



California Department of Fish and Wildlife



Klamath River Project

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

October 9, 2017 to January 5, 2018



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ABSTRACT

A total of 10,636 fall-run Chinook Salmon, (Chinook, *Oncorhynchus tshawytscha*), entered Iron Gate Hatchery (IGH) during the fall 2017 spawning season from October 9, 2017 through November 27, 2017. Klamath River Project (KRP) staff systematically sampled 1 in every 5 Chinook, as well as all adipose-clipped (AD) Chinook during recovery efforts, for a sample size of 3,604. Scale samples and sex and fork length data were collected from systematically sampled Chinook. Analysis of the length-frequency distribution for systematically sampled Chinook males indicates that the cutoff point between grilse and adults occurred at <57 cm fork length (FL). Systematically sampled male Chinook ranged in size from 39 to 90 cm FL, and systematically sampled female Chinook ranged from 45 to 84 cm FL. Based on scale age analysis, the Klamath River Technical Team (KRTT) estimated that 30.0% (3,193) of the run were grilse. Females accounted for 41.1% (4,370) of the run while males accounted for 58.9% (6,266). Based on coded wire tag expansion, KRP staff estimated that 74% (7,914) of the Chinook entering IGH during the 2017 season were of hatchery origin.

In 2017, 121 Coho Salmon (Coho, *Oncorhynchus kisutch*) entered IGH during the spawning season and one Coho was trapped at Bogus Creek for a total of 122 Coho. The recorded dates for the Coho run were from October 25th 2017 to January 5th 2018. KRP staff collected biological data (sex, fork length, presence of marks or clips, and tissue samples) on every Coho that entered the hatchery as well as scales from mortalities and Coho used in spawning. Otoliths were collected from all unmarked Coho used for spawning or recovered as mortalities. Males ranged in size from 36 to 78 cm FL (mean FL 53 cm) and represented 51% (62) of the run, while females ranged in size from 53 to 72 cm fork length (mean FL 65 cm) and represented 49% (60) of the run. Based on the length frequency distribution of 62 male Coho, grilse were estimated to be <50 cm FL. Using this grilse cutoff, the age composition of the 2017 IGH male Coho run was 47% (29) grilse and 53% (33) adults. Of the Coho that entered IGH during 2017, 80% (98) had left maxillary clips and 20% (24) had no clips. No AD or right maxillary clipped Coho were recovered at IGH in 2017. The 2017 Coho spawning season was the eighth in which Coho were spawned at IGH using a spawning matrix provided weekly by the National Oceanic and Atmospheric Administration.

INTRODUCTION

Iron Gate Hatchery

The Iron Gate Hatchery (IGH) is located adjacent to the Klamath River at river kilometer 306 (river mile 190) just upstream of where Bogus Creek flows into the Klamath River in Siskiyou County, California, approximately 193 kilometers (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 IGH Goals and Constraints, 1996).

Klamath River Project

The California Department of Fish and Wildlife’s (CDFW) Klamath River Project (KRP) conducts systematic sampling of fall-run Chinook Salmon (Chinook, *Oncorhynchus tshawytscha*) annually during the spawning season at IGH. The purpose of the sampling is to characterize Chinook entering IGH in terms of timing, age and sex composition, and to recover data from all coded wire tags (CWT) recovered from the heads of adipose fin clipped (AD) Chinook. Approximately 25% of all Chinook at IGH are adipose fin-clipped and implanted with CWT’s so they can be identified 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. The CWT data are also used to evaluate Chinook release strategies, survival rates, ocean distribution and harvest as well as in-river migration timing, straying and harvest. KRP staff also sample Coho Salmon (Coho, *Oncorhynchus kisutch*) that enter IGH, typically from mid-October through December. All Coho entering IGH are sampled, and spawning protocols are employed that are in accordance with the recommendations of the Hatchery and Genetic Management Plan (HGMP) for Iron Gate Hatchery.

Coded Wire Tagging

In 2018, 25% of the brood year 2017 Chinook smolt and yearling groups were adipose-clipped and coded wire tagged prior to release. Tagging operations at IGH were conducted by staff of the Pacific States Marine Fisheries Commission with assistance from the IGH staff.

Table 1: Iron Gate Hatchery Production Goals

Species	Number released	Released	Adult return timing
Chinook Salmon	5,100,000 smolts	May-June	mid-September to early November
	900,000 yearlings	November	
Coho Salmon	75,000 yearlings	March	late October to early January
Steelhead	200,000 yearlings	March-May	November to March

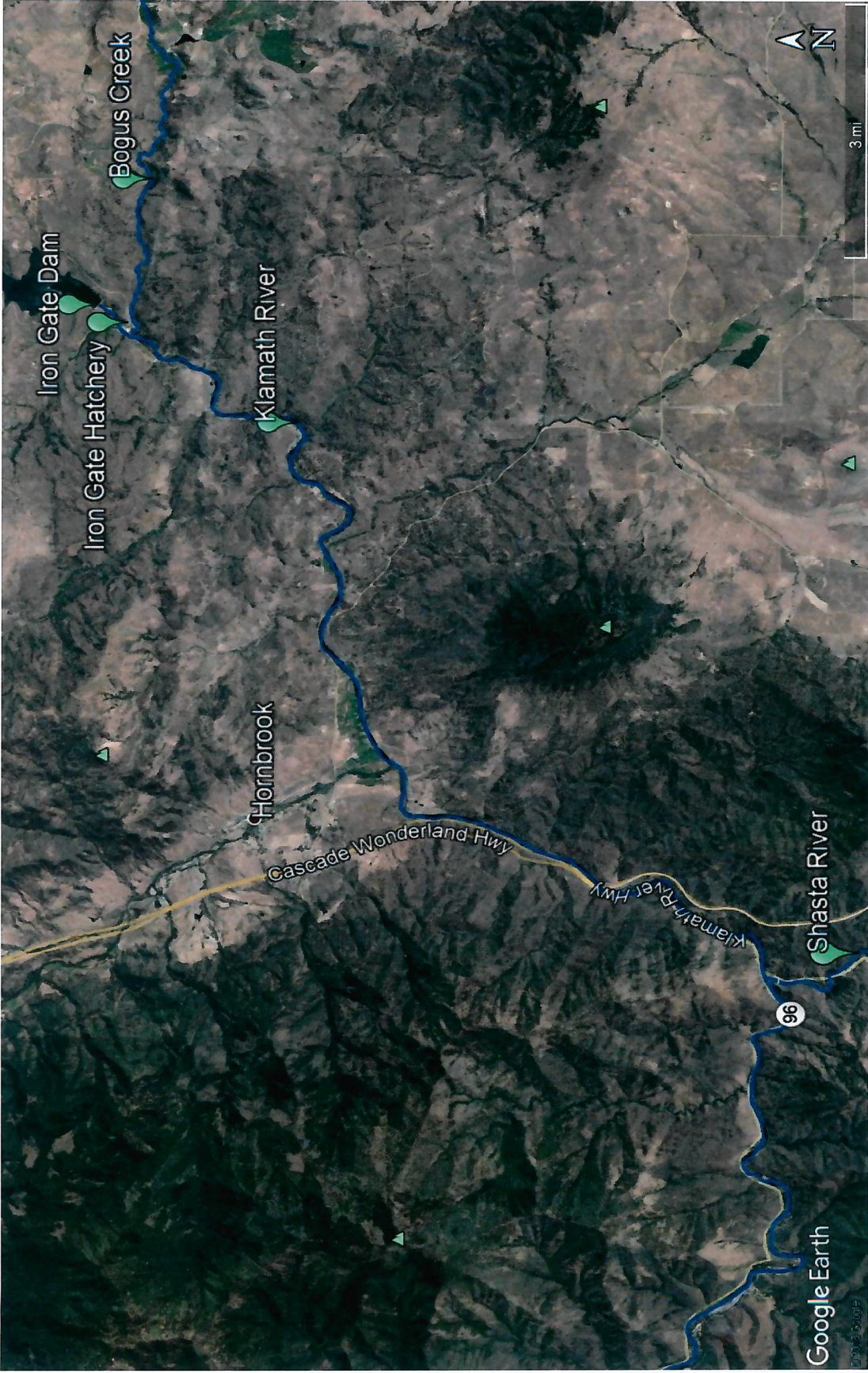


Figure 1: A Map of Iron Gate Hatchery and surrounding area, Siskiyou County, CA.

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 are sorted by IGH staff. Those selected as brood stock are spawned (if ready) 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 collected for off-site processing by American-Canadian fisheries for later distribution to interested individuals and organizations.

In 2017, KRP staff conducted a systematic sample of every 5th 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, and sex, as well as 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). All heads were transported to the KRP's Yreka laboratory for tag extraction and reading.

Since 2015, Chinook at IGH have been spawned using a 1:1 male to female ratio. In this method, the eggs of one female Chinook and milt of one male Chinook are mixed in a pan. After fertilization, the eggs are combined with eggs of other pairs in a 5 gallon bucket along with PVP Iodophor solution for disinfection. The eggs are water hardened prior to transport to the hatchery building. The egg lots are labeled by date, and individual pairings are not tracked when measured into Heath stack incubators.

Another methodology implemented in 2015 and continued in 2016 and 2017 is the air spawning of Chinook and Coho. In this method a euthanized female fish is hung from a hook and a hypodermic needle inserted into the body ½ to 1 inch deep, usually in the hollow area below a pelvic fin. Air pressure applied at 2-3 psi forces the eggs to be expelled from the body cavity through the vent. This method replaces the technique of evisceration, in which an incision is made along the ventral surface of the female salmon and the eggs manually stripped from the ovaries.

Grilse/adult and age composition determinations were made by the Klamath River Technical Team (KRTT 2018) using scale age proportions.

Systematic sampling for the presence of Ich (*Ichthyophthirius multifiliis*) in IGH Chinook was conducted by KRP staff throughout the 2017 spawning season. The first gill arch from the left and right gills of systematically sampled, recently euthanized fish were removed with scissors immediately post-mortem and placed in a sealable plastic bag with a sample number. The samples were cross-referenced with data on sex, fork length, left or right gill, clip information, and general appearance of gills. Samples were then placed on ice in insulated containers and were evaluated with a stereo (dissecting) microscope upon return to the Yreka laboratory. In addition to Ich, gills were inspected for columnaris (*Flavobacter columnare*) and copepods (*Salmincola californensis*) as well as other observed abnormalities.

Coho Salmon

As Coho entered IGH during the 2017 season, hatchery personnel netted each fish and placed it in a flume, then a processing tank, where KRP staff collected biological data including tissue samples, fork length, sex, and clip/tag information. Tissue samples were sent via overnight mail to the National Oceanic and Atmospheric Administration (NOAA) for genetic analysis and the creation of a weekly spawning matrix designed to avoid the mating of closely related fish. Coho were not anaesthetized, but kept in water throughout processing. In 2017, six Coho were trapped on October 25th 2017, it was deemed too early to spawn Coho so they were PIT tagged and released. Additionally 10 fish were PIT tagged and released in December 2017 and seven fish were PIT tagged and released in January 2018 because they were in poor condition or were genetically incompatible with the brood stock on hand.

Those Coho retained as potential brood stock were assigned a unique number, placed in individual PVC tubes, and placed in a round tank (Figure 2) with heads oriented into the flow. As genetic information was received in the form of a spawning matrix from NOAA, fish were either used as brood stock (if suitable mates were available), held for future spawning or PIT-tagged and released. Scale samples were collected from spawned fish as well as fish that experienced pre-spawn mortality, and otoliths were collected from all unmarked Coho (spawned or pre-spawn mortalities) and also from the first left-maxillary clipped spawned Coho on each spawning day.

On subsequent spawning days, those Coho that were included in the spawning matrix were checked in their tubes for spawning readiness, and were either left in the tubes if not ready to spawn (or did not have suitable mates available), or brought into the spawning building from the round tanks, euthanized and spawned with fish chosen from the matrix. In 2017, Coho crosses consisted of two males to one female when possible, with half of each female's eggs placed in labeled containers (Figure 3) and fertilized by one male for each container and the egg lots kept separate. IGH and KRP personnel tracked the use of marked vs. unmarked individuals and the use of grilse for spawning.



Figure 2: Coho brood stock in PVC tubes in a round tank. Photo by Rosa Albanese



Figure 3: Coho eggs from one female being split into two lots.

NOAA laboratory staff developed a spawning matrix designed to avoid the spawning of closely related individuals. The weekly matrix, sent via e-mail to the KRP and IGH, displayed a series of columns with the brood stock ID number of each female Coho at the top of a column, and beneath it, brood stock ID numbers of males in descending order of spawning suitability for that female (Table 2).

Table 2: Spawning Matrix created by NOAA. M= male adult left max clip. MJ= male jack left max clip. MN= male adult no marks. MJN= male jack no marks. F=female adult left max clipped male. FN= female adult no marks

F_24FN	F_32F	F_34F	F_35F	F_38F
M_62MJ	M_68MN	M_68MN	M_71M	M_59MJ
M_59MJ	M_59MJ	M_59MJ	M_62MJ	M_73MN
M_72M	M_57MJ	M_73MN	M_63MJ	M_68MN
M_68MN	M_58MJ	M_57MJ	M_68MN	M_65MN
M_63MJ	M_67MJ	M_60MN	M_72M	M_62MJ
M_57MJ	M_62MJ	M_65MN	M_67MJ	M_72M**
M_58MJ	M_65MN	M_70M	M_73MN	M_60MN**
M_67MJ	M_73MN	M_67MJ	M_57MJ	M_63MJ**
M_65MN**	M_63MJ	M_62MJ	M_60MN	M_70M**
M_71M**	M_60MN	M_58MJ**	M_70M	M_67MJ**
M_73MN**	M_72M**	M_72M**	M_59MJ	M_58MJ**
M_60MN**	M_71M**	M_63MJ**	M_58MJ	M_71M**
M_70M**	M_70M**	M_71M**	M_65MN**	M_57MJ**

RESULTS

Chinook Salmon

Chinook began entering IGH on October 9, 2017. A total of 10,636 Chinook returned to IGH during the fall 2017 spawning season. Of these, KRP staff collected biological data including sex, fork length, clip information, and spawning disposition for 3,604 Chinook, which included 2,022 systematically (1:5) sampled "random" fish and 1,582 AD fish which were not part of the 1:5 sampling (non-random AD fish). Scale samples were collected from all random fish. Tissue and otolith samples were collected from every 50th Chinook. The grilse and adult components of the 2017 run were estimated using scale age analysis (KRTAT, 2017), yielding approximately 3,193 grilse (30%) and 7,443 adults (70%) for a total run size of 10,636 (figure 4). Females accounted for 40% of the systematically sampled fish (804) and males accounted for 60% (1,217) one fish did not have sex recorded on the data sheet. The last Chinook of the season entered IGH on November 27, 2017. Systematically sampled male Chinook ranged in size from 39 to 90 cm fork length (FL) and averaged 61 cm (Figure 5). Systematically sampled female Chinook ranged from 45 to 84 cm FL and averaged 64 cm (Figure 6).

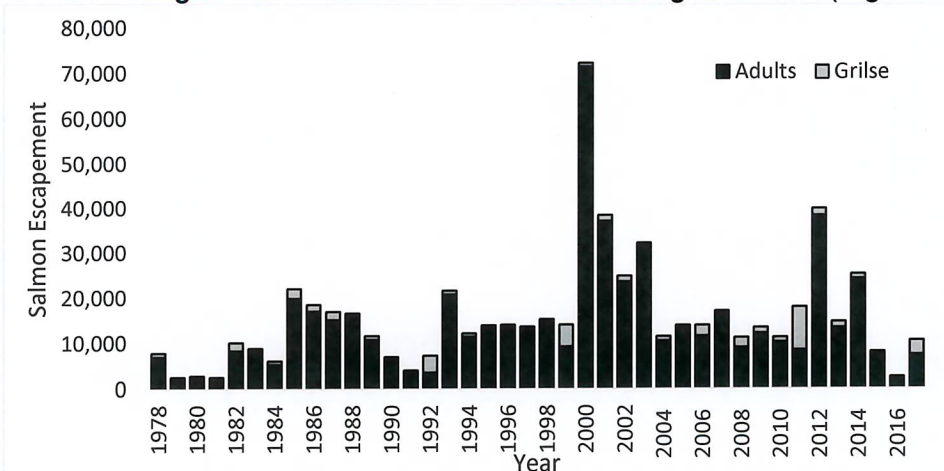


Figure 4: IGH Chinook salmon grilse and adult escapement counts 1978-2017

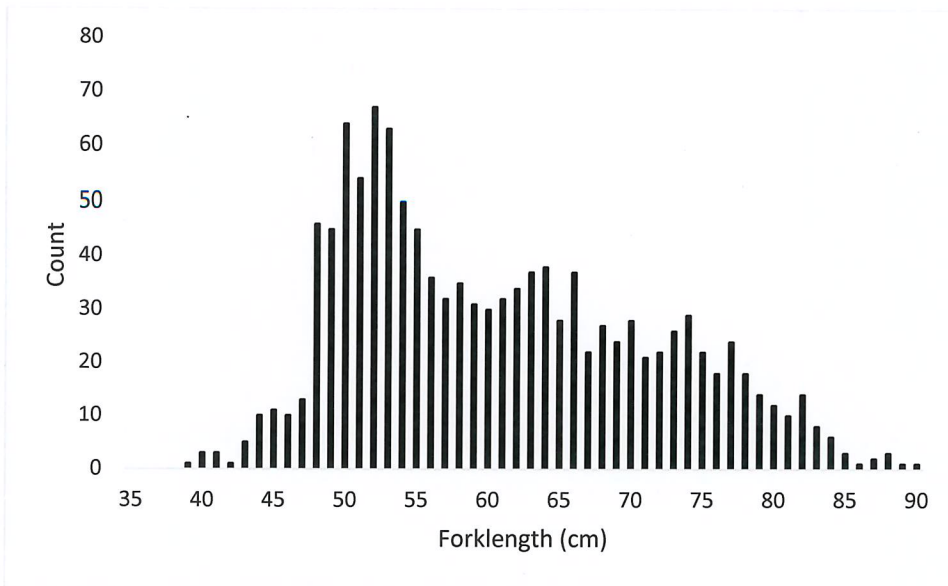


Figure 5: 2017 IGH Random Chinook Male fork length histogram

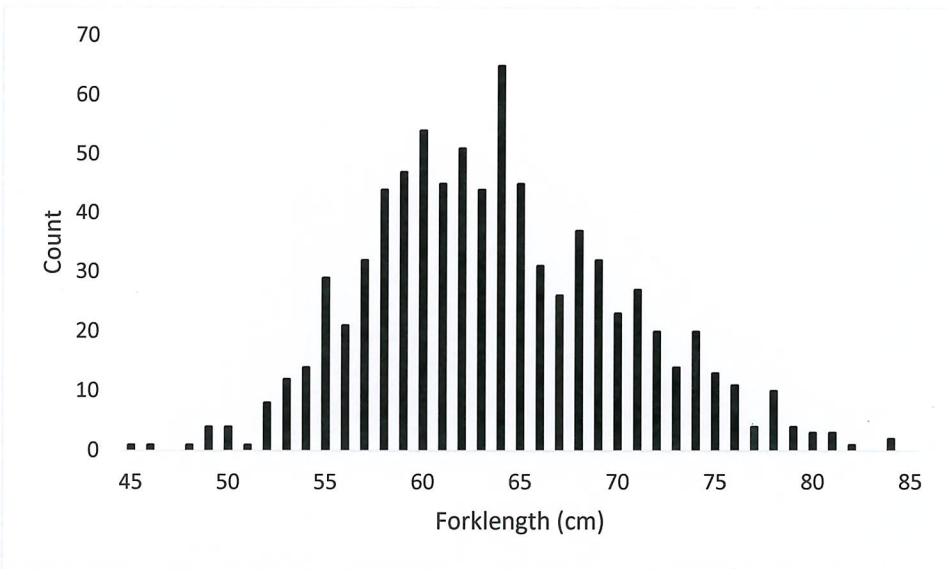


Figure 6: 2017 IGH Random Chinook female fork length histogram

Heads from 1,988 AD Chinook (random and non-random fish) were collected for CWT recovery, from which positive reads were obtained for 1,925 (Table 3). The remainder were either lost prior to or during extraction (34), did not have a tag (21) or the tags were unreadable (8). The contribution of lost or unreadable CWTs was estimated by applying the proportions of known CWTs (1,925) to the 42 lost or unreadable CWTs (Table 4).

Table 3: 2017 Hatchery composition of Fall Run Chinook salmon at Iron Gate Hatchery

CWT	Release Location	Brood Year	AGE	Release Type	Number Recovered	Production Multiplier	Expanded Estimate	Total by Age	Percent of total
60422	IGH	2011	6	Y	1	4.00	4.00	4.00	0.0376444
60375	IGH	2012	5	F	2	4.02	8.03		
68798	IGH	2012	5	F	2	4.01	8.01		
60507	IGH	2012	5	Y	3	4.02	12.05	28.10	0.2641892
60417	IGH	2013	4	F	3	4.01	12.04		
60601	IGH	2013	4	F	24	4.04	96.94		
60602	IGH	2013	4	F	10	4.02	40.16		
60603	IGH	2013	4	F	7	4.00	28.01		
68205	IGH	2013	4	F	1	7.31	7.31		
60597	IGH	2013	4	F	42	4.05	170.21		
60604	IGH	2013	4	Y	245	4.01	982.85		
60613	TRINITY	2013	4	Y	1	4.12	4.12	1341.63	12.614052
60449	IGH	2014	3	F	2	4.01	8.02		
60684	IGH	2014	3	F	180	4.04	727.75		
60685	IGH	2014	3	F	27	4.00	108.06		
60686	IGH	2014	3	F	69	4.02	277.32		
60687	IGH	2014	3	F	21	4.03	84.57		
68206	IGH	2014	3	F	3	5.38	16.13		
68657	IGH	2014	3	F	6	4.01	24.07		
60688	IGH	2014	3	Y	812	4.02	3262.79	4508.71	42.39099
60712	IGH	2015	2	F	9	4.17	37.51		
60784	IGH	2015	2	F	228	4.01	913.71		
60785	IGH	2015	2	F	77	4.01	308.85		
60786	IGH	2015	2	F	86	4.02	345.78		
60787	IGH	2015	2	F	38	4.00	152.06		
60454	IGH	2015	2	Y	13	4.02	52.30		
60783	IGH	2015	2	Y	12	4.00	48.04		
68703	IGH	2015	2	Y	1	4.00	4.00	1862.26	17.509045
				Subtotal	1925		7744.70		
Total Run	10636								
Estimated Contribution of Unknown CWTs									
200000	CWT Lost				30				
300000	Head Lost				4				
400000	CWT Unreadable				8				
				Subtotal	42		169		
100000	No tag found in head (excluded)				21				
Total Estimated Hatchery Contribution							7913.70	0.744286655	

Table 4: Estimated contribution of 42 AD Chinook with unknown CWT codes (lost or unreadable) that were recovered based on the proportional distribution of known CWTs recovered at IGH during the 2017 season.

CWT	Brood Year	# of CWTs recovered	Proportion of CWT's Recovered	Estimated Number	Production Multiplier	Expanded Estimate
60422	2011	1	0.0005	0.02	4.00	0.09
60375	2012	2	0.0010	0.04	4.02	0.18
60507	2012	3	0.0016	0.07	4.02	0.26
68798	2012	2	0.0010	0.04	4.01	0.17
60417	2013	3	0.0016	0.07	4.01	0.26
60597	2013	42	0.0218	0.92	4.05	3.71
60601	2013	24	0.0125	0.52	4.04	2.12
60602	2013	10	0.0052	0.22	4.02	0.88
60603	2013	7	0.0036	0.15	4.00	0.61
60604	2013	245	0.1273	5.35	4.01	21.44
60613	2013	1	0.0005	0.02	4.12	0.09
68205	2013	1	0.0005	0.02	7.31	0.16
60449	2014	2	0.0010	0.04	4.01	0.18
60684	2014	180	0.0935	3.93	4.04	15.88
60685	2014	27	0.0140	0.59	4.00	2.36
60686	2014	69	0.0358	1.51	4.02	6.05
60687	2014	21	0.0109	0.46	4.03	1.85
60688	2014	812	0.4218	17.72	4.02	71.19
68206	2014	3	0.0016	0.07	5.38	0.35
68657	2014	6	0.0031	0.13	4.01	0.53
60454	2015	13	0.0068	0.28	4.02	1.14
60712	2015	9	0.0047	0.20	4.17	0.82
60783	2015	12	0.0062	0.26	4.00	1.05
60784	2015	228	0.1184	4.97	4.01	19.94
60785	2015	77	0.0400	1.68	4.01	6.74
60786	2015	86	0.0447	1.88	4.02	7.54
60787	2015	38	0.0197	0.83	4.00	3.32
68703	2015	1	0.0005	0.02	4.00	0.09
Totals:		1925	1	42		169

The estimated contribution of unknown CWTs was then added to the contribution of known CWTs to determine the total contribution of hatchery-origin Chinook entering IGH. Of the 1,925 CWTs recovered (and successfully read), 1,924 originated from IGH and one from Trinity River Hatchery. Based on the expansion of CWTs, KRP staff estimated that 74% of the Chinook entering IGH during the 2017 season were of hatchery origin (Figure 6). Of the expanded CWT returns (positive reads) in 2017, 1,112 (57%) were from yearling release groups and 855 (43%) were from smolt release groups (Table 3). An additional 169 tag codes were apportioned for lost or unreadable tags (Table 4) and a final estimate of 7,914 (74%) chinook salmon were of hatchery origin during the 2017 run (Figure 7).

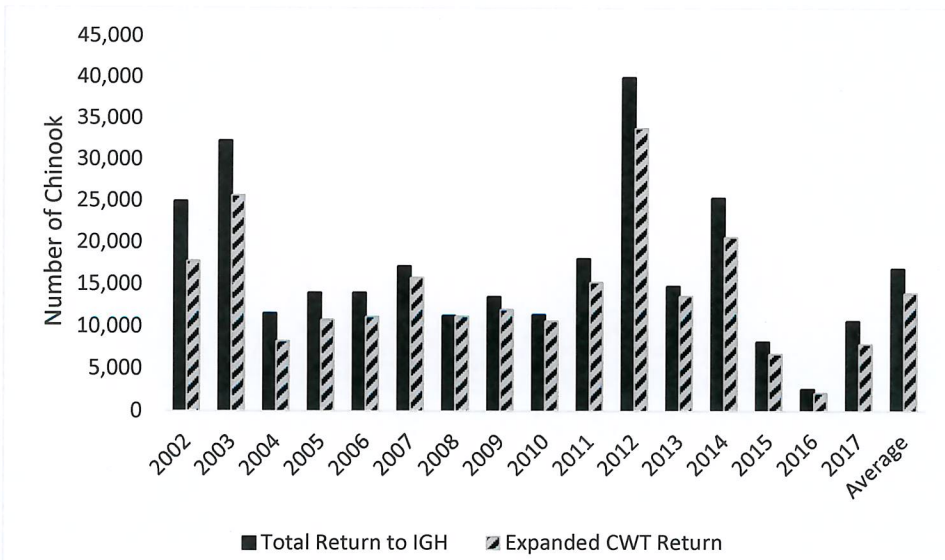


Figure 7: IGH returns of adult fall run Chinook salmon with hatchery contribution 2002-2017

Coded Wire Tagging

2017 was the 9th year of 25% constant fractional marking at IGH, although Brood Year 2010 was tagged at a rate of 17.2% due to losses from disease and the necessity of releasing surviving smolts before temperature and flow conditions in the Klamath River became detrimental. In 2017, tagging operations were conducted by staff of the Pacific States Marine Fisheries Commission, under contract with PacifiCorp. A total of 369,991 juvenile Chinook were AD clipped and coded wire tagged, and 1,098,522 counted but not tagged, for a total of 1,468,513 Chinook processed during the 2017 tagging season (brood year 2016). The smolt component accounted for 107,045 tagged and 309,024 counted. The yearling component accounted for 262,946 tagged and 789,498 counted (Buttars, 2018) Production of juveniles was low in 2016 because egg take goals were not met due to low adult returns.

Table 5: IGH Chinook salmon smolt and yearling tagged release numbers and return rates, 1990-1996 and 1999-2015

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	1,015	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
2001 ^a	198,311	11	0.006%	110,167	764	0.693%	125.02
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 ^b	986,141	269	0.027%	192,339	197	0.102%	3.75
2009	1,119,054	10,224	0.914%	264,253	581	0.220%	0.24
2010 ^c	671,755	2,473	0.368%	261,332	278	0.106%	0.29
2011	1,158,028	2,694	0.233%	286,947	844	0.294%	1.26
2012	1,040,836	1,112	0.107%	263,614	25	0.009%	0.09
2013*	1,117,134	233	0.021%	263,836	462	0.1751%	8.40
2014*	965,584	317	0.033%	263,272	820	0.3115%	9.49
2015*	911,162	438	0.048%	241,678	26	0.0108%	0.22
AVERAGE			0.178%			0.352%	9.59
* Incomplete returns for BY 2013-2015							
^a BY 2001 smolt releases subject to critically dry conditions at release, record low return rates observed							
^b BY 2008 was the first to receive 25% constant fractional mark							
^c BY 2010 smolt release tagged at 17.16% due to disease and river conditions							

Ich Sampling

During the 2017 Ich monitoring effort at IGH, 30 adult Chinook were sampled over 3 sampling dates from mid-October to early November. Sampled fish represented 3.8% of the Chinook that entered the hatchery during the sampling dates. Of the 30 Chinook, 8 were positive for Ich trophonts (26.6%), but at a very low level of infection. None of the fish sampled appeared to be in a diseased state. One of the 30 Chinook (3.6%) showed signs of columnaris (*Flavobacter columnare*) infection (Hileman 2018).

Coho Salmon

During the 2017 season 122 Coho entered IGH with the first Coho being trapped on October 25, 2017 and the last on January 2, 2018 additionally one Coho was trapped at the Bogus Creek Fish Counting Facility on November 21, 2017 and transferred to IGH for use as brood stock. The Coho run consisted of 62 males (50.8%) and 60 females (49.2%). Male Coho ranged in size from 36 to 78 cm in FL and averaged 53 cm (Figure 8), and female Coho ranged in size from 53 to 72 cm in FL and averaged 65 cm (Figure 9). Grilse were estimated to be <50 cm FL, yielding a grilse component of 24% (29) and an adult component of 76% (93). The proportion of grilse among male Coho was 47%. The mean FL for grilse was 40 cm, and the mean FL for adult male Coho was 65 cm.

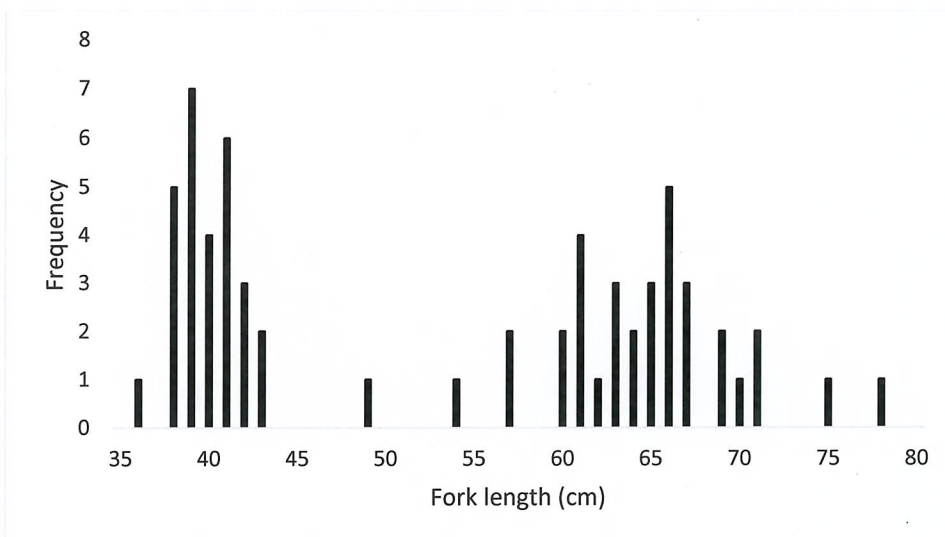


Figure 8: 2017 IGH Male Coho fork length frequency

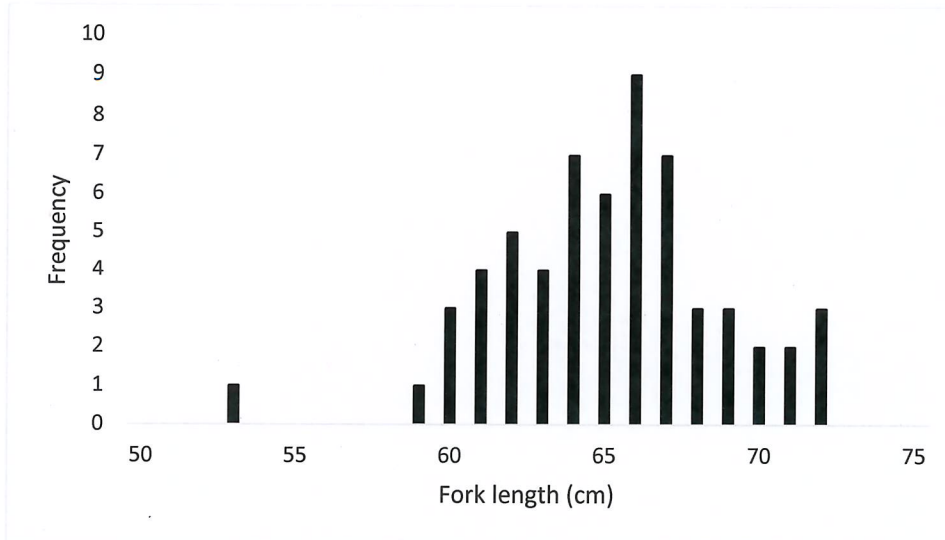


Figure 9: 2017 IGH Female Coho fork length frequency

Of the 122 Coho trapped, 98 (80%) had left maxillary clips, indicating IGH origin, and 24 (20%) were unmarked. No right maxillary or AD clipped Coho were observed during the 2017 season (table 6).

Table 6: IGH Coho Hatchery Mark Proportions 1997-2017

Year	# Sampled	LM	RM	AD	OTHER	MARKED	UNMARKED	% MARKED
1997	2174	1970	5	28	6	2009	165	92%
1998	669	378	0	2	0	380	289	57%
1999	169	153	0	1	0	154	15	91%
2000	1354	1067	4	58	4	1133	262	84%
2001	2573	2130	138	51	8	2327	246	90%
2002	1301	1006	25	38	7	1076	225	83%
2003	1558	838	69	58	4	969	589	62%
2004	1734	1203	32	69	1	1305	424	75%
2005	1425	1282	2	1	0	1285	140	90%
2006	301	204	2	16	0	222	80	74%
2007	779	643	6	2	1	652	127	84%
2008	1296	1268	2	0	1	1271	25	98%
2009	45	29	7	0	0	36	9	80%
2010	258	222	1	0	0	223	36	86%
2011	586	522	0	2	1	525	63	90%
2012	644	609	4	1	1	615	29	95%
2013	1268	1158	2	1	2	1163	105	92%
2014	384	346	0	5	0	351	33	91%
2015	72	59	0	2	0	61	11	85%
2016	86	66	0	0	0	66	20	77%
2017	122	98	0	0	0	98	24	80%

A total of 22 were PIT tagged and released during the 2017 spawning season. 5 Coho were trapped on October 25th 2017 and it was deemed too early to spawn Coho so they were PIT tagged and placed back into the Klamath River. Between December 4, 2017 and December 19, 2017 10 Coho were PIT tagged and released from brood stock because they were in poor condition or were not genetically compatible with other brood stock. Finally on January 2, 2018 7 Coho were PIT tagged and released from brood stock because they were in poor condition or were not genetically compatible with other brood stock. Nineteen of the released Coho had left maxillary clips, and 3 were unmarked. 39 female Coho were used for spawning in 2017, and 45 male Coho were used for spawning during the 2017 season. None of the PIT tagged fish were detected after release in 2017.

DISCUSSION

Chinook Salmon

The 2017 run of Chinook including adults and jacks to IGH (10,636) was 5,148 fish less than the 40-year average of 15,784 (Figure 9). Escapement to IGH was 30.3% of the Klamath basin spawner escapement in 2017 (Figure 10). Klamath Basin returns of adult Chinook were 170.7% of the projected forecast, with 29,700 adults returning vs. the projected forecast of 17,400.

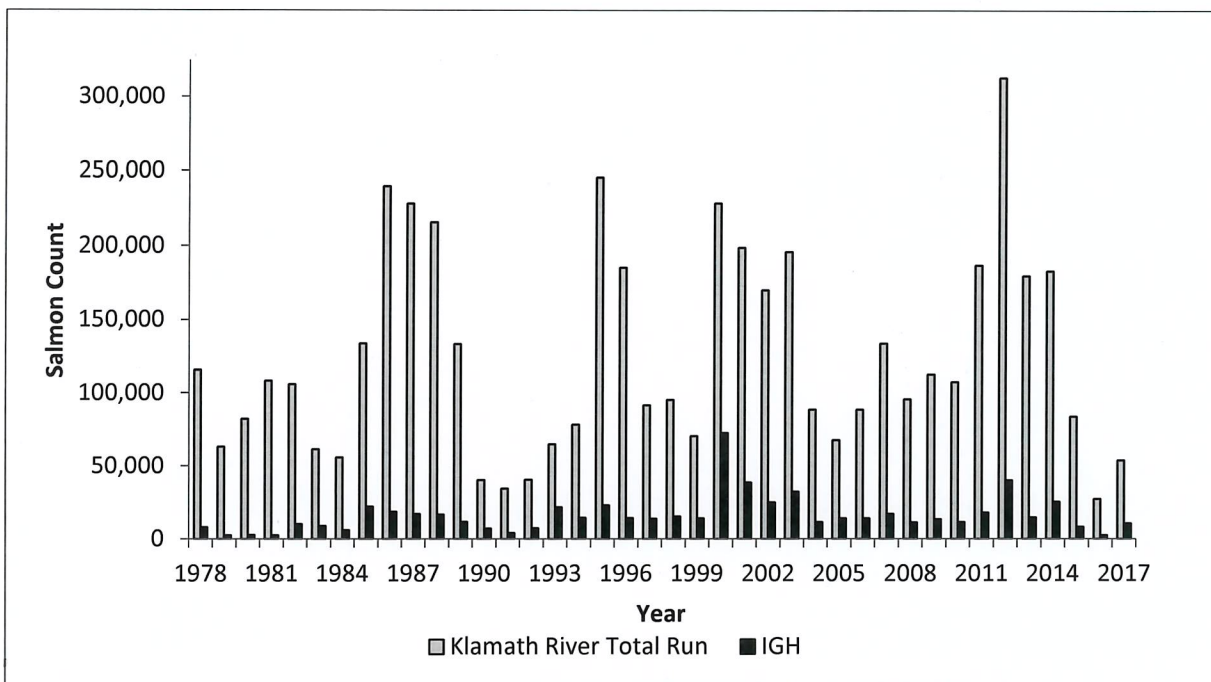


Figure 10: Chinook salmon escapement including adults and jacks to the Klamath Basin and Iron Gate Hatchery 1978-2017

The brood years returning to the Klamath River in 2017 were subjected to adverse river conditions during their outmigration as juveniles, and in the marine environment. Both 2014 and 2015 were critically dry water years in California in general and the Klamath River in particular. Ongoing research on *Ceratonova shasta* and *Parvicapsula minibicornis* in the mainstem Klamath River, using sentinel fish during the peak migration period of May to the end of July indicate that in 2014 and 2015, juvenile Chinook experienced infection rates of 81% and 91%, compared to the 10 year mean of 44% (True et al, 2016).

Both *C. shasta* and *P. minibicornis* are myxosporean parasites that are known to be significant contributors to mortality in juvenile fish exposed to the parasites as they migrate downstream (Ray et al., 2013). Higher flows are believed to not only dilute the infectious spore stages, but also dislodge the intermediate *C. shasta* host polychaete worms, *Manayunkia speciosa*, and decrease the rate of infection and mortality associated with infection. (Hallett et al., 2012; True et al., 2016).

In 2015, the Iron Gate Hatchery Coordination Team (HCT) made a recommendation to the Statewide Policy Team to implement the use of one-on-one (1:1) spawning of Chinook. This method was first used in 2015. One-on-one spawning has been shown to increase the overall number of parents contributing to a population, and to reduce the effects of sperm competition. Sometimes male Chinook are spawned with more than one female, but no more than one male and one female were spawned per pan.

Air spawning is another method implemented in 2015 and has been used since implementation. According to IGH manager Keith Pomeroy (pers.comm.), this method has been found to result in cleaner eggs that are less likely to be broken or contaminated by blood, and also results in a cleaner spawning house environment compared to the previous method of evisceration. Internal examination of spawned female Chinook showed very few residual eggs when the air spawning technique was employed. Another recommendation of the HCT is to exclude AD fish (known hatchery origin fish) from spawning to increase the natural component of the brood stock. This was not implemented in 2017 due to low spawner abundance, but may be implemented in future seasons.

The Chinook egg take in 2017 was 7,396,627 which was 2,803,373 eggs short of the target of 10,200,000 eggs.

The Chinook 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 the following November. Between 1990 and 2010, data on 19 brood years show only four years in which fingerlings outperformed yearlings. Due to concerns about domestication of yearling-released Chinook, the HCT is evaluating the HSRG's recommendation that yearling-released IGH Chinook be marked with an external, distinguishing mark and excluded from spawning during years of adequate returns.

Coho Salmon

The 2017 run of Coho to IGH (121) was 861 fish less than the 56-year average of 982 (Figure 12). Southern Oregon Northern California Coho (SONCC) have been subjected to the same adverse ocean and in-river conditions as previously described for Chinook. The HGMP (HGMP, v.10, 2013) was developed for IGH as part of the CDFW'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. Many recommendations of the draft HGMP (2009) have been implemented at IGH since 2010. These include the use of NOAA's Coho spawning matrix, bird exclusion netting in the outdoor rearing raceways, and the installation of a new water filtration system in the hatchery building. The HGMP also recommends increasing the proportion of natural origin broodstock (pNOB target 20-50%) and the proportion of jacks (pJacks) included in the broodstock (Table 7).

Unmarked Coho are presumed to be of non-hatchery origin, and are incorporated into spawning as close to the target as possible, if the NOAA matrix shows they are suitable as brood stock. Proportions of marked and unmarked Coho that entered IGH from 1997 to 2017 are shown in Table 8.

The relatedness coefficient (R_{xy}) of pairs of Coho spawned at IGH during the 2017 season with the use of the NOAA spawning matrix is shown in Figure 14. This was the eighth season for which the matrix was used. The green 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 R_{xy} values are represented by blue bars, and the yellow bars represent actual crosses. Highly inbred pairings result in R_{xy} values > 0.10 .

During the 2017 season, Coho that entered IGH during October and early November, while the Chinook spawning season was still underway, were released. Despite infrastructure challenges, early holding of Coho and more frequent spawnings may be necessary during years of small Coho returns. More frequent spawning also minimizes pre-spawning (tube) mortality. Proportions of Coho retained at IGH and released into the Klamath River between 2004 and 2017 are shown in Figure 12.

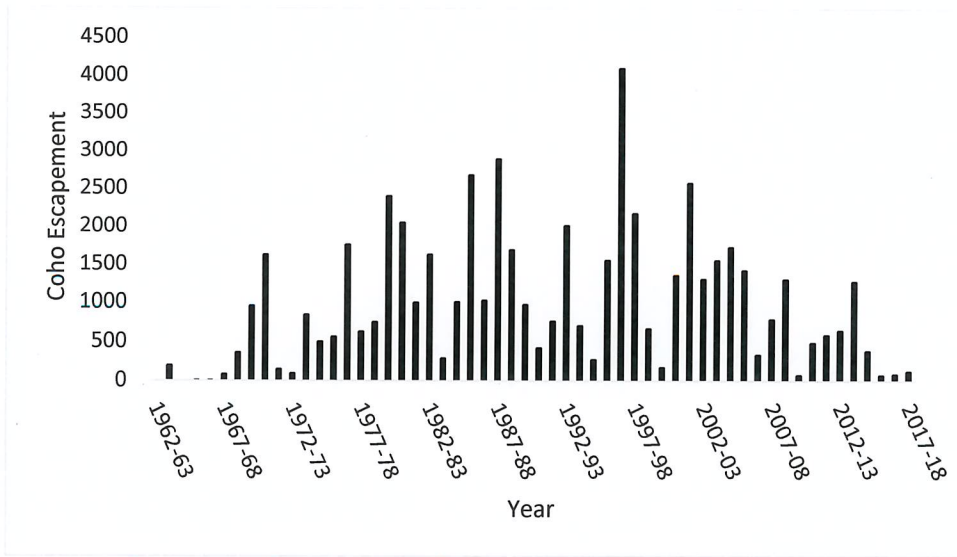


Figure 11: Coho salmon Returns to Iron Gate Hatchery 1962-2017

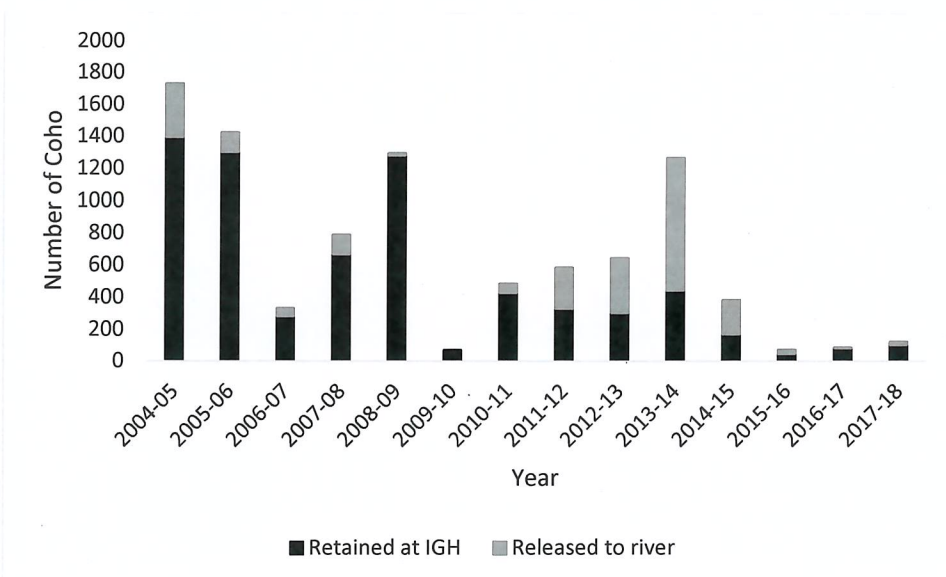


Figure 12: Count of Coho retained at IGH and released alive into the Klamath River, 2004-2017

Table 7: Iron Gate Hatchery Coho Data 1993-2017

Year	Adult Males	Females	Total Adults	Jacks	Total Run	Females Spawned	Natural Origin Broodstock	pNOB	pJacks	# Eggs	Fecundity	Yearlings released	Egg to Smolt Survival	Date released
1993	361	314	675	29	704	219	?	~15	~1	503,326	2,298	79,506	16%	1995
1994	100	72	172	97	269	57	?	~15	~1	141,397	2,481	74,250	53%	1996
1995	708	793	1501	29	1530	294	?	~15	~1	782,170	2,660	81,489	10%	1997
1996	1,715	1,831	3546	551	4097	200	?	~15	~1	547,255	2,736	79,607	15%	1998
1997	825	1,047	1872	302	2174	126	16	6.3	~1	304,728	2,418	75,156	25%	1999
1998	243	268	511	158	669	122	75	30.7	~1	298,357	2,446	77,147	26%	2000
1999	90	61	151	18	169	35	5	7.1	~1	86,519	2,472	46,250	53%	3/29/2001
2000	295	428	723	631	1354	95	52	27.4	~1	270,151	2,844	67,933	25%	3/27/2002
2001	972	1,494	2466	107	2573	126	22	8.7	~1	404,370	3,209	74,271	18%	3/27/2003
2002	566	627	1193	108	1301	187	68	18.2	~1	609,193	3,258	109,374	18%	3/29/2004
2003	609	708	1317	241	1558	197	172	43.7	~1	502,048	2,548	74,716	15%	4/13/2005
2004	630	865	1495	239	1734	276	10	1.8	~1	799,623	2,897	89,482	11%	4/17/2006
2005	596	799	1395	30	1425	103	10	4.9	~1	295,101	2,865	118,487	40%	4/25/2007
2006	112	151	263	69	332	85	10	5.9	~1	236,406	2,781	53,950	23%	4/9/2008
2007	300	325	625	154	779	124	10	4.0	~1	316,155	2,550	117,832	37%	4/17/2009
2008	508	770	1278	18	1296	148	9	3.0	~1	455,480	3,078	121,000	27%	4/8/2010
2009	21	25	46	24	70	20	6	30.0	40	53,435	2,672	22,236	42%	4/14/2011
2010	193	235	428	57	485	80	21	26	18	259,490	3,244	155,840	60%	3/29/2012
2011	248	204	452	134	586	57	26	23	11	151,241	2,653	39,250	26%	3/18/2013
2012	98	203	301	343	644	64	12	9	64	158,651	2,479	78,000	49%	3/17/2014
2013	552	653	1205	63	1268	80	37	23	17	224,071	2,801	89,500	40%	3/17/2015
2014*	39	95	134	250	384	62	24	31	51	121,421	1,958	27,568	23%	4/5/2016
					0	20				37,350	1,500	27,568	74%	4/5/2016
2015	13	21	34	38	72	13	9	52	40	22,240	2,471	17,232	77%	3/24/2017
2016	30	26	56	30	86	23	22	47	49	43,705	1,900	34,376	79%	3/16/2018
2017	33	60	93	29	122	39	24	31	32	74,966	1,922	N/A	N/A	N/A
Avg	394	483	877	150	988	110	30	21	36	296,110	2,582	73,281	25%	

*2014, egg loss due to equipment failure

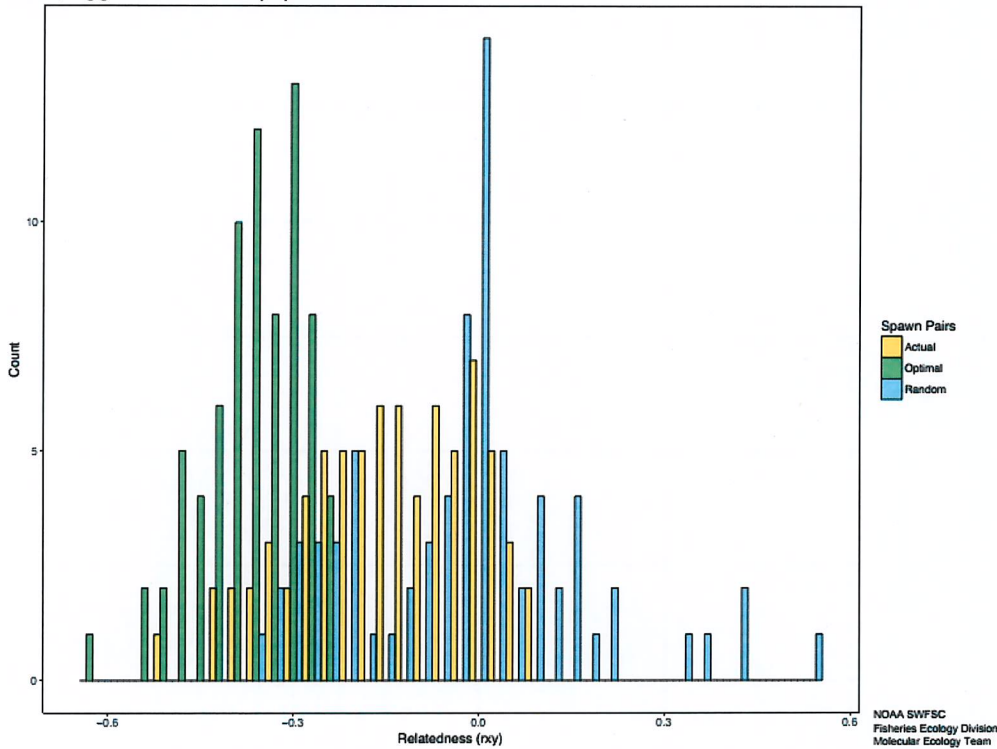


Figure 13: Observed relatedness coefficients of actual spawned pairs, optimally spawned pairs, and randomly chosen pairs for IGH Coho during the 2017 season (figure provided by NOAA SW Fisheries Science Center Salmonid Genetic Laboratory)

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