U.S. Fish and Wildlife Service
Columbia River Fish and Wildlife Conservation Office

2015 Migration Year Juvenile Upriver Bright Fall Chinook Release Report from Little White Salmon and Willard National Fish Hatcheries

FY 2016 Progress Report


Kari J. Dammerman

U.S. Fish and Wildlife Service
Columbia River Fish and Wildlife Conservation Office
Vancouver, WA 98683

July 2016

On the cover: *The Little White Salmon (left) and Willard (right) National Fish Hatcheries are two facilities within the Columbia River Gorge Complex. U.S. Fish and Wildlife Service stock photographs by Speros Doulos and Cheri Anderson.*

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The correct citation for this report is:

Dammerman, K.J. 2015 Migration Year Juvenile Upriver Bright Fall Chinook Release Report from Little White Salmon and Willard National Fish Hatcheries, 2016 Progress Report. U.S. Fish and Wildlife Service, Columbia River Fish and Wildlife Conservation Office, Vancouver, WA. 10 p. www.fws.gov/columbiariver/publications.html

2015 MIGRATION YEAR JUVENILE UPRIVER BRIGHT FALL CHINOOK RELEASE REPORT FROM LITTLE WHITE SALMON AND WILLARD NATIONAL FISH HATCHERIES

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Kari J. Dammerman

U.S. Fish and Wildlife Service
Columbia River Fish and Wildlife Conservation Office
1211 SE Cardinal Court, Suite 100
Vancouver, WA 98683

Abstract

Juvenile upriver bright fall Chinook are reared and released from the Little White Salmon and Willard National Fish Hatcheries as mitigation for the effects of hydropower development. In 2015, juveniles were released from both facilities earlier than planned (early July vs. late July) due to elevated water temperatures in the Columbia River. The effects of this release date on juvenile metrics including downstream migration time and survival, and whether 2015 metrics differed between facilities and among previous release years had not been evaluated. Release data including release dates, number of juveniles released, and size at release from 2001-2015 was compiled from the Columbia River Information System (CRiS). The number of PIT tagged juveniles annually released from each facility and detection histories throughout the Columbia River basin was downloaded from the PIT Tag Information System (PTAGIS). T-tests and a one-way ANOVA were used to compare mean juvenile size at release and travel times to BONN among release years. Juvenile survival and encounter probabilities at BONN were estimated using a Cormack-Jolly-Seber model in the program, MARK. Fish released from both facilities in 2015 were comparable in size and larger than fish released in 2014. However, mean juvenile size did not statistically differ among all release years ($p=0.55$). Juvenile detection rates at BONN were comparable across release years ranging from 4.6 to 13.2%. Mean travel time to BONN ranged from 11.0 to 31.4 days, and was statistically different for fish that were released from 2008-2011 versus 2012-2015 ($p = 0.04$). Juveniles released in 2015 from the Little White Salmon facility had half the mean travel time, twice the detection rate, higher survival probability, and a higher encounter probability at BONN in comparison to juveniles released from the Willard facility. However, estimated juvenile survival was lower in 2015 in comparison to fish released in 2014. Results indicate that post-release riverine conditions including temperature may have a significant influence on juvenile survival and downstream migration at both facilities. Future studies include examining whether detection rates and survival at BONN differed between the facilities due to geographic location, potential differences in fish condition at release, differing predation pressure during downstream migration, residualization within the stream, or precociousness. Evaluating these differences would be beneficial for accurately predicting year-class strength, and estimating future adult return rates.

[1]kari_dammerman@fws.gov

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Introduction

The Little White Salmon (LW) National Fish Hatchery (NFH) and Willard (WI) NFH are two facilities in the Columbia River Gorge Complex. Both hatcheries are located on the Little White Salmon River, upstream of the confluence of the Columbia and Little White Salmon rivers (Fig. 1). Juvenile Chinook salmon (*Oncorhynchus tshawytscha*) are reared and released from both facilities as mitigation for the effects of hydropower development on Columbia River fisheries. Funding for these programs is provided by the Mitchell Act passed by Congress in 1938, administered by the National Marine Fisheries Service, and from the U.S. Army Corps of Engineers through the John Day/The Dalles Dam Mitigation program. Juveniles released from both facilities into the Little White Salmon River migrate approximately 30km downstream in the Columbia River to Bonneville Dam (BONN) before continuing to the Pacific Ocean. Adults migrating through the Pacific Ocean and returning to the Little White Salmon River provide sport, commercial and tribal harvest opportunities as well as serve as broodstock, thereby relieving pressure on wild stocks.

The Upriver Bright (URB) fall Chinook program began at the LW facility in the 1980s. Juveniles are reared from artificial propagation of broodstock caught in the fall, and released the next summer as age-0 fish. Juvenile production has greatly expanded over the years with the facility currently having an annual release goal of 4.5 million juvenile URBs. PIT tagging of juveniles prior to release began at LW NFH in 2008 in order to monitor downstream movement and estimate survival. Given a projected smolt-to-adult survival rate of 0.32%, the annual juvenile release goal is expected to result in approximately 14,400 total adult production including those harvested plus returns to the LW facility (USFWS 2015). The WI facility began rearing URBs in 2014 from broodstock collected at the LW facility. Juveniles were first PIT tagged in 2015 prior to release. The facility has an annual goal of releasing 2.0 million juvenile URB into the Little White Salmon River consistent with the Endangered Species Act Biological Opinion (NMFS 2007). Assuming a projected smolt-to-adult survival rate of 0.32%, the annual juvenile release of 2 million fingerlings is expected to result in approximately 6,400 total adult production, including those harvested plus returns to the hatchery. Juvenile release metrics that are monitored annually at these facilities include the timing of release, size at release, migration time, and predicted survival during migration. Despite long-term monitoring at LW NFH, understanding the influence of riverine processes on these metrics is not well-understood.

In 2015, elevated water temperatures in the Columbia River necessitated a release date of early July vs. late July for the juvenile URBs at both facilities. The consequences of this release date and how juvenile monitoring metrics differed between facilities and from previous release years was unknown. The purpose of this report is to: 1) summarize release metrics for juveniles released from LW and WI NFHs in 2015; 2) compare and contrast 2015 data between facilities and to data from previous release years; and 3) discuss the biological basis for differences in release metrics and potential future monitoring studies. Findings from this report provide insight on how in-stream environmental variation affects juvenile migration timing and survival through the Columbia River, one of the key goals of the monitoring and evaluation plans for Columba River Gorge facilities. Knowledge on these juvenile metrics is imperative for accurately forecasting annual adult return rates, and designing effective hatchery management strategies for salmonid restoration.

Methods

Mean daily water temperature data at BONN during the juvenile URB release period was downloaded from the Fish Passage Center website for 2008 to 2015. In 2015, approximately 15,000 juvenile URBs at each facility were retrieved from hatchery raceways using dipnets, and PIT tagged on June 8th and June 22nd. Juveniles were weighed to determine size (fish/pound), and subsequently released from WI and LW NFHs (Fig. 1) on July 1st and 2nd, respectively. Release dates, the number of juveniles released, and mean size at release for URB juveniles reared in previous years was obtained from the Columbia River Information System (CRiS) database maintained at the Columbia River Fish and Wildlife Conservation Office. Comparisons among release years in mean juvenile size at release and mean travel times to BONN were conducted using a one-way ANOVA and two-tailed, t-tests in the statistical program, R version 3.3.0 (R Core Development Team).

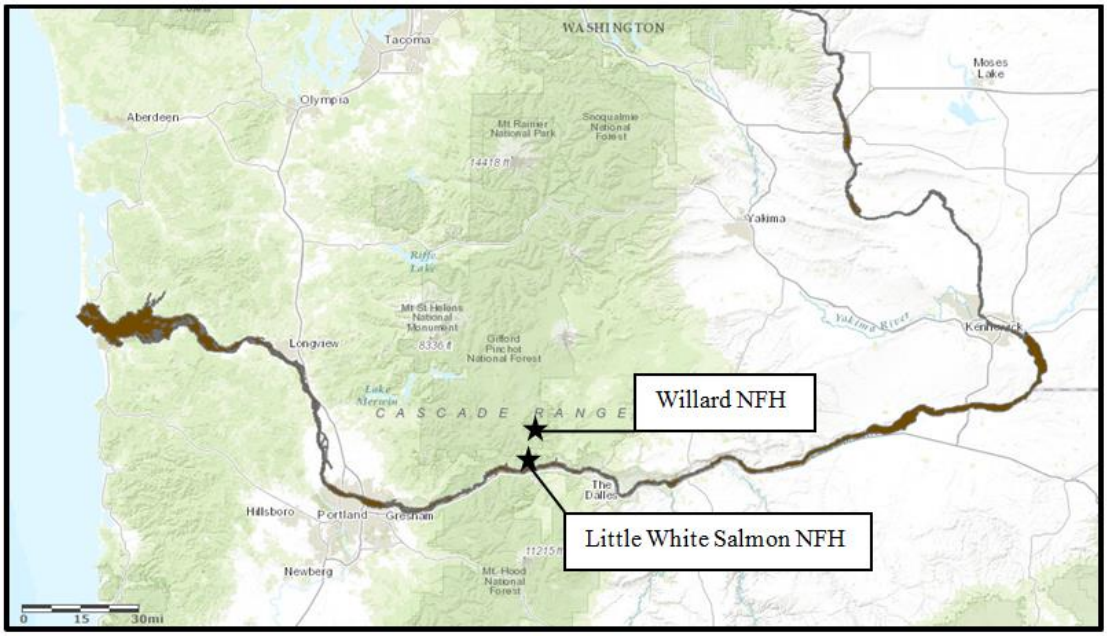

Figure 1. The LW and WI NFHs are located on the Little White Salmon River in Washington, upstream of the Columbia River (brown). Map was modified from a Columbia River Basin layer map available on the ArcGIS REST API (Environmental Systems Research Institute).

PIT tag detection records for juvenile URBs released from both facilities since 2008 were downloaded from the Columbia Basin PIT Tag Information System (PTAGIS) database. Travel time was quantified for each fish as the number of days from release to detection at BONN. Mean, minimum, and maximum travel time to BONN for juveniles released from both facilities was calculated for each release year. Apparent juvenile survival (ϕ_t) and encounter probabilities ($\mathbf{p_t}$) at BONN were estimated for the 2015 juvenile release using an open population, Cormack-Jolly-Seber (CJS) model implemented in the program, MARK (v. 6.1; White and Burnham 1999). Major assumptions of the CJS model include: the number of released individuals is known, tagged fish are representative of the population, all marked individuals have the same

probability of surviving and being encountered, and tags are not lost or misread (Cooch and White 2006). Estimates were obtained based on the model: ***Capture*** = ϕ_t * p_t with apparent survival and encounter probability being estimated at each capture event (White and Burnham 1999). Encounter histories for all of the juvenile URBs were compiled with PIT tagging date as the initial "marking" date, and PIT tag detection records to BONN and downstream of BONN classified as "recapture" events.

Results

At the WI facility, high mean water temperatures in 2015 (Fig. 2) led juvenile URBs to be released approximately one month earlier than planned, but at a larger mean size than the juveniles that were released in 2014 (Table 1). At the LW facility, juvenile URB release dates from 2001 to 2014 occurred between June 17th and July 3rd. In 2015, juveniles were released on the same date as fish reared in 2014, but mean fish size was larger (Table 1).

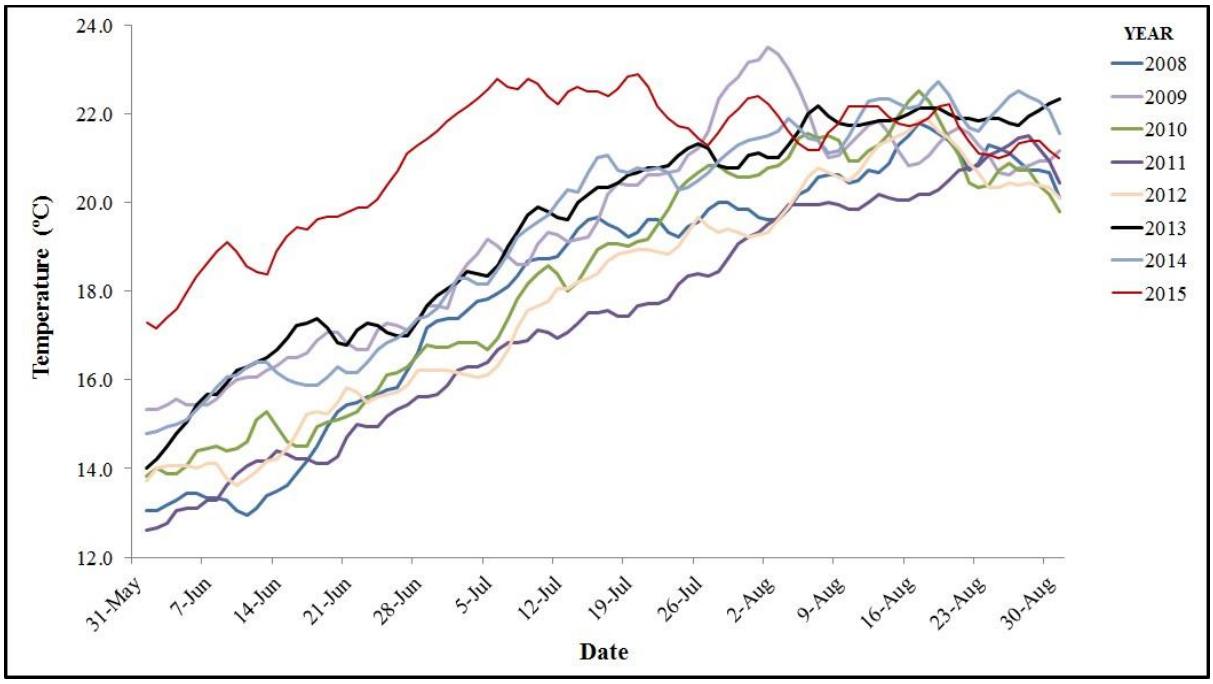

Figure 2. Mean daily water temperatures at Bonneville Dam from 2008 to 2015 during the juvenile URB release periods from LW and WI NFHs.

The number of juvenile URBs annually released from LW NFH doubled starting in 2009; however there was no significant difference in mean juvenile size ($p = 0.28$; $t = 1.12$) for URBs reared from 2001-2008 versus 2009-2015 (Table 1). Additionally, mean size did not statistically differ among release years ($p = 0.55$; $F = 0.99$) for juveniles released from LW NFH.

Table 1. Release metrics for juvenile URBs reared at the LW and WI NFHs.

Hatchery	Release Year	Release Date	Total Number Released	Mean Size at Release (Fish/lb)
LW	2001	21-Jun	1,937,764	109.2
	2002	20-Jun	2,074,295	82.2
	2003	26-Jun	2,084,184	91.9
	2004	17-Jun	2,031,737	87.4
	2005	23-Jun	1,459,873	75.0
	2006	22-Jun	1,802,174	82.2
	2007	28-Jun	2,061,924	77.1
	2008	3-Jul	2,001,760	96.0
	2009	18-Jun, 25-Jun	4,685,907	77.0
	2010	17-Jun, 24-Jun	4,551,259	85.0
	2011	23-Jun	4,475,868	87.0
	2012	26-Jun, 3-Jul	4,569,429	87.0
	2013	2-Jul	4,421,578	66.0
	2014	1-Jul, 2-Jul	4,406,392	89.5
	2015	2-Jul	3,972,526	82.4
WI	2014	28-Jul	1,873,260	94.4
	2015	1-Jul	1,803,264	81.8

Nearly 25,000 individuals were annually PIT tagged at LW NFH from 2008 to 2012. The number of juveniles that were annually PIT tagged decreased to 15,000 juveniles starting in 2013. Despite the differences in tagging efforts, the percent of PIT tagged juveniles detected at BONN were similar across release years ranging from 4.6 to 13.2% (Table 2). Mean travel time to BONN started decreasing in 2012, and was significantly different when comparing mean travel times from 2008-2011 versus 2012-2015 ($p = 0.04$, $t = 2.73$). Mean and maximum travel times to BONN were substantially lower for juveniles released in 2015 than observed in previous years (Table 2). In 2015, juveniles released from WI NFH had much lower detection rates and longer minimum, maximum, and mean travel times to BONN in comparison to juveniles released from LW NFH (Table 2).

Table 2. Juvenile UBR travel times to BONN following release from LW and WI NFHs

Hatchery	Release Year	# PIT Tagged	# Detected at BONN	% Detected	Travel Times (Days)		
					Min	Mean	Max
LW	2008	24,888	2,650	10.65	1.00	19.22	139.00
	2009	24,951	2,340	9.38	9.00	31.44	154.00
	2010	24,958	2,245	9.00	1.00	25.75	149.00
	2011	24,879	1,193	11.97	2.00	20.23	126.00
	2012	24,953*	1,140	4.57	0.50	16.03	127.00
	2013	14,961	1,978	13.22	0.50	14.52	143.00
	2014	14,931	1,787	11.97	1.00	19.18	137.00
	2015	14,963	1,194	7.98	1.00	11.24	44.00
WI	2015	14,934	433	2.91	5.00	20.20	123.00

*Total # of PIT Tagged fish at LW in 2012 was lower than total number actually PIT Tagged as reported on PTAGIS given fish loss due to piping error during PIT tagging.

In 2015, primary juvenile URB detection locations downstream of BONN were the Avian Colony on East Sand Island (ESANIS) and at Columbia River Estuary at rkm70 (PD7). Upstream of BONN, a few individuals were detected at the Avian Colony on Central Blalock Island (CBLAIS), and as a return to LW NFH (LWL). In previous years, additional (but infrequent) detection locations both upstream and downstream of BONN included Estuary Towed Array (TWX), Miller Sands Island/Columbia River Estuary (LMRSNI), McNary Oregon Shore Ladder (MC1), Little Miller Island (LMILIS), Crescent Island (CRESIS), Ice Harbor (ICH), the Dalles East Fish Ladder (TD1), Sherars Falls Fishway Trap on the Deschutes River (SHERFT), and Willamette Falls Fishway (WFF).

Survival estimates obtained from MARK indicated that survival in 2015 was approximately twice as high for juveniles released from LW NFH versus juveniles that were released from WI NFH (Table 3). Additionally, the probability of encountering an individual at BONN was higher for juveniles released from LW NFH. Survival and encounter probability estimates to BONN were overall lower for juveniles released from LW NFH in 2015 versus those released in 2014. Detection rates downstream of BONN were low with 254 and 302 total detections for juveniles released from LW NFH in 2014 and 2015, respectively, and 91 total detections for juveniles released from WI NFH in 2015.

Table 3. Survival (ϕ) and encounter probability (p) estimates ± SE (95% CI) for juvenile URBs released in 2015 from LW and WI NFHs.

Hatchery	Release Year	At BONN	
		ϕ_1	p_1
LW	**2014**	**0.63** ± **0.8** (0.50, 0.81)	**0.19** ± **0.02** (0.15, 0.24)
LW	**2015**	**0.48** ± **0.06** (0.38, 0.62)	**0.17** ± **0.02** (0.13, 0.21)
WI	**2015**	**0.26** ± **0.08** (0.16, 0.51)	**0.11** ± **0.03** (0.06, 0.18)

Discussion

Juvenile size at release

Size at release objectives for each facility are generally determined by hatchery management goals outlined in Hatchery and Genetic Management Plans. Variability in mean size of juveniles at release was observed among release years and between the two facilities. Juvenile size can vary due to a number of factors including rearing water temperature, amount of food fed and consumed on a daily basis, quality of food sources, fish health (disease events), timing of adult reproduction/gamete collection from broodstock (duration of rearing period in the hatchery), and selection of broodstock crosses as maternal effects have been well-documented in salmonids (Dunham 2011). Fish densities within raceways are also known to impact size; however, densities within the facilities have been consistent despite the increase in production levels starting in 2009.

Travel times, survival, and encounter probabilities

Juveniles released from WI NFH have a longer geographic distance to travel to BONN explaining why there were differences in juvenile travel times between facilities. However, the similar detection rates observed among release years at LW NFH and decreased juvenile travel times in 2015 suggest that post-release riverine conditions have a significant influence on juvenile downstream migration. In 2015, mean water temperature at Bonneville was approximately 2-4 degrees higher when juveniles were released in comparison to releases in previous years. Elevated water temperatures in the Columbia River may have prompted swifter migration through the system to cooler, ocean conditions in the Pacific. Additional riverine conditions that may have influenced juvenile downstream migration include flow conditions, water depth, availability of food sources, and the abundance of predators.

Notably, juveniles released in 2015 from LW NFH had decreased survival and encounter probabilities at BONN in comparison to fish released in 2014 indicating that faster downstream migration times do not necessarily improve juvenile survival. Higher survival and encounter probabilities for juveniles released from LW NFH were expected given that the facility is geographically closer to BONN. However, survival and encounter probabilities of juveniles released from WI NFH were almost half that of juveniles released from LW NFH even though fish were approximately the same size. The differential juvenile survival could be due to fish from WI NFH spending longer in the rivers thus making them more susceptible to predation. Alternatively, fish condition prior to release, stage of maturity (precociousness), residualization time, and environmental conditions within the Little White Salmon River between the facilities may also be impacting juvenile survival as they migrate downstream.

Future considerations

This report highlights the differences among rearing facilities as well as the importance of post-release, riverine conditions on survival during downstream migration for juvenile URBs. However, further areas of consideration include:

1) **Evaluating what in-stream conditions may be influencing juvenile migration times and survival within the Columbia River.** Apparent juvenile survival from release to BONN in 2015 was less than 60%. In addition, in some years, juveniles spent up to 154 days in the rivers following release before being detected at BONN. Knowledge on where these fish went, whether there is differential survival among individuals based on downstream migration time, and what factors may be influencing potential straying following release would be beneficial. Additionally, fish that migrate out of the stream faster have a higher probably of entering the ocean at a smaller size which could also lead to different survival within year classes.
2) **Determining the impact of riverine conditions and differences in juvenile fish condition between WI and LW NFHs on juvenile survival.** If survival estimates for juveniles released from WI NFH continue to be substantially lower, the timing of release and location for juvenile URBs reared at WI NFH should be evaluated. Additionally, intrinsic differences among juveniles reared at the two facilities should be considered including growth rates, precociousness, and fish health prior to release.
3) **Examine what factors within the facilities are contributing to differential survival among release years**. Size is a significant indicator of survival in juvenile fishes, and understanding why there is variation among release years would be beneficial to

designing effective rearing strategies within facilities and accurately predicting adult return rates.

4) **Increase detection rates at and downstream of BONN.** Detection rates at BONN are comparable across release years, but are low (4-13%) suggesting that a substantial number of fish are either not being detected at BONN or that post-release juvenile survival is very low. Detection rates downstream of BONN are too low to be able to estimate survival and encounter probability estimates as juveniles migrate downstream. Thus, increasing detection probabilities at and below BONN by conducting studies that track juvenile survival as they migrate downstream may be beneficial for accurately estimating the annual number of hatchery-reared juveniles that successfully migrate to the Pacific Ocean following release.

Knowledge within each of these areas would contribute to the long-term monitoring goals within the Columbia River Gorge facilities, and aid in determining whether facilities are successfully meeting their restoration goals of Pacific salmonids.

Acknowledgements

Data used in this report was downloaded from Columbia River Information System (CRiS), Columbia Basin PIT Tag Information System (PTAGIS), and the Fish Passage Center. Hatchery personnel at the Little White Salmon and Willard National Fish Hatcheries collected data on fish size and annual release numbers from the facilities. Marking crews from the U.S. Fish and Wildlife Service PIT-tagged juveniles prior to release to monitor downstream movement. Funding for production of Upriver Brights at the Little White Salmon and Willard NFHs was provided by the USACE (John Day/The Dalles Dam Mitigation) and National Marine Fisheries Service (Mitchell Act). Thank you to David Hand, Doug Olson, Steve Wingert, and Bob Turik for providing editorial assistance on the report.

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