HATCHERY EVALUATION of the DWORSHAK NATIONAL FISH HATCHERY SPRING CHINOOK SALMON PROGRAM, 2015-2019

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INTRODUCTION

Dworshak National Fish Hatchery (DNFH) is located at the confluence of the North Fork Clearwater River and the mainstem Clearwater River near Ahsahka, Idaho, approximately 811 km from the Pacific Ocean. Construction of the hatchery was included in the authorization for Dworshak Dam and Reservoir (Public Law 87-847, October 23, 1962) to mitigate for losses of steelhead (*Oncorhynchus mykiss*) caused by the dam and reservoir. The hatchery was designed and constructed by the U.S. Army Corps of Engineers and was administered and operated solely by the U.S. Fish and Wildlife Service (USFWS)since the first phase of construction was completed in 1969 until 2007. From 2007 to present day the USFWS and Nez Perce Tribe (NPT) jointly operate the facility, as authorized under the Snake River Basin Adjudication (SRBA) agreement.

In 1982, thirty 8-ft by 80-ft raceways were constructed under the Lower Snake River Compensation Plan (LSRCP) to produce spring Chinook salmon (*O. tshawytscha*) as mitigation for construction of the four lower Snake River dams between Lewiston, Idaho, and the mouth of the Snake River. The LSRCP mitigation goal for the DNFH Chinook salmon program was to return 9,135 adults past Lower Granite Dam annually with a coastwide harvest objective of 36,540 adults. Spring Chinook salmon were extirpated from the Clearwater River Basin after the Lewiston Dam was constructed in 1927. The dam was eventually removed and spring Chinook reintroduction efforts were attempted beginning in 1961. Clearwater River spring Chinook are not listed under the Endangered Species Act (ESA).

There are four hatcheries in the Clearwater River Basin that rear spring Chinook salmon: DNFH operated by the USFWS and NPT; Clearwater State Fish Hatchery [CFH] operated by Idaho Fish and Game; Kooskia National Fish Hatchery [KNFH] operated by the NPT, and the Nez Perce Tribal Hatchery (NPTH) operated by the NPT. Under certain conditions such as during low return years, returning broodstock and/or their eggs are routinely shared between the these hatcheries. Additionally, during very low return years, eggs from hatcheries outside the Clearwater River Basin may be brought in to meet DNFH’s egg needs, generally from hatcheries with the same founding stock.

This document reports metrics that evaluate the DNFH spring Chinook program, i.e., Chinook collected, reared at, and released from (onsite or by trucking) DNFH whenever possible. Extensive, cooperative spring Chinook hatchery production among the four hatcheries in the basin resulted in conflation of data in some instances, particularly regarding characteristics (number, sex, age) of broodstock spawned. The hatchery evaluation program concerns itself primarily with performance metrics after release from the hatchery as well as metrics that can have ecological implications (e.g., spawn timing, broodstock age composition, etc.) that can affect the long-term success of the program. Additional information on specific hatchery production practices and interchange of broodstock or eggs between hatcheries can be found in individual hatchery production reports.

Because Chinook from a given brood year return at different ages, and other data from regional databases may not have been processed as of this writing, data will be serially added into subsequent annual reports as it becomes available. Tables and figures follow the Literature Cited section.

METRICS

Migratory Timing

PIT-tagged Clearwater River basin spring Chinook salmon (return years 2015-2019 combined) began to arrive at Lower Granite Dam (LGR) in April with the bulk of the returns arriving in May and early June (Figure 1). Jack Chinook (1-ocean) arrived later than adults.

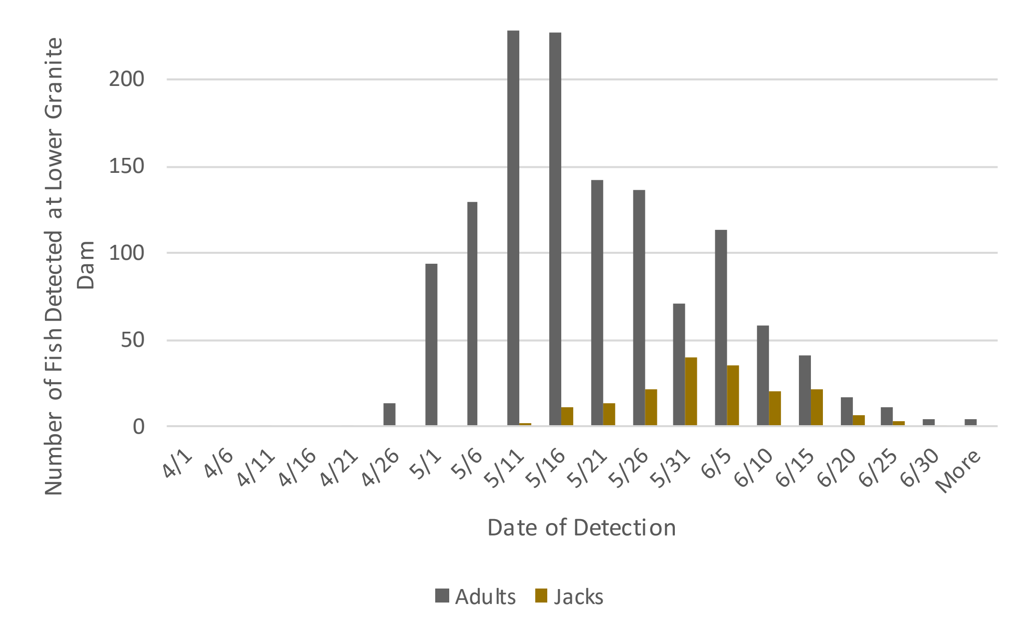

Figure 1. Detections of PIT-tagged Clearwater River basin hatchery-origin adult and jack spring Chinook at Lower Granite Dam, years 2015 thru 2019 combined.

PIT-tagged DNFH spring Chinook salmon (return years 2015-2019 combined) migratory timing was very similar (Figure 2) to overall Clearwater basin spring Chinook migratory timing.

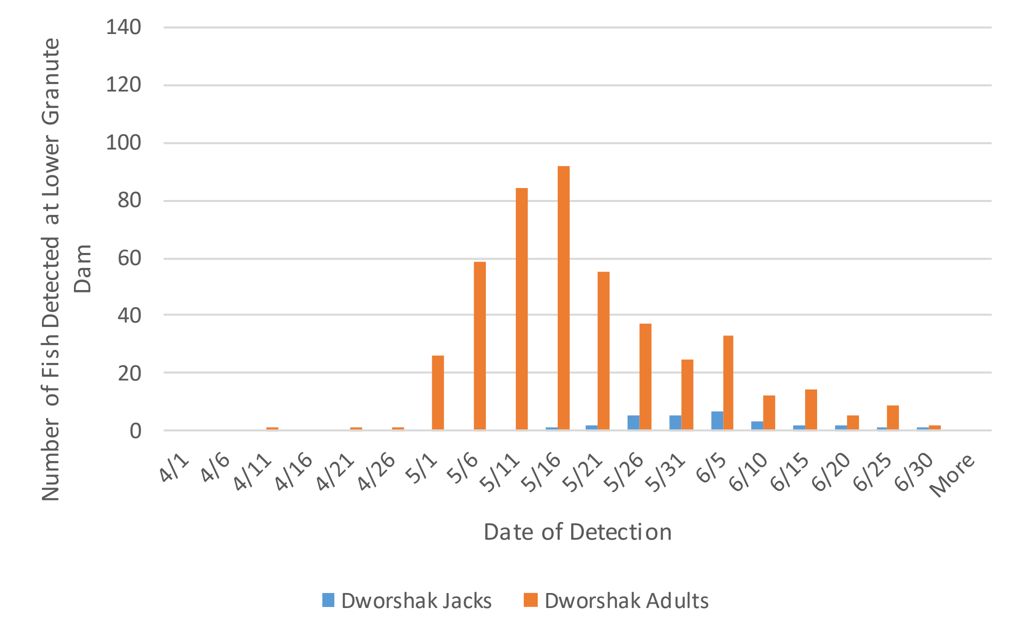

Figure 2. Detections of PIT-tagged Dworshak National Fish Hatchery adult and jack spring Chinook at Lower Granite Dam, years 2015 thru 2019 combined.

Broodstock Collection

Native Clearwater River basin spring Chinook salmon were extirpated from the basin following the construction and operation of Lewiston Dam (1927-1973) located near the mouth of the Clearwater River. As such, the stock is not listed under the Endangered Species Act and was developed from a variety of different egg sources, primarily from Little White Salmon National Fish Hatchery (near Cook, Washington along the mid-Columbia River) and Rapid River Idaho State Hatchery (near Riggins, Idaho in the Salmon River basin) (Appendix A). In the event that broodstock needs for spring Chinook salmon at DNFH cannot be met, the egg deficit can be filled from other hatcheries within the basin and outside of the basin. Today, Clearwater River basin spring Chinook are considered one stock by fisheries managers.

The adult ladder at DNFH typically operates from mid-June through mid-September depending on brood needs and the strength of the adult return (Table 1). Due to the low number of adult returns in 2019, the ladder was opened at the end of May and remained open continuously from June through August (Table 1). Because the trap is not necessarily operated the same number of days or during the same time period each year, trap days and fish trapped are not necessarily indicative of population run timing or abundance.

Table 1. First, last and total days per month when the Dworshak National fish Hatchery ladder was open for Chinook salmon broodstock collection by return year.

Return Year	First Day	Last Day	Number of Days May	Jun	Jul	Aug	Sept
2019	5/30	9/20	1	30	31	31	20
2018	6/15	9/24	0	16	31	31	24
2017	6/15	9/14	0	16	31	31	14
2016	6/15	8/13	0	15	31	13	0
2015	6/15	9/21	0	15	31	9	21

The majority of fish trapped during return years 2015 - 2019 were hatchery-origin, with a small number of adipose fin intact (AD-intact), potentially natural-origin fish, trapped each year (Table 2). Some AD-intact fish may still be hatchery-origin fish potentially from spring Chinook reared at DNFH and released as unmarked parr into the Selway River basin, DNFH spring Chinook missed during fin-clipping, or unmarked fish straying into the DNFH trap.

Table 2. Spring Chinook salmon trapped at Dworshak National Fish Hatchery (DNFH) including the number of marked and un-marked fish and the percent that were reared and released from DNFH that returned to DNFH, estimated from coded-wire tag recoveries.

	Adults				Jacks			
Return Year	Total trapped	Ad-intact	Hatchery-origin	Percent from on-site DNFH release	Total trapped	Ad-intact	Hatchery-origin	Percent from on-site DNFH release
2019	1,439	24	1,415	51	248	3	245	52
2018	869	18	851	38	78	1	77	32
2017	1,441	31	1,410	78	422	0	422	40
2016	1,843	60	1,783	83	108	1	107	96
2015	3,154	84	3,070	75	251	8	243	75
			Avg	65			Avg	59

Across the five years considered here, an average of 65% of the Chinook entering the DNFH trap were released on-site at DNFH based on CWT recoveries (Table 2).

Virtually all of the remaining fish were Clearwater stock that were released at other locations in the Clearwater basin. Few out-of-basin, non-Clearwater stock Chinook strayed into the DNFH trap during the 2015-19 return years (Table 3). Clearwater stock Chinook trapped in the DNFH trap that were also reared at and released from DNFH accounted for an average of 67.9% of the Chinook trapped. Fish reared at CFH and released into Clear Cr. accounted for the next highest percentage of fish returning to DNFH at 9.0%, followed by CFH fish released directly into the North Fork Clearwater River (across the North Fork Clearwater River from the DNFH trap entrance) at 8.4%.

Table 3. Estimated number of Chinook trapped at DNFH, by return year (2015-2019), hatchery, and release location. Expanded returns by year and release location were based on proportions and expansions of recovered coded-wire tags from fish returning to DNFH (spawned and not spawned [killed-for-tag]).

Hatchery	Release Location	5-year Percent Contribution	Expanded Returns by Year 2019	2018	2017	2016	2015
DNFH	DNFH	67.9%	603	299	994	1,012	2,300
KNFH	KNFH	0.4%	8	13	13	0	0
CFH	SF CLWR	2.7%	0	4	4	0	198
CFH	Red River	0.8%	65	0	0	0	0
CFH	NF CLWR	8.4%	196	276	175	0	0
CFH	Clear Cr.	9.0%	186	106	169	147	86
CFH	Powell	0.5%	18	2[a]	6[b]	3	18
NPTH	Lolo CK	0.2%	13	0	3	0	0
NPTH	NPTH	7.5%	51	77	63	27	359
NPTH	Newsome Cr.	0.0%	0	0	1	0	0
CFH	Selway R	2.1%	30	10	1	21	96
Various	Out-of-Basin	0.3%	4	19	1	0	0

[a] Includes one summer run Chinook.

[b] Includes six summer run Chinook

Spawning for the DNFH spring Chinook program typically began in mid-August and ended the second or third week in September (Table 4). The total number of females spawned to meet DNFH spring Chinook production needs, including out-of-basin spawnings averaged 724 females. In 2017, 2018 and 2019 insufficient broodstock were captured in the DNFH trap so egg capacity was met using eggs either from Rapid River State Fish Hatchery in Idaho or Little White Salmon National Fish Hatchery in the mid-Columbia (original sources of Clearwater stock) (Table 4).

Table 4. Number of fish spawned at DNFH and other hatcheries that contributed eggs to the DNFH spring Chinook production program including smolts and pre-smolts

Brood year	DNFH Spawn Date Range Begin	End	Number Spawned at DNFH Males	Females	Number Spawned Elsewhere for Rearing and Release at DNFH Hatchery	Stock	Males	Females	Eggs Transferred	Smolts Released[a]	Pre-smolts Released[a]
2019	13-Aug	23-Sep	526	632	Rapid River	Rapid River	not available	145	536,500	Not yet available	
2018	14-Aug	25-Sep	391	449	Little White Salmon	Carson	not available	176	668,800	Not yet available	
2017	15-Aug	12-Sep	419	549	Rapid River	Rapid River	not available	251	879,268	1,709,621	422,713
2016	16-Aug	13-Sep	465	616	.	.	.	.	0	1,645,125	291,467
2015	11-Aug	22-Sep	622	801	.	.	.	.	0	1,511,173	301,197
		Average	485	609					Average	1,621,973	338,459
Avg. Including Off-station Spawning			not avail	724							

[a] The smolt release goal was 1.65M and the pre-smolt release goal was 300k.

Straying

Chinook salmon released from DNFH demonstrated low stray rates to areas outside of the Clearwater River basin (Table 5). Selway parr reared at DNFH were released without tags so determining straying rates was not possible. However, due to expected low returns for the

Selway group (due to their small size at release), a substantial number of strays from this release group into other basins is unlikely.

Table 5. Dworshak National Fish Hatchery spring Chinook hatchery fish that strayed and were detected in other river basins by return year, tag type, recovered and expanded.

Return Year	Recovery or Interrogation Site	No. of coded-wire tags Recovered	No. of coded-wire tags Expanded	No. of PIT Tags Recovered
2019	No records of coded-wire tags or PIT tag interrogations documented at this time.			
2018	No records of coded-wire tags or PIT tag interrogations documented at this time.			
2017	Entiat R.	0	0	1
	Tucannon Hatchery	0	0	1
2016	Tumwater Dam	1	11	0
	Chewuch R.	1	25	0
	Eastbank Hatchery	1	14	0
	Wenatchee R. system	0	0	1
2015	Entiat R.	0	0	1
	American R.	1	34	0
	Deschutes R. mouth	0	0	1

<u>Age at Return of Chinook Trapped at Dworshak National Fish Hatchery</u>

Across all return years and hatcheries of origin, an average of eight percent of the Chinook trapped were age 1-ocean (jack) Chinook. Among fish originating from DNFH, an average of six percent returned as 1-ocean fish (Table 6). In 2017, an estimated 55% of the CFH Chinook trapped in the DNFH trap were age 1-ocean.

Age 2-ocean returns were the dominant age class trapped from all hatcheries combined (87%) and for DNFH spring Chinook (88%) (Table 6). Age 3-ocean returns comprised four and six percent of the return on average for all hatcheries combined and DNFH, respectively.

Table 6. Hatchery of origin and age at return of spring Chinook salmon returning to the DNFH trap by return year, based on coded-wire tag recovery and expansion. (DNFH- Dworshak National Fish Hatchery, KNFH- Kooskia National Fish Hatchery, CFH- Clearwater State Fish Hatchery, NPTH- Nez Perce Tribal Hatchery)

		Number by Ocean Age				Percent by Ocean Age		
Return Year	Hatchery	1	2	3	Total	1	2	3
2019	DNFH	96	487	21	604	16	81	3
	KNFH	8	0	0	8	100	0	0
	CFH	60	398	22	480	13	83	5
	NPTH	5	38	22	65	8	58	34
		169	923	65	1,157	15	80	6
2018	DNFH	21	262	15	299	7	88	5
	KNFH	0	13	0	13	0	100	0
	CFH	22	374	0	396	6	94	0
	NPTH	1	74	0	75	1	99	0
		44	722	15	782	6	92	2
2017	DNFH	133	827	33	993	13	83	3
	KNFH	0	7	6	13	0	54	46
	CFH	194	157	3	354	55	44	1
	NPTH	3	63	1	67	4	94	1
		330	1,054	43	1,427	23	74	3
2016	DNFH	24	798	190	1,012	2	79	19
	KNFH	0	0	0	0	0	0	0
	CFH	0	163	8	171	0	95	5
	NPTH	1	25	1	27	4	93	4
		25	986	199	1,210	2	81	16
2015	DNFH	101	2,175	24	2,300	4	95	1
	KNFH	0	28	0	28	0	100	0
	CFH	19	349	2	370	5	94	1
	NPTH	14	346	0	360	4	96	0
		134	2,898	26	3,058	4	95	1
					All Hatcheries	8	87	4
					DNFH	6	88	6

Most of the Chinook spawned at DNFH for DNFH production were age 2-ocean fish (Table 7). Age 1-ocean fish were limited to males and ranged from 6 to 31%. The age 3-ocean fish contribution was variable from none to 26%.

Table 7. Percent of spring Chinook salmon spawned at Dworshak National Fish Hatchery (DNFH) for DHFH production, by ocean-age and sex by return year as determined by coded-wire tagged fish (n).

Return		% Males at Ocean-age				% Females at Ocean-age		
Year	n	1	2	3	n	1	2	3
2019				Data not yet available				
2018	13	15	77	8	10	0	100	0
2017	35	31	69	0	39	0	92	8
2016	36	6	83	11	46	0	74	26
2015	98	9	90	1	99	0	98	2
	Avg	17	76	6	Avg	0	89	11

Length at Age

Length of known-age spring Chinook salmon returning to DNFH was analyzed using data from 781 individual coded-wire tagged fish from return years 2013-19. Data were pooled and probabilities were generated from a discriminant function for males and a logistic model for females. Different models were used because male Clearwater basin spring chinook return over three years, ocean-ages 1-3, and females return over only two years, ocean-ages 2 and 3.

There was a 90% chance that a male chinook 60cm fork length (FL) or less was age one-ocean (Table 8). At six centimeters larger, 66cm FL, there was a 90% chance the male was age two-ocean. At 97cm FL there was an 88% chance the male was age three-ocean. For females at 84cm FL, there was a 47% chance the fish was age two-ocean and a 53% chance it was age three-ocean (Table 8). At 4cm larger, 88cm FL, there was a 91% chance the female was age three-ocean.

Table 8. Probability a spring Chinook salmon trapped at DNFH will be a certain ocean age at length, by sex. Based on data from 781 DNFH spring Chinook salmon with coded-wire tags from return years 2013-2019. Probabilities were generated from a discriminant function for males and a logistic model for females.

	Male			Female	
Fork	Probability of Being:			Probability of Being:	
Length (cm)	1-Ocean	2-Ocean	3-Ocean	2-Ocean	3-Ocean
45	100	0	0	100	0
46	100	0	0	100	0
47	100	0	0	100	0
48	100	0	0	100	0
49	100	0	0	100	0
50	100	0	0	100	0
51	100	0	0	100	0
52	100	0	0	100	0
53	99.9	0.1	0	100	0
54	99.9	0.1	0	100	0
55	99.7	0.3	0	100	0
56	99.4	0.6	0	100	0
57	98.8	1.2	0	100	0
58	97.5	2.5	0	100	0
59	95	5	0	100	0
60	90.2	9.8	0	100	0
61	81.6	18.4	0	100	0
62	68.2	31.8	0	100	0
63	50.9	49.1	0	100	0
64	33.4	66.6	0	100	0
65	19.5	80.5	0	100	0
66	10.5	89.5	0	100	0
67	5.3	94.7	0	100	0
68	2.7	97.3	0	100	0
69	1.3	98.7	0	100	0
70	0.6	99.4	0	100	0
71	0.3	99.7	0	99.9	0.1
72	0.1	99.8	0	99.9	0.1
73	0.1	99.9	0	99.8	0.2
74	0	99.9	0	99.6	0.4
75	0	99.9	0	99.3	0.7
76	0	99.9	0.1	98.7	1.3
77	0	99.9	0.1	97.8	2.2
78	0	99.9	0.1	96.3	3.7
79	0	99.8	0.2	93.6	6.4
80	0	99.7	0.3	89.3	10.7
81	0	99.5	0.5	82.7	17.3
82	0	99.2	0.8	73.3	26.7
83	0	98.7	1.3	61	39
84	0	98	2	47.2	52.8
85	0	96.9	3.1	33.9	66.1
86	0	95.2	4.8	22.6	77.4
87	0	92.6	7.4	14.3	85.7
88	0	88.9	11.1	8.7	91.3
89	0	83.6	16.4	5.2	94.8
90	0	76.4	23.6	3	97
91	0	67.3	32.7	1.8	98.2
92	0	56.7	43.3	1	99
93	0	45.4	54.6	0.6	99.4
94	0	34.6	65.4	0.3	99.7
95	0	25.2	74.8	0.2	99.8
96	0	17.6	82.4	0.1	99.9
97	0	12	88	0.1	99.9
98	0	8	92	0	100
99	0	5.2	94.8	0	100
100	0	3.4	96.6	0	100

Multiple Male Spawning

An average of 77% of male chinook spawned at DNFH were spawned with more than one female (Table 9). An average of 12% were spawned with two females and 10% were spawned with three females. Some males were spawned with five and six females, but that was rare. Larger males were spawned with multiple females more frequently than smaller males in an effort to produce more larger fish (Figure 3). The number of ripe fish isn't known at the beginning of a spawning take so if more ripe females are available at the end of a take than anticipated, males may be used with multiple females regardless of size. Additionally, the number of females in the broodstock always outnumbered the number of males (Table 4) requiring that some males are used with multiple females.

Table 9. The percentage of male Chinook by the number of females (1 - 6) they were spawned with by brood year.

Brood	Number of	% of Male Chinook by the Number of Females They Were Spawned With					
Year	Males	1	2	3	4	5	6
2019	647	73	9	18	0.6	0.0	0.0
2018	344	75	11	10	3.5	0.0	0.0
2017	405	80	7	13	1.0	0.0	0.0
2016	472	73	21	5	0.4	0.4	0.2
2015	621	82	12	5	0.3	0.2	0.0
	Average	77	12	10	1.2	0.1	0.0

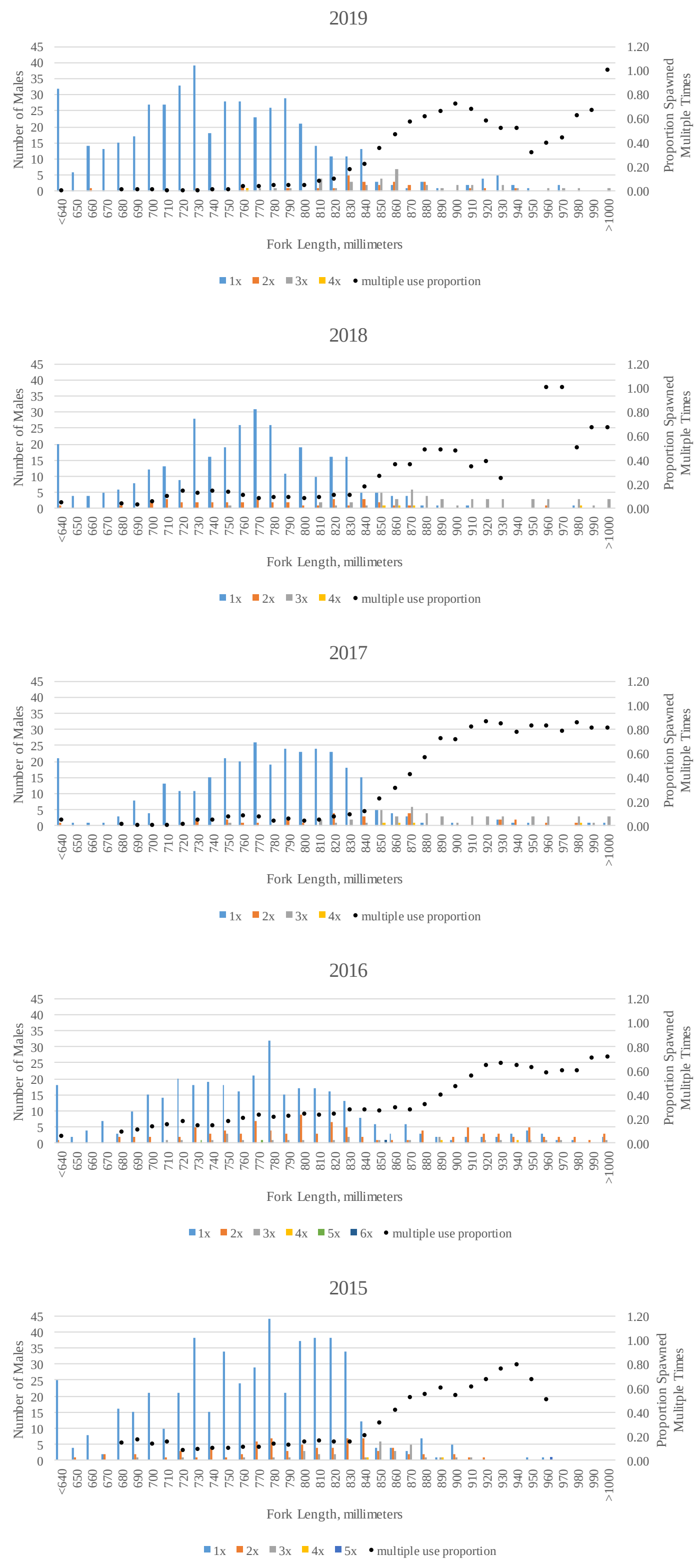

Figure 3. Number, size and times spawned of male broodstock spawned at Dworshak National Fish Hatchery from brood years 2015 – 2019. (Interpreting Figure 3: The left side y-axis represents the number of males spawned at a given length. The right side y-axis represents the proportion of males of a given length that were spawned multiple times. A value of 1.0 on the right side y-axis would mean that 100% of the males of that length were spawned more than once.)

Releases

The spring Chinook program release target from DNFH is 1.65 million smolts released on site and 300,000 pre-smolts released in the Selway River (Table 10). Through year 2014, the onsite release target was 1.47 million smolts, but beginning in 2015 co-managers increased production to 1.65 million smolts based on preliminary results from a study that showed that smolt rearing density could be increased without negatively impacting survival and the ability to produce returning adults (Appendix B).

The target size at release for onsite DNFH releases is 20 fish per pound (fpp) and the Selway parr release group has a target size of 100 fpp. Pre-release sampling typically occurred within one month of the release date. Fish per pound data was collected by DNFH production staff and IFWCO staff supplemented these data with individual measurements of length and weight in some years (Appendix C).

Measured size at release was close to target size. Smolts released in 2017 were released slightly earlier because they were exposed to high dissolved gas resulting from water released from Dworshak Reservoir from a record snow pack and mechanical problems with one of the dam's turbines. Chinook smolt fpp for the 2017 release was 23.1 (Table 10).

Chinook smolts were first sampled for precocity (mature male Chinook at smolt size) in 2018 in response to NOAA Biological Opinion reporting requirements (NOAA 2017). No precocious Chinook smolts have been documented to date (Table 10). Precocial fish in the parr group are not expected.

Table 10. Release date, number released, and fish per pound by brood year for spring Chinook salmon reared at Dworshak National Fish Hatchery.

	Onsite Smolt Releases[a]				Selway River Parr Releases[a]		
Brood Year	Release Date	Number Released	Fish per Pound	Percent Precocious	Release Date	Number Released	Fish per Pound
2017	3/27/2019	1,717,039	20	0	9/10/2018	422,713	81
2016	4/2/2018	1,645,125	20	0	9/11/2017	291,467	98
2015	3/20/2017	1,498,736	23	0		301,917	157
2014	3/23/2016	1,454,208	22	no data	9/8/2015	350,198	119
2013	3/25/2015	1,550,313	22	no data	9/8/2014	384,051	93

[a] The smolt release goal was 1.65M and the pre-smolt release goal was 300k.

Emigration Performance and Survival

Emigrant survival to Lower Granite Dam and Bonneville dam were estimated using the University of Washington's Data Access in Real Time (DART) website: http://www.cbr.washington.edu/dart which applies Cormack-Jolly-Seber estimates (University of Washington 2020).
Median travel time from DNFH to LGR ranged from 14 to 30 days and travel to Bonneville Dam ranged from 37 to 48 days (Table 11). Ninety percent of the emigrating Chinook were typically

detected at LGR by the first week in May and at Bonneville Dam by mid-May. Survival to LGR ranged from 68 to 78 percent and survival to Bonneville ranged from 38 to 49 percent (Table 11).

Table 11. Percent survival of DNFH spring Chinook smolts to Lower Granite and Bonneville dams and days until specified percentages were detected at each dam by release

				Travel to Lower Granite Dam						Travel to Bonneville Dam					
Release Year	Brood Year	Release Date[a]	Release Location	Median Travel Time (days)[b]	Date of Percent Detection 10%	50%	90%	Percent Survival	Std Err	Median Travel Time (days)[b]	Date of Percent Detection 10%	50%	90%	Percent Survival	Std Err
2019	2017	3/27/19	NF Clw R.	14	31-Mar	10-Apr	4-May	68	0.012	37	30-Apr	7-May	17-May	47.2	0.074
2018	2016	4/2/18	instem Clw	27	9-Apr	29-Apr	10-May	75	0.015	37	1-May	8-May	15-May	49	0.141
2017	2015	3/20/17	NF Clw R.	34	25-Mar	23-Apr	4-May	69	0.014	47	28-Apr	6-May	14-May	38	0.122
2016	2014	3/23/16	NF Clw R.	30	4-Apr	22-Apr	4-May	71	0.007	43	28-Apr	5-May	11-May	38.6	0.071
2015	2013	3/25/15	NF Clw R.	30	14-Apr	24-Apr	6-May	78	0.018	48	6-May	12-May	18-May	33	0.028

[a] Beginning release date; total releases may take days.
[b] Median Travel time is from the Fish Passage Center.

The arrival profile of PIT-tagged smolts emigrating downstream to LGR was generally similar with the exception of emigration year 2015 where smolts arrived at LGR earlier relative to the other years (Figure 4).

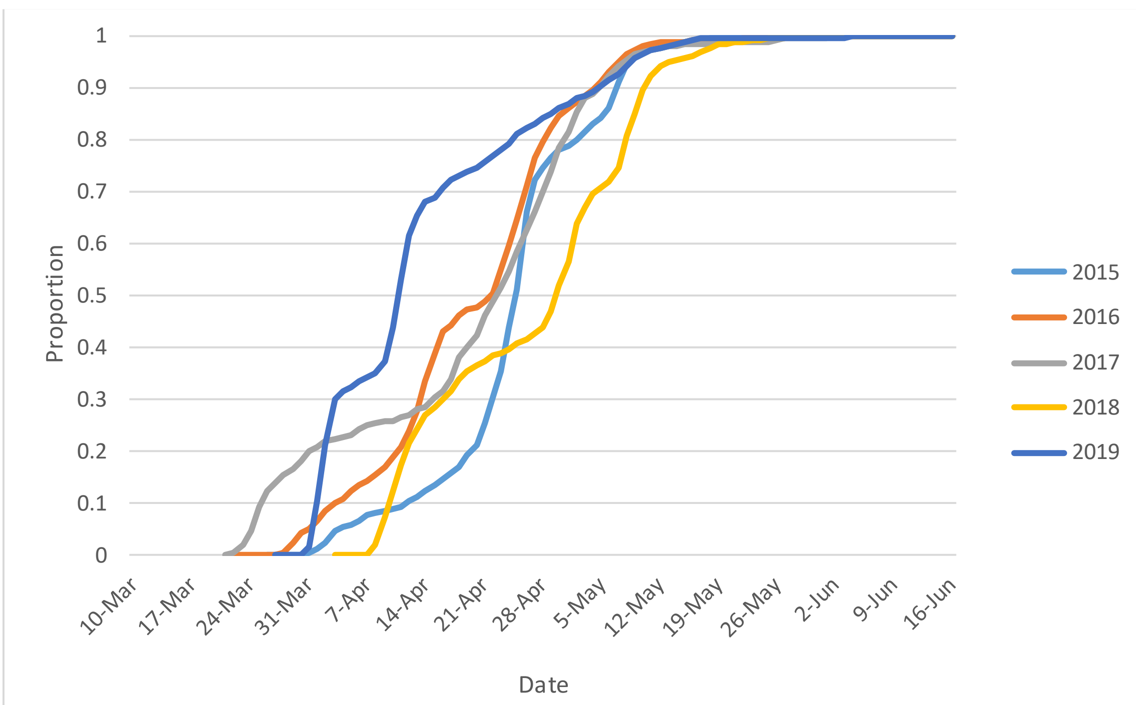

Figure 4. Proportion of Dworshak NFH spring Chinook smolt PIT tag detections at Lower Granite Dam by dated and emigration year.

The arrival profile of DNFH spring Chinook salmon PIT-tagged smolts emigrating and detected at Bonneville Dam was noteworthy due to the high degree of similarity of the profile between years (Figure 5).

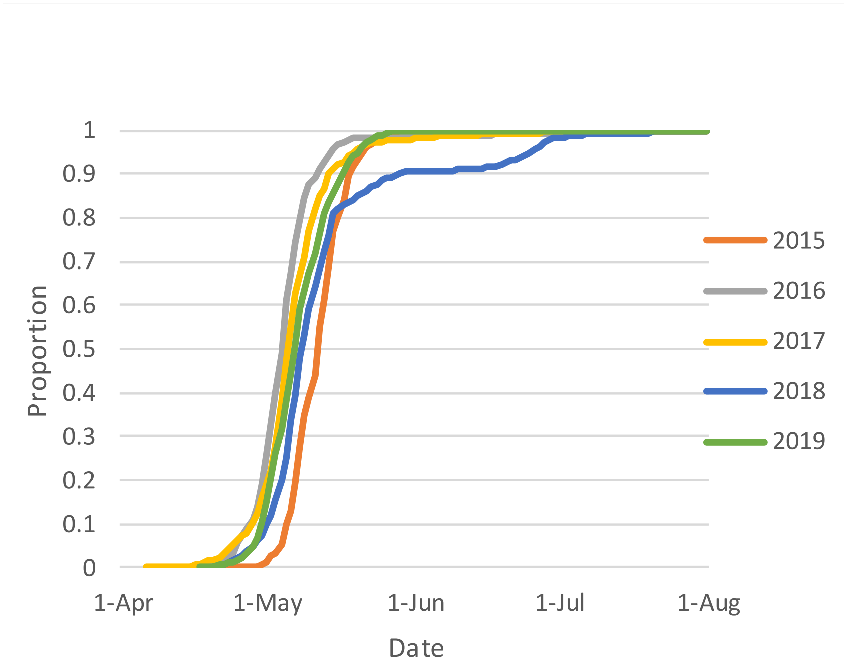

Figure 5. Proportion of Dworshak NFH spring Chinook smolt PIT tag detections at Bonneville Dam by date and emigration year.

Harvest

Harvest of DNFH spring Chinook salmon was estimated through coded-wire tag recoveries as reported in the Regional Mark Information System (RMIS) database. Coded-wire tag recoveries were expanded by effort and tagging rate to provide an estimate of the number of Chinook harvested downstream of LGR.

Estimated harvest downstream of Lower Granite Dam for the last 10 years for which all data was complete (brood years 2003 – 2012) was variable ranging from 484 to 2,816 fish and averaged 1,221 (Table 12).

Table 12. Number of Dworshak National Fish Hatchery (DNFH) spring Chinook salmon returning to Lower Granite Dam (LGR), smolt-to-adult return rate (SAR), number harvested in the Snake and Columbia Rivers downstream of LGR, and smolt-to-adult survival (SAS [SAS includes harvested fish when calculating survival]) by brood year. (Brood year and return year are the same for DNFH spring Chinook. Brood year "X" spring Chinook smolts are released in year "X + 2" and the adult returns from that brood year are complete in year "X +5".)

Brood Year	No. of DNFH spring Chinook to LGR[a]	Smolt-to-adult Return (SAR) to LGR (%)	No. of DNFH spring Chinook Harvested Downstream of LGR[b]	Smolt-to-adult Survival (SAS %)
2019				
2018				
2017	Returns not yet complete.			
2016				
2015				
2014	2,526	0.17	Not Available	
2013	1,990	0.13	Not Available	
2012	6,874	0.48	529	0.52
2011	14,103	1.02	2,816	1.23
2010	7,549	0.72	1,001	0.82
2009	3,135	0.29	484	0.34
2008	12,653	1.14	1,187	1.25
2007	5,757	0.57	502	0.62
2006	8,496	0.90	2,526	1.17
2005	3,879	0.40	665	0.47
2004	3,322	0.33	1,928	0.52
2003	1,568	0.15	572	0.20
2002	2,897	0.27	812	0.34
2001	1,682	0.16	463	0.21
2000	7,040	0.70	1,957	0.90
1999	1,266	0.38	81	0.40
1998	10,359	1.02	4,739	1.48
1997	12,306	1.18	4,934	1.65
1996	10,851	1.11	1,070	1.22
1995	340	0.64	3	0.65
1994	343	0.33	113	0.44
1993	4,913	0.37	586	0.42
1992	1,703	0.13	271	0.15
1991	65	0.90	16	1.12
1990	45	0.00	2	0.00
1989	553	0.05	444	0.09
1988	828	0.07	354	0.09
1987	148	0.01	70	0.01
1986	2,636	0.17	2,581	0.34
1985	1,945	0.11	138	0.12
1984	932	0.14	129	0.16
1983	3,211	0.28	23	0.28
1982	767	0.29	0	0.29
1981	390	0.07	0	0.07

[a] The LSRCP goal for the DNFH program is to return 9,135 spring Chinook to LGR.

[b] The LSRCP harvest goal in the Snake and Columbia Rivers downstream of LGR is 36,540 spring Chinook.

Smolt-to-adult Survival Indices

Smolt-to-adult return rate (SAR) was the initial metric established for the survival needed to achieve the requisite number of returning adults. The LSRCP mitigation goal for the DNFH spring Chinook program was 9,135 adults returned upstream of Lower Granite Dam annually based on an SAR of 0.87%. Smolt-to-adult return rate is estimated as: (smolts detected at LGR/adults detected at LGR). Smolt-to-adult return rate does not take into account harvest in the mainstem Columbia River and Snake River basin.

Smolt-to-adult survival (SAS) is related to SAR but includes fish harvested in the mainstem Columbia River and Snake River basin (smolts detected at LGR/adults detected at LGR + Chinook harvested in the Columbia R. mainstem + Chinook harvested in the Snake R. basin) and as such is a more accurate metric of the success of the program to return DNFH Chinook to LGR. The LSRCP target SAS was 4.35% for DNFH spring Chinook.

Smolt-to-adult return rates ranged from 0.13% to 1.14% and averaged 0.58% for the 10 brood years 2005-2014 (Table 12). The target threshold of 0.87 was met or exceeded in 3 of those 10 years. SAS ranged from 0.47 to 1.25 for the most recent 10 brood years (2005 – 2014) and never achieved the target threshold of 4.35% (Table 12).

Parentage-based tagging (DNA analysis) and sampling of returning adults at LGR has made it possible to estimate adult returns for unmarked groups such as the Selway parr group. Adult returns and SAR's were low for this group (Table 13), likely due to size at release and release timing (parr were released the year before smolt emigration). Due to their small size parr were to coded-wire tagged so it was not possible to determined harvest or SAS.

Table 13. Number of Dworshak National Fish Hatchery spring Chinook salmon parr released into the upper Selway River by brood year and the resulting smolt-to-adult return rate. (Brood year "X" spring Chinook parr are released in year "X + 1" and the adult returns from that brood year are complete in year "X + 5".)

Brood year	Selway Releases Sampled at LGR	SAR (%) to LGR
2019	Returns not yet complete	
2018		
2017		
2016		
2015		
2014	4	0.0001
2013	0	0.0000
2012	6	0.0002
2011	352	0.0012
2010	79	0.0003

RECOMMENDATIONS

1. Modify broodstock handling, spawning and data collection procedures to improve broodstock accounting for the various hatchery programs.

2. Investigate the temporal use of 1-ocean males in past brood years and devise a strategy to limit their inclusion in the future to less than a specified percentage.

3. Investigate the efficacy of producing larger and older-aged fish through selectively using larger and older-aged males to fertilize the eggs of multiple females.

4. Compare survivals of spring Chinook released from the four hatcheries in the Clearwater basin, resulting spring Chinook returns, and identify variables affecting those outcomes to improve returns.

5. Encourage managers to review the results of increased rearing densities at DNFH on returns and make recommendations on future management and research actions.

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APPENDIX A

Appendix A. Spring Chinook stocks used for Dworshak National Fish Hatchery production by brood year.

		Spring Chinook Stock (%)			
Brood year	Release year	Leavenworth	Little White Salmon	Rapid River	Clearwater
1981	1983	13	75	12	0
1982	1984	100	0	0	0
1983	1985	32	68	0	0
1984	1986	100	0	0	0
1985-86	1987-88	0	0	100	0
1987-1993	1989-95	0	0	0	100
1994-98	1996-2000	0	0	0	100
1999	2001	0	0	36	64
2000-13	2002-15	0	0	0	100

APPENDIX B

Dworshak National Fish Hatchery Spring Chinook Salmon Density Study

Progress Report

Study Design
by
The Dworshak National Fish Hatchery
Hatchery Evaluation Team:
U.S. Fish and Wildlife Service
Nez Perce Tribe
Idaho Department of Fish and Game

Pedigree Analysis
by
Idaho Department of Fish and Game
Eagle Fish Genetics Laboratory
Matt Campbell & Craig Steele

Progress Report
by
Doug Nemeth
U.S. Fish and Wildlife Service
Idaho Fish and Wildlife Conservation Office (IFWCO)

Bill Young
Nez Perce Tribe & IFWCO

Idaho Fish Department of Fish and Game
Eagle Fish Genetics Laboratory

August 2018

INTRODUCTION

The Dworshak National Fish Hatchery Complex Hatchery Evaluation Team (2013) created a study design to "determine the maximum effective carrying capacity of spring Chinook salmon in raceways at Dworshak National Fish Hatchery". The initial strategy was to implement incremental increases in rearing density every three years. By the time the study design was completed in 2013, the co-managers agreed to conduct only the first three-year experiment using brood years 2012- 2014. This progress report provides available results from that action.

Brood year 2012 returns are complete and brood year 2013 1-ocean and 2-ocean returns are complete, have been analyzed, and are included in this report (Table 1). Adult returns from the study will be completed following 2019 returns. Few DNFH chinook salmon return as 3-ocean fish so the bulk of returns from the density study will have returned in calendar year 2018. The majority of brood year 2014 returns (2-ocean fish) are not included.

Table 1. Brood years, release years and return year by ocean age.

Year		Ocean Age		
Brood	Release	1-Ocean	2-Ocean	3-Ocean
2012	2014	2015	2016	2017
2013	2015	2016	2017	2018
2014	2016	2017	2018	2019

The high density or "treatment" groups were reared in a raceway with approximately 20,000 more smolts than the low density or "control" groups. Although termed "low" density, this density level represented the usual loading of about 45,000 smolts per raceway. The "high" density groups had about 65,000 smolts per raceway. Total smolt releases from the treatment and control groups were approximately equal each year. The study evaluation included rearing costs, juvenile metrics and adult returns.

Adults returning from the study groups were identified by the Idaho Fish and Game Eagle Fish Genetics Laboratory (EFGL) using parental-based tagging (PBT). All adults spawned to create the progeny released in this study were sampled and had their DNA analyzed and recorded in the EFGL database. Subsequent returns from the released progeny were 100% sampled and their pedigree analyzed to identify if they were reared in a low or high density raceway.

SPAWNING and REARING COSTS

The details of the cost analysis are provided in Jones et al. (2014). In summary, eggs from seven adult females (and milt from seven males to maintain a 1:1 ratio) were needed to produce an additional 20,000 smolts for each raceway. Costs by task were estimated (Table 2) and production of an additional 20,000 smolts per raceway was estimated to cost about $2,600 (Jones et al. 2014). Tasks were completed by existing personnel.

Table 2. Estimated costs for producing an additional 20,000 Chinook salmon smolts at DNFH (Jones et al. 2014).

Task	Cost
Spawning an additional seven females with seven males	$385
Fish Health (sampling spawned female ovarian fluid and for BKD)	$336
Egg incubation and care	$246
Ponding	$120
Feed and Feeding	$1,115
Adipose clipping	$400
Total per extra 20,000 smolts produced	$2,602

JUVENILE METRICS

Three metrics were evaluated for the rearing juveniles between the test groups: mortality occurring in the hatchery from October – March, size at release (length, weight and condition factor), and survival to Lower Granite Dam (LGR) and Bonneville Dam (BON). Results were compared using a t-test or two-way analysis of variance (ANOVA).

Mortality

Total percent, and average percent mortality observed from October – March revealed no significant difference between the low and high density groups (Table 3). Statistical analysis using a two-way ANOVA indicated significant differences among brood years ($P < 0.001$), but not between low and high density treatments ($P = 0.272$).

Size at Release

Length, weight and condition factor ($CF = weight/length^3$) were measured for 300 fish per raceway each month from October – March to estimate differences in growth rate between the low and high density rearing groups. Growth rates were similar between the groups so this analysis only compared juvenile size in March, which was a good estimate of size at release. Differences in mean length, weight and CF between the low and high density groups was determined using a t-test. Results demonstrated only a single significant difference in CF between low and high density groups for BY2012 ($p < 0.001$). All other comparisons were not significantly different (Table 4). Although statistically significant, the difference between the two groups (less than 2mm) is likely not biologically meaningful.

Juvenile Survival to Lower Granite (LGR) and Bonneville (BON) dams

Juveniles from low and high density groups were representatively PIT-tagged prior to release to estimate survival to LGR and BON. Approximately 5,000 – 7,000 fish in two or three low and two high density raceways were PIT tagged for brood years 2012 – 2014. Survival was estimated using the *SURvival under Proportional Hazards (SURPH)* model (Lady et al. 2013). Results demonstrated no differences in survival between the groups (Table 5).

Table 3. Total percent and average mortality for juveniles reared at low and high densities from brood years 2012 – 2014. Total mortality and percent mortality were measured from October to March in three low and three high density raceways.

Brood Year	Density	Raceway	Total Mortality	Percent Mortality	Average Mortality (std.dev.)
2012	Low	B22	93	0.217	0.285 (0.059)
		B27	140	0.321	
		B30	138	0.317	
	High	B17	133	0.203	0.185 (0.031)
		B19	130	0.202	
		B20	97	0.150	
2013	Low	B22	324	0.690	0.506 (0.167)
		B27	221	0.460	
		B30	176	0.367	
	High	B17	244	0.365	0.547 (0.354)
		B19	219	0.322	
		B20	645	0.955	
2014	Low	B22	2318	5.204	3.89 (1.239)
		B27	1306	2.744	
		B30	1735	3.721	
	High	B17	2650	4.066	2.818 (1.095)
		B19	1332	2.018	
		B20	1546	2.371	

Table 4. Mean (standard deviation) length, weight and condition factor (C.F.) at release for juveniles reared at low and high densities. Numbers in bold represent significant differences (t-test; $p < 0.01$) between the low and high density groups.

			Length	Weight	C.F.
2012	Low	Avg.	115.9	18.2	**1.148**
		Std. dev.	1.9	0.8	0.004
	High	Avg.	117.6	19.1	**1.163**
		Std. dev.	1.1	0.5	0.003
2013	Low	Avg.	121.6	20.2	1.105
		Std. dev.	2.6	1.5	0.017
	High	Avg.	124.2	21.4	1.103
		Std. dev.	3.0	1.4	0.010
2014	Low	Avg.	120.8	20.2	1.118
		Std. dev.	2.9	1.3	0.019
	High	Avg.	118.8	19.1	1.105
		Std. dev.	0.7	0.7	0.014

Table 5. Estimated mean survival to Lower Granite and Bonneville dams for PIT-tagged spring Chinook salmon juveniles reared at low and high density. Estimates were generated using the *SURvival under Proportional Hazards (SURPH)* model.

Brood Year	Density	LGR	BON
2012	Low	80.5	ND[a]
	High	85.6	ND[a]
2013	Low	77.7	36.2
	High	78.3	34.4
2014	Low	74.4	35.0
	High	73.5	36.8

[a] Anomalous detections made the accuracy of this calculation unreliable.

SMOLT RELEASES and ADULT RETURNS

Average smolt numbers per raceway from the control groups across the three brood years ranged from about 43,000 to 48,000 and the average per raceway for the treatment group ranged from about 64,000 to 67,000 (Table 6). Total release numbers between control and treatment groups differed from about 2,400 to 27,000 fish (Table 6).

Table 6. Number of chinook per raceway and total number for control and treatment groups by brood year.

	BY12		BY13		BY14	
	Control	Treatment	Control	Treatment	Control	Treatment
Average / Raceway	43,075	65,018	47,896	67,317	45,036	64,309
Total	387,675	390,105	431,064	403,900	405,322	385,851

Because total releases were similar between the groups, a similar number of returning fish between the two groups would indicate that the higher rearing density did not negatively affect survival to return. Returns from the control and treatment groups were very similar for brood year 2012 and the control group from brood year 2013 returned 60 more fish than did the treatment group (Table 7). However, the control group from brood year 2013 had about 27,000 more fish released. The associated smolt-to-adult return rate ([60/27,000]*100=0.22%) is within the range of SARs for DNFH Chinook, i.e., the additional 60 fish returning from the control group releases can be explained by the additional 27,000 fish released in the control group.

Table 7. Dworshak National Fish Hatchery (DNFH) spring Chinook returns to DNFH, Lower Granite Dam (LGR) and harvested in the Idaho sport fishery by brood year, experimental group and sex as determined from parental-based tagging (PBT).

	BY12		BY13		BY14	
Sex	Control	Treatment	Control	Treatment	Control	Treatment
Male	189	169	128	79	11	12
Female	172	185	116	105	0	0
Subtotal	361	354	244	184	11	12

There was no pattern between the two groups at producing fish of a certain age or differences in returns by sex (Table 8).

Table 8. Dworshak National Fish Hatchery (DNFH) spring Chinook returns to DNFH, Lower Granite Dam (LGR) and harvested in the Idaho sport fishery by brood year, sex, experimental group and ocean age as determined from parental-based tagging (PBT).

	BY12				BY13				BY14			
Ocean	Male		Female		Male		Female		Male		Female	
Age	Control[a]	Treatment[a]	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment
1	30	15	0	0	2	7	0	0	11	12	0	0
2	150	143	157	175	126	72	116	105	RY18	RY18	RY18	RY18
3	9	11	15	10	RY18	RY18	RY18	RY18	RY19	RY19	RY19	RY19
Subtotal	189	169	172	185	128	79	116	105	11	12	0	0

SUMMARY

The data show no meaningful differences in any of the measured parameters as a result of a higher density rearing environment; although returns from all three brood years are not complete. If returns in 2018 and 2019 are similar to the results provided here, production of DNFH could be increased by 600,000 smolts (30 raceways * 20,000 smolts per raceway) without an expectation of decreased survival. Applying an average SAR of 0.38% (years 2005-2014 [FPC January 2017 report]) to these additional smolts, would produce an additional 2,300 DNFH Chinook to LGR. The estimated cost for this production would be about $78,000 (2,600*30) or $34 per returning DNFH Chinook to LGR.

The original stated goal of this study was to determine the carrying capacity of raceways at DNFH to rear Chinook. The results presented here don’t satisfy that goal except to note that the carrying capacity is likely greater than the high density tested, 65,000 smolts per raceway.

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APPENDIX C

Appendix C. Length, weight, condition factor, and percent parr and precocial for Dworshak National Fish Hatchery spring Chinook salmon smolts prior to release, release years 2017-2019.

2019

Raceway	Sample Date	n	Avg. Length (mm)	Avg. Weight (g)	Condition Factor (K)	% Parr	% Precocial
2	25-Mar	202	124	22	1.16	0	0
27	25-Mar	215	123	NA	NA	0	0
		Average	124	22	1.16	0	0

2018

Raceway	Sample Date	n	Avg. Length (mm)	Avg. Weight (g)	Condition Factor (K)	% Parr	% Precocial
1	8-Mar	100	120	no data	.	0	0
2	8-Mar	100	116	no data	.	0	0
6	8-Mar	100	120	no data	.	0	0
7	8-Mar	100	114	17.3	1.1	0	0
8	8-Mar	100	121	21.1	1.2	0	0
10	8-Mar	100	119	no data	.	0	0
16	8-Mar	100	116	no data	.	0	0
21	8-Mar	100	123	22.4	1.2	0	0
25	8-Mar	100	120	21.0	1.2	0	0
27	8-Mar	100	117	no data	.	0	0
		Average	119	20.5	1.2	0	0

2017

Raceway	Sample Date	n	Avg. Length (mm)	Avg. Weight (g)	Condition Factor (K)	% Parr	% Precocial
A4	16-Mar	100	113	16.2	1.1	no data	no data
B20	16-Mar	100	120	19.8	1.1	no data	no data
B21	16-Mar	100	120	19.8	1.1	no data	no data
A6	16-Mar	100	119	19.2	1.1	no data	no data
A5	16-Mar	100	121	19.5	1.1	no data	no data
A8	16-Mar	99	117	17.3	1.1	no data	no data
B19	16-Mar	100	122	20.3	1.1	no data	no data
B22	16-Mar	100	120	19.6	1.1	no data	no data
B23	16-Mar	99	118	17.7	1.1	no data	no data
A7	16-Mar	99	121	19.8	1.1	no data	no data
82	17-Mar	100	119	18.9	1.1	no data	no data
80	17-Mar	100	120	20.0	1.2	no data	no data
78	17-Mar	100	118	18.5	1.1	no data	no data
76	17-Mar	100	118	18.6	1.1	no data	no data
74	17-Mar	100	116	18.2	1.2	no data	no data
72	17-Mar	100	117	18.8	1.2	no data	no data
57	17-Mar	100	120	20.3	1.2	no data	no data
55	17-Mar	100	121	20.0	1.1	no data	no data
53	17-Mar	100	118	19.5	1.2	no data	no data
51	17-Mar	97	121	21.9	1.2	no data	no data
		Average	119	19.2	1.1		