

# Recovery of Chinook and Coho Salmon at Iron Gate Hatchery

October 4, 2004 to December 20, 2004



By:

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### **ABSTRACT**

A total of 11,519 Chinook salmon returned to IGH during the 2004 spawning season. KRP staff collected biological data on 1,109 Chinook salmon that were systematically sampled and recovered heads from a total 793 ad-clipped salmon. Examination of the length frequency distribution for systematically sampled fall Chinook males suggests that the grilse cutoff point is  $\leq 56$  cm. Male Chinook salmon ranged in size between 40 cm and 105 cm FL and females ranged in size from 51 cm to 95 cm FL. KRP staff estimate that the 2004 fall Chinook salmon run was comprised of 872 grilse (7.6%) and 10,064 adults (87.4%). Females accounted for 46% (5,242 fish) of the run and males accounted for 54% (6,277 fish) of the run. From analysis of coded wire tags that were recovered from ad-clipped Chinook, KRP estimated that the number of hatchery origin Chinook that returned was 8,275 fish. Of those fish with a CWT, 696 (8.8%) were estimated to be age 2 (grilse), 3,149 (39.9%) were estimated to be age 3, 3,794 (48.0%) were estimated to be age 4, and 259 (3.3%) were estimated to be age 5. Based on the expansion of estimated CWT recoveries, hatchery origin Chinook salmon comprised approximately 71.8% of the Chinook salmon run that returned to IGH during the 2004 season.

The total number of coho salmon to enter IGH during the 2004 season was 1,734 fish. IGH staff counts for the 2004 coho salmon run are as follows, 1203 left maxillary clips, 32 right maxillary clips, 69 ad-clips, 2 left and right maxillary clips, 2 left and right maxillary clips and an ad-clip, 1 right maxillary clip and ad-clip, and 424 unmarked fish. KRP staff examined 1,593 coho salmon and collected fork lengths on 1,548 coho during the season. Male coho salmon ranged in fork length from 18 cm to 84 cm and averaged 62 cm. Female coho salmon ranged in fork length from 37 cm to 79 cm and averaged 69 cm. Grilse were estimated to be  $\leq 51$  cm in fork length and comprised approximately 13.3% (231 fish) of the total run. Based on the proportion of male and female coho observed in the sample of 1,593 fish, KRP estimates that males comprised 48.3% (838 fish) of the run and females comprised 51.7% (896 fish) of the run.

Ten (10) unmarked coho salmon spawned with marked coho salmon in a one to one ratio. The U.S. Fish and Wildlife Service applied radio tags to 40 adult coho salmon to monitor their movement after release from the hatchery. Twenty four (24) unmarked coho died during recovery at the hatchery as a result of either handling stress, or died while holding in the ponds during the final maturation process. Seven (7) unmarked coho salmon contained CWTs and were all found to be progeny from Cole Rivers Hatchery on the Rogue River. A total of 337 unmarked coho salmon were Floy tagged and released from IGH to the Klamath River. Of these, 25 coho reentered IGH and were returned to the river, 72 coho were observed in Bogus Creek, 20 unmarked coho were observed passing the video flume on the Shasta River, and 2 coho were recovered in the mainstem Klamath River, one just upstream of the Klamathon Bridge by the Yurok Tribe, and the other just downstream of the confluence of Beaver Creek by the Karuk Tribe. Two of the 25 unmarked coho that returned to IGH after their initial tagging, reentered the hatchery on more than one occasion and 3 of the 25 coho that returned to IGH were eventually recovered in Bogus Creek.

### **INTRODUCTION**

#### **IRON GATE HATCHERY**

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

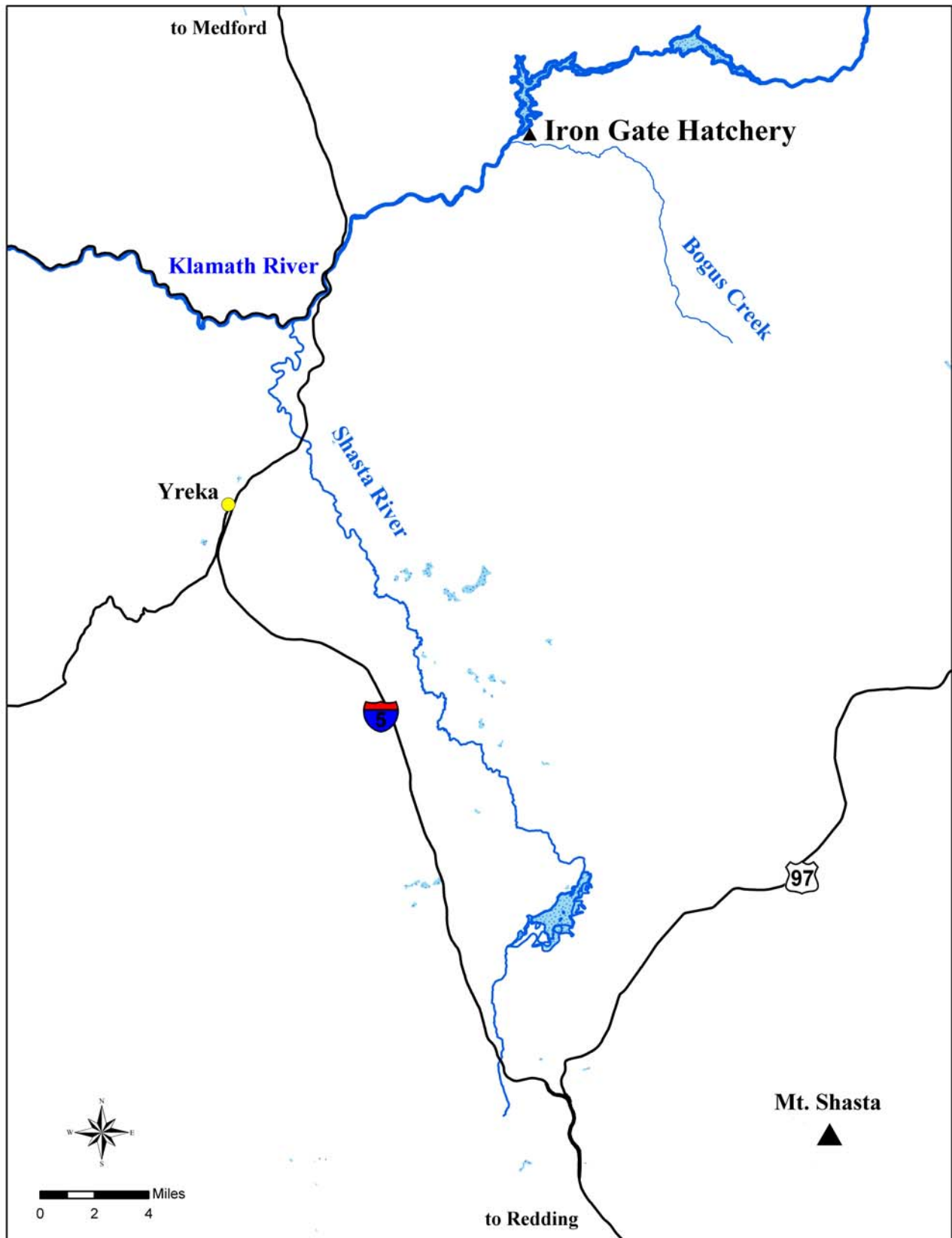


Figure 1. Location of Iron Gate Hatchery (California Department of Fish and Game, Siskiyou County).

**Table 1. Salmon and steelhead trout production goals for Iron Gate Hatchery (CDFG, Siskiyou County).**

Species	Number released	Release Date	Adult Run Timing
Chinook Salmon	4,920,000 smolts	May-June	September through 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

**KLAMATH RIVER PROJECT**

All tagged fish are marked with an adipose fin clip (ad-clip), which allows for identification and recovery of the coded wire tags (CWTs) when the Chinook return to the hatchery during subsequent spawning seasons. The goals of the recovery project are to collect biological data for Chinook and coho salmon entering IGH and to recover all coded wire tags from adipose fin clipped fish observed. The recovery of CWTs from adipose fin clipped fish provide information necessary to estimate the survival and contribution rates of hatchery releases through time. In addition, CWTs data provide a reference for known-age fish which is used, along with scale samples and analysis of length frequency distribution, for the determination of the age structure for the run annually.

**CODED WIRE TAGGING**

During April and May of each year (since 1979), staff of the KRP insert CWTs and apply an ad-clip to approximately 200,000 Chinook smolt (90 fish/lb) and 100,000 yearling Chinook salmon. These tags contain a code that allows for the identification of four separate groups of fingerlings and two groups of yearlings (which correspond to rearing locations and release times). One of the goals of the tagging program is to determine the success of the early release strategy (Hampton 2001). Prior to 2001, smolts were released at IGH from June 1 to June 15. At the recommendation of the Joint Hatchery Review Committee (2001), The Department developed an early release strategy, which allows for the release of smolts in four groups, each separated by about 1 week, usually beginning in mid-May. There may be several benefits of the early release strategy which are currently under investigation. These may include reduced competition with natural salmonids and improved survival of smolts (due to lower water temperatures and higher flows). Yearling Chinook salmon are generally released in one group during November.

**METHODS**

**BIOLOGICAL SAMPLING AND CODED WIRE TAG RECOVERY**

**Chinook Salmon**

Upon entering IGH in the fall of 2004, hatchery staff examined each salmon to determine the species, sex, and readiness to spawn. Unripe Chinook salmon were held in holding ponds until they were ready to spawn. Readiness to spawn was determined by hatchery staff based on run timing, firmness of the ovaries, and ease of stripping eggs when handled. Once the fish were spawned, they were counted, sexed and examined for fin clips and/or marks, by staff of the KRP. During each sampling day, a systematic sample (every 10<sup>th</sup> Chinook,) with a random start determined at the beginning of the season was processed. Fork length and sex were determined and a scale sample was collected from each of these fish. Heads containing CWTs and scale samples, as well as

fork length measurements and sex determinations, were collected from all ad-clipped Chinook salmon. The CWTs were then recovered from the heads of each ad-clipped Chinook salmon that was collected during the season.

## Coho Salmon

In 2004 KRP staff also collected biological data for coho salmon that were recovered at IGH during the spawning season. Data collected included sex, fork length, and presence of marks or clips. With the exception of the first two sampling days after coho began entering IGH in numbers, on October 25<sup>th</sup> and 29<sup>th</sup>, data was collected for every coho salmon that entered IGH. On October 25<sup>th</sup> and 29<sup>th</sup> biological data was only collected for every fifth fish. However, every coho salmon that entered IGH on those two days was examined for the presence of any clips or marks. Beginning with the 1994 brood year, all hatchery reared coho salmon that have been released from IGH have been marked with a left maxillary bone clip (LM) and all coho released from Trinity River Hatchery (TRH) have been marked with a right maxillary bone clip (RM).

In the fall of 2004, just prior to the beginning of the coho salmon spawning season, NOAA fisheries and the Department held several discussions 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, the Department implemented interim protocols for the disposition of unmarked adult coho salmon that enter IGH and TRH during the 2004 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 26,000 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 Rivers Hatchery in Oregon. All unmarked fish determined to be of Cole 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 and then be tagged and 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 fish after release (Figure 2). Once released, these fish could return to the hatchery, spawn in the Klamath River downstream, or enter one of several tributary streams downstream of Iron Gate Dam. Application of the caudal clip served as insurance should the Floy tag shed and also provided the Department with the ability to identify of these fish should they pass through one of the video fish counting facilities located on Bogus Creek or on the Shasta River. Individually numbered Floy tags provides the ability to track individual fish should they return to the hatchery or be recovered in one of the spawning ground surveys that are conducted by the Department or one of the other resource agencies that are active within the basin.

As part of this monitoring effort, the Department also collaborated with the U.S. Fish and Wildlife Service to assist with their effort to radio tag 40 unmarked adult coho salmon recovered at IGH. The purpose of this investigation was to monitor the behavior and movement of these unmarked coho salmon after release from the hatchery. Radio tags were applied throughout the season and the findings of this study will be reported by the U.S. Fish and Wildlife Service's office in Arcata.



**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 2004 spawning season.**

## RESULTS

### FALL CHINOOK SALMON

A total of 11,519 Chinook salmon returned to IGH during the 2004 spawning season. KRP staff collected biological data on 1,109 Chinook salmon that were systematically sampled and recovered heads from a total 793 ad-clipped salmon. Examination of the length frequency distribution for systematically sampled fall Chinook males suggests that the grilse cutoff point is  $\leq 56$  cm (Figure 2). Male Chinook salmon ranged in size between 40 cm and 105 cm FL and females ranged in size from 51 cm to 95 cm FL (Figure 3). Based on the male length frequency distribution and sex composition observed by IGH staff, KRP staff estimate that the 2004 fall Chinook salmon run was comprised of 872 grilse (7.6%) and 10,647 adults (87.4%). Females accounted for 46% (5,242 fish) of the run and males accounted for 54% (6,277 fish) of the run.

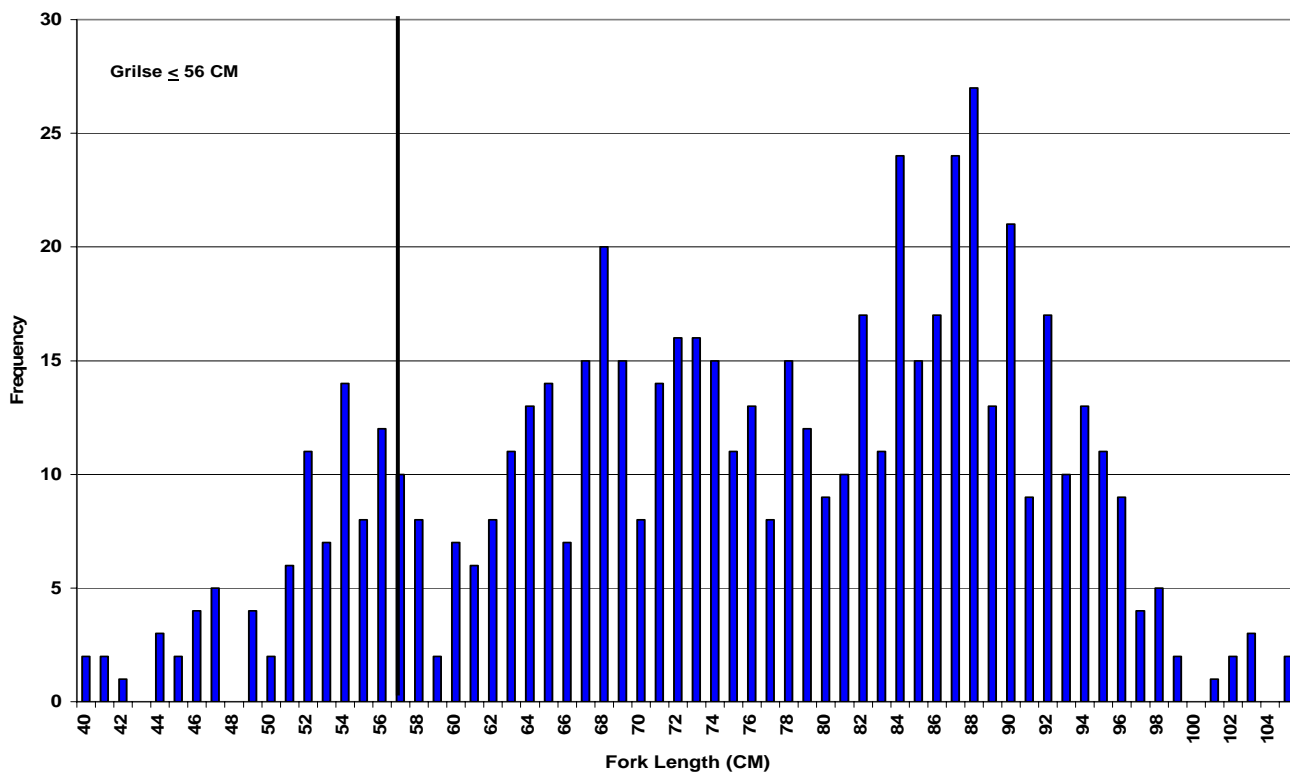
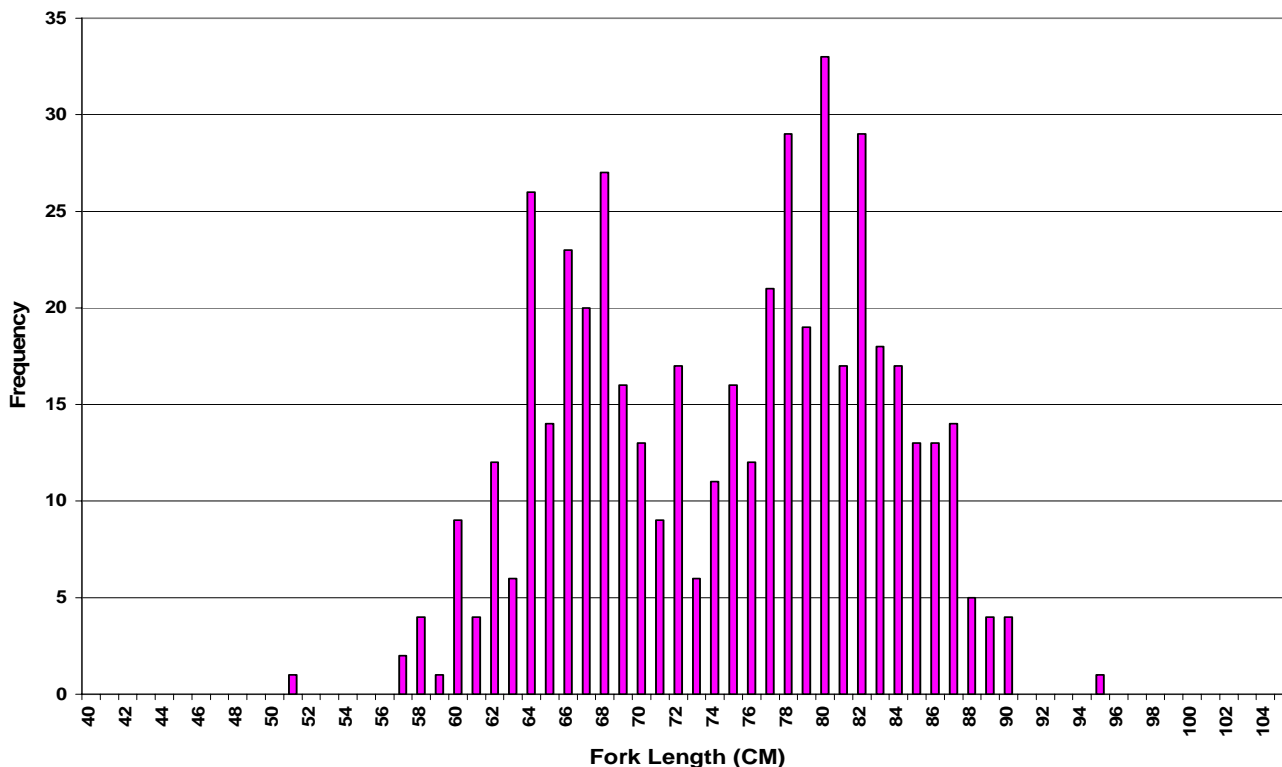


Figure 2. Length frequency distribution for systematically sampled male Chinook salmon recovered at IGH during the 2004 spawning season (n = 623 fish).



**Figure 3. Length frequency distribution for systematically sampled female Chinook salmon recovered at IGH, during the 2004 spawning season (n = 486 fish).**

In addition to the systematic sampling, heads from 793 ad-clipped Chinook salmon were collected for CWT recovery. Results of the CWTs that were recovered, and expansion of those tag codes, based on the proportion of tags applied to each release group, from IGH is presented in Table 2. Of the 793 heads that were recovered, 1 head was lost prior to tag recovery efforts, 80 heads either contained tags that were unreadable (23), lost during recovery (10), or had shed the tag (47). To estimate the hatchery contribution for those 34 ad-clipped fish for which either the head was lost or the tag was lost or unreadable, staff assigned a CWT code to these fish based on the proportion of the readable CWTs that were recovered during the season (Table 3). The number of hatchery progeny that returned to IGH in 2004 was then estimated by expanding the readable CWT codes and estimated CWT codes by their specific production multiplier. The resulting number of hatchery origin Chinook salmon that returned to IGH was estimated to be 8,275 fish (Table 2). Of the estimated hatchery origin fish, represented by a readable CWT (7,898 fish), 696 (8.8%) were estimated to be age 2 (grilse), 3,149 (39.9%) were estimated to be age 3, 3,794 (48.0%) were estimated to be age 4, and 259 (3.3%) were estimated to be age 5. Based on the expansion of estimated CWT recoveries, hatchery origin Chinook salmon comprised approximately 71.8% of the Chinook salmon run that returned to IGH during the 2004 season.



**Table 2. Estimated contribution of hatchery origin Chinook salmon recovered at Iron Gate Hatchery during the 2004 spawning season.**

<b>CWT</b>	<b>Release Location</b>	<b>Release Type*</b>	<b>Brood Year</b>	<b>Age</b>	<b>Number Recovered</b>	<b>Production Multiplier</b>	<b>Expanded Estimate</b>
0601020309	IGH	F	1999	5	2	27.4933	55
0601020310	IGH	F	1999	5	1	27.4935	27
0601020311	IGH	F	1999	5	1	27.4938	27
066351	IGH	Y	1999	5	9	11.4591	103
066352	IGH	Y	1999	5	4	11.4592	46
0601020305	IGH	F	2000	4	8	17.6863	141
0601020306	IGH	F	2000	4	5	17.7568	89
0601020307	IGH	F	2000	4	10	39.2989	393
0601020308	IGH	F	2000	4	14	32.4353	454
066353	IGH	Y	2000	4	99	9.6434	955
066354	IGH	Y	2000	4	207	8.5096	1,761
0601020400	IGH	F	2001	3	1	17.4979	17
0601020401	IGH	F	2001	3	2	17.9742	36
0601020402	IGH	F	2001	3	2	33.0950	66
0601020403	IGH	F	2001	3	2	30.6631	61
066355	IGH	Y	2001	3	161	9.3246	1,501
066356	IGH	Y	2001	3	74	10.5505	781
066357	IGH	Y	2001	3	70	9.8064	686
0601020404	IGH	F	2002	2	13	16.3173	212
0601020405	IGH	F	2002	2	10	15.7441	157
0601020406	IGH	F	2002	2	6	32.9650	198
0601020407	IGH	F	2002	2	1	28.4657	28
066358	IGH	Y	2002	2	4	10.5224	42
066359	IGH	Y	2002	2	5	9.9983	50
066360	IGH	Y	2002	2	1	7.9880	8
<b>Subtotal =</b>					<b>712</b>		<b>7,898</b>
<b>Estimated contribution of lost or unreadable CWTs from Table 3 =</b>							<b>377</b>
<b>Total Estimated Hatchery Contribution =</b>							<b>8,275</b>

\* Release Type: F = Fingerling, Y = Yearling

**Table 3. Estimated CWT assignments for 34 ad-clipped Chinook Salmon recovered at IGH with unknown tag codes assigned based on the proportional distribution of actual CWT recoveries at IGH during the 2004 season.**

CWT	BY	Number of Actual CWTs Recovered	Proportion of Actual CWTs Recovered	Estimated Number of CWTs	Production Multiplier	Expanded Estimate
0601020309	1999	2	0.0028	0.0955	27.4933	3
0601020310	1999	1	0.0014	0.0478	27.4935	1
0601020311	1999	1	0.0014	0.0478	27.4938	1
066351	1999	9	0.0126	0.4298	11.4591	5
066352	1999	4	0.0056	0.1910	11.4592	2
0601020305	2000	8	0.0112	0.3820	17.6863	7
0601020306	2000	5	0.0070	0.2388	17.7568	4
0601020307	2000	10	0.0140	0.4775	39.2989	19
0601020308	2000	14	0.0197	0.6685	32.4353	22
066353	2000	99	0.1390	4.7275	9.6434	46
066354	2000	207	0.2907	9.8848	8.5096	84
0601020400	2001	1	0.0014	0.0478	17.4979	1
0601020401	2001	2	0.0028	0.0955	17.9742	2
0601020402	2001	2	0.0028	0.0955	33.0950	3
0601020403	2001	2	0.0028	0.0955	30.6631	3
066355	2001	161	0.2261	7.6882	9.3246	72
066356	2001	74	0.1039	3.5337	10.5505	37
066357	2001	70	0.0983	3.3427	9.8064	33
0601020404	2002	13	0.0183	0.6208	16.3173	10
0601020405	2002	10	0.0140	0.4775	15.7441	8
0601020406	2002	6	0.0084	0.2865	32.9650	9
0601020407	2002	1	0.0014	0.0478	28.4657	1
066358	2002	4	0.0056	0.1910	10.5224	2
066359	2002	5	0.0070	0.2388	9.9983	2
066360	2002	1	0.0014	0.0478	7.9880	0
<b>Totals =</b>		<b>712</b>	<b>1</b>	<b>34</b>		<b>377</b>

From the known CWT expansions presented in Table 2, the Department estimates that 7,898 Chinook salmon progeny from IGH returned back to IGH as adults during the 2004 season. IGH smolt releases accounted for 1,964 (24.9%) of these returning adults and IGH yearling releases accounted for 5,934 (75.1%) of the returning adults. The 2001 brood year smolt release, age 3 fish, only contributed 181 fish or 9.2% of all of the smolt releases that returned to IGH during the 2004 season (Table 4). Smolts from the 2001 brood year were released from IGH in four separate tag groups during the spring of 2002 on May 10 (862,908 fish), May 21 (854,456 fish), May 28 (1,699,858 fish) and June 5 (1,549,867 fish). Since the 3 and 4 year old age classes typically comprise the majority of returning adults at IGH each year, the low number of age 3 returns from the 2001 smolt release is cause for concern and may be an indication that significant mortalities occurred to these smolts during their emigration downstream in the spring and summer of 2002. This was not the case for the 2001 yearling release from IGH which was released on November 13<sup>th</sup> of 2002 (1,087,081 fish), and therefore, were not exposed to the same emigration conditions in the Klamath River as the smolt releases which occurred in May and June of 2002. To the contrary, the 2001 BY yearling release, age 3 fish, comprised 50% of all the yearling returns to IGH in 2004.

**Table 4. Summary of expanded IGH Chinook salmon smolt and yearling release return rates observed at IGH from known CWT recoveries in 2004.**

Brood Year	Smolt Returns		Yearling Returns		Total Returns	
	Number	Percent	Number	Percent	Number	Percent
2002	596	30.3%	100	1.7%	696	8.8%
2001	181	9.2%	2968	50.0%	3149	39.9%
2000	1077	54.9%	2716	45.8%	3794	48.0%
1999	110	5.6%	149	2.5%	259	3.3%
Totals =	1964		5934		7898	

The Klamath River Technical Advisory Team (KRTAT) met in January of 2005 to review the 2004 Chinook salmon run size monitoring efforts and estimate the age composition of the run in 2004 (KRTAT 2005). Results of the age composition analysis for IGH were developed by the KRTAT from scale age proportions and were used to describe the age structure of IGH fall Chinook salmon returns (Table 5).

**Table 5. Age composition of the 2004 Chinook salmon run that entered Iron Gate Hatchery as developed by the KRTAT.**

Hatchery Spawners	Age				Total Adults	Total Run
	2	3	4	5		
	937	3,810	6,570	202	10,582	11,519

**COHO SALMON**

IGH staff conducts a count of marked and unmarked coho salmon during the sorting process as fish are brought into the spawning building. As fish are raised out of the anesthetic tank and slide onto the sorting table a technician (sorter) examines each fish for fin clips or marks, determines the sex, and spawning ripeness. Another staff person records the information on a tally sheet throughout the sorting process. The total number of coho salmon to enter IGH during the 2004 season was 1,734 fish. IGH staff counts for the 2004 coho salmon run are as follows, 1203 left maxillary clips, 32 right maxillary clips, 69 ad-clips, 3 left and right maxillary clips, 2 left and right maxillary clips and an ad-clip, 1 right maxillary clip and ad-clip, and 424 unmarked fish.

KRP staff examined 1,593 coho salmon and collected fork lengths on 1,548 coho during the season. Male coho salmon ranged in fork length from 18 cm to 84 cm and averaged 62 cm (Figure 4). Female coho salmon ranged in fork length from 37 cm to 79 cm and averaged 69 cm (Figure 5). Grilse were estimated to be  $\leq 51$  cm in fork length and comprised approximately 13.3% (231 fish) of the total run. Based on the proportion of male and female coho observed in the sample of 1,593 fish, KRP estimates that males comprised 48.3% (838 fish) of the run and females comprised 51.7% (896 fish) of the run.

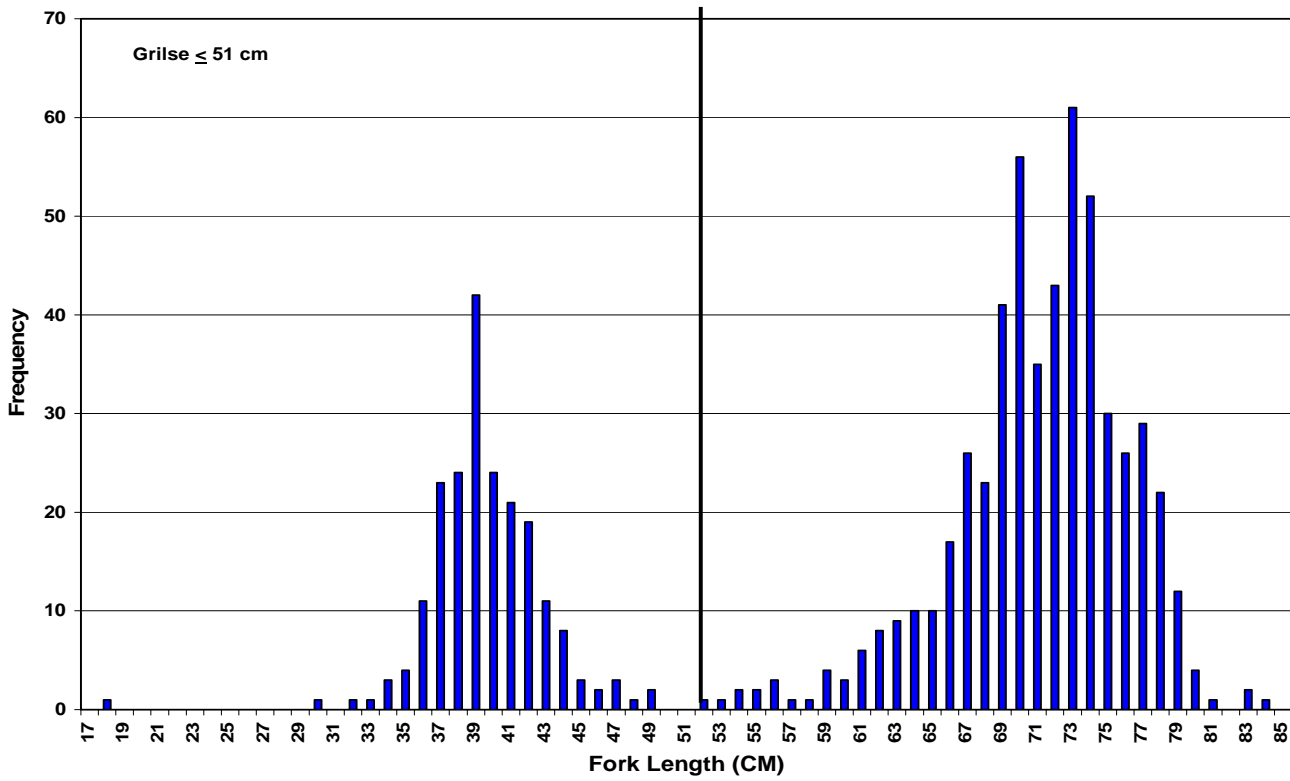


Figure 4. Fork length frequency distribution for male coho salmon recovered at IGH during the 2004 season (n = 747 fish).

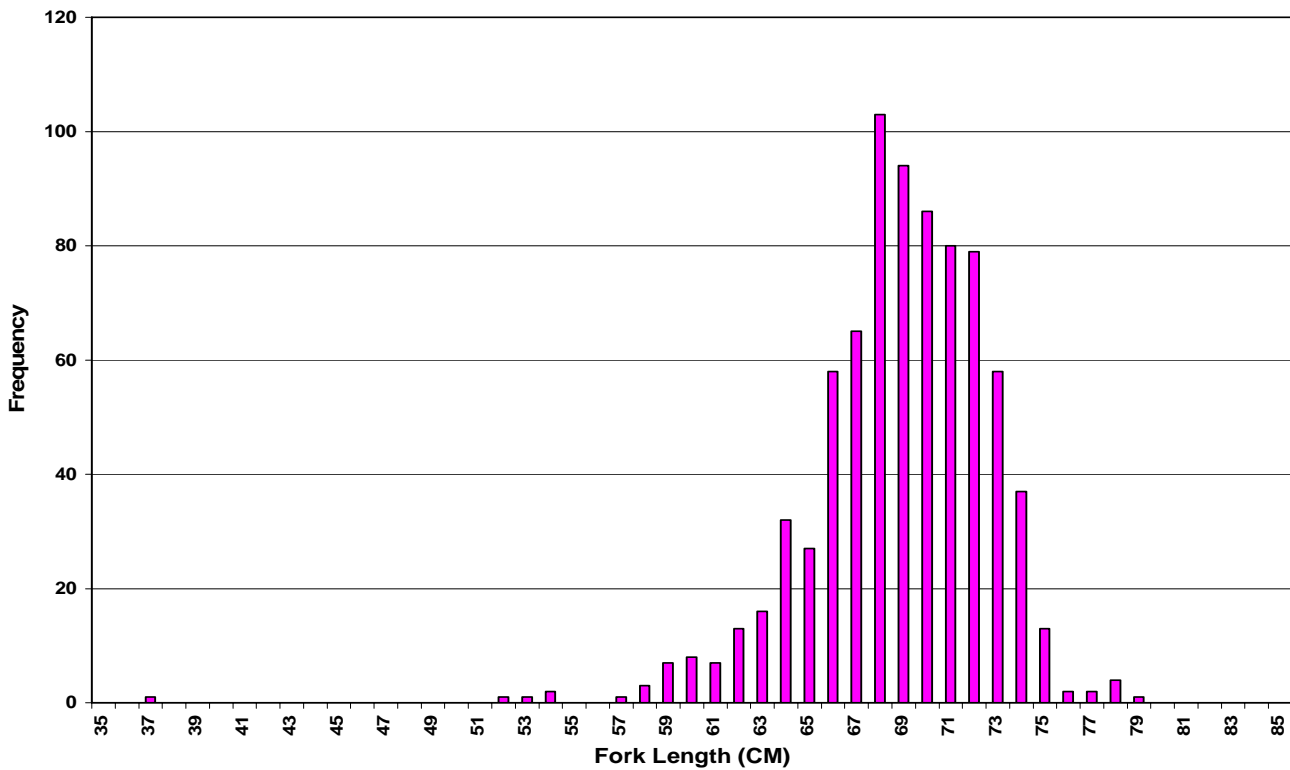


Figure 5. Fork length frequency distribution for female coho salmon recovered at IGH during the 2004 season (n = 801 fish).

KRP staff examined 58 coho salmon with an ad-clip and tested each of these fish for the presence of a CWT by passing the head of each of these fish through a V Detector. Seven of the ad-clipped coho salmon tested positive for a CWT and the removal and examination of each of these CWTs revealed that all of these fish were progeny from Cole Rivers Hatchery which is operated by the Oregon Department of Fish and Wildlife on the Rogue River. Of the 7 CWTs that were retrieved, 6 were code number 093520 and 1 was 093519. Both of these codes were from the 2001-02 BY and were released from Cole Rivers Hatchery in March of 2003.

### **Unmarked Coho Salmon**

As stated earlier, IGH staff identified a total of 424 coho as unmarked during the recovery process. KRP sampling efforts examined a total of 422 unmarked coho salmon. As a result 2 unmarked coho are unaccounted for and the discrepancy between these two observations is likely a recording error. Ten (10) unmarked coho salmon, 5 males and 5 females, were spawned with marked coho salmon in a one to one ratio as specified in the interim protocols that were established for this year. The U.S. Fish and Wildlife Service applied radio tags to 40 adult coho salmon to monitor their movement after release from the hatchery. Twenty four (24) unmarked coho died during recovery at the hatchery as a result of either handling stress, or died while holding in the ponds during the final maturation process. Eight (8) unmarked coho salmon gave a positive read when they were passed through a tag detector to determine the potential presence of a CWT. All of these fish were killed and their heads were collected for recovery and analysis. During the removal of the head from one of these fish, a hook was found in the back of the throat, and after removal of the hook the head tested negative for a CWT. The remaining 7 heads contained a CWT and the analysis of these tag codes indicated that all of these fish were age 3 (2001 BY) released from Cole Rivers Hatchery on the Rogue River in Oregon in March of 2003. On November 22, a single unmarked coho salmon (no clips) with a spaghetti tag and radio transmitter and was recovered and immediately released back to the river. Review of the radio signal code obtained from the receiver located inside the spawning building by Mr. Jason Ogawa of the USFWS, revealed that signal from this fish was being used by the by the Karuk Tribe in their coho migration study.

The remaining 339 unmarked coho were selected for release after application of caudal clip and Floy tag. Two unmarked coho escaped during the tagging operation. One large male coho jumped out of the dip net and fell directly into the river return hole as staff attempted to move this fish from the holding cage into the anesthetic tank. The second unmarked coho, a small grilse, escaped into one of the hatchery flumes after tagging. This fish was small enough to pass through the crowding screens and staff was unable to catch this fish on multiple attempts. A total 337 unmarked coho salmon were successfully tagged and released back to the river during the season.

Of the 337 unmarked coho salmon that were subsequently tagged and released from IGH, 25 of these fish reentered IGH and were returned to the river, 72 unmarked coho were observed in Bogus Creek, 20 unmarked coho were observed passing the video flume at the SRFCF, and two unmarked coho were recovered in the main stem Klamath River, one just upstream of the Klamathon Bridge by the Yurok Tribe, and the other just downstream of the confluence of Beaver Creek by the Karuk Tribe. Two of the 25 unmarked coho that returned to IGH after their initial tagging, reentered the hatchery on more than one occasion and 3 of the 25 coho that returned to IGH were eventually recovered in Bogus Creek.

A total of 71 unmarked coho (caudal clipped and Floy tagged) were observed entering Bogus Creek at the BCFCF through December 8<sup>th</sup> and 31 unmarked coho salmon carcasses were retrieved during spawning ground surveys. Thirty of these carcasses were recovered upstream of the BCFCF and one was recovered downstream bringing the total number of unmarked coho salmon observed to 72. Twenty unmarked coho salmon were also observed entering the Shasta River at the SRFCF and 4 unmarked coho salmon carcasses were recovered as

wash backs at that facility. Therefore, of the 337 unmarked coho salmon that were released from IGH, 72 (21%) were observed in Bogus Creek and 20 (6%) were observed in the Shasta River. The fate of the remaining 243, less the two that were recovered in the Klamath River, is uncertain. However it is likely that the majority of these fish spawned in the Klamath River downstream of IGH. The USFWS observed coho salmon spawning at several locations in the main stem Klamath River during the 2004 spawning season. Specific locations within the Klamath River where coho salmon were observed spawning include areas of the river near Klamath River Country Estates, near the mouth of Willow Creek, near the Interstate 5 crossing, near the mouth of Barkhouse Creek, and near the mouth of Horse Creek. (Pers. Comm. Tom Shaw, Supervisory Fish Biologist, USFWS, Arcata, CA).

### Coho Salmon Run Timing

The 2004 coho salmon spawning run entered IGH between Julian Week 42 (October 18) and Julian Week 1 of 2005 (January 6). The run peaked during Julian Week 45 when a total of 375 coho salmon were observed at IGH (Figure 6).

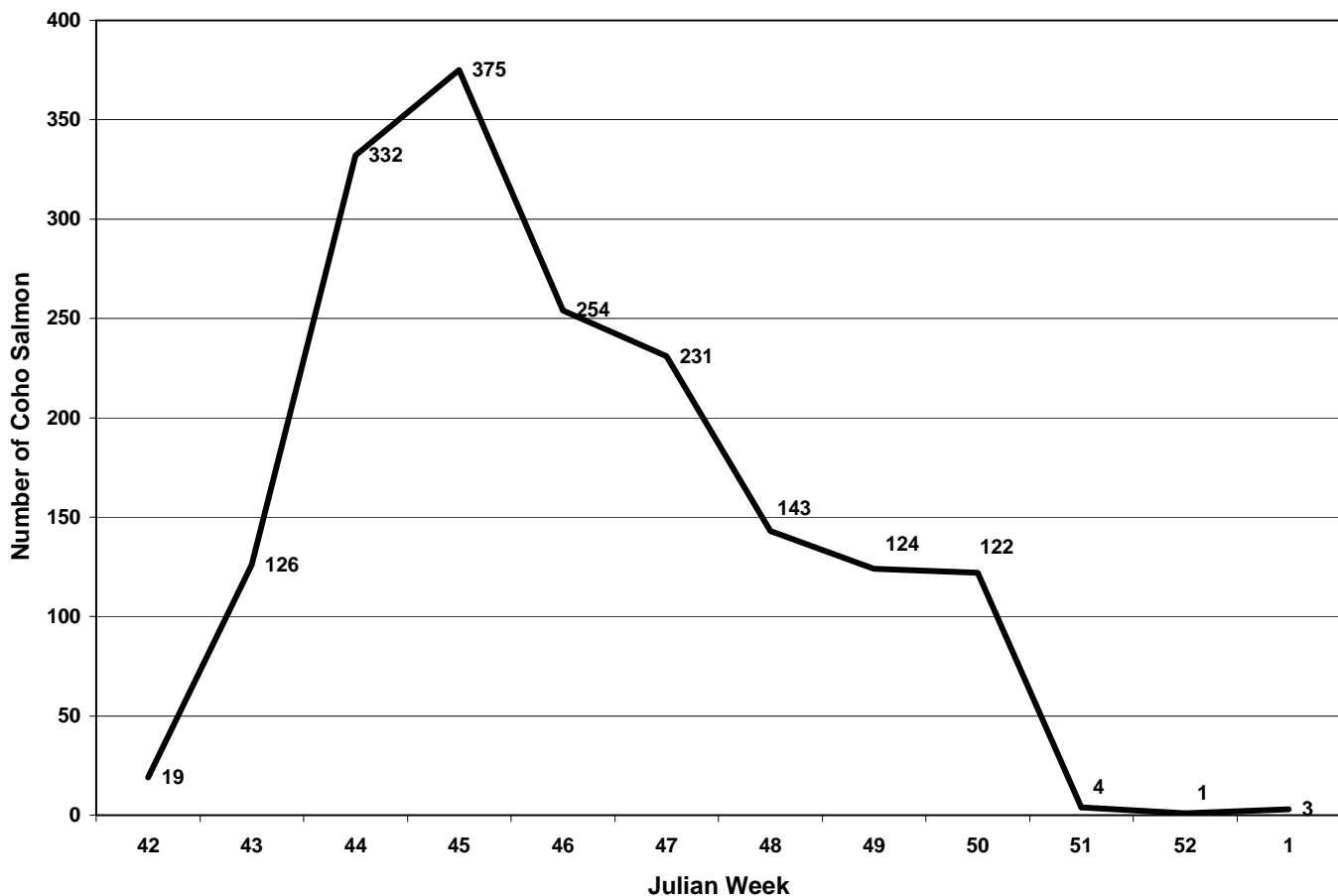


Figure 6. Run timing of coho salmon that entered IGH during the 2004 spawning season (n = 1,734).



## 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 that is generated from these two efforts is summarized in the Department's "Mega Table" each year. Chinook salmon run size data provided in the Mega is then reviewed by the Klamath River Technical Advisory Team (KRTAT) during their annual age composition meeting which is held over several days 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 2004 and previous years, coupled with data on coded-wire tag (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 2005). The 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.

Annual returns of Chinook salmon to IGH have ranged from a low of 2,558 fish in 1979, to a high of 72,474 fish in 2000 (Figure 7). The average number of Chinook that have returned over this same period is 16,368 fish. The 2004 Chinook salmon run (11,519 fish) ranks 11<sup>th</sup> out of the 27 years of data that are available and is 4,849 fish less than the average return. During the 1995 Chinook salmon spawning season, the ladder gates at IGH were closed after production goals were met, therefore a significant portion of the IGH Chinook returns likely spawned in the main stem Klamath River below Iron Gate Dam or entered nearby Bogus Creek. Subsequent to 1995, hatchery policy was modified to allow all Chinook to enter the hatchery. Excess Chinook are now killed and added to the post-spawned fish. Therefore, run size estimates that were reported for IGH prior to 1996 may underestimate the actual contribution of IGH origin Chinook salmon, particularly in years of high escapement.

The number of returning grilse (2 year old fish) provides some insight into the survival and abundance of 3 year old fish that are anticipated to be available in the next year. Since 1978 the number of grilse that have returned to IGH has ranged from 65 in 1991 to 4,830 in 1999, and has averaged 1,078 (Figure 8). In 2004, 872 grilse were estimated at IGH based on length frequency analysis. The KRTAT, based the proportion of age 2 scales analyzed, estimated that the 2004 Chinook run at IGH was comprised of 937 grilse.

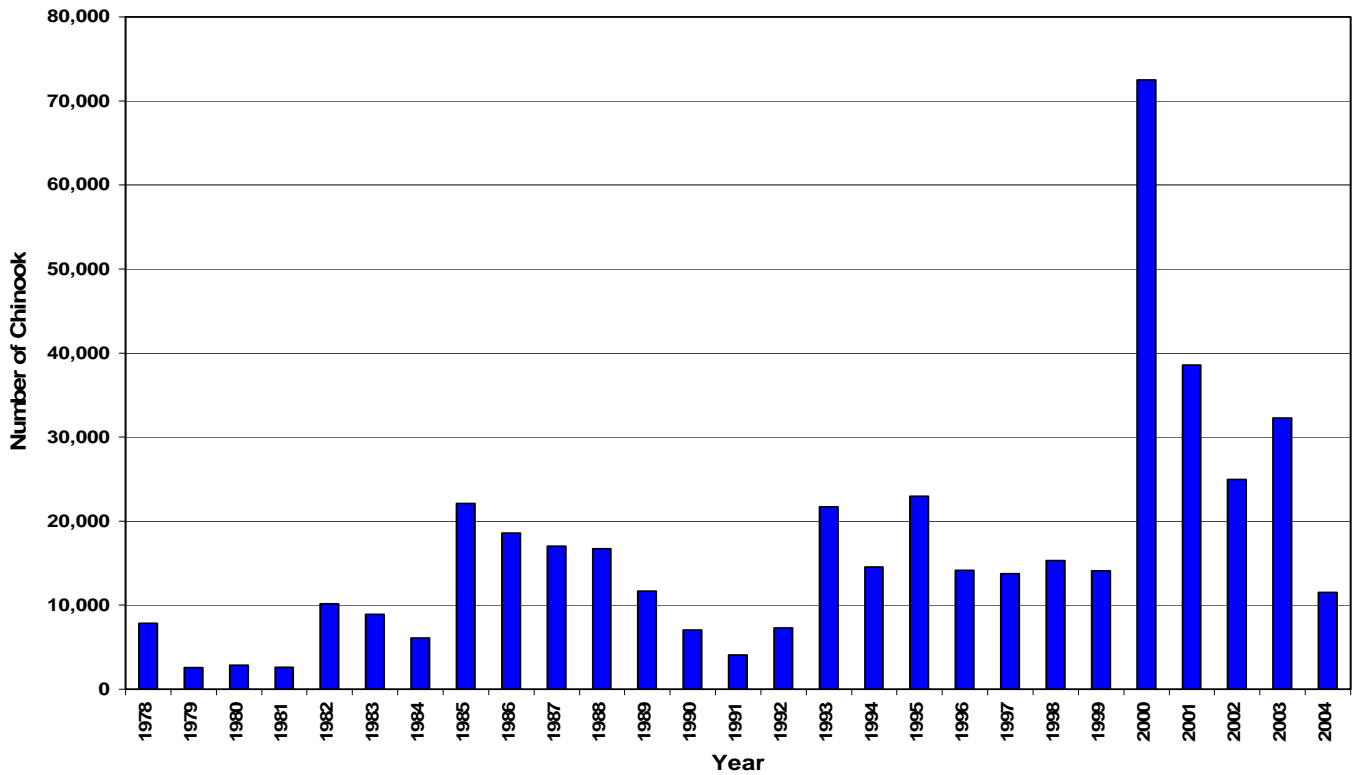


Figure 7. Total number of Chinook salmon that have returned to IGH from 1978 to 2004.

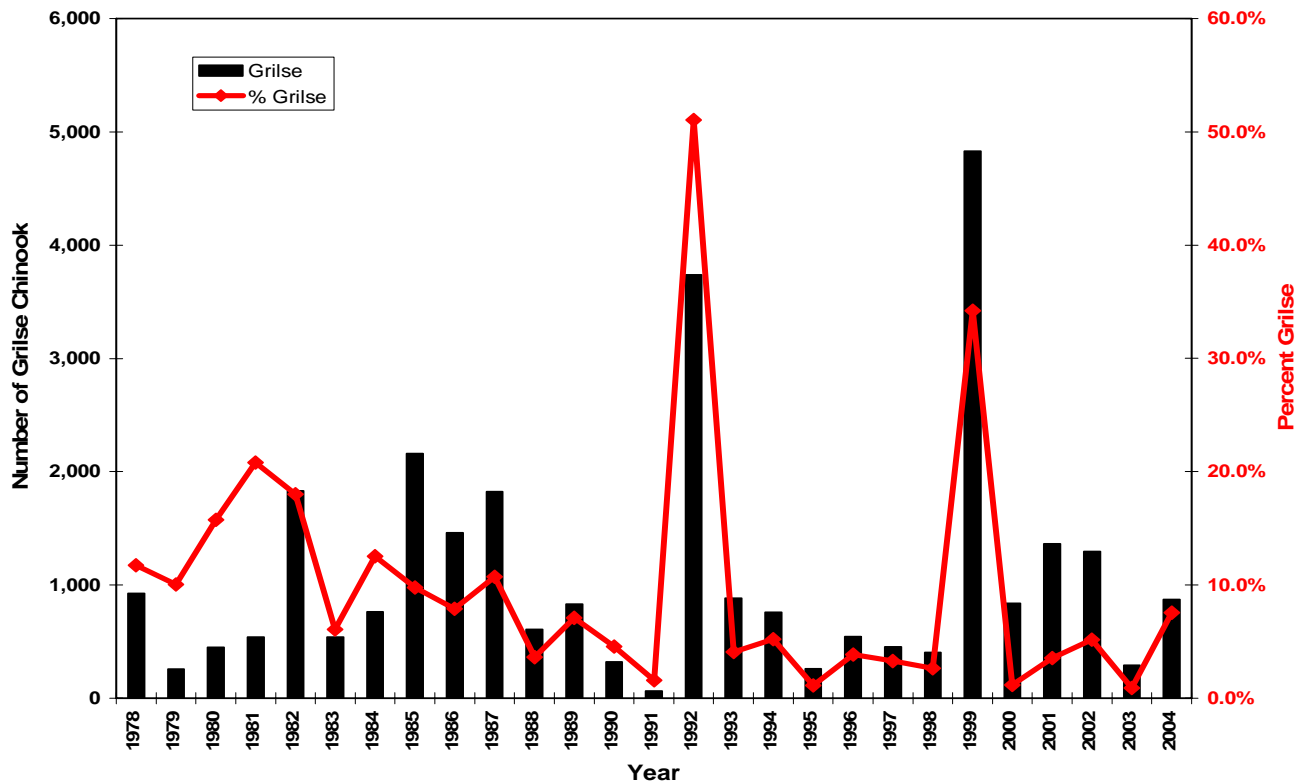


Figure 8. Total estimated number and percent contribution of Chinook salmon grilse (age 2) that returned to IGH from 1978 to 2004.

**IGH Smolt and Yearling Return Rates**

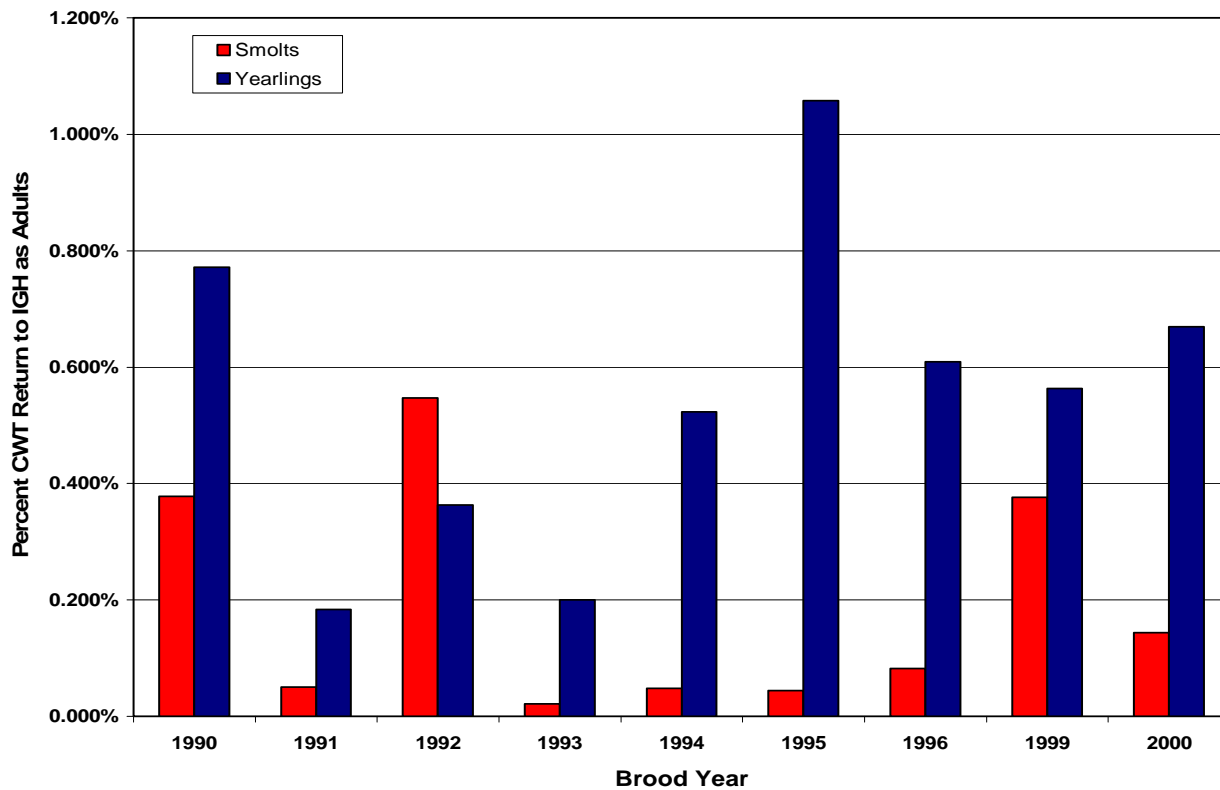
Current production goals for IGH allow for the release of approximately 4,920,000 Chinook salmon smolts and 1,080,000 Chinook salmon yearlings. In the spring of 2001 (2000 BY) the Department implemented an early release strategy for Chinook salmon smolts reared at IGH. In their *Review Draft of the Final Report on Anadromous Salmonid Fish Hatcheries In California* (Joint Hatchery Review Committee, 2001) the Joint Hatchery Review Committee stated that the current smolt release times (June 1 to June 15) often coincides with a reduction in the flow of water released by Bureau of Reclamation into the Klamath River, and that this reduction in flows also coincides with a deterioration of water quality and reduces the rearing and migration habitat available for both natural and hatchery reared fish. In response to these concerns the Department, in coordination with our stakeholders, proposed an Early Release Strategy and Cooperative Monitoring Program (ERS) in April of 2001 (CDFG, 2001). The goals of implementing the ERS are to:

1. Improve the survival of hatchery released fall Chinook salmon smolts from IGH to the commercial, tribal, and sport fisheries.
2. Reduce the potential for competition between hatchery and natural salmonid populations for habitats in the Klamath River, particularly for limited cold water refugia habitat downstream of Iron Gate Dam.

The yearling release of approximately 1,080,000 fish occurs in November and corresponds to a time when flows and water temperatures are generally more favorable for survival of emigrating salmon. Funding limitations prevented tagging of yearlings for the 1997 and 1998 brood years. A comparison of the CWT return rates between IGH smolt and yearling releases for brood years 1990 to 1996, 1999 and 2000 is presented in Table 6 and Figure 9. More recent brood year releases are not included since the adult returns for these years have not yet occurred in their entirety.

**Table 6. Return rates of IGH smolt and yearling CWT releases for brood years 1990 to 1996, 1999 and 2000. There were no yearling CWT releases from IGH in 1997 and 1998 do 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	270	0.144%	100,702	674	0.67%	4.65
<b>Average =</b>							<b>7.11</b>



**Figure 9. Iron Gate Hatchery adult Chinook salmon CWT return rates for smolt and yearling CWT releases for 1990 to 1996, 1999 and 2000. There were no CWT yearling releases from IGH for the 1997 and 1998 brood years because of budget constraints.**

In each of the years examined, except for the 1992 brood year, survival of yearling releases from IGH greatly exceed the survival rates for smolt releases that have been observed. For all of the years examined, the yearling return rates exceeded the smolt return rates by an average of seven times and ranged from 0.66 to 23.87. Smolt return rates for the 1992 brood year (0.547%) were the highest of any of the smolt returns examined and also exceeded the yearling return rates for that year. Examination of June flows in the Klamath River for 1991 to 1997, 2000 and 2001, which correspond to the timing of the smolt releases for those brood years examined, found that the flows in the Klamath River during 1993 were substantially higher than in any of the other years examined (Figure 10 and Figure 11). It appears that these higher flows provided better emigration conditions for the 1992 smolt brood year, and likely resulted in greater survival rates relative to the other smolt releases that were examined since 1991. Assuming that the contribution rates for both the smolt and yearling releases to the various fisheries is similar, the overall effectiveness of the yearling releases from IGH is much greater than that for the smolt releases. However, based on the findings for the 1992 brood year smolt release, survival of smolt releases can be improved under higher flow conditions such as those present under wet year scenarios as occurred in 1993.

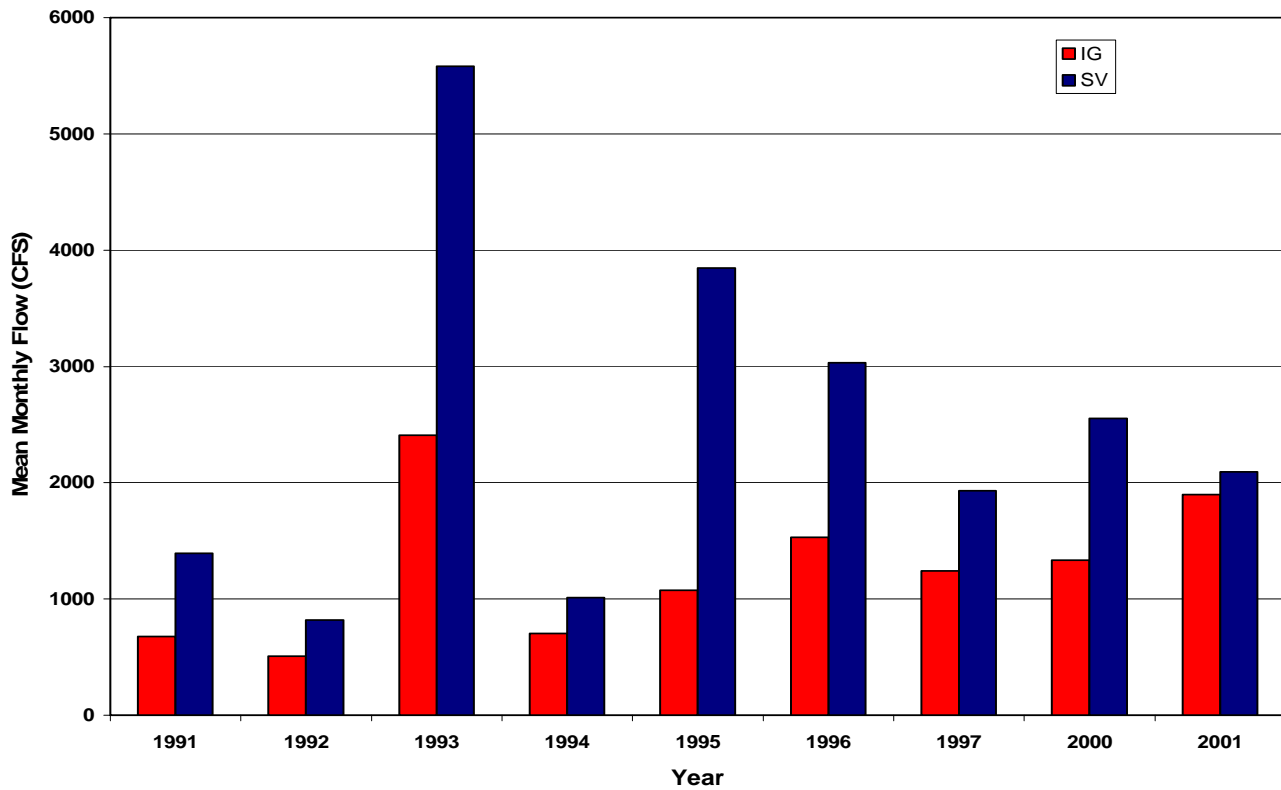


Figure 10. Mean monthly June flows (CFS) recorded in the Klamath River at the USGS gauges located below Iron Gate Reservoir (USGS Gauge #11516530) and at Seiad Valley (USGS Gauge #11520500).

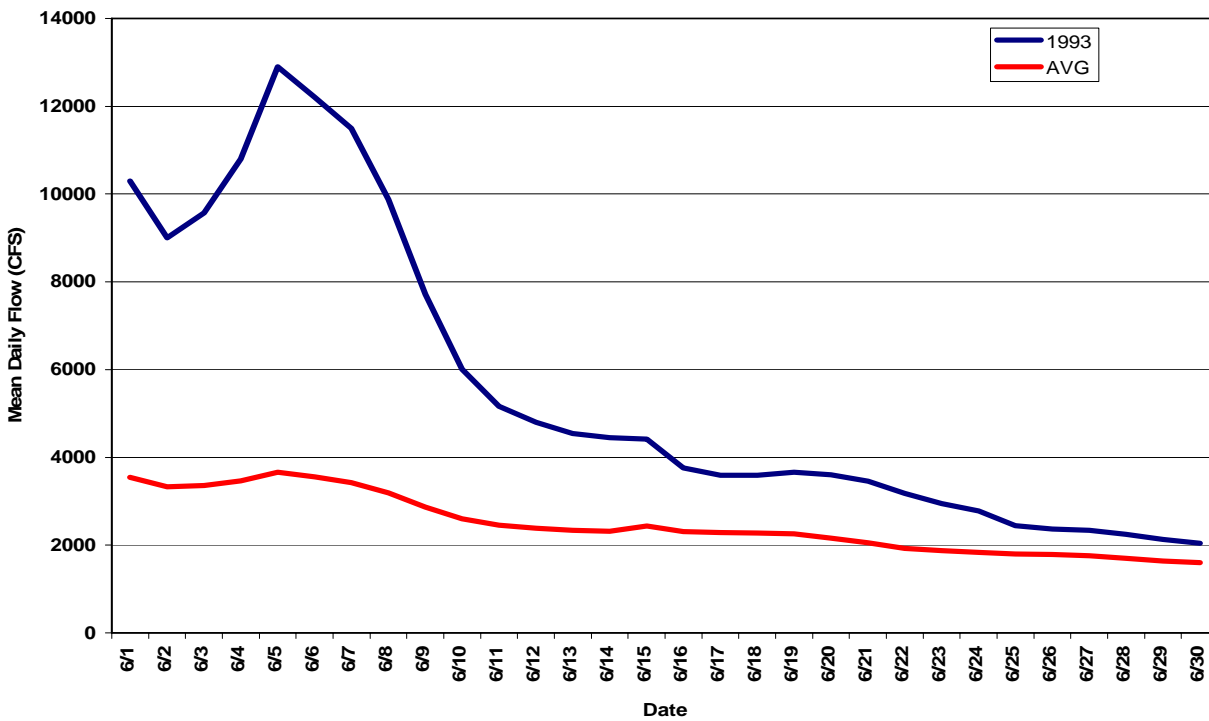


Figure 11. Comparison of mean daily flows recorded in the Klamath River at Seiad Valley (USGS Gauge #11520500) in June of 1993 versus the average mean daily flows for June for years 1991 to 1997, 2000 and 2001.

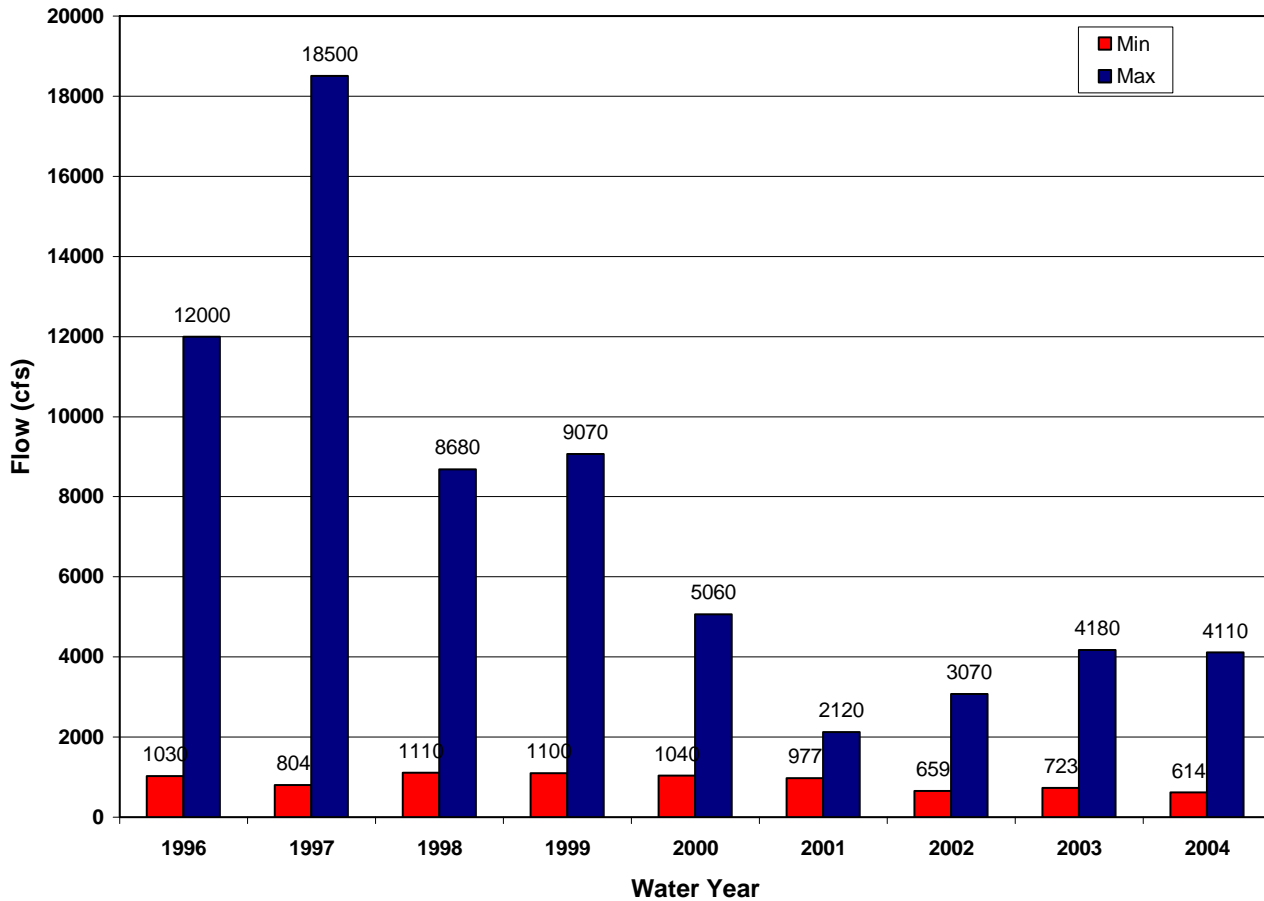
## **2001 Brood Year Return Rates**

The KRP tagged a total of 198,761 Chinook smolts from the 2001 brood year and these fish were released between May 10<sup>th</sup> and June 5<sup>th</sup> of 2002. Of the 198,761 CWT Chinook smolts from the 2001 brood that were released in the spring of 2002, only 7 CWT Chinook returned to IGH as 3 year old adults in 2004 and only 2 CWT Chinook returned as grilse (2 year old fish) in 2003. The 2001 Chinook yearlings included a total of 110,167 CWTs that were released in November of 2003. Of these, 13 CWTs returned to IGH as grilse in 2003 and 305 returned as 3 year old fish in 2004. A summary of the expanded return rates for the 2001 brood year smolt and yearling releases is presented in Table 4. Preliminary returns of these two release groups indicate that the 2001 smolt release experienced very high mortality after their release from IGH in the spring of 2002. Dry year conditions prevailed in the spring of 2002 and the mean monthly flows that were present during June of that year were 993 cfs at Iron Gate and 1,853 cfs at Seiad Valley.

In recent years significant levels of disease infections have been documented in natural and hatchery origin Chinook salmon juveniles within the main stem Klamath River (Foott et al 2002). The primary pathogens believed responsible for the disease include two myxozoan parasites *Ceratomyxa shasta* (C Shasta) and *Parvicapsula minibicornis* (Parvicapsula) and the bacterial disease *Columnaris*. C Shasta is endemic to the Klamath River and has a complex life cycle using both salmonids and a polychaete worm, *Manaynukia speciosa*, as host species during their life cycle. The polychaete worm is often associated with algae including attached periphyton species such as *Cladophora* which is commonly found in the Klamath River (Stocking and Bartholomew 2004). Stocking and Bartholomew hypothesize that the high incidence of C Shasta in the Klamath River is related to increased populations of the polychaete worm in response to an increase in available habitat for the worm which is provided by *Cladophora*. Nutrient rich water, stable flow releases and lack of scouring flows in recent years have created favorable conditions for establishment and production of algae species which are used by the polychaete worm. Dry year conditions have prevailed in the Klamath River since the 2000 water year, and peak daily flows at Iron Gate have ranged from 5,060 cfs in 2000 to 2,120 cfs in 2001. In the four years prior to 2000, peak daily flows were considerable higher and ranged from 18,500 cfs in 1997 to 8,680 cfs in 1998 (Figure 12).

The lack of scouring flows in recent years have undoubtedly benefited establishment of periphyton and likely resulted in an increase in polychaete worm populations. The low flow conditions that existed in the spring of 2002, combined with the lack of any scouring flows since 1999, probably created ideal conditions for the myxozoan parasite populations to flourish. The potential increase in intermediate host populations for the disease, combined with poor emigration conditions, may be responsible for the poor survival of the 2001 brood year Chinook smolt release from IGH. Given the continued dry conditions that have prevailed in the Klamath River since 2000, survival of recent smolt releases from IGH since 2002 may also be in jeopardy. Rotary trapping efforts conducted by the USFWS and Tribal Fisheries Departments documented high disease infection rates in 2003 and 2004.





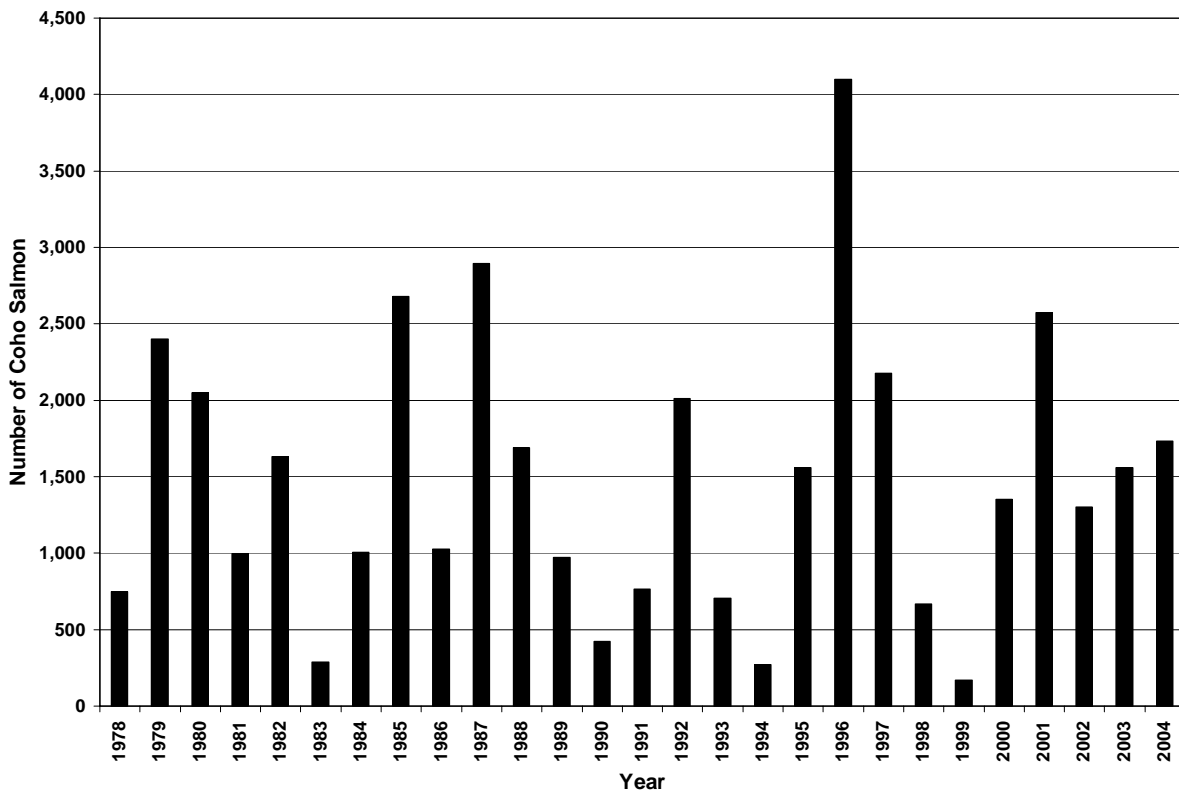
**Figure 12. Minimum and maximum daily flows (cfs) recorded at the USGS Gauge# 11516530 at Iron Gate for water years 1996 through 2004.**

### Juvenile Chinook Fish Kills

Other juvenile Chinook salmon fish kills have been documented in June 2000 and June 1998. 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. Direct mortality was believed to be caused by two pathogens, C Shasta and Columnaris, which occur naturally in the Klamath River. The presence of unseasonably high air temperatures during the spring and early of summer of 2000 lead to mainstem water temperatures above 24°C (75°F) in June. IGH Chinook tend to be more resistant to C Shasta at temperatures  $\leq 16$  °C (61°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).

### **COHO SALMON**

During the 2004 spawning season a total of 1,734 coho salmon returned to IGH. Since 1978 the number of coho returning to IGH has ranged from a low of 169 coho in 1999 to a high of 4,097 coho in 1996 and has averaged 1,472 (Figure 13).



**Figure 13. Annual returns of coho salmon to Iron Gate Hatchery from 1978 to 2004.**

Since 1995 (1994 Brood Year) all hatchery reared coho salmon released with in the Klamath Basin from either TRH or IGH 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). Some coho salmon with an adipose fin clip have consistently been observed in the coho salmon population at IGH. The Oregon Department of Fish and Wildlife does apply adipose fin clips to various hatchery coho releases each year. The closest of these hatcheries is Cole Rivers Hatchery located at the base of Lost Creek Dam on the Rogue River about 153 river miles upstream from the Pacific Ocean on the Southern Oregon Coast. Cole Rivers Hatchery 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. Recovery of CWTs from some adipose fin clipped and unmarked coho salmon at IGH have shown that the origin of these fish originated from Cole Rivers Hatchery. The coho release of 200,000 from Cole Rivers Hatchery compares to the 75,000 coho released from IGH and 500,000 coho released from TRH.

The age 3 coho returns of 1997 would be representative of 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 2001. Adult coho salmon from progeny released in 2002 will return to IGH in 2005. A summary of coho salmon releases, adult returns, and survival of LM clipped coho to IGH is provided in Table 7. Survival of coho salmon progeny released from IGH since the 1994 brood year has ranged from 0.27% to 3.45% and has averaged 1.60%.

**Table 7. Survival estimates for coho salmon yearlings released from IGH (left maxillary clipped) by brood year from 1994 through 2001. Numbers of grilse and adult coho salmon that returned to IGH were corrected to adjust for tagging error based on clip quality control observations conducted 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	2.75%
1995	81,052	256	306	562	0.69%
1996	79,607	76	140	216	0.27%
1997	75,156	16	524	540	0.72%
1998	77,147	576	2,087	2,664	3.45%
1999	46,254	77	930	1,007	2.18%
2000	67,933	93	639	732	1.08%
2001	74,271	219	996	1,215	1.64%
<b>Average Survival Rate =</b>					<b>1.60%</b>

This year the Department initiated interim protocols to reduce the potential take of unmarked coho salmon (potentially of natural origin) at IGH and TRH. There is some uncertainty regarding the origin of unmarked coho salmon that return to IGH each year. Although naturally produced coho are likely present in these unmarked returns, an unknown number of hatchery origin coho are also present with in these returns. The source of these unmarked coho of hatchery origin is related to clipping error with in IGH and TRH and tagging efforts that occur outside of the basin. Beginning with the 1997 spawning season all coho that return to IGH from within the Klamath Basin that are progeny from either TRH or IGH have received a maxillary clip prior to release with the exception of a small number of coho that are not 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). 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 that returned to IGH for each brood year can be estimated. Table 8 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 2001 the number unmarked coho salmon that were estimated to have originated from progeny of IGH ranges from 3 to 43 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 be negligible in most, if not all years.

Seven unmarked coho with a CWT were recovered at IGH this year, and all of these coho originated from Cole 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 and therefore, an unknown number (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 of hatchery origin that return to IGH in any given year is likely very small (depending on the clip expansion rate) and for most return 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 8. 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 for brood years 1995 through 2001.**

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	81,052	0.9900	811	80,241	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

A summary of the number of marked and unmarked coho salmon that have returned to IGH since 1997 is presented in Table 9. From 1997 to 2001 the percentage of marked coho salmon that have returned to IGH has averaged 79%. 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 that basin that are of hatchery origin, mainly Cole Rivers Hatchery.

**Table 9. Summary of marked and unmarked coho salmon that have entered IGH from 1997 to 2004.**

1997/1998				1998/1999				1999/2000			
FIN CLIPS	ADULTS	GRILSE	Total	FIN CLIPS	ADULTS	GRILSE	Total	FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	121	44	165	Unmarked	207	82	289	Unmarked	12	3	15
LM	1,717	253	1,970	LM	303	75	378	LM	138	15	153
RM	5		5	RM			0	RM			0
AD	24	4	28	AD	1	1	2	AD	1		1
ADLM	5	1	6	ADLM			0	ADLM			0
ADRM			0	ADRM			0	ADRM			0
Total Clipped	1,751	258	2,009	Total Clipped	304	76	380	Total Clipped	139	15	154
Total Returns	1,872	302	2,174	Total Returns	511	158	669	Total Returns	151	18	169
2000/2001				2001/2002				2002/2003			
Unmarked	198	64	262	Unmarked	217	29	246	Unmarked	216	9	225
LM	500	567	1,067	LM	2,054	76	2,130	LM	916	90	1,006
RM	4		4	RM	136	2	138	RM	25	0	25
AD	13		13	AD	51		51	AD	31	7	38
ADLM	8		8	ADLM	7		7	ADLM	5	2	7
ADRM			0	ADRM	1		1	ADRM			0
Total Clipped	525	567	1,092	Total Clipped	2,249	78	2,327	Total Clipped	977	99	1,076
Total Returns	723	631	1,354	Total Returns	2,466	107	2,573	Total Returns	1,193	108	1,301
2003/2004				2004/2005				Proportion of clipped to unclipped coho			
Unmarked	575	14	589	Unmarked	399	25	424 <sup>*1</sup>	Season	Clipped	Total	% Clipped
LM	620	218	838	LM	990	213	1,203	1997/1998	2,009	2,174	92.4%
RM	66	3	69	RM	31	1	32	1998/1999	380	669	56.8%
AD	52	6	58	AD	69	0	69	1999/2000	154	169	91.1%
ADLM	2	0	2	ADLM	0	0	0	2000/2001	1,092	1,354	80.6%
ADRM	2	0	2	ADRM	1	0	1	2001/2002	2,327	2,573	90.4%
Total Clipped	742	227	969	Other	5	0	5	2002/2003	1,076	1,301	82.7%
Total Returns	1,317	241	1,558	Total Clipped	1,096	214	1,310	2003/2004	969	1,558	62.2%
				Total Returns	1,495	239	1,734	2004/2005	1,310	1,734	75.5%
								<b>Average</b>	<b>1,165</b>	<b>1,442</b>	<b>79.0%</b>

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

ADLM = Origin unknown, possible ODFW release or injury caused  
ADRM = Origin unknown, possible ODFW release or injury caused  
Other = Multiple clips observed, either result of tag error, injury, or unknown origin

\*1 : 7 of these unmarked coho carried a cwt and were actually from Cole Rivers Hatchery age 3

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