coho released from TRH (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 determined from video review.

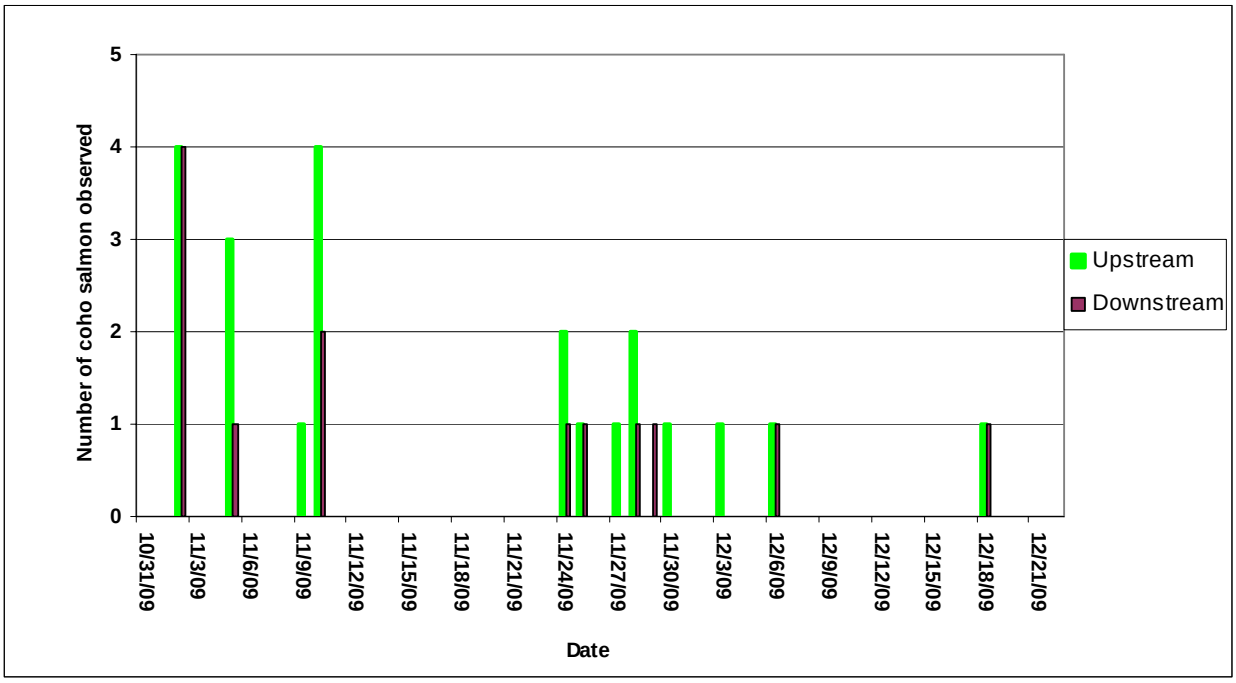

Figure 7. Run timing of coho salmon observed at the Shasta River Fish Counting Facility in 2009.

Nine (9) observations were made of upstream migrating coho with lamprey attachments as they passed through the SRFCF, and three (3) of these were observed with at least two lamprey attachments.

During the 2009 season, the Department's Shasta/Scott Resource Assessment program conducted a radio telemetry investigation in which three (3) male unmarked

coho were trapped and tagged at the SRFCF between November 5, 2009 and December 18, 2009. Of three tagged coho, the furthest upstream detection occurred at RM 9, upstream of the I-5 bridge just above the canyon. The second was detected at the Highway 263 bridge ten days after tagging and the third never left the weir area (Olswang, 2009).

Steelhead Trout

A total of 814 observations of steelhead trout were recorded by SRFCF video reviewers during the 2009 season, 316 less than the 2008 observations of 1,130. After subtracting the downstream observations from the upstream, a net total of 668 steelhead trout were estimated to have migrated into the Shasta River during the recording period. Of these, 538 (80.5%) were classified as juveniles by the reviewers. Of the steelhead observed in 2008, 72% were classified as juveniles. Since fork length calculations were not attempted, these determinations of life stage may vary among observers.

Flow

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. Complete flow records are available for this gauge for water years 1934 through 1941 and 1946 to the present. Flow data for the 2009-2010 water year are provisional at this time and may be subject to revision once these records have been finalized by the USGS. Annual discharge volumes in the Shasta River have ranged from a low of 56,299 acre feet (AF) in 1934 to a high of 263,128 AF in 1974.

Flow data for the SRFCF 2009 season are shown in Figure 8. The agricultural irrigation season on the Shasta River officially ends on October 1 of each year, after which time flows in the Shasta River typically increase. Immediately following the end of irrigation season and following storm events, KRP staff increased efforts to clear debris off the weir panels. Recording was not disrupted due to high flows in 2009; however, a period of cold weather from December 9 to December13 caused ice to form on the weir, resulting in a broken tripod. Weir integrity was compromised for four days until temperatures increased, ice melted and water levels allowed filming to resume.

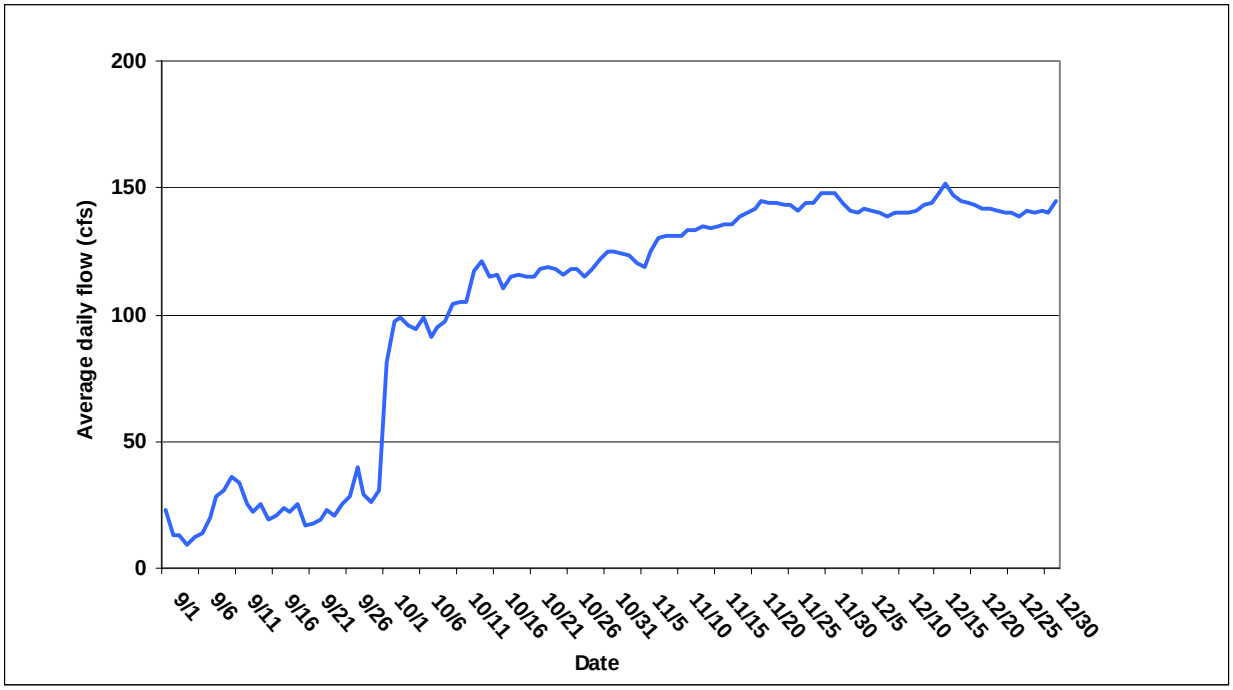

Figure 8. Average daily flows (cfs) in the Shasta River at USGS Gauge No. 11517500 from September 1, 2009 to December 31, 2009.

DISCUSSION

Chinook Salmon

Since 1978 the run size of fall Chinook in the Shasta River has averaged 7,215 fish, and has ranged from a low of 533 fish in 1990 to a high of 18,731 fish in 1978. The 2009 fall Chinook run totaled 6,287 fish, and ranks as the 11th highest run recorded since 1978 (Figure 9).

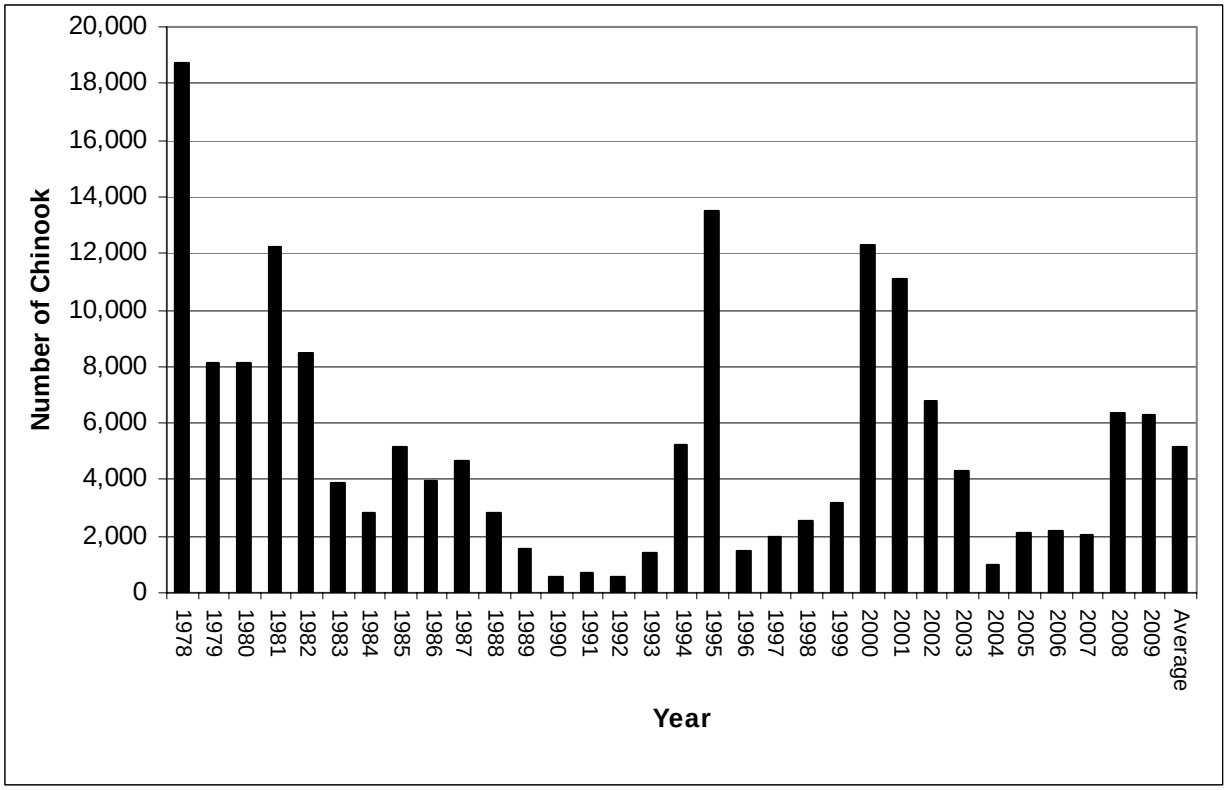

Figure 9. Chinook salmon run size estimates for the Shasta River from 1978 through 2009.

During the late summer and early fall of 2009, flows in the Shasta River were among the lowest on record: 4.74 cfs measured at the SRFCF site on July 29, 2009, with water temperature 25.5 degrees C (Hampton, 2009). On September 23, 2009, the USGS gauge recorded a reading of 23 cfs, a record low for that date, the historical impaired mean being 95 cfs. Over 1,400 Chinook had passed through the SRFCF by September 24, 2009. Field observations during the last week of September indicated that most of these Chinook were holding in pools in the canyon. Elevated air and water temperatures and low flows created conditions in which Chinook might be at risk for pre-spawning mortality due to stress or disease outbreaks, or reduced egg viability due to high temperatures and a delay in reaching spawning areas. Marine (2010) found in controlled trials of Trinity River spring Chinook that at temperatures of 14.5 degrees C and above, mortality increased rapidly for incubating embryos and pre-emergent larvae. While adult Chinook salmon were present (Figure 10) in the Shasta River, daily mean stream temperatures recorded at the counting facility were in excess of 14.5º C from when the first Chinook was observed on September 4, 2009 to September 29, 2009 when stream temperatures rapidly started to decline (Figure 11).

DFG staff monitored water temperatures and dissolved oxygen (DO) levels in several large pools where Chinook were holding from September 24 to September 30, 2009. Evening water temperatures were as high as 20 degrees C; however, DO levels remained within tolerance levels and no signs of distress or unusual mortality were observed in the fish. Conditions improved by September 27, 2009 when air temperatures cooled and six Shasta River irrigators, aware of the potential for a fish kill, shut off their diversions early in an effort to increase in-river flows.

Between 2001 and 2009, an average of 31% of the Shasta River fall Chinook runs passed through the SRFCF on or before September 30, prior to the end of irrigation season (Table 4).

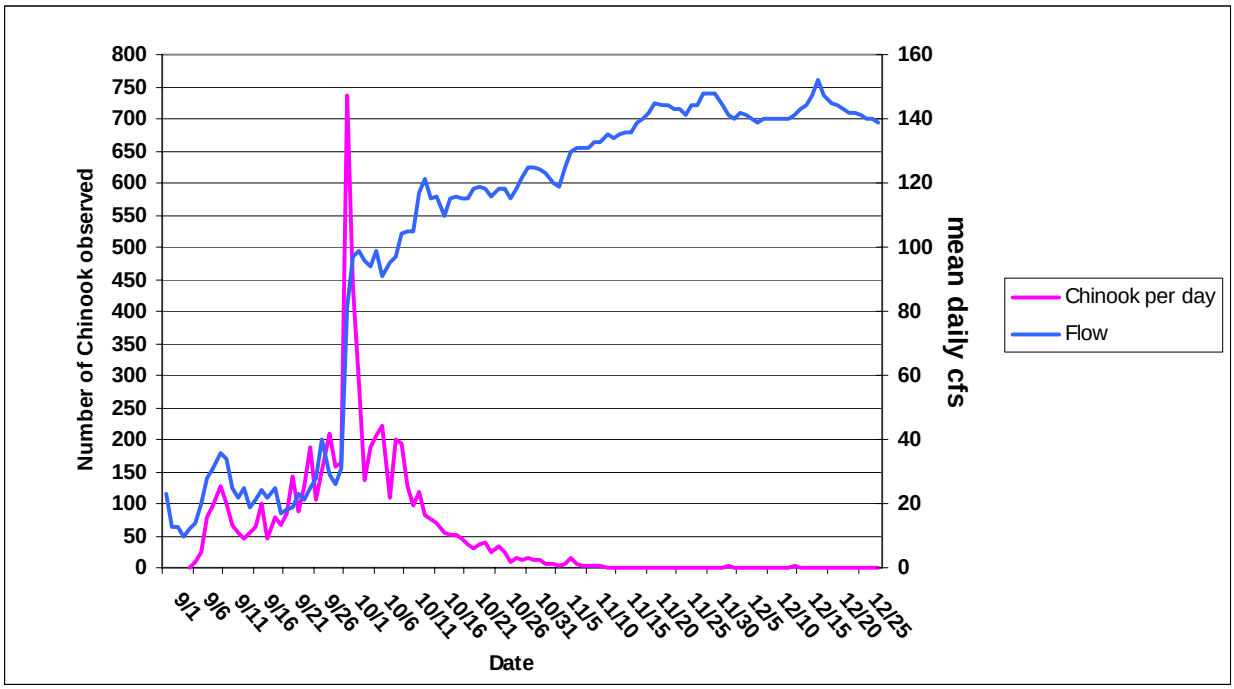

Figure 10. 2009 Shasta River Chinook migrating through the SRFCF per day and average daily flows (cfs) at USGS Gauge No. 11517500 from September 1, 2009 to December 31, 2009.

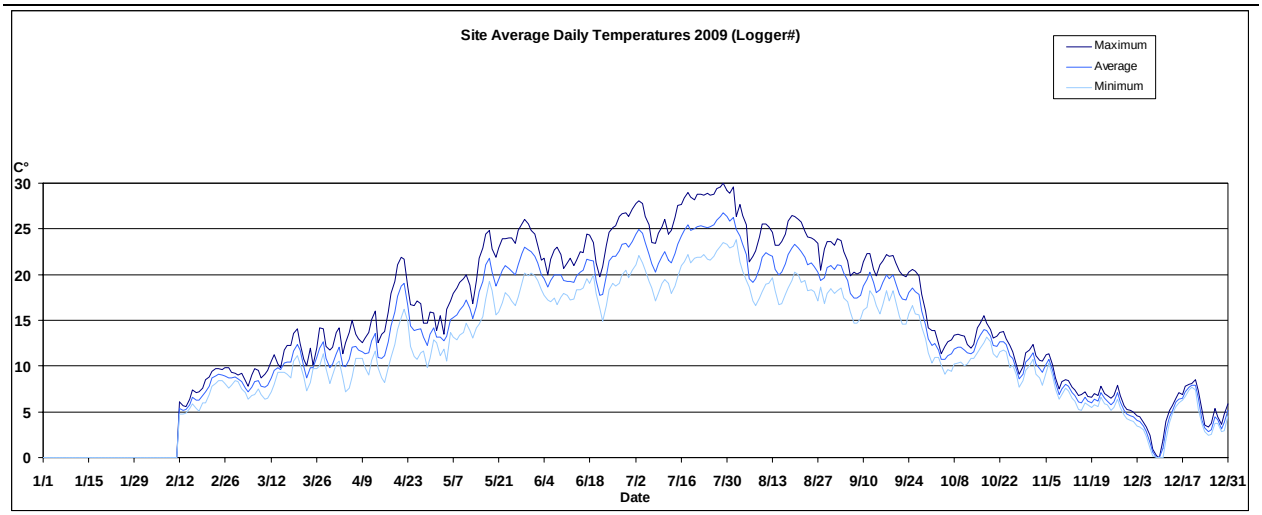

Figure 11. Average daily temperatures recorded at the Shasta River Fish Counting facility from February 12, 2009 to December 31, 2009.

Table 4. Percentage of the total annual Shasta River fall Chinook run counted through the SRFCF on or before September 30, and October1 through 8, from 2001 to 2009.

Percent of Chinook observed on or before September 30		Percent of Chinook observed October 1 through October 8	
Year	**Percent of run**	**Year**	**Percent of run**
2001	25%	2001	32%
2002	51%	2002	16%
2003	26%	2003	28%
2004	18%	2004	32%
2005	33%	2005	16%
2006	36%	2006	28%
2007	15%	2007	24%
2008	39%	2008	27%
2009	32%	2009	42%
Average	**31%**	**Average**	**27%**

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 2.1% in 2009.

Table 5. Estimates of hatchery strays as percentage of Chinook entering the Shasta River, 2002-2009.

Year	Total Number of Chinook	Hatchery Stray Estimate	Percent Hatchery
2002	6,820	79	1.2%
2003	4,289	436	10.2%
2004	962	372	38.7%
2005	2,129	469	22.0%
2006	2,184	106	4.9%
2007	2,035	69	3.4%
2008	6,362	66	1.0%
2009	6,287	131	2.1%

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 an ocean harvest model to estimate age specific ocean abundance and 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 2009 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**

In 2008, the grilse (2006 Brood Year (BY) component of the Shasta River Chinook run was the third highest in KRP history at 56.9 percent . A strong 3-year old component of the 2009 run was expected, and in 2009, the basin-wide component of 3-year olds was estimated to be 89% of the total run (Table 6).

Closures of ocean commercial and extreme reductions of sport Chinook fisheries off California and most of Oregon in 2008 and 2009, enacted to protect weak Sacramento River fall Chinook stocks, may be having a positive effect on Klamath Basin stocks. The target of 40,700 natural area adult spawners was met in 2009, when 44,589 natural area adult spawners returned to the Klamath Basin.

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 2009. As habitat conditions improve in the Shasta River watershed the ability of the watershed to produce fish will hopefully improve. The river under its current habitat conditions continues to produce more 0+ Chinook as more adults return, indicating that the watershed has not reached a “saturated level” or a “carrying capacity” for Chinook salmon (Figure 12). The Shasta River has been know for its extremely productive conditions and at the current levels of fish abundance the Shasta River is spawner limited.

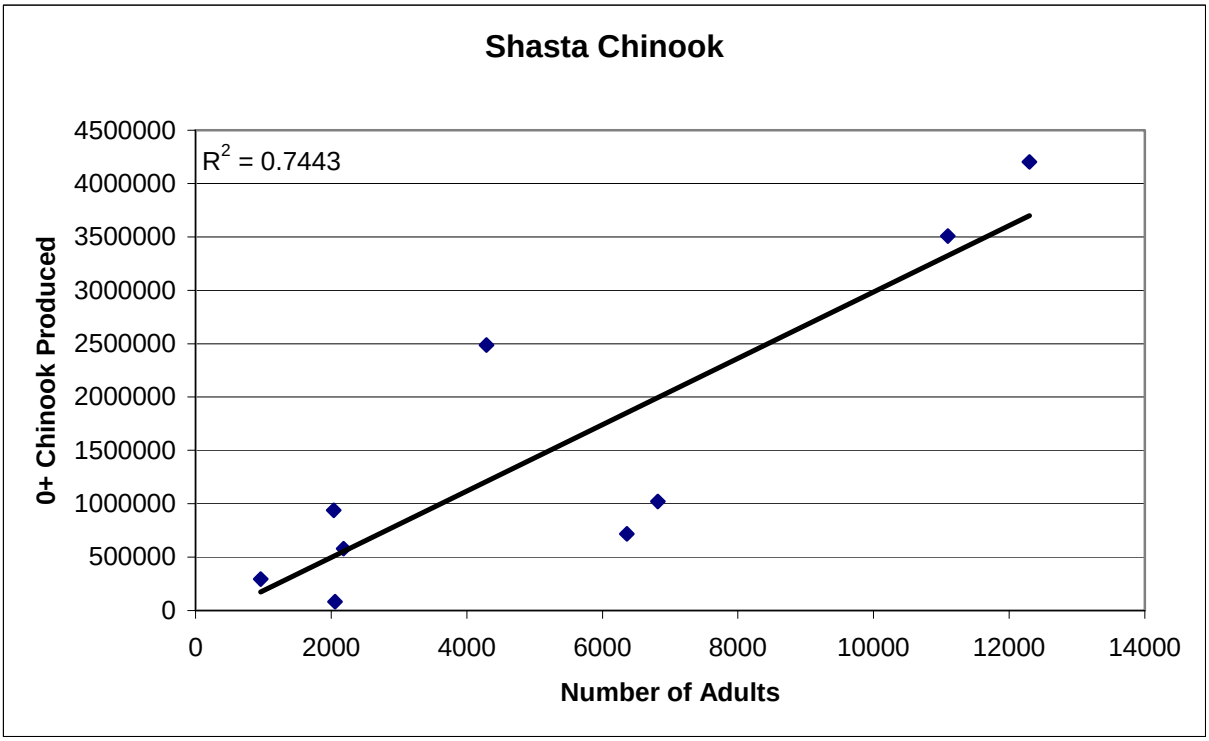

Figure12. Number of 0+ Chinook produced per adult spawner in the Shasta River, Brood Years 2000-2008.

Table 7. Klamath Basin and Shasta River Chinook natural spawner escapements (age 2-5), 1978-2009.

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%
Average	**58,500**	**5,194**	**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 13 shows returns of coho to the Shasta River from 1978 to 2009. As indicated in Figure 13, sampling from 1983 to 2000 cannot be directly compared to other years, since the weir was removed on or before November 11 during those years and cannot be considered to have sampled the entire run of coho.

Returns of wild coho to the Shasta River and throughout the Klamath Basin were extremely poor in 2009. All nine of the coho known to have entered the Shasta River appeared to be males. Five of the nine were captured in the SRFCF trap and sex was determined by direct observation, and the other four were observed in the video review.

One of the five coho (20%) that was handled in the trap was marked with a left maxillary clip indicating that this fish was of hatchery origin. Based on a sub-sample of coho that have been handled at the trap the proportion of hatchery origin fish has be estimated from 2007-2009 (Table 8).

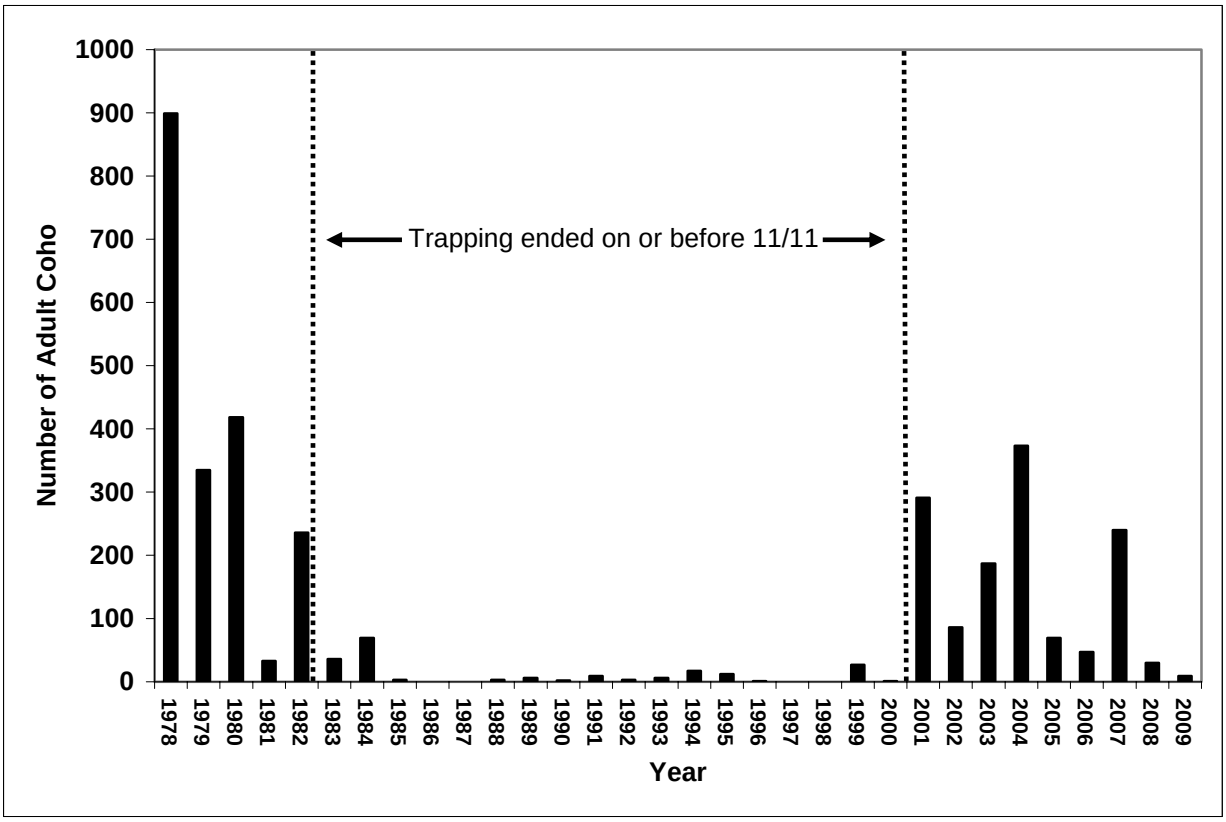

Figure 13. Returns of coho salmon to the Shasta River, 1978-2009.

Table 8. **Estimates of hatchery strays as percentage of coho entering the Shasta River, 2007-2009.**

Year	Total Number of Coho	Hatchery Stray Estimate	Percent Hatchery
2007	249	5	2%
2008	30	22	73%
2009	9	2	20%

During the ice buildup from December 9 to December 13, 2009, when there was a break in the weir, it is possible that additional coho may have entered the river over the weir (Figure 14), but given that no coho were observed during the four days prior to or the four days following that event, and given that the ice buildup was not associated with an increase in flow, it seems unlikely that a significant portion of the coho run entered the river during that period.

Figure 14. Ice buildup caused the collapse of a tripod supporting the Alaskan weir at the SRFCF, December, 4, 2009.

Radio tagging studies conducted in 2004 through 2009 identified two main areas of coho spawning 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). Rotary 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 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.

In the Big Springs complex, during the summers of 2008 and 2009 direct observations as well as pit tagging studies located several cold water spring areas where coho were rearing over the summer. Pit tagged coho were observed to move upstream into these

cold water areas when water temperatures rose elsewhere in the river. Chesney et al concluded that conservation of these cold water areas were essential to the survival of juvenile coho.

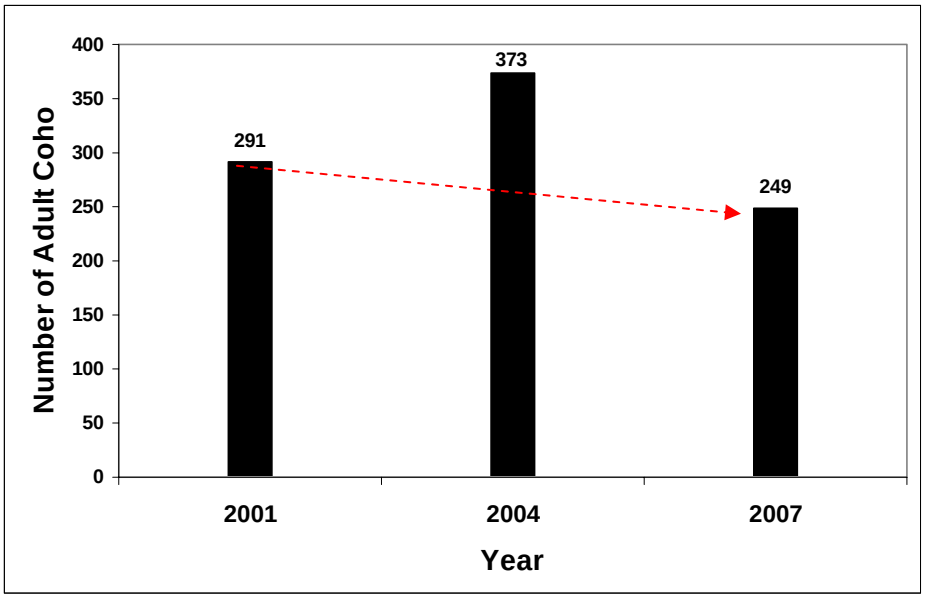

Figure 15. Returns of Shasta coho cohort 1.

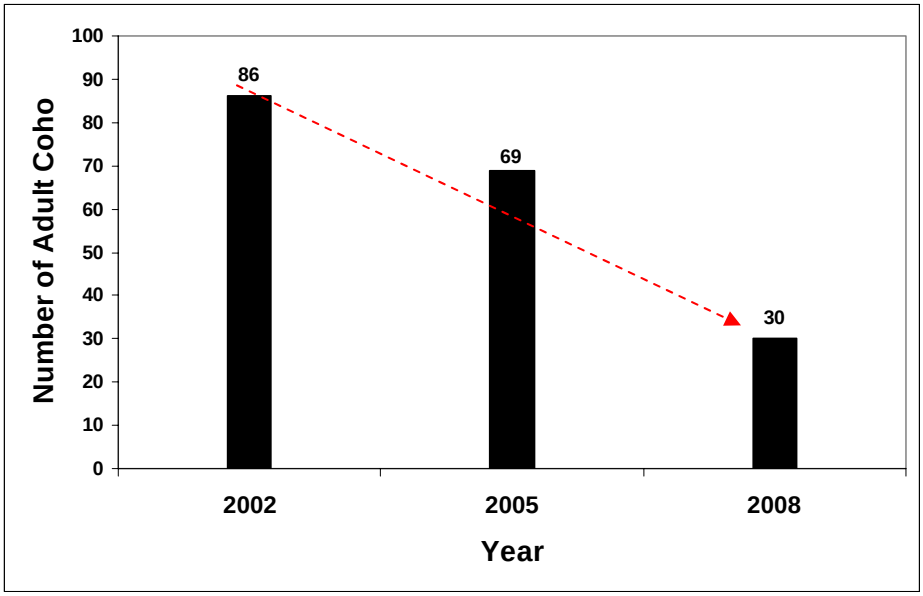

Figure 16. Returns of Shasta coho cohort 2.

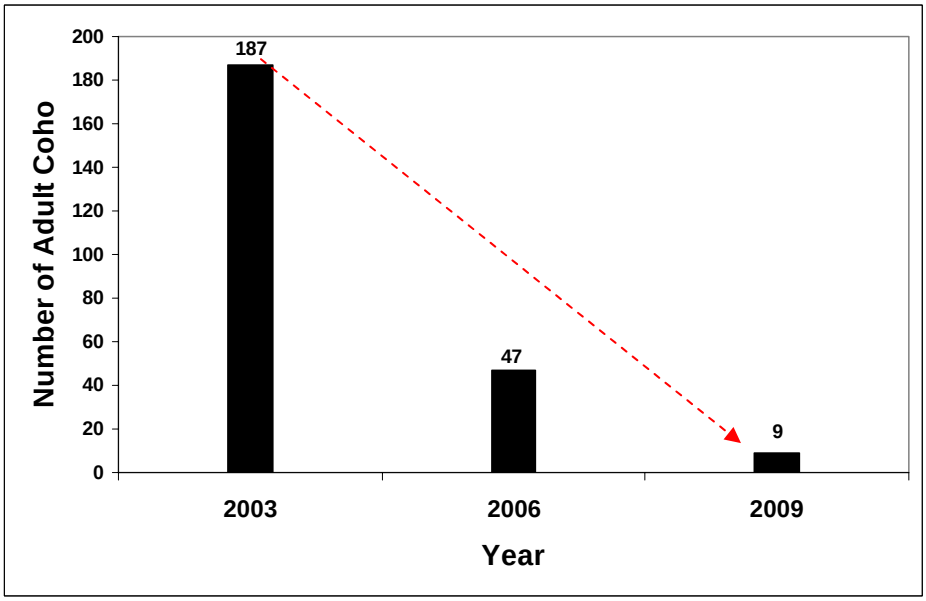

Figure 17. Returns of Shasta coho cohort 3.

Figures 15, 16 and 17 show declines in the three Shasta River coho cohorts. Given the extremely poor returns of cohorts 2 and 3, it appears that the best chance for restoration of Shasta River coho remains with cohort 1, which is due to return in 2010. At this time, management options being considered include a conservation hatchery using captured and captively reared Shasta coho, and flow enhancing agreements with irrigators to ensure adequate flows for rearing of juveniles and upstream migration of adults.

Utilizing the number of yearling coho produced in the Shasta River (Chesney et al 2010) 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 33.83 and ranged from a low of 23.11 to a high of 43.7 for brood years 2001-2006. The corresponding out of basin survival has averaged 3.14 percent and ranged from a low of 2.35 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 outside our control 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 2001-2006.

Brood Year	Yearling Year	Yearling point Estimate	Adult Year	Adult Estimate	Yearlings to adult	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
Average					**33.83**	**3.14**

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 20.0 and ranged from a low of 4.4 to a high of 38.0 for brood years 2001-2006 (Table 10). The number of yearlings produced per returning adult by brood year is a direct measure of freshwater survival. 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 2001-2006.

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
Average				**20.0**

It is hoped that as conditions in Big Springs Creek and other properties being managed and restored for the benefit of Salmonids improve, the production, survival and successful out-migration of future coho runs will improve in the Shasta River.

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