



California Department of Fish and Game

Klamath River Project

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

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ABSTRACT

In 2006, fall-run Chinook salmon (*Oncorhynchus tshawytscha*) began entering Iron Gate Hatchery (IGH) on 9/22/06. A total of 13,990 Chinook salmon entered IGH during the fall 2006 spawning season. Klamath River Project (KRP) staff systematically sampled 1 in every 10 Chinook recovered at IGH. In addition, staff sampled 100% of spawned Chinook (7,349) and all adipose-clipped Chinook during recovery efforts. Scale samples, sex and fork length data were collected for all sampled Chinook. Analysis of the length-frequency distribution for randomly sampled fall-run Chinook males indicates that the cutoff point between grilse and adults occurred at ≤ 58 cm fork length (Figure 3). Randomly sampled male Chinook ranged in size from 39 cm. to 102 cm. fork length, and randomly sampled female Chinook ranged from 51 cm. to 92 cm. fork length. During the 2006 spawning season, KRP staff estimated that 2,350 (16.8%) of the run were grilse according to length frequency analysis (17.0% according to scale analysis by the KRTAT). Females accounted for 44% (6155) of the run while males accounted for 56% (7,835). The last Chinook of the 2006 spawning season was observed on 11/15/06. The 2006 run total contributed roughly 16% to the total (Klamath basin) in-river run and 20% to the total spawner escapement (Table 6). Based on coded wire tag expansion, KRP staff estimated that 11,116 (79%) of the Chinook entering IGH during the 2006 season were of hatchery origin

332 coho salmon (*Oncorhynchus kisutch*) entered IGH during the 2006-07 spawning season. The recorded dates for the coho run were from October 20 to December 4, 2006. KRP staff collected biological data (sex, fork length, presence of marks or clips and scale samples) on 301 coho, approximately 90% of the run. Males ranged in size from 31 to 83 cm. fork length (Figure 6), while female coho ranged in size from 55 to 79 cm. fork length (Figure 7). IGH counts for the 2006-07 coho spawning season included 151 adult females, 112 adult males, and 69 grilse. IGH staff counted 109 coho with left maxillary clips, 2 with right maxillary clips and 16 with an adipose clip among these 332 coho. . A total of 53 unmarked coho salmon were caudal clipped, Floy tagged and released from IGH to the Klamath River. Of these, 14 coho reentered IGH and were returned to the river, 3 were observed in nearby Bogus Creek, and 2 were observed passing the video fish counting station on the Shasta River. No Floy tagged coho were reported for the mainstem Klamath River. Three of the 14 unmarked coho that returned to IGH after their initial tagging reentered the hatchery on more than one occasion (Table 5). Two coded wire tags were recovered from coho, one from Cole Rivers Hatchery in Oregon and one from Klickitat Hatchery in Washington. Both CWT coho were from Brood Year 2003.

INTRODUCTION

Iron Gate Hatchery

The Iron Gate Hatchery (IGH) 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 to mitigate for loss of habitat between Iron Gate Dam and Copco Dam. 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
	1,080,000 yearlings	November	November
Coho	75,000 yearlings	March	late October to early January
Steelhead	200,000 yearlings	March-May	November to March

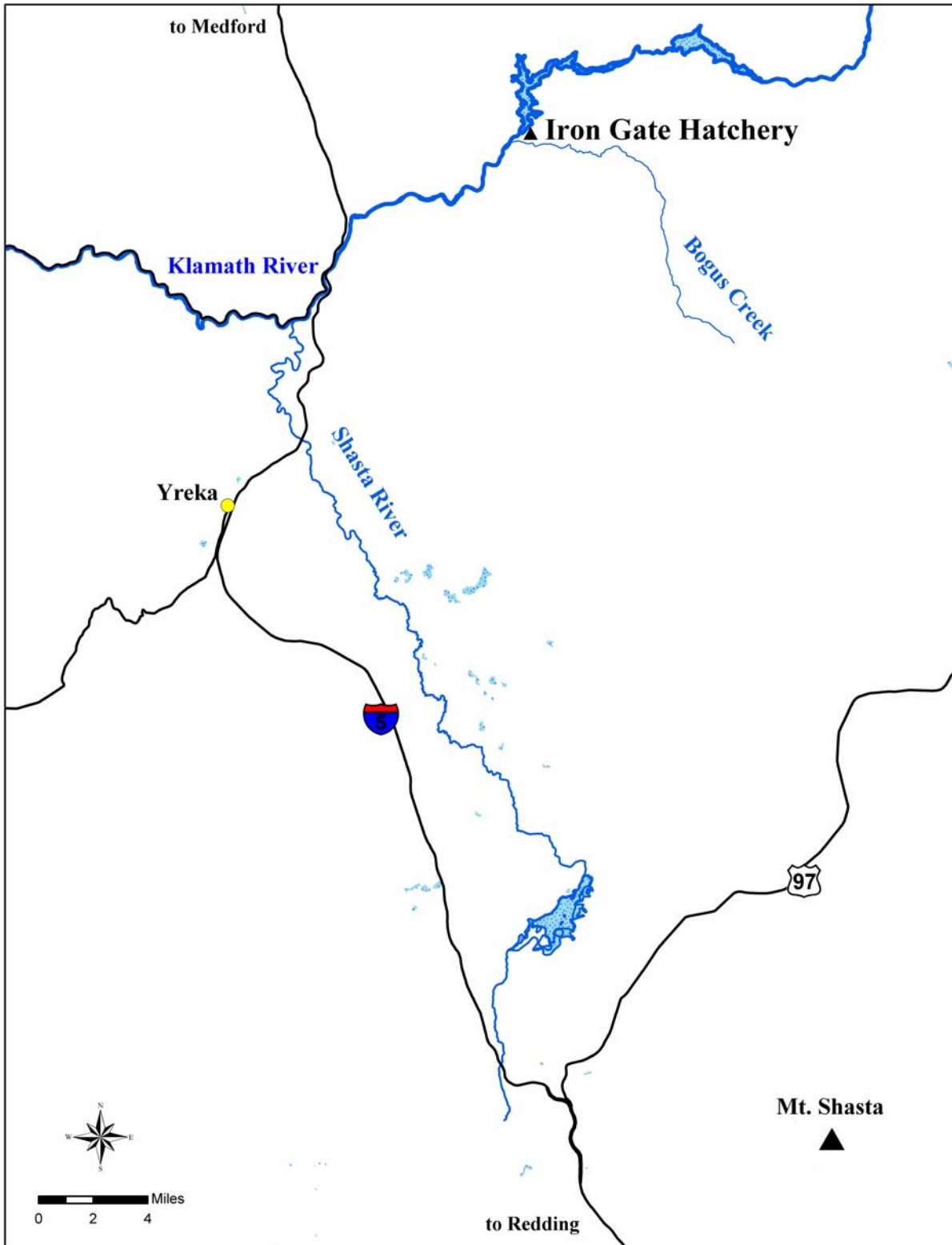


Figure 1. Location of Iron Gate Hatchery (California Department of Fish and Game, Siskiyou County).

Klamath River Project

The California Department of Fish and Game's (CDFG), Klamath River Project (KRP) conducts systematic random sampling of fall-run Chinook salmon annually during the Chinook spawning season. The purpose of the sampling is to characterize the adult fall-run Chinook salmon entering IGH, in terms of age and sex composition, and to recover data from all coded wire tags (CWT) recovered from the heads of adipose fin clipped (ad-clipped) Chinook. All Chinook salmon tagged at IGH are marked with an adipose fin clip to identify the CWT salmon when they return to the hatchery or other locations during subsequent spawning seasons. 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 the age composition of the run.

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). Until 2003, one of the yearling groups was raised at Fall Creek Hatchery, which is adjacent to Fall Creek (a tributary to Iron Gate Reservoir), an excellent source of high quality water. Unique Fall Creek tags were used for the 1995, 2001 and 2002 brood years. This unique CWT code allows evaluation of Fall Creek yearling survival rates relative to IGH yearlings. The rearing of yearlings at Fall Creek Hatchery was discontinued after BY 2002 due to budget constraints.

MATERIALS AND METHODS

Chinook Salmon

In 2006, all Chinook were allowed to enter IGH. Upon entering the hatchery, Chinook salmon were held until they were ready to spawn. Readiness to spawn was determined by hatchery staff and based on timing, firmness of the ovaries, and ease of stripping eggs when handled. KRP staff sampled 100% of the Chinook spawned by IGH staff. In addition to sampling all of the spawned fish, KRP staff also conducted a systematic random sample of every 10th Chinook during each sampling day. After the fish were spawned, KRP staff collected data on fork length, sex, and presence or absence of clips and/or marks. Heads containing CWTs, scale samples, fork length measurements and sex determinations were also collected from all ad-clipped Chinook (random and non-random fish).

Coho Salmon

In 2006, staff of the KRP collected biological data (sex, fork length, presence of marks or clips and scale samples) for 301 of the 332 coho which entered IGH. Each coho was inspected for the presence of marks and clips. 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 and Trinity River Hatchery (TRH) coho are marked with a right maxillary clip. All adipose-clipped coho are checked for the presence of a coded wire tag by passing them through a V-detector.

The protocol developed in 2004 by NOAA Fisheries and CDFG to reduce potential take of naturally produced coho was followed at IGH in 2006. The goals of the protocol are to incorporate unmarked coho into the spawning matrix, to release unmarked coho not spawned, and to monitor unmarked coho releases. The protocol is summarized as follows:

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 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, will be 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 should 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.

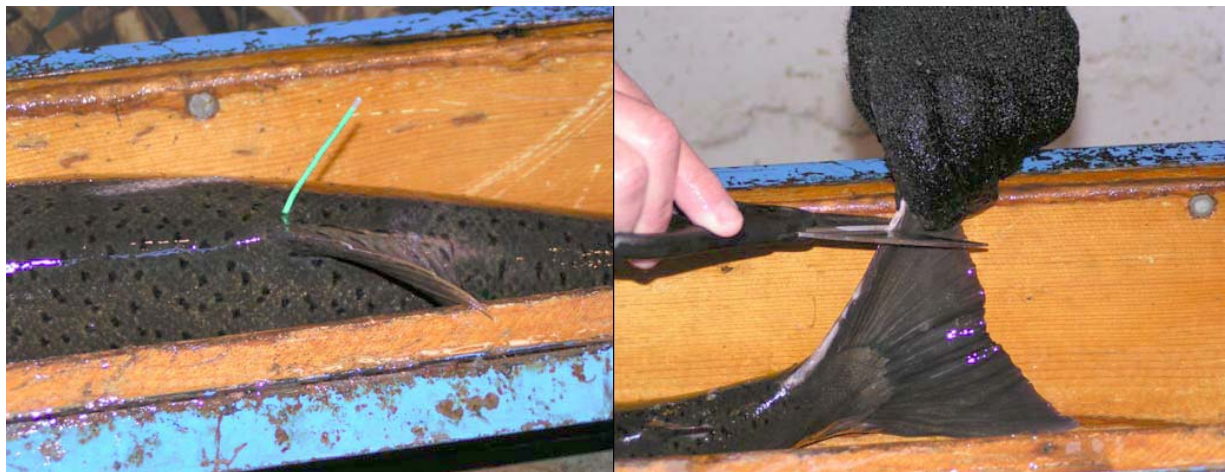


Figure 2. Photograph of Floy Tag application (left) and anterior caudal clip (right) applied to unmarked Coho salmon at Iron Gate Hatchery prior to release back to the river during the 2005 spawning season.

RESULTS

Chinook Salmon

In 2006, fall-run Chinook salmon began entering IGH on 9/22/06. A total of 13,990 Chinook salmon returned to IGH during the fall 2006 spawning season. Of these, KRP staff collected scale samples, determined sex, and measured fork lengths for 7,439 Chinook salmon (100% of the Chinook spawned). Randomly sampled male Chinook ranged in size from 39 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 ≤ 58 cm in fork length, yielding approximately 16.8% grilse.. Therefore, staff estimate that 2,350 grilse and 11,640 adults entered IGH during the 2006 season. Females accounted for 44% (6,156) of the run and males accounted for 56% (7,834). Randomly sampled female Chinook ranged in size from 51 to 92 cm (Figure 4). The last Chinook to enter IGH for the 2006 spawning season was observed on November 15, 2006.

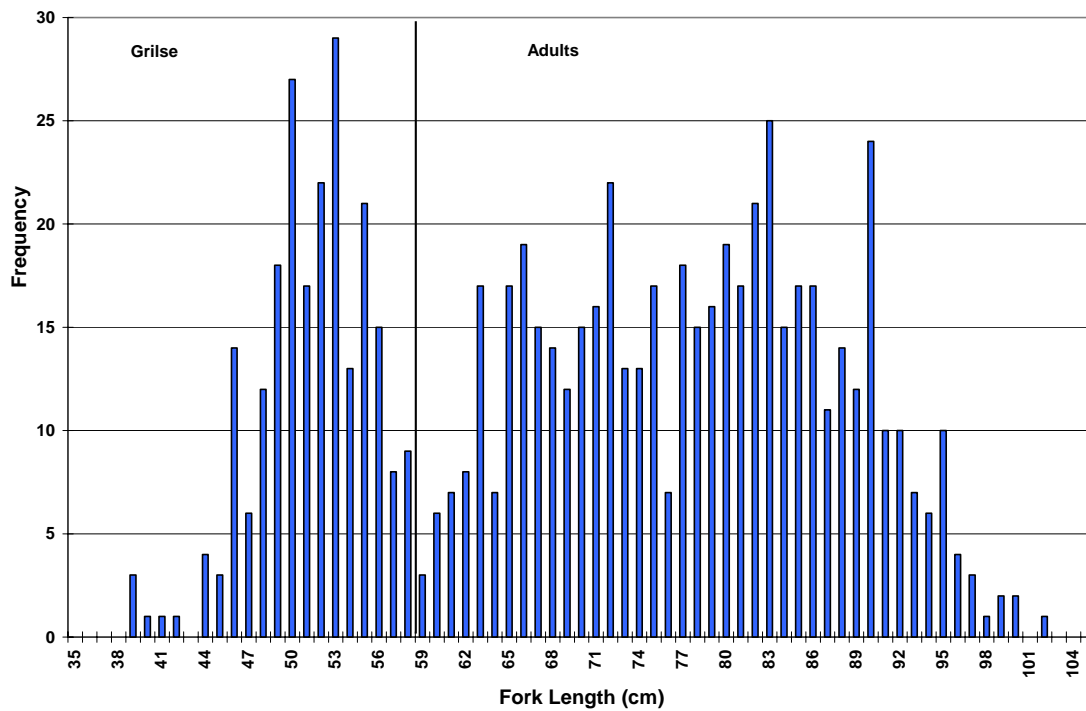


Figure 3. Length frequency distribution for systematic sample (n = 749) of male Chinook salmon recovered at IGH during the 2006 spawning season.

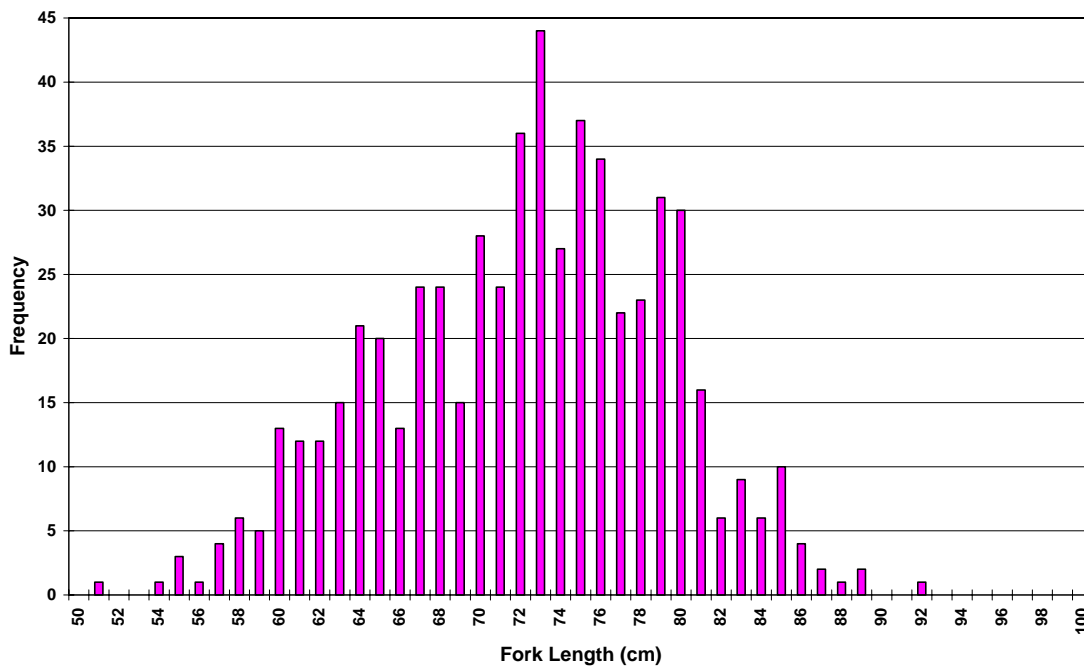


Figure 4. Length frequency distribution for systematic sample (n = 583) of female Chinook salmon recovered at IGH during the 2006 spawning season.

Heads from 754 ad-clipped Chinook salmon (from random and non-random fish) were collected for CWT recovery. However, 226 of these heads were misplaced during the season, therefore, CWT recovery data are not available for 29% of the heads collected during the 2006 season. An additional 4 CWTs were lost during dissection and 2 CWTs were unreadable. The contribution of lost or unreadable CWTs was estimated by applying the proportions of known CWTs (454) to the 233 lost or unreadable CWT ad-clipped Chinook (Table 2).

Table 2: Estimated contribution of 233 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 2006 season.

CWT codes	Brood Year	Number of CWTs recovered	Proportion of CWTs recovered	Estimated Number	Production Multiplier	Expanded Estimate
65307	2002	1	0.002202643	0.513215859	4.09	2
65323	2004	2	0.004405286	1.026431718	4.06	4
65325	2004	1	0.002202643	0.513215859	4.14	2
66355	2001	3	0.00660793	1.539647577	9.32	14
66356	2001	5	0.011013216	2.566079295	10.55	27
66357	2001	7	0.015418502	3.592511013	8.81	32
66358	2002	40	0.088105727	20.52863436	9.52	195
66359	2002	62	0.136563877	31.81938326	9.00	286
66360	2002	68	0.149779736	34.89867841	6.99	244
601020404	2002	34	0.074889868	17.44933921	17.32	302
601020405	2002	31	0.068281938	15.90969163	16.74	266
601020406	2002	32	0.070484581	16.42290749	33.97	558
601020407	2002	13	0.028634361	6.671806167	29.47	197
601020408	2003	22	0.04845815	11.2907489	19.20	217
601020409	2003	13	0.028634361	6.671806167	19.28	129
601020500	2003	9	0.019823789	4.618942731	18.80	87
601020501	2003	2	0.004405286	1.026431718	20.34	21
601020502	2003	31	0.068281938	15.90969163	14.11	224
601020503	2003	5	0.011013216	2.566079295	21.42	55
601020504	2004	16	0.035242291	8.211453744	17.12	141
601020505	2004	20	0.044052863	10.26431718	16.61	170
601020506	2004	24	0.052863436	12.31718062	34.04	419
601020507	2004	8	0.017621145	4.105726872	37.42	154
601020508	2004	5	0.011013216	2.566079295	9.10	23
Totals		454	1.0	233		3,770

The estimated contribution of unknown CWT Chinook was then added to the contribution of known CWTs to determine the total contribution of hatchery Chinook entering IGH (Table 3). Ninety-nine percent of CWTs recovered (and successfully read) originated from IGH. Four CWT codes were recovered from fish tagged and released at Trinity River Hatchery by the Hoopa Fisheries Program. Of these 4 fish, 2 were from brood year (BY) 2004, one from BY 2002 and one tag recovered was from BY 1997. KRP staff believes that the 1997 tag resulted from an error during CWT recovery, and that record was omitted from the CWT database.

Based on the expansion of CWTs, KRP staff estimated that 11,116 (79%) of the Chinook entering IGH during the 2006 season were of hatchery origin (Table 3).

Table 3: Estimated contribution of Chinook from Iron Gate Hatchery (IGH) to total run at IGH, based on coded wire tags (CWT) recovered from fall-run Chinook salmon recovered at IGH during the 2006 spawning season.

CWT	Release Location	Brood Year		Release Type	Number Recovered	Production Multiplier	Expanded Estimate
	Location	Year	Age	Type	Recovered	Multiplier	Estimate
Estimated contribution of known CWTs:							
65307	TRH	2002	4	Ff	1	4.09	4
65323	TRH	2004	2	Ff	2	4.06	8
65325	TRH	2004	2	Ff	1	4.14	4
66355	IGH	2001	5	Fy	3	9.32	28
66356	IGH	2001	5	Fy	5	10.55	53
66357	IGH	2001	5	Fy	7	8.81	62
66358	IGH	2002	4	Fy	40	9.52	381
66359	IGH	2002	4	Fy	62	9.00	558
66360	IGH	2002	4	Fy	68	6.99	475
601020404	IGH	2002	4	Ff	34	17.32	589
601020405	IGH	2002	4	Ff	31	16.74	519
601020406	IGH	2002	4	Ff	32	33.97	1,087
601020407	IGH	2002	4	Ff	13	29.47	383
601020408	IGH	2003	3	Ff	22	19.20	422
601020409	IGH	2003	3	Ff	13	19.28	251
601020500	IGH	2003	3	Ff	9	18.80	169
601020501	IGH	2003	3	Ff	2	20.34	41
601020502	IGH	2003	3	Fy	31	14.11	437
601020503	IGH	2003	3	Ff	5	21.42	107
601020504	IGH	2004	2	Ff	16	17.12	274
601020505	IGH	2004	2	Ff	20	16.61	332
601020506	IGH	2004	2	Ff	24	34.04	817
601020507	IGH	2004	2	Ff	8	37.42	299
601020508	IGH	2004	2	Ff	5	9.10	46
				Subtotal	454		7,346
Estimated contribution of unknown CWTs (see Table 3):					233		3,770
Total Estimated Hatchery Contribution =							11,116
Unknown CWTs: 200000=CWT lost, 300000=head lost (or not collected), 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.							

The Klamath River Technical Advisory Team (KRTAT) met in January of 2007 to review the 2006 Chinook salmon run size monitoring efforts and estimate the age composition of the 2006 run (KRTAT 2007). The KRTAT used scale age proportions for developing adult structure and length frequency analysis for the grilse cutoff point for the 2006 IGH fall Chinook salmon returns (Table 4).

Table 4. Age composition of the 2006 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	2386	4216	7227	161	11,604	13,990
Percent of Total Run	17.0%	30.0%	52.0%	1.0%		

Coho Salmon

The first coho returning to IGH was observed on October 20, 2006 and the last coho of the 2006-07 spawning season was observed on December 4, 2006. A total of 332 coho salmon entered IGH during the season. Of the 301 sampled by KRP staff, 204 (68%) had left maxillary clips, indicating they were of IGH origin. In addition to IGH returns, one coho from Cole River Hatchery in Oregon and one from Klickitat Hatchery in Washington were recovered. Staff collected biological data from 301 coho, approximately 90% of the run. Male coho ranged in size from 31 cm to 83 cm (Figure 6). Female coho ranged in size from 44 cm to 78 cm (Figure 7). Based on the length frequency distribution of 139 male coho, grilse were estimated to be ≤ 49 cm fork length (Figure 6).

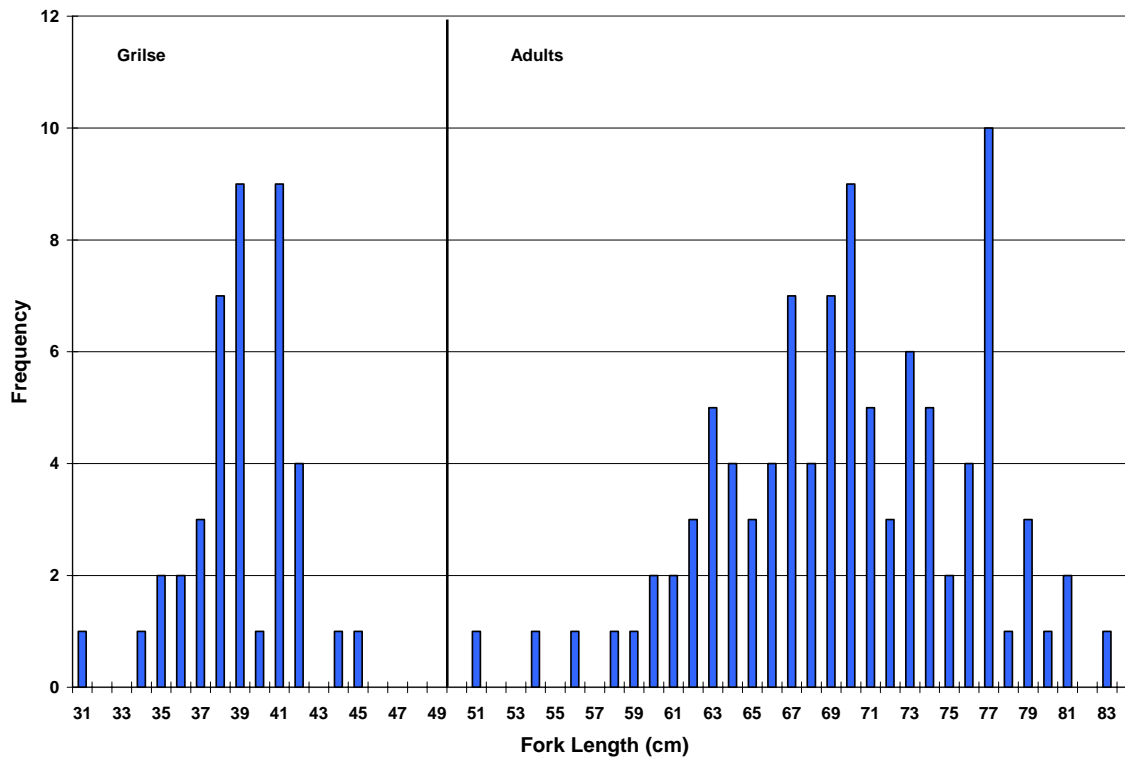


Figure 6. Length frequency distribution for male coho salmon sampled (n = 139) at Iron Gate Hatchery during the 2006-07 spawning season.

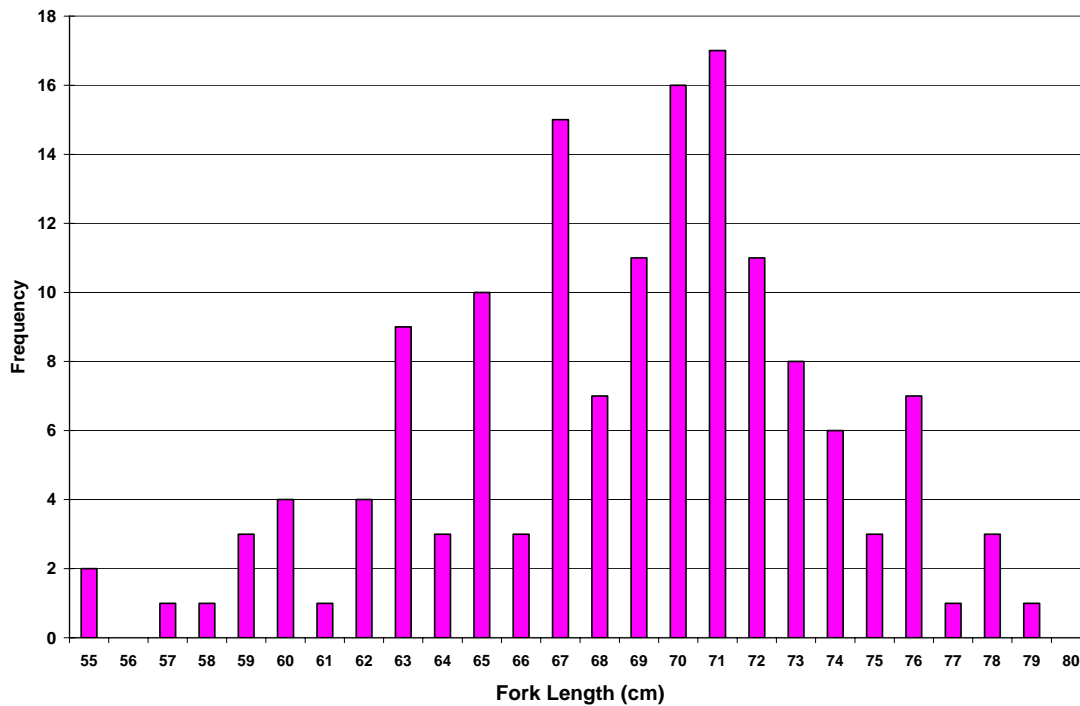


Figure 7. Length frequency distribution for female coho salmon sampled (n = 147) at Iron Gate Hatchery during the 2006-07 spawning season.

A total of 53 unmarked coho salmon were Floy tagged and released from IGH to the Klamath River in 2006. Of these, 14 coho reentered IGH and were returned to the river, 3 were observed in nearby Bogus Creek, 1 was observed passing through the video flume at the Shasta River Fish Counting Facility, and 1 was trapped, examined and released in good condition at the Shasta River Fish Counting Facility on 11/24/06. No Floy tagged coho were reported in the main stem Klamath River. Three of the 14 unmarked coho that returned to IGH after their initial tagging reentered the hatchery on more than one occasion (Table 5).

Table 5: Floy tagged (and caudal clipped) coho salmon that returned to Iron Gate Hatchery following initial release during the 2006 spawning season.

Floy Tag #	Sex	FL	Date Tagged	Return Dates (to IGH unless otherwise noted)
2147	M	37	11/1/06	
1554	M	39	11/3/06	
1583	M	41	11/17/06	
1595	M	41	11/13/06	
2136	M	41	10/20/06	
2137	M	60	10/23/06	
1556	F	62	11/6/06	
2141	M	62	10/27/06	
2149	F	62	11/1/06	
1561	F	63	11/9/06	Recovered at Bogus Creek SGS, 11/21/06
2146	F	65	10/30/06	
1555	M	66	11/6/06	
2138	F	67	10/23/06	
2140	F	67	10/24/06	
1578	F	68	11/20/06	11/22/06
1584	F	68	11/17/06	
1579	F	69	11/20/06	11/22/06
2145	M	69	10/30/06	11/1/06, 11/3/06
1558	F	70	11/6/06	
1580	F	70	11/20/06	
1581	F	70	11/20/06	
1586	M	70	11/17/06	
1557	F	71	11/6/06	11/13/06
1571	F	71	11/9/06	
1628	F	71	11/22/06	
1630	F	71	11/27/06	
1631	F	71	12/4/06	
1560	F	72	11/9/06	11/13/06
1587	F	72	11/17/06	
1593	M	72	11/15/06	
1594	F	72	11/15/06	11/17/06
1551	F	73	11/3/06	
1572	M	73	11/9/06	11/13/06
2139	F	73	10/24/06	
2144	F	73	10/30/06	
1590	M	74	11/15/06	11/17/06
1629	M	74	11/27/06	
1552	F	75	11/3/06	
1574	M	75	11/9/06	
2142	M	76	10/30/06	11/09/06
2143	F	76	10/30/06	
1550	M	77	11/3/06	
1559	F	77	11/6/06	
1588	M	77	11/17/06	
1592	M	77	11/15/06	Trapped & released at Shasta River FCF 11/24/06
1625	M	77	11/20/06	11/22/06, 11/27/06
1582	M	78	11/20/06	11/22/06
1585	F	78	11/17/06	
1562	F	79	11/9/06	
1598	M	79	11/13/06	11/15/06
1627	M	79	11/20/06	
1597	M	65	11/13/06	11/17/06
1553	F	75	11/3/06	11/6/06, 11/9/06

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 2006 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 2007). These forecasts are used by the KRTAT as essential inputs to the Klamath Ocean Harvest Model to predict abundance of fall run Chinook at sea. This information is then used to determine fishery allocation levels and determine the potential effects of harvest options upon salmon fisheries along the Pacific Coast. 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 2006 run (13,990) of fall Chinook salmon at IGH was 2,213 fish below the average for the period from 1978 to 2006 (16,203) and was nearly identical to the 2005 run of 13,997. This year IGH Chinook comprised roughly 15.8% of the total (Klamath basin) in-river run (88,258) and 19.7% of the total natural spawner escapement (70,986) (Table 6).

During the 2006 spawning season 16.8% (2,350) of the run was composed of grilse. This is above the 28-year average of 9.7% (1,087). The previous year’s grilse percentage, 0.3%, was the lowest in KRP history. The highest percentage (51.1%) of grilse (3,737) was observed in 1992 (Figure 8). From 1978 to 1990, at least 10% of the run were grilse in 7 out of 13 years. In contrast, from 1991 to 2006 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).

Since 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, it is not surprising that the 3-year old component of the in-river run (21%) and the 3 year old component of the IGH 2006 Chinook run, (30%), were lower than average since the 2005 grilse components (3.4% in-river and 0.3% of the IGH run), were the lowest in KRP history.

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	% IRR	Totals	% IRR	% SE	Totals	% IRR	% 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	2,863	3.5	5	5,070	6.2	8.8
1981	108,422	56,333	52	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	6.4
1984	55,542	30,375	54.7	6,094	11	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	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 ¹	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
1997	91,729	70,303	76.6	13,727	15	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
2003	195,791	152,390	77.8	32,260	16.5	21.2	15,610	8	10.2
2004	88,589	53,478	60.4	11,519	13	21.5	3,788	4.3	7.1
2005	67,579	56,188	83.1	13,997	20.7	24.9	54	8	9.6
2006	88,258	70,986	80.4	13,990	15.8	19.7	4,132	4.6	5.8
Average	121,615	85,895	69.8	16,203	14	19	8,981	6.8	9.5
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	2,558	2.4	4.6	54	1.9	3.1
ST DEV	67,525	51,378	10.1	13,770	7.4	9.2	10,062	3.8	4.6

^{1/} 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.

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.

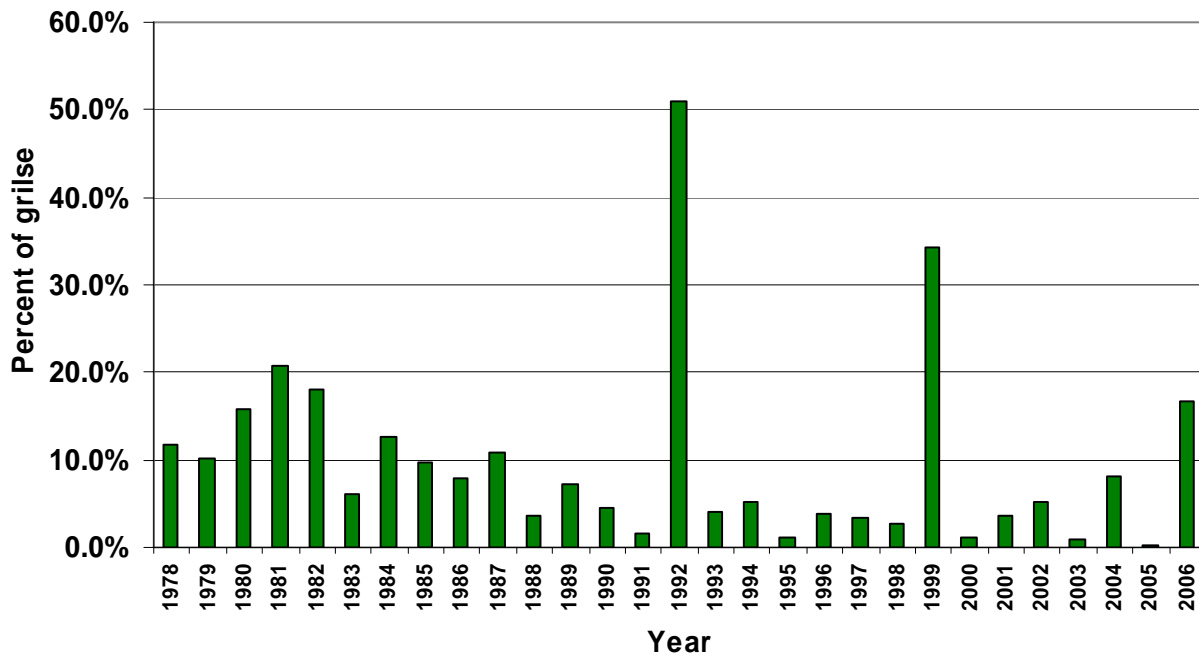


Figure 8. Historical percentages of Chinook grilse observed at Iron Gate Hatchery, Siskiyou County.

Although the magnitude of the fish kill could not be 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 its tributary streams upstream of the Trinity River in 2005, and the corresponding low run of 3 year olds in 2006, appear to support this theory.

Table 7: Summary of fall Chinook salmon escapement to Iron Gate Hatchery and Bogus Creek from 1978 to 2006.

Year	Iron Gate Hatchery				Bogus Creek			
	Grilse	Adults	Total	% Grilse	Grilse	Adults	Total	% Grilse
1978	925	6945	7870	11.8%	651	4928	5579	11.7%
1979	257	2301	2558	10.0%	494	5444	5938	8.3%
1980	451	2412	2863	15.8%	1749	3321	5070	34.5%
1981	540	2055	2595	20.8%	912	2730	3642	25.0%
1982	1833	8353	10186	18.0%	2325	4818	7143	32.5%
1983	541	8371	8912	6.1%	335	2713	3048	11.0%
1984	764	5330	6094	12.5%	465	3039	3504	13.3%
1985	2159	19951	22110	9.8%	1156	3491	4647	24.9%
1986	1461	17096	18557	7.9%	1184	6124	7308	16.2%
1987	1825	15189	17014	10.7%	1208	9748	10956	11.0%
1988	609	16106	16715	3.6%	225	16215	16440	1.4%
1989	831	10589	11690	7.1%	444	2218	2662	16.7%
1990	321	6719	7040	4.6%	53	732	785	6.8%
1991	65	4002	4067	1.6%	20	1261	1281	1.6%
1992	3737	3581	7318	51.1%	556	598	1154	48.2%
1993	883	20828	21711	4.1%	431	3285	3716	11.6%
1994	758	13808	14566	5.2%	443	7817	8260	5.4%
1995	259	22681	22940	1.1%	1207	45225	46432	2.6%
1996	543	13622	14165	3.8%	377	10420	10797	3.5%
1997	452	13275	13727	3.3%	221	9809	10030	2.2%
1998	403	14923	15326	2.6%	205	6630	6835	3.0%
1999	4830	9290	14120	34.2%	2628	3537	6165	42.6%
2000	839	71635	72474	1.2%	373	34678	35051	1.1%
2001	1364	37204	38568	3.5%	648	11927	12575	5.2%
2002	1294	23667	24961	5.2%	304	17530	17834	1.7%
2003	290	31970	32260	0.9%	188	15422	15610	1.2%
2004	937	10582	11519	8.1%	295	3493	3788	7.8%
2005	42	13955	13997	0.3%	58	5339	5397	1.1%
2006	2386	11604	13990	17.1%	764	3368	4132	18%
Average	1,090	15,105	16,204	9.72%	687	8478	9165	12.8%

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 2006, IGH Chinook smolt releases have varied from a low of 3,300,312 in 1993 to a high of 6,171,838 in 2006. 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 5,004,021 and 973,573, respectively. The largest run of Chinook to IGH, from 1962 to 2006, occurred in 2000 (72,474), the lowest in 1965 (678) (Figure 9). 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

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. In 2007, The KRP will apply coded-wire tags to an additional 100,000 Chinook smolts for a total of 300,000 smolt tags, and 100,000 yearling tags.

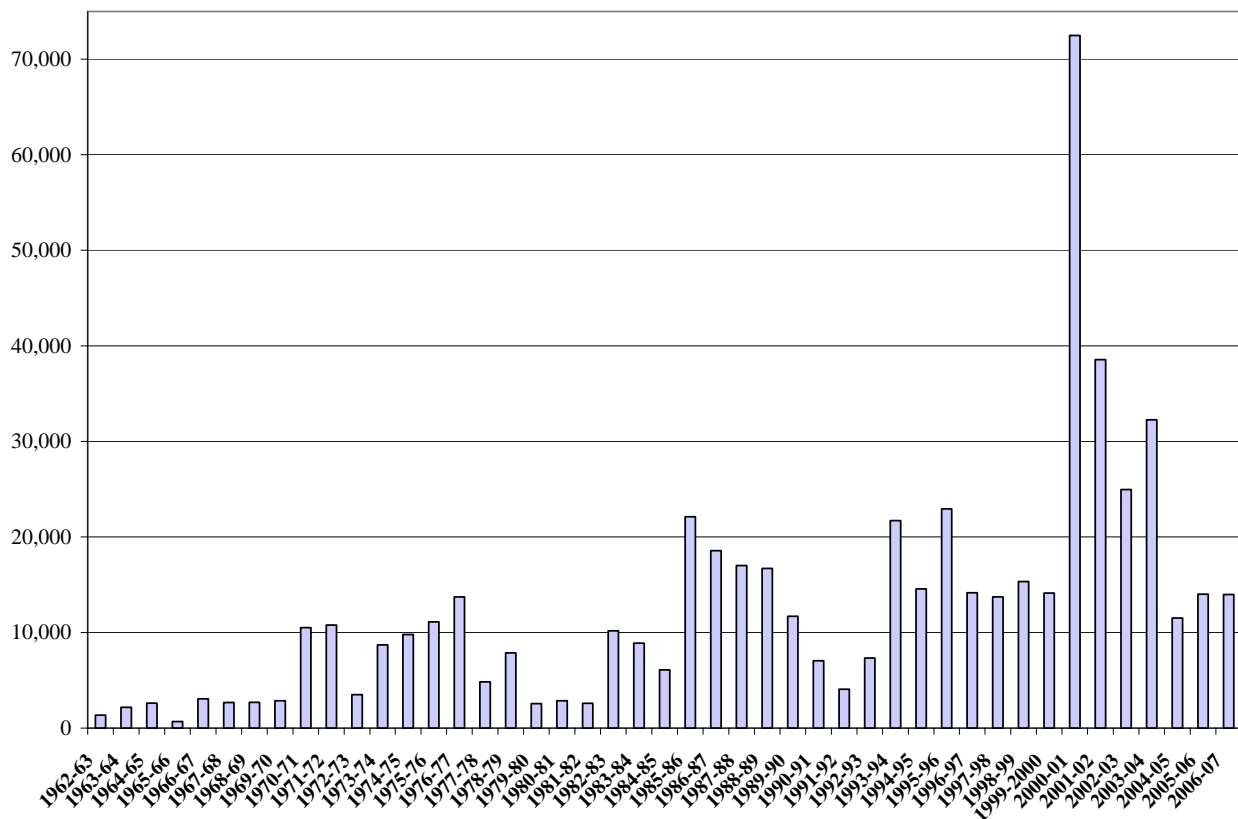


Figure 9. Chinook salmon runs at Iron Gate Hatchery (California Department of Fish and Game), 1962 to 2006.

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 smolt 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 332 coho salmon entered IGH during the 2006 spawning season, of which 301 were sampled by KRP staff. 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 1,470 (Figure 10), so the 2006 coho return was well below the average.

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 Rivers Hatchery located at the base of Lost Creek Dam on the Rogue River in Oregon 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 Rivers Hatchery on the Rogue River. In 2006, only 2 of 7 ad-clipped coho contained

CWTs. One of the tags was from Cole River Hatchery (BY 2003, released in May 2005) and the other was from Klickitat Hatchery in Washington (BY 2003, also released in May 2005).

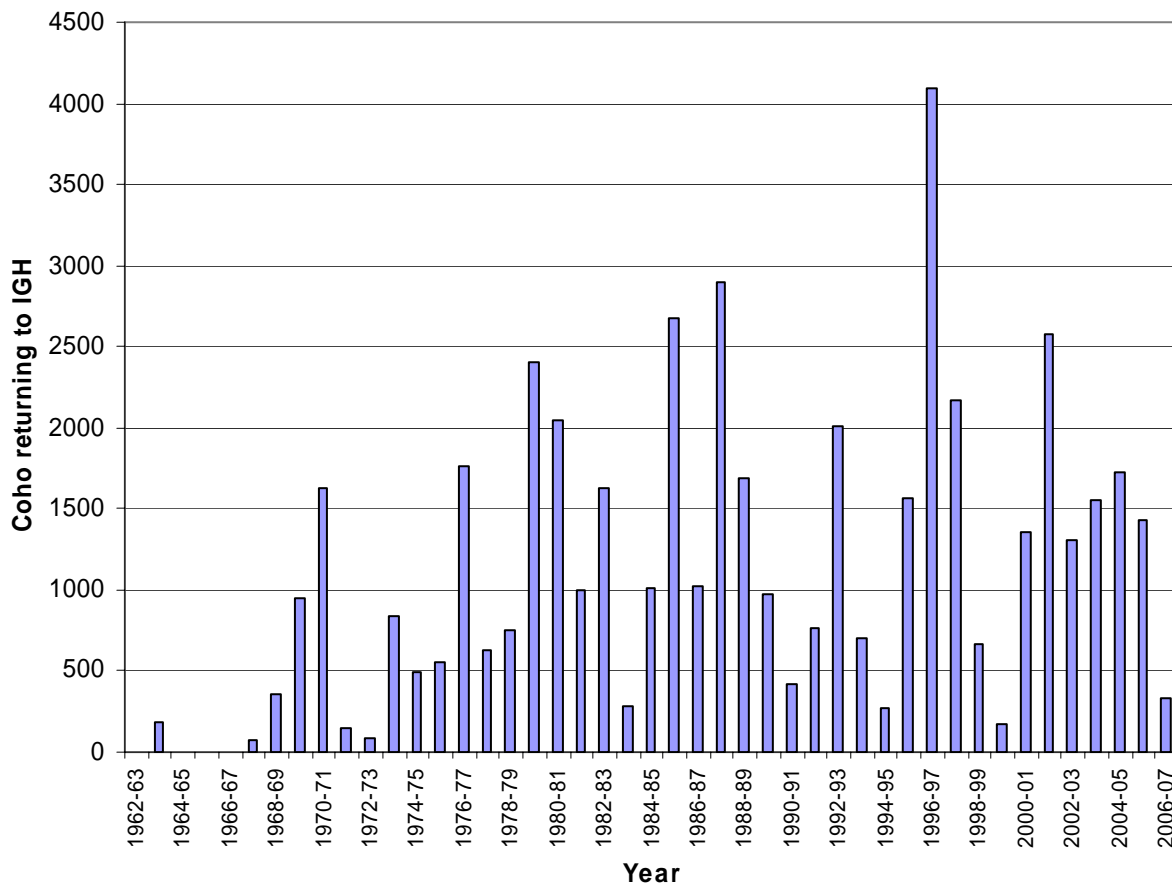


Figure 10. Coho salmon runs at Iron Gate Hatchery (California Department of Fish and Game), 1962 to 2006.

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 2003. A summary of coho salmon releases, adult returns, and survival of LM clipped coho to IGH is provided in Table 9. Survival of coho salmon progeny released from IGH since the 1994 brood year has ranged from 0.3% to 3.5% and has averaged 1.49%.

Table 9. 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	Release Year	Coho Yearlings	QC Rate	Percent Clipped	Unmarked Release	Marked Release	Production Multiplier	LM Grilse	Grilse Expanded	LM Adults	Adults Expanded	Expanded BY Returns	Percent Survival
1994	1996	74,250				74,250	1	322	322	1,717	1,717	2,039	2.75%
1995	1997	81,498	0.0100	0.9900	815	80,683	1.0101	253	256	303	306	562	0.70%
1996	1998	79,607	0.0150	0.9850	1194	78,413	1.0152	75	76	138	140	216	0.28%
1997	1999	75,156	0.0460	0.9540	3454	71,702	1.0482	15	16	500	524	540	0.75%
1998	2000	77,147	0.0160	0.9840	1234	75,913	1.0163	567	576	2,054	2,087	2,664	3.51%
1999	2001	46,254	0.0150	0.9850	694	45,560	1.0152	76	77	916	930	1,007	2.21%
2000	2002	67,933	0.0300	0.9700	2038	65,895	1.0309	90	93	620	639	732	1.11%
2001	2003	74,271	0.0060	0.9940	446	73,825	1.0060	218	219	990	996	1,215	1.65%
2002	2004	109,374	0.1000	0.9000	10937	98,437	1.1111	213	237	1,254	1,393	1,630	1.66%
2003	2005	74,716	0.0017	0.9983	127	74,589	1.0017	21	21	183	183	204	0.27%
Average Survival Rate=												1.49%	

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. . In 2006, the percentage of coho with an IGH clip was relatively low at 67% of the sample. 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 10 provides a summary, by brood year, of the number of LM clips observed, the expanded number, an estimate of number of unmarked coho that are likely progeny of IGH, and returns of unmarked coho to IGH. For brood years 1995 to 2003 the number of unmarked coho salmon that were estimated to have originated from progeny of IGH ranged from 0 to 163 fish.

Table 10. Iron Gate Hatchery (IGH) coho salmon yearling release numbers, LM clip return rates, and expanded return estimates with estimated and observed number of unmarked coho that have returned to IGH.

Brood Year	Release 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	Observed return of unmarked grilse	Observed return of unmarked adults	Total unmarked return by BY
1995	1997	81,498	0.9900	815	80,683	253	303	556	1.0101	562	6	44	207	251
1996	1998	79,607	0.9850	1194	78,413	75	138	213	1.0152	216	3	82	12	94
1997	1999	75,156	0.9540	3454	71,702	15	500	515	1.0482	540	25	3	198	201
1998	2000	77,147	0.9840	1234	75,913	567	2,054	2621	1.0163	2,664	43	64	217	281
1999	2001	46,254	0.9850	694	45,560	76	916	992	1.0152	1,007	15	29	216	245
2000	2002	67,933	0.9700	2038	65,895	90	620	710	1.0309	732	22	9	575	584
2001	2003	74,271	0.9940	446	73,825	218	990	1208	1.0060	1,215	7	14	401	415
2002	2004	109,374	0.9000	10937	98,437	213	1,254	1467	1.1111	1,630	163	25	138	163
2003	2005	74,716	0.9983	127	74,589	21	183	204	1.0017	204	0	2	72	74

In previous years the Department has not scanned unmarked coho that entered IGH to determine the presence of CWTs. Therefore, an unknown number 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 11 contains a summary of the number of marked and unmarked coho salmon that have returned to IGH since 1997. From 1997 to 2006 the percentage of marked coho salmon that have returned to IGH has averaged 79.5%. 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 Rivers Hatchery.

Table 11. Marked and unmarked Coho salmon that entered Iron Gate Hatchery from 1997 to 2006.

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			
FIN CLIPS	ADULTS	GRILSE	Total	FIN CLIPS	ADULTS	GRILSE	Total	FIN CLIPS	ADULTS	GRILSE	Total
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				2005/2006			
FIN CLIPS	ADULTS	GRILSE	Total	FIN CLIPS	ADULTS	GRILSE	Total	FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	575	14	589	Unmarked	401	25	426	Unmarked	138	2	140
LM	620	218	838	LM	989	213	1,202	LM	1,254	28	1,282
RM	66	3	69	RM	31	1	32	RM	2	0	2
AD	52	6	58	AD	69	0	69	AD	1	0	1
ADLM	2	0	2	ADLM	0	0	0	ADLM	0	0	0
ADRM	2	0	2	ADRM	1	0	1	ADRM	0	0	0
				LM/RM	2	0	2	LM/RM	0	0	0
				LM/RM/AD	2	0	2	LM/RM/AD	0	0	0
Total Clipped	742	227	969	Total Clipped	1,094	214	1,308	Total Clipped	1,257	28	1,285
Total Returns	1,317	241	1,558	Total Returns	1,495	239	1,734	Total Returns	1,395	30	1,425
				2006/2007				Proportion of clipped to unclipped coho			
7 of the unmarked coho observed in 2004 contained a CWT which indicated they originated from				FIN CLIPS	ADULTS	GRILSE	Total	Season	Clipped	Total	% Clipped
Cole M. Rivers Hatchery				Unmarked	72	8	80	1997/1998	2,009	2,174	92.4%
				LM	176	27	203	1998/1999	380	669	56.8%
1 of the unmarked coho observed in 2005 contained a CWT which indicated it originated from Cole M. Rivers Hatchery				RM	1	1	2	1999/2000	154	169	91.1%
				AD	16	0	16	2000/2001	1,092	1,354	80.6%
				ADLM	0	0	0	2001/2002	2,327	2,573	90.4%
				ADRM	0	0	0	2002/2003	1,076	1,301	82.7%
								2003/2004	969	1,558	62.2%
								2004/2005	1,308	1,734	75.4%
LM= Iron Gate Hatchery (left maxillary clip)				Total Clipped	193	28	221	2005/2006	1,285	1,425	90.2%
RM = Trinity River Hatchery (right maxillary clip)				Total Returns	265	36	301	2006/2007	221	301	73.42%
AD = Cole M. Rivers Hatchery (adipose clip)								Average	1,082	1,326	79.5%
*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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