California Department of Fish and Wildlife

Klamath River Project

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

September 26, 2012 to December 6, 2012

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ABSTRACT

A total of 40,015 fall-run Chinook salmon (*Oncorhynchus tshawytscha),* entered Iron Gate Hatchery (IGH) during the fall 2012 spawning season from September 26, 2012 through November 26, 2012. Klamath River Project (KRP) staff systematically sampled 1 in every 10 Chinook, as well as all adipose-clipped (AD) Chinook during recovery efforts, for a systematic random sample size of 3,885 and non-random sample size of 7,665. Scale samples, sex and fork length data were collected for all sampled Chinook. Analysis of the length-frequency distribution for systematically sampled Chinook males indicates that the preliminary cutoff point between grilse and adults occurred at ≤ 59 centimeters (cm) fork length (FL). Systematically sampled male Chinook ranged in size from 40 to 98 cm FL, and systematically sampled female Chinook ranged from 56 to 93 cm FL. Based on scale age analysis, the Klamath River Technical Team (KRTT) estimated that 3.8% (1,537) of the run were grilse. Females accounted for 52.5% (21,014) of the run while males accounted for 47.5% (19,001). The 2012 return to IGH contributed roughly 12% to the total (Klamath basin) in-river run and 20% to the total spawner escapement. Based on coded wire tag expansion, KRP staff estimated that 84% of the Chinook entering IGH during the 2012 season were of hatchery origin.

A total of 644 coho salmon (*Oncorhynchus kisutch*) entered IGH during the 2012 spawning season. The recorded dates for the coho run were from October 11, 2012 to December 6, 2012. KRP staff collected biological data (sex, fork length, presence of marks or clips, scale samples, and tissue samples) on every coho that entered the hatchery as well as otoliths from coho used for spawning. Males ranged in size from 35 to 77 cm FL and represented 68% of the run, while females ranged in size from 40 to 74 cm. fork length and represented 32% of the run. Based on the length frequency distribution of 441 male coho, grilse were estimated to be ≤ 55 cm. fork length, for an age composition of 54% grilse and 46% adult coho in 2012. The proportion of grilse among males was 77.7%. Of the 644 coho sampled by KRP staff, 609 (94.6%) had left maxillary clips, 29 (4.5%) had no clips, 4 (0.6%) had a right maxillary clip, one (0.15%) had both a left and a right maxillary clip, and one (0.15) had an AD clip but no CWT. For the third season, coho were spawned at IGH in 2012 using a spawning matrix provided weekly by the National Oceanic and Atmospheric Administration (NOAA) Fisheries Salmon Genetics Repository in Santa Cruz, CA., using tissue samples obtained from coho as they entered IGH. Potential brood stock were held in individual tubes pending genetic analysis, and all coho not used as brood stock (342) were tagged with a Passive Integrated Transponder (PIT) and released back to the Klamath River at IGH.

INTRODUCTION

Iron Gate Hatchery

The Iron Gate Hatchery (IGH) is located adjacent to the Klamath River (river kilometer 306), 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	5,100,000 smolts	May-June	mid September to early November
	900,000 yearlings	November	
Coho	75,000 yearlings	March	late October to early January
Steelhead	200,000 yearlings	March-May	November to March

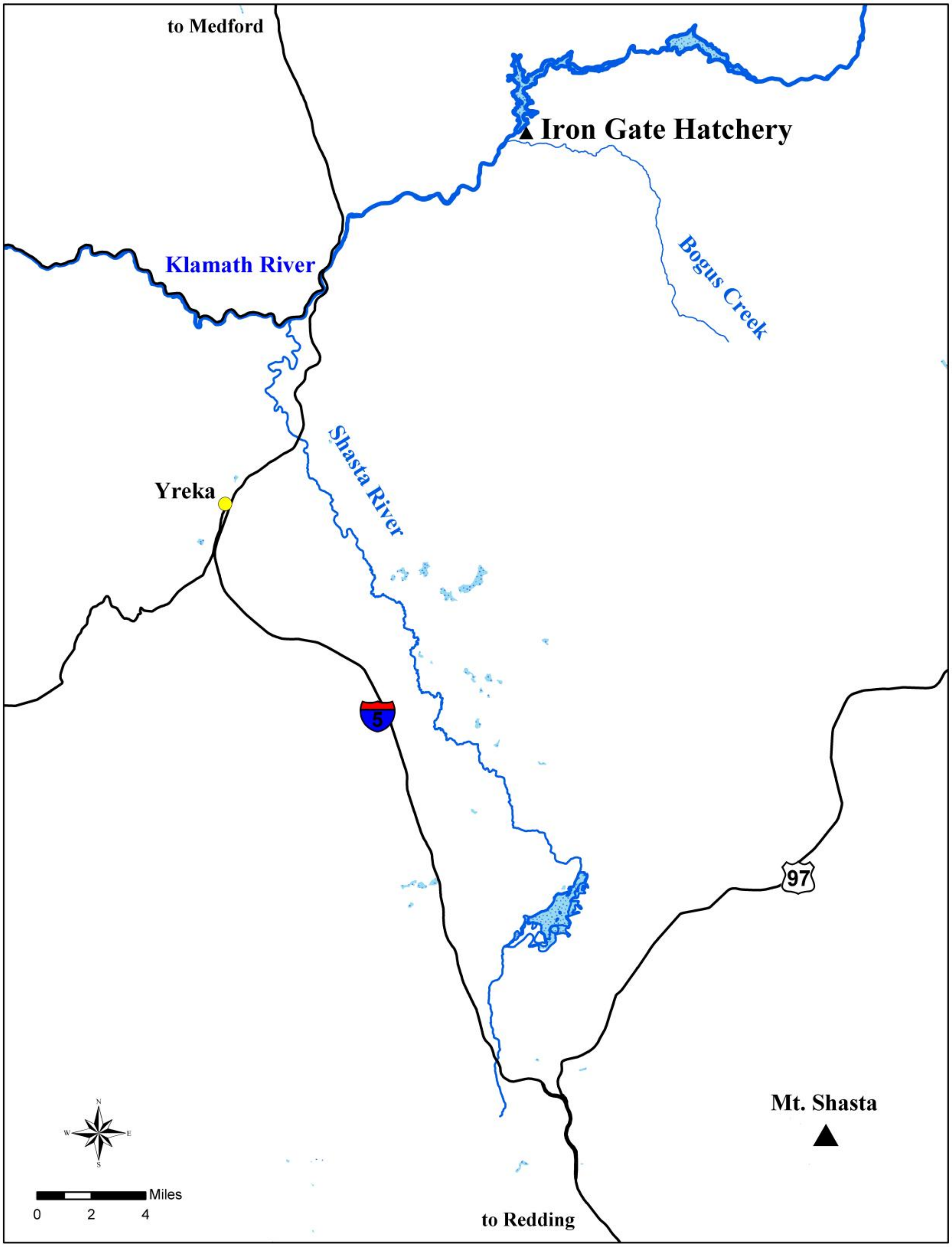

Figure 1. Location of Iron Gate Hatchery, Siskiyou County, California.

Klamath River Project

The California Department of Fish and Wildlife's (CDFW) Klamath River Project (KRP) conducts systematic sampling of fall-run Chinook (Chinook) salmon annually during the spawning season. The purpose of the sampling is to characterize the Chinook run 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) Chinook. All Chinook tagged at IGH are marked with an adipose fin clip to identify the presence of a CWT 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. KRP staff also sample coho salmon (coho) that enter IGH, typically from mid-October through December.

Coded Wire Tagging

The KRP was historically responsible for the adipose-clipping and coded- wire tagging of Chinook smolts and yearlings at IGH, however, in 2011 and 2012 tagging operations were transferred to Pacific States Marine Fisheries Commission personnel, utilizing full-time trailer operators and a regional tagging coordinator.

MATERIALS AND METHODS

Chinook Salmon

Starting in 1997 all Chinook entering the fish ladders have been allowed to enter IGH. Upon entering the hatchery, Chinook selected by IGH staff as brood stock are spawned or held in round tanks until they are ready to spawn. Readiness to spawn is determined by hatchery staff and based on timing, firmness of the ovaries, and ease of stripping eggs when handled. Once daily or weekly egg goals are met, extra Chinook are sacrificed and put on ice, and loaded into trucks by American-Canadian fisheries on site, for processing and later distribution to interested individuals and organizations.

In 2012, KRP staff conducted a systematic sample of every 10th Chinook along the process line, as well as all AD Chinook. These systematic and non-systematic fish were set aside for sampling. Sampling included collection of data on fork length, sex, scale samples, presence or absence of clips and/or marks, and spawning disposition. Heads were taken from all AD Chinook (systematic and non-systematic fish). Heads collected from AD-clipped fish were run through a tag detector prior to freezing, and whether a tag was detected was noted on the data sheets. All heads were sent to the KRP's Arcata or Yreka laboratories for tag extraction and reading.

Preliminary grilse and adult cutoff fork lengths were determined using length frequency analysis of systematically sampled male Chinook, and final grilse/adult and age composition determinations were made by the KRTT using scale age proportions.

Coho Salmon

As coho entered IGH in 2012, hatchery personnel anaesthetized each fish, determined whether it would be retained for potential spawning or released, then sent the fish to a processing tank, where KRP staff collected biological data including tissue samples, fork length, sex, scale samples, and clip/tag information. Those coho retained as potential brood stock were assigned a brood stock number, placed in individual PVC tubes, and placed in a round tank (Figure 2). These fish were tracked on data sheets and a master board, and as genetic information was received from the National Oceanic and Atmospheric Administration (NOAA), were either used as brood stock or tagged with a PIT tag and released into the Klamath River at the spawning building. Tissue samples were sent to NOAA's salmon genetics repository in Santa Cruz, CA. via overnight Federal Express.

Photo by Rosa Albanese

Figure 2. Coho brood stock held in individually numbered tubes awaiting spawning matrix.

NOAA laboratory staff developed a spawning matrix designed to minimize the spawning of closely related individuals. The weekly matrix, sent via e-mail to the KRP, displayed a series of columns with brood stock number of each female coho at the top of a column, and beneath it, brood stock numbers of males in descending order of spawning suitability for that female. Males which were determined to be too closely related to any given female were denoted with an asterisk as "do not spawn" and were listed at the bottom of each column. A sample matrix is shown in Appendix 1.

On subsequent spawning days, coho were checked in their tubes for spawning readiness, and were either left in the tubes if not ready to spawn, or brought into the spawning building from the round tanks, sacrificed and spawned with fish chosen from the spawning matrix. In 2012, coho crosses were 2:1 (two males to one female, with half of the female's eggs being fertilized by each male, and the egg lots kept separate), except for seven 1:1 pairings where only one suitable male was available. IGH and KRP personnel tracked the use of marked vs. unmarked individuals and the use of grilse for spawning. Otoliths were collected from all spawned coho.

After IGH reached its egg-taking goal, all coho not used in spawning were released into the Klamath River at the IGH spawning building. KRP personnel tagged these fish with PIT tags. PIT tag numbers of released coho that re-entered the hatchery were recorded as well. All coho tissue samples were sent at the end of the season to the NOAA facility in Santa Cruz.

RESULTS

Chinook Salmon

Chinook began entering IGH on September 26, 2012. A total of 40,015 Chinook returned to IGH during the fall 2012 spawning season. Of these, KRP staff collected scale samples, determined sex, and measured fork lengths for 11,550 Chinook (3,885 systematic random samples and 7,665 non-random samples). Systematically sampled male Chinook ranged in size from 40 to 98 cm. fork length (Figure 3), and systematically sampled female Chinook ranged from 56 to 93 cm. fork length (Figure 4). A preliminary grilse cutoff was made using the length frequency distribution from 1,808 systematically sampled Chinook males. The preliminary cutoff point of grilse occurred at ≤ 58 cm. in fork length, yielding approximately 3.9% grilse (1,537) and 96.1% adults (38,478) for a total run size of 40,015. Females accounted for 53.5% (21,393) of the run and males accounted for 46.5% (18,622). The last Chinook of the season entered IGH on November 26, 2012.

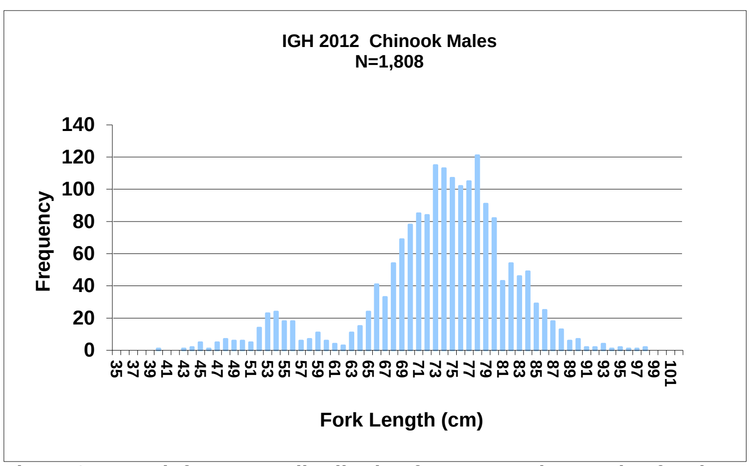

Figure 3. Length frequency distribution for systematic sample of male Chinook salmon recovered at IGH during the 2012 spawning season.

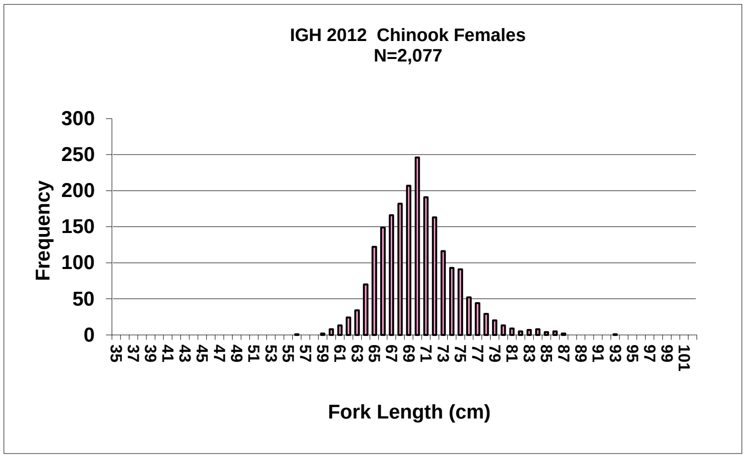

Figure 4. Length frequency distribution for systematic sample of female Chinook salmon recovered at IGH during the 2012 spawning season.

The KRTT met in February of 2013 to review the 2012 Chinook run monitoring efforts and estimate the age composition of the 2012 run (KRTT 2013). The KRTT used scale age proportions for developing adult and grilse age structure for the 2012 IGH Chinook returns (Table 2).

Heads from 8,400 AD Chinook (from systematic and non-systematic fish) were collected for CWT recovery, from which positive reads were obtained for 8,083. The remainder were either lost during extraction (124), were unreadable (56), or had shed their tags (137). The contribution of lost or unreadable CWTs was estimated by applying the proportions of known CWTs (8,083) to the 180 lost or unreadable CWTs (Table 3).

The estimated contribution of unknown CWTs was then added to the contribution of known CWTs to determine the total contribution of hatchery Chinook entering IGH. All but 4 of the 8,083 CWTs recovered (and successfully read) originated from IGH**,** and the remaining 4 originated from Trinity River Hatchery (TRH). Based on the expansion of CWTs, KRP staff estimated that 84.4% of the Chinook entering IGH during the 2012 season were of hatchery origin (Table 4). Proportions of hatchery-origin Chinook returning to IGH from 2002-2012 are shown in Figure 5. Of the expanded CWT returns in 2012, 833 (2.5%) were from yearling release groups and 32,225 (97.5%) were from smolt release groups.

Table 2. Age composition of the 2012 Chinook salmon run that entered Iron Gate Hatchery (IGH), as developed by the Klamath River Technical Team (KRTT).

Age 2	Age 3	Age 4	Age 5	Total Adults	Total Run
1,537	36,485	1,992	0	38,478	40,015
3.8%	91.2%	5%	0%		

Table 3. Estimated contribution of 180 Ad-cliped Chinook salmon with unknown coded-wire-tag (CWT) codes (lost or unreadable) that were recovered at IGH based on the proportional distribution of known CWTs recovered at IGH during the 2012 season.

CWT	BY	# CWTs Recovered	Proportion of CWTs recovered	Estimated Number	Production Multiplier	Expanded Estimate
68642	2008	12	0.001484597	0.26723	4.02	**1**
68643	2008	9	0.001113448	0.20042	4.02	**1**
68644	2008	34	0.004206359	0.75714	4.03	**3**
68645	2008	58	0.007175554	1.29160	4.02	**5**
68646	2008	67	0.008289002	1.49202	4.03	**6**
68647	2008	88	0.010887047	1.95967	4.06	**8**
68648	2008	143	0.017691451	3.18446	4.02	**13**
68661	2008	25	0.003092911	0.55672	4.02	**2**
68662	2008	29	0.003587777	0.64580	4.03	**3**
68818	2008	1	0.000123716	0.02227	4.05	**0**
68710	2009	1639	0.202771248	36.49882	4.02	**147**
68711	2009	1680	0.207843622	37.41185	4.01	**150**
68712	2009	1230	0.152171224	27.39082	4.04	**111**
68713	2009	1081	0.133737474	24.07275	4.17	**100**
68714	2009	901	0.111468514	20.06433	4.01	**80**
68715	2009	612	0.075714462	13.62860	4.04	**55**
68716	2009	260	0.032166275	5.78993	4.01	**23**
68720	2009	6	0.000742299	0.13361	4.29	**1**
68837	2009	3	0.000371149	0.06681	4.03	**0**
68792	2010	54	0.006680688	1.20252	4.03	**5**
68793	2010	51	0.006309539	1.13572	4.17	**5**
68794	2010	45	0.005567240	1.00210	4.02	**4**
68795	2010	48	0.005938389	1.06891	12.17	**13**
68799	2010	7	0.000866015	0.15588	4.03	**1**
Totals		**8,083**	**1.0000**	**180**		**736**

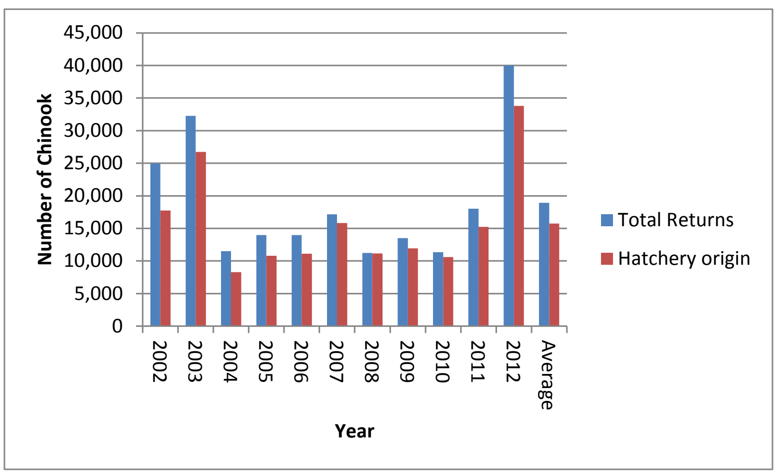

Figure 5. Number of Chinook returns to Iron Gate Hatchery that were determined to be of hatchery origin, 2002-2012.

Table 4. Estimated contribution of hatchery origin Chinook salmon recovered at IGH during the 2012 spawning season.

CWT	Release Location	Brood Year	Age	Release Type	Number Recovered	Production Multiplier	Expanded Estimate
Estimated contribution of known CWTs:							
68642	IGH	2008	4	Ff	12	4.02	48
68643	IGH	2008	4	Ff	9	4.02	36
68644	IGH	2008	4	Ff	34	4.03	137
68645	IGH	2008	4	Ff	58	4.02	233
68646	IGH	2008	4	Ff	67	4.03	270
68647	IGH	2008	4	Ff	88	4.06	357
68648	IGH	2008	4	Fy	143	4.02	575
68661	IGH	2008	4	Fy	25	4.02	101
68662	IGH	2008	4	Fy	29	4.03	117
68818	TRH	2008	4	Ff	1	4.05	4
68710	IGH	2009	3	Ff	1,639	4.02	6,589
68711	IGH	2009	3	Ff	1,680	4.01	6,737
68712	IGH	2009	3	Ff	1,230	4.04	4,969
68713	IGH	2009	3	Ff	1,081	4.17	4,508
68714	IGH	2009	3	Ff	901	4.01	3,613
68715	IGH	2009	3	Ff	612	4.04	2,472
68716	IGH	2009	3	Ff	260	4.01	1,043
68720	IGH	2009	3	Ff	6	4.29	26
68837	TRH	2009	3	Fy	3	4.03	12
68792	IGH	2010	2	Ff	54	4.03	218
68793	IGH	2010	2	Ff	51	4.17	213
68794	IGH	2010	2	Ff	45	4.02	181
68795	IGH	2010	2	Ff	48	12.17	584
68799	IGH	2010	2	Fy	7	4.03	28
				Subtotal	**8,083**		**33,070**
Estimated contribution of unknown CWTs							
200000					124		
400000					56		
				Subtotal	**180**		**736**
	Total Estimated Hatchery Contribution =						**33,806**
Unreadable CWTs: 200000=CWT lost, 400000=CWT unreadable							

Coded-Wire Tagging

In the spring of 2012 a 25 percent constant fractional mark (cfm) was applied to brood year (BY) 2011 Chinook salmon at IGH, the fourth consecutive year that this was accomplished. . A total of 1,468,533 juvenile Chinook were AD clipped and CWT'd in 2012. The release of clipped and tagged fingerlings was 1,171,585 and the release of clipped and tagged yearlings was 296,948. The total release of fingerlings (tagged and untagged) was 4,695,117 and the total release of yearlings was 1,188,881. Both groups had a tagging rate of 25%. The first smolt release occurred on June 6, 2012 with Klamath River temperature at 63 degrees F and flow of 1,560 cfs, and the remainder of the smolt releases occurred during the week of June 18, 2012 with Klamath River temperature 64.5 degrees F and flow of 1,540 cfs below Iron Gate Dam. The first yearling groups were released on November 7 and 8, 2012, with Klamath River temperature 56 degrees F and flow of 1,000 cfs, and the last group of approximately 200,000 was released on November 15, 2012 with river temperature at 52 degrees F and flow at 1,000 cfs.

Coho Salmon

Six hundred forty-four (644) coho entered IGH during the fall 2012 season between October 11, 2012 and December 6, 2012. Of these, 609 (94.6%) had left maxillary (LM) clips, indicating they were of IGH origin***,*** 29 (4.5%) were unmarked, 4 (0.6%) had a right maxillary clip, indicating Trinity River Hatchery origin, one (0.1%) had both a left and right maxillary clip, and one had an AD clip but no CWT. Male coho ranged in size from 35 to 77 cm. in fork length (Figure 6). Female coho ranged in size from 45 to 74 cm. in fork length (Figure 7). Based on the length frequency distribution of 441 male coho, grilse were estimated to be $\leq$ 55 cm fork length. Analysis of 641 coho salmon (male and female) fork lengths determined that 53.5% (343) were grilse. Among males, the grilse component was 77.7%

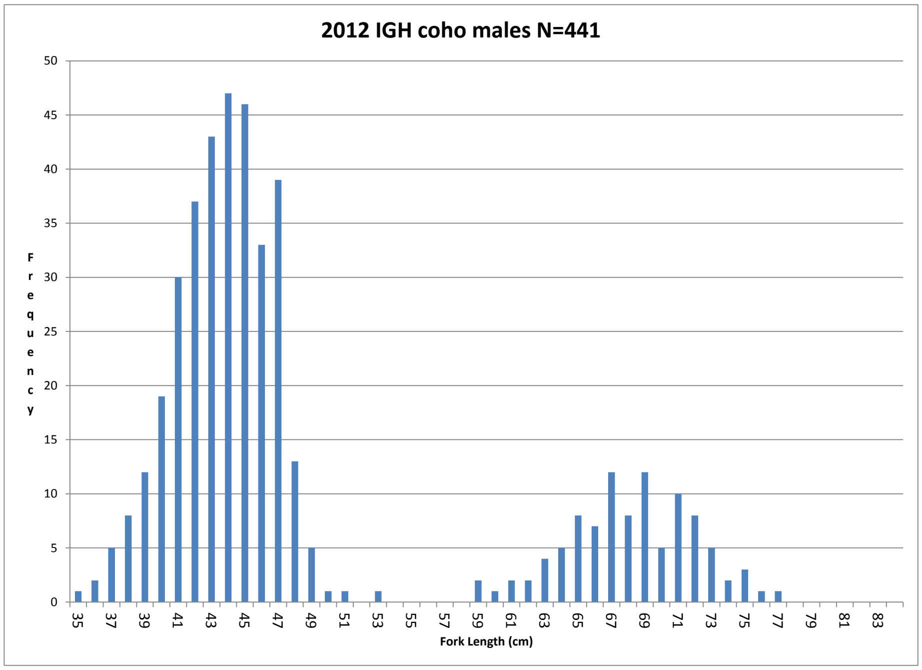

Figure 6. Length frequency distribution for male coho salmon recovered at Iron Gate Hatchery during the 2012 spawning season.

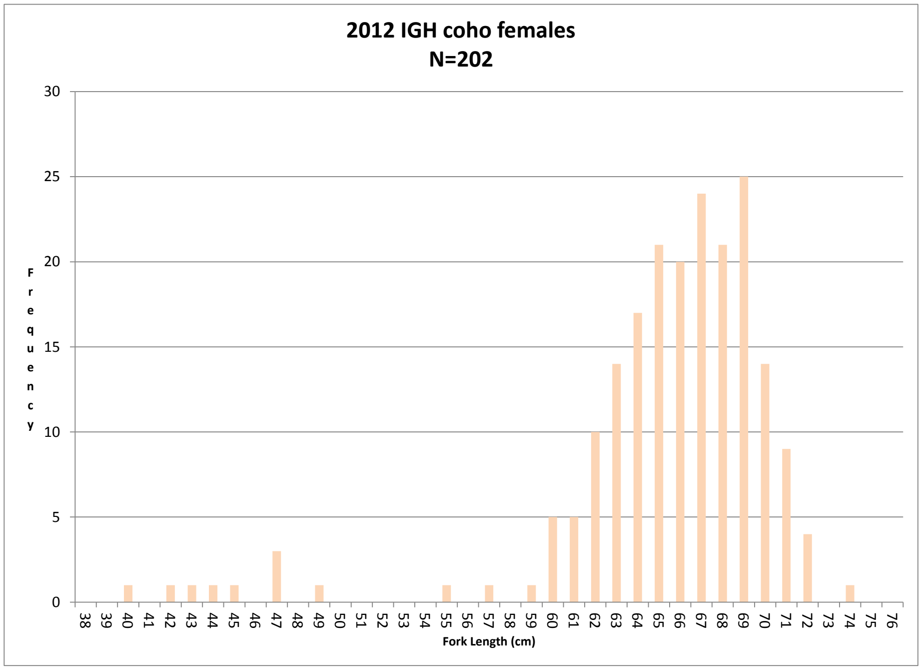

Figure 7. Length frequency distribution for female coho salmon recovered at Iron Gate Hatchery during the 2012 spawning season.

A total of 342 coho salmon which entered IGH and were in excess of brood stock needs were PIT tagged and released back to the Klamath River between October 17, 2012 and December 6, 2012. Of these, 59 were detected by antenna arrays in nearby Bogus

Creek (Klamath River RKM 304) and 50 in the Shasta River (Klamath River RKM 283). Eighty-two (24%) PIT tagged coho re-entered IGH after their initial release. Of these, 67 re-entered the hatchery once after initial release, 14 re-entered twice and 1 re-entered three times. Bogus Creek and Shasta River were the only locations where antenna arrays were installed and maintained by CDFW, so it is unknown where else IGH-released coho may have strayed.

The number of days that elapsed between the release of PIT tagged coho from IGH and the date of first detection in the Shasta River ranged from 2 to 27 days, and the average was 10 days. The river miles travelled per day ranged from 0.4 to 6 miles. Of the 50 coho, all were detected at the arrays located furthest downstream near the Shasta River Fish Counting Facility (SRFCF) at RKM 0, two were also detected at RKM12 , although that array was not installed until November 18, 2012 and is likely to have missed some coho, and one was detected at RKM 56 .

Fifty-nine coho salmon PIT tagged and released from IGH were detected at the nearby Bogus Creek Fish Counting Facility (BCFCF), located approximately .3 miles from the mouth of Bogus Creek just below IGH. The number of days elapsed from release from IGH and detection at the BCFCF ranged from 1 to 40 days, and the average was 17 days. One 44 cm. coho grilse, released from IGH on 11/15/12, was detected at the BCFCF on 11/16/12 and again at the SRFCF five days later on 11/21/2012.

DISCUSSION

Chinook Salmon

The 2012 run (40,015) of Chinook salmon at IGH was the second highest since KRP monitoring began in 1978, and exceeded the 35-year average of 16,556 by 23,459 fish (Figure 8). In 2012 IGH Chinook comprised roughly 12% of the total (Klamath basin) in-river run (323,582) and 20% of the total spawner escapement (195,291) (Table 5).

Since 1978, KRP has been monitoring the escapement of fall-run Chinook in the Klamath River basin, excluding the Trinity River. 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 run size data are compiled and reviewed by the KRTT during their annual age composition meeting in late January or early February. 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 natural and hatchery in-river escapement coupled with ocean harvest data allow for cohort reconstruction of Klamath River fall-run Chinook, and are the foundation of model-based forecasting of next year’s abundance in the ocean (KRTT 2013).

Klamath Basin fall Chinook ocean abundance forecasts are input by the KRTT into the Klamath Ocean Harvest Model, which models ocean mortality and fishery impacts to allow for ocean fishery options and meet mandated in-river tribal and sport harvest sharing and in-river adult natural area spawner escapement targets. Thus, the run -size estimates that are compiled each year provide a critical source of data necessary for the effective management of fall Chinook each year.

After a record return of grilse to the Klamath Basin in 2011, the forecast was for a large return of three year old Chinook, and this was observed in 2012 (Table 6). Grilse and adult returns to IGH and Bogus Creek from 1978 to 2012 are shown in Table 7. A low observed incidence of *Ceratomyxa shasta* in 2010 (True et al., 2011), along with favorable flow and temperature conditions in the main stem Klamath River during the spring and early summer outmigration period, and favorable ocean conditions were likely contributors to the above normal survival of age three fall Chinook (brood year 2009).

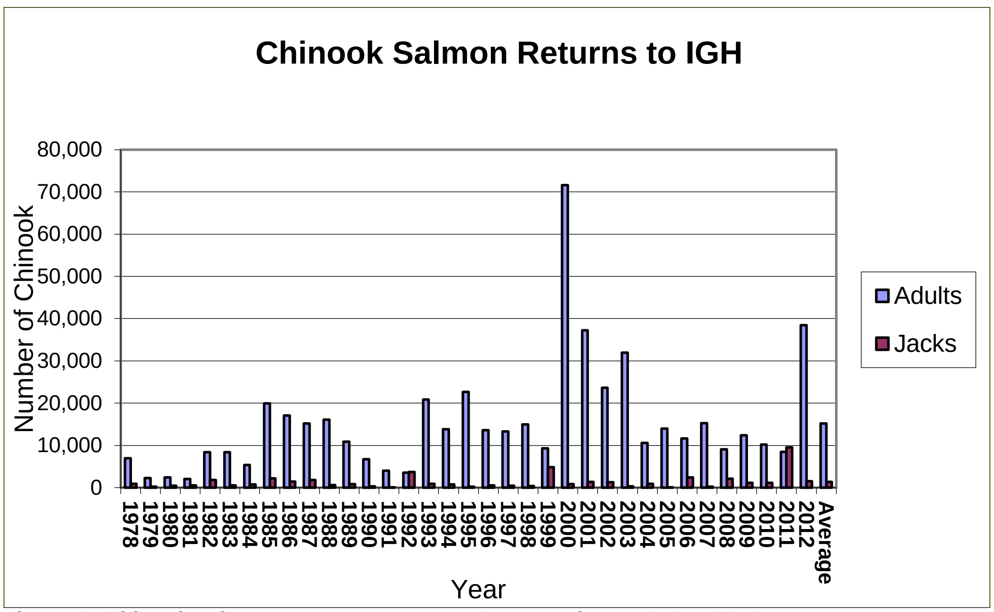

Figure 8. Chinook salmon escapement to Iron Gate Hatchery, 1978 to 2012.

The Chinook salmon releases from IGH include both smolt and yearling releases. The current production goals include releases of 5,100,000 Chinook smolts in May and June and 900,000 yearlings in November. With the advent of the automated tagging trailer, more accurate raceway counts are possible, compared to the estimates of prior years (Chesney and Knechtle, 2011). Raceway counts in 2012 once again showed smolt release numbers below the hatchery goal, however, aggressive bird deterrent methods being employed at IGH appear to be reducing losses due to bird predation in the raceways during the period between tagging and release. The yearling release exceeded the goal by 288,881.

One of the recommendations of the Joint Hatchery Review Committee (2001) was for IGH to produce more yearlings and fewer smolts, to reduce hatchery-origin/natural-origin interactions during the typically low flow and poor water quality months of June and July. Flows during the mid-October to mid-November yearling release period are typically higher, and water quality better, resulting in less competition for food and space during out-migration (CDFG and NMFS 2001). Table 8 shows a comparison of return rates between CWT Chinook released as smolts and as yearlings. 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.

Table 5. Historic Chinook salmon totals (includes adults and grilse) for the Klamath Basin, Iron Gate Hatchery and Bogus Creek, 1978-2012.

Year	In-River Run (IRR)	Spawner Escapement (SE)		Iron Gate Hatchery			Bogus Creek		
	Totals	Totals	%IRR	Totals	%IRR	%SE	Totals	%IRR	%SE
1978	115,728	90,135	77.9%	7,870	7%	9%	5,579	5%	6%
1979	62,970	42,255	67.1%	2,558	4%	6%	5,938	9%	14%
1980	82,413	57,683	70.0%	2,863	3%	5%	5,070	6%	9%
1981	108,422	56,333	52.0%	2,595	2%	5%	3,642	3%	6%
1982	106,020	67,076	63.3%	10,186	10%	15%	7,143	7%	11%
1983	61,392	47,960	78.1%	8,885	14%	19%	3,048	5%	6%
1984	55,542	30,375	54.7%	6,094	11%	20%	3,504	6%	12%
1985	133,827	104,487	78.1%	22,110	17%	21%	4,647	3%	4%
1986	239,559	180,263	75.2%	18,557	8%	10%	7,308	3%	4%
1987	228,182	143,890	63.1%	17,014	7%	12%	10,956	5%	8%
1988	215,696	130,749	60.6%	16,715	8%	13%	16,440	8%	13%
1989	133,440	72,438	54.3%	11,690	9%	16%	2,662	2%	4%
1990	40,274	25,705	63.8%	7,040	17%	27%	785	2%	3%
1991	34,425	19,121	55.5%	4,067	12%	21%	1,281	4%	7%
1992	40,391	28,479	70.5%	7,318	18%	26%	1,154	3%	4%
1993	64,810	48,945	75.5%	21,711	33%	44%	3,716	6%	8%
1994	78,354	60,850	77.7%	14,566	19%	24%	8,260	11%	14%
1995	245,542	217,312	88.5%	22,940	9%	11%	46,432	19%	21%
1996	185,305	108,325	58.5%	14,165	8%	13%	10,797	6%	10%
1997	91,729	70,303	76.6%	13,727	15%	20%	10,030	11%	14%
1998	95,286	75,157	78.9%	15,326	16%	20%	6,835	7%	9%
1999	70,296	50,088	71.3%	14,120	20%	28%	6,165	9%	12%
2000	228,323	188,642	82.6%	72,474	32%	38%	35,051	15%	19%
2001	198,676	142,324	71.6%	38,568	19%	27%	12,575	6%	9%
2002	170,014	99,016	58.2%	24,961	15%	25%	17,834	10%	18%
2003	195,791	152,390	77.8%	32,260	16%	21%	15,610	8%	10%
2004	88,589	53,478	60.4%	11,519	13%	22%	3,788	4%	7%
2005	67,579	56,188	83.1%	13,997	21%	25%	5,397	8%	10%
2006	88,258	70,986	80.4%	13,990	16%	20%	4,132	5%	6%
2007	132,167	95,998	72.6%	17,149	13%	18%	4,741	4%	5%
2008	95,619	64,487	67.4%	11,231	12%	17%	4,566	5%	7%
2009	112,685	73,688	65.4%	13,492	12%	18%	5,926	5%	8%
2010	107,500	69,584	64.7%	11,347	11%	16%	4,566	4%	7%
2011	188,845	144,314	76.4%	18,039	10%	12%	5,517	3%	4%
2012	323,582	195,291	60.4%	40,015	12%	20%	12,631	4%	6%
Average	**128,207**	**89,552**	**69.5%**	**16,605**	**13%**	**19%**	**8,678**	7%	**9%**
MAX	**245,542**	**217,312**	**89%**	**72,474**	**34%**	**44%**	**46,432**	**19%**	**21%**
MIN	**34,425**	**19,121**	**52%**	**2,558**	**2%**	**5%**	**785**	**2%**	**3%**
ST DEV	**71,234**	**51,392**	**0.1**	**13,207**	**0.1**	**0.1**	**9,166**	**0.0**	**0.0**

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.

Table 6. Estimate of age composition of Klamath River fall Chinook salmon returning to the Klamath River Basin in 2012.

Run Size		
Age	Number	Proportion
2	21,473	0.07
3	248,532	0.77
4	51,352	0.16
5	2,225	0.01
Total	323,582	

Table 7. Adult and grilse components of Chinook salmon returns to the Klamath Basin and Iron Gate Hatchery, 1978-2012.

Total Klamath Basin Fall Chinook Escapement					Iron Gate Hatchery Returns				
Year	**Grilse**	**Adults**	**Total**	**%Grilse**	Year	Grilse	Adults	Total	% Grilse
1978	22,745	92,983	115,728	20%	1978	925	6,945	7,870	12%
1979	11,675	51,295	62,970	19%	1979	257	2,301	2,558	10%
1980	36,773	45,640	82,413	45%	1980	451	2,412	2,863	16%
1981	28,130	80,292	108,422	26%	1981	540	2,055	2,595	21%
1982	39,408	66,612	106,020	37%	1982	1,833	8,353	10,186	18%
1983	3,846	57,546	61,392	6%	1983	514	8,371	8,885	6%
1984	8,281	47,261	55,542	15%	1984	764	5,330	6,094	13%
1985	69,389	64,438	133,827	52%	1985	2,159	19,951	22,110	10%
1986	44,540	195,019	239,559	19%	1986	1,461	17,096	18,557	8%
1987	19,048	209,134	228,182	8%	1987	1,825	15,189	17,014	11%
1988	24,054	191,642	215,696	11%	1988	609	16,106	16,715	4%
1989	9,100	124,340	133,440	7%	1989	831	10,859	11,690	7%
1990	4,392	35,882	40,274	11%	1990	321	6,719	7,040	5%
1991	1,755	32,670	34,425	5%	1991	65	4,002	4,067	2%
1992	13,693	26,698	40,391	34%	1992	3,737	3,581	7,318	51%
1993	7,598	57,212	64,810	12%	1993	883	20,828	21,711	4%
1994	14,371	63,983	78,354	18%	1994	758	13,808	14,566	5%
1995	22,774	222,768	245,542	9%	1995	259	22,681	22,940	1%
1996	9,532	175,773	185,305	5%	1996	543	13,622	14,165	4%
1997	7,993	83,736	91,729	9%	1997	452	13,275	13,727	3%
1998	4,639	90,647	95,286	5%	1998	403	14,923	15,326	3%
1999	19,248	51,048	70,296	27%	1999	4,830	9,290	14,120	34%
2000	10,246	218,077	228,323	4%	2000	839	71,635	72,474	1%
2001	11,343	187,333	198,676	6%	2001	1,364	37,204	38,568	4%
2002	9,226	160,788	170,014	5%	2002	1,296	23,667	24,963	5%
2003	3,845	191,948	195,793	2%	2003	290	31,970	32,260	1%
2004	9,646	78,943	88,589	11%	2004	937	10,582	11,519	8%
2005	2,398	65,125	67,523	4%	2005	42	13,955	13,997	0%
2006	27,073	61,629	88,702	31%	2006	2,386	11,604	13,990	17%
2007	22,745	92,983	115,728	20%	2007	196	15,249	15,445	1%
2008	25,261	70,358	95,619	26%	2008	2,130	9,101	11,231	19%
2009	11,938	100,747	112,685	11%	2009	1,132	12,360	13,492	8%
2010	14,307	55,277	69,584	21%	2010	1,113	10,234	11,347	10%
2011	74,223	70,091	144,314	51%	2011	9,549	8,490	18,039	53%
2012	17,344	177,957	195,301	9%	2012	1,537	38,478	40,015	4%
Average	**18,931**	**102,796**	**121,727**	**16%**	**Average**	**1,349**	**15,206**	**16,556**	**8%**

Table 8. Return rates of IGH smolt and yearling CWT releases for brood years 1990-1996, 1999, 2000 and 2002-2008.

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	0.772%	2.04
1991	191,200	96	0.050%	90,982	167	0.184%	3.66
1992	185,464	1015	0.547%	74,024	269	0.363%	0.66
1993	188,562	40	0.021%	98,099	196	0.200%	9.42
1994	194,644	94	0.048%	86,564	453	0.523%	10.84
1995	191,799	85	0.044%	90,172	954	1.058%	23.87
1996	196,648	162	0.082%	95,396	581	0.609%	7.39
1999	182,131	686	0.377%	91,220	514	0.563%	1.50
2000	187,417	277	0.148%	100,702	707	0.702%	4.75
2002	210,114	367	0.175%	109,711	295	0.269%	1.54
2003	261,888	70	0.027%	48,592	60	0.123%	4.62
2004	205,950	691	0.336%	98,752	215	0.218%	0.65
2005	209,754	194	0.092%	103,157	445	0.431%	4.66
2006	309,671	224	0.072%	103,361	230	0.223%	3.08
2007	307,204	340	0.111%	103,876	300	0.289%	2.61
2008	986,141	269	0.027%	192,339	197	0.102%	3.75
AVERAGE			**0.158%**			**0.414%**	**5.32**

Coho Salmon

In recent years, returns of coho salmon to IGH (Figure 9) have been more stable than returns of naturally produced coho salmon throughout the basin (Chesney, D. et al 2011; Knechtle, M. et al 2011). There is increasing concern among fishery managers that the conservation of remaining upper Klamath River coho genetic resources is essential if the short-term risk of extinction is to be prevented. Because of the relatively stable returns of coho to IGH, there are proposals in place to use IGH coho in excess of brood stock needs to supplement escapement to areas of severely depressed runs, such as the Shasta River.

The 2009 Draft Hatchery Genetic Management Plan (HGMP) was developed for IGH as part of the CDFG's application for an ESA Section 10(a)(1)(A) permit for hatchery operation. The HGMP is intended to guide hatchery practices toward the conservation and recovery of listed species, specifically, the upper Klamath River coho population unit. Changes to the management of IGH coho, including the use of NOAA's spawning matrix and the addition of bird exclusion netting in the outdoor rearing raceways, were recommendations of the draft HGMP and were implemented in 2010 (CDFG, 2011). The draft HGMP also recommends increasing the proportion of natural origin broodstock (pNOB) and the proportion of jacks included in the broodstock (pJacks) (Table 9).

Table 9. Male, female and jack returns, number of females spawned, proportion of natural origin broodstock and jacks used in spawning, egg take, fecundity and yearlings released by brood year at IGH from 1993-2012.

Year	Males	Females	Jacks	Females Spawned	Natural Origin Broodstock	pNOB	pJacks	# Eggs	Fecundity	Yearlings released
1993	361	314	29	219	?	~15	~1	503,326	2,298	79,506
1994	100	72	97	57	?	~15	~1	141,397	2,481	74,250
1995	708	793	29	294	?	~15	~1	782,170	2,660	81,489
1996	1,715	1,831	551	200	?	~15	~1	547,255	2,736	79,607
1997	825	1,047	302	126	16	6.3	~1	304,728	2,418	75,156
1998	243	268	158	122	75	30.7	~1	298,357	2,446	77,147
1999	90	61	18	35	5	7.1	~1	86,519	2,472	46,250
2000	295	428	631	95	52	27.4	~1	270,151	2,844	67,933
2001	972	1,494	107	126	22	8.7	~1	404,370	3,209	74,271
2002	566	627	108	187	68	18.2	~1	609,193	3,258	109,374
2003	609	708	241	197	172	43.7	~1	502,048	2,548	74,716
2004	630	865	239	276	10	4.0	~1	799,623	2,897	89,482
2005	596	799	30	103	10	4.9	~1	295,101	2,865	118,487
2006	112	151	69	85	10	5.9	~1	236,406	2,781	53,950
2007	300	325	154	124	10	4.0	~1	316,155	2,550	117,832
2008	508	770	24	148	9	3.0	~1	455,480	3,078	121,000
2009	21	25	18	20	6	15.0	~1	53,435	2,672	22,236
2010	193	235	57	91	22	12	6	259,490	2,852	155,840
2011	248	204	134	57	21	25	12	151,241	2,653	39,250
2012	98	203	345	66	12	10	58	158,651	2,404	N/A
Average	**460**	**561**	**167**	**131**	**33**	**14**	**25**	**358,755**	**2,722**	**81,988**

The relatedness coefficient (Rxy) of pairs of coho salmon spawned at IGH during the 2012 season are shown in Figure 10. This was the third season for which the NOAA spawning matrix was used. Yellow bars represent actual spawned pairs. The maroon bars represent the optimal pairings of males and females that could be achieved if the most unrelated male was spawned with its most unrelated female for each mating. In the absence of the spawning matrix and if pairs were selected purely at random the resulting Rxy values are represented by blue bars (Garza et al., 2013) Highly inbred pairings result in Rxy values > 0.10, and as a result of utilizing the spawning matrix, 76 inbred matings were prevented in 2012. Twelve pairings which were made in the absence of a matrix (female coho entering the hatchery ready to spawn, and in condition unlikely to survive until the next matrix was available) were analyzed after spawning. The NOAA lab recommended culling 11 of the 12 egg lots, as the parents were too closely related. Ten of the 11 “blind” pairings were between an adult female and a grilse male, and the 11th was between an unmarked female and an unmarked male.

The findings of these analyses appear to contradict the long-held assumption that using jacks and unmarked fish for spawning reduces, with some certainty, the risk of pairing closely related individuals. As can be seen in Appendix 1, jacks and unmarked males can be closely related to an adult female, and are therefore not always safe choices for pairing. With the combined efforts of NOAA, CDFW and PacifiCorps, future coho spawning operations will likely continue to improve the genetic fitness of IGH coho.

Beginning in 1997 all coho that entered IGH, whose origin was either IGH or TRH, would have been maxillary clipped prior to release. Returns of clipped and unclipped coho from 1997 to 2012 are shown in Table 10.

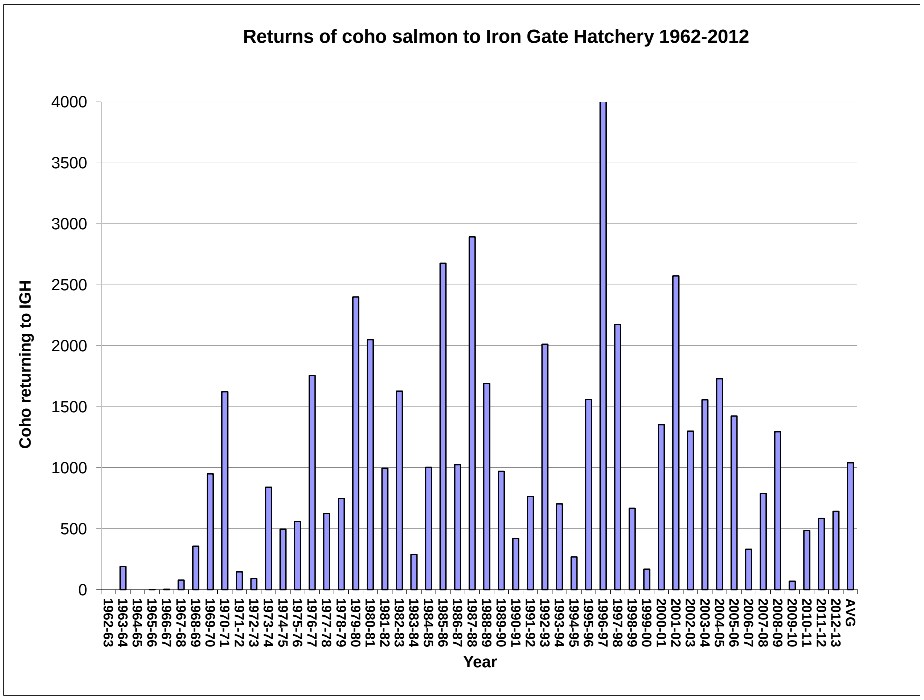

Figure 9. Coho salmon returns at Iron Gate Hatchery from 1962 to 2012.

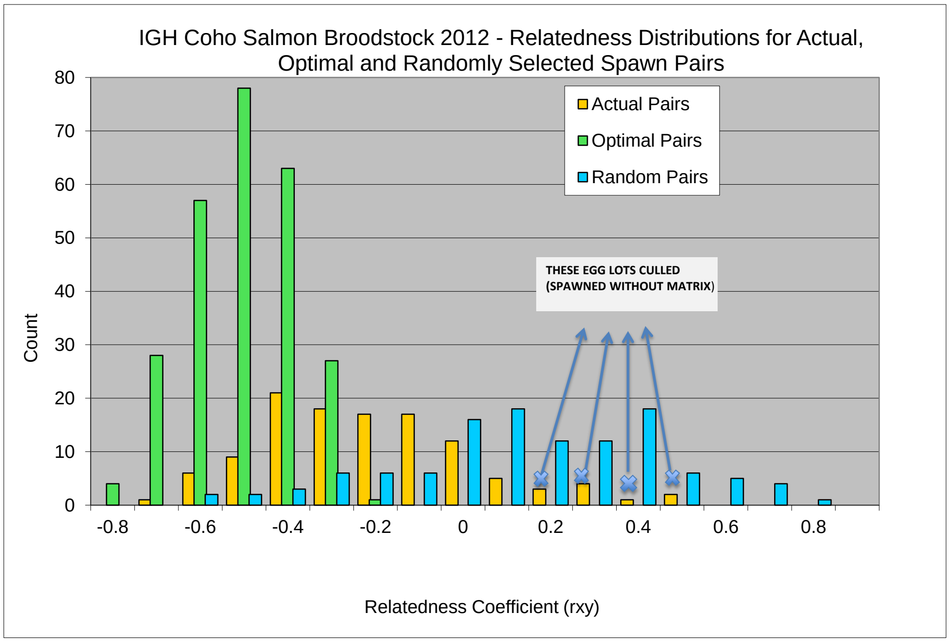

Figure 10. Observed relatedness coefficients of actual spawned pairs, optimally spawned pairs and randomly chosen pairs for IGH coho during the 2012 season (Figure provided by NOAA Southwest Fisheries Science Center Salmonid Genetic Laboratory).

Table 10. Summary of marked and unmarked coho salmon that entered IGH 1997-2012

1997/1998

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

1998/1999

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

1999/2000

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

2000/2001

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

2001/2002

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

2002/2003

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

2003/2004

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

2004/2005

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	399	25	424*1
LM	990	213	1,203
RM	31	1	32
AD	69	0	69
ADLM	0	0	0
ADRM	1	0	1
Other	5	0	5
Total Clipped	1,096	214	1,310
Total Returns	1,495	239	**1,734**

2005/2006

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

2006/2007

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	72	8	80
LM	176	27	203
RM	1	1	2
AD	16	0	16
ADLM	0	0	0
ADRM	0	0	0
Total Clippe	193	28	221
Total Retur	265	36	**301**

2007/2008

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	135	2	137
LM	480	163	643
RM	6	0	6
AD	2	0	2
ADLM	1	0	1
ADRM	0	0	0
Total Clipped	489	163	652
Total Returns	624	165	**789**

2008/2009

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	23	1	24
LM	1224	44	1268
RM	0	2	2
AD	0	0	0
ADLM	0	0	0
ADRM	0	0	0
LMRM	2	0	2
Total Clippe	1226	46	1272
Total Retur	1249	47	**1296**

2009/2010

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	11	5	16
LM	24	17	41
RM	11	2	13
AD	0	0	0
ADLM	0	0	0
ADRM	0	0	0
Total Clippe	35	19	54
Total Retur	46	24	**70**

2010/2011

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	84	3	87
LM	344	53	397
RM	0	1	1
AD	0	0	0
ADLM	0	0	0
ADRM	0	0	0
Total Clipped	344	54	398
Total Returns	428	57	**485**

2011/2012

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	61	0	61
LM	386	136	522
LM/RM	1	0	1
AD	2	0	2
ADLM	0	0	0
ADRM	0	0	0
Total Clippe	389	136	525
Total Retur	450	136	**586**

2012/2013

FIN CLIPS	ADULTS	GRILSE	Total
Unmarked	22	7	29
LM	275	334	609
RM	3	1	4
AD	0	1	1
ADLM	0	0	0
LMRM	1	0	1
		336	615
Total Clippe	279	336	615
Total Retur	301	343	**644**

Proportion of total returns that were clipped

Season	Clipped	Total	% Clipped
1997/1998	2,009	2,174	92%
1998/1999	380	669	57%
1999/2000	154	169	91%
2000/2001	1,092	1,354	81%
2001/2002	2,327	2,573	90%
2002/2003	1,076	1,301	83%
2003/2004	969	1,558	62%
2004/2005	1310	1,734	76%
2005/2006	1285	1,425	90%
2006/2007	221	301	73%
2007/2008	652	789	83%
2008/2009	1272	1296	98%
2009/2010	54	70	77%
2010/2011	398	485	82%
2011/2012	525	586	90%
2012/2013	614	643	95%
Average	**896**	**1,070**	**82.5%**

LM=Iron Gate Hatchery (left maxillary clip)
RM=Trinity River Hatchery (right maxillary clip)
AD = Cole M. Rivers Hatchery (adipose clip)
*1 : 7 of these unmarked coho carried a cwt and were actually from Cole Rivers Hatchery

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

Appendix 1. . Spawning matrix created by NOAA Salmon Genetics Repository. Females are shown at the top of each column with suffix F. Males are shown below in order of suitability for spawning with that female. The suffix MJ refers to a grilse male, and MU an unmarked male. Males shown in black text are acceptable for spawning, and males in red text are too closely related to that female and are not to be used for spawning.

F_100F	F_101F	F_102F	F_103F	F_104F	F_105F	F_106F	F_107F
M_127MJ	M_143MJ	M_7M	M_120MJ	M_113MJ	M_127MJ	M_116MJ	M_104M
M_104M	M_51M	M_113MJ	M_116MJ	M_141MJ	M_114MJ	M_119MJ	M_127MJ
M_113MJ	M_104M	M_111MJ	M_140MJ	M_143MJ	M_94M	M_132MJ	M_51M
M_124MJ	M_127MJ	M_120MJ	M_143MJ	M_120MJ	M_136M	M_104M	M_114MJ
M_114MJ	M_114MJ	M_108MJ	M_154MJ	M_127MJ	M_96M	M_93M	M_130MJ
M_51M	M_140MJ	M_139M	M_117MJ	M_153MJ	M_153MJ	M_94M	M_93M
M_135MJ	M_154MJ	M_93M	M_104M	M_101M	M_104M	M_103M	M_120MJ
M_93M	M_117MJ	M_122MJ	M_93M	M_114MJ	M_109MJ	M_114MJ	M_143MJ
M_120MJ	M_93M	M_142MJ	M_111MJ	M_135MJ	M_130MJ	M_21MJ	M_124MJ
M_150MJ	M_120MJ	M_150MJ	M_110MJ	M_21MJ	M_98MJ	M_143MJ	M_140MJ
M_111MJ	M_147MJ	M_135MJ	M_112MJ	M_147MJ	M_21MJ	M_112MJ	M_154MJ
M_21MJ	M_130MJ	M_21MJ	M_129MJ	M_111MJ	M_141MJ	M_129MJ	M_153MJ
M_143MJ	M_116MJ	M_117MJ	M_124MJ	M_115MJ	M_134MJ	M_136M	M_116MJ
M_133MJ	M_112MJ	M_131MJ	M_80MJ	M_106MJ	M_146MJ	M_49M	M_112MJ
M_106MJ	M_129MJ	M_104M	M_119MJ	M_94M	M_80MJ	M_101M	M_129MJ
M_103M	M_110MJ	M_80MJ	M_132MJ	M_98MJ	M_51M	M_140MJ	M_94M
M_142MJ	M_137MJU	M_99M	M_147MJ	M_126MJ	M_101M	M_96M	M_103M
M_105M	M_124MJ	M_134MJ	M_130MJ	M_140MJ	M_144MJ	M_117MJ	M_21MJ
M_140MJ	M_148M**	M_97MJ	M_145MJ	M_144MJ	M_106MJ	M_154MJ	M_96M
M_108MJ	M_111MJ**	M_123MJ	M_155MJ	M_96M	M_103M	M_153MJ	M_150MJ
M_153MJ	M_151MJ**	M_75MJ	M_151MJ	M_93M	M_126MJ	M_120MJ	M_148M
M_130MJ	M_135MJ**	M_124MJ	M_51M	M_105M	M_142MJ	M_80MJ	M_80MJ
M_115MJ	M_133MJ**	M_106MJ	M_135MJ**	M_142MJ	M_150MJ	M_141MJ	M_119MJ**
M_155MJ	M_123MJ**	M_149M	M_97MJ**	M_119MJ	M_140MJ	M_147MJ	M_132MJ**
M_151MJ	M_94M**	M_103M	M_49M**	M_132MJ	M_108MJ	M_130MJ	M_105M**
M_110MJ	M_103M**	M_126MJ	M_100M**	M_108MJ	M_7M	M_135MJ	M_115MJ**
M_122MJ	M_113MJ**	M_140MJ	M_137MJU	M_116MJ	M_121MJ	M_51M	M_147MJ**
M_123MJ	M_150MJ**	M_121MJ	M_114MJ**	M_130MJ	M_138MU	M_124MJ**	M_155MJ**
M_144MJ	M_7M**	M_105M	M_106MJ**	M_145MJ	M_148M	M_127MJ**	M_135MJ**
M_96M	M_96M**	M_119MJ	M_152MJ**	M_104M	M_147MJ	M_113MJ**	M_133MJ**
M_126MJ	M_115MJ**	M_132MJ	M_127MJ**	M_122MJ**	M_119MJ	M_126MJ**	M_137MJU
M_117MJ	M_145MJ**	M_116MJ	M_123MJ**	M_134MJ**	M_132MJ	M_144MJ**	M_98MJ**
M_154MJ	M_105M**	M_115MJ	M_21MJ**	M_49M**	M_115MJ	M_115MJ**	M_109MJ**
M_148M	M_155MJ**	M_130MJ	M_126MJ**	M_124MJ**	M_116MJ	M_145MJ**	M_117MJ**
M_7M	M_125M**	M_151MJ	M_113MJ**	M_128MJ**	M_112MJ	M_108MJ**	M_110MJ**
M_119MJ	M_49M**	M_51M	M_103M**	M_109MJ**	M_129MJ	M_155MJ**	M_113MJ**
M_132MJ	M_100M**	M_100M	M_87MJ**	M_136M**	M_49M	M_111MJ**	M_142MJ**
M_141MJ	M_153MJ**	M_78MJ	M_96M**	M_117MJ**	M_133MJ	M_98MJ**	M_108MJ**
M_116MJ	M_21MJ**	M_79MJ	M_7M**	M_103M**	M_137MJU	M_134MJ**	M_151MJ**
M_99M	M_106MJ**	M_133MJ	M_115MJ**	M_138MU*	M_118MJ	M_106MJ**	M_99M**
M_137MJU	M_109MJ**	M_127MJ**	M_105M**	M_80MJ**	M_152MJ	M_152MJ**	M_125M**
M_100M	M_126MJ**	M_152MJ**	M_108MJ**	M_121MJ**	M_124MJ	M_128MJ**	M_111MJ**
M_98MJ**	M_80MJ**	M_128MJ**	M_99M**	M_148M**	M_128MJ	M_138MU*	M_97MJ**

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