California Department of Fish and Game

Klamath River Project

Recovery of Fall-run Chinook and Coho Salmon at Iron Gate Hatchery

2005

Jeannine Richey

Fishery Biologist
California Department of Fish and Game
Klamath River Project
303 South Street
Yreka, CA 96097

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ABSTRACT

In 2005, fall-run Chinook salmon (*Oncorhynchus tshawytscha*) began entering IGH on September 11. A total of 13,997 Chinook salmon entered IGH during the fall 2005 spawning season. Of these, Klamath River Project (KRP) staff collected scale samples, determined sex, and measured fork lengths for 2,128 Chinook salmon and recovered heads from 892 ad-clipped Chinook salmon. Analysis of the length-frequency distribution for randomly sampled fall-run Chinook males indicates that the cutoff point between grilse and adults occurred at 50 cm (Figure 3). During the 2005 spawning season 0.3% (42) of the run were grilse, according to length-frequency analysis. This is the lowest percentage of grilse observed since the beginning of the KRP (1978) (Figure 9). The average during this period is 9.5%. Females accounted for 50.4% (7,056) of the run while males accounted for 49.6% (6,941). The last Chinook of the 2005 spawning season was observed on December 5, 2005. The 2005 run (13,997) of fall-run Chinook salmon recovered at IGH was close to the average for the period 1978-2005 (16,282). The 2005 IGH Chinook run total (13,997) contributed roughly 21% to the total (Klamath basin) in-river run and 25% to the total spawner escapement (Table 6).

KRP staff also collected biological data for coho salmon (*Oncorhynchus kisutch*) (sex, fork length, presence of marks or clips and scale samples) during the 2005-06 coho spawning season. Biological data was collected on 466 coho, which was approximately one third of the coho which entered IGH (1,425). Males ranged in size from 38 to 102 cm (Figure 6), while female coho ranged in size from 44 to 78 cm (Figure 7). Iron Gate Hatchery counts for the 2005-06 coho spawning season included 799 adult females, 596 adult males, and 30 grilse. IGH staff counted 1,282 coho with left maxillary clips, 2 with right maxillary clips and 1 with an adipose clip among these 1,425 coho. The recorded dates for the coho run were from October 19 to December 28, 2005. A total of 124 unmarked coho salmon were Floy tagged and released from IGH to the Klamath River. Of these, 39 coho reentered IGH and were returned to the river, 10 coho were observed in nearby Bogus Creek, and 3 unmarked coho were observed passing the video fish counting station on the Shasta River. No Floy tagged coho were reported for the mainstem Klamath River. Eleven of the 39 unmarked coho that returned to IGH after their initial tagging reentered the hatchery on more than one occasion (Table 5). Two of the coho that were eventually recovered in Bogus Creek had previously reentered IGH on multiple occasions.

INTRODUCTION

Iron Gate Hatchery

The Iron Gate Hatchery is located adjacent to the Klamath River (river mile 190), in Siskiyou County, CA, approximately 120 miles north of Redding, near the Oregon border (Figure 1). This hatchery was established in 1963 in order to mitigate for the effects of Iron Gate Dam on anadromous species. The production goals for the hatchery are listed in Table 1 (CDFG and PP&L 1996).

Table 1. Production goals for anadromous salmonid releases from Iron Gate Hatchery, Klamath River.

Species	Number released	Released	Run timing
Chinook Salmon	4,920,000 smolts	May-June	mid September to early November
	1,080,000 yearlings	November	
Coho	75,000 yearlings	March	late October to early January
Steelhead	200,000 yearlings	March-May	November to March

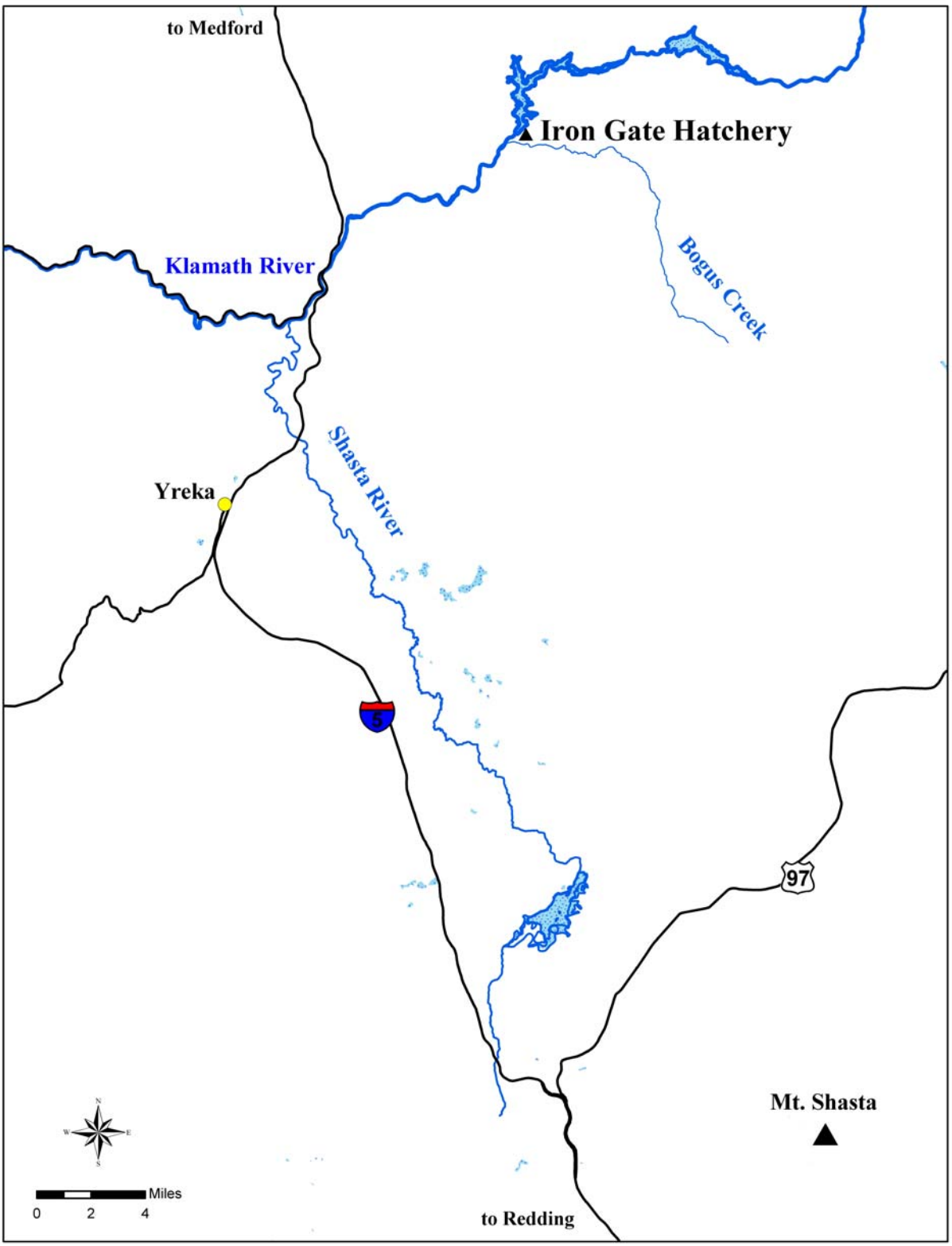

Figure 1. Location of Iron Gate Hatchery (California Department of Fish and Game, Siskiyou County).

Klamath River Project

The California Department of Fish and Game's (CDFG), Klamath River Project (KRP) conducts random sampling of fall-run Chinook salmon annually, during the Chinook spawning season. The purpose of the sampling is to determine the abundance of adult fall-run Chinook salmon entering Iron Gate Hatchery (IGH), to characterize the run in terms of age and sex composition, and to recover data from all coded wire tags (CWT) from adipose fin clipped (ad-clipped) Chinook. All Chinook salmon tagged at IGH are marked with an adipose fin clip, which is the mark used to identify tagged Chinook salmon when they return to the hatchery during subsequent spawning seasons. The goals of the project are to collect biological data on a random sample of Chinook and coho salmon entering IGH and to recover all coded wire tags. Data from CWT fish provide a reference of known-age fish which is used, along with scale samples and analysis of length frequency distribution, to determine age composition.

Coded Wire Tagging

During April and May of each year (since 1979), staff of the KRP insert CWTs into 200,000 Chinook smolt (90 fish/lb) and 120,000 yearling Chinook salmon. Smolts (fingerlings) receive a half length tag; yearlings receive a full length tag. These tags contain a code that allows for the identification of four separate groups of fingerlings and three groups of yearlings (which correspond to different raceways). One of the goals of the tagging program is to determine the success of the early release strategy (Hampton 2001). Formerly, smolts were released at IGH from June 1 to June 15. At the recommendation of the Joint Hatchery Review Committee (2001), CDFG developed this early release strategy, which allows for the release of smolts in four groups, each separated by approximately 1 week, beginning around mid-May. There are several benefits to the early release strategy, including reduced competition with natural salmonids and improved survival of smolts (due to lower water temperatures and higher flows). One of these yearling groups are raised at Fall Creek Hatchery, which is adjacent to Fall Creek (a tributary to Iron Gate Reservoir), an excellent source of high quality water. 2002 was the first year that Fall Creek yearlings were tagged with a unique CWT code. This unique CWT code allows evaluation of Fall Creek yearling survival rates relative to IGH yearlings.

MATERIALS AND METHODS

Chinook Salmon

All Chinook are allowed to enter IGH. Upon entering IGH in the fall of 2005, Chinook salmon were held until they were ready to spawn. Readiness to spawn is determined by hatchery staff and based on timing, firmness of the ovaries, and ease of stripping eggs when handled. Once the fish are spawned, they are counted, sexed and examined for clips and/or marks, by staff of the KRP. During each sampling day, a systematic random sample (every 10^{th} Chinook,) was performed. Fork length and sex were determined and a scale sample was collected for each of these random fish. Heads containing CWTs and scale samples, as well as fork length measurements and sex determinations, were collected from all ad-clipped Chinook (random and non-random fish). Excess fish are killed and added to the post-spawned fish. All fish are processed and donated to local food banks, churches, and the public.

Coho Salmon

In addition to collecting biological data for the Chinook run, staff of the KRP collected biological data (sex, fork length, presence of marks or clips and scale samples) for a large portion

of the coho which entered IGH. Each coho was inspected for the presence of marks and clips (adipose and right or left maxillary). Since 1995, all hatchery reared coho salmon within the Klamath River basin have been marked with a maxillary clip prior to release. IGH coho receive a left maxillary clip; Trinity River Hatchery (TRH) coho are marked with a right maxillary clip.

In the fall of 2004, prior to the beginning of the coho salmon spawning season, NOAA fisheries and CDFG held several meetings intended to reduce the potential take of naturally produced coho salmon (unknown portion of unmarked coho that enter each facility) that may occur at IGH and TRH during recovery efforts. The discussions primarily focused on three aspects or action items: 1) how to incorporate unmarked coho into the spawning matrix, 2) how and where to release unmarked coho not used in the spawning matrix and 3) how to monitor unmarked coho releases. In response to these concerns, CDFG implemented interim protocols for the handling unmarked adult coho salmon that enter IGH and TRH during the spawning season.

In summary, the Department agreed to implement the following protocols:

1. Only enough eggs and sperm from unmarked coho will be taken to account for the overall egg take needed to make up 20 to 25% of the total annual release of yearlings at each hatchery. To determine how many coho females will need to be spawned this season at each hatchery to obtain the desired percentage of yearlings released, we assumed 2,600 eggs per female, a 70% survival rate from green eggs to eyed eggs and an 80% survival rate from eyed eggs to yearlings. These figures are based on historical averages we have seen at both hatcheries over the past 30 years. This will mean that IGH will need to take approximately 10 unmarked coho (5 male and 5 female) to procure 26,000 green eggs. This will produce about 18,200 eyed eggs and 14,560 yearlings (19.4% of 75k). TRH will need to take approximately 70 unmarked coho (35 male and 35 female) to procure 182,000 green eggs. This will produce about 127,400 eyed eggs and 101,920 yearlings (20.4% of 500k). The remainder of the green eggs needed to meet the overall coho production goals at each hatchery will come only from spawning marked adults of hatchery origin.

2. Spawning protocols will follow a one-to-one mating of males to females. By definition, eggs determined to be of unmarked origin will come from mating one unmarked fish with a marked hatchery origin fish. The Department **will not** pair an unmarked fish with another unmarked fish during spawning activities.

3. By closely following the above spawning protocols, there will be no need to cull any eggs from unmarked origin fish. There is a chance that the final percentage of unmarked origin yearlings released may be slightly higher or lower than 20% depending on the size of the run and survival rates experienced this season at both hatcheries.

4. All unmarked adults returning to the hatchery will be passed through a tag detector to determine if they contain a coded wire tag indicating they came from Cole M. Rivers Hatchery in Oregon. All unmarked fish determined to be of Cole M. Rivers Hatchery origin will not be included in the spawning matrix and will be killed and the cwt will be recovered and analyzed to verify the origin of these fish.

5. All unmarked adults not used in the spawning matrix will have their caudal fin clipped, are Floy tagged and then released back into the river at the hatchery site.

Application of a caudal clip and insertion of an individually numbered Floy tag to unmarked coho salmon provides an opportunity to monitor the movement of these coho after release (Figure 2). Once released, these coho may return to the hatchery, spawn in the Klamath River downstream of IGH, or enter one of several tributary streams downstream of Iron Gate Dam. Application of the caudal clip serves as a backup mark, in case the Floy tag is shed. The caudal clip also provides CDFG with the ability to identify these coho if they pass through one of the video fish counting facilities located in Bogus Creek and the Shasta River. Individually numbered Floy tags provide the ability to track individual coho if they return to the hatchery or are recovered in one of the spawning ground surveys.

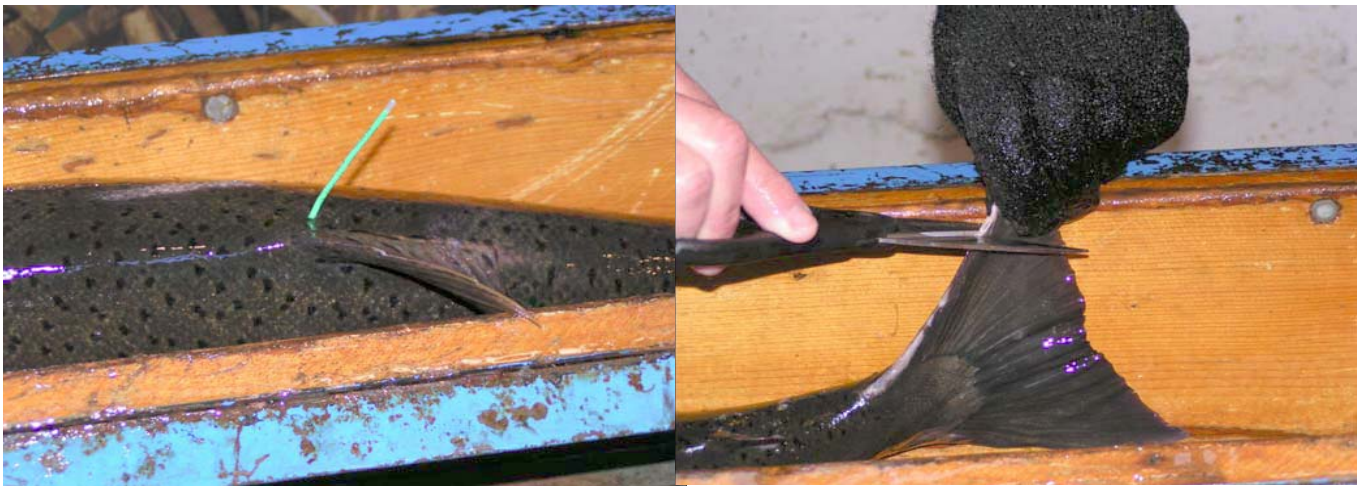

Figure 2. Photograph of Floy Tag application (left) and anterior caudal clip (right) applied to unmarked coho salmon at Iron Gate Hatchery prior to release back to the river during the 2005 spawning season.

RESULTS

Chinook Salmon

In 2005, fall-run Chinook salmon began entering IGH on September 11. A total of 13,997 Chinook salmon returned to IGH during the fall 2005 spawning season. Of these, KRP staff collected scale samples, determined sex, and measured fork lengths for 2,128 Chinook salmon. Randomly sampled male Chinook ranged in size from 42 cm to 102 cm (Figure 3). Analysis of the length frequency distribution for randomly sampled fall-run Chinook males indicated that the cutoff point between grilse and adults occurred at 50 cm in fork length, yielding approximately 0.3% grilse. Therefore, based on the 50 cm cutoff, it is estimated that 42 grilse and 13,955 adults entered IGH. Females accounted for 50.4% (7,056) of the run and males accounted for 49.6% (6,941). Randomly sampled female Chinook ranged in size from 53 to 97 cm (Figure 4). The last Chinook to enter IGH for the 2005 spawning season was observed on December 5, 2005.

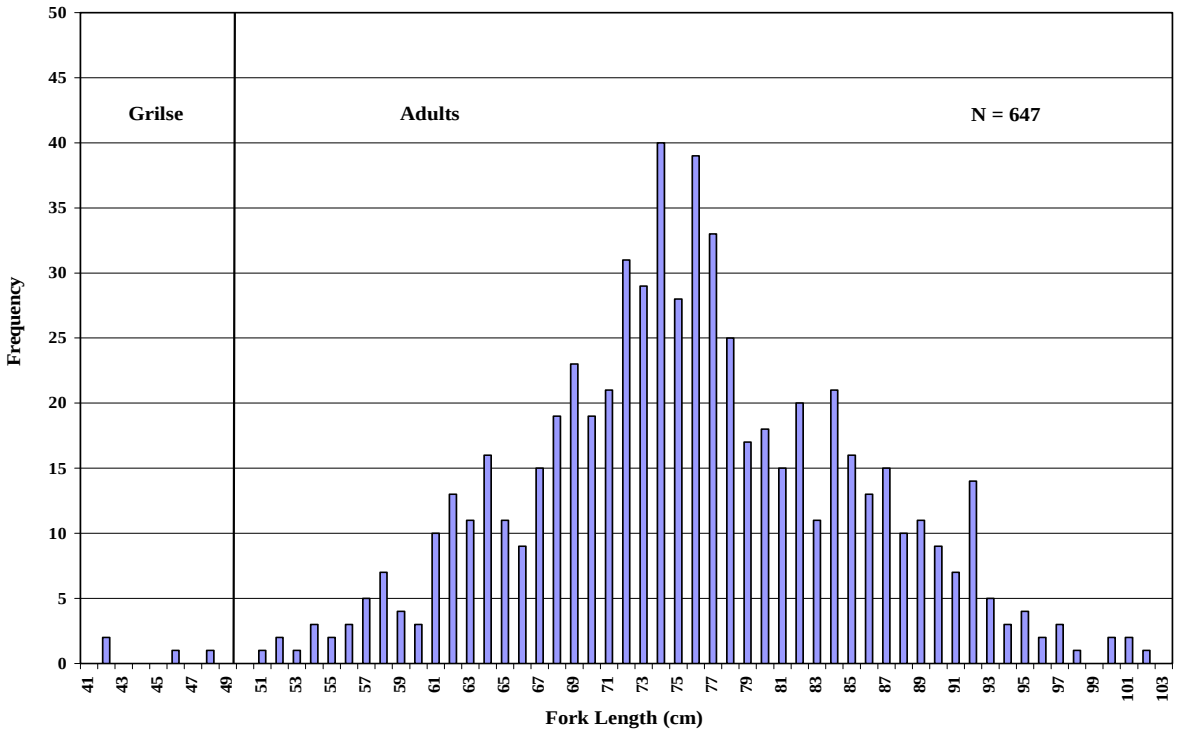

Figure 3. Length frequency distribution for random male Chinook salmon recovered at IGH during the 2005 spawning season.

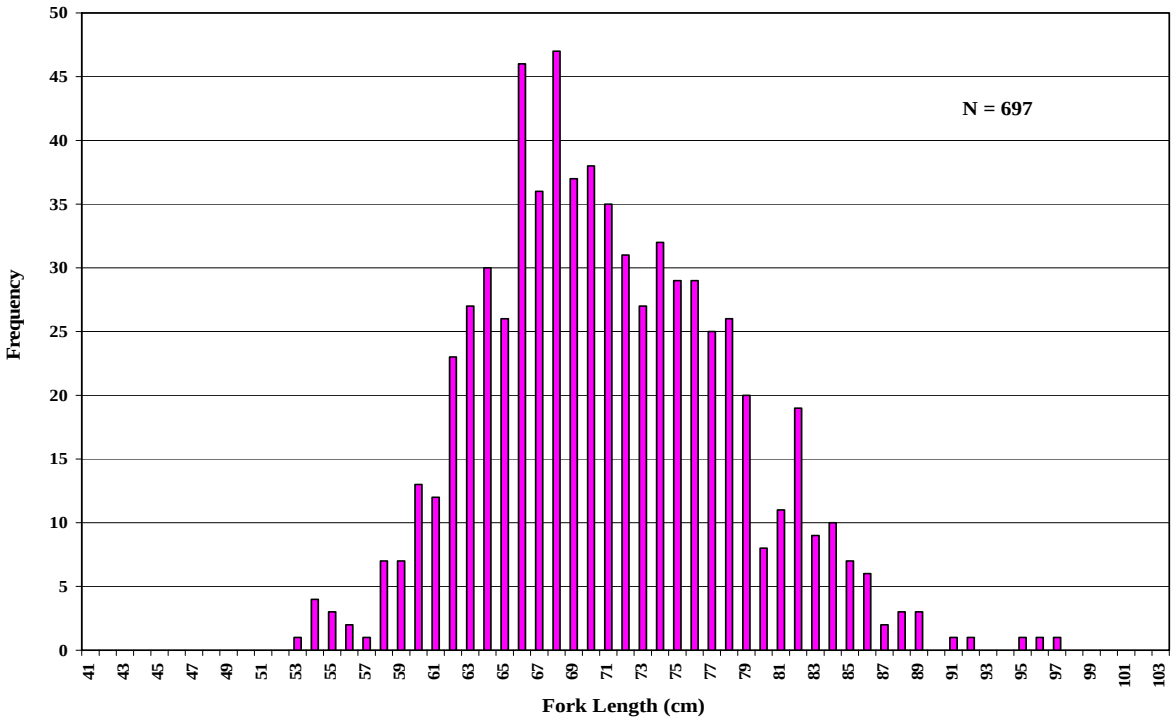

Figure 4. Length frequency distribution for random female Chinook salmon recovered at IGH, during the 2005 spawning season.

Heads from 839 ad-clipped Chinook salmon (from random and non-random fish) were collected for CWT recovery (Figure 5 and Table 2). The contribution of lost or unreadable CWT ad-clipped Chinook was estimated by applying the proportions of known CWTs (802) to the 37 lost or unreadable CWT ad-clipped Chinook (Table 3). This estimated contribution was then added to the contribution of known CWTs to yield the total contribution of hatchery Chinook entering IGH (Table 2). All Chinook CWTs recovered (and successfully read) originated from IGH. Based on the expansion of these CWTs, KRP staff estimated that 10,785 (77%) of the Chinook entering IGH during the 2005 season were of hatchery origin (Table 2). The majority of these known age fish were age 3 (53.9%) and age 4 (40.7%); grilse only accounted for 0.6% and age 5 fish contributed only 4.8%. These proportions are similar to what the KRTAT developed for the 2005 run, based on scale age proportions (Table 4).

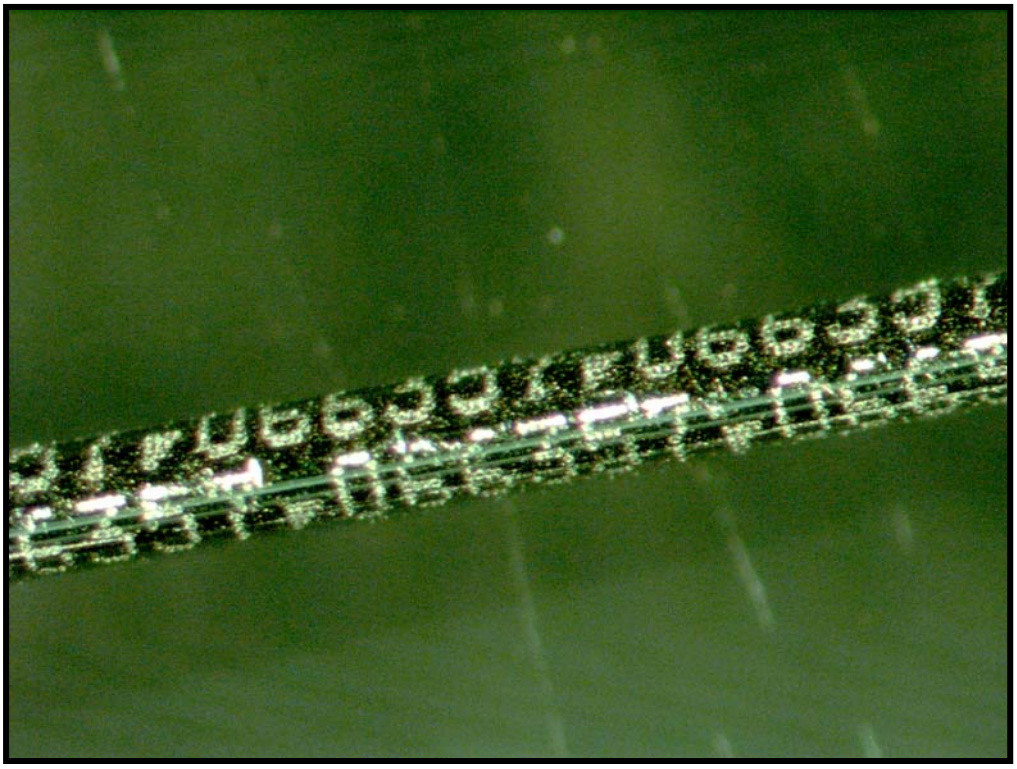

Figure 5. Example of Coded Wire Tag (CWT) wire used in tagging IGH Chinook salmon. Code 066357 corresponds to the brood year 2001 Chinook yearlings which were released in November 2002.

Table 2. Estimated contribution of Chinook from Iron Gate Hatchery to total run at Iron Gate Hatchery, based on coded wire tags (CWTs) recovered from fall-run Chinook salmon that entered Iron Gate Hatchery, during the 2005 spawning season.

CWT	Release Location	Brood Year	Age	Release Type	Number Recovered	Production Multiplier	Expanded Estimate
Estimated contribution of known CWTs:							
66353	IGH	2000	**5**	Fy	18	9.64	**174**
66354	IGH	2000	**5**	Fy	15	8.51	**128**
66355	IGH	2001	**4**	Fy	183	9.32	**1,706**
66356	IGH	2001	**4**	Fy	119	10.55	**1,256**
66357	IGH	2001	**4**	Fy	121	9.81	**1,187**
66358	IGH	2002	**3**	Fy	40	10.52	**421**
66359	IGH	2002	**3**	Fy	41	10.00	**410**
66360	IGH	2002	**3**	Fy	30	7.99	**240**
601020306	IGH	2000	**5**	Ff	3	17.76	**53**
601020307	IGH	2000	**5**	Ff	2	39.30	**79**
601020308	IGH	2000	**5**	Ff	2	32.44	**65**
601020400	IGH	2001	**4**	Ff	1	17.50	**17**
601020403	IGH	2001	**4**	Ff	1	30.66	**31**
601020404	IGH	2002	**3**	Ff	104	16.32	**1,697**
601020405	IGH	2002	**3**	Ff	62	15.74	**976**
601020406	IGH	2002	**3**	Ff	42	32.97	**1,385**
601020407	IGH	2002	**3**	Ff	15	28.47	**427**
601020408	IGH	2003	**2**	Ff	1	19.20	**19**
601020409	IGH	2003	**2**	Ff	1	19.28	**19**
601020503	IGH	2003	**2**	Ff	1	21.42	**21**
				Subtotal	**802**		**10,310**
Estimated contribution of unknown CWTs (see Table 2):							
200000					15		
400000					22		
				Subtotal	**37**		**476**

Total Estimated Hatchery Contribution = 10,785

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

Ff = Fall-run Chinook fingerling, Fy = Fall-run Chinook yearling

The production multiplier value is the inverse of the proportion initially tagged.

Table 3. Estimated contribution of 37 ad-clipped Chinook salmon with unknown coded wire tag (CWT) codes (lost or unreadable) that were recovered at Iron Gate Hatchery (IGH), based on the proportional distribution of known CWT recoveries at IGH during the 2005 season.

CWT Codes	Brood Year	Number of CWTs Recovered	Proportion of CWTs recovered	Estimated Number	Production Multiplier	Expanded Estimate
66353	2000	18	0.022443890	0.83042394	9.64	**8**
66354	2000	15	0.018703242	0.69201995	8.51	**6**
66355	2001	183	0.228179551	8.442643392	9.32	**79**
66356	2001	119	0.148379052	5.490024938	10.55	**58**
66357	2001	121	0.150872818	5.582294264	9.81	**55**
66358	2002	40	0.049875312	1.845386534	10.52	**19**
66359	2002	41	0.051122195	1.891521197	10.00	**19**
66360	2002	30	0.037406484	1.3840399	7.99	**11**
601020306	2000	3	0.003740648	0.13840399	17.76	**2**
601020307	2000	2	0.002493766	0.092269327	39.30	**4**
601020308	2000	2	0.002493766	0.092269327	32.44	**3**
601020400	2001	1	0.001246883	0.046134663	17.50	**1**
601020403	2001	1	0.001246883	0.046134663	30.66	**1**
601020404	2002	104	0.129675810	4.798004988	16.32	**78**
601020405	2002	62	0.077306733	2.860349127	15.74	**45**
601020406	2002	42	0.052369077	1.93765586	32.97	**64**
601020407	2002	15	0.018703242	0.69201995	28.47	**20**
601020408	2003	1	0.001246883	0.046134663	19.20	**1**
601020409	2003	1	0.001246883	0.046134663	19.28	**1**
601020503	2003	1	0.001246883	0.046134663	21.42	**1**
Totals		**802**	**1**	**37**		**476**

The Klamath River Technical Advisory Team (KRTAT) met in January of 2006 to review the 2005 Chinook salmon run size monitoring efforts and estimate the age composition of the 2005 run (KRTAT 2006). The KRTAT used scale age proportions for developing adult structure and length frequency analysis for the grilse cutoff point for the 2005 IGH fall Chinook salmon returns (Table 4).

Table 4. Age composition of the 2005 Chinook salmon run that entered Iron Gate Hatchery (IGH), as developed by the Klamath River Technical Advisory Team (KRTAT).

	Age				Total Adults	Total Run
	2	3	4	5		
Number of Chinook	42	8,145	4,969	840		
Percent of Total Run	0.3%	58.2%	35.5%	6.0%	13,955	13,997

Coho Salmon

The first coho returning to IGH was observed on October 19, 2005 and the last coho of the 2005-06 spawning season was observed on December 28, 2005. A total of 1,425 coho salmon entered IGH during the season. Of these, 1,282 were progeny of IGH. In addition to IGH returns, 2

coho from Trinity River Hatchery (TRH), and one adipose clipped coho from Cole M. Rivers Hatchery was observed. Staff collected biological data from 466 coho, approximately one third of the entire run. Male coho ranged in size from 38 cm to 102 cm (Figure 6). Female coho ranged in size from 44 cm to 78 cm (Figure 7).

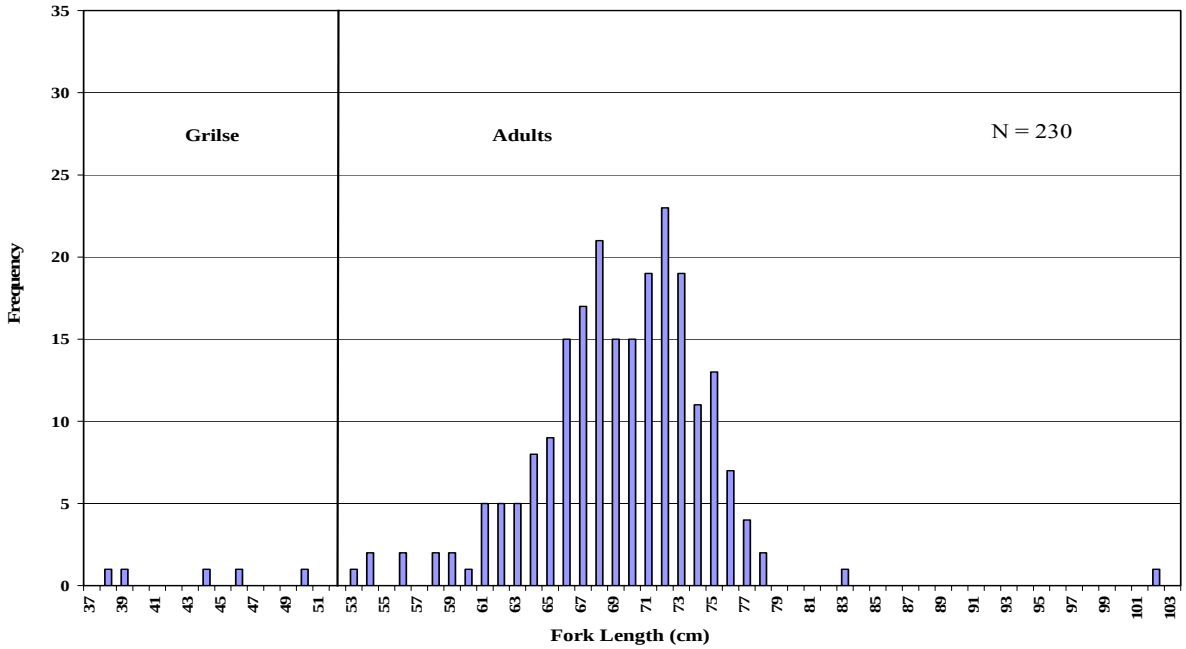

Figure 6. Length frequency distribution for male coho salmon recovered at Iron Gate Hatchery during the 2005-06 spawning season.

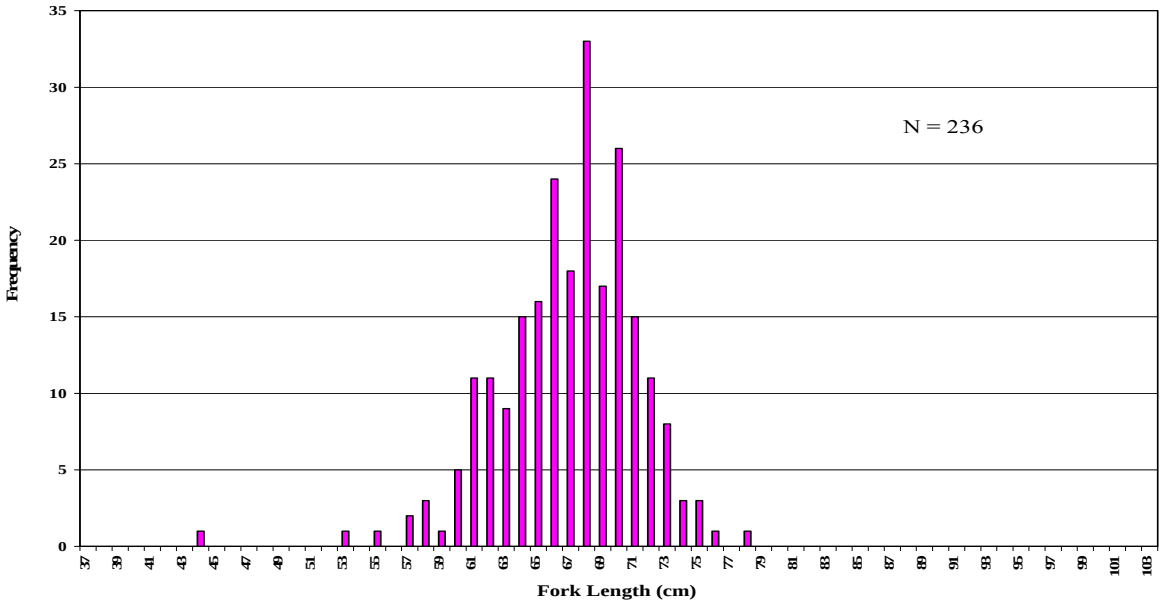

Figure 7. Length frequency distribution for female coho salmon recovered at Iron Gate Hatchery during the 2005-06 spawning season.

A total of 124 unmarked coho salmon were Floy tagged and released from IGH to the Klamath River. Of these, 39 coho reentered IGH and were returned to the river, 10 were observed in nearby Bogus Creek, and 3 were observed passing through the video flume at the Shasta River Fish Counting Facility. No Floy tagged coho were reported in the main stem Klamath River. Eleven of the 39 unmarked coho that returned to IGH after their initial tagging reentered the hatchery on more than one occasion (Table 5). Two of the coho that were eventually recovered in Bogus Creek had previously reentered IGH on multiple occasions.

Table 5. Floy tagged (and caudal clipped) coho salmon that returned to Iron Gate Hatchery following initial release during the 2005 spawning season.

Floy Tag #	Sex	FL	Date Tagged	Return Dates
2368	F	72	Nov 3	Nov 10, Nov 14
2376	M	66	Nov 4	Nov 7
2377	M	68	Nov 4	Nov 7
2385	F	66	Nov 7	Nov 16
2386	M	72	Nov 7	Nov 10
2076	M	72	Nov 10	Nov 14
2079	F	74	Nov 10	Nov 14
2081	M	73	Nov 10	Nov 14
2083	M	61	Nov 10	Nov 14, Nov 16
2389	F	68	Nov 10	Nov 14
1540	M	59	Nov 14	Nov 16
1543	M	67	Nov 14	Nov 16, Nov 18
1546	F	61	Nov 14	Nov 28, Dec 1
1548	M	69	Nov 14	Nov 18
2090	F	60	Nov 14	Nov 16
2095	M	54	Nov 14	Nov 16
2098	F	64	Nov 14	Nov 16
2099	M	71	Nov 14	Nov 16
1500	M	70	Nov 16	Nov 28
1526	M	65	Nov 16	Nov 18, Nov 21
1531	M	66	Nov 16	Nov 21, Nov 23
1507	M	76	Nov 18	Nov 21, Nov 23, Nov 28
1511	F	64	Nov 21	Nov 23
1515	F	65	Nov 21	Nov 23
1519	M	76	Nov 23	Nov 28
1521	M	78	Nov 23	Nov 28
2326	M	70	Nov 28	Dec 5
2327	F	70	Nov 28	Dec 5
2328	M	70	Nov 28	Dec 1
2329	F	64	Nov 28	Dec 1, Dec 5, Dec 8
2334	F	67	Nov 28	Dec 1
2343	F	63	Nov 28	Dec 5
2348	F	72	Nov 28	Dec 1
2335	M	76	Dec 1	Dec 5, Dec 8
2338	F	72	Dec 1	Dec 5, Dec 8
2340	M	74	Dec 1	Dec 5
2131	M	63	Dec 5	Dec 8, Dec 12
2133	F	68	Dec 5	Dec 8
2135	F	61	Dec 5	Dec 8

DISCUSSION

Chinook Salmon

The Klamath River Project has been monitoring the escapement of fall-run Chinook salmon in the Klamath River basin, excluding the Trinity River, since 1978. The Trinity River Project (TRP) has been monitoring salmon returns in the Trinity River basin during the same period, and the combined run size information generated from these two efforts is summarized in the CDFG "Mega Table" each year. Chinook salmon run size data provided in the Mega Table is reviewed by the KRTAT during their annual age composition meeting in late January. During the age composition meeting, results of the scale analysis are integrated into run size data to estimate the age structure for each of the various stocks within the basin. Age-specific estimates of escapement for 2005 and previous years, coupled with data from CWT recoveries from hatchery stocks, allow for cohort reconstruction of both hatchery and natural components of Klamath River fall-run Chinook. The results of cohort reconstruction allow model-based forecasting of next year's abundance in the ocean, ocean fishery contact rates, and percentage of spawners escaping to natural areas (KRTAT 2006). These forecasts are used by the Pacific Fishery Management Council, as essential inputs to the Klamath Ocean Harvest Model to predict effects of salmon fisheries on Klamath River fall Chinook. Thus, the run size estimates that are compiled each year provide a critical source of data necessary for the effective management of fall Chinook salmon each year.

The 2005 run (13,997) of fall Chinook salmon at IGH was slightly less then the average run size that has been observed for the period from 1978 to 2005 (16,282). This year IGH Chinook comprised roughly 21% of the total (Klamath basin) in-river run (67,579) and 25% of the total natural spawner escapement (56,188) (Table 6).

During the 1995 Chinook salmon spawning season, the gates at IGH were closed at times; therefore a significant portion of the IGH Chinook returns were diverted to nearby Bogus Creek. The largest in-river run of Chinook also occurred in 1995 (245,542), which was nearly double the average run (122,806) for the period 1978 to 2005 (Figure 8). As expected, total Chinook spawner escapement for this period also peaked in 1995 at 217,312. The fall Chinook salmon escapement estimate for Bogus Creek in 1995 was 46,432 which accounted for 19% of total in-river run (245,542) and 21% of the natural spawner escapement (217,312) for the basin. In comparison, the peak contributions of IGH Chinook occurred in 1993 when IGH Chinook (21,711) comprised 34% of the total in-river run (64,810) and 44% of the natural spawner escapement (48,954). However, if all of the Chinook returning to IGH in 1995 had entered IGH, then the contribution rates for IGH would have been much higher in 1995.

The number of returning grilse provides some insight into the survival and abundance of 3 year old fish that are anticipated to be available in the next year (KRTAT 2006). During the 2005 spawning season 0.3% (42) of the run was composed of grilse. This is the lowest percentage of grilse observed since the beginning of the KRP in 1978. The highest percentage (51.1%) of grilse (3,737) was observed in 1992 and the average during this period was 9.5% (1,043) (Figure 9). From 1978 to 1990, at least 10% of the run were grilse in 7 out of 13 years. In contrast, from 1991 to 2005 the proportion of grilse exceeded 10% for only 2 of the 15 years (Table 7). This proportion is similar to what has been observed in nearby Bogus Creek during those same time periods. From 1978 to 1990, at least 10% of the Bogus Creek run were grilse in 10 out of 13

years. In contrast, from 1991 to 2005 the proportion of grilse in Bogus Creek exceeded 10% for only 3 of the 15 years (Table 7). The average percentage of grilse Chinook in Bogus Creek during this 28 year period was 12.6% (684).

Table 6. Historic fall-run Chinook salmon totals (includes adults and grilse) for the Klamath Basin, Iron Gate Hatchery, and Bogus Creek.

Year	In-River Run (IRR)	Spawner Escapement (SE)		Iron Gate Hatchery (IGH)			Bogus Creek		
	Totals	Totals	% of IRR	Totals	% of IRR	% of SE	Totals	% of IRR	% of SE
1978	115,728	90,135	77.9	7,870	6.8	8.7	5,579	4.8	6.2
1979	62,970	42,255	67.1	2,558	4.1	6.1	5,938	9.4	14.1
1980	82,413	57,683	70.0	2,863	3.5	5.0	5,070	6.2	8.8
1981	108,422	56,333	52.0	2,595	2.4	4.6	3,642	3.4	6.5
1982	106,020	67,076	63.3	10,186	9.6	15.2	7,143	6.7	10.6
1983	61,392	47,960	78.1	8,885	14.5	18.5	3,048	5.0	6.4
1984	55,542	30,375	54.7	6,094	11.0	20.1	3,504	6.3	11.5
1985	133,827	104,487	78.1	22,110	16.5	21.2	4,647	3.5	4.4
1986	239,559	180,263	75.2	18,557	7.7	10.3	7,308	3.1	4.1
1987	228,182	143,890	63.1	17,014	7.5	11.8	10,956	4.8	7.6
1988	215,696	130,749	60.6	16,715	7.7	12.8	16,440	7.6	12.6
1989	133,440	72,438	54.3	11,690	8.8	16.1	2,662	2.0	3.7
1990	40,274	25,705	63.8	7,040	17.5	27.4	785	1.9	3.1
1991	34,425	19,121	55.5	4,067	11.8	21.3	1,281	3.7	6.7
1992	40,391	28,479	70.5	7,318	18.1	25.7	1,154	2.9	4.1
1993	64,810	48,945	75.5	21,711	33.5	44.4	3,716	5.7	7.6
1994	78,354	60,850	77.7	14,566	18.6	23.9	8,260	10.5	13.6
*1995	245,542	217,312	88.5	22,940	9.3	10.6	46,432	18.9	21.4
1996	185,305	108,325	58.5	14,165	7.6	13.1	10,797	5.8	10.0
1997	91,729	70,303	76.6	13,727	15.0	19.5	10,030	10.9	14.3
1998	95,286	75,157	78.9	15,326	16.1	20.4	6,835	7.2	9.1
1999	70,296	50,088	71.3	14,120	20.1	28.2	6,165	8.8	12.3
2000	228,323	188,642	82.6	72,474	31.7	38.4	35,051	15.4	18.6
2001	198,676	142,324	71.6	38,568	19.4	27.1	12,575	6.3	8.8
2002	170,014	99,016	58.2	24,961	14.7	25.2	17,834	10.5	18.0
2003	195,791	152,390	77.8	32,260	16.5	21.2	15,610	8.0	10.2
2004	88,589	53,478	60.4	11,519	13.0	21.5	3,788	4.3	7.1
2005	67,579	56,188	83.1	13,997	20.7	24.9	5,399	8.0	9.6
Average	122,806	86,427	69.5	16,282	13.7	19.4	9,345	6.8	9.7
MAX	245,542	217,312	88.5	72,474	33.5	44.4	46,432	18.9	21.4
MIN	34,425	19,121	52.0	2,558	2.4	4.6	785	1.9	3.1
STDEV	68,453	53,167	10.1	14,016	7.5	9.4	10,075	3.9	4.7

Note: As of Feb 2004, all In-River Run and Spawner Escapement values changed due to a retroactive change in the angling and net mortality rates.
*For the 1995 season the gates at IGH were closed at times; therefore a significant portion of the IGH returns were diverted to Bogus Creek.

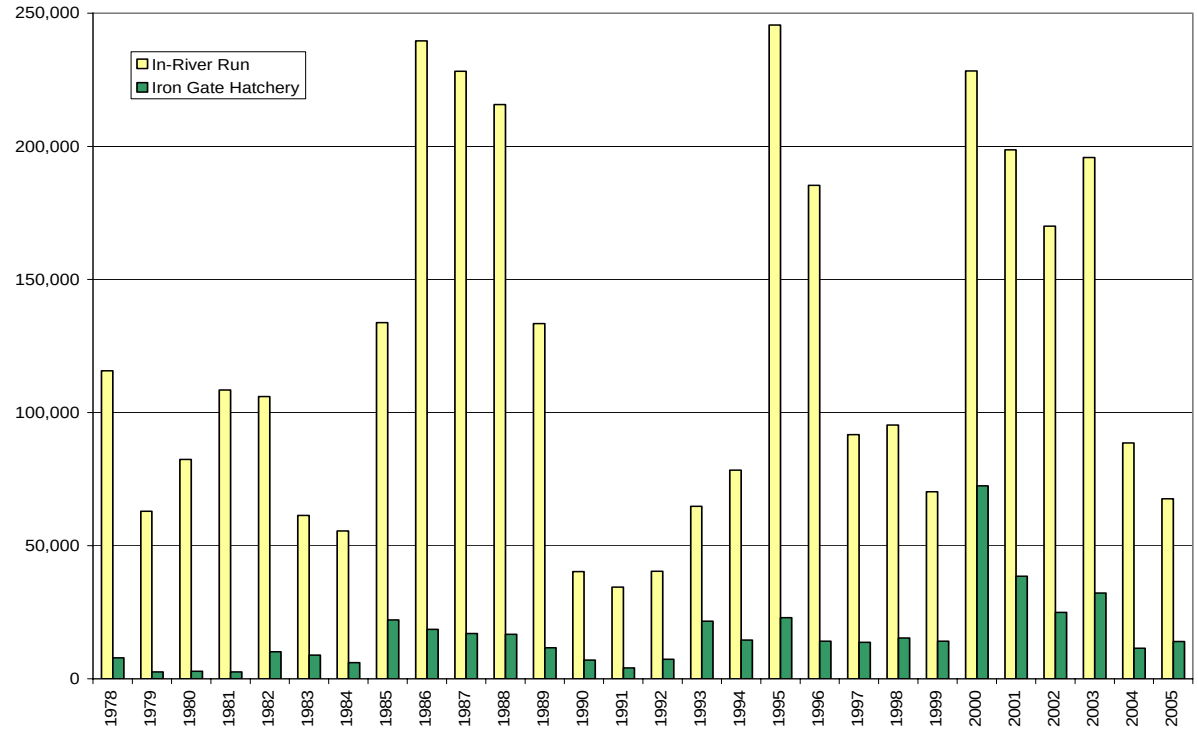

Figure 8. Chinook salmon escapement to Iron Gate Hatchery and in-river run of Chinook salmon in the Klamath River, 1978 to 2005.

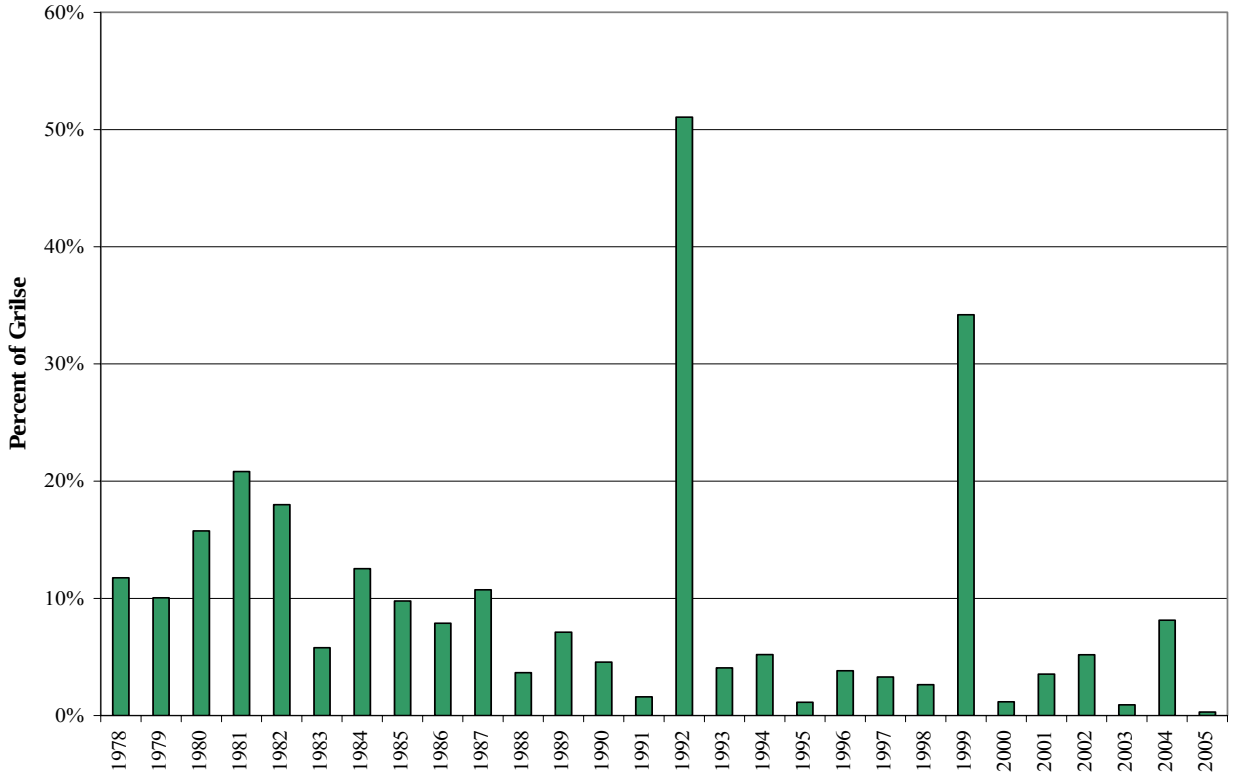

Figure 9. Historical percentages of Chinook grilse observed at Iron Gate Hatchery, Siskiyou County.

Table 7. Summary of fall Chinook salmon escapement to Iron Gate Hatchery and Bogus Creek from 1978 to 2005.

Year	Iron Gate Hatchery				Bogus Creek			
	Number			Percent	Number			Percent
	Grilse	Adults	Total	Griles	Grilse	Adults	Total	Grilse
1978	925	6,945	7,870	11.8%	651	4928	5,579	11.7%
1979	257	2,301	2,558	10.0%	494	5444	5,938	8.3%
1980	451	2,412	2,863	15.8%	1749	3321	5,070	34.5%
1981	540	2,055	2,595	20.8%	912	2730	3,642	25.0%
1982	1,833	8,353	10,186	18.0%	2325	4818	7,143	32.5%
1983	541	8,371	8,912	6.1%	335	2713	3,048	11.0%
1984	764	5,330	6,094	12.5%	465	3039	3,504	13.3%
1985	2,159	19,951	22,110	9.8%	1156	3491	4,647	24.9%
1986	1,461	17,096	18,557	7.9%	1184	6124	7,308	16.2%
1987	1,825	15,189	17,014	10.7%	1208	9748	10,956	11.0%
1988	609	16,106	16,715	3.6%	225	16215	16,440	1.4%
1989	831	10,859	11,690	7.1%	444	2218	2,662	16.7%
1990	321	6,719	7,040	4.6%	53	732	785	6.8%
1991	65	4,002	4,067	1.6%	20	1261	1,281	1.6%
1992	3,737	3,581	7,318	51.1%	556	598	1,154	48.2%
1993	883	20,828	21,711	4.1%	431	3285	3,716	11.6%
1994	758	13,808	14,566	5.2%	443	7817	8,260	5.4%
1995	259	22,681	22,940	1.1%	1207	45225	46,432	2.6%
1996	543	13,622	14,165	3.8%	377	10420	10,797	3.5%
1997	452	13,275	13,727	3.3%	221	9809	10,030	2.2%
1998	403	14,923	15,326	2.6%	205	6630	6,835	3.0%
1999	4,830	9,290	14,120	34.2%	2628	3537	6,165	42.6%
2000	839	71,635	72,474	1.2%	373	34678	35,051	1.1%
2001	1,364	37,204	38,568	3.5%	648	11,927	12,575	5.2%
2002	1,294	23,667	24,961	5.2%	304	17,530	17,834	1.7%
2003	290	31,970	32,260	0.9%	188	15,422	15,610	1.2%
2004	937	10,582	11,519	8.1%	295	3,493	3,788	7.8%
2005	42	13,955	13,997	0.3%	58	5,339	5,397	1.1%
Average	1,043	15,240	16,283	9.5%	684	8,660	9,345	12.6%

In September of 2002 a large fish kill occurred in the lower Klamath River (CDFG 2004). Columnaris (*Flavobacter columnare*) and ICH (*Ichthypthirius multifilis*) were the primary pathogens responsible for the 2002 fish kill, which resulted in the loss of over 33,000 adult salmonids, the majority of which Chinook salmon. The fish kill extended from the mouth of Klamath River to Coon Creek Falls (36 river miles). Low flows coupled with increased water temperature and fish densities (due to the low flows and potentially inadequate fish passage) stressed fish to the point that they were susceptible to the naturally occurring pathogens. If these fish kills had not occurred, the number of Chinook entering IGH during the 2002 spawning season would most likely have been higher than 24,961.

Large scale mortality of juvenile salmonids, primarily Chinook salmon, has been documented in recent years. In May of 2004 the U.S. Fish and Wildlife Service, the Yurok Tribe and the Karuk Tribe, reported unusually high levels of mortality and disease infections among naturally

produced juvenile Chinook salmon captured in downstream migrant traps fished in the Klamath River (KFHAT 2005). Trapping efforts were located near Kinsman Creek (RM 146) just upstream of the Scott River confluence, adjacent to the Bulk Plant in Happy Camp (RM 108), at Persido Bar (RM 81) upstream of the Salmon River confluence, and at Big Bar (RM 51) upstream of the Trinity River confluence. Infection rates and mortalities observed were highest at the most upstream sampling location near Kinsman Creek and tended to decrease in intensity downstream. The symptoms observed included bloated abdominal cavities, pale gills, bloody vents, and pop-eye. Infected fish also exhibited lethargic behavior, poor swimming ability and increased vulnerability to handling stress. The primary cause of the disease was found to be the myxosporean parasite *Ceratomyxa Shasta* which is endemic to the Klamath River. Other diseases observed include another myxosporean parasite, *Parvicapsula minibicornis*, and the bacteria, *Flavobacterium columnare*. KFHAT immediately recognized that an accurate quantification of juvenile salmonid mortalities in the Klamath River would not be possible given limited resources and other problems associated with sampling small fish in a large river system, which include loss to predators and scavengers, and rapid decay rates. Therefore, only reconnaissance level surveys were conducted and the sampling protocols were developed accordingly. Although the magnitude of the fish kill could not quantified, the impacts of this kill were believed to be large in scale and the low return of grilse that was observed in the Klamath River and it's tributary streams upstream of the Trinity River in 2005 appear to substantiate this possibility.

Other recent fish kills include the June 2000 and June 1998 fish kills. The 2000 fish kill occurred in late June (CDFG 2000), in the mainstem of the Klamath River, between Coon Creek and Pecwan Creek (64 river miles). Estimates of the number of fish killed, primarily young-of-the-year, range from 10,000 to 300,000 individuals. Direct mortality was believed to be caused by two pathogens, ceratomyxosis (*Ceratomyxa shasta*) and columnaris, which occur naturally in the Klamath River. Recent findings seem to indicate that *Parvicapsula minibicornis* may have been a contributing factor as well. The presence of unseasonably high air temperatures during the spring and early of summer of 2000 lead to mainstem water temperatures above 24^{o}C (75^{o}F) in June. IGH Chinook tend to be resistant to *C. shasta* at temperatures ≤ 16 ^{o}C (61^{o}F), therefore elevated river temperatures appear to exacerbate this disease (Foott et al. 1999). At least 240,000 juvenile Chinook perished during the June 1998 fish kill, caused by columnaris and bacterial septicemia (Williamson and Foott 1998).

The Chinook salmon releases from IGH include both smolt and yearling releases. The current production goals include releases of 4,920,000 Chinook salmon smolts in May and June and 1,080,000 yearlings in the following November. For the period of 1991 to 2005, IGH Chinook smolt releases have varied from a low of 3,300,312 in 1993 to a high of 5,626,408 in 1996 (Figure 10). For this same period, Chinook yearling releases have varied from 407,177 in 1996 to 1,155,096 in 1993. The average smolt and yearling releases for this period are 4,926,167 and 980,150, respectively. The largest run of Chinook to IGH, from 1962 to 2005, occurred in 2000 (72,474), the lowest in 1965 (678) (Figure 11). The largest in-river Chinook run (1995) occurred two years after the largest yearling release (1993). One of the recommendations of the Joint Hatchery Review Committee is for IGH to produce more yearlings and less smolts: "DFG should consider the desirability of expanding the Chinook yearling program at IGH and reducing the smolt production. Releasing fewer smolts and more yearlings would relieve some of the

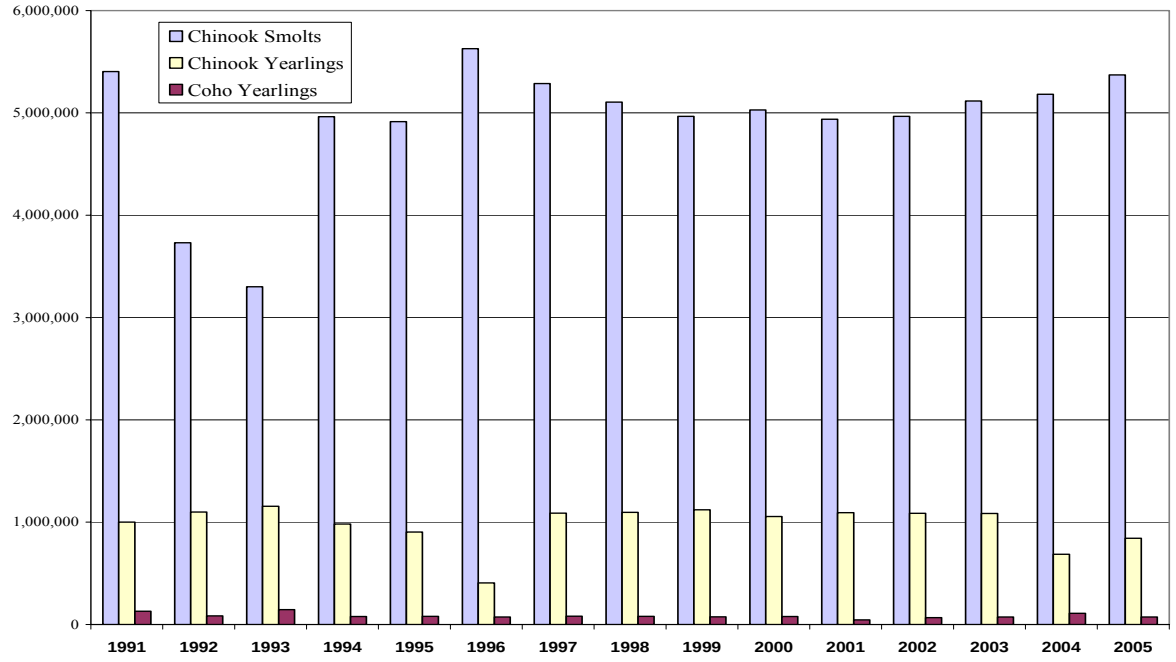

Figure 10. Iron Gate Hatchery (California Department of Fish and Game) Chinook and coho salmon releases, 1991 to 2005.

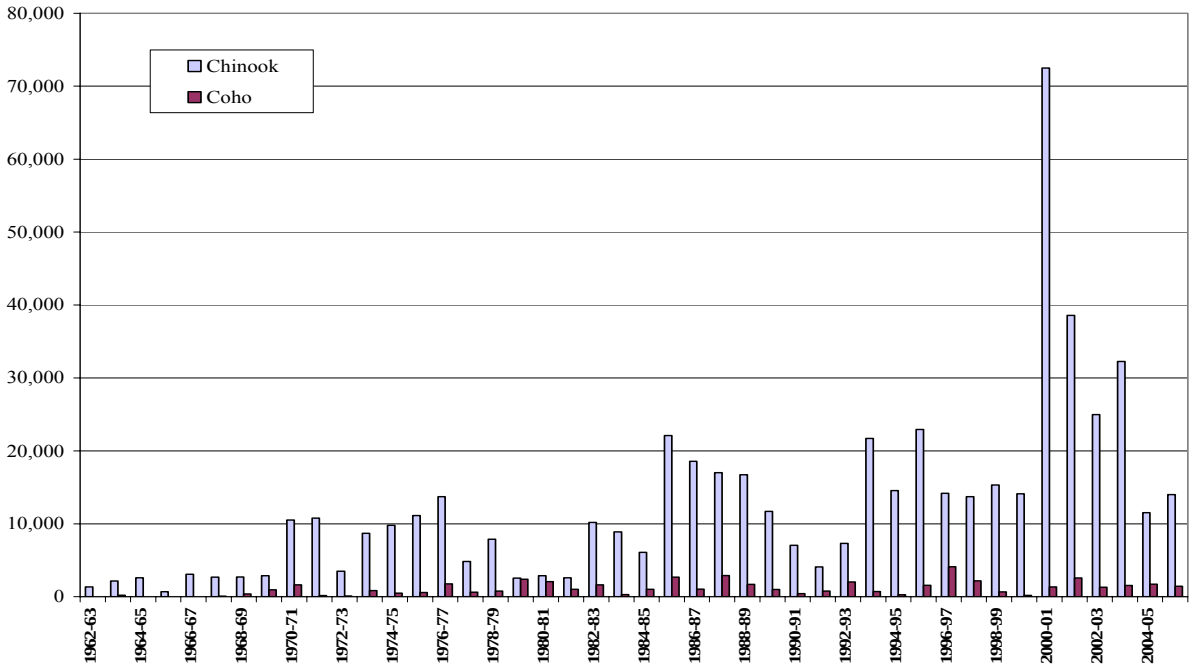

Figure 11. Chinook and coho salmon runs at Iron Gate Hatchery (California Department of Fish and Game), 1962 to 2005.

hatchery-natural interactions that occur during the low-flow and poor water quality conditions present in the Klamath River during June and July. The time of the release from IGH occurs during October 15 – November 15, which coincides with flow release increases from Iron Gate Dam, increased precipitation in the Klamath Basin, and substantially improved water quality conditions in the Klamath River. Interactions between hatchery and natural Chinook would be minimized as a result of improved water quality and because most natural produced Chinook would have already left the Klamath Basin." (CDFG and NMFS 2001). At this time there are physical and funding constraints that limit the Department's ability to implement an increased rearing program for yearling Chinook salmon.

Analysis of Brood Year (BY) 1979-1984 CWTs recovered from Chinook salmon that were released as yearlings from IGH indicates that yearlings outperform fingerlings roughly 4 to 1 in both ocean fisheries and river returns (Baracco 1990). Therefore, yearling releases provide a combined benefit of lower competition/interaction with natural production and higher percent returns. Analysis of a subset (BY 1990-2000) of fall-run Chinook CWT returns to IGH yields similar results (Table 8). The most striking example of this occurred with BY 1995 where smolts returned at a rate of 0.04% and yearlings at 1.1%. Yearlings were not tagged in 1998 or 1999 (BY 1997 and 1998) due to budget constraints therefore, contribution rates for these two brood year yearling releases is unknown. Brood Year 1990 through 2000 CWT returns contain the most recent data that includes all potential returns (age-classes: 2, 3, 4, and 5). In view of the fact that yearlings generally return at a substantially higher rates than smolts releases it would be reasonable to assume BY 1997 and 1998 yearlings would return at a higher rate as well, which should be factored in to the historical estimates of hatchery contributions.

Table 8. Return rates of IGH smolt and yearling CWT releases for brood years 1990 to 1996 and 1999 and 2000. There were no yearling CWT releases for Brood Years 1997 and 1998 due to budget constraints.

Brood Year	IGH Smolt Releases			IGH Yearling Releases			Ratio of yearling/smolt return rates
	# CWTs Released	# CWTs Returned	% Return	# CWTs Released	# CWTs Returned	% Return	
1990	188,595	713	0.378%	95,880	740	0.77%	2.04
1991	191,200	96	0.050%	90,982	167	0.18%	3.66
1992	185,464	1,015	0.547%	74,024	269	0.36%	0.66
1993	188,562	40	0.021%	98,099	196	0.20%	9.42
1994	194,644	94	0.048%	86,564	453	0.52%	10.84
1995	191,799	85	0.044%	90,172	954	1.06%	23.87
1996	196,648	162	0.082%	95,396	581	0.61%	7.39
1999	182,131	686	0.377%	91,220	514	0.56%	1.50
2000	187,417	277	0.148%	100,702	707	0.70%	4.75
						Average =	**7.13**

Coho Salmon

A total of 1,425 coho salmon entered IGH during the 2005 spawning season. Since 1978 the number of coho entering IGH has ranged from a low of 169 in 1999 to a high of 4,097 in 1996 and has averaged 16,282 (Figure 14).

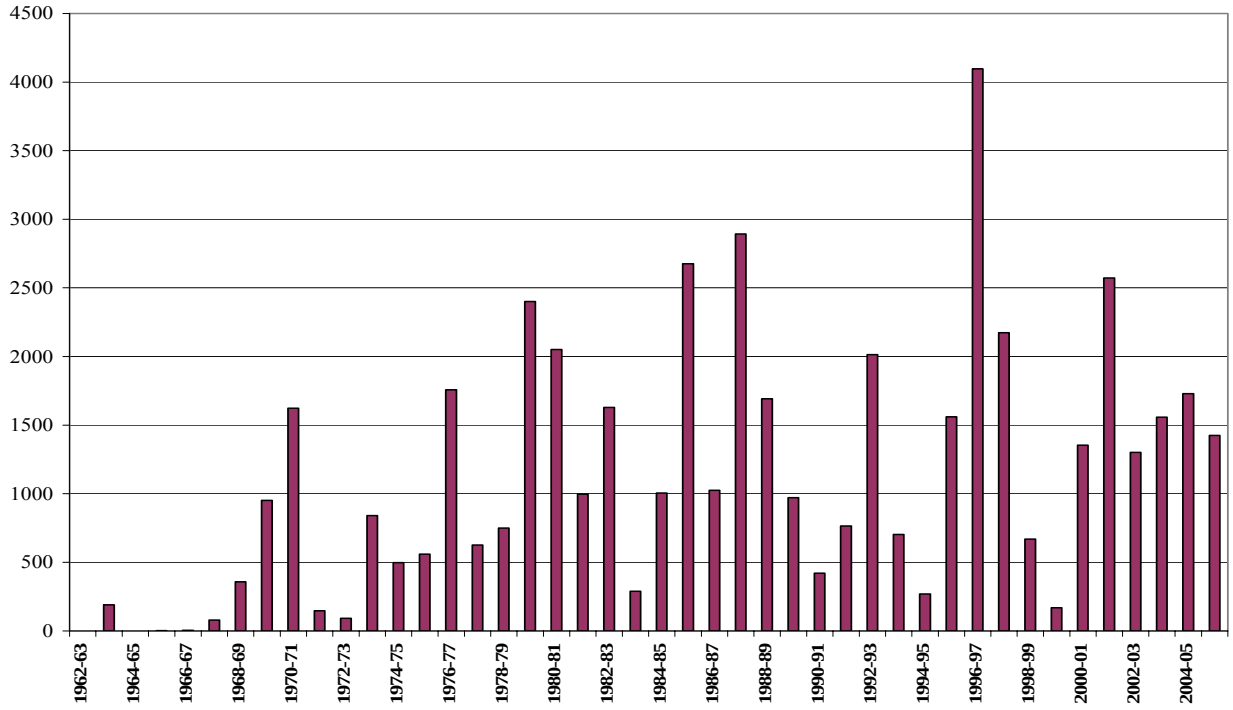

Figure 14. Coho salmon runs at Iron Gate Hatchery (California Department of Fish and Game), 1962 to 2005.

Starting with the 1994 brood year all hatchery reared coho salmon released within the Klamath Basin have been maxillary clipped. All coho salmon released from TRH receive a right maxillary clip (RM) and all coho salmon released from IGH receive a left maxillary clip (LM). Production goals for coho salmon within the Klamath Basin call for the release of 75,000 yearlings from IGH and 500,000 yearlings from TRH. Cole M. Rivers Hatchery located at the base of Lost Creek Dam on the Rogue River releases about 200,000 coho salmon annually, which include approximately, 150,000 fish with an ad-clip only, 25,000 fish with an ad-clip and CWT, and 25,000 fish that are tagged with a CWT and are not ad-clipped. CWTs recovered from both ad-clipped and unmarked coho salmon at IGH have typically found that these fish are progeny from Cole M. Rivers Hatchery on the Rogue River.

The age 3 coho returns in 1997 represent the first adult returns that were marked with a LM clip prior to release from the hatchery. Therefore, survival estimates for coho salmon releases from IGH can be calculated for brood years from 1994 to 2002. A summary of coho salmon releases, adult returns, and survival of LM clipped coho to IGH is provided in Table 8. Survival of coho salmon progeny released from IGH since the 1994 brood year has ranged from 0.3% to 3.5% and has averaged 1.6%.

Table 8. Survival estimates for coho salmon yearlings released from Iron Gate Hatchery (IGH). Since 1995 all IGH coho have been marked with a left maxillary clip. Numbers of grilse and adult coho salmon that returned to IGH were adjusted based on clip quality control observations by IGH staff.

Brood Year	Number of Yearlings Released	Number of Returning Grilse	Number of Returning Adults	Total Brood Year Return	Percent Survival to IGH
1994	74,250	322	1,717	2,039	2.7%
1995	81,498	256	306	562	0.7%
1996	79,607	76	140	216	0.3%
1997	75,156	16	524	540	0.7%
1998	77,147	576	2,087	2,664	3.5%
1999	46,254	77	930	1,007	2.2%
2000	67,933	93	639	732	1.1%
2001	74,271	219	996	1,215	1.6%
2002	109,374	237	1,393	1,630	1.5%
				Average Survival Rate =	**1.6%**

There is some uncertainty regarding the origin of unmarked coho salmon that return to IGH each year. Both naturally produced coho salmon and those of hatchery origin are potentially present within these returns. Returns of unmarked coho salmon of hatchery origin may be related to clipping error within IGH and TRH, or are unmarked coho salmon that are released from hatcheries located outside the basin. Beginning in 1997 all coho salmon that entered IGH, whose origin was either IGH or TRH, would have been maxillary clipped prior to release. There are a small number of coho that may not have been clipped as a result of clipping error. Quality control estimates for clipping operations have been conducted at IGH since 1996 (1995 BY) and have ranged from a low 90% effective (2002 BY) to a high of 99.83% effective (2003 BY). Due to budget constraints, the 2002 BY was clipped by non-hatchery staff, which is most likely where the abnormally high clipping error originated. As a result, the number of LM clips observed at IGH during recovery efforts slightly underestimates the actual number of hatchery origin coho present. By expanding the number of LM clips observed with a clip rate expansion multiplier, derived from the inverse of the clip rate observed during quality control, the number of unmarked IGH origin coho salmon that returned to IGH for each brood year can be estimated. Table 9 provides a summary, by brood year, of the number of LM clips observed, the expanded number, and an estimate of number of unmarked coho that are likely progeny of IGH. For brood years 1995 to 2002 the number of unmarked coho salmon that were estimated to have originated from progeny of IGH ranged from 3 to 163 fish. Similar results would likely be found for coho progeny released from TRH however, given the small number of RM clips that are observed at IGH this number would probably by negligible in most, if not all years.

Table 9. Iron Gate Hatchery (IGH) coho salmon yearling release numbers, LM clip return rates, and expanded return estimates with estimated number of unmarked coho that have returned to IGH.

Brood Year	Total Yearling Release	Quality Control	Unmarked Release	Marked Release	LM Grilse Observed	LM Adults Observed	Total LM Brood Year Returns	Clip Expansion Multiplier	Expanded Brood Year Returns	Estimated Number of Unmarked IGH coho
1995	81,498	0.9900	815	80,683	253	303	556	1.0101	562	6
1996	79,607	0.9850	1194	78,413	75	138	213	1.0152	216	3
1997	75,156	0.9540	3454	71,702	15	500	515	1.0482	540	25
1998	77,147	0.9840	1234	75,913	567	2,054	2621	1.0163	2,664	43
1999	46,254	0.9850	694	45,560	76	916	992	1.0152	1,007	15
2000	67,933	0.9700	2038	65,895	90	620	710	1.0309	732	22
2001	74,271	0.9940	446	73,825	218	990	1208	1.0060	1,215	7
2002	109,374	0.9000	10937	98,437	213	1,254	1467	1.1111	1,630	163

One unmarked coho with a CWT was recovered at IGH this year, this coho originated from Cole M. Rivers Hatchery operated by the Oregon Department of Fish and Wildlife on the Rogue River. In previous years the Department has not scanned unmarked coho that entered IGH to determine the presence of CWTs. Therefore, an unknown number (most likely very small) of unmarked coho salmon that returned to IGH during those years also may have been of hatchery origin. The number of unmarked coho salmon of hatchery origin that return to IGH in any given year is likely very small (depending on the clip expansion rate) and for most years a comparison of the number of marked versus unmarked coho salmon can be used to conservatively estimate the number of naturally produced coho salmon that enter IGH annually.

Table 10 contains a summary of the number of marked and unmarked coho salmon that have returned to IGH since 1997. From 1997 to 2005 the percentage of marked coho salmon that have returned to IGH has averaged 80%. The number of unmarked coho observed has ranged from a low of 15 in 1999 to a high of 589 in 2003. As previously discussed, these estimates are conservative as they do not account for clipping error or unmarked coho salmon from outside the basin that are of hatchery origin, mainly from Cole M. Rivers Hatchery. Seven of the unmarked coho observed in 2004/2005 contained a CWT which indicated they originated from Cole M. Rivers Hatchery and one of the unmarked coho observed in 2005 contained a CWT which indicated it originated from Cole M. Rivers Hatchery.

Table 10. Marked and unmarked coho salmon that entered Iron Gate Hatchery from 1997 to 2005.

1997/1998

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	121	44	165
LM	1,717	253	1,970
RM	5		5
AD	24	4	28
ADLM	5	1	6
ADRM			0
Total Clipped	1,751	258	2,009
Total Returns	1,872	302	**2,174**

1998/1999

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	207	82	289
LM	303	75	378
RM			0
AD	1	1	2
ADLM			0
ADRM			0
Total Clipped	304	76	380
Total Returns	511	158	**669**

1999/2000

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	12	3	15
LM	138	15	153
RM			0
AD	1		1
ADLM			0
ADRM			0
Total Clipped	139	15	154
Total Returns	151	18	**169**

2000/2001

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	198	64	262
LM	500	567	1,067
RM	4		4
AD	13		13
ADLM	8		8
ADRM			0
Total Clipped	525	567	1,092
Total Returns	723	631	**1,354**

2001/2002

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	217	29	246
LM	2,054	76	2,130
RM	136	2	138
AD	51		51
ADLM	7		7
ADRM	1		1
Total Clipped	2,249	78	2,327
Total Returns	2,466	107	**2,573**

2002/2003

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	216	9	225
LM	916	90	1,006
RM	25	0	25
AD	31	7	38
ADLM	5	2	7
ADRM			0
Total Clipped	977	99	1,076
Total Returns	1,193	108	**1,301**

2003/2004

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	575	14	589
LM	620	218	838
RM	66	3	69
AD	52	6	58
ADLM	2	0	2
ADRM	2	0	2
Total Clipped	742	227	969
Total Returns	1,317	241	**1,558**

2004/2005

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	401	25	426
LM	989	213	1,202
RM	31	1	32
AD	69	0	69
ADLM	0	0	0
ADRM	1	0	1
LM/RM	2	0	2
LM/RM/AD	2	0	2
Total Clipped	1,094	214	1,308
Total Returns	1,495	239	**1,734**

2005/2006

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	138	2	140
LM	1,254	28	1,282
RM	2	0	2
AD	1	0	1
ADLM	0	0	0
ADRM	0	0	0
LM/RM	0	0	0
LM/RM/AD	0	0	0
Total Clipped	1,257	28	1,285
Total Returns	1,395	30	**1,425**

7 of the unmarked coho observed in 2004 contained a CWT which indicated they originated from Cole M. Rivers Hatchery

1 of the unmarked coho observed in 2005 contained a CWT which indicated it originated from Cole M. Rivers Hatchery

LM= Iron Gate Hatchery (left maxillary clip)
RM = Trinity River Hatchery (right maxillary clip)
AD = Cole M. Rivers Hatchery (adipose clip)
ADLM *
ADRM *

Proportion of clipped to unclipped coho

Season	Clipped	Total	% Clipped
1997/1998	2,009	2,174	92.4%
1998/1999	380	669	56.8%
1999/2000	154	169	91.1%
2000/2001	1,092	1,354	80.6%
2001/2002	2,327	2,573	90.4%
2002/2003	1,076	1,301	82.7%
2003/2004	969	1,558	62.2%
2004/2005	1,308	1,734	75.4%
2005/2006	1,285	1,425	90.2%
Average	**1,178**	**1,440**	**80.2%**

*The adipose left maxillary and adipose right maxillary clipped coho are either Cole M. Rivers Hatchery fish without maxillaries due to injury, improperly marked coho, or IGH coho that birds may have dropped into the steelhead ponds prior to steelhead clipping (steelhead are marked with an adipose left maxillary or right maxillary clip, depending on the year).

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