YAKIMA/KLICKITAT FISHERIES PROJECT MONITORING AND EVALUATION

Yakima Subbasin

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FINAL REPORT
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THE CONFEDERATED TRIBES AND BANDS OF
THE YAKAMA NATION
Toppenish, WA 98948

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Table of Contents

List of Tables

List of Figures

Acknowledgements

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Executive Summary

The Yakima-Klickitat Fisheries Project (YKFP) is a joint project of the Yakama Nation (lead entity) and the Washington State Department of Fish and Wildlife (WDFW) and is sponsored in large part by the Bonneville Power Administration (BPA) with oversight and guidance from the Northwest Power and Conservation Council (NPCC). It is among the largest and most complex fisheries management projects in the Columbia Basin in terms of data collection and management, physical facilities, habitat enhancement and management, and experimental design and research on fisheries resources. The YKFP is attempting to evaluate all stocks historically present in the Yakima Subbasin and apply a combination of habitat restoration and hatchery supplementation or reintroduction, to restore the Yakima Subbasin ecosystem with sustainable and harvestable populations of salmon, steelhead and other at-risk species. This project and report address regional monitoring and evaluation strategies and sub-strategies as they apply to spring Chinook, summer/fall Chinook, and coho work in the Yakima Subbasin. This project (199506325) is related to numerous other projects in the Yakima Subbasin; additional information is available in the annual reports of these related projects.

The YKFP began a spring Chinook salmon hatchery program at the Cle Elum Supplementation and Research Facility (CESRF) near Cle Elum on the upper Yakima River in 1997. This program is a supplementation effort targeting the upper Yakima River population and is designed to test whether artificial propagation can be used to increase natural production and harvest opportunities while limiting ecological and genetic impacts. It is an integrated hatchery program because only natural-origin brood-stock are used and returning hatchery-origin adults are allowed to spawn in the wild. The program employs "best practice" hatchery management principles including reduced pond densities, strict disease management protocols, random brood-stock selection, and factorial mating to maximize effective population size. Fish are reared at the central facility, but released from three acclimation sites located near the central facility at: Easton approximately 25km upstream of the central facility, Clark Flat about 25km downstream of the central facility, and Jack Creek about 12km upstream from the Teanaway River's confluence with the Yakima River. The CESRF collected its first spring Chinook brood-stock in 1997, released its first fish in 1999, and age-4 adults have been returning since 2001. The first generation of offspring of CESRF and wild fish spawning in the wild returned as adults in 2005. The program uses the adjacent, un-supplemented Naches River population as an environmental and wild control or reference system.

Adult returns of fall Chinook to the Yakima River Basin consist mostly of hatchery-origin fish returning from releases averaging 1.6 million Upriver Brights annually from the Prosser Hatchery which have occurred since 1983. Summer-run Chinook were extirpated from the Yakima Basin by 1970. To increase the temporal and spatial distribution of summer/fall run Chinook in the Yakima River Subbasin, the program began releases of Wells Hatchery summer-run Chinook in the Yakima River Basin in 2009. Coho were extirpated from the Yakima Subbasin by the early 1980s. Pursuant to *U.S. v. Oregon* court-mandated agreements, substantial numbers (annual average > 700,000) of hatchery-reared coho salmon were released into the Yakima River since the mid-1980s. Prior to 1996 the primary purpose of releases was harvest augmentation and fish were released in sub-optimal spawning and rearing areas below Wapato Dam. With the inception of the YKFP in 1996, the objective of the coho program became "to determine the feasibility of reestablishing a naturally spawning coho population" and releases were moved upriver to more suitable habitats for natural coho.

Annual adult abundance of spring Chinook at Prosser Dam has increased from a 1982-2000 average of about 4,000 fish to a 2001-2014 average of approximately 11,200 fish. These increases can be attributed to returns from the Cle Elum supplementation program beginning in 2001, improved freshwater passage conditions, improved marine survival, and habitat restoration and enhancement work. Annual abundance of fall Chinook at Prosser Dam has increased from a 1983-1999 average of just over 1,000 fish to a 2000-2014 average of nearly 3,800 fish. While this increase coincides with improved ocean conditions, some of the increase may also be due to improved passage in the mainstem Columbia River, changes in the lower Yakima River that are making fish seek more amenable spawning areas further upriver, and improvements in spawning and rearing protocols. Over 1,500 summer-run Chinook passed above Prosser Dam in 2014, among the first adults to return to the Yakima Basin in over 40 years. A modern day record exceeding 21,000 Coho passed above Prosser Dam in 2014. Adult Coho returns to Prosser Dam averaged about 4,800 fish from 1997-2014 (an order of magnitude improvement from the average for years prior to the project) including estimated returns of wild/natural coho averaging about 1,000 fish since 2001.

Trends in adult productivity indices for Yakima Basin natural-origin spring Chinook appear to be very similar for both Upper Yakima and Naches populations. Trends in adult productivity indices for natural-origin coho are not as clear and 2014 marks the first year of observed high spawner escapements as we have seen with spring Chinook. Under present conditions, productivity for spring Chinook appears to peak at about 1,000 to 1,500 spawners and decline as spawner abundance approaches 2,000 fish or greater. These data indicate that density-dependent limiting factors depress natural productivity at fairly low population abundance in the Yakima River Basin. Until these factors are fully addressed, supplementation yields higher overall productivity rates and can be used to return adults to fisheries and to augment natural spawning populations.

For juvenile migration years 2000-present, annual abundance estimates of juvenile smolts migrating downstream at Prosser Dam averaged 243,140 wild/natural spring Chinook, 333,230 CESRF-origin spring Chinook, 27,490 wild/natural-origin coho, and 279,020 hatchery-origin coho. Preliminary smolt-to-adult survival indices averaged approximately 3.1% and 3.7% for natural-origin spring Chinook and coho, respectively. Because of many complexities associated with the production of smolt indices, these data are useful for analysis of trends but should not be used as direct citations of, or for comparisons of marked and unmarked, smolt-to-adult survival rates. Substantial juvenile mortality occurs as smolts migrate through the Yakima River system. Strategies have been proposed to address limiting factors and improve survival of emigrating Yakima Basin juveniles. As these strategies are implemented, we expect smolt and smolt-to-adult survival to improve.

Spatial distribution of spring Chinook spawners has increased as a result of acclimation site location, salmon homing fidelity and more fully seeding preferred spawning habitats. Spring Chinook redd counts in the Teanaway River increased from a pre-supplementation average of 3 redds per year to a post-supplementation average of 70 redds per year. Fall Chinook redd distribution in the Yakima River Basin appears to be experiencing a transition with an increasing proportion of redds observed above Prosser Dam in the most recent decade. This change is primarily attributed to substantial changes in lower Yakima River habitats in recent years. Redd counts and spatial distribution of coho have increased substantially in recent years, with over 200 redds enumerated annually in tributaries in the upper watersheds in most years since 2004. In 2014, over 700 coho redds were found in tributaries in the Naches and Upper Yakima Subbasins.

Monitoring and evaluation of diversity metrics is presently focused on the CESRF spring Chinook program in the Upper Yakima River. Generally, we have detected small, but significant differences between hatchery- and natural-origin fish in some juvenile and adult traits with many results already published in the peer-reviewed literature.

Overall average fine sediment levels in the Naches and Upper Yakima River subbasins appear to be trending downward.

We believe Yakima Basin spring Chinook contribute minimally to marine fisheries as their spatial and temporal ocean migration patterns do not appear to intersect with marine fisheries. However, Yakima Basin fall- and summer-run Chinook and coho do contribute substantially to marine fisheries and to mainstem Columbia River fisheries from the mouth to the Hanford Reach area. Recreational spring Chinook fisheries have returned to the Yakima River Basin after a 40-year absence. This has contributed to improved relationships between all the Basin's stakeholders and increased opportunities for collaboration.

Supplementation has increased spring Chinook redd abundance in the Upper Yakima relative to the Naches control system. We observed an average increase in redd counts in the upper Yakima about 75% greater than that in the Naches system from the pre- to post-supplementation periods. Natural-origin returns of adult spring Chinook in the post-supplementation period (2005-2014) were maintained or increased in the supplemented Upper Yakima River and appear to be declining in the Naches control system relative to the pre-supplementation period (1982-2004). After three generations of study, the results (many of which are published in the peer-reviewed literature) from the spring chinook supplementation program in the Upper Yakima River demonstrate that a well-designed and carefully managed integrated hatchery program using 100% natural-origin broodstock can produce fish for harvest and return fish to the natural spawning grounds with minimal negative impacts to the target ecosystem. Coho re-introduction research in the published literature suggests that hatchery-origin coho, with a legacy of as many as 10 to 30 generations of hatchery-influence, can reestablish a naturalized population after as few as 3 to 5 generations of outplanting in the wild.

YKFP efforts to monitor and evaluate hatchery reform focus on the CESRF spring Chinook program which was designed explicitly for this purpose from its inception. By designing the program to use only natural-origin fish for brood-stock, the program is meeting or exceeding scientific recommendations for proportionate natural influence (PNI) on an annual basis with a 14-year mean annual PNI of 65%. The project is thus far meeting or exceeding most other established objectives related to hatchery reform.

Major piscivorous predators in the Yakima River Basin include: common mergansers, American white pelicans, double-crested cormorants, gulls, great blue herons, northern pike minnows, and smallmouth bass. The project has initiated efforts to control the pike minnow and smallmouth bass populations.

Project results are communicated broadly through the annual science and management conference, technical reports and peer-reviewed journal publications (see references and project-related publications), and via several related web sites described in Appendix A.

Introduction

The Yakima-Klickitat Fisheries Project (YKFP) is a joint project of the Yakama Nation (lead entity) and the Washington State Department of Fish and Wildlife (WDFW) and is sponsored in large part by the Bonneville Power Administration (BPA) with oversight and guidance from the Northwest Power and Conservation Council (NPCC). It is among the largest and most complex fisheries management projects in the Columbia Basin in terms of data collection and management, physical facilities, habitat enhancement and management, and experimental design and research on fisheries resources. Consistent with Wy-Kan-Ush-Mi Wah-Kish-Wit (CRITFC 1995) and using principles of adaptive management (Salafsky et al. 2001), the YKFP is attempting to evaluate all stocks historically present in the Yakima Subbasin and apply a combination of habitat restoration and hatchery supplementation or reintroduction, to restore the Yakima Subbasin ecosystem with sustainable and harvestable populations of salmon, steelhead and other at-risk species.

The original impetus for the YKFP resulted from the landmark fishing disputes of the 1970s, the ensuing legal decisions in *United States versus Washington* and *United States versus Oregon*, and the region's realization that lost natural production needed to be mitigated in upriver areas where these losses primarily occurred. The YKFP was first identified in the NPCC's 1982 Fish and Wildlife Program (FWP) and supported in the *U.S. v Oregon* 1988 Columbia River Fish Management Plan (CRFMP). A draft Master Plan was presented to the NPCC in 1987 and the Preliminary Design Report was presented in 1990. In both circumstances, the NPCC instructed the Yakama Nation, WDFW and BPA to carry out planning functions that addressed uncertainties in regard to the adequacy of hatchery supplementation for meeting production objectives and limiting adverse ecological and genetic impacts. At the same time, the NPCC underscored the importance of using adaptive management principles to manage the direction of the Project. The 1994 FWP reiterated the importance of proceeding with the YKFP because of the added production and learning potential the project would provide. The YKFP is unique in having been designed to rigorously test the efficacy of hatchery supplementation. Given the current depressed status of many salmon and steelhead stocks, and the heavy reliance on artificial propagation as a recovery tool, YKFP monitoring results have great region-wide significance.

Supplementation is envisioned as a means to enhance and sustain the abundance of wild and naturally-spawning populations at levels exceeding the cumulative mortality burden imposed on those populations by habitat degradation and by natural cycles in environmental conditions. A supplementation hatchery is properly operated as an adjunct to the natural production system in a watershed. By fully integrating the hatchery with a naturally-producing population, high survival rates for the component of the population in the hatchery can raise the average abundance of the total population (hatchery component plus naturally-producing component) to a level that compensates for the high mortalities imposed by human development activities and fully seeds the natural environment. However, it is important to recognize that "rebuilding natural populations will ultimately depend on improving habitat quality and quantity" (ISRP 2011) of which habitat connectivity is an essential component (CRITFC 1995, Milbrink et al. 2011). Hatchery programs, even "state of the art" integrated supplementation programs designed to follow all of the best management practice recommendations (Cuenco et al. 1993, Mobrand et al. 2005), do not directly affect any of these habitat parameters which are vital to improving natural productivity. Therefore, the YKFP is working with partners in multiple forums to implement habitat restoration and water resource management projects designed to address factors limiting productivity (see Yakima Subbasin, Recovery, and Integrated plans).

The objectives of the YKFP are to: use Ecosystem Diagnosis and Treatment (EDT) and other modeling tools to facilitate planning for project activities, enhance existing stocks, re-introduce extirpated stocks, protect and restore habitat in the Yakima Subbasin, and operate using a scientifically rigorous process that will foster application of the knowledge gained about hatchery supplementation and habitat restoration throughout the Columbia River Basin. In scientific terms the stated purpose of the project is, "to test the assumption that new artificial production can be used to increase harvest and natural production while maintaining the long-term genetic fitness of the fish population being supplemented and keeping adverse genetic and ecological interactions with non-target species or stocks within acceptable limits" (RASP 1992, BPA 1996). WDFW is addressing hatchery uncertainties (see Columbia River Basin Research Plan) related to genetic and ecological interactions under project 1995-064-25. We are working jointly with WDFW to address the following additional hatchery uncertainties:

Hatchery Critical Uncertainty 3. What is the magnitude of any demographic benefit to the production of natural-origin juveniles and adults from the natural spawning of hatchery-origin supplementation adults?

Hatchery Critical Uncertainty 4. What are the range, magnitude, and rates of change of natural spawning fitness of integrated (supplemented) populations?

YKFP-related project research in the Yakima River Basin has resulted in the publication of approximately 50 manuscripts in the peer-reviewed literature (see References and Project-Related Publications). The status of ongoing research relative to the above two uncertainties is presented as part of this report.

This report includes sections on the following regional research, monitoring, and evaluation (RME) strategies: fish population status, harvest, hatchery, and predation. Each section addresses all relevant sub-strategies that apply to this project. The report addresses these strategies and sub-strategies as they apply to spring Chinook (*Oncorhynchus tshawytscha*), summer/fall Chinook (*O. tshawytscha*), and coho (*O. kisutch*) RM&E work in the Yakima subbasin. Steelhead (*O. mykiss*) RME work is addressed in related VSP (2010-030-00), on-reservation watersheds (1996-035-01), and Kelt Reconditioning (CRITFC 2008-458-00 and 2007-401-00) projects. WDFW is addressing hatchery uncertainties related to genetic and ecological interactions under project 1995-064-25. YKFP-related habitat activities for the Yakima Subbasin are addressed under projects 1997-051-00 and 1996-035-01 (except for sediment sampling which is addressed here). Hatchery Production Implementation (O&M) is addressed under project 1997-013-25. **Data and findings presented in this report should be considered preliminary until results are published in the peer-reviewed literature.**

Study Area

The project study area is the Yakima River Basin WRIA 37/38/39 (Figure 1).

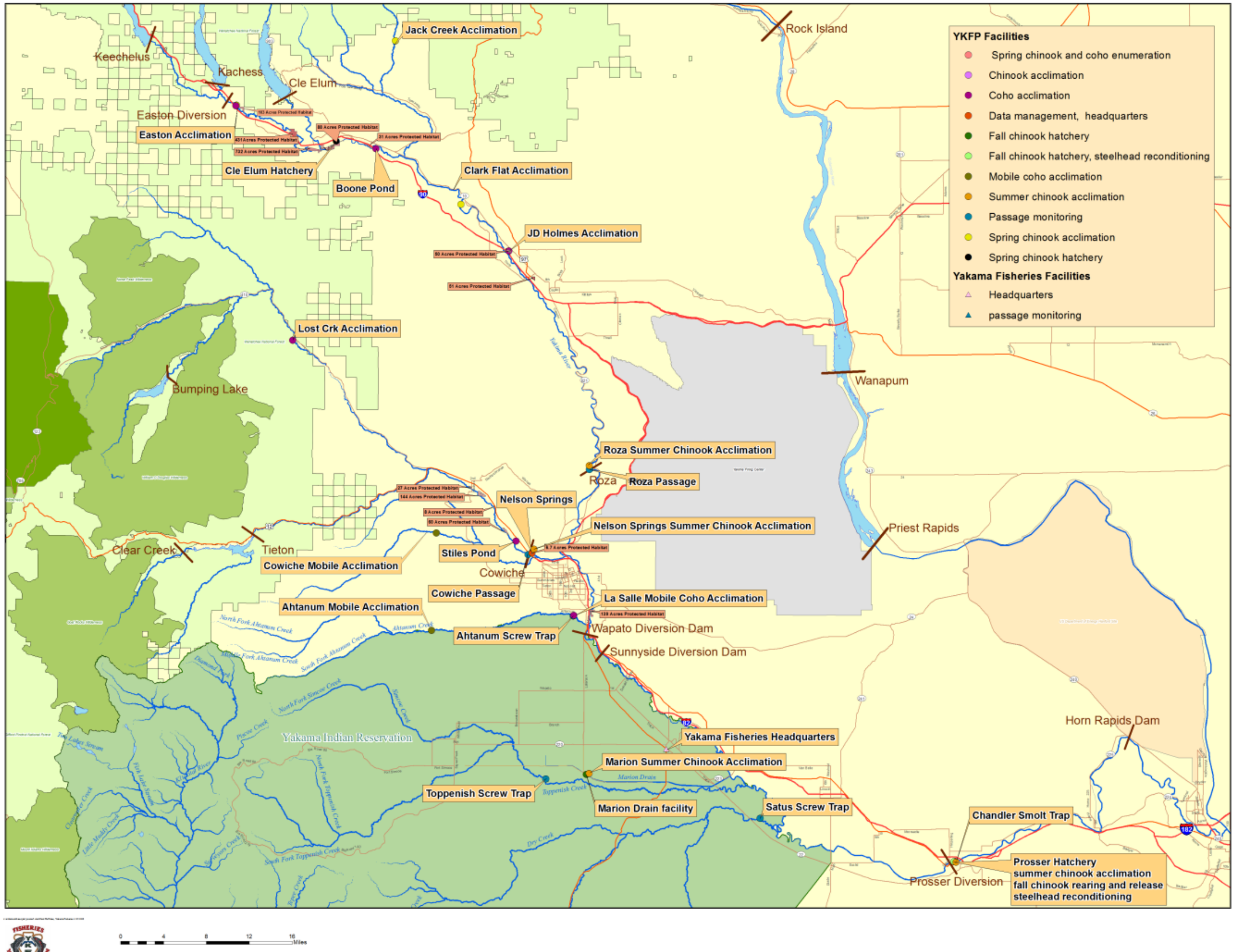


Figure 1. Yakima River Basin and Yakama Nation/YKFP-related artificial production and monitoring facilities (map provided by Paul Huffman).

Fish Population Status Monitoring

Status and Trend of Adult Fish Populations (Abundance)

Methods: Adult salmon populations in the Yakima River Basin are enumerated at Prosser Dam using video equipment installed in all three adult fish ladders (monitoringmethods.org methods 143, 144, 307, 418, 515). At both Prosser and Roza Dams, adult fish traps are also used on a seasonal basis for biological sampling and enumeration (monitoringmethods.org methods 135). When the Roza adult trap is not in operation, video equipment is also employed at the adult fish ladders there. However, camera placement and actual viewing area are limited; these combined with water clarity issues during certain river conditions all affect video enumeration at Roza Dam. Automatic Passive Integrated Transponder (PIT) tag detectors are also employed at all fish ladders at both dams (see sites RZF and PRO in ptagis.org). For the safety and protection of personnel and equipment, video and PIT-detection equipment are removed during periods of high river flow. In these instances, biologists attempt to extrapolate fish counts using data from before and after the high flow event. Although adult passage over spillways is believed to occur when flows are favorable, Prosser Dam counts are generally considered by Yakama Nation biologists to be within +/- 5% of actual fish passage. Roza Dam counts during trap operation (generally the entire spring Chinook counting period, March-September) are considered virtually 100% accurate; however during the late fall and winter counting period when video equipment is used at least part of the time, accuracy may fall to only 50-75% of actual fish passage based on preliminary evaluation of PIT tag detection data. Fish are denoted as hatchery- or natural-origin based on presence or absence respectively, of observed external or internal marks or tags (monitoringmethods.org method 342). Chinook are denoted as spring-, summer-, or fall-run based on review of PIT-detection data and visual observations of coloration and body morphometry.

At Prosser Dam, time-lapse video recorders (VHS) and a video camera were used at viewing windows at each of the three fishways. Digital video recorders (DVR) and progressive scan cameras (to replace the VHS systems) were tested at each of the three Prosser fishways in 2007 and became fully operational in February of 2008. The new system functions very similarly to the VHS system but provides digital video data readily downloadable to the viewing stations in Toppenish. This new system also allows technicians in Toppenish to scan rapidly to images of fish giving a more timely and accurate fish count. The technicians review the images and record various types of data for each fish that migrates upstream via the ladders. The data are entered into a Microsoft Access database, and daily dam count reports are regularly posted to the ykfp.org and Data Access in Real-Time (DART) web sites. Similarly at Roza Dam, adult trap data are entered into a Microsoft Access database, and daily dam count reports (with video counts integrated) are regularly posted to the ykfp.org and DART web sites. Post-season, counts are reviewed and adjusted for data gaps and knowledge about adult and jack lengths from sampling activities. Historical final counts are posted to the ykfp.org and DART web sites.

Spring Chinook began returning from the Cle Elum Supplementation and Research Facility (CESRF) in 2000 (jacks) and 2001 (adults). All CESRF-origin spring Chinook are marked. Due to physical and logistical constraints at the Prosser Hatchery it is not possible to mark all hatchery releases of summer/fall run Chinook without jeopardizing fish health and survival but these issues are being addressed through the Master Planning process (Yakama Nation 2012). Thus, enumeration of hatchery- and natural-origin summer/fall run Chinook adult returns is not presently available but will be available in the future. New marking protocols made it possible to distinguish hatchery- and natural-origin coho beginning with return year 2001.

Results:

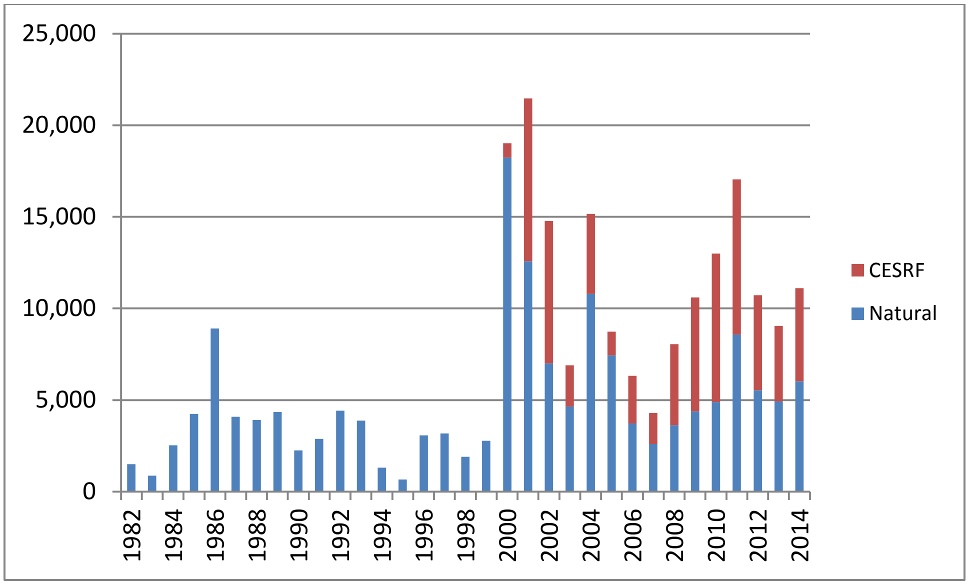


Figure 2. Estimated counts of natural- and Cle Elum Supplementation and Research Facility (CESRF-) origin spring Chinook (adults and jacks) at Prosser Dam, 1982-present.

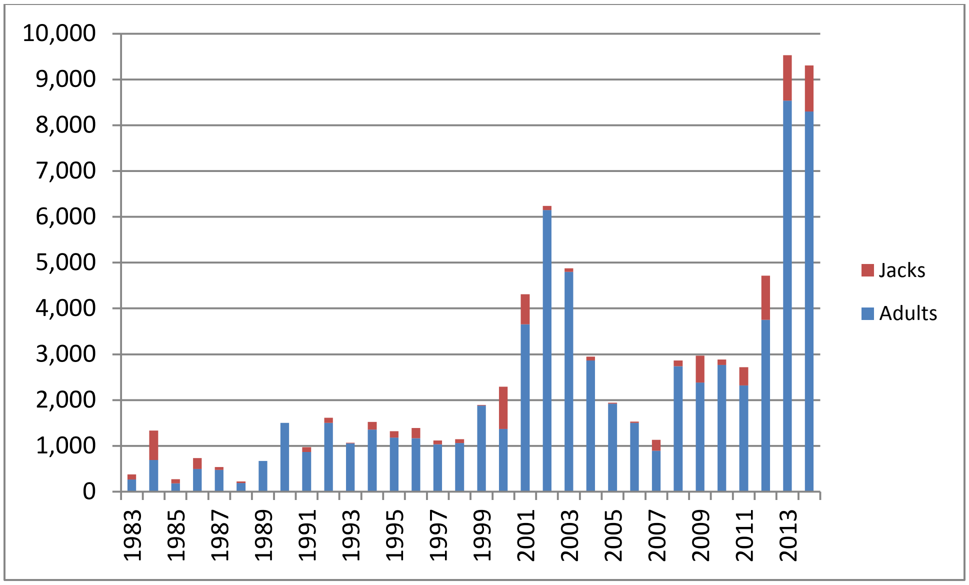


Figure 3. Estimated counts of adult and jack summer/fall run Chinook at Prosser Dam, 1983-present.

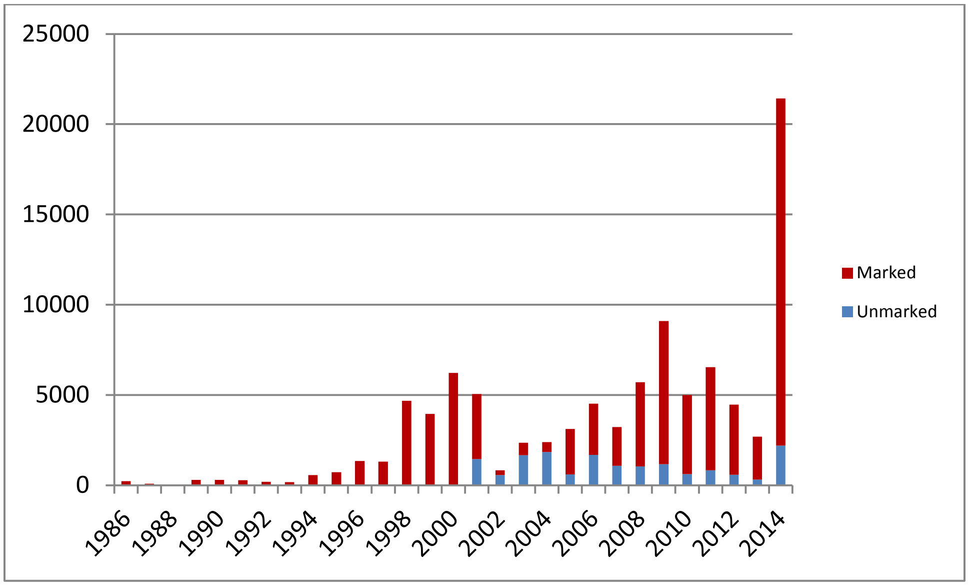


Figure 4. Estimated counts of marked (presumed hatchery-origin) and unmarked (presumed natural-origin) Coho (adults and jacks) at Prosser Dam 1986-present.

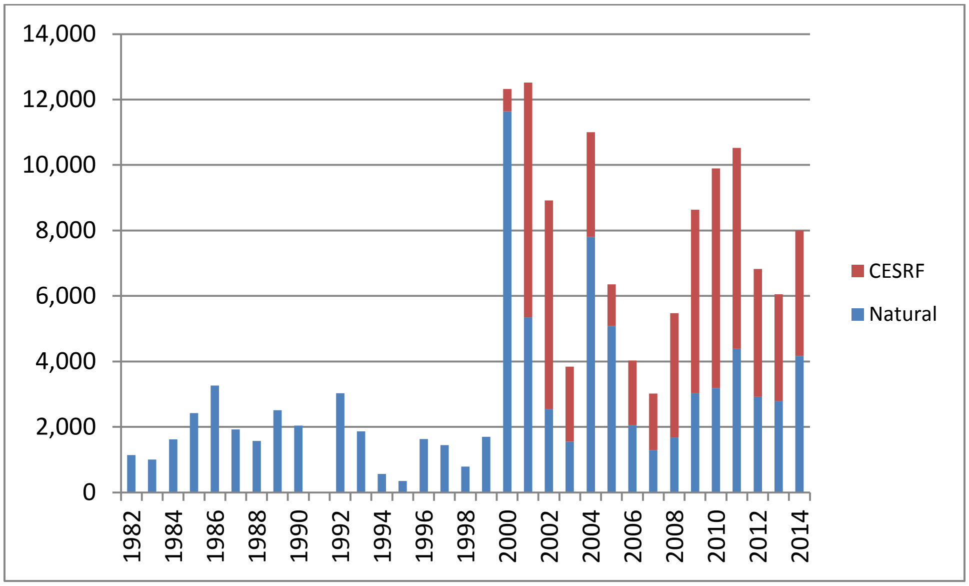


Figure 5. Estimated counts of natural- and Cle Elum Supplementation and Research Facility (CESRF-) origin spring Chinook (adults and jacks) at Roza Dam, 1982-present.

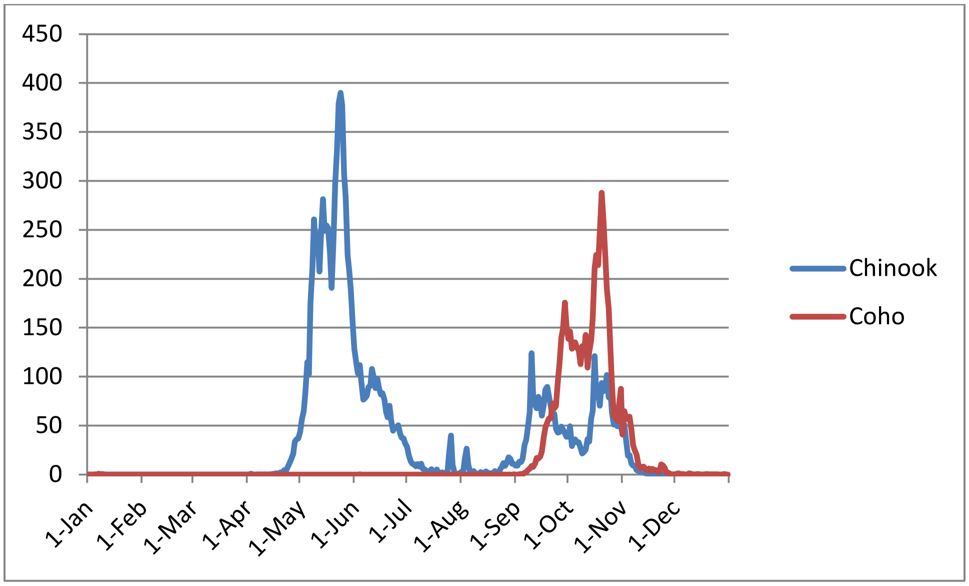


Figure 6. Average daily passage of Chinook and Coho (adults and jacks) at Prosser Dam, 2005-2014.

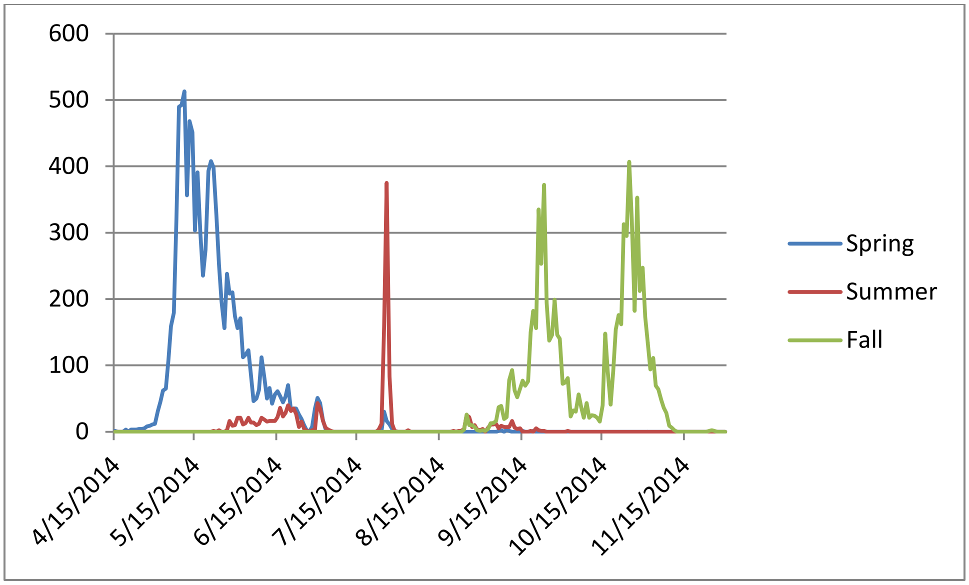


Figure 7. Passage timing of adult and jack Chinook at Prosser Dam in 2014 by run (see Methods).

Discussion:

Annual abundance of spring Chinook at Prosser Dam has increased from a 1982-2000 average of about 4,000 fish to a 2001-2014 average of approximately 11,200 fish (Figure 2). Annual abundance of spring Chinook at Roza Dam has increased from a 1982-2000 average of about 2,300 fish to a 2001-2014 average of approximately 7,500 fish (Figure 5). These increases can be attributed to returns from the Cle Elum supplementation program beginning in 2001, improved freshwater passage conditions, improved marine survival, and habitat restoration and enhancement work. The lowest adult returns since 2000 followed two years after the notable droughts which occurred during smolt outmigration years 2001 and 2005. Discussion of uncertainties relating to the Cle Elum spring Chinook supplementation program is included under Hatchery Monitoring later in this report. Additional data and detail on the Cle Elum spring Chinook supplementation program and the status of natural- and CESRF-origin spring Chinook in the Yakima River Basin are provided in Appendix B.

Although some natural production is occurring, adult returns of fall Chinook to the Yakima River Basin consist mostly of hatchery-origin fish returning from annual releases of Upriver Brights from the Prosser Hatchery which have occurred since 1983 and averaged about 1.9 million since 1999 (Yakama Nation 2012). In addition, the Yakama Nation has a goal of re-establishing Summer-run Chinook which were extirpated from the Yakima Basin by 1970. Pursuant to this goal we began releases of Wells Hatchery summer-run Chinook in the Yakima River Basin in 2009. Annual abundance of summer/fall Chinook at Prosser Dam has increased from a 1983-1999 average of just over 1,000 fish to a 2000-2014 average of over 4,000 fish (Figure 3). While this increase coincides with improved ocean conditions, some of the increase may also be due to improved passage in the mainstem Columbia River, changes (e.g., increased aquatic vegetation like stargrass *Heterantera dubia*, Wise et al. 2009) in the lower Yakima River that are making fish seek more amenable spawning areas further upriver, and improvements in spawning and rearing protocols. By re-establishing the summer-run component we seek to increase the temporal (Figures 6 and 7) and spatial distribution of summer/fall run Chinook in the Yakima River Subbasin (Yakama Nation 2012). Approximately 1,500 summer-run Chinook were estimated to pass above Prosser Dam in 2014 (Figure 7).

Coho were extirpated from the Yakima Subbasin by the early 1980s. Pursuant to *U.S. v. Oregon* court-mandated agreements, substantial numbers (annual average > 700,000) of hatchery-reared coho salmon were released into the Yakima River since the mid-1980s. Prior to 1996 the primary purpose of releases was harvest augmentation and fish were released in sub-optimal spawning and rearing areas below Wapato Dam. With the inception of the YKFP in 1996, the objective of the coho program became "to determine the feasibility of reestablishing a naturally spawning coho population" and releases were moved upriver to more suitable habitats for natural coho. Monitoring of these efforts to re-introduce a sustainable, naturally spawning coho population in the Yakima Basin have indicated that adult coho returns averaged about 4,800 fish from 1997-2014 (an order of magnitude improvement from the average for years prior to the project) including estimated returns of wild/natural coho averaging about 1,000 fish annually since 2001 (Figure 4).

Status and Trend of Adult Productivity

Methods:

We used recruit-per-spawner relationships (Ricker 1975) to describe adult-to-adult productivity indices. Species-specific methods were as follows.

Spring Chinook

Estimated natural-origin spawners for the Upper Yakima River were calculated as the estimated escapement above Roza Dam plus the estimated number of spawners between the confluence with the Naches River and Roza Dam. Total natural-origin returns to the Upper Yakima River were developed using run reconstruction techniques (Appendix B). Age composition for Upper Yakima returns was estimated from spawning ground carcass scale samples (monitoring methods.org method 112) for the years 1982-1996 and from Roza Dam brood-stock collection samples (Knudsen et al. 2006; Appendix B) for the years 1997 to present. Since age-3 fish (jacks) are not collected for brood-stock in proportion to the jack run size, the proportion of age-3 fish in the upper Yakima for 1997 to present was estimated using the proportion of jacks (based on visual observation) counted at Roza Dam relative to the total run size.

Estimated spawners and total returns for Naches River Subbasin natural-origin spring Chinook were calculated using run reconstruction techniques (Appendix B). Age composition for Naches Basin age-4 and age-5 returns were estimated from spawning ground carcass scale samples (monitoring methods.org method 112). The proportion of age-3 fish was estimated after reviewing jack count (based on visual observations) data at Prosser and Roza dams.

Estimated spawners at the CESRF were the total number of wild/natural fish collected at Roza Dam and taken to the CESRF for production brood-stock (Knudsen et al. 2006; Appendix B). Total returns of CESRF-origin fish were based on run reconstruction and Roza dam sampling operations. Age composition for CESRF fish was estimated using scales and PIT tag detections from CESRF fish sampled passing upstream through the Roza Dam adult monitoring facility (Knudsen et al. 2006; Appendix B).

Coho

From central British Columbia south, the vast majority of coho salmon adults are 3-year-olds, having spent approximately 18 months in fresh water and 18 months in salt water (Loeffel and Wendler 1968, Wright 1970). Therefore we estimated a natural-origin productivity (recruits per spawner) index by dividing natural-origin returns to Prosser Dam by the estimated returns to Prosser Dam three years prior. We computed this index for both adult and combined adult and jack returns per adult and combined adult and jack spawner. Note that this method will bias productivity estimates high, as it assumes no natural production from hatchery-origin spawners.

Summer/Fall Run Chinook

Adult fall Chinook returning to the Yakima Basin consist of hatchery-origin returns from releases at and above Prosser Dam and natural-origin returns from fish spawning naturally in the Yakima River. Due to fiscal, physical, logistical, and policy considerations, only a small proportion of hatchery-origin releases have been externally marked. Therefore it is impossible at present to know the origin of unmarked adult fall Chinook counted at Prosser. Additional marking is proposed for hatchery-origin releases as part of the Master Plan (Yakama Nation 2012), which will allow development of a comprehensive brood/cohort age at return table for natural- and hatchery-origin returns. Methods and results for evaluating adult productivity of summer/fall run Chinook will be included in future reports and publications as the data become available.

Results:

Table 1. Adult-to-adult productivity indices for upper Yakima wild/natural spring Chinook.

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns Age-3	Age-4	Age-5	Total	Returns/ Spawner
1984	1,715	92	1,348	139	1,578	0.92
1985	2,578	114	2,746	105	2,965	1.15
1986	3,960	171	2,574	149	2,893	0.73
1987	2,003	53	1,571	109	1,733	0.87
1988	1,400	53	3,138	132	3,323	2.37
1989	2,466	68	1,779	9	1,856	0.75
1990	2,298	79	566	0	645	0.28
1991	1,713	9	326	22	358	0.21
1992	3,048	87	1,861	95	2,043	0.67
1993	1,925	66	1,606	57	1,729	0.90
1994	573	60	737	92	890	1.55
1995	364	59	1,036	129	1,224	3.36
1996	1,657	1,059	12,882	630	14,571	8.79
1997	1,204	621	5,837	155	6,613	5.49
1998	390	434	2,803	145	3,381	8.68
1999	1,021[1]	164	722	45	930	0.91
2000	11,864	856	7,689	127	8,672	0.73
2001	12,084	775	5,074	222	6,071	0.50
2002	8,073	224	1,875	148	2,247	0.28
2003	3,341	158	1,036	63	1,257	0.38
2004	10,377	207	1,547	75	1,828	0.18
2005	5,713	293	2,630	14	2,936	0.51
2006	3,378	868	2,887	133	3,888	1.15
2007	2,322	456	3,976	65	4,498	1.94
2008	4,343	1,135	3,410	123	4,668	1.07
2009	7,056	283	2,572	109	2,964	0.42
2010	8,383	923	3,854			
2011	8,584	832				
2012	5,483					
2013	4,984					
2014	6,751					
Mean	4,228	364	2,892	119	3,299	1.72

1. The mean jack proportion of spawning escapement from 1999-2014 was 0.23 (geometric mean 0.17).

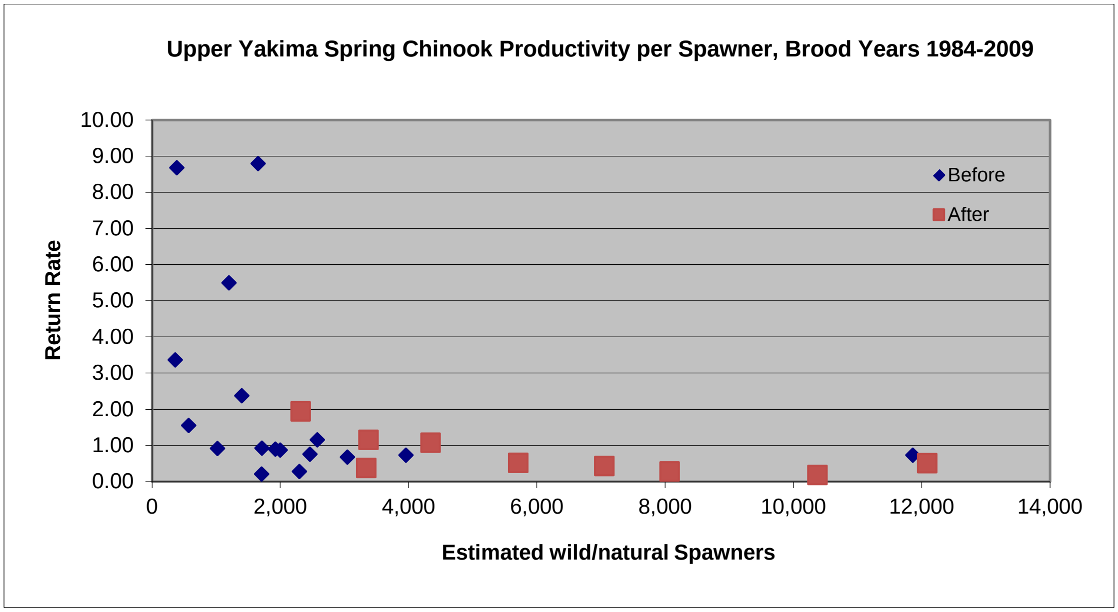


Figure 8. Upper Yakima wild/natural spring Chinook return rate per spawner, before (brood years 1984-2000) and after (brood years 2001-2009) commencement of supplementation.

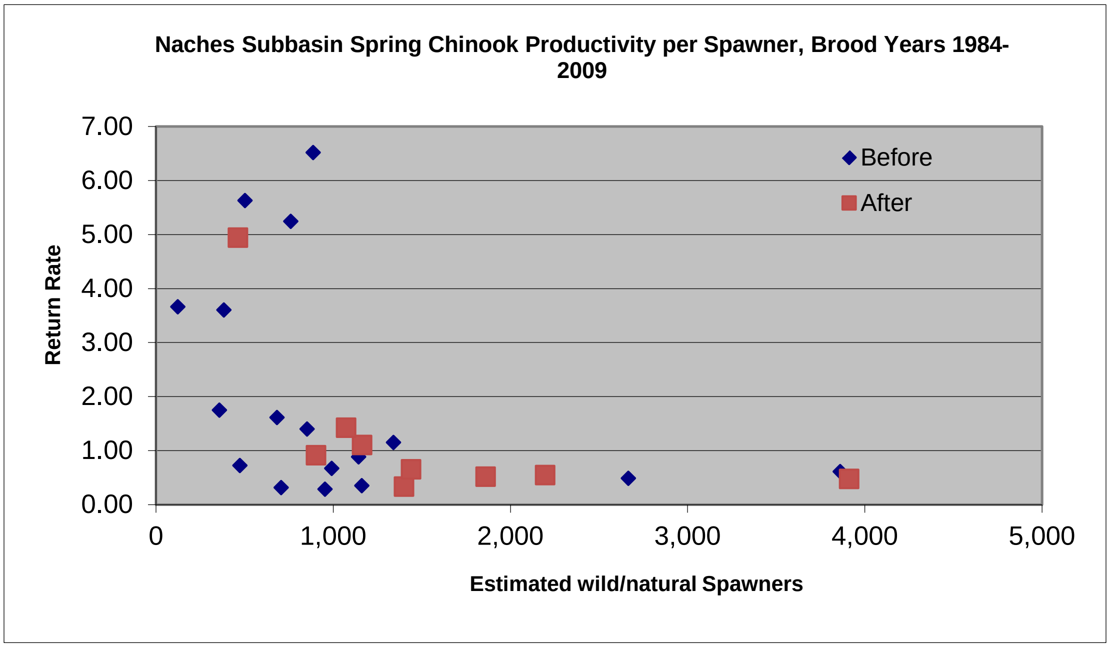


Figure 9. Naches subbasin spring Chinook return rate per spawner, before (brood years 1984-2000) and after (brood years 2001-2009) commencement of supplementation in the Upper Yakima River.

Table 2. Adult-to-adult productivity indices for Naches River Subbasin wild/natural spring Chinook.

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns					Returns/ Spawner
		Age-3	Age-4	Age-5	Age-6	Total	
1984	570	164	1,109	1,080	0	2,354	4.13
1985	1,020	213	667	931	0	1,811	1.77
1986	4,123	103	670	852	31	1,657	0.40
1987	1,729	39	231	400	0	669	0.39
1988	2,167	51	815	1,557	11	2,434	1.12
1989	1,517	39	332	371	0	741	0.49
1990	1,380	40	326	168	0	533	0.39
1991	1,121	10	32	144	127	314	0.28
1992	1,188	52	1,034	661	0	1,747	1.47
1993	1,865	53	603	817	17	1,489	0.80
1994	704	21	160	167	0	348	0.49
1995	223	73	201	498	0	771	3.46
1996	1,047	209	4,010	2,359	0	6,579	6.29
1997	1,133	220	4,644	1,377	0	6,241	5.51
1998	917	364	2,167	2,316	12	4,859	5.30
1999	418[1]	185	369	279	0	833	1.99
2000	4,112	131	2,286	346	0	2,762	0.67
2001	5,829	144	1,598	785	0	2,526	0.43
2002	3,041	78	975	443	0	1,496	0.49
2003	2,592	75	387	1,028	0	1,489	0.57
2004	2,515	227	514	232	0	973	0.39
2005	1,904	246	845	174	0	1,264	0.66
2006	1,672	237	1,215	759	0	2,211	1.32
2007	986	182	2,239	1,033	0	3,454	3.50
2008	1,578	653	1,262	803	0	2,718	1.72
2009	1,117	144	542	116		802	0.72
2010	1,491	381	972				
2011	3,060	208					
2012	1,900						
2013	1,369						
2014	1,130						
Mean	1,788	162	1,119	757	8	2,041	1.72

1. The mean jack proportion of spawning escapement from 1999-2014 was 0.12 (geometric mean 0.09).

Table 3. Adult-to-adult productivity indices for Cle Elum SRF spring Chinook.

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns Age-3	Age-4	Age-5	Total	Returns/ Spawner
1997	261	741	7,753	176	8,670	33.22
1998	408	1,242	7,939	602	9,782	23.98
1999	738[1]	134	714	16	864	1.17
2000	567	1,103	3,647	70	4,819	8.50
2001	595	396	845	9	1,251	2.10
2002	629	345	1,886	69	2,300	3.66
2003	441	121	800	12	932	2.11
2004	597	805	3,101	116	4,022	6.74
2005	510	1,305	3,052	21	4,378	8.58
2006	419	3,038	5,812	264	9,114	21.75
2007	449	1,277	5,174	108	6,558	14.61
2008	457	2,344	4,567	65	6,976	15.27
2009	486	461	2,663	58	3,181	6.55
2010	336	1,495	3,183			
2011	377	1,233				
2012	374					
2013	398					
2014	384					
Mean	468	1,069	3,652	122	4,835	7.50[2]

1. 357 or 48% of these fish were jacks.
2. Geometric mean.

Table 4. Estimates of adult-to-adult productivity indices for Yakima Basin natural-origin coho.

	Prosser Dam Counts		Return per Spawner Indices	
Return Year	Adults	Jacks	With Jacks	Without Jacks
2001	1,432	21		
2002	309	245		
2003	1,523	135		
2004	1,820	25	1.27	1.27
2005	472	120	1.07	1.53
2006	1,562	114	1.01	1.03
2007	1,049	32	0.59	0.58
2008	459	587	1.77	0.97
2009	982	173	0.69	0.63
2010	573	37	0.56	0.55
2011	802	24	0.79	1.75
2012	550	33	0.50	0.56
2013	424	79	0.83	0.74
2014	1,082	18	1.33	1.35
Mean	931	117	0.95	0.99

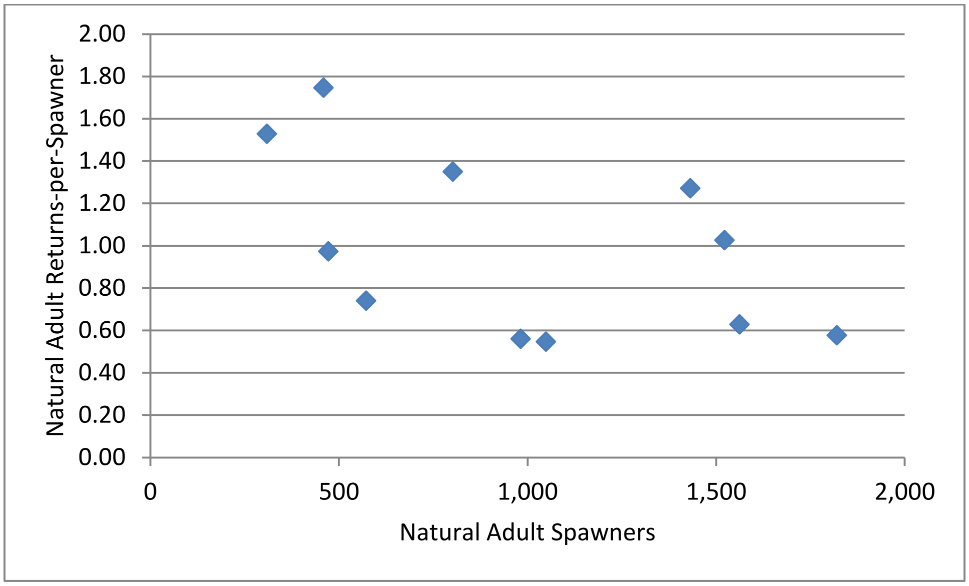


Figure 10. Productivity indices for age-3 natural-origin coho, brood years 2001-2011.

Discussion:

Trends in adult productivity indices for Yakima Basin natural-origin spring Chinook appear to be very similar for both Upper Yakima (Figure 8) and Naches (Figure 9) populations. The trend in adult productivity indices for natural-origin coho (Figure 10) is similar, but 2014 marks the first year of observed high coho spawner escapements (when hatchery-origin spawning escapement is included) similar to those we have observed with spring Chinook in some recent years. Under present conditions, productivity for spring Chinook appears to peak at about 1,000 to 1,500 spawners and declines as spawner abundance approaches 2,000 fish or greater (Figures 8-9). These data indicate that density-dependent limiting factors (see YSFWPB 2004) depress natural productivity at fairly low population abundance in the Yakima River Basin, as is the case for most salmon populations throughout the Columbia River Basin (ISAB 2015). Until these factors are fully addressed, supplementation yields higher overall productivity rates and can be used to return adults to fisheries and to augment natural spawning populations (Table 3). While higher spawner abundances under present conditions do not yield increased adult production, these fish still contribute to more fully seeding available habitats, increased spatial and temporal diversity, and nutrient enhancement that should eventually lead to increased natural food supply and higher productivity in the future (NRC 1996, see especially pp. 368-369; Kiffney et al. 2014).

Status and Trend of Juvenile Abundance (Chandler smolt estimates)

Methods: Above Prosser Dam, a portion of the river flow is diverted into the Chandler canal to generate electrical power and serve irrigation districts downstream. Juvenile fish are diverted into the Canal (and subsequently the Chandler juvenile monitoring facility-CJMF, Figure 1) at different rates depending on river and canal flow. Smolt sampling efforts at the CJMF near Prosser Dam were conducted annually from early winter through early summer corresponding with salmon smolt out-migrations. A portion of entrained salmon outmigrants (regulated by a timed gate) was manually counted and sampled for biological data on a daily basis and all PIT tagged fish were interrogated. Sampling methods were described in Busack et al. (1997) and were consistent with monitoringmethods.org methods 1562, 1563, 1595, and 1614.

Paired releases of PIT-tagged smolts were made in order to estimate the fish entrainment and canal survival rates in relation to river conditions and canal operations. These data were used to generate a multi-variate river flow/canal entrainment relationship (Neeley 2010 and 2012a). Over a range of flow diversion rates, juvenile fish entrainment rates generally fit a logistic curve: at low diversion rates, the entrainment rate is lower than the diversion rate, and at high diversion rates the entrainment rate is higher than the diversion rate. In recent years it became difficult to adapt the model to higher winter and spring flows and to river channel changes, partly because at low diversion rates it was difficult to capture enough fish to get many point estimates of entrainment rate. The releases that were made, however, still tended to support a low entrainment rate relative to diversion rate at high river flows. For some years, Prosser smolt passage estimates produced by this model were outside of what were considered reasonable bounds (e.g., entrainment-based Prosser passage estimates approached or even exceeded known releases for hatchery-origin spring Chinook far upstream). This required us to adjust passage estimates using PIT-based estimates of hatchery-origin fish survival from acclimation site release to Prosser. These methods were generally consistent with monitoringmethods.org methods 435, 623 and 1743.

Results and Discussion:

For smolt migration years 2000 to present, annual abundance estimates of juvenile smolts migrating downstream at Prosser Dam (Figure 1) averaged 243,140 wild/natural spring Chinook, 333,230 CESRF-origin spring Chinook, 27,490 wild/natural-origin coho, and 279,020 hatchery-origin coho (Table 5). These are the years for which our data and methods are considered most reliable. Juvenile passage estimates for earlier years are provided below under "Status and Trend of Juvenile Productivity"; however, the reader should be aware that we have less confidence in these data because we have refined data collection protocols and passage estimation methods over time. As the majority of fall Chinook smolt migrants are unmarked hatchery-origin fish, we provide only the gross abundance indices below under "Status and Trend of Juvenile Productivity". The reader is cautioned to pay particular attention to the factors complicating estimates of juvenile abundance and productivity described under "Status and Trend of Juvenile Productivity".

Table 5. Estimated smolt passage at Prosser Dam for Yakima Basin wild/natural and hatchery-origin spring Chinook and coho.

Brood Year	Smolt Migr. Year	Spring Chinook Wild/ Natural	Spring Chinook Hatchery (CESRF)	Coho Wild/ Natural	Coho Hatchery
1998	2000	91,908	268,660	37,359	331,503
1999	2001	62,759	268,232	40,605	134,574
2000	2002	474,206	320,866	19,859	155,814
2001	2003	332,323	142,319	9,092	139,135
2002	2004	142,297	256,542	18,787	148,810
2003	2005	166,364	282,649	31,631	204,728
2004	2006	202,346	446,304	8,298	204,602
2005	2007	118,553	401,101	20,131	260,455
2006	2008	122,867	199,744	43,046	416,708
2007	2009	349,598	416,572	25,108	496,594
2008	2010	153,020	272,007	35,158	341,145
2009	2011	270,507	461,669	24,108	333,891
2010	2012	621,994	622,956	14,675	244,503
2011	2013	317,980	309,368	56,947	483,122
2012	2014	220,402	329,455	NA	289,746
	Mean	243,142	333,230	27,486	279,022

Status and Trend of Juvenile Migration Survival to McNary Dam

Methods: For all species, releases of PIT tagged smolts provided a means to estimate smolt survival to McNary Dam. PIT-tag detectors were located in or near the exit(s) from the release sites (monitoringmethods.org 1558) and allowed estimation of the number of PIT-tagged fish leaving the release sites. To estimate the survival of smolts detected leaving the release sites that eventually pass McNary Dam, the proportion of PIT-tagged smolts detected leaving the release sites that were later detected at McNary Dam was divided by McNary Dam's detection efficiency. The estimated detection efficiency was the number of smolts detected passing dams downstream of McNary that were previously detected passing McNary divided by the total number of smolts passing the downstream dams, whether or not the smolts were previously detected at McNary. These methods were generally consistent with Sandford and Smith (2002) and with monitoringmethods.org methods 623 and 1536. We used weighted logistic or weighted least squares analysis of variance to analyze differences in survival metrics and indices between various release sites, years and treatments. Additional detail, results and discussion are provided in Appendices C-F.

Results and Discussion:

For spring Chinook, we compared survivals to McNary Dam of CESRF hatchery-and natural-origin PIT-tagged smolts released into the Roza Dam bypass and migrating downstream of Roza Dam contemporaneously on or after March 16. This date was selected because CESRF fish were not allowed to begin volitional emigration from the acclimation sites until March 15. Approximately 81% of natural-origin spring Chinook smolts PIT-tagged and released at Roza since 1999 migrated downstream of Roza Dam prior to March 16 (derived using queries of PTAGIS database 7/12/2013). Natural and hatchery-origin smolts contemporaneously migrating past Roza from March 16 on are referred to as "late" migrants.

Survival to McNary Dam for late-migrating natural-origin smolts exceeded that of the hatchery-origin smolts in 12 of the 15 outmigration years (Figure 11). The pooled survival and weighted survival estimates over years were significantly higher for the natural-origin smolts (Appendix C of 2013 Annual Report). Survival analyses for additional spring Chinook treatments are presented in Appendices C and D of this report.

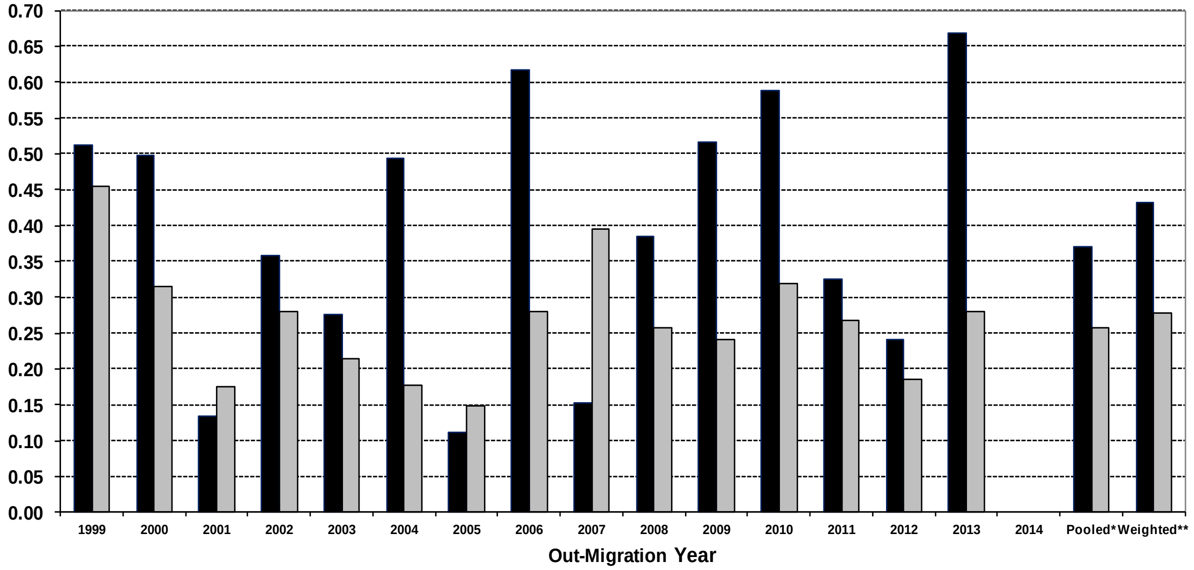


Figure 11. Upper-Yakima Spring-Chinook Roza-to-McNary Smolt Survival for late-migrating (>March 15) Natural- (dark-colored bars) and Hatchery-origin (light-colored bars) Smolts.

We estimated juvenile survival to McNary Dam for summer- and fall-run Chinook. Subyearling and yearling fall Chinook were released from Prosser for migration years 2008 through 2014. Summer-run Chinook subyearlings were released from Stiles pond in outmigration-years 2009 through 2011, from Nelson Springs (Buckskin Slough) in 2011 through 2014, from Prosser and Marion Drain in 2012, and from Roza Dam in 2013-14 (for locations see Figure 1).

Estimates for release-to-McNary survival from Stiles and Prosser are presented in Figure 12; for complete results see Appendix E. The summer-run Chinook, released as subyearlings from Stiles Pond in 2009, had a very low survival rate (1.8%) due in part to the following factors:

- late volitional Summer Chinook release date (June 22 in 2009 versus May dates in subsequent years) and associated later McNary passage in 2009 (Appendix E), and

- the blockage of some irrigation diversion screen bypasses in 2009 upstream of the Prosser project resulting in fish stranding.

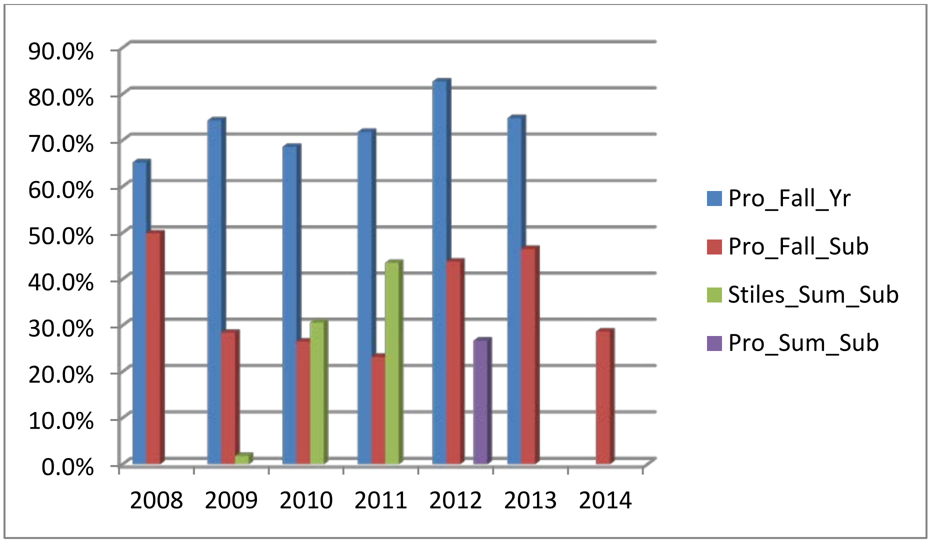


Figure 12. Estimated smolt survival to McNary Dam of summer- and fall-run Chinook that were PIT-tagged and detected at release from various sites in the Yakima River, 2008-2014. Data source: Appendix E, Table 3.a (Neeley 2015).

For coho, we estimated survival (Appendix F) from acclimation site release to McNary Dam for fish that were the progeny of local (Yakima) and Eagle Creek National Fish Hatchery (Eagle Creek) brood stock as well as a cross of the two brood stocks (2011 only). Yakima stock survival was higher than that of the Eagle Creek stock for all 17 paired-releases (Figure 13 and Appendix F). The 2013 releases consisted of 100% in-basin Yakima River coho. Therefore, the comparison was not in stock but in rearing location (Prosser Hatchery vs. Eagle Creek NFH).

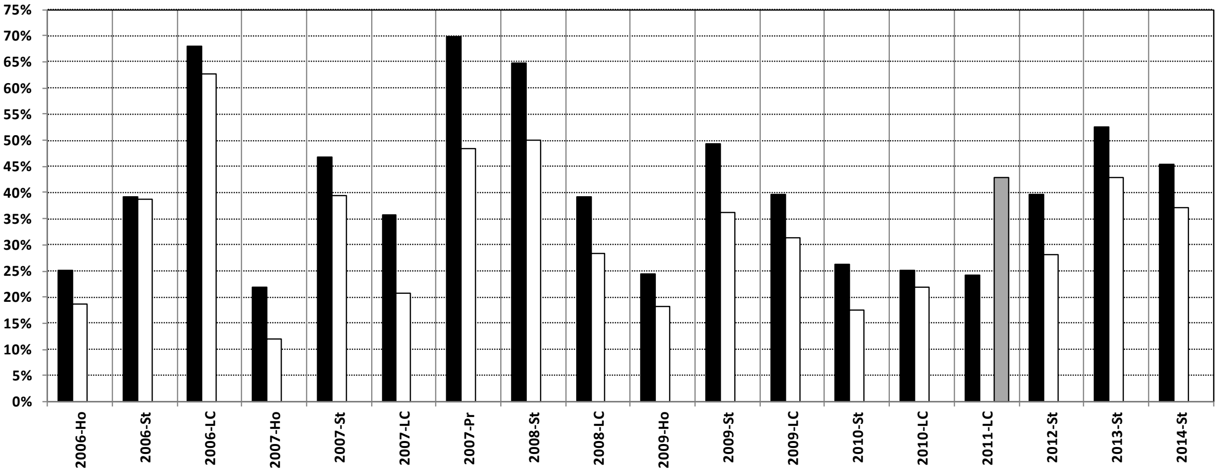


Figure 13. Estimated smolt survival to McNary Dam of Yakima (black), Eagle Creek (white), and a Yakima/Eagle Creek cross (gray) brood source coho that were PIT-tagged and detected at release from various sites (Holmes-Ho, Stiles-St, Lost Creek-LC, and Prosser-Pr; Figure 1) in the Yakima River, 2006-2014.

The data indicate that there are substantial sources of juvenile mortality limiting survival of smolts migrating from release sites in the Yakima River basin. The YKFP is working with partners in multiple forums to implement habitat restoration and water resource management projects that address factors limiting survival and productivity (see Yakima Subbasin, Recovery, and Integrated plans).

Status and Trend of Juvenile Productivity (smolt-to-adult returns)

Methods:

Smolt abundance passage estimates at Prosser and the methods used to derive them were described above. For spring Chinook, adult return estimates to the Yakima River mouth were derived using Prosser and Roza adult abundance and harvest data (described in other sections of this report and in Appendix B) and run reconstruction techniques (Appendix B). For coho, we used Prosser adult abundance.

Adult fall Chinook returning to the Yakima Basin consist of hatchery-origin returns from releases at and above Prosser Dam and natural-origin returns from fish spawning naturally in the Yakima River. Due to fiscal, physical, logistical, and policy considerations, only a small proportion of hatchery-origin releases have been externally marked. Therefore it is impossible at present to know the origin of unmarked adult fall Chinook counted at Prosser. Additional marking is proposed for hatchery-origin releases as part of the Master Plan (Yakama Nation 2012). To derive rough smolt-to-adult return indices for fall Chinook, aggregate (marked and unmarked combined) smolt passage estimates for the age-3, -4, and -5 components for a given return year were averaged and the aggregate adult passage estimate for that return year was divided by this average smolt passage estimate. For example, the "Prosser Average Smolts" for adult return year 1988 is the average of marked and unmarked Prosser smolt estimates for juvenile migration years 1983-1985.

Results:

Table 6. Estimated smolt passage at Chandler and smolt-to-adult return indices (Chandler smolt to Yakima R. mouth adult) for Yakima Basin wild/natural and CESRF-origin spring Chinook.

			Estimated Smolt Passage at Chandler			Yakima R. Mouth Adult Returns[4]		Smolt-to-Adult Return Index[4]	
Brood Year	Smolt Migr. Year	Mean Flow[1] at Prosser Dam	Wild/ Natural[2]	CESRF Total	CESRF smolt-to-smolt survival[3]	Wild/ Natural[2]	CESRF Total	Wild/ Natural[2]	CESRF Total
1982	1984	4134	381,857			6,753		1.8%	
1983	1985	3421	146,952			5,198		3.5%	
1984	1986	3887	227,932			3,932		1.7%	
1985	1987	3050	261,819			4,776		1.8%	
1986	1988	2454	271,316			4,518		1.7%	
1987	1989	4265	76,362			2,402		3.1%	
1988	1990	4141	140,218			5,746		4.1%	
1989	1991		109,002			2,597		2.4%	
1990	1992	1960	128,457			1,178		0.9%	
1991	1993	3397	92,912			544		0.6%	
1992	1994	1926	167,477			3,790		2.3%	
1993	1995	4882	172,375			3,202		1.9%	
1994	1996	6231	218,578			1,238		0.6%	
1995	1997	12608	52,028			1,995		3.8%	
1996	1998	5466	491,584			21,151		4.3%	
1997	1999	5925	322,105	97,844	25.3%	12,855	8,670	4.0%	8.9%
1998	2000[5]	4946	91,908	268,660	45.6%	8,228	9,782	9.0%	3.6%
1999	2001	1321	62,759	268,232	35.4%	1,764	864	2.8%	0.3%
2000	2002	5015	474,206	320,866	38.5%	11,434	4,819	2.4%	1.5%
2001	2003	3504	332,323	142,319	38.4%	8,597	1,251	2.6%	0.9%
2002	2004	2439	142,297	256,542	30.7%	3,743	2,300	2.6%	0.9%
2003	2005	1285	166,364	282,649	34.3%	2,746	932	1.7%	0.3%
2004	2006	5652	202,346	446,304	56.8%	2,802	4,022	1.4%	0.9%
2005	2007	4551	118,553	401,101	46.6%	4,201	4,378	3.5%	1.1%
2006	2008	4298	122,867	199,744	31.1%	6,099	9,114	5.0%	4.6%
2007	2009	5784	349,598	416,572	54.0%	7,952	6,558	2.3%	1.6%
2008	2010	3592	153,020	272,007	32.0%	7,385	6,976	4.8%	2.6%
2009	2011	9414	270,507	461,669	55.4%	3,766	3,181	1.4%	0.7%
2010	2012	8556	621,994	622,956	78.4%	6,130[6]	4,677[6]	1.0%[6]	0.8%[6]
2011	2013	4875	317,980	309,368	40.2%				
2012	2014[6]	4923	220,402	329,455	41.0%				

1. Mean flow (cfs) approaching Prosser Dam March 29-July 4 of juvenile migration year. No data available for migration year 1991. In high flow years (flows at or > 5000 cfs) operation of the Chandler smolt sampling facility may be precluded during portions of the outmigration. Data courtesy of U.S. BOR hydromet.
2. Aggregate of Upper Yakima, Naches, and American wild/natural populations.
3. Estimated smolt-to-smolt (release from upper Yakima River acclimation sites to Chandler) survival for CESRF juveniles.
4. Includes combined age-3 through age-5 returns. CESRF adult returns and smolt-to-adult survival values are understated relative to wild/natural values since these figures are not adjusted for differential harvest rates in mark selective fisheries in marine and lower Columbia River fisheries.
5. Available data were not sufficient to estimate juvenile flow-entrainment and passage of wild/natural fish.
6. Data for most recent year are preliminary; return data do not include age-5 adult fish.

Table 7. Average combined hatchery- and natural-origin smolt counts at Prosser for fish returning at age-3, -4, and -5, combined adult returns to Prosser Dam of all age classes, and estimated Prosser smolt-to-adult return indices for Yakima River fall Chinook for adult return years 1988-2014.

Adult Return Year	Prosser Average Smolts[1]	Prosser Total Adults	Prosser Smolt-to-Adult Return Index (SAR)
1988	1,029,429	224	0.02%
1989	1,469,019	670	0.05%
1990	1,664,378	1,504	0.09%
1991	1,579,989	971	0.06%
1992	1,811,088	1,612	0.09%
1993	2,034,865	1,065	0.05%
1994	1,976,301	1,520	0.08%
1995	1,329,664	1,322	0.10%
1996	1,023,053	1,392	0.14%
1997	1,097,032	1,120	0.10%
1998	1,533,093	1,148	0.07%
1999	1,786,511	1,896	0.11%
2000	1,716,156	2,293	0.13%
2001	1,867,966	4,311	0.23%
2002	1,946,676	6,241	0.32%
2003	2,108,238	4,875	0.23%
2004	2,653,056	2,947	0.11%
2005	2,707,132	1,942	0.07%
2006	2,724,824	1,528	0.06%
2007	2,312,562	1,132	0.05%
2008	2,450,308	2,863	0.12%
2009	2,353,675	2,972	0.13%
2010	2,125,125	2,888	0.14%
2011	1,630,482	2,718	0.17%
2012	1,738,951	4,477	0.26%
2013	1,932,626	7,706	0.40%
2014	2,632,813	7,792	0.30%
Mean	1,897,593	2,634	0.14%

[1] Average combined hatchery- and natural-origin smolt counts for the years which would comprise the age-3, -4, and -5 adult return components for each adult return year. For example, the “Prosser Average Smolts” for adult return year 1988 is the average of hatchery- and natural-origin Prosser smolt estimates for juvenile migration years 1983-1985.

Table 8. Preliminary estimates of smolt-to-adult survival (SAR) indices for adult returns from hatchery- and natural-origin coho for the Yakima reintroduction program, juvenile migration years 2000-2013.

Juvenile Migration Year	Hatchery-origin Chandler Smolts[a]	Hatchery-origin Prosser Adults[b]	Hatchery-origin SAR Index	Natural-origin Chandler Smolts[a]	Natural-origin Prosser Adults[b]	Natural-origin SAR Index
2000	331,503	3,546	1.1%	37,359	1,432	3.8%
2001	134,574	166	0.1%	40,605	309	0.8%
2002	155,814	669	0.4%	19,859	1,523	7.7%
2003	139,135	505	0.4%	9,092	1,820	20.0%
2004	148,810	2,405	1.6%	18,787	472	2.5%
2005	204,728	2,646	1.3%	31,631	1,562	4.9%
2006	204,602	2,203	1.1%	8,298	1,049	12.6%
2007	260,455	4,132	1.6%	20,131	459	2.3%[c]
2008	416,708	8,835	2.1%	43,046	982	2.3%[c]
2009	496,594	5,153	1.0%	25,108	573	2.3%[c]
2010	341,145	7,216	2.1%	35,158	802	2.3%[c]
2011	333,891	4,948	1.5%	24,108	550	2.3%[c]
2012	244,503	1,865	0.8%	17,667	424	2.4%
2013	483,122	19,913	4.1%	56,947	1,082	1.9%
Mean	278,256	4,586	1.4%	27,700	931	3.7%

[a] Yakama Nation estimates of coho smolt passage at Chandler.

[b] Yakama Nation estimates of age-2 and age-3 coho returns to Prosser Dam for this juvenile migration cohort.

[c] Average estimate derived from PIT-tag detections of Taneum Creek natural coho for juvenile migration years 2009-2011.

Discussion:

Calculation of smolt-to-adult survival rate indices for Yakima Basin anadromous salmonids are complicated by the following factors:

1) Smolt accounting at Prosser is based on statistical expansion of Chandler smolt trap sampling data using available flow data and estimated Chandler entrainment rates. Chandler smolt passage estimates are prepared primarily for the purpose of comparing relative marked versus unmarked passage estimates and not for making survival comparisons. While these Chandler smolt passage estimates represent the best available data, there may be a high degree of error associated with these estimates due to inherent complexities, assumptions, and uncertainties in the statistical expansion process. Therefore, these estimates are subject to revision.

2) Large numbers of Yakima Basin salmonid releases (all CESRF spring Chinook) are adipose-fin clipped and subjected to higher harvest rates than unmarked wild/natural fish in marine and Columbia River mark-selective fisheries. No adjustments have yet been made in the above SAR estimates to account for differential harvest rates in these mark-selective fisheries.

3) Due to issues such as water diversion permitting, size required for tagging, and allowing sufficient time for acclimation, release time for many hatchery-origin juveniles (including all CESRF spring Chinook) may be delayed relative to their wild counterparts. For example, spring Chinook from the CESRF are not allowed to volitionally migrate until at least March 15 of their smolt outmigration year; however, juvenile sampling observations at Roza Dam indicate that a substantial number of wild/natural juveniles migrate downstream during the summer, fall, and winter months prior to their smolt outmigration year. Analysis of juvenile migrant PIT detections at Roza Dam (PTAGIS queries run 7/12/2013) indicated that approximately 81% of natural-origin spring Chinook migrated downstream of Roza in the fall or winter as juveniles (before CESRF fish would have the opportunity). Comparison of SAR data for non-contemporaneously migrating juveniles may be invalid.

Given these complicating factors, Tables 6-8 present available smolt-to-adult survival indices for Yakima River spring and summer/fall Chinook and coho. Because of the complexities noted above, these data are useful for analysis of trends but should not be used as direct citations of, or for comparisons of marked and unmarked, smolt-to-adult survival rates. The reader is encouraged to contact Yakama Nation technical staff to discuss these and other issues prior to any use of these data or any other estimation of Yakima Basin SARs that may be available through data obtained from public web sites such as RMPC, PTAGIS, DART, FPC or others.

Substantial juvenile mortality of subyearling releases of summer- and fall-run Chinook occurs in the Yakima River between their release sites and McNary Dam (Neeley 2012b). Strategies have been proposed to address limiting factors (YSFWPB 2004) and improve survival of these releases (Yakama Nation 2012). As these strategies are implemented, we expect SARs for summer- and fall-run Chinook to improve substantially from the estimates provided in Table 7 (Yakama Nation 2012). Additional discussion and results for Yakima Basin spring Chinook SARs and various treatments are presented in Appendices B, G, and H.

Status and Trend of Spatial Distribution (Redd Counts)

Methods: Regular foot and/or boat surveys (monitoringmethods.org methods 30, 131, 285, 1508) were conducted within the established geographic range for each species (this is increasing for coho as acclimation sites are located upriver and as the run increases in size). Redds were individually marked during each survey and carcasses were sampled to collect egg retention, scale sample, sex, and body length information and to check for possible experimental marks. River conditions vary from year to year and preclude complete accounting, especially for fall Chinook and

Coho. Other agencies (WDFW, Pacific Northwest National Laboratory, and private contractors) have also conducted foot, boat, or aerial surveys for fall Chinook redds in the Yakima River Basin and we have incorporated available information from those surveys here.

Results:

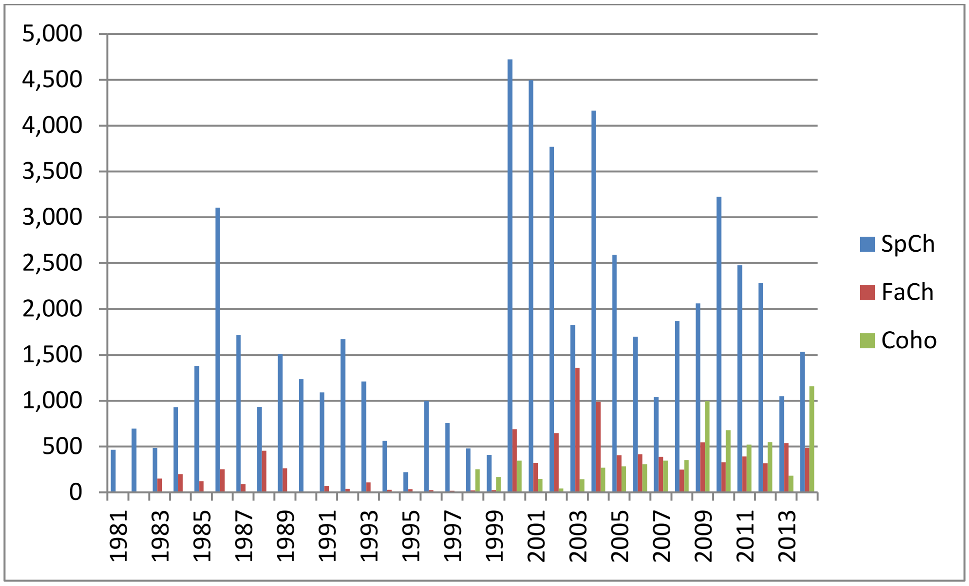
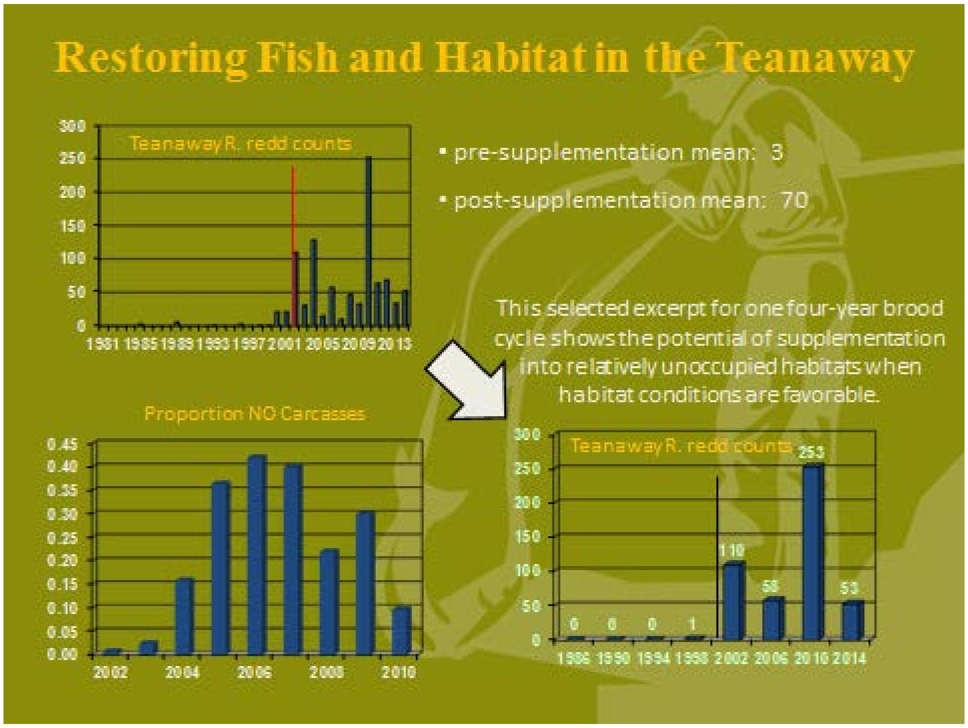


Figure 14. Redd Counts upstream of Prosser Dam in the Yakima River Basin by species, 1981-present.

Table 9. Yakima Basin spring Chinook redd counts and distribution, 1981 – present.

	Upper Yakima River System				Naches River System				
Year	Mainstem[1]	Cle Elum	Teanaway	Total	American	Naches[1]	Bumping	Little Naches	Total
1981	237	57	0	294	72	64	20	16	172
1982	610	30	0	640	11	25	6	12	54
1983	387	15	0	402	36	27	11	9	83
1984	677	31	0	708	72	81	26	41	220
1985	795	153	3	951	141	168	74	44	427
1986	1,716	77	0	1,793	464	543	196	110	1,313
1987	968	75	0	1,043	222	281	133	41	677
1988	369	74	0	443	187	145	111	47	490
1989	770	192	6	968	187	200	101	53	541
1990	727	46	0	773	143	159	111	51	464
1991	568	62	0	630	170	161	84	45	460
1992	1,082	164	0	1,246	120	155	99	51	425
1993	550	105	1	656	214	189	88	63	554
1994	226	64	0	290	89	93	70	20	272
1995	105	12	0	117	46	25	27	6	104
1996	711	100	3	814	28	102	29	25	184
1997	364	56	0	420	111	108	72	48	339
1998	123	24	1	148	149	104	54	23	330
1999	199	24	1	224	27	95	39	25	186
2000	3,349	466	21	3,836	54	483	278	73	888
2001	2,910	374	21	3,305	392	436	257	107	1,192
2002	2,441	275	110	2,826	366	226	262	89	943
2003	772	87	31	890	430	228	216	61	935
2004	2,985	330	129	3,444	91	348	205	75	719
2005	1,717	287	15	2,019	140	203	163	68	574
2006	1,092	100	58	1,250	136	163	115	33	447
2007	665	51	10	726	166	60	60	27	313
2008	1,191	137	47	1,375	158	165	102	70	495
2009	1,349	197	33	1,579	92	159	163	68	482
2010	2,199	219	253	2,671	173	171	168	40	552
2011	1,663	171	64	1,898	212	145	175	48	580
2012	1,276	125	69	1,470	337	196	189	89	811
2013	552	85	34	671	170	66	85	55	376
2014	962	138	53	1,153	129	65	158	27	379
Mean	1,068	130	28	1,226	163	172	116	49	499

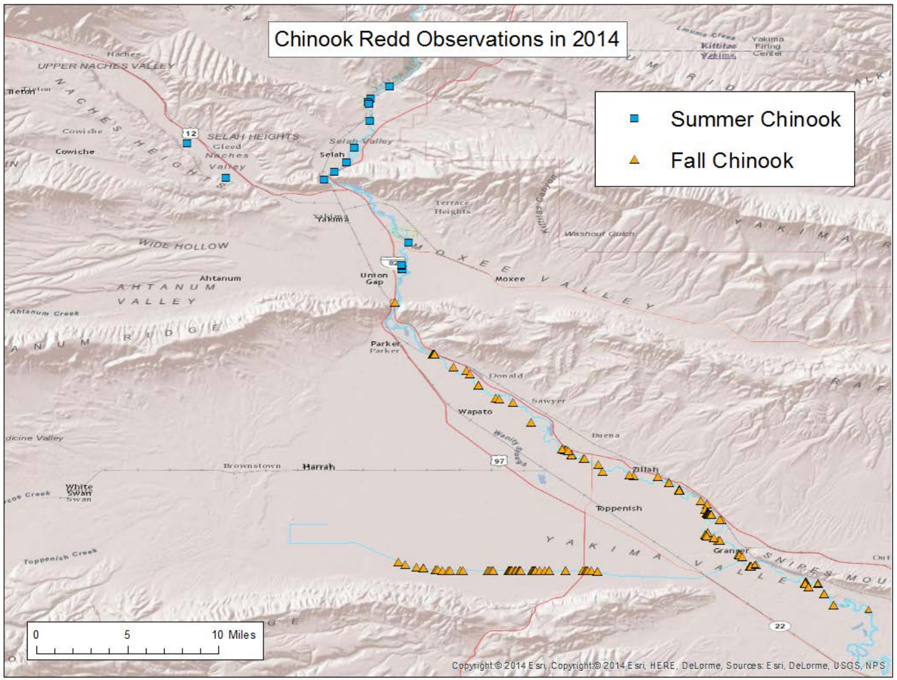
[1] Including minor tributaries.


Restoring Fish and Habitat in the Teanaway

- pre-supplementation mean: 3
- post-supplementation mean: 70

This selected excerpt for one four-year brood cycle shows the potential of supplementation into relatively unoccupied habitats when habitat conditions are favorable.

Figure 15. Teanaway River Spring Chinook redd counts, 1981-2014 (vertical lines denote pre- and post-supplementation periods) and the proportion of natural-origin (NO) carcasses observed in intensive spawning ground surveys, 2002-2010.


Chinook Redd Observations in 2014

Copyright:© 2014 Esri, Copyright:© 2014 Esri, HERE, DeLorme, Sources: Esri, DeLorme, USGS, NPS

C:\avdata\FallChinookRedds\2014\fallchinook2014.mxd Paul Huffman, Yakama Fisheries, 6/15/2015

Figure 16. Distribution of summer and fall run Chinook redds in the Yakima River Basin (above Prosser Dam) in 2014.

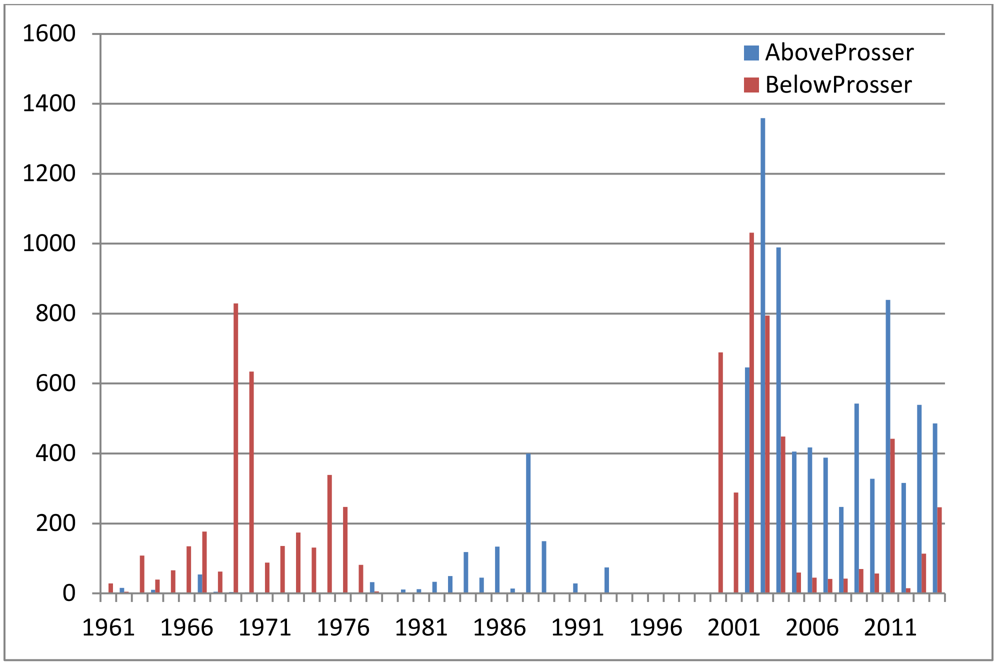


Figure 17. Fall Chinook redd counts above and below Prosser Dam, 1961-present, for years in which surveys were conducted and data are available. Data from YN, WDFW, and Pacific Northwest National Laboratory files; survey data are partial or incomplete for most years prior to 2000.

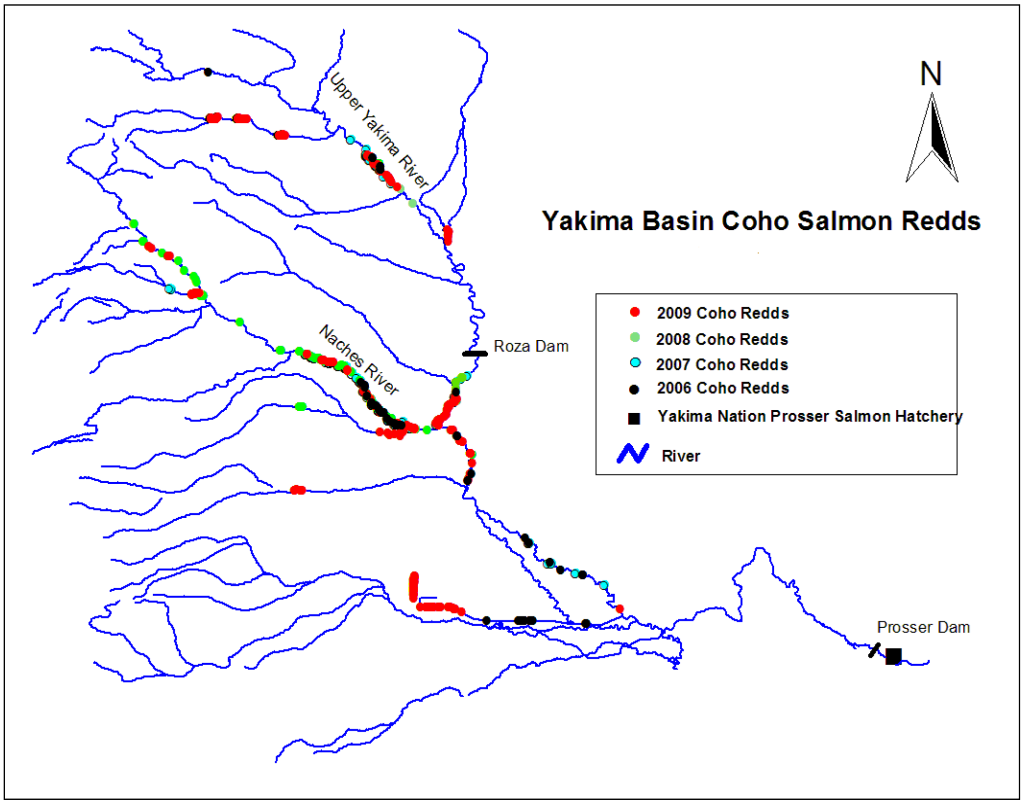


Figure 18. Distribution of coho redds in the Yakima River Basin.

Table 10. Yakima Basin coho redd counts and distribution, 1998 – present.

	Yakima River	Naches River	Tributaries	Total
1998	53	6	193	252
1999	104		62	166
2000	142	137	67	346
2001	27	95	25	147
2002	4	23	16	43
2003	32	56	55	143
2004	33	87	150	270
2005	57	72	153	282
2006	44	76	187	307
2007	63	87	195	345
2008	49	60	242	351
2009	229	281	485	995
2010	75	276	327	678
2011	82	243	196	521
2012	148	228	172	548
2013	45	69	67	181
2014	320	86	751	1157

Discussion:

Spatial distribution of spring Chinook spawners has increased as a result of acclimation site location, salmon homing fidelity and more fully seeding preferred spawning habitats (Dittman et al. 2010). Redd surveys in the Teanaway River conducted annually by Yakama Nation staff since 1981 demonstrate the benefits of reintroducing salmonids into underutilized habitat (Figure 15). The Jack Creek acclimation site began releasing CESRF spring chinook in 2000, with the first age-4 females returning from these releases in 2002. Redd counts in this tributary have increased from a pre-supplementation average of 3 redds per year to a post supplementation average of 70 redds per year. The proportion of natural-origin carcasses increased from less than one percent in 2002 (when CESRF fish first returned to the natural spawning grounds) to 42% in 2006 when the progeny of the 110 redds produced in 2002 (virtually 100% of which were produced by CESRF-origin fish) returned. These data clearly indicate that naturally-spawning CESRF spring Chinook were successful in returning natural-origin adults back to the Teanaway River.

Fall Chinook redd distribution in the Yakima River Basin appears to be experiencing a major transition in recent years. Historical redd survey data indicates that a substantial number of fall Chinook spawned below Prosser Dam in the lower Yakima River. However, from 2003-present, an average of approximately 80 percent (range 62 to 90 percent) of surveyed fall Chinook redds have been located above Prosser Dam (Figure 17). Biologists and habitat experts in the subbasin at least partially attribute this change in spawning distribution to the invasion of water stargrass (see Wise et al. 2009) in the lower 43 miles of the Yakima River. With the reintroduction of summer run Chinook, the Yakama Nation is expanding the distribution of summer/fall run Chinook spawners and redds into the middle reaches of the Yakima Basin between the town of Wapato upstream to the confluence with the Tieton River in the Naches subbasin and to Roza Dam in the Upper Yakima subbasin (Figures 1 and 16; Yakama Nation 2012). Figure 16 indicates a good distribution of reintroduced summer-run spawners into the intended habitats above Parker Dam in 2014, primarily age-4 fish returning from subyearling releases in 2011. This is the second year of substantial natural summer-run Chinook spawning in these habitats in over 40 years.

Coho redd counts and spawner distribution have increased substantially (Table 10 and Figure 18). Many redds in the mainstem were located intermixed with fall chinook redds, tucked under cut banks or were found in side channels. Tributary redd enumeration and identification continues to be accurate due to the fall low water levels, improving interagency cooperation, and relatively good weather. One of the overall goals during the present implementation phase (Phase II) of the coho program is to evaluate the transition of redds from the mainstem river into historic tributaries. With the beginning of Phase II of the Coho Program we observed large increases in tributary spawning, with an annual average exceeding 200 redds counted in tributaries since 2004 (Table 10). Although, there were large numbers of potential spawners in 2014 (~9,000 females), river conditions were very unfavorable for finding redds. Winter anchor ice in early December kept surveys to a minimum. This was followed by winter freshets that reduced visibility in the Naches River to the point where visibility was near zero. However, coho continued to volunteer into many tributaries, and the fidelity of adults from the summer parr plants is showing good results. Record tributary redd counts in Cowiche Creek and Ahtanum Creek showed encouraging trends. We continue to find natural returns from the Taneum Creek adult out-plant study (Table 11). The study in Taneum Creek was set up to test reintroduction and interactions (Temple et al. 2012); it was not set up for full reintroduction. With implementation of the Coho Master Plan, we expect to double adult out plant numbers, increase escapement into Taneum Creek, and fully seed the available habitat.

Table 11. Results from Taneum Creek adult out-plant study.

Year	Number of Adult Females Outplanted	Redds	Number of Juvenile coho PIT Tagged	Juvenile Migration Year	Juvenile Survival to McNary	Natural-Origin Adults to McNary
2007	150	75	1300	2009	16%	1
2008	150	50	1812	2010	10%	16
2009	150	130	4515	2011	13%	13
2010	150	134	1054	2012	26%	7
2011	150	100	743	2013	13%	9
2012	60	54	1941	2014	12%	
2013	9	5	231	2015		

Status and Trend of Diversity Metrics

Methods:

Diversity metrics collected for the Cle Elum Supplementation and Research Facility spring Chinook program in the Upper Yakima River include parameters relating to: eggs (e.g., egg size, KD at emergence, emergence timing, etc.), juveniles (growth and survival, migration timing, fish health, etc.), and adults (size at age, sex composition, migration timing, etc.). Methods for monitoring the spring Chinook program were documented in: the YKFP Monitoring Plan (Busack et al. 1997) and the project's "Supplementation Monitoring Plan" (Chapter 7 in 2005 annual report on project genetic studies), and numerous manuscripts in the published literature (see Results and References).

Diversity metrics for returning adult summer/fall Chinook and coho collected at the Prosser Dam denil fish trap include sex ratios, lengths, and weights (monitoringmethods.org methods 454, 1454, 1548, 1549, 1551, 4008, 4041).

Results and Discussion:

A detailed presentation of current results for the spring Chinook monitoring program (YN-collected data) are included in Appendix B of this report and are discussed in greater detail in the annual report(s) for WDFW-companion project 1995-064-25. Generally, we have detected small, but significant differences between hatchery- and natural-origin fish in some juvenile and adult traits. Results in the published literature include: Busack et al. (2007), Knudsen et al. (2006, 2008), Larsen et al. (2004, 2006, 2010, 2013), and Pearsons et al. (2009).

Sex ratios, lengths, and weight data for fall Chinook and coho salmon sampled at the Prosser denil adult sampling facility from 2001-present are presented in Tables 12-15. In addition, preliminary results of some diversity metrics relating to the effort to reestablish a natural spawning coho population in the Yakima Basin were published in Bosch et al. (2007). That study observed divergence in some diversity traits between hatchery- and natural-origin fish suggesting that some re-naturalization can be detected in just a few generations after outplanting of hatchery-origin fish in the wild.

Table 12. Sex ratio of upstream migrating fall Chinook sampled at the Prosser Dam right bank denil ladder and fish trap, 2001-present.

Return	Sample Size			Female	Female	Sample Date Range	
Year	F	J	M	Adult %	Total %	First	Last
2001	186	80	213	46.6%	38.8%	09/10/01	11/19/01
2002	389	61	512	43.2%	40.4%	09/09/02	11/25/02
2003	396	24	224	63.9%	61.5%	09/07/03	11/17/03
2004	185	40	201	47.9%	43.4%	09/06/04	11/23/04
2005	201	8	233	46.3%	45.5%	09/06/05	11/14/05
2006	107	11	84	56.0%	53.0%	09/13/06	11/06/06
2007	42	44	39	51.9%	33.6%	09/10/07	11/06/07
2008	81	23	101	44.5%	39.5%	09/08/08	11/13/08
2009	110	132	95	53.7%	32.6%	09/08/09	11/07/09
2010	239	4	162	59.6%	59.0%	09/08/10	11/03/10
2011	67	10	34	66.3%	60.4%	09/07/11	11/09/11
2012	249	109	264	48.5%	40.0%	09/04/12	11/06/12
2013	272	86	460	37.2%	33.3%	09/16/13	11/22/13
2014	681	78	725	48.4%	45.9%	09/04/14	12/10/14
			Mean	51.0%	44.8%		

Table 13. Sample size (N), mean fork and mid-eye to hypural plate (MEH) lengths (cm), and weights (pounds) of upstream migrating fall Chinook sampled at the Prosser Dam right bank denil ladder and fish trap, 2001-present.

Run	Females				Males			
Year	N	Fork	POH	Weight	N	Fork	POH	Weight
2001	186	72.7	60.1	11.0	213	71.5	57.8	9.3
2002	389	78.4	63.9	13.5	512	76.1	60.2	12.1
2003	397	83.4	68.5	15.6	225	83.7	67.0	16.2
2004	185	82.3	67.8	15.1	201	73.9	60.0	11.2
2005	201	80.5	66.3	14.2	233	75.1	60.6	11.5
2006	107	81.5	66.3	15.6	84	81.3	64.6	15.3
2007	42	79.9	64.4	14.8	39	72.8	56.8	11.7
2008	81	70.1	56.5	9.8	101	67.8	54.0	8.9
2009	110	74.1	57.8	11.2	95	69.4	52.5	9.6
2010	239	73.3	57.8	11.3	162	70.9	54.7	9.7
2011	67	76.5	60.4	12.4	34	74.2	57.7	11.3
2012	249	70.1	53.3	9.5	264	66.4	49.6	7.9
2013	272	72.5	56.1	10.1	460	69.8	52.9	8.7
2014	681	76.1	60.8	11.9	725	69.0	53.2	8.6
Mean		76.5	61.4	12.6		73.0	57.3	10.9

Table 14. Sex ratio of upstream migrating coho sampled at the Prosser Dam right bank denil ladder and fish trap, 2001-present.

Return	Sample Size			Female	Female	Sample Date Range	
Year	F	J	M	Adult %	Total %	First	Last
2001	1147	44	1024	52.8%	51.8%	09/11/01	11/22/01
2002	72	201	71	50.3%	20.9%	09/11/02	11/25/02
2003	473	89	452	51.1%	46.6%	09/11/03	11/21/03
2004	586	49	509	53.5%	51.2%	09/07/04	11/16/04
2005	531	146	405	56.7%	49.1%	09/13/05	11/15/05
2006	826	97	586	58.5%	54.7%	09/17/06	11/19/06
2007	676	34	538	55.7%	54.2%	09/11/07	11/20/07
2008	666	930	516	56.3%	31.5%	09/08/08	12/04/08
2009	1644	76	1576	51.1%	49.9%	09/09/09	11/20/09
2010	999	35	673	59.7%	58.5%	09/08/10	11/19/10
2011	907	12	776	53.9%	53.5%	09/16/11	11/17/11
2012	1156	108	961	54.6%	52.0%	09/08/12	11/17/12
2013	523	146	528	49.8%	43.7%	09/20/13	11/22/13
2014	4302	135	3668	54.0%	53.1%	09/03/14	12/23/14
			Mean	54.2%	47.9%		

Table 15. Sample size (N), mean fork and mid-eye to hypural plate (MEH) lengths (cm), and weights (pounds) of upstream migrating coho sampled at the Prosser Dam right bank denil ladder and fish trap, 2001-present.

Run	Females				Males			
Year	N	Fork	POH	Weight	N	Fork	POH	Weight
2001	1147	65.4	53.7	6.7	1024	65.6	52.4	6.5
2002	72	68.1	54.9	8.5	71	69.4	54.0	8.1
2003	473	65.3	52.9	7.0	452	65.7	51.4	6.8
2004	586	68.8	56.4	8.0	509	67.8	53.9	7.4
2005	531	67.5	54.9	8.0	405	67.6	53.5	7.8
2006	826	71.6	58.2	10.0	586	71.3	55.8	9.4
2007	676	66.3	52.1	7.0	538	65.5	49.9	6.6
2008	666	69.9	56.7	9.6	516	69.8	54.6	9.0
2009	1644	68.1	52.4	7.9	1576	67.2	49.7	7.2
2010	999	69.7	54.2	8.7	673	68.5	51.5	7.8
2011	907	68.6	53.7	8.2	776	68.5	51.7	7.7
2012	1156	64.3	49.5	6.8	961	62.6	46.4	6.0
2013	523	66.2	51.9	6.9	528	64.0	48.4	5.9
2014	4302	65.6	52.6	7.0	3668	63.5	49.8	6.1
Mean		67.5	53.9	7.9		66.9	51.6	7.3

Habitat Monitoring

While the majority of YKFP habitat activities in the Yakima Basin are addressed in a separate project (1997-051-00), we are monitoring stream sediment loads associated with the operation of dams and other anthropogenic factors (e.g. logging, agriculture and road building) under this contract as sediment loads can affect survival of salmonids (see description and references here).

Status and Trend of Fine Sediment

Methods: Representative gravel samples (McNiel core samples, monitoring methods 1504) were collected from various reaches in the Little Naches, South Fork Tieton, and Upper Yakima Rivers in the fall of 2014. Each sample was analyzed to estimate the percentage of fine or small particles present (<0.85 mm). The Washington State Timber, Fish, and Wildlife program established guidelines that specify the impacts that estimated sedimentation levels can have on salmonid egg-to-smolt survival. These impact guidelines will inform future analyses of "extrinsic" factors on natural production in the Yakima Basin.

Results and Discussion:

Little Naches

A total of 96 McNiel core samples were collected and processed from 8 spawning reaches in the Little Naches drainage this past year. Pyramid Creek and North Fork Reach 2 have not been sampled since 2009 when the main road going into these reaches was decommissioned. Other means to access these sampling sites is needed. With this year's monitoring work, the data set for the Little Naches drainage now covers a time period of 30 years for the two historical reaches, and 23 years for the expanded sampling area that includes several tributary streams.

The average percent fine sediment less than 0.85mm for the entire Little Naches drainage is very similar to the previous year (cumulative average of 8.6% for 2014 compared to 9.2% for 2013). This compares to recent years when overall fine sediment conditions in the Little Naches drainage ranged from about 10.5% to 12% fines (Figure 19). Similar trends can be seen when looking at individual reach conditions over the longer term monitoring period since 1992. Most reaches have had a declining level of fine sediment in recent years.

The overall average fine sediment found in spawning substrate remains relatively low and should lessen mortality on incubating eggs and alevins. The reduced rate of fine sediment found can be partially attributed to less anthropogenic disturbance occurring in the watershed in recent years, other than recreational activity. Timber harvest activity and road building has been minimal for several years. Landowners have also improved roads and trails to reduce sediment delivery. Further, enhanced stream protection measures have been instituted through the Northwest Forest Plan and the Central Cascades Habitat Conservation Plan for almost 20 years. These factors have likely helped reduce fine sediment inputs to the stream system. However recreational activity, such as dispersed camping sites and off-road vehicle use near streams, continues to be a concern. Sediment delivery, bank erosion, and loss of riparian vegetation from recreational use have been observed in some localized areas.

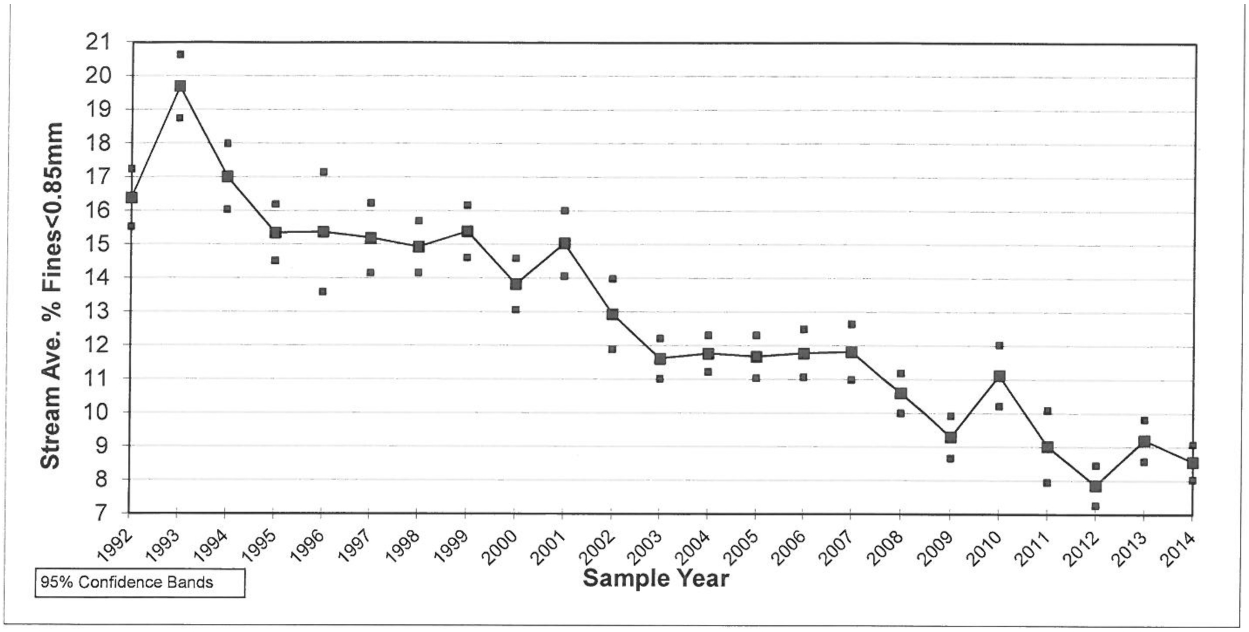


Figure 19. Overall Fine Sediment (<0.85mm) Trends with 95% confidence bounds in the Little Naches River Drainage, 1992-2014.

South Fork Tieton

One reach on the South Fork Tieton River (in the vicinity of Minnie Meadows) was sampled again this past season by the U.S. Forest Service. This marks 16 years that the USFS has been sampling this area. This stream reach typically receives significant bull trout spawning activity and the monitoring efforts provide valuable information on their spawning conditions. Average fine sediment in this reach was 11.9% in 2014, which is slightly greater than the 11.1% observed in 2013, but below the mean for sediment levels for the 16-year sampling period (Figure 20).

Upper Yakima

A total of 60 samples were collected and processed from the Upper Yakima River drainage this past year (5 reaches, 12 samples from each reach). The same reaches (Stampede Pass, Easton, Camelot to Ensign Ranch, Elk Meadows, and Cle Elum) have been sampled annually for the past 18 years. Although average fine sediment levels in 3 of the 5 reaches increased from 2013, overall average percent fine sediment less than 0.85mm for the combined Upper Yakima drainage was again relatively low (Figure 21).

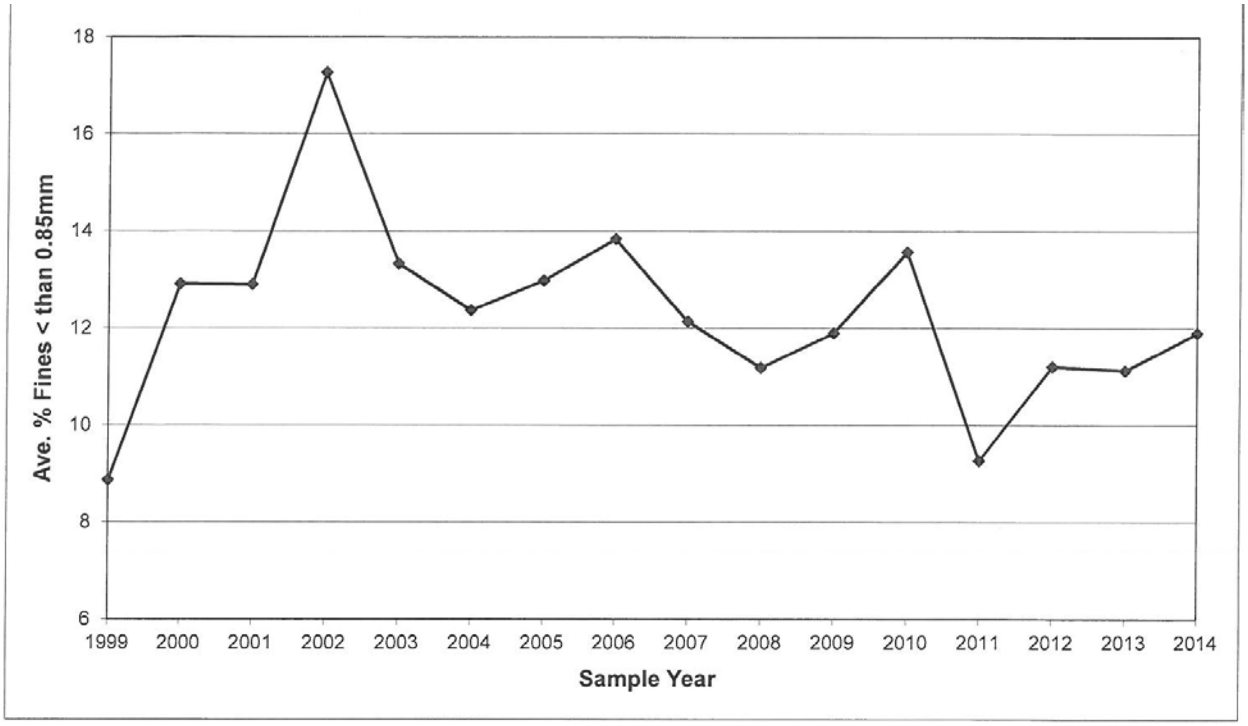


Figure 20. Fine Sediment Trends in the South Fork Tieton River, 1999-2014. Note: Data for 2007 were collected from only 1 Riffle.

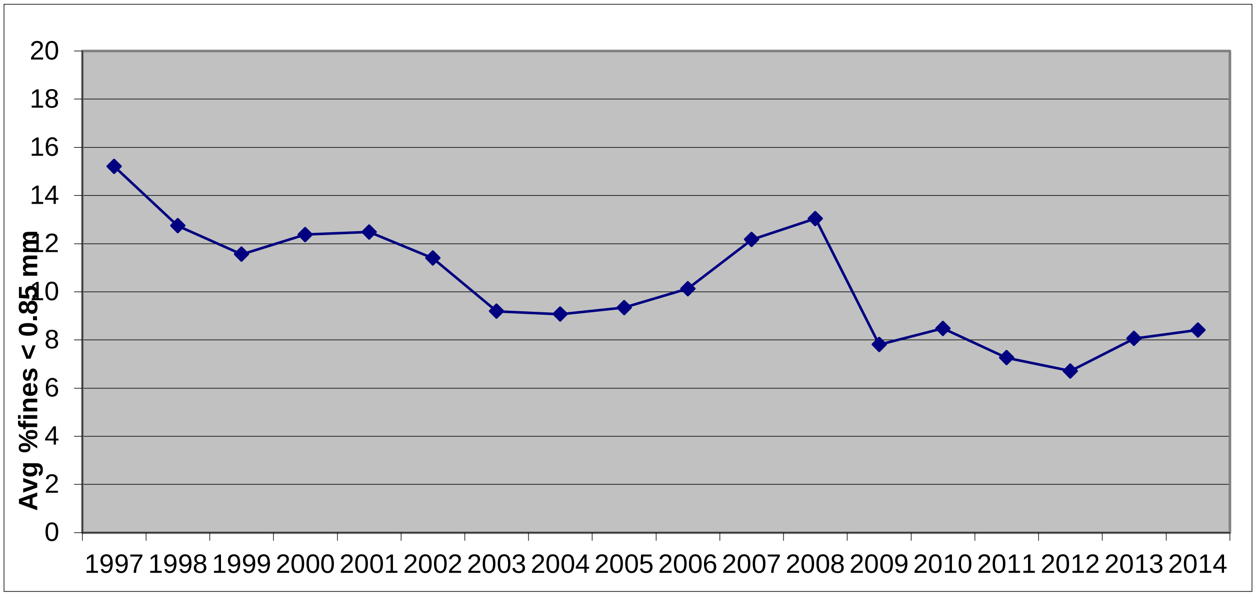


Figure 21. Overall average percent fine sediment (< 0.85 mm) in spawning gravels of the Upper Yakima River, 1997-2014.

Summary

We continue to observe an overall decreasing trend in average fine sediment levels in the Little Naches and Upper Yakima drainages. These low rates of fine sediment should be conducive for egg and alevin survival and should favor salmonid spawning success.

The results of the USFS sampling in the South Fork Tieton River were similar to the past two years and below mean sediment levels for the 16-year sampling period. These conditions should still be favorable for early life history survival of bull trout.

Detailed field data including additional tables and graphs for samples collected in the upper Yakima and Naches basins can be obtained from Jim Mathews, fisheries biologist for the Yakama Nation (matj@yakamafish-nsn.gov).

Harvest Monitoring

Marine and Mainstem Columbia Fisheries

Methods: We evaluated recoveries of coded-wire tags (CWTs) and PIT tags in out-of-basin fisheries using queries of regional mark information system (RMIS) and PIT Tag Information System (PTAGIS) databases. We coordinated with agencies responsible for harvest management (WDFW, ODFW, USFWS, CRITFC, etc.) to estimate the harvest of target stocks. We reviewed reports produced annually by the Pacific Fisheries Management Council (marine) and the *U.S. v Oregon* Technical Advisory Committee (mainstem Columbia) to evaluate estimated harvest or exploitation rates on comparable stocks in these fisheries.

For spring Chinook, additional information was employed that is not readily available for fall Chinook and coho. Standard run reconstruction techniques (Appendix B) were employed to derive estimates of harvest from the Columbia River mouth to the Yakima River mouth for spring Chinook. Data from databases maintained by the *U.S. v Oregon* Technical Advisory Committee were used to obtain harvest rate estimates downstream of the Yakima River for the aggregate Yakima River spring Chinook population and to estimate passage losses from Bonneville through McNary reservoirs. These data, combined with the Prosser Dam counts and estimated harvest below Prosser, were used to derive a Columbia River mouth run size estimate and Columbia River mainstem harvest estimate for Yakima spring Chinook.

Results:

Table 16. Marine and freshwater recoveries of CWTs from brood year 1997-2009 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) 30 Dec 2014.

Brood	Observed CWT Recoveries			Expanded CWT Recoveries		
Year	Marine	Fresh	Marine %	Marine	Fresh	Marine %
1997	5	56	8.2%	8	321	2.4%
1998	2	53	3.6%	2	228	0.9%
1999		2	0.0%		9	0.0%
2000		14	0.0%		34	0.0%
2001		1	0.0%		1	0.0%
2002		7	0.0%		36	0.0%
2003		4	0.0%		10	0.0%
2004	2	154	1.3%	15	526	2.8%
2005	2	96	2.0%	2	304	0.7%
2006	14	329	4.1%	16	1165	1.4%
2007	8	145	5.2%	13	1142	1.1%
2008	5	245	2.0%	7	1629	0.4%
2009[1]	3	87	3.3%	5	467	1.1%

1. Reporting of CWT recoveries to the RMIS database typically lags actual fisheries by one to two years. Therefore, CWT recovery data for brood year 2009 are considered preliminary or incomplete.

Table 17. Estimated run size, harvest, and harvest rates of Yakima Basin spring Chinook in Columbia River mainstem and terminal area fisheries, 1983-present.

						Columbia Basin Harvest Summary			Col. Basin Harvest Rate	
Year	Columbia R. Mouth Run Size	Col. R. Mouth to BON Harvest	BON to McNary Harvest	Yakima R. Mouth Run Size	Yakima River Harvest	Total	Wild	CESRF	Total	Wild
1983	2,470	119	99	1,441	84	302	302	0	12.2%	
1984	3,890	135	258	2,658	289	682	682	0	17.5%	
1985	5,274	192	179	4,560	865	1,236	1,236	0	23.4%	
1986	13,480	279	781	9,439	1,340	2,400	2,400	0	17.8%	
1987	6,165	96	372	4,443	517	986	986	0	16.0%	
1988	5,610	359	371	4,246	444	1,174	1,174	0	20.9%	
1989	8,936	213	668	4,914	747	1,628	1,628	0	18.2%	
1990	6,870	348	450	4,372	663	1,461	1,461	0	21.3%	
1991	4,611	183	277	2,906	32	492	492	0	10.7%	
1992	6,226	103	375	4,599	345	823	823	0	13.2%	
1993	5,135	44	312	3,919	129	485	485	0	9.4%	
1994	2,228	86	107	1,302	25	219	219	0	9.8%	
1995	1,375	1	68	666	79	148	148	0	10.8%	
1996	5,790	6	303	3,179	475	784	784	0	13.5%	
1997	5,235	3	350	3,173	575	928	928	0	17.7%	
1998	2,825	3	142	1,903	188	332	332	0	11.8%	
1999	3,944	4	182	2,781	604	790	790	0	20.0%	
2000	28,705	58	1,745	19,100	2,458	4,261	4,138	123	14.8%	
2001	30,818	943	4,026	23,265	4,630	9,599	5,511	4,087	31.1%	29.8%
2002	23,916	1,235	2,549	15,099	3,108	6,891	2,570	4,321	28.8%	24.7%
2003	9,735	275	764	6,957	440	1,479	891	588	15.2%	14.2%
2004	21,978	967	1,900	15,289	1,679	4,545	2,521	2,025	20.7%	16.1%
2005	11,879	327	740	8,758	474	1,541	1,213	327	13.0%	12.2%
2006	11,583	299	761	6,314	600	1,660	943	717	14.3%	12.7%
2007	4,996	170	344	4,303	279	793	382	411	15.9%	13.8%
2008	11,434	1,152	1,509	8,598	1,532	4,193	1,182	3,011	36.7%	26.5%
2009	12,833	1,171	936	10,726	2,353	4,460	1,238	3,222	34.8%	25.7%
2010	17,406	1,567	2,291	13,142	1,741	5,599	1,305	4,294	32.2%	21.4%
2011	22,193	1,060	1,397	17,960	4,380	6,836	2,374	4,463	30.8%	22.2%
2012	15,716	795	1,347	12,053	3,320	5,462	2,203	3,259	34.8%	28.3%
2013	14,092	839	754	10,245	2,653	4,245	1,679	2,566	30.1%	23.4%
2014[1]	16,461	693	1,778	11,322	2,171	4,642	1,845	2,797	28.2%	21.5%
Mean	10,744	429	879	7,613	1,226	2,534	1,402	1,132	20.2%	17.9%

1. Preliminary.

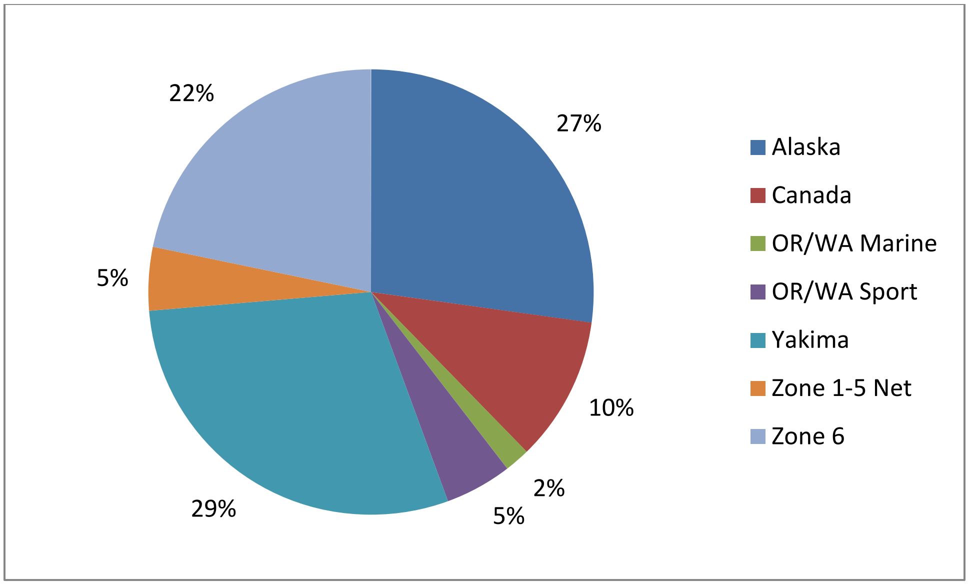


Figure 22. Distribution of coded-wire tag recoveries of Yakima Basin summer/fall run Chinook releases in marine, mainstem Columbia River, and Yakima Basin fisheries. Data retrieved from the regional mark information system (RMIS) for brood year 1997-2007 recoveries.

Recovery data for Yakima River-origin coho are presently limited because few fish have been coded wire-tagged until recent years. We will continue to collect and analyze CWT-recovery data from regional databases and will report this information in the future. 'All H Analyzer' (AHA) modeling for Master Planning purposes assumed that natural- and hatchery-origin Yakima River coho have an exploitation rate of approximately 40 and 60 percent, respectively (Yakama Nation 2012). These estimates include coho caught in marine, Columbia River and Yakima River fisheries.

Discussion:

Based on available CWT information, harvest managers have long assumed that Columbia River spring Chinook are not harvested in any abundance in marine fisheries as their ocean migration does not generally overlap either spatially or temporally with the occurrence of marine fisheries (TAC 1997). Harvest recoveries of CESRF spring Chinook as reported to RMIS to date appear to confirm this, as marine harvest apparently accounts for only about 0-3% of the total harvest of Yakima Basin spring Chinook (Table 16). Adult returns of spring Chinook from the CESRF appear to be making substantial contributions to Columbia Basin fisheries (Table 17).

Yakima Basin summer/fall Chinook are harvested in marine fisheries from Alaska to southern Oregon, and in Columbia River fisheries from the mouth to the Hanford Reach (Figure 22). Approximately 71% of harvest recoveries from Yakima Basin fall Chinook releases for brood years 1997-2007 occurred in marine (44%) and mainstem

Columbia (27%) fisheries. Out-of-basin harvest rates have not been estimated specifically for Yakima Basin summer/fall run Chinook, but the 1982-89 brood year average ocean fisheries exploitation rate for mid-Columbia River summer/fall Chinook was 39%, with a total exploitation rate of 68% estimated for the same years (PSC 1994). Chapman et al. (1994) estimated that the 1975-87 brood year mean exploitation rate for fall Chinook released from Priest Rapids Hatchery was 64%. Harvest rates of these stocks in U.S. fisheries since the mid-1990s have been reduced due to Endangered Species Act (ESA) management concerns as these stocks are intermixed with ESA-listed Snake River fall Chinook populations (NMFS 1999a-d and 2000a-c). It is assumed that Yakima River summer/fall run Chinook are harvested at the same rate in these fisheries as other mid-Columbia River summer/fall Chinook stocks.

Yakima Subbasin Fisheries

Methods: The two co-managers, Yakama Nation and WDFW, are responsible for monitoring their respective fisheries in the Yakima River. Each agency employs fish monitors dedicated to creel surveys and/or fisher interviews at the most utilized fishing locations and/or boat ramps. From these surveys, standard techniques are employed to expand fishery sample data for total effort and open areas and times to derive total harvest estimates. Fish are interrogated for various marks. Methods are consistent with monitoringmethods.org methods 404 and 960.

Results:

Table 18. Spring Chinook harvest in the Yakima River Basin, 1983-present.

	Tribal		Non-Tribal		River Totals			Harvest
Year	CESRF	Natural	CESRF	Natural	CESRF	Natural	Total	Rate[1]
1983		84		0		84	84	5.8%
1984		289		0		289	289	10.9%
1985		865		0		865	865	19.0%
1986		1,340		0		1,340	1,340	14.2%
1987		517		0		517	517	11.6%
1988		444		0		444	444	10.5%
1989		747		0		747	747	15.2%
1990		663		0		663	663	15.2%
1991		32		0		32	32	1.1%
1992		345		0		345	345	7.5%
1993		129		0		129	129	3.3%
1994		25		0		25	25	1.9%
1995		79		0		79	79	11.9%
1996		475		0		475	475	14.9%
1997		575		0		575	575	18.1%
1998		188		0		188	188	9.9%
1999		604		0		604	604	21.7%
2000	53	2,305		100	53	2,405	2,458	12.9%
2001	572	2,034	1,252	772	1,825	2,806	4,630	19.9%
2002	1,373	1,207	492	36[2]	1,865	1,243	3,108	20.6%
2003	134	306	0	0	134	306	440	6.3%
2004	289	712	569	109[2]	858	820	1,679	11.0%
2005	46	428	0	0	46	428	474	5.4%
2006	246	354	0	0	246	354	600	9.5%
2007	123	156	0	0	123	156	279	6.5%
2008	521	414	586	11[2]	1,107	426	1,532	17.8%
2009	1,089	715	541	8[2]	1,630	722	2,353	19.4%
2010	345	194	1,154	48[2]	1,499	241	1,741	13.2%
2011	1,361	1,261	1,579	179[2]	2,940	1,440	4,380	24.4%
2012	1,220	1,302	735	63[2]	1,955	1,364	3,320	27.5%
2013	846	975	786	46[2]	1,632	1,021	2,653	25.9%
2014	576	715	826	54[2]	1,402	769	2,171	19.2%
Mean	624	634	609	95	1,233	677	1,202	13.8%

1. Harvest rate is the total Yakima Basin harvest as a percentage of the Yakima River mouth run size.
2. Includes estimate of post-release mortality of unmarked fish.

Table 19. Estimated fall Chinook return, escapement, and harvest in the Yakima River, 1998-2014. Data from WDFW and YN databases.

			Escapement						
	Total Return		Above Prosser		Below Prosser		WA Recreational Harvest		
Year	Adult	Jack	Adult	Jack	Adult	Jack	Adult	Jack	Rate
1998	1,743	106	1,064	84	645	22	34	0	1.8%
1999	4,056	43	1,876	20	2,046	23	134	0	3.3%
2000	4,557	1,138	1,371	922	2,931	194	255	22	4.9%
2001	5,886	869	3,651	660	1,293	151	942	58	14.8%
2002	13,369	211	6,146	95	4,923	116	2,300	0	16.9%
2003	10,092	193	4,796	79	3,874	73	1,422	41	14.2%
2004	5,825	354	2,862	85	2,231	223	732	46	12.6%
2005	3,121	45	1,920	22	491	7	710	16	22.9%
2006	2,299	67	1,499	29	363	10	437	28	19.7%
2007	1,318	460	892	240	194	26	232	194	24.0%
2008	3,403	208	2,739	124	137	17	527	67	16.4%
2009	3,315	772	2,381	591	424	106	510	75	14.3%
2010	3,474	176	2,763	125	270	12	441	39	13.2%
2011	3,325	705	2,318	400	470	81	537	224	18.9%
2012	5,436	1,348	3,634	843	1098	211	704	294	14.7%
2013	11,471	1,249	7,003	703	1936	194	2,532	352	22.7%
2014	11,592	1,002	7,127	665	2897	271	1,568	66	13.0%

Table 20. Estimated Coho return, escapement, and harvest in the Yakima River, 1999-2014. Data from WDFW and YN databases.

			Escapement						
	Total Return		Prosser Dam		Hatchery Denil		WA Recreational Harvest		
Year	Adult	Jack	Adult	Jack	Adult	Jack	Adult	Jack	Rate
1999	3,906	91	3,852	91			54	0	1.4%
2000	4,444	1,841	4,390	1,826			54	15	1.1%
2001	5,032	68	4,978	68			54	0	1.1%
2002	515	343	475	343			40	0	4.7%
2003	2,192	162	2,192	162			0	0	0.0%
2004	2,367	74	2,325	64			42	10	2.1%
2005	2,897	225	2,890	225			7	0	0.2%
2006	4,478	175	4,335	175	125	0	18	0	0.4%
2007	3,461	64	3,153	60	300	4	8	0	0.2%
2008	4,636	1,917	3,890	1,809	700	58	46	50	1.5%
2009	9,843	873	8,517	573	1300	300	26	0	0.2%
2010	5,776	567	4,811	183	915	384	50	0	0.8%
2011	8,073	171	6,424	121	1594	50	55	0	0.7%
2012	5,511	264	4,298	164	1200	100	13	0	0.2%
2013	3,173	848	2,290	395	837	412	46	41	2.2%
2014	25,368	584	20,997	427	4263	157	108	0	0.4%

Discussion:

Adult returns of spring Chinook from the CESRF have substantially increased fishing opportunity for all fishers in the Yakima Basin (Table 18) and returned recreational fisheries to the Basin after a 40-year absence. This has contributed to improved relationships between all the Basin's stakeholders and increased opportunities for collaboration.

Recreational fishers enjoy a successful annual fall Chinook fishery situated primarily near the mouth of the Yakima River (Table 19). Tribal fishers harvest a substantial, but unquantified number of Yakima Basin-destined fall Chinook (Figure 22) and coho in commercial gillnet fisheries in the Zone 6 fishing area. Because of the quantity and relatively higher quality of fall Chinook and coho available to tribal fishers in Zone 6 Columbia and Klickitat River fisheries, Yakima River tribal harvest is typically at or near zero even though regulations allowing fall season fisheries in the Yakima River are propagated annually by the Yakama Nation.

Hatchery Monitoring

Effect of Artificial Production on the Viability of Natural Fish Populations

WDFW is reporting hatchery uncertainties (see Columbia River Basin Research Plan) related to genetic and ecological interactions in their associated annual report 1995-063-25. We are working jointly with WDFW to address the following additional hatchery uncertainties:

Hatchery Critical Uncertainty 3. What is the magnitude of any demographic benefit to the production of natural-origin juveniles and adults from the natural spawning of hatchery-origin supplementation adults?

Hatchery Critical Uncertainty 4. What are the range, magnitude, and rates of change of natural spawning fitness of integrated (supplemented) populations?

Methods:

The YKFP began a spring Chinook salmon hatchery program at the CESRF near Cle Elum on the upper Yakima River (river kilometer 297, measuring from the confluence with the Columbia River; Figures 1 and 23) in 1997. This program is a supplementation effort targeting the upper Yakima River population and is designed to test whether artificial propagation can be used to increase natural production and harvest opportunities while limiting ecological and genetic impacts (RASP 1992). It is an integrated hatchery program (Mobrand et al. 2005) because only natural-origin brood-stock are used and returning hatchery-origin adults are allowed to spawn in the wild. The program employs "best practice" hatchery management principles (see

Cuenco et al. 1993, Mobrand et al. 2005) including reduced pond densities, strict disease management protocols, random brood-stock selection, and factorial mating (Busack and Knudsen 2007) to maximize effective population size. Fish are reared at the central facility, but released from three acclimation sites located near the central facility at: Easton approximately 25km upstream of the central facility, Clark Flat about 25km downstream of the central facility, and Jack Creek about 12km upstream from the Teanaway River's confluence with the Yakima River (Figure 23). The CESRF collected its first spring Chinook brood-stock in 1997, released its first fish in 1999, and age-4 adults have been returning since 2001. The first generation of offspring of CESRF and wild fish spawning in the wild returned as adults in 2005. The program uses the adjacent, un-supplemented Naches River population as an environmental and wild control system.

To evaluate demographic benefits for spring Chinook, we compared redd count and natural-origin adult return data for the supplemented Upper Yakima and un-supplemented (control) Naches populations using a Before/After Control/Impact (BACI) analysis (Stewart-Oaten et al. 1986; Smith et al. 1993). For redd counts, the before period was defined as 1981 to 2000 and the after period as 2001 to present (hatchery-origin age-4 adults first returned to integrate with natural-origin fish on the natural spawning grounds in 2001). The first natural-origin returns of age-4 fish from these integrated population redds did not occur until 2005, so the pre- and post-supplementation (before/after) periods for natural-origin return evaluation were defined as 1982 to 2004 and 2005 to present, respectively. The spring Chinook findings described below were published in Fast et al. (2015). We are working with WDFW to incorporate additional out-of-basin control populations in this evaluation and these results will be considered for publication at a later date.

To evaluate fitness parameters for an integrated spring Chinook population, we used methods described in Knudsen et al. (2008) and Schroder et al. (2008, 2010, and 2012). For coho, we conducted preliminary evaluation of both demographic benefits and some fitness parameters using methods described in Bosch et al. (2007).

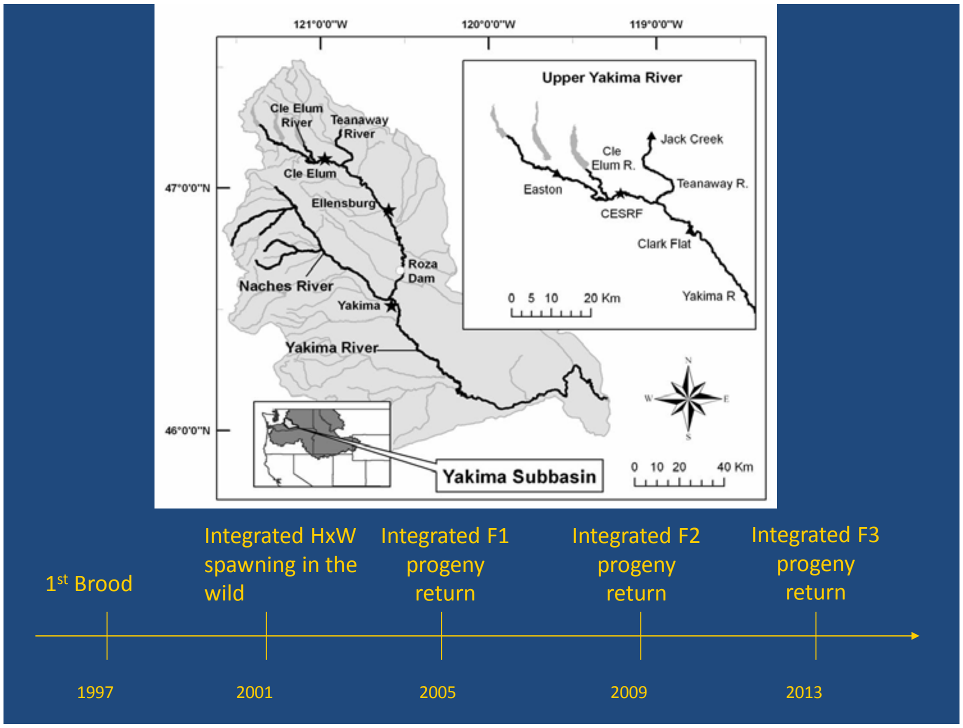
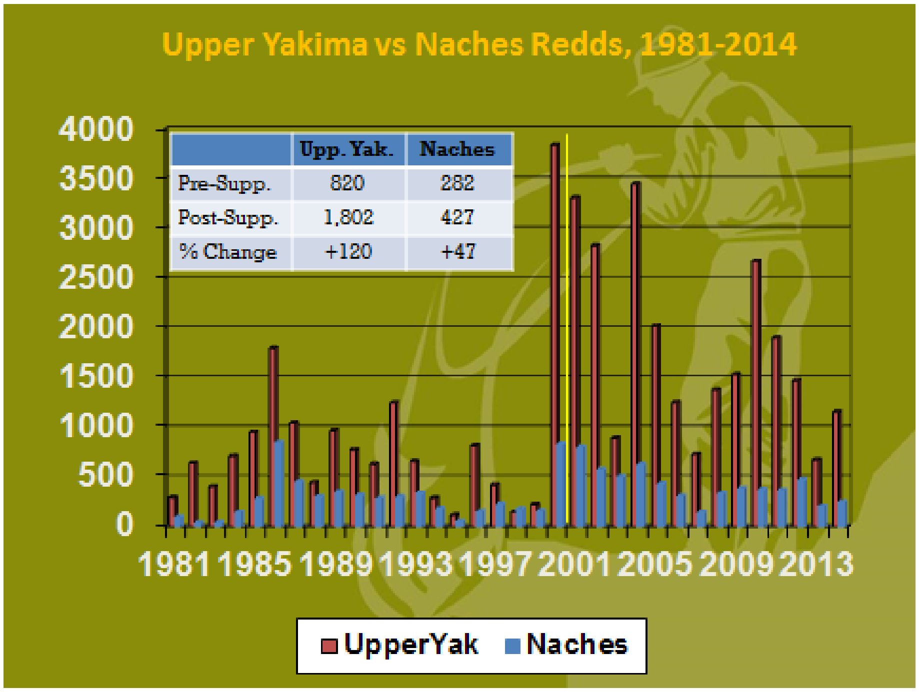


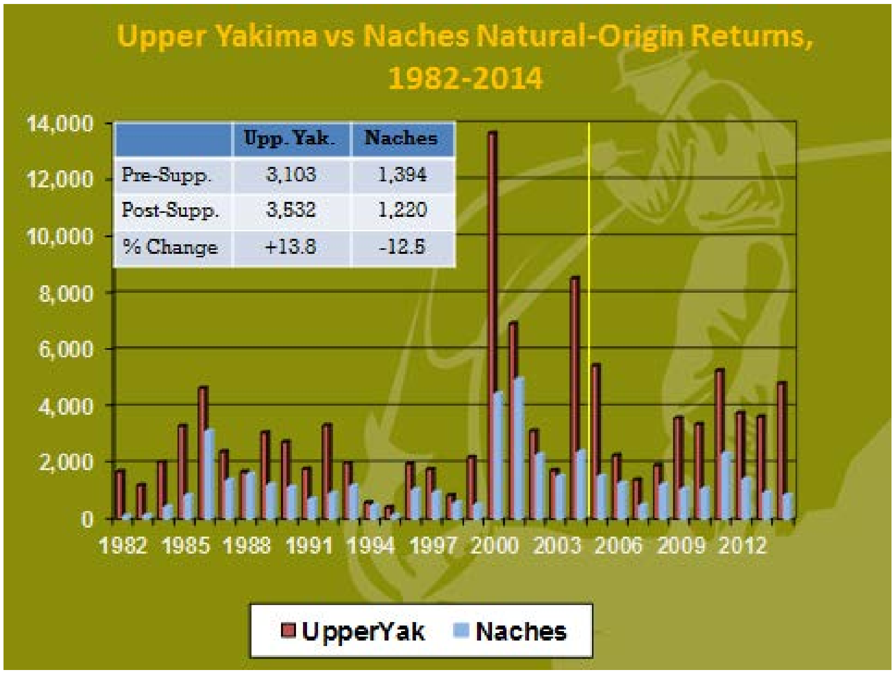
Figure 23. Map of the Yakima River Basin, Cle Elum Supplementation and Research Facility (CESRF) locations, and timeline of the spring Chinook supplementation program.

Results:



	Upp. Yak.	Naches
Pre-Supp.	820	282
Post-Supp.	1,802	427
% Change	+120	+47

Figure 24. Spring Chinook redd counts in the supplemented Upper Yakima (red bar) relative to the un-supplemented Naches (control; blue bar) for the pre- (1981-2000) and post-supplementation (2001-2014) periods.



	Upp. Yak.	Naches
Pre-Supp.	3,103	1,394
Post-Supp.	3,532	1,220
% Change	+13.8	-12.5

Figure 25. Natural-Origin returns of Spring Chinook in the supplemented Upper Yakima (blue bar) relative to the un-supplemented Naches (control; yellow bar) for the pre- (1982-2004) and post-supplementation (2005-2014) periods.

Discussion:

Supplementation has increased spring Chinook redd abundance in the Upper Yakima relative to the Naches control system (Figure 24). Redd counts in the post-supplementation period (2001-2014) increased in the supplemented Upper Yakima (+120%; P=0.003) but the change observed in the un-supplemented Naches control system relative to the pre-supplementation period (1981-2000) was not significant (+47%; P=0.07). As noted above, spatial distribution of spring Chinook has also increased as a result of supplementation with dramatic increases in redd abundance observed in the Teanaway River (Figure 15).

Changes in mean natural-origin return abundance in the post-supplementation period (2005-2014) relative to the pre-supplementation period (1982-2004) were not significant in either the supplemented upper Yakima River (+13.8%; P=0.667; Figure 25) or the unsupplemented Naches River system (-12.5%; P=0.682; Figure 25). We have already noted that limiting factors appear to be inhibiting natural productivity (see status and trend of adult productivity) throughout the Yakima Basin. It may also be that the post-supplementation time period is not yet long enough to detect a significant change in this natural production parameter. Given the short post-supplementation time series, these findings are preliminary. We will continue to incorporate additional years of data and out-of-basin control populations into this evaluation and publish more complete findings at a later date.

With respect to spring Chinook fitness parameters we found the following. The relationships between reproductive traits and body length were not significantly altered by a single generation of hatchery exposure. However, because hatchery females had smaller body sizes, the distributions of linked traits, such as total gamete mass and fecundity, differed by as much as 0.6 SD, probably resulting in some fitness loss. Our data support the idea that a single generation of state-of-the-art conservation hatchery propagation can produce fish with reproductive traits similar to those of wild fish, given comparable body size (Knudsen et al. 2008). No differences were detected in the egg deposition rates of wild and hatchery origin females, but pedigree assignments based on microsatellite DNA showed that the eggs deposited by wild females survived to the fry stage at a 5.6% higher rate than those spawned by hatchery-origin females (Schroder et al. 2008). Behavior and breeding success of wild and hatchery-origin males were found to be comparable (Schroder et al. 2010). Large anadromous males produced 89%, jacks 3%, yearling precocious 7%, and sub-yearling precocious 1% of the fry in our tests suggesting that large anadromous males generate most of the fry in natural settings when half or more of the males present on a spawning ground use this life history strategy (Schroder et al 2012). For additional detail on Spring Chinook findings, see Fast et al. (2015).

The YKFP is presently studying the release of over 1.0 million coho smolts annually from acclimation sites in the Naches and Upper Yakima subbasins. These fish are a combination of in-basin production from brood-stock collected in the vicinity of Prosser Dam plus out-of-basin stock generally reared at Willard or Eagle Creek National Fish Hatcheries and moved to the Yakima Subbasin for final rearing and release. Monitoring of these efforts to re-introduce a sustainable, naturally spawning coho population in the Yakima Basin have indicated that adult coho returns averaged about 4,800 fish from 1997-2014 (an order of magnitude improvement from the average for years prior to the project) including estimated returns of wild/natural coho averaging about 1,100 fish annually since 2001 (Figure 4). Coho re-introduction research has demonstrated that hatchery-origin coho, with a legacy of as many as 10 to 30 generations of hatchery-influence, can reestablish a naturalized population after as few as 3 to 5 generations of outplanting in the wild (Bosch et al. 2007). The project is working to further develop a locally adapted brood-stock and to establish specific release sites and strategies that optimize natural reproduction and survival.

Effectiveness of Hatchery Reform

YKFP efforts to monitor and evaluate hatchery reform focus on the CESRF spring Chinook program which was designed explicitly for this purpose from its inception (BPA 1996). We will evaluate similar metrics for the summer/fall run Chinook and coho programs and publish those results in future reports as the Master Plan (Yakama Nation 2012) is implemented and the programs mature over time.

Methods:

Methods for enumerating natural- and CESRF-origin fish at Roza Dam were described above (Status and Trend of adult abundance) and in Knudsen et al. (2006). Proportionate natural influence (PNI) is an approximation of the rate of gene flow between the natural environment and the hatchery environment (Busack et al. 2006). The equation describing PNI is

$$\mathrm{PNI} = \frac{\mathrm{pNOB}}{\mathrm{pNOB} + \mathrm{pHOS}}$$

where pNOB is the proportion of natural-origin brood-stock and pHOS is the proportion of hatchery-origin spawners. We evaluated PNI for the CESRF program using a pNOB value of 1.0 as only natural-origin fish were used for the integrated program's broodstock.

As stated in the introduction to this report and in the final Environmental Impact Statement for the Yakima Fisheries Project (BPA 1996), one of the explicit purposes of the project is to test the assumption that new artificial propagation or hatchery reform techniques (Cuenco et al. 1993, Mobrand et al. 2005) can be used to increase natural production without causing significant impacts to existing natural populations. Therefore it has always been the intent of this project to purposely allow hatchery-origin fish to escape to the natural spawning grounds. There are good arguments for the merits of this concept (Cuenco et al. 1993, Bosch 2004, Brannon et al. 2004, Paquet et al. 2011) but additional evaluation is required before definitive answers to key biological cost and benefit questions relative to these types of programs will be known with scientific certainty (Fraser 2008).

Results:

Table 21. Escapement (Roza Dam counts less brood-stock collection and harvest above Roza) of natural- (NoR) and hatchery-origin (HoR) spring Chinook to the upper Yakima subbasin, 1982 – present.

	Wild/Natural (NoR)			CESRF (HoR)				Total			
Year	Adults	Jacks	Total	Adults	Jacks	Total	Adults	Jacks	Total	PHOS[1]	PNI[1]
1982			1,146								
1983			1,007								
1984			1,535								
1985			2,331								
1986			3,251								
1987			1,734								
1988			1,340								
1989			2,331								
1990			2,016								
1991			*1,583*[2]								
1992			3,009								
1993			1,869								
1994			563								
1995			355								
1996			1,631								
1997	1,141	43	1,184								
1998	369	18	387								
1999	498	468	966								
2000	10,491	481	10,972		688	688	10,491	1,169	11,660	5.9%	
2001	4,454	297	4,751	6,065	982	7,047	10,519	1,279	11,798	59.7%	62.6%
2002	1,820	89	1,909	6,064	71	6,135	7,884	160	8,044	76.3%	56.7%
2003	394	723	1,117	1,036	1,105	2,141	1,430	1,828	3,258	65.7%	60.3%
2004	6,536	671	7,207	2,876	204	3,080	9,412	875	10,287	29.9%	77.0%
2005	4,401	175	4,576	627	482	1,109	5,028	657	5,685	19.5%	83.7%
2006	1,510	121	1,631	1,622	111	1,733	3,132	232	3,364	51.5%	66.0%
2007	683	161	844	734	731	1,465	1,417	892	2,309	63.4%	61.2%
2008	988	232	1,220	2,157	957	3,114	3,145	1,189	4,334	71.9%	58.2%
2009	1,843	701	2,544	2,234	2,260	4,494	4,077	2,961	7,038	63.9%	61.0%
2010	2,436	413	2,849	4,524	1,001	5,525	6,960	1,414	8,374	66.0%	60.2%
2011	3,092	926	4,018	3,162	1,404	4,566	6,254	2,330	8,584	53.2%	65.3%
2012	2,359	191	2,550	2,661	265	2,926	5,020	456	5,476	53.4%	65.2%
2013	1,708	678	2,386	1,587	840	2,427	3,295	1,518	4,813	50.4%	66.5%
2014	3,099	685	3,784	2,150	794	2,944	5,249	1,479	6,728	43.8%	69.6%
Mean[3]	2,657	393	3,050	2,679	801	3,479	5,202	1,234	6,435	54.9%	65.2%

1. Proportionate Natural Influence equals Proportion Natural-Origin Brood-stock (PNOB; 1.0 as only NoR fish are used for supplementation line brood-stock) divided by PNOB plus Proportion Hatchery-Origin Spawners (PHOS).
2. This is a rough estimate since Roza counts are not available for 1991.
3. For NoR columns, mean of 1997-present values. For all other columns, mean of 2001-present values.

Discussion:

While the project does not actively manage for a specific spawning escapement proportion (natural- to hatchery-origin adults), we are monitoring the proportionate natural influence (PNI). By designing the program to use only natural-origin fish for brood-stock, the program is meeting or exceeding scientific recommendations for PNI on an annual basis with a 14-year mean annual PNI of 65% (range 57-84%; Table 21). As noted throughout this report and in numerous publications related to the project, we are also meeting or exceeding project objectives with respect to providing additional harvest opportunity, increasing viable salmon population (VSP; McElhany et al. 2000) parameters, and minimizing biological concerns regarding genetic and ecological impacts.

The project will continue to monitor PNI considering factors such as: policy input regarding controlling the number and types of fish allowed to escape to natural spawning areas, meeting overall production goals of the project, guidance from the literature relative to percentage of hatchery fish on the spawning grounds with fitness loss, considerations about what risk is acceptable in a project designed to evaluate impacts from that risk, and the numerous risk containment measures already in place in the project. The State of Washington is using mark-selective fisheries in the lower Columbia River and, when possible, in the lower Yakima River in part as a tool to manage escapement proportions. In 2011, the project implemented an effort to transfer some returning hatchery-origin CESRF adults from Roza Dam to Lake Cle Elum for the purpose of returning marine derived nutrients and salmon to the watersheds that feed the lake. These measures will also increase PNI in the major spawning areas of the Upper Yakima Basin. Additional adaptive management measures will be considered when and if monitoring and evaluation indicates a need. Additional information and results from the CESRF program are provided in Appendix B and in Fast et al. (2015).

Predation Management and Predator Control

Avian Predation Index

Avian predators are capable of significantly depressing smolt production. The loss of wild spring Chinook salmon juveniles to various types of avian predators has long been suspected as a significant constraint on production and could limit the success of supplementation. Therefore, a long-standing objective of the YKFP has been to monitor, evaluate, and index the impact of avian predation on annual salmon and steelhead smolt production in the Yakima Subbasin. Accurate methods of indexing avian predation across years have been developed.

Methods:

River Reach Surveys

The spring river surveys included nine river reaches (Table 22) and were generally consistent with avian point count methods described in monitoringmethods.org method 1151. The surveys account for coverage of approximately 40% of the total length of the Yakima River.

Table 22. Avian predation river reach survey start and end locations and total reach length.

Name	Start	End	Length (km)
Easton	Easton Acclimation Site	Bridge	29.3
Cle Elum	South Cle Elum Bridge	Thorp Hwy Bridge	28.3
Canyon	Ringer Road	Lmuma or Roza Recreation Site	20.8 or 29.8
Selah Section	Harrison Rd Bridge	Harlan Landing Park	6.42
Gap to gap	Harlan Landing Park	Union Gap	15.85
Parker	Below Parker Dam US Hwy 97	Hwy 8 Bridge	20.3
Zillah	US Hwy 97/ Hwy 8 Bridge	Granger Bridge Ave Hwy Bridge	16.0
Benton	Chandler Canal Power Plant	Benton City Bridge	9.6
Vangie	1.6 km above Twin Bridges	Van Giesen St Hwy Bridge	9.3

All river reach surveys were conducted by a two-person team from a 16 foot drift boat or 12 foot raft. Surveys began between 8:00 am and 9:00 am and lasted between 2 to 6 hours depending upon the length of the reach and the water level. All surveys were conducted while actively rowing the drift boat or raft downstream to decrease the interval of time required to traverse the reach. One person rowed the boat while the other person recorded piscivorous birds encountered.

All birds detected visually or aurally were recorded, including time of observation, species, and sex and age if distinguishable. Leica 10x42 binoculars were used to help observe birds. All piscivorous birds encountered on the river were recorded at the point of initial observation. Most birds observed were only mildly disturbed by the presence of the survey boat and were quickly passed. Navigation of the survey boat to the opposite side of the river away from encountered birds minimized escape behaviors. If the bird attempted to escape from the survey boat by moving down river a note was made that the bird was being pushed. Birds being pushed were usually kept in sight until passed by the survey boat. If the bird being pushed down river moved out of sight of the survey personnel, a note was made, and the next bird of the same species/age/sex to be encountered within the next 1000 meters of river was assumed to be the pushed bird. If a bird of the same species/age/sex was not encountered in the subsequent 1000 meters, the bird was assumed to have departed the river or passed the survey boat without detection, and the next identification of a bird of the same species/age/sex was recorded as a new observation.

Acclimation Site Surveys

Three Spring Chinook acclimation sites in upper Yakima River (Clark Flat, Jack Creek, and Easton) and one Coho site (JD Holmes) were surveyed for piscivorous birds again in 2014 (Figure 1). Surveys were conducted between January 23 and June 10, though dates varied for each site. Three surveys were conducted at the Spring Chinook sites each day, at 8:00 am, 12:00 noon, and 4:00 pm. The Coho site was surveyed once or twice on days hatchery personnel were feeding smolts. Surveys were conducted on foot. All piscivorous birds within the acclimation facility, along the length of the artificial acclimation stream, and 50 meters above and 150 meters below the acclimation stream outlet, into the main stem of the Yakima River or North Fork Teanaway, were recorded.

Salmon PIT Tag Surveys at Great Blue Heron Rookeries

A Passive Integrated Transponder (PIT) tag reader was used to survey for PIT tags deposited in various Yakima River Great Blue Heron Rookeries (Figure 26). Methods were generally consistent with Evans and Hostetter (2012) and with monitoringmethods.org method 255.

Areas surveyed included: Great Blue Heron Rookeries in Yakima Basin: Selah, Toppenish Creek, Buena, Wapato Wildlife area, Grandview, and Satus. Based on the salmon tags found at these sites consumption could be assigned to piscivorous fish, American White Pelicans, Double Crested Cormorants, and the Great Blue Herons. Predation assignment was strictly by observation. For example, the Chandler Bypass has been heavily used by pelicans since 2003 while the Selah Heronry supports herons and sometimes cormorants.

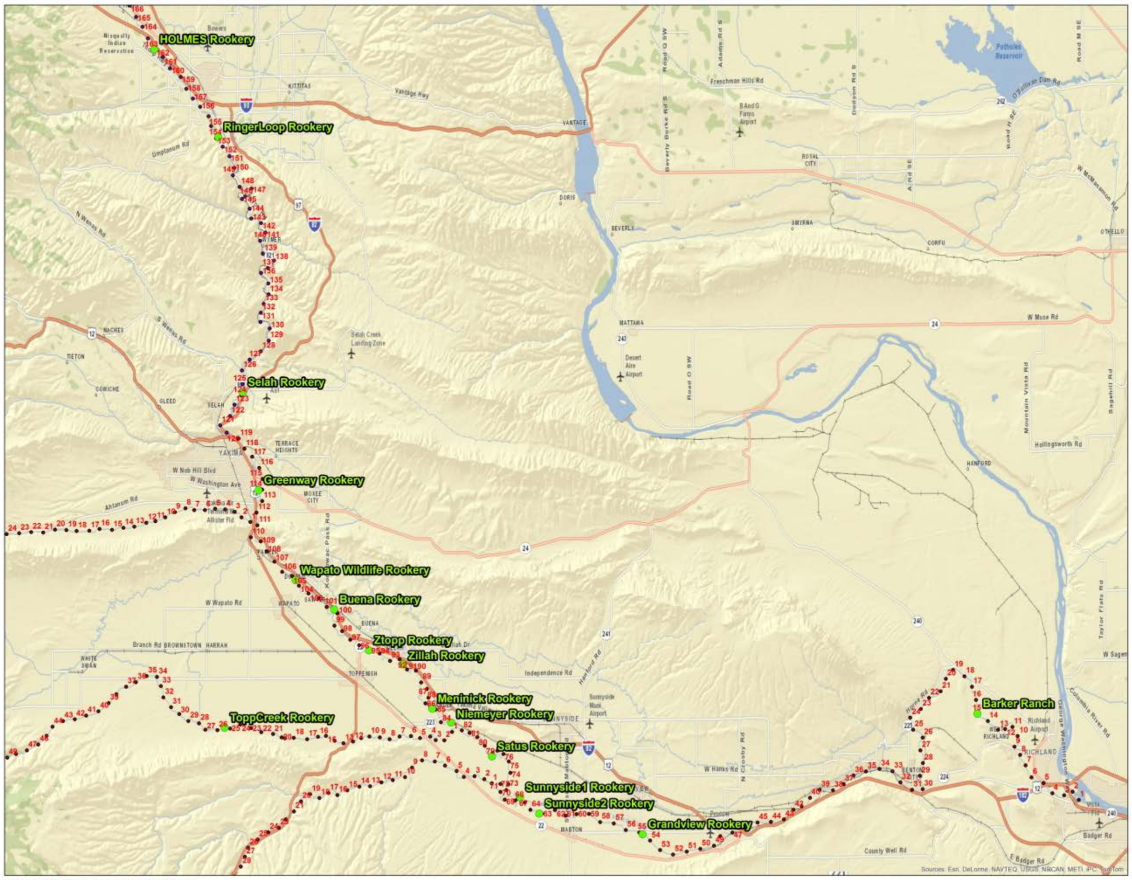


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Figure 26. Map of Yakima Basin Heron Rookeries.

PIT Tag surveys were conducted using the *Portable Transceiver System: PTS Model FS2001F-ISO from Biomark*. The transceiver is designed to scan for PIT tags and identify them by their given code. A Garmin GPS unit was used to map rookeries along with survey plots or points. Additional equipment included the use of camouflage to limit disturbance for bird nest identification and counts.

Rookeries were surveyed to determine total rookery numbers and Great Blue Heron population numbers via jet boat, plane, and foot. Rookeries were surveyed in the spring and summer for population numbers using binoculars; rookeries were not entered for fear of causing bird abandonment. Once birds had fledged, rookeries were cleared of debris under nests to scan for defecated/regurgitated PIT tags.

The objectives for the study were:

- Identify all Rookeries in the Yakima Basin
- Survey populations during nesting
- Estimate detection efficiencies by seeding PIT Tags

- Clear PIT Tag deposit areas after fledging
- Survey for PIT Tags post fledge and after flooding
- Remove PIT Tags (tag collision causes interference)
- Conduct aerial flights and river surveys to monitor populations

Results and Discussion:

River Reach Surveys

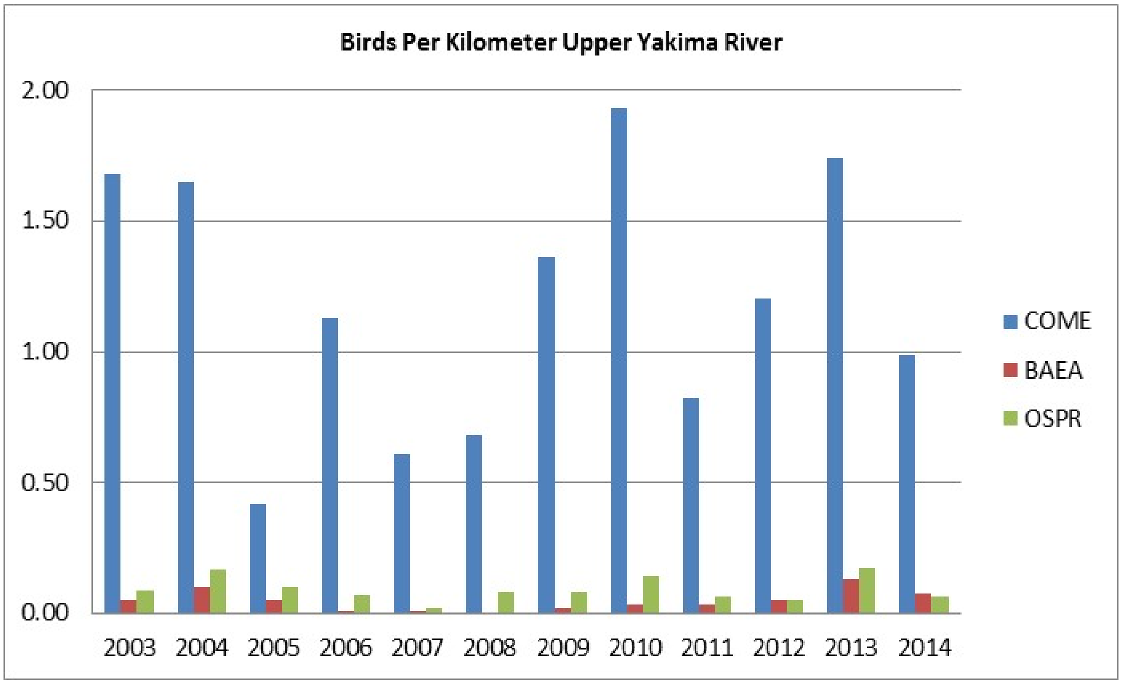

Figure 27. Upper Yakima piscivorous birds per kilometer (Common Merganser-COME, Bald Eagle-BAEA, and Osprey-OSPR).

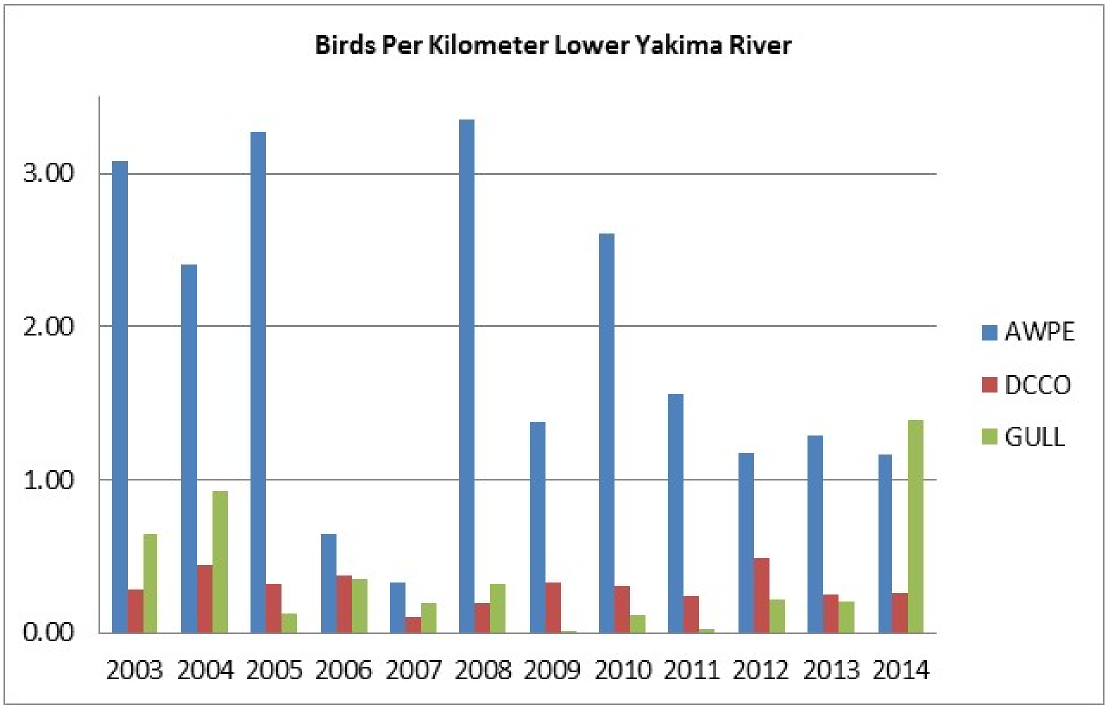

Figure 28. Lower Yakima piscivorous birds per kilometer (American White Pelican-AWPE, Double Crested Cormorant-DCCO, and Gulls-GULL).

Thirteen different piscivorous bird species were observed on the Yakima River. These included: American White Pelican, Bald Eagle, Black-crowned Night Heron, Belted Kingfisher, Caspian Tern, Common Merganser, Double-crested Cormorant, Forster's Tern, Great Egret, Great Blue Heron, Gull species, Hooded Merganser, and Osprey. These same 13 species were observed in most survey years. Graph data for river reach surveys represents a combined view of the upper Yakima River (surveys above Wapato Dam; Figure 27) and the lower Yakima River (surveys below Wapato Dam; Figure 28). The three top bird predators within these bisected areas were chosen for graph representation.

Osprey, Great Blue Heron, and Belted Kingfisher were the only species found on all six reaches in the spring, and Common Mergansers were observed on all reaches except the Vangie reach. Common Mergansers were most abundant in the upper reaches of the river (Easton and Cle Elum reaches) which was the case in all years surveyed (Figure 27).

Gull numbers in the lower Yakima River rose considerably for 2014 (Figure 28). Double Crested Cormorant numbers surveyed remained consistent with prior years. This species remains a concern due to takeover of Great Blue Heron Rookeries in various areas along the Yakima River. Monitoring of the Double Crested Cormorant on the river and in rookeries will be a priority in upcoming years as the Army Corp of Engineers culls and removes breeding habitat at the estuary of the Columbia River in efforts to reduce juvenile salmon predation (USACE 2014). These actions may result in displacement and searching out of new habitat for the Cormorants and lead to impacts on salmon in other rivers and basins. The American White Pelicans numbers remain consistently high in the lower Yakima River. In the Yakima River pelicans can be seen in groups of over 100 in the Wapato Reach of the river along the borders of the Yakama Indian Reservation.

Acclimation Sites Surveys

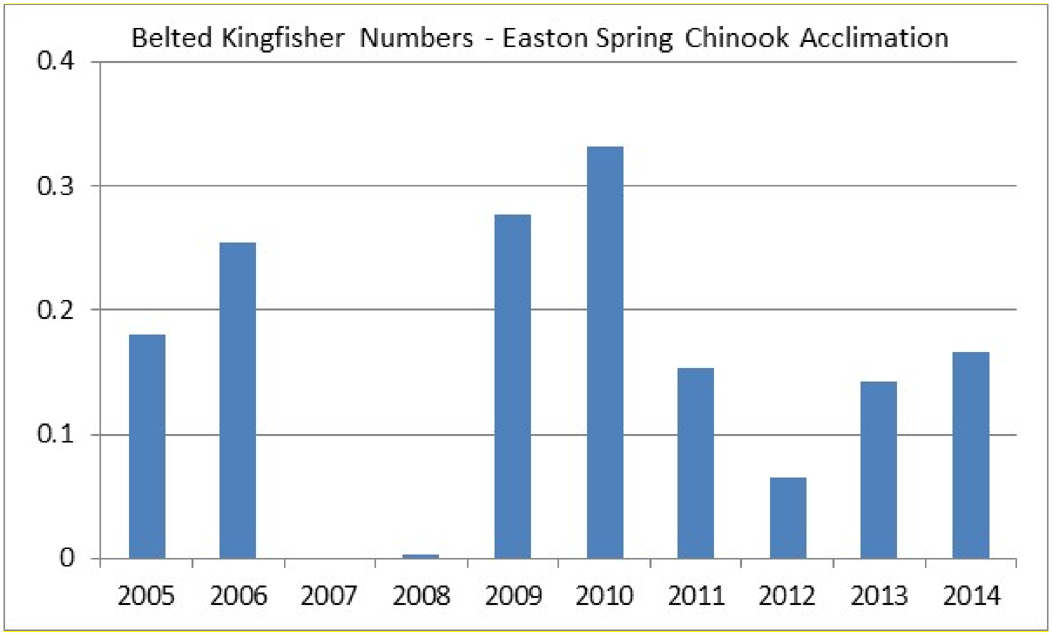

Figure 29. Average number of Belted King Fishers observed per day at the Easton spring Chinook acclimation site between 2005 and 2014 when fish were present.

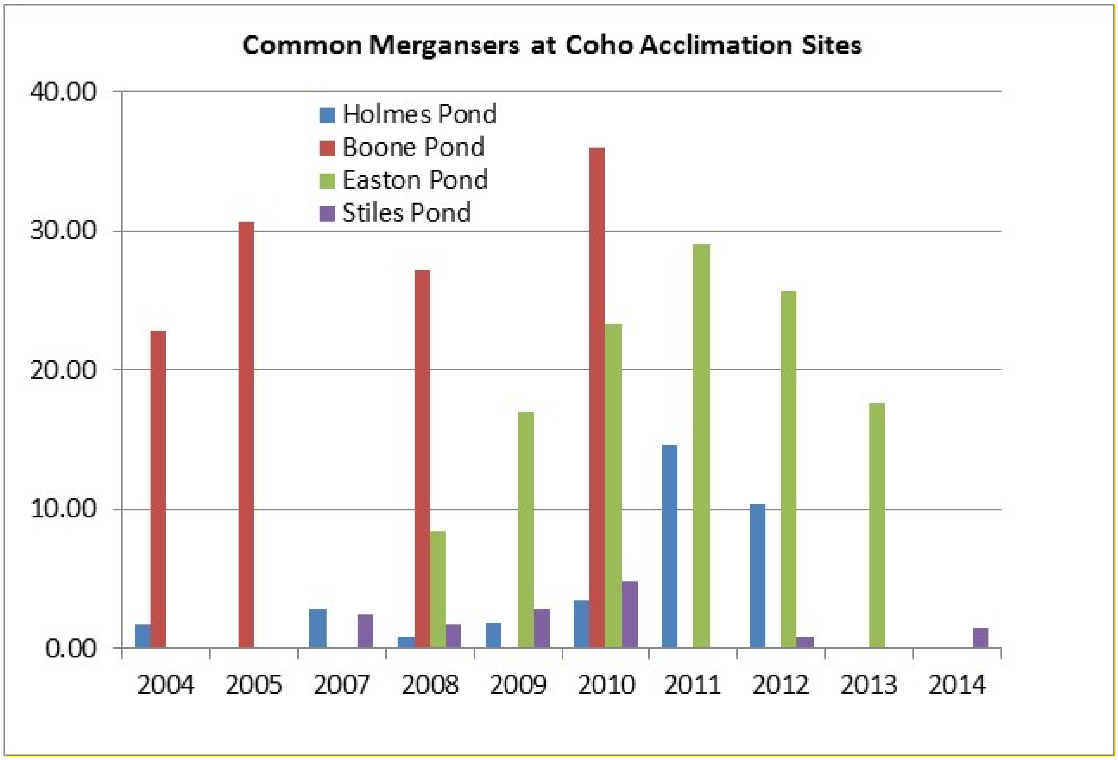

Figure 30. Average number of Common Mergansers observed per day at the JD Holmes, Boone, Easton, and Stiles Pond Coho acclimation sites between 2004 and 2014 when fish were present.

Acclimation site avian abundance varied greatly between manmade concrete structures and natural or manmade ponds. Spring Chinook from the CESRF were acclimated in concrete raceways in three different locations in the Upper Yakima Basin. The raceways were covered with guide wires to control access to fish by piscivorous birds and provide a deterrent to predation. The Belted Kingfisher, due to its small size and fishing style, was the dominant predator in these acclimation sites, but numbers per day remained below any level of concern for management strategies to be implemented (Figure 29).

Coho acclimation was conducted in natural or manmade ponds which were highly accessible to piscivorous birds. The Common Merganser was the most common predator at these Coho acclimation sites (Figure 30). From 2004 to 2014 various ponds were used in alternation as Coho acclimation sites. Boone pond in the upper Yakima Basin showed a tendency to draw large numbers of Common Mergansers during coho acclimation and during recent years has been abandoned as a site of acclimation. Easton pond was used consistently as a Coho acclimation site from 2004 to 2014 (however, no data were available for this pond in 2014). Recent years have shown a steady growth in Common Mergansers utilizing Holmes pond during Coho acclimation; this may be due to the fact of lack of fish at Boone pond.

The most common birds preying on smolts in acclimations sites were the Bald Eagle, Belted Kingfishers, Common Merganser, and Great Blue Heron. If it is assumed that birds feeding in acclimation ponds are consuming only smolts on bird days on site, an average of consumption can be calculated using the average number of birds at each site, daily energy requirements of the birds, and the average size of smolts. Calculated estimates assume that acclimation fish were the only prey for the bird species surveyed.

For the Spring Chinook sites (Clark Flat, Easton and Jack Creek), it was estimated that these bird species together consumed 946 smolts at Clark Flat, 394 smolts at Easton and 639 smolts at Jack Creek.

At Coho acclimation sites no bird species were observed during the acclimation season at Lost Creek. At Stiles Pond the most common bird predators were the Belted Kingfisher, Common Merganser, and the Great Blue Heron. It was estimated that these bird species when combined together may have consumed up to 1,879 Coho. For Easton Pond no data was provided for 2014. In 2013 the most common birds preying on smolts at Easton pond were Bald Eagle, Common Merganser, Great Blue Herons, and Osprey. It is estimated that these bird species together consumed 34,551 smolts.

Great Blue Heron Rookeries

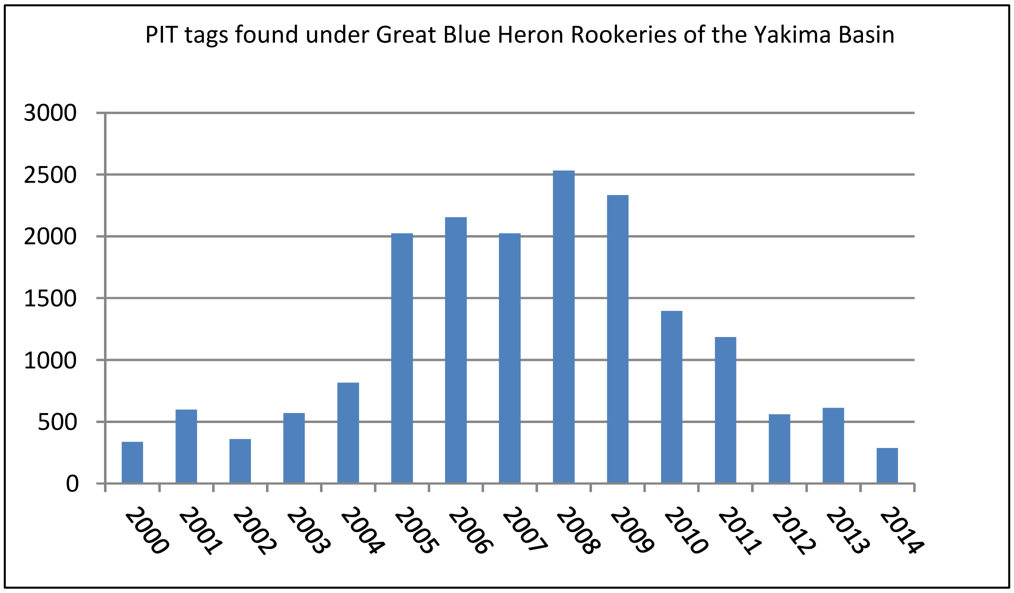

Figure 31. Number of PIT tags recovered at Yakima Basin Great Blue Heron rookery sites during surveys conducted from 2008-2014. Tags were from juvenile salmonids migrating downstream between 2000 and 2014. Total PIT tags recovered are shown by their corresponding migration year.

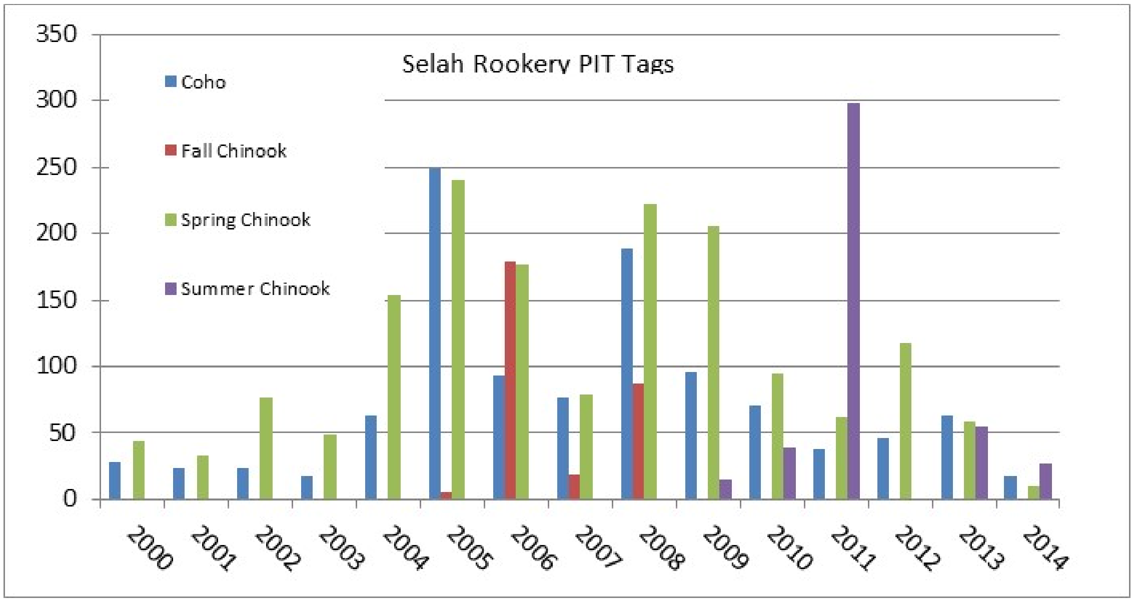

Figure 32. Number of PIT tags recovered at the Selah Great Blue Heron rookery during surveys conducted from 2008-2014. Tags were from juvenile salmonids migrating downstream between 2000 and 2014. Total PIT tags recovered are shown by species and their corresponding migration year.

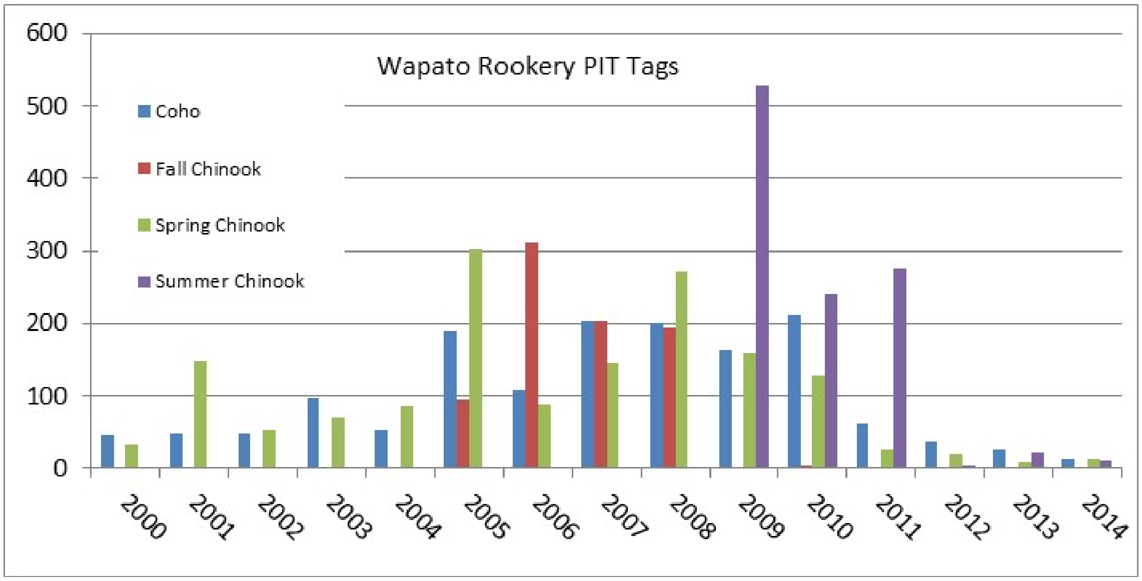

Figure 33. Number of PIT tags recovered at the Wapato Wildlife Area Great Blue Heron rookery during surveys conducted from 2008-2014. Tags were from juvenile salmonids migrating downstream between 2000 and 2014. Total PIT tags recovered are shown by species and their corresponding migration year.

Surveys of the Yakima Basin Great Blue Heron rookery sites between 2008 and 2014 recovered approximately 18,000 salmonid related PIT tags (Figure 31). Heron rookery PIT recoveries, when sorted by migration year, show higher mortality rates for juvenile migration years 2005 to 2009. This may correspond to river conditions (e.g., lower flows) that are likely conducive to increased smolt mortalities. For example, the migration year of 2008 was the most prevalent in PIT recoveries which could be related to drought conditions in 2007 when many 2008 migrants were released.

PIT recoveries in the Selah Heron Rookery may show the highest correlation to increases in predation opportunities due to low water flows in the Yakima River (Figure 32). Spring Chinook, released in Yakima River waters upriver of the rookery, exhibited the highest number of PIT recoveries for migration year 2005 which was a year of relatively low flows in the Yakima River. The Selah Rookery is located near the Roza reach of the Yakima River below Roza Dam which generally produces flows lower than most Yakima River reaches during poor water years. These low flows may inhibit fish passage and increase predation opportunities.

Large numbers of summer Chinook tags have been recovered over the last few years in the Selah Rookery (Figure 32). Beginning in 2013, some summer Chinook were released from a portable acclimation raceway at the Roza juvenile sampling facility (upstream of Selah; Figure 1). It is also possible that summer Chinook, acclimated at the nearby Stiles pond on the Naches River, could migrate to the Yakima River near the Selah rookery. Anecdotal evidence from the owner of the acclimation pond indicates that Herons congregate at the pond's release channel to the Naches River. These Herons are most likely from the Selah rookery.

The Wapato Wildlife area Great Blue Heron Rookery has produced the highest number of PIT recoveries when compared to all other Yakima Basin Rookeries. While Heron numbers in the rookery are high the overall difference in the Heron numbers when compared with other rookeries in the Basin is minimal. The high numbers of PIT recoveries in this rookery may be due to its location which is near to irrigation diversions and fish screening facilities. Fish diverted into these facilities are subjected to unfavorable flow conditions before being diverted back to the Yakima River via an underground pipe. Fish may become disoriented or severely injured during the diversion process making them susceptible to predation from the nearby Herons. PIT recoveries for summer Chinook migrating downstream in 2010 and 2011 were noticeably high at this rookery (Figure 33). Late release dates, low flows, and release location are the most likely factors related to the high mortality rates of these summer Chinook at the Wapato Rookery.

Fish Predation Index and Predator Control

Fish predators are also capable of significantly depressing smolt production. Thus the YKFP has a long-established objective to monitor, evaluate, and manage the impact of piscivorous fish on annual smolt production of Yakima Subbasin salmon and steelhead. By indexing the mortality rate of upper Yakima spring Chinook attributable to piscivorous fish in the lower Yakima River, the contribution of in-basin predation to variations in hatchery- and natural-origin spring Chinook smolt-to-adult survival rate can be deduced.

Based on YKFP and WDFW studies of piscivorous fish in the Yakima River Basin (Fritts and Pearsons 2004, 2006, 2008), it was determined that management of the piscivorous fish populations in the area is necessary to improve survival of juvenile salmonids. Initial steps were taken in 2009 to identify locations that would be suitable for a multi-pass removal population study. In early 2010, the YKFP began initial study checks to determine management and study goals for piscivorous fish. Presence and absence of piscivorous fish was determined through electro-fishing various sections of the Yakima River to determine temporal and spatial trends of each species of piscivorous fish. On March 1, 2013, the Washington Fish and Wildlife Commission adopted numerous changes to sport fishing rules, including the elimination of catch restrictions for non-native predators.

Methods:

Surveys for piscivorous fish were conducted year round in the Yakima River via electrofishing and were generally consistent with Tiffan et al. (2009) and with monitoringmethods.org methods 47 and 1712. Electro-fishing was conducted by jet-boat in the main stem or by backpack in side channels of the Yakima River. A Smith Root vvp-15b electro-fishing unit was used on the main stem while a smith root model 24 backpack unit was used in side channels. The preferred method of electro-fishing is pulsed direct current with varying frequencies dependent on specific conductivity and water temperature. The preferred method has been ideal for targeting piscivorous fish while not injuring salmonids. A GPS was used to locate survey transects and to calculate total distance of surveys. Electrode on time was recorded to calculate catch per unit effort, which was used as an estimate of abundance in each survey location. Piscivorous fish were collected during surveys in a bucket and sacrificed at the end of the survey.

During this project year, monthly multi-pass predator removal efforts (generally consistent with monitoringmethods.org methods 438) were conducted from March through August at Selah Gap to Union Gap (Section 1-4), Parker Dam to Toppenish (Sections 5-8), Toppenish to Granger (Sections 9-13), Benton (14-18), and Vangie (19-22) (Figure 34). Transects were approximately 1 mile sections separated by up to 1 mile and were chosen based on river flows (CFS) and ability to continue to survey these areas during low river water flows. Entire transects were sampled for presence of piscivorous fish. A comparative analysis of the multi-pass numbers for each transect was used to determine population numbers of piscivorous fish.

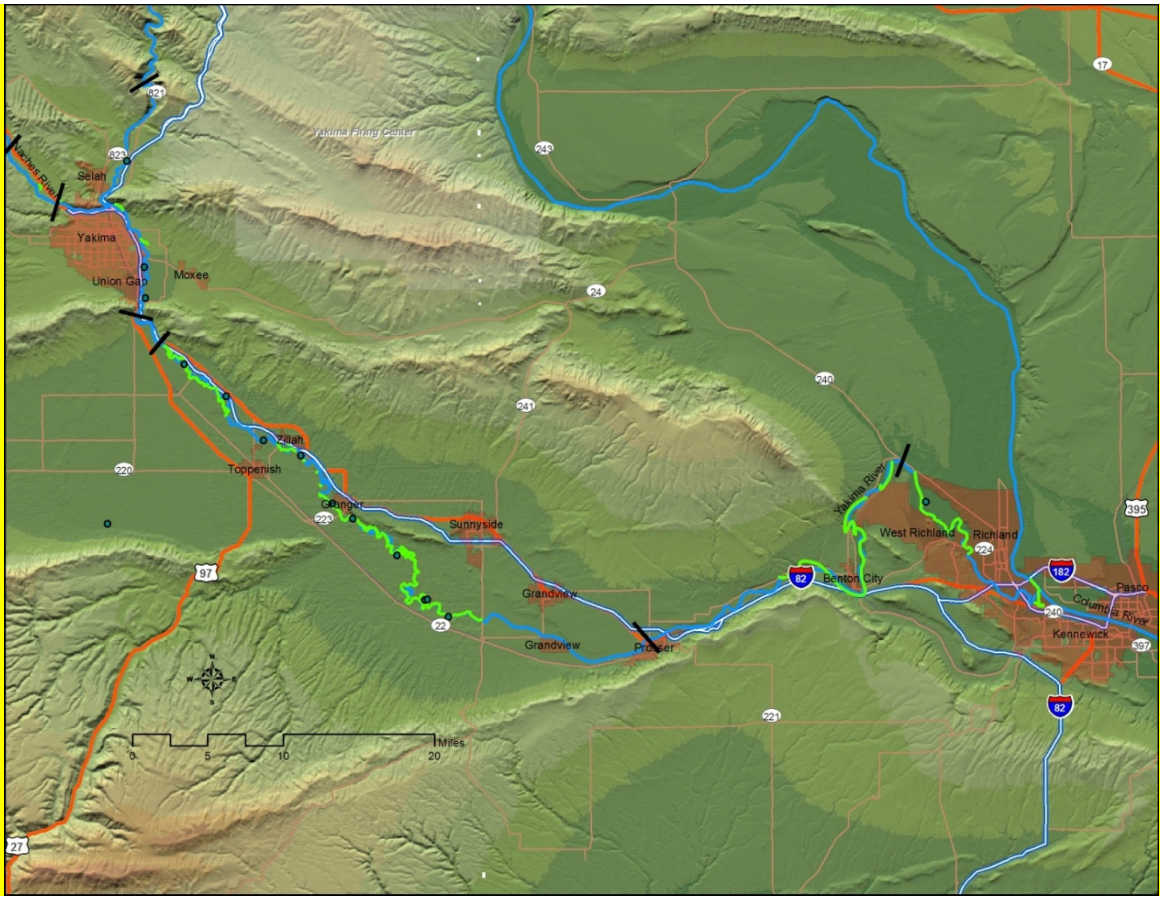

Figure 34. Map of Yakima River Piscivorous Fish Populations Study Areas.

In addition to population estimates, stomach samples were collected from every 5th Northern Pikeminnow (NPM, *Ptychocheilusoregonensis*) greater than 200 mm in fork length and every 5th Smallmouth bass (*Micropterusdolomieu*) less than 200mm in fork length within the transects (monitoringmethods.org method 152 and 4044). NPM stomachs with fish present were further analyzed to determine the number and types of species consumed (monitoringmethods.org methods 1317 and 1445). This analysis was performed using diagnostic bones which allows determination of species (though for salmonids this is more difficult) and approximate body length.

Survey efforts for 2011 to present also included recording all fish species and their corresponding catch per unit effort for select areas of importance on the Yakima River. Included for the inclusive species monitoring is the Wapato reach, a section of the Yakima River, designated as the area (for the purpose of this report) between Union Gap at USGS River mile 107 to the boundary of the Yakama Indian

Reservation at USGS River mile 60. Additional sections of the Yakima River which the species monitoring incorporates are three sections at the Yakima River Delta which include an area of the Yakima River at USGS river mile 1 to the confluence at the Columbia River, and the Delta sections to the East and West of the Bateman Island Causeway (Figure 35).

The inclusive species monitoring for the Yakima River will be used as an aid for tracking changes in fish populations and abundance as the area experiences global climate change.

Figure 35. Yakima River Delta Survey Areas.

Results and Discussion:

Wapato Reach fish species included the piscivorous Northern Pikeminnow and 10 other species of fish (Table 23). Relative catch numbers of the Northern Pikeminnow, for 2010 to present, were small compared to other fish species. Fish from the family *Catostomidae*, or suckers, were the highest relative catch for the Wapato reach (Figure 36). Salmonids were found in high abundance in the Wapato reach; catch abundance was dependent on time of year and is highest during the salmon smolt out-migration through the reach.

Table 23. Wapato Reach of the Yakima River - Fish Species identified during surveys 2010-2014.

Wapato Reach Fish Species

Family	Common Name	*Scientific Name*
Salmonidae:		
	Steelhead/Rainbow trout	*Oncorhynchus mykiss*
	Coho Salmon	*Oncorhynchus kisutch*
	Chinook Salmon	*Oncorhynchus tshawytscha*
	Mountain Whitefish	*Prosopium williamsoni*
Cyprinidae:		
	Chiselmouth	*Acrocheilus alutaceus*
	Carp	*Cyprinus carpio*
	Northern Pikeminnow	*Ptychocheilus oregonensis*
	Redside Shiner	*Richardsonius balteatus*
Catostomidae:		
	Sucker	*Catostomus columbianus,* *Catostomus catostomus*
Centrarchidae:		
	Smallmouth Bass	*Micropterus dolomieui*

Northern Pike Minnow were the dominant piscivorous fish in the Wapato reach of the Yakima River. Catch and CPUE of Northern Pikeminnow can vary widely over time periods in this reach (Figure 37). While numbers vary over seasons it is evident that Northern Pikeminnow populations remain in high numbers over the course of the year.

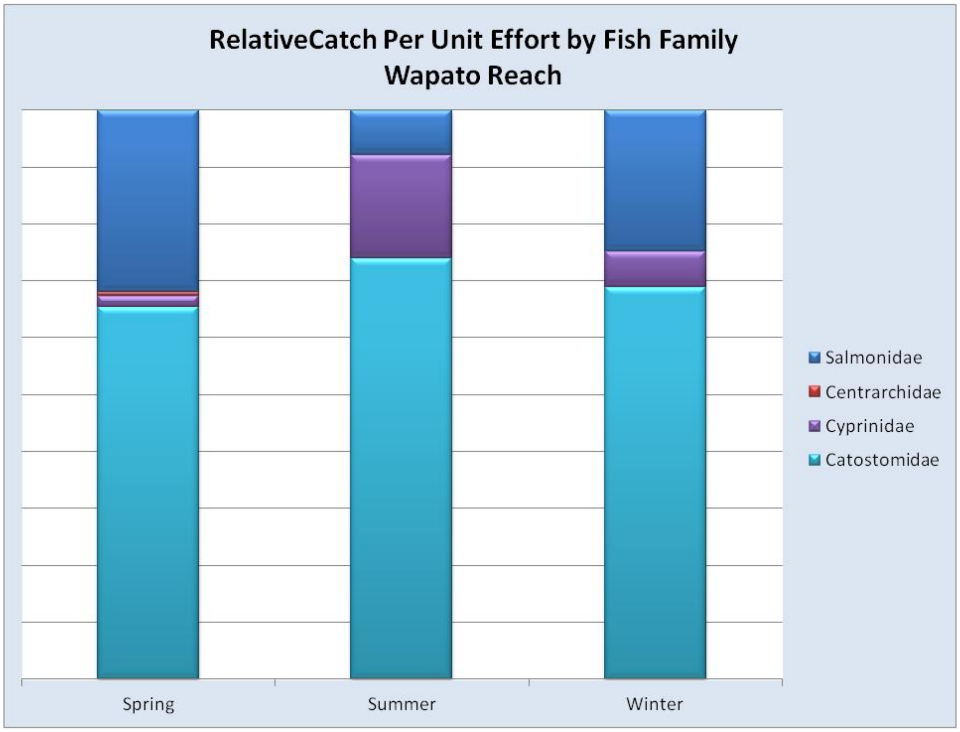

Figure 36. Wapato Reach of the Yakima River – Relative catch per unit effort by fish family.

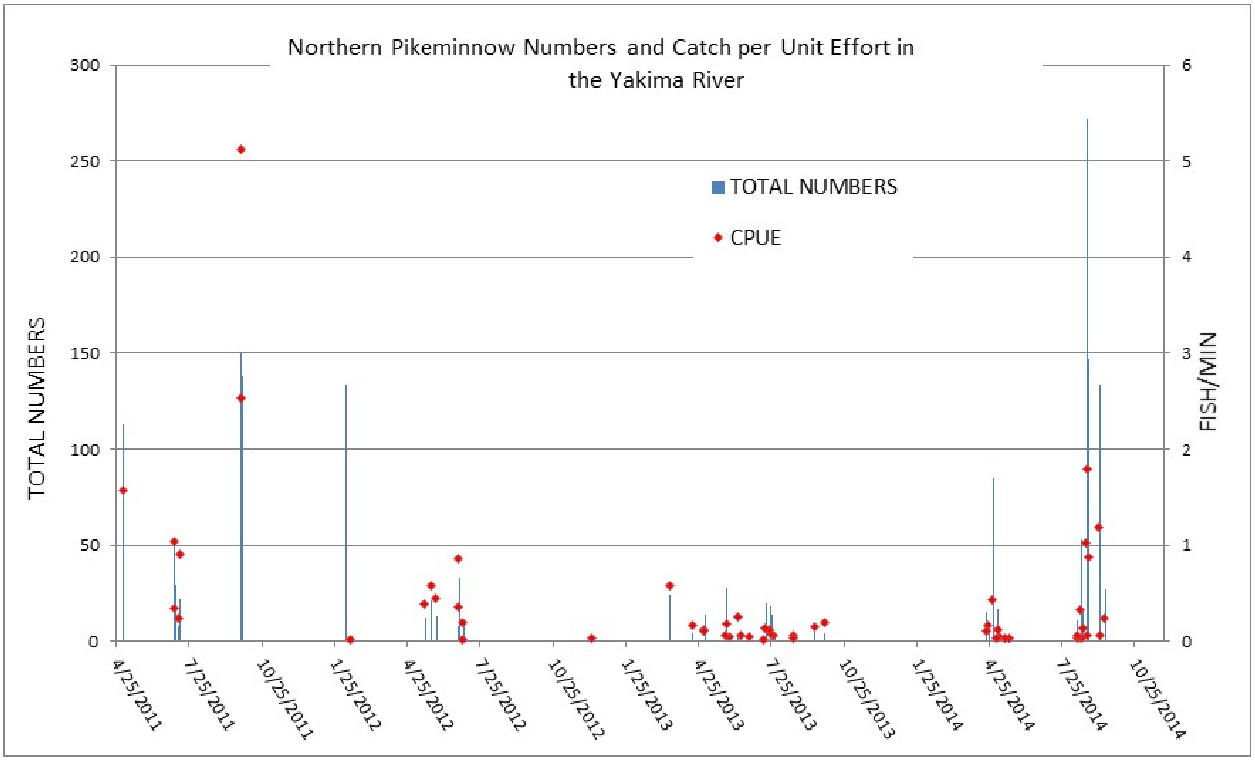

Figure 37. Number and Catch per Unit Effort (CPUE) of Northern Pike Minnow observed in surveys of the Yakima River Wapato Reach. Data are from 2011-2014 surveys and display NPM presence over varying seasons.

Large amounts of piscivorous fish were found to inhabit the Lower Yakima River, which is defined as that portion of the river between Prosser Dam and the confluence of the Yakima River with the Columbia River. During winter months high amounts of piscivorous fish, in particular NPM, were found in irrigation drains along the Yakima River. These drains remain highly productive over the winter months as their temperatures typically remain higher than the Yakima River and may range up to 10 degrees Celsius higher.

With increased catch success during the late summer months electro-fishing efforts were increased to maximize management efforts of introduced piscivorous fish species in the lower Yakima River. Smallmouth Bass were found in higher numbers in the lower river with a spike in presence during their spawning periods, between April 1 and July 1. Because of their abundance, Smallmouth Bass continue to be a target for population management to increase smolt survival. Catch and catch per unit effort (Figure 38) begins to rise in May and June as Smallmouth bass begin their migration from the Columbia River upstream in the Yakima River to spawn. The numbers of Smallmouth Bass observed in the Yakima River increased in 2014 with a high of over 329 fish caught per day and catch per unit effort near 3 fish per minute.

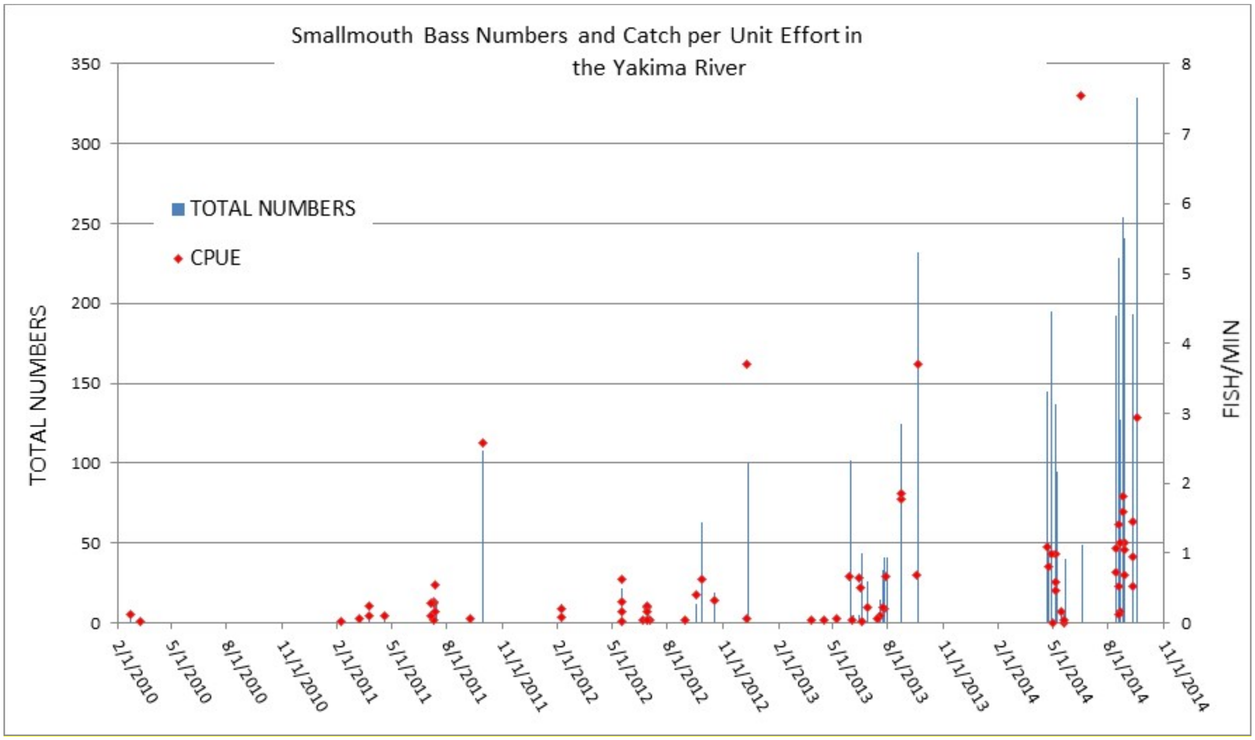

Figure 38. Number and Catch per Unit Effort (CPUE) of Smallmouth Bass observed in surveys of the Lower Yakima River.

Yakima River Delta surveys from 2010 to 2014 found 23 different fish species occupied the delta at varying temporal and spatial distributions (Table 24). This is twice the number of fish species in the Delta when compared to the fish species of the Wapato Reach. Many of the fish species in the delta are introduced, non-native fish and are a warm-water species of fish. These introduced fish are adapted to the highly altered water conditions, of increased temperatures and low dissolved oxygen, which the Yakima delta displays. Water temperatures may reach highs of 80 degrees Fahrenheit in the late summer months. Relative catch abundance in the Yakima Delta for the surveys shows a high number of fish from the families of: *Centrarchidae*, *Cyprinidae*, and *Ictaluridae* (Figure 39). These families are highly represented because of large numbers of piscivorous fish present in the delta. Smallmouth Bass, Largemouth Bass, and numerous catfish are present here and use the area for spawning and rearing of juveniles.

Table 24. Yakima River Delta - Fish Species identified during surveys 2010-2014.

Yakima River Delta Fish Species

Family	Common Name	*Scientific Name*
Salmonidae:		
	Steelhead/Rainbow trout	*Oncorhynchus mykiss*
	Coho Salmon	*Oncorhynchus kisutch*
	Chinook Salmon	*Oncorhynchus tshawytscha*
	Mountain Whitefish	*Prosopium williamsoni*
Cyprinidae:		
	Chiselmouth	*Acrocheilus alutaceus*
	Carp	*Cyprinus carpio*
	Peamouth	*Mylocheilus caurinus*
	Speckled Dace	*Rhinichthys osculus*
	Northern Pikeminnow	*Ptychocheilus oregonensis*
	Redside Shiner	*Richardsonius balteatus*
Catostomidae:		
	Sucker	*Catostomus columbianus,* *Catostomus catostomus*
Ictaluridae:		
	Brown Bullhead	*Ameiurus nebulosus*
	Channel Catfish	*Ictalurus punctatus*
Centrarchidae:		
	Pumpkin Seed	*Lepomis gibbosus*
	Blue Gill	*Lepomis macrochirus*
	Smallmouth Bass	*Micropterus dolomieui*
	Large Mouth Bass	*Micropterus salmoides*
	White Crappie	*Pomoxis annularis*
Percidae:		
	Walleye	*Stizostedion vitreum vitreum*
	Yellow Perch	*Perca flavescens*
Cottidae:		
	Sculpin	*Cottus bairdi*
Clupeidae:		
	Shad	*Alosa sapidissima*

When comparing the Wapato Reach Species/Relative Catch Abundance (Figure 36) to the Yakima Delta Species/Relative Catch Abundance (Figure 39) a glaring dissimilarity in the type of fish and their abundance between the two sections of the Yakima River is obvious. In the upper portion of the Yakima River, where natural attributes such as water temperature, riparian cover, nutrient loading, and flow that is closer to historical values the fish species consist of native species which are adapted to cold water conditions. In the lower section of the Yakima River and the Yakima River delta river attributes have been highly altered by: dams, irrigation diversions, water drawn for power, lowered flows, little riparian cover, irrigation water returned loaded with nutrients, and a blocked section of the river delta, fish species consist of a high number of introduced species many of which are piscivorous.

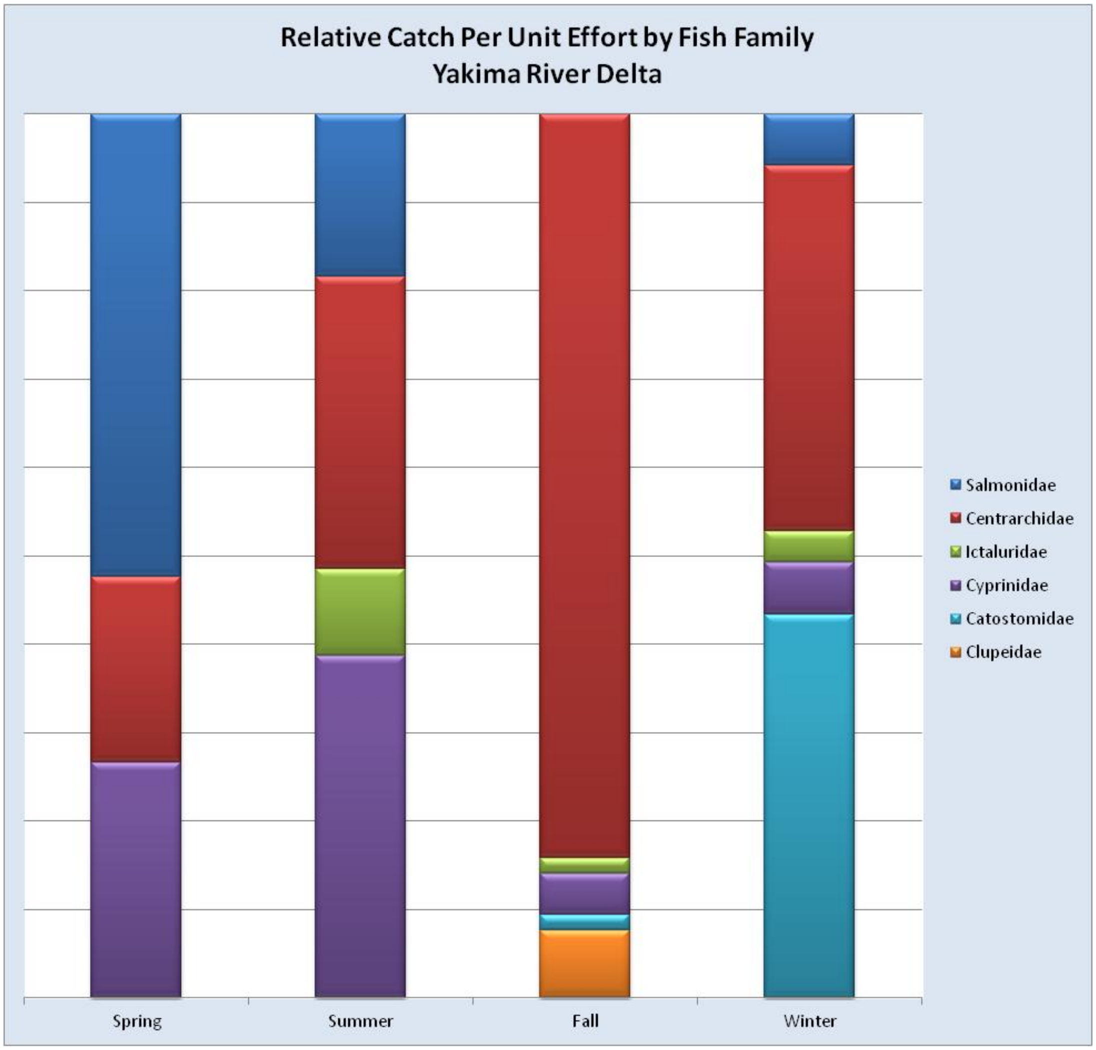

Figure 39. Yakima River Delta – Relative catch per unit effort by fish family.

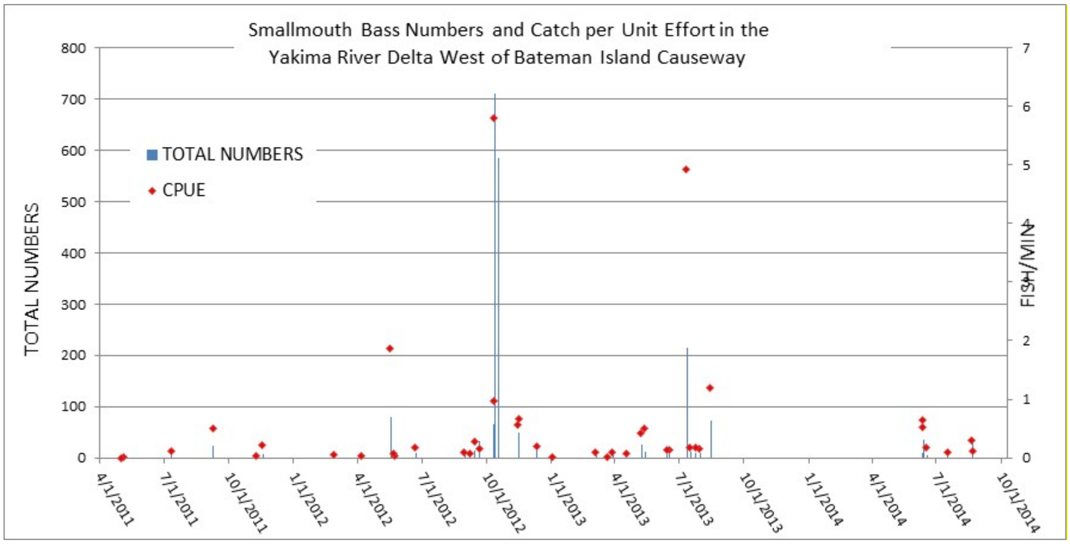

Figure 40. Number and Catch per Unit Effort (CPUE) of Smallmouth Bass observed in surveys of the Yakima River Delta area (West of the Bateman Island Causeway).

Smallmouth Bass in the delta of the Yakima River have been found in surprisingly high numbers. The Yakima delta at all times of the year contains some presence of Smallmouth Bass and during rearing times it becomes a haven for rearing Smallmouth Bass juveniles. In the autumn, times of extreme low water in the Delta have resulted in extremely high abundance and CPUE's of Smallmouth Bass (Figure 40).

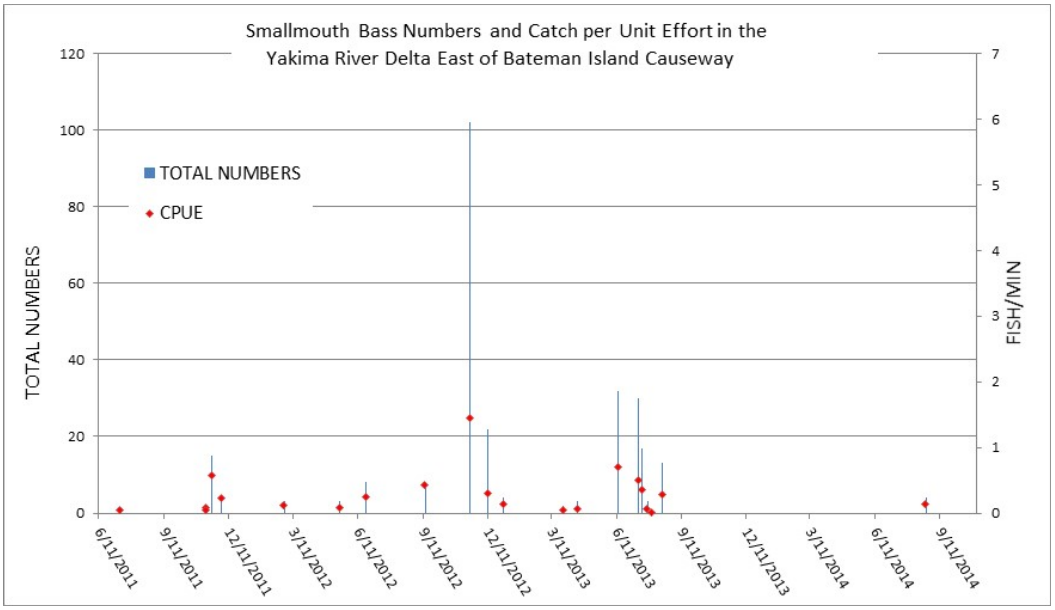

Figure 41. Number and Catch per Unit Effort (CPUE) of Smallmouth Bass observed in surveys of the Yakima River Delta area (East of the Bateman Island Causeway).

Smallmouth Bass in the delta of the Yakima River, on the disconnected (east) side of the River by Bateman Island, were also found in high numbers (Figure 41), though considerably less than their presence on the west side of the causeway. Numbers on this side of the delta rise as temperatures in the Yakima River drop and Columbia River temperatures remain higher (as this side of delta is connected to the Columbia). Total catch numbers of smallmouth bass rise during the early winter months and CPUE can rise to near 1.5 fish per minute. This disconnected area of the Yakima River also rears large numbers of juvenile Largemouth bass during the fall and winter months. Also present is a significant spawning population of Brown Bullhead catfish.

Adaptive Management and Lessons Learned

As noted extensively throughout this report, this project is a collaborative effort involving many agencies, boards, and individuals. As such, project coordination and review of project standards and protocols occurs continually amongst tribal, state, federal, and local entities during normal day-to-day operations of the project. Project results are communicated broadly through the annual science and management conference, technical reports and peer-reviewed journal publications (see references and project-related publications), and via several related web sites described in Appendix A.

We support the principles established in Mobrand et al. (2005) and Paquet et al. (2011) that hatchery programs should be well-defined, scientifically defensible, and use informed decision making tools including adaptive management. Many of these principles were initially published in Cuenco et al. (1993) including specific recommended decision criteria, management protocols, release strategies, and risk management strategies for hatchery programs. We designed a number of these protocols and strategies into the CESRF program and they are clearly contributing to the results documented here for the Upper Yakima River Basin spring Chinook populations.

Yakama Nation supplementation and research efforts in the Yakima River Basin indicate several lessons that may be of broader application on the regional scale.

1. We need to be realistic. Can or should we expect to see “self-sustaining natural populations” in river systems that have been highly altered from their historical state due to ever-increasing human demands on shared resources? In the highly altered systems we live and work in today, hatchery programs provide a necessary means to ameliorate some of the effects of human population growth and development.

2. We need to be honest. Hatchery programs are not the cause of poor productivity. The historical record is replete with documentation (see Dompier 2005) that the region knew exactly what it was doing to natural salmon productivity when development of the region began to intensify with implementation of the Federal Columbia River Power System as early as the 1930s.

3. We need to be patient. Hatchery reform is a relatively new concept and it is only recently beginning to be implemented on a broader scale. Results for the CESRF program to date provide some empirical support that hatchery reform principles can provide the expected benefits.

4. However, to accommodate expanding human population growth and resource demand, it is imperative that we continue and maybe even increase habitat restoration actions to ensure that sufficient habitat remains available to natural stocks and to additional fish returning from supplementation programs.

5. Every subbasin, species, and study is unique, so we should not be surprised to see differing results from the many studies of hatchery effects that are ongoing.

6. Evaluation of hatchery programs should include evaluation of environmental and other factors so that hatchery effects are properly reported.

7. Researchers need to continue efforts to better understand the root causes of poor natural productivity and the extent to which hatchery programs effect productivity.

8. Hatchery programs should be regularly evaluated at the local level using expertise across disciplines to collaboratively and iteratively develop appropriate solutions that address the unique problems and limiting factors encountered in each subbasin or tributary that hosts a hatchery program. In the Yakima Basin, this is achieved with the annual Yakima Basin Aquatic Science and Management Conference, and we use the results to evaluate existing goals, objectives, and strategies and to adaptively manage projects in response to new information.

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APPENDICES

A. Use of Data and Products

B. Yakima River / CESRF Spring Chinook Salmon – Yakama Nation Data Summary

C. IntSTATS, Inc. Annual Report: Comparison of Salt-Water-Transfer-Supplemented-Feed and Unsupplemented-Feed Treatments evaluated on Natural-Origin Hatchery-Reared Upper-Yakima Spring Chinook Smolt released in 2007 and 2009 through 2014

D. IntSTATS, Inc. Annual Report: Comparisons between Smolt-Trait Measures of Hatchery x Hatchery- and Natural x Natural-Brood Stock for Brood-Years 2002-2012 Upper Yakima Spring Chinook

E. IntSTATS, Inc. 2014 Annual Report: Smolt-to-Smolt Survival to McNary Dam of Yakima Fall and Summer Chinook

F. IntSTATS, Inc. Annual Report: 2014 Coho Smolt-to-Smolt Survival of Releases into the Yakima Basin

G. IntSTATS, Inc. Annual Report: Comparison of Salt-Water-Transfer Supplemented and Unsupplemented Feed Treatments evaluated on Upper-Yakima Spring Chinook Smolt-to-Adult Survival for 2009 through 2011 Smolt Releases

H. IntSTATS, Inc. Spring Chinook Release-to-Roza-Dam Smolt-to-Adult Survival: Comparison of Hatchery and Natural Origin Brood Stock

Appendix A: Use of Data & Products

All data and findings should be considered preliminary until results are published in the peer-reviewed literature.

Where will you post or publish the data your project generates?

Fish Passage Center
Yakama Nation Fisheries website
DART - Data Access in Real Time
RMIS - Regional Mark Information System
Yakima-Klickitat Fisheries Project website
BPA Pisces
StreamNet Database
cbfish.org
PTAGIS Website
Washington State SaSI

Describe the accessibility of the data and what the requirements are to access them?

- Automated integration of Prosser and Roza dam daily count data with Data Access in Real-Time (DART)
- Integration of PIT and CWT release and recovery data with PTAGIS, RMIS, and Fish Passage Center databases
- Production and support of data bases necessary to support BPA quarterly and annual reports (available via PISCES and BPA reports web site)
- Production and support of data bases necessary to support NPCC project proposals (available via CBfish.org)

Additional data is available on the ykfp.org web site and by email contact through the data managers (Yakima Basin, contact Bill Bosch, bbosch@yakama.com; Klickitat Basin, contact Michael Babcock, mbabcock@ykfp.org). Project data managers participated in the Coordinated Assessments process to develop pilot exchange templates for adult and juvenile abundance and productivity parameters. However, as documented in a letter from Phil Rigdon, Director of Natural Resources for the Yakama Nation to Phil Anderson Director of the Washington Department of Fish and Wildlife, dated 7Nov2012, the Yakama Nation would like to see the region develop strong, enforceable data sharing agreements before we can support broad population and unlimited use of and access to these regional databases with data from YN/YKFP projects. We remain concerned about the potential for misuse of project data obtained from existing regional databases.

Appendix B

Summary of Data Collected by the Yakama Nation relative to Yakima River Spring Chinook Salmon and the Cle Elum Spring Chinook Supplementation and Research Facility

2014 Annual Report

July 30, 2015

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Acknowledgments

Monitoring and evaluation efforts for the Cle Elum Supplementation and Research Facility (CESRF) and Yakima River spring Chinook salmon are the result of a cooperative effort by many individuals from a variety of agencies including the Yakama Nation Fisheries Program (YN), the Washington Department of Fish and Wildlife (WDFW), the United States Fish and Wildlife Service (USFWS), the National Oceanic and Atmospheric Administration Fisheries department (NOAA Fisheries) as well as some consultants and contractors.

The core project team includes the following individuals: Dave Fast, Mark Johnston, Bill Bosch, David Lind, Paul Huffman, Joe Hoptowit, and a number of technicians from the YN; Charles Strom and a number of assistants from the CESRF; Andrew Murdoch, Steve Schroder, Anthony Fritts, Gabe Temple, Christopher Johnson, and a number of assistants from the WDFW; Curt Knudsen from Oncorh Consulting and Doug Neeley from IntSTATS Consulting; Ray Brunson and assistants from the USFWS; and Don Larsen, Andy Dittman, and assistants from NOAA Fisheries. The technicians and assistants are too numerous and varied to mention each by name (and risk leaving some out). However, their hard work in the field is the source of much of the raw data needed to complete this report. We sincerely appreciate their hard work and dedication to this project.

We would especially like to thank former members of the Yakima/Klickitat Fisheries Project, Bruce Watson, Joel Hubble, Bill Hopley, Todd Pearsons, and Craig Busack. These individuals put in countless hours of hard work during the planning, design, and implementation of this project. Their contributions helped to lay a solid foundation for this project and our monitoring and evaluation efforts. Dan Barrett (retired) served as the manager of the CESRF from 1997-2002. He helped to lay a solid foundation for the critical work done day in and day out at the Cle Elum facility.

We also need to recognize and thank the Yakama Nation and WDFW for their continued support, and the Columbia River Inter-Tribal Fish Commission, the University of Idaho, the Pacific States Marine Fisheries Commission, Mobrand, Jones, and Stokes, and Central Washington University for their many contributions to this project including both recommendations and data services.

This work is funded by the Bonneville Power Administration (BPA) through the Northwest Power and Conservation Council's (NPCC) Fish and Wildlife Program. Patricia Smith is BPA's contracting officer and technical representative (COTR) for this project. David Byrnes preceded Patricia in this position and contributed substantially to the project over the years.

Abstract

Historically, the return of spring Chinook salmon (*Oncorhynchus tshawytscha)* to the Yakima River numbered about 200,000 fish annually (BPA, 1990). Spring Chinook returns to the Yakima River averaged fewer than 3,500 fish per year through most of the 1980s and 1990s (less than 2% of the historical run size).

In an attempt to reverse this trend the Northwest Power and Conservation Council (formerly the Northwest Power Planning Council, NPPC) in 1982 first encouraged Bonneville Power Administration (BPA) to "fund the design, construction, operation, and maintenance of a hatchery to enhance the fishery for the Yakima Indian Nation as well as all other harvesters" (NPPC 1982). After years of planning and design, an Environmental Impact Statement (EIS) was completed in 1996 and the CESRF was authorized under the NPCC's Fish and Wildlife Program with the stated purpose being "to test the assumption that new artificial production can be used to increase harvest and natural production while maintaining the long-term genetic fitness of the fish population being supplemented and keeping adverse genetic and ecological interactions with non-target species or stocks within acceptable limits". The CESRF became operational in 1997. This project is co-managed by the Yakama Nation and the Washington Department of Fish and Wildlife (WDFW) with the Yakama Nation as the lead entity.

This report documents data collected from Yakama Nation tasks related to monitoring and evaluation of the CESRF and its effect on natural populations of spring Chinook in the Yakima Basin through 2010. This report is not intended to be a scientific evaluation of spring Chinook supplementation efforts in the Yakima Basin. Rather, it is a summary of methods and data (additional information about methods used to collect these data may be found in the main section of this annual report) relating to Yakima River spring Chinook collected by Yakama Nation biologists and technicians from 1982 (when the Yakama Nation fisheries program was implemented) to present. Data summarized in this report include:

- Adult-to-adult returns
- Annual run size and escapement
- Adult traits (e.g., age composition, size-at-age, sex ratios, migration timing, etc.)
- CESRF reproductive statistics (including fecundity and fish health profiles)
- CESRF juvenile survival (egg-to-fry, fry-to-smolt, smolt-to-smolt, and smolt-to-adult)
- CESRF juvenile traits (e.g., length-weight relationships, migration timing, etc.)
- Harvest impacts

The data presented here are, for the most part, "raw" data and should not be used without paying attention to caveats associated with these data and/or consultation with project biologists. No attempt is made to explain the significance of these data in this report as this is left to more comprehensive reports and publications produced by the project. Data in this report should be considered preliminary until published in the peer reviewed literature.

Table of Contents

List of Tables

List of Figures

List of Appendices

Introduction

Program Objectives

The CESRF was authorized in 1996 under the NPCC's Fish and Wildlife Program with the stated purpose being "to test the assumption that new artificial production can be used to increase harvest and natural production while maintaining the long-term genetic fitness of the fish population being supplemented and keeping adverse genetic and ecological interactions with non-target species or stocks within acceptable limits". The CESRF became operational in 1997. The experimental design calls for a total release of 810,000 smolts annually from each of three acclimation sites associated with the facility (see facility descriptions). To minimize risk of over-collecting brood stock and to maintain lower pond rearing densities, the YKFP policy group took action in 2011 to reduce the release target to 720,000 smolts for brood collection purposes. Female percentage, fecundity and survival rates are expected to result in releases between 720,000 and 810,000 smolts in most years. The first program cycle (brood years 1997 through 2001) also included testing new Semi-Natural rearing Treatments (SNT) against the Optimum Conventional Treatments (OCT) of existing successful hatcheries in the Pacific Northwest. The second program cycle (brood years 2002-2004) tested whether a slower, more natural growth regime could be used to reduce the incidence of precocialism that may occur in hatchery releases without adversely impacting overall survival to adult returns. Brood years 2005-2007 tested survival using different types of feed treatment. Subsequent broods have used a standard treatment in all raceways. With guidance and input from the NPCC and the Independent Scientific Review Panel (ISRP) in 2001, the Naches subbasin population of spring Chinook was established as a wild/natural control. A hatchery control line at the CESRF was also established with the first brood production for this line collected in 2002. Please refer to the project's "Supplementation Monitoring Plan" (Chapter 7 in 2005 annual report on project genetic studies) for additional information regarding these control lines.

Facility Descriptions

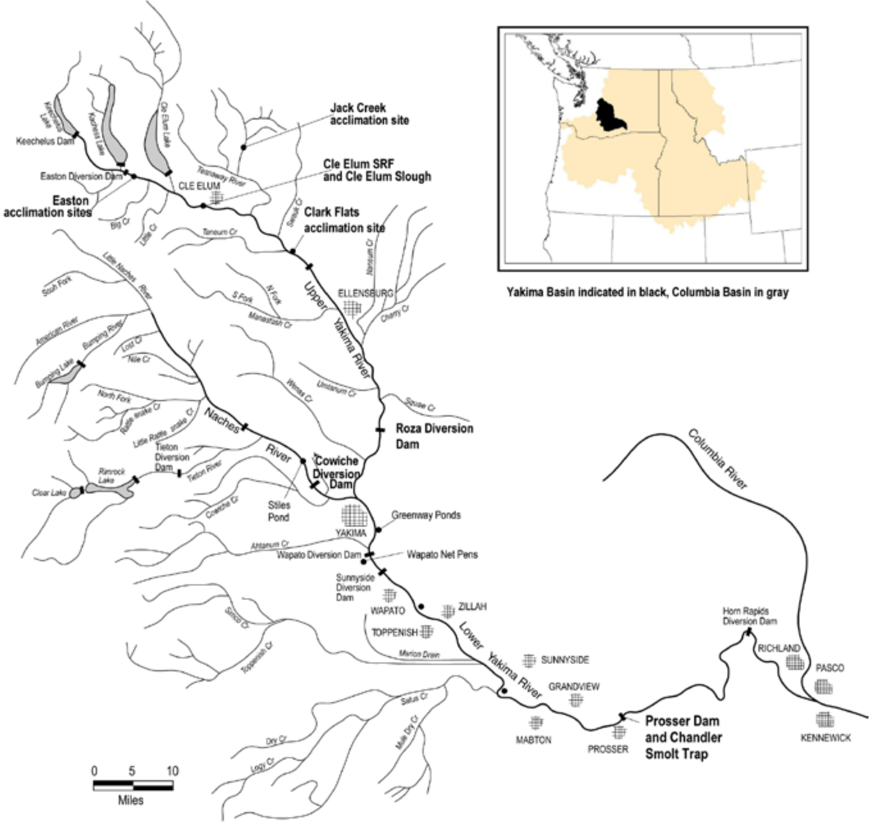
Returning adult spring Chinook are monitored at the Roza adult trapping facility located on the Yakima River (Rkm 205.8). This facility provides the means to monitor every fish returning to the upper Yakima Basin and to collect adults for the CESRF program. All returning CESRF fish (adipose-clipped fish) are sampled for biological characteristics and marks and returned to the river with the exception of fish collected for broodstock, experimental sampling, and all hatchery control line fish. Through 2006, all wild/natural fish passing through the Roza trap were returned directly to the river with the exception of fish collected for broodstock or fish with metal tag detections which were sampled for marks and biological characteristics. Beginning in 2007, all wild/natural fish were sampled (as described above) and tissue samples were collected for a "Whole Population" Pedigree Study of Upper Yakima Spring Chinook.

The CESRF is located on the Yakima River just south of the town of Cle Elum (rkm 295.5). It is used for adult broodstock holding and spawning, and early life incubation and rearing. Fish are spawned in September and October of a given brood year (BY). Fish are typically ponded in March or April of BY+1. The juveniles are reared at Cle Elum, marked in October through December of BY+1, and moved to one of three acclimation sites for final rearing in January to

February of BY+2. Acclimation sites are located at Easton (ESJ, rkm 317.8), Clark Flats near the town of Thorp (CFJ, rkm 266.6), and Jack Creek (JCJ, approximately 32.5 km north of Cle Elum) on the North Fork Teanaway River (rkm 10.2). Fish are volitionally released from the acclimation sites beginning on March 15 of BY+2, with any remaining fish "flushed out" of the acclimation sites by May 15 of BY+2. The annual production goal for the CESRF program is 720,000 to 810,000 fish for release as yearlings at 30 g/fish or 15 fish per pound (fpp) although size-at-release may vary depending on experimental protocols (see Program Objectives).

Yakima River Basin Overview

The Yakima River Basin is located in south central Washington. From its headwaters near the crest of the Cascade Range, the Yakima River flows 344 km (214 miles) southeastward to its confluence with the Columbia River (Rkm 539.5; Figure 1).



Yakima Basin indicated in black, Columbia Basin in gray

Figure 1. Yakima River Basin.

Three genetically distinguishable populations of spring Chinook salmon exist in the Yakima basin: the American River, the Naches, and the Upper Yakima Stocks (Figure 1). The upper Yakima was selected as the population best suited for supplementation and associated evaluation and research efforts.

Local habitat problems related to irrigation, logging, road building, recreation, agriculture, and livestock grazing have limited the production potential of spring Chinook in the Yakima River basin. It is hoped that recent initiatives to improve habitat within the Yakima Basin, such as those being funded through the NPCC's fish and wildlife program, the Pacific Coastal Salmon Recovery Fund, and the Washington State salmon recovery fund, will: 1) restore and maintain natural stream stability; 2) reduce water temperatures; 3) reduce upland erosion and sediment delivery rates; 4) improve and re-establish riparian vegetation; and 5) re-connect critical habitats throughout the basin. These habitat restoration efforts should permit increased utilization of habitat by spring Chinook salmon in the Yakima basin thereby increasing fish survival and productivity.

Adult Salmon Evaluation

Broodstock Collection and Representation

One of the program's goals is to collect broodstock from a representative portion of the population throughout the run. If the total run size could be known in advance, collecting brood stock on a daily basis in exact proportion to total brood need as a proportion of total run size would result in ideal run representation. Since it is not possible to know the run size in advance, the CESRF program uses a brood collection schedule that is based on average run timing once the first fish arrive at Roza Dam. We have found that, while river conditions dictate run timing (i.e., fish may arriver earlier or later depending on flow and temperature), once fish begin to move at Roza, the pattern in terms of relative run strength over time is very similar from year to year. Thus a brood collection schedule matching normal run timing patterns was developed to assure that fish are collected from all portions of the run (Figure 2).

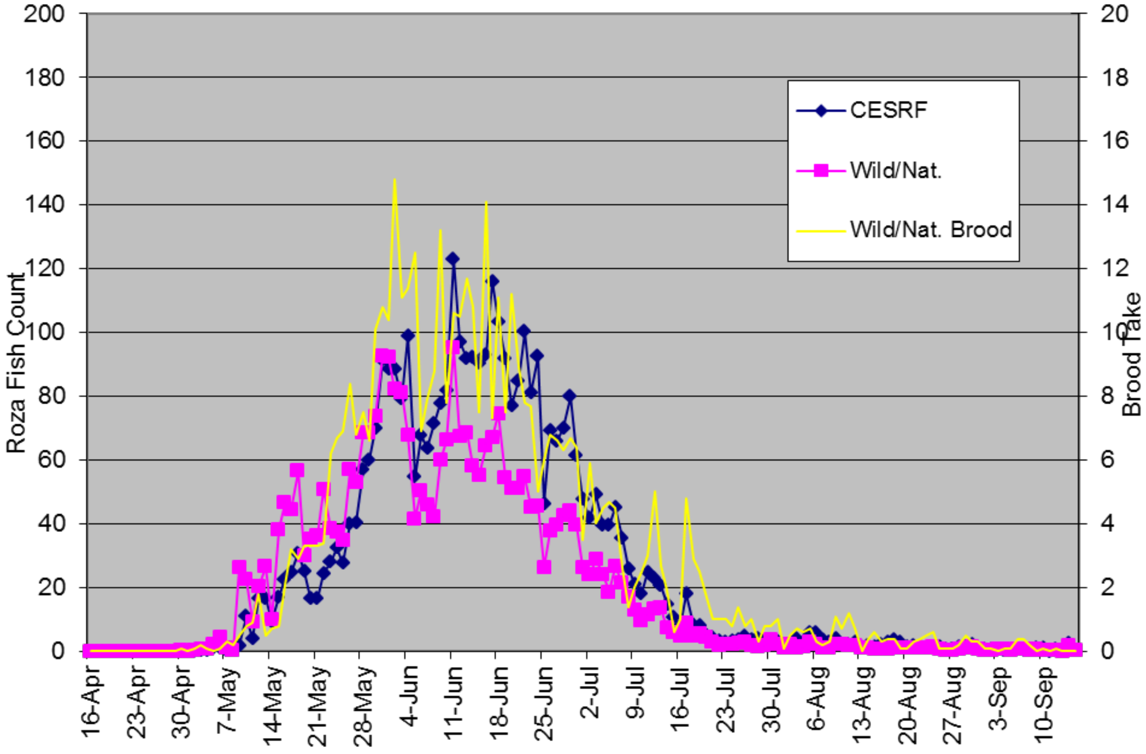


Figure 2. Mean spring Chinook run timing and broodstock collection at Roza Dam, 2005-2014.

Another program goal is to take no more than 50% of the wild/natural adult return to Roza Dam for broodstock. Given this goal and with a set brood collection schedule at Roza Dam, the project imposed a rule that no more than 50% of the fish arriving on any given day be taken for broodstock. Under-collection relative to the schedule is "carried over" to subsequent days and weeks. This allows brood collection to adjust relative to actual run timing and run strength. Performance across years with respect to these brood collection goals is given in Table 1.

Table 1. Counts of wild/natural spring Chinook (including jacks), brood collection, and brood representation of wild/natural run at Roza Dam, 1997 – present.

Year	Trap Count	Brood Take	Brood %	Portion of run collected:[1]			Portion of collection from:[2]		
				Early[3]	Middle[3]	Late[3]	Early[3]	Middle[3]	Late[3]
1997	1,445	261	18.1%	26.4%	17.6%	17.7%	7.3%	83.1%	9.6%
1998	795	408	51.3%	51.1%	51.3%	51.9%	5.6%	84.3%	10.0%
1999	1,704	738	43.3%	44.6%	44.1%	35.9%	5.6%	86.3%	8.1%
2000	11,639	567	4.9%	10.7%	4.5%	4.4%	12.5%	77.8%	9.7%
2001	5,346	595	11.1%	6.9%	11.4%	10.7%	3.0%	87.7%	9.2%
2002	2,538	629	24.8%	15.7%	25.2%	26.1%	3.2%	86.3%	10.5%
2003	1,558	441	28.3%	52.5%	25.9%	36.4%	9.5%	77.8%	12.7%
2004	7,804	597	7.6%	2.6%	7.4%	12.8%	2.0%	81.6%	16.4%
2005	5,086	510	10.0%	2.2%	9.5%	21.9%	1.3%	77.0%	21.7%
2006	2,050	419	20.4%	48.5%	22.2%	41.0%	9.1%	75.1%	15.8%
2007	1,293	449	34.7%	25.0%	34.4%	60.6%	3.2%	80.0%	16.9%
2008	1,677	457	27.3%	57.7%	26.7%	32.4%	9.3%	79.0%	11.6%
2009	3,030	486	16.0%	10.0%	14.1%	35.9%	3.5%	73.9%	22.6%
2010	3,185	336	10.5%	6.4%	15.0%	22.5%	2.0%	82.6%	15.3%
2011	4,395	377	8.6%	11.3%	9.2%	21.3%	5.6%	73.2%	21.2%
2012	2,924	374	12.8%	1.9%	12.3%	27.4%	1.1%	79.9%	19.0%
2013	2,784	398	14.3%	18.5%	13.0%	22.0%	9.5%	75.1%	15.3%
2014	4,168	384	9.2%	4.8%	8.6%	16.9%	2.3%	80.5%	17.1%

1. This is the proportion of the earliest, middle, and latest running components of the entire wild/natural run which were taken for broodstock. Ideally, this collection percentage would be equal throughout the run and would match the "Brood %".
2. This is the proportion of the total broodstock collection taken from the earliest, middle, and latest components of the entire wild/natural run. Ideally, these proportions would match the definitions for early, middle, and late given in 3.
3. Early is defined as the first 5% of the run, middle is defined as the middle 85%, and late as the final 10% of the run.

Natural- and Hatchery-Origin Escapement

While the project does not actively manage for a specific spawning escapement proportion (natural- to hatchery-origin adults), we are monitoring the proportion of natural influence (PNI; Table 2). The project will adaptively manage this parameter considering factors such as: policy input regarding surplusing of fish, meeting overall production goals of the project, guidance from the literature relative to percentage of hatchery fish on the spawning grounds with fitness loss, considerations about what risk is acceptable in a project designed to evaluate impacts from that risk, and the numerous risk containment measures already in place in the project. The State of Washington is using mark-selective fisheries in the lower Columbia River and, when possible, in the lower Yakima River in part as a tool to manage escapement proportions. In 2011, the project implemented an effort to transfer some returning hatchery-origin CESRF adults from Roza Dam to Lake Cle Elum for the purpose of returning marine derived nutrients and salmon to the watersheds that feed the lake. This effort will also increase PNI in the major spawning areas of the Upper Yakima Basin. Natural- and hatchery-origin escapement to the upper Yakima Basin is given in Table 2. Wild/natural escapement to the Naches subbasin is given in Table 3.

Table 2. Escapement (Roza Dam counts less brood stock collection and harvest above Roza) of natural- (NoR) and hatchery-origin (HoR) spring Chinook to the upper Yakima subbasin, 1982 – present.

	Wild/Natural (NoR)			CESRF (HoR)			Total				
Year	Adults	Jacks	Total	Adults	Jacks	Total	Adults	Jacks	Total	pHOS[1]	PNI[1]
1982			1,146								
1983			1,007								
1984			1,535								
1985			2,331								
1986			3,251								
1987			1,734								
1988			1,340								
1989			2,331								
1990			2,016								
1991			*1,583*[2]								
1992			3,009								
1993			1,869								
1994			563								
1995			355								
1996			1,631								
1997	1,141	43	1,184								
1998	369	18	387								
1999	498	468	966								
2000	10,491	481	10,972		688	688	10,491	1,169	11,660	5.9%	
2001	4,454	297	4,751	6,065	982	7,047	10,519	1,279	11,798	59.7%	62.6%
2002	1,820	89	1,909	6,064	71	6,135	7,884	160	8,044	76.3%	56.7%
2003	394	723	1,117	1,036	1,105	2,141	1,430	1,828	3,258	65.7%	60.3%
2004	6,536	671	7,207	2,876	204	3,080	9,412	875	10,287	29.9%	77.0%
2005	4,401	175	4,576	627	482	1,109	5,028	657	5,685	19.5%	83.7%
2006	1,510	121	1,631	1,622	111	1,733	3,132	232	3,364	51.5%	66.0%
2007	683	161	844	734	731	1,465	1,417	892	2,309	63.4%	61.2%
2008	988	232	1,220	2,157	957	3,114	3,145	1,189	4,334	71.9%	58.2%
2009	1,843	701	2,544	2,234	2,260	4,494	4,077	2,961	7,038	63.9%	61.0%
2010	2,436	413	2,849	4,524	1,001	5,525	6,960	1,414	8,374	66.0%	60.2%
2011	3,092	926	4,018	3,162	1,404	4,566	6,254	2,330	8,584	53.2%	65.3%
2012	2,359	191	2,550	2,661	265	2,926	5,020	456	5,476	53.4%	65.2%
2013	1,708	678	2,386	1,587	840	2,427	3,295	1,518	4,813	50.4%	66.5%
2014	3,099	685	3,784	2,150	794	2,944	5,249	1,479	6,728	43.8%	69.6%
Mean[3]	2,657	393	3,050	2,679	801	3,479	5,202	1,234	6,435	54.9%	65.2%

1. Proportion Natural Influence equals Proportion Natural-Origin Broodstock (pNOB; 1.0 as only NoR fish are used for supplementation line brood stock) divided by pNOB plus Proportion Hatchery-Origin Spawners (pHOS).
2. This is a rough estimate since Roza counts are not available for 1991.
3. For NoR columns, mean of 1997-present values. For all other columns, mean of 2001-present values.

Adult-to-adult Returns

The overall status of Yakima Basin spring Chinook is summarized in Table 3. Adult-to-adult return and productivity data for the various populations are given in Tables 4-8 (Means are for 1988 to present).

Table 3. Yakima River spring Chinook run (CESRF and wild, adults and jacks combined) reconstruction, 1988-present.

	River Mouth Run Size[1]			Harvest Below Prosser	Prosser Count	Harvest Above Prosser	Spawners Below Roza[2]	Roza Count	Roza Removals[3]	Est. Escapement		Redd Counts	
Year	Adults	Jacks	Total							Upper Y.R.[4]	Naches[5]	Upper Y.R.	Naches
1988	3,919	327	4,246	333	3,913	111	60	1,575	235	1,340	2,167	424	490
1989	4,640	274	4,914	560	4,354	187	135	2,515	184	2,331	1,517	915	541
1990	4,280	92	4,372	131	*2,255*	532	282	2,047	31	2,016	*1,380*	678	464
1991	2,802	104	2,906	27	2,879	5	131		40	*1,583*	*1,121*	582	460
1992	4,492	107	4,599	184	4,415	161	39	3,027	18	3,009	1,188	1,230	425
1993	3,800	119	3,919	44	3,875	85	56	1,869	0	1,869	1,865	637	554
1994	1,282	20	1,302	0	1,302	25	10	563	0	563	704	285	272
1995	526	140	666	0	666	79	9	355	0	355	223	114	104
1996	3,060	119	3,179	100	3,079	375	26	1,631	0	1,631	1,047	801	184
1997	3,092	81	3,173	0	3,173	575	20	1,445	261	1,184	1,133	413	339
1998	1,771	132	1,903	0	1,903	188	3	795	408	387	917	147	330
1999	1,513	1,268	2,781	8	2,773	596	55	1,704	738	966	418	212	186
2000	17,519	1,582	19,101	90	19,011	2,368	204	12,327	667	11,660	4,112	3,770	888
2001	21,225	2,040	23,265	1,793	21,472	2,838	286	12,516	718	11,798	5,829	3,226	1,192
2002	14,616	483	15,099	328	14,771	2,780	29	8,922	878	8,044	3,041	2,816	943
2003	4,868	2,089	6,957	59	6,898	381	83	3,842	584	3,258	2,592	868	935
2004	13,974	1,315	15,289	135	15,154	1,544	90	11,005	718	10,287	2,515	3,414	719
2005	8,059	699	8,758	34	8,724	440	28	6,352	667	5,685	1,904	2,009	574
2006	5,951	363	6,314	0	6,314	600	14	4,028	664	3,364	1,672	1,245	447
2007	2,968	1,335	4,303	10	4,293	269	13	3,025	716	2,309	986	722	313
2008	6,615	1,983	8,598	539	8,059	993	9	5,478	1,144	4,334	1,578	1,372	495
2009	7,441	4,679	12,120	1,517	10,603	836	18	8,633	1,595	7,038	1,117	1,575	482
2010	11,027	2,114	13,142	156	12,986	1,585	9	9,900	1,526	8,374	1,491	2,668	552
2011	13,398	4,561	17,960	909	17,051	3,471	0	10,520	1,936	8,584	3,060	1,898	580
2012	11,083	970	12,053	1,331	10,722	1,989	7	6,826	1,350	5,476	1,900	1,468	811
2013	7,101	3,144	10,245	1,191	9,054	1,462	171	6,053	1,240	4,813	1,369	648	376
2014	8,850	2,472	11,322	221	11,101	1,950	23	7,997	1,269	6,728	1,130	1,149	379
Mean[6]	8,249	2,232	10,481	591	9,891	1,359	29	6,881	1,211	5,671	1,621	1,475	501

1. River Mouth run size is the greater of the Prosser count plus lower river harvest or estimated escapement plus all known harvest and removals.
2. Estimated as the average number of fish per redd in the upper Yakima times the number of redds between the Naches confluence and Roza Dam.
3. Roza removals include harvest above Roza, hatchery removals, and/or wild broodstock removals.
4. Estimated escapement into the upper Yakima River is the Roza count, less harvest or broodstock removals above Roza Dam except in 1991 when Upper Yakima River escapement is estimated as the (Prosser count - harvest above Prosser - Roza subtractions) times the proportion of redds counted in the upper Yakima.
5. Naches River escapement was estimated as the Prosser count, less harvest above Prosser and the Roza counts, except in 1982, 1983 and 1990 when it was estimated as the upper Yakima fish/redd times the Naches redd count.
6. Recent 10-year average (2005-2014).

Estimated spawners for the Upper Yakima River are calculated as the estimated escapement to the Upper Yakima plus the estimated number of spawners in the Upper Yakima between the confluence with the Naches River and Roza Dam (Table 3). Total returns are based on the information compiled in Table 3. Age composition for Upper Yakima returns is estimated from spawning ground carcass scale samples for the years 1982-1996 (Table 11) and from Roza Dam brood stock collection samples for the years 1997 to present (Table 13). Since age-3 fish (jacks) are not collected for brood stock in proportion to the jack run size, the proportion of age-3 fish in the upper Yakima for 1997 to present is estimated using the proportion of jacks (based on visual observation) counted at Roza Dam relative to the total run size.

Table 4. Adult-to-adult productivity indices for upper Yakima wild/natural stock.

Brood	Estimated	Estimated Yakima R. Mouth Returns				Returns/
Year	Spawners	Age-3	Age-4	Age-5	Total	Spawner
1984	1,715	92	1,348	139	1,578	0.92
1985	2,578	114	2,746	105	2,965	1.15
1986	3,960	171	2,574	149	2,893	0.73
1987	2,003	53	1,571	109	1,733	0.87
1988	1,400	53	3,138	132	3,323	2.37
1989	2,466	68	1,779	9	1,856	0.75
1990	2,298	79	566	0	645	0.28
1991	1,713	9	326	22	358	0.21
1992	3,048	87	1,861	95	2,043	0.67
1993	1,925	66	1,606	57	1,729	0.90
1994	573	60	737	92	890	1.55
1995	364	59	1,036	129	1,224	3.36
1996	1,657	1,059	12,882	630	14,571	8.79
1997	1,204	621	5,837	155	6,613	5.49
1998	390	434	2,803	145	3,381	8.68
1999	1,021[1]	164	722	45	930	0.91
2000	11,864	856	7,689	127	8,672	0.73
2001	12,087	775	5,074	222	6,071	0.50
2002	8,073	224	1,875	148	2,247	0.28
2003	3,341	158	1,036	63	1,257	0.38
2004	10,377	207	1,547	75	1,828	0.18
2005	5,713	293	2,630	14	2,936	0.51
2006	3,378	868	2,887	133	3,888	1.15
2007	2,322	456	3,976	65	4,498	1.94
2008	4,343	1,135	3,410	123	4,668	1.07
2009	7,056	283	2,572	109	2,964	0.42
2010	8,383	923	3,854			
2011	8,584	832				
2012	5,483					
2013	4,984					
2014	6,751					
Mean	4,228	364	2,892	119	3,299	1.72

1. The mean jack proportion of spawning escapement from 1999-2014 was 0.23 (geometric mean 0.17).

Estimated spawners for the Naches/American aggregate population (Table 7) are calculated as the estimated escapement to the Naches Basin (Table 3). Estimated spawners for the individual Naches and American populations are calculated using the proportion of redds counted in the Naches Basin (excluding the American River) and the American River, respectively (see Table 31). Total returns are based on the information compiled in Table 3. Age composition for Naches Basin age-4 and age-5 returns are estimated from spawning ground carcass scale samples (see Tables 9-12). The proportion of age-3 fish is estimated after reviewing jack count (based on visual observations) data at Prosser and Roza dams. Since sample sizes for carcass surveys in the American and Naches Rivers can be very low in some years (Tables 9 and 10), it is recommended that the data in Tables 5 and 6 be used as indices only. Table 7 likely provides the most accurate view of overall productivity rates in the Naches River Subbasin.

Table 5. Adult-to-adult productivity indices for Naches River wild/natural stock.

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns Age-3	Age-4	Age-5	Age-6	Total	Returns/ Spawner
1984	383	110	706	564	0	1,381	3.60
1985	683	132	574	396	0	1,102	1.61
1986	2,666	68	712	499	15	1,294	0.49
1987	1,162	27	183	197	0	407	0.35
1988	1,340	32	682	828	0	1,542	1.15
1989	992	28	331	306	0	665	0.67
1990	954	24	170	74	0	269	0.28
1991	706	7	37	121	57	222	0.31
1992	852	29	877	285	0	1,191	1.40
1993	1,145	45	593	372	0	1,010	0.88
1994	474	14	164	164	0	343	0.72
1995	124	40	164	251	0	455	3.66
1996	887	179	3,983	1,620	0	5,782	6.52
1997	762	207	3,081	708	0	3,996	5.24
1998	503	245	1,460	1,128	0	2,833	5.63
1999	358[1]	113	322	190	0	626	1.75
2000	3,862	71	2,060	215	0	2,346	0.61
2001	3,912	126	1,254	471	0	1,850	0.47
2002	1,861	59	753	153	0	965	0.52
2003	1,400	52	237	175	0	464	0.33
2004	2,197	107	875	218	0	1,200	0.55
2005	1,439	167	653	119	0	940	0.65
2006	1,163	192	834	254	0	1,280	1.10
2007	463	125	1,649	514	0	2,288	4.94
2008	1,074	414	827	290	0	1,531	1.42
2009	903	84	448	65		597	0.66
2010	1,207	209	653				
2011	2,476	137					
2012	1,537						
2013	1,107						
2014	915						
Mean	1,275	109	899	391	3	1,407	1.75

1. The mean jack proportion of spawning escapement from 1999-2014 was 0.12 (geometric mean 0.09).

Table 6. Adult-to-adult productivity indices for American River wild/natural stock.

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns Age-3	Age-4	Age-5	Age-6	Total	Returns/ Spawner
1984	187	54	301	458	0	813	4.36
1985	337	81	149	360	0	590	1.75
1986	1,457	36	134	329	11	509	0.35
1987	567	12	71	134	0	216	0.38
1988	827	19	208	661	5	892	1.08
1989	524	11	69	113	0	193	0.37
1990	425	15	113	84	0	213	0.50
1991	414	3	5	22	0	30	0.07
1992	335	23	157	237	0	417	1.24
1993	721	8	218	405	8	639	0.89
1994	230	7	36	16	0	59	0.26
1995	98	33	32	98	0	163	1.65
1996	159	30	176	760	0	967	6.07
1997	371	13	1,543	610	0	2,166	5.84
1998	414	120	766	1,136	0	2,022	4.88
1999	61	72	99	163	0	334	5.50
2000	250	60	163	110	0	333	1.33
2001	1,917	18	364	256	0	638	0.33
2002	1,180	19	279	257	0	555	0.47
2003	1,192	23	183	440	0	646	0.54
2004	318	121	52	33	0	206	0.65
2005	464	79	173	263[1]	0	515	1.11
2006	509	45	172[1]	451	0	668	1.31
2007	523	57[1]	645	493	0	1,194	2.28
2008	504	239	461	465		1,165	2.31
2009	213	60	143	44		247	1.16
2010	285	172	326				
2011	584	71					
2012	363						
2013	261						
2014	216						
Mean	513	54	261	323	1	630	1.80

1. No survey samples in 2010 return year; data approximated using 2007-09, 2011 survey samples.

Table 7. Adult-to-adult productivity indices for Naches/American aggregate (wild/natural) population.

Brood	Estimated	Estimated Yakima R. Mouth Returns					Returns/
Year	Spawners	Age-3	Age-4	Age-5	Age-6	Total	Spawner
1984	570	164	1,109	1,080	0	2,354	4.13
1985	1,020	213	667	931	0	1,811	1.77
1986	4,123	103	670	852	31	1,657	0.40
1987	1,729	39	231	400	0	669	0.39
1988	2,167	51	815	1,557	11	2,434	1.12
1989	1,517	39	332	371	0	741	0.49
1990	1,380	40	326	168	0	533	0.39
1991	1,121	10	32	144	127	314	0.28
1992	1,188	52	1,034	661	0	1,747	1.47
1993	1,865	53	603	817	17	1,489	0.80
1994	704	21	160	167	0	348	0.49
1995	223	73	201	498	0	771	3.46
1996	1,047	209	4,010	2,359	0	6,579	6.29
1997	1,133	220	4,644	1,377	0	6,241	5.51
1998	917	364	2,167	2,316	12	4,859	5.30
1999	418[1]	185	369	279	0	833	1.99
2000	4,112	131	2,286	346	0	2,762	0.67
2001	5,829	144	1,598	785	0	2,526	0.43
2002	3,041	78	975	443	0	1,496	0.49
2003	2,592	75	387	1,028	0	1,489	0.57
2004	2,515	227	514	232	0	973	0.39
2005	1,904	246	845	174[2]	0	1,264	0.66
2006	1,672	237	1,215[2]	759	0	2,211	1.32
2007	986	182[2]	2,239	1,033	0	3,454	3.50
2008	1,578	653	1,262	803	0	2,718	1.72
2009	1,117	144	542	116		802	0.72
2010	1,491	381	972				
2011	3,060	208					
2012	1,900						
2013	1,369						
2014	1,130						
Mean	1,788	162	1,119	757	8	2,041	1.72

1. The mean jack proportion of spawning escapement from 1999-2014 was 0.12 (geometric mean 0.09).
2. Age composition using only Naches survey samples in 2010 return year.

Estimated spawners at the CESRF are the total number of wild/natural fish collected at Roza Dam and taken to the CESRF for production brood stock. Total returns are based on the information compiled in Table 3 and at Roza dam sampling operations. Age composition for CESRF fish is estimated using scales and PIT tag detections from CESRF fish sampled passing upstream through the Roza Dam adult monitoring facility.

Table 8. Adult-to-adult productivity for Cle Elum SRF spring Chinook.

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns				Returns/ Spawner
		Age-3	Age-4	Age-5	Total	
1997	261	741	7,753	176	8,670	33.22
1998	408	1,242	7,939	602	9,782	23.98
1999	738[1]	134	714	16	864	1.17
2000	567	1,103	3,647	70	4,819	8.50
2001	595	396	845	9	1,251	2.10
2002	629	345	1,886	69	2,300	3.66
2003	441	121	800	12	932	2.11
2004	597	805	3,101	116	4,022	6.74
2005	510	1,305	3,052	21	4,378	8.58
2006	419	3,038	5,812	264	9,114	21.75
2007	449	1,277	5,174	108	6,558	14.61
2008	457	2,344	4,567	65	6,976	15.27
2009	486	461	2,663	58	3,181	6.55
2010	336	1,495	3,183			
2011	377	1,233				
2012	374					
2013	398					
2014	384					
Mean	468	1,069	3,652	122	4,835	7.50[2]

1. 357 or 48% of these fish were jacks.
2. Geometric mean.

Age Composition

Comparisons of the age composition in the Roza adult monitoring facility (RAMF) samples and spawning ground carcass recovery samples show that older, larger fish are recovered as carcasses on the spawning grounds at significantly higher rates than younger, smaller fish (Knudsen et al. 2003 and Knudsen et al. 2004). Based on historical scale-sampled carcass recoveries between 1986 and 2014, age composition of American River spring Chinook has averaged 1, 42, 55, and 1 percent age-3, -4, –5, and -6, respectively (Table 9). Naches system spring Chinook averaged 2, 61, 36.5 and 0.5 percent age-3, -4, –5 and -6, respectively (Table 10). The upper Yakima River natural origin fish averaged 8, 88, and 4 percent age-3, -4, and –5, respectively (Table 11). While these ages are biased toward the older age classes, we believe the bias is approximately equal across populations and is a good relative indicator of differences in age composition between populations. The data show distinct differences with the American River population having the oldest age of maturation, followed closely by the Naches system and then the upper Yakima River which has significantly more age-3's, fewer age-5's and no age-6 fish.

Table 9. Percentage by sex and age of American River wild/natural spring Chinook carcasses sampled on the spawning grounds and sample size (n), 1986-present.

Return Year	Males					Females					Total			
	3	4	5	6	n	3	4	5	6	n	3	4	5	6
1986		23.8	76.2		21		8.9	86.7	4.4	45		13.6	83.3	3.0
1987		70.8	25.0	4.2	24		42.9	57.1		21		57.8	40.0	2.2
1988			100.0		1		100.0			1		33.3	66.7	
1989		39.6	60.4		48		10.0	90.0		50		24.5	75.5	
1990	2.5	25.0	72.5		40		28.3	71.7		46	1.2	26.7	72.1	
1991		23.8	76.2		42		13.3	86.7		60		17.6	82.4	
1992		71.2	23.1	5.8	52		45.8	54.2		48		59.0	38.0	3.0
1993	4.8	14.3	81.0		21		8.0	92.0		75	1.0	9.4	89.6	
1994		44.4	55.6		18		50.0	46.7	3.3	30		49.0	49.0	2.0
1995	14.3	14.3	71.4		7			100.0		13	5.0	5.0	90.0	
1996		100.0			2		83.3	16.7		6		87.5	12.5	
1997		40.0	60.0		5		22.2	64.4	13.3	45		24.0	64.0	12.0
1998		12.1	87.9		33		6.6	93.4		76		8.3	91.7	
1999		100.0			2		40.0	40.0	20.0	5		57.1	28.6	14.3
2000		66.7	33.3		15		61.5	38.5		13		64.3	35.7	
2001		65.6	34.4		90		67.9	32.1		106		67.0	33.0	
2002	1.7	53.4	44.8		58		56.4	43.6		110	0.6	55.4	44.0	
2003		8.1	91.9		74		7.9	92.1		151		8.0	92.0	
2004		100.0			3		20.0	80.0		5		50.0	50.0	
2005		64.7	35.3		17		84.0	16.0		25		76.7	23.3	
2006		61.5	38.5		13		48.6	51.4		35		52.1	47.9	
2007	10.5	31.6	57.9		19		43.8	56.3		48	3.0	40.3	56.7	
2008		8.7	91.3		23		11.9	88.1		42		10.6	89.4	
2009	30.8	69.2			13		75.0	25.0		16	13.8	72.4	13.8	
2010	No carcasses were sampled													
2011		40.0	60.0		10		63.2	36.8		19		58.8	41.2	
2012		50.0	50.0		14		47.8	52.2		16		48.3	51.7	
2013	11.1	11.1	77.8		9		26.9	73.1		26	2.9	22.9	74.3	
2014	5.6	77.8	16.7		18		90.9	9.1		33	2.0	86.3	11.8	
Mean	2.9	46.0	50.8	0.4			41.6	56.9	1.5		1.0	42.4	55.3	1.3

Table 10. Percentage by sex and age of Naches River wild/natural spring Chinook carcasses sampled on the spawning grounds and sample size (n), 1986-present.

Return	Males					Females					Total			
Year	3	4	5	6	n	3	4	5	6	n	3	4	5	6
1986	5.0	60.0	30.0	5.0	20		33.3	64.3	2.4	42	1.6	41.9	53.2	3.2
1987	5.9	76.5	11.8	5.9	17		69.0	31.0		42	1.7	71.7	25.0	1.7
1988		50.0	50.0		8	5.6	38.9	55.6		18	3.3	46.7	50.0	
1989		70.2	29.8		47		34.9	63.5	1.6	63		50.0	49.1	0.9
1990	9.1	60.6	30.3		33	10.7	57.1	32.1		28	11.1	57.1	31.7	
1991	4.3	52.2	43.5		23		13.3	86.7		45	1.5	26.5	72.1	
1992	4.0	80.0	12.0	4.0	25		70.6	29.4		34	1.7	75.0	21.7	1.7
1993		42.3	57.7		26		18.6	81.4		43		28.6	71.4	
1994		50.0	50.0		4		30.0	70.0		10		35.7	64.3	
1995		25.0	75.0		4		28.6	71.4		7		33.3	66.7	
1996		100.0			17		75.0	25.0		16		87.9	12.1	
1997	2.9	70.6	20.6	5.9	34		57.1	36.7	6.1	49	1.2	62.7	30.1	6.0
1998		29.4	70.6		17		27.9	72.1		43		30.6	69.4	
1999	12.5	62.5	25.0		8		33.3	66.7		9	5.9	47.1	47.1	
2000	1.7	94.9	3.4		59		92.2	7.8		77	0.7	93.4	5.9	
2001	1.7	72.9	25.4		59		61.0	39.0		118	0.6	65.2	34.3	
2002	2.1	78.7	19.1		47		63.3	36.7		98	0.7	66.9	32.4	
2003	7.8	25.0	67.2		64	1.1	18.9	80.0		95	3.8	21.4	74.8	
2004	7.5	87.5	5.0		40		91.3	8.7		92	2.3	89.5	8.3	
2005		81.8	18.2		11		83.8	16.2		37		83.7	16.3	
2006		61.5	38.5		13		61.5	38.5		13		61.5	38.5	
2007		75.0	25.0		4		57.9	42.1		19		60.9	39.1	
2008	36.4	45.5	18.2		11		87.0	13.0		23	11.8	73.5	14.7	
2009	7.1	71.4	21.4		14		76.9	23.1		26	2.4	73.2	24.4	
2010		100.0			9		81.8	18.2		22	3.0	84.8	12.1	
2011	11.5	80.8	7.7		26		78.9	21.1		19	6.3	81.3	12.5	
2012	11.8	41.2	47.1		17		64.4	33.3		45	4.8	58.7	36.5	
2013	15.4	53.8	30.8		13		56.3	43.8		16	6.7	56.7	36.7	
2014		86.7	13.3		15		92.3	7.7		26		90.9	9.1	
Mean	5.1	65.0	29.2	0.7		0.7	57.1	41.9	0.3		2.4	60.6	36.5	0.5

Table 11. Percentage by sex and age of upper Yakima River wild/natural spring Chinook carcasses sampled on the spawning grounds and sample size (n), 1986-present.

Return Year	Males				Females				Total		
	3	4	5	n	3	4	5	n	3	4	5
1986		100.0		12		94.1	5.9	51		95.2	4.8
1987	10.8	81.5	7.7	65		77.8	22.2	126	3.7	79.1	17.3
1988	22.5	70.0	7.5	40	10.4	75.0	14.6	48	15.6	73.3	11.1
1989	0.8	93.1	6.2	130	0.4	95.5	4.1	246	0.5	94.7	4.8
1990	6.3	88.4	5.3	95	2.1	94.8	3.1	194	3.4	92.8	3.8
1991	9.1	87.3	3.6	55		89.2	10.8	111	3.0	88.6	8.4
1992	2.4	91.6	6.0	167		98.1	1.9	315	0.8	95.9	3.3
1993	4.0	90.0	6.0	50	0.9	92.0	7.1	112	1.9	91.4	6.8
1994		100.0		16		98.0	2.0	50		98.5	1.5
1995	20.0	80.0		5		100.0		12	5.6	94.4	
1996	9.1	89.6	1.3	154	0.7	98.2	1.1	282	3.7	95.2	1.1
1997		96.7	3.3	61		96.3	3.7	136		96.4	3.6
1998	14.3	85.7		21	5.3	86.8	7.9	38	8.5	86.4	5.1
1999	61.8	38.2		34		94.4	5.6	36	31.0	66.2	2.8
2000	2.8	97.2		72		100.0		219	1.0	99.0	
2001	2.7	89.2	8.1	37		83.6	16.4	122	0.6	85.0	14.4
2002	2.4	58.5	39.0	41	3.6	87.5	8.9	56	5.1	73.7	21.2
2003	60.5	39.5		38	4.3	82.6	13.0	23	39.3	55.7	4.9
2004	6.5	93.5		108	0.0	99.5	0.5	198	2.3	97.4	0.3
2005	9.2	90.0		120	1.4	97.2	1.4	214	4.2	94.7	1.2
2006	23.7	74.6		59	2.3	96.5	1.2	86	11.0	87.6	1.4
2007	17.1	82.9		76	0.9	93.8	5.4	112	7.4	89.4	3.2
2008	11.8	88.2		34	0.0	95.8	4.2	24	6.9	91.4	1.7
2009	47.7	52.3		111	2.2	95.6	2.2	45	34.6	64.7	0.6
2010	27.7	72.3		47		100.0		71	11.0	89.0	
2011	37.5	62.5		16		100.0		27	13.6	86.4	
2012	25.0	75.0		8	7.7	92.3		13	14.3	85.7	
2013						100.0		8		100.0	
2014	3.3	96.7		30		100.0		59	1.1	98.9	
Mean	15.7	80.9	3.4		1.5	93.6	4.9		7.9	87.8	4.3

Carcasses from upper Yakima River CESRF origin fish allowed to spawn naturally have also been sampled since age-4 adults began returning in 2001. These fish averaged 13, 85, and 1 percent age-3, -4, and –5, respectively (Table 12) from 2001-2014 compared to 11, 86, and 3.5 percent respectively for their wild/natural counterparts in the upper Yakima for the same years (Table 11). The observed difference in age distribution between wild/natural and CESRF sampled on the spawning grounds may be due in part to the carcass recovery bias described above. A better comparison of age distribution between upper Yakima wild/natural and CESRF fish is from samples collected at Roza Dam which are displayed in Tables 13 and 14. However, it must be noted that jacks (age-3 males) were collected at Roza in proportion to run size from 1997 to 1999, but from 2000-present we have attempted to collect them at their mean brood representation rate (approximately 7% of the spawning population). Age-3 females do occur rarely in the Upper Yakima population, but it is likely that the data in Table 13 slightly over-represent the proportion of age-3 females due to human error associated with scale collection, handling, processing, and management and entry of these data.

Table 12. Percentage by sex and age of upper Yakima River CESRF spring Chinook carcasses sampled on the spawning grounds and sample size (n), 2001-present.

Return	Males				Females				Total		
Year	3	4	5	n	3	4	5	n	3	4	5
2001	23.5	76.5		34	0.9	99.1		108	6.3	93.7	
2002	8.0	81.3	10.7	75		88.6	11.4	140	2.8	86.2	11.1
2003	100.0			1		100.0		1	50.0	50.0	
2004	9.5	90.5		21		98.0	2.0	51	2.8	95.8	1.4
2005	42.9	57.1		21		90.9	4.5	22	23.3	74.4	2.3
2006	26.7	73.3		15		100.0		43	6.9	93.1	
2007	66.7	33.3		6		100.0		11	23.5	76.5	
2008				0		100.0		1		100.0	
2009	60.0	40.0		5				0	60.0	40.0	
2010	28.6	71.4		7		100.0		11	11.1	88.9	
2011	37.5	62.5		16	4.5	95.5		22	18.4	81.6	
2012		100.0		4	5.3	94.7		19	4.3	95.7	
2013		100.0		1		100.0		7		100.0	
2014		100.0		20		100.0		62	1.2	98.8	
Mean[1]	25.3	73.8	0.9		0.5	97.2	1.8		13.4	85.4	1.2

1. Excludes years where sample size < 5.

Table 13. Percentage by sex and age of upper Yakima River wild/natural spring Chinook collected for brood stock at Roza Dam and sample size (n), 1997-present.

Return	Males				Females				Total		
Year	3	4	5	n	3	4	5	n	3	4	5
1997	4.5	92.0	3.4	88		94.6	5.4	111	2.0	93.5	4.5
1998	22.4	73.1	4.5	134		91.6	8.4	179	9.6	83.7	6.7
1999	71.1	26.1	2.8	425		92.6	7.4	215	48.8	47.0	4.2
2000	17.8	81.7	0.4	230		98.7	1.3	313	7.5	91.5	0.9
2001	12.4	77.4	10.3	234	0.9	90.5	8.5	328	5.7	85.2	9.2
2002	16.4	78.3	5.3	226	0.6	94.8	4.7	343	6.9	88.2	4.9
2003	27.4	60.2	12.4	201		83.3	16.7	228	12.8	72.6	14.7
2004	15.1	84.5	0.4	239	0.3	99.0	0.7	305	6.8	92.6	0.6
2005	15.5	82.3	2.2	181	0.4	97.1	2.5	276	6.3	91.2	2.4
2006	11.1	77.4	11.5	226		89.4	10.6	255	5.2	83.8	11.0
2007	13.6	74.7	11.7	162		87.8	12.2	255	5.3	82.7	12.0
2008	20.0	77.4	2.6	190		95.6	4.4	252	8.6	87.8	3.6
2009	17.4	81.2	1.4	207	0.8	96.1	3.1	258	8.2	89.5	2.4
2010	20.0	79.4	0.6	155	0.4	99.3	0.4	285	7.3	92.3	0.5
2011	18.1	81.3	0.5	182	0.8	95.3	3.8	236	8.4	89.2	2.4
2012	12.5	86.5	1.0	104		97.4	2.6	189	4.4	93.5	2.0
2013	18.0	77.6	4.3	161	0.0	96.2	3.8	183	8.4	87.5	4.1
2014	20.9	76.3	2.8	177	0.0	97.8	2.2	184	10.2	87.3	2.5
Mean	19.7	76.0	4.4		0.2	94.3	5.5		9.6	85.5	4.9

Table 14. Percentage by sex and age of upper Yakima River CESRF spring Chinook collected for research or brood stock at Roza Dam and sample size (n), 2001-present.

Return Year	Males				Females				Total		
	3	4	5	n	3	4	5	n	3	4	5
2001	12.5	87.5		40		100.0		75	5.1	94.9	
2002	14.7	83.8	1.5	68		98.3	1.7	115	5.5	92.9	1.6
2003	36.1	34.7	29.2	72		61.2	38.8	67	18.7	47.5	33.8
2004	19.6	80.4		46		100.0		60	8.5	91.5	
2005	17.8	75.6	6.7	45		88.1	11.9	59	7.7	82.7	9.6
2006	18.3	80.0	1.7	60		100.0		65	8.8	90.4	0.8
2007	33.3	60.8	5.9	51		87.5	12.5	56	15.9	74.8	9.3
2008	50.0	50.0		40		100.0		56	20.8	79.2	
2009	25.4	71.2	3.4	59	1.2	97.6	1.2	84	11.2	86.7	2.1
2010	27.9	72.1		61		99.0	1.0	100	10.6	88.8	0.6
2011	21.2	72.7	6.1	66	0.9	97.2	1.9	107	8.7	87.9	3.5
2012	13.0	85.2	1.9	54		97.0	3.0	101	4.5	92.9	2.6
2013	17.9	80.6	1.5	67	1.1	96.7	2.2	92	8.2	89.9	1.9
2014	31.9	66.0	2.1	47	0.0	100.0	0.0	33	18.8	80.0	1.3
Mean	24.3	71.5	4.3		0.2	94.5	5.3		10.9	84.3	4.8

Sex Composition

In the American River, the mean proportion of males to females in wild/natural carcasses sampled on the spawning grounds from 1986-2014 was 42:58 for age-4 and 32:68 for age-5 spring Chinook (Table 15). In the Naches River, the mean proportion of males to females was 41:59 for age-4 and 27:73 for age-5 fish (Table 16). In the upper Yakima River, the mean proportion of males to females was 33:67 for age-4 and 23:77 for age-5 fish (Table 17).

For upper Yakima fish collected at Roza Dam for brood stock or research purposes from 1997-2014, the mean proportion of males to females was 38:62 and 36:64 for age-4 fish from the wild/natural and CESRF populations, respectively (Tables 19 and 20). For these same samples, the mean proportion of males to females was 36:64 and 41:59 for age-5 fish from the wild/natural and CESRF populations (excluding years with very small age-5 sample sizes), respectively (Tables 19 and 20). For adult fish, the mean proportion of males to females in spawning ground carcass recoveries was substantially lower than the ratio found at RAMF (Tables 17 and 19), indicating that sex ratios estimated from hatchery origin carcass recoveries were biased due to female carcasses being recovered at higher rates than male carcasses (Knudsen et al, 2003 and 2004). Again, despite these biases, we believe these data are good relative indicators of differences in sex composition between populations and between years.

Sample sizes for Tables 15-20 were given in Tables 9-14. As noted earlier, few age-6 fish are found in carcass surveys and those that have been found were located in the American and Naches systems. The data indicate that age-3 females may occasionally occur in the upper Yakima and, to a lesser extent, the Naches systems.

Table 15. Percent of American River wild/natural spring Chinook carcasses sampled on the spawning grounds by age and sex, 1986-present.

Return	Age-3		Age-4		Age-5		Age-6	
Year	M	F	M	F	M	F	M	F
1986			55.6	44.4	29.1	70.9		100.0
1987			65.4	34.6	33.3	66.7	100.0	
1988			0.0	100.0	100.0	0.0		
1989			79.2	20.8	39.2	60.8		
1990	100.0		43.5	56.5	46.8	53.2		
1991			55.6	44.4	38.1	61.9		
1992			62.7	37.3	31.6	68.4	100.0	
1993	100.0		33.3	66.7	19.8	80.2		
1994			34.8	65.2	41.7	58.3		100.0
1995	100.0		100.0	0.0	27.8	72.2		
1996			28.6	71.4	0.0	100.0		
1997			16.7	83.3	9.4	90.6		100.0
1998			44.4	55.6	29.0	71.0		
1999			50.0	50.0	0.0	100.0		100.0
2000			55.6	44.4	50.0	50.0		
2001			45.0	55.0	47.7	52.3		
2002	100.0		33.3	66.7	35.1	64.9		
2003			33.3	66.7	32.9	67.1		
2004			75.0	25.0	0.0	100.0		
2005			34.4	65.6	60.0	40.0		
2006			32.0	68.0	21.7	78.3		
2007	100.0		22.2	77.8	28.9	71.1		
2008			28.6	71.4	36.2	63.8		
2009			42.9	57.1	0.0	100.0		
2010			No carcasses were sampled					
2011			25.0	75.0	46.2	53.8		
2012			24.1	75.9	22.6	77.4		
2013			12.5	87.5	26.9	73.1		
2014			31.8	68.2	50.0	50.0		
mean			41.6	58.4	32.3	67.7		

Table 16. Percent of Naches River wild/natural spring Chinook carcasses sampled on the spawning grounds by age and sex, 1986-present.

Return	Age-3		Age-4		Age-5		Age-6	
Year	M	F	M	F	M	F	M	F
1986	100.0		46.2	53.8	18.2	81.8	50.0	50.0
1987	100.0		31.0	69.0	13.3	86.7	100.0	
1988		100.0	36.4	63.6	28.6	71.4		
1989			60.0	40.0	25.9	74.1		100.0
1990	50.0	50.0	55.6	44.4	52.6	47.4		
1991	100.0		66.7	33.3	20.4	79.6		
1992	100.0		45.5	54.5	23.1	76.9	100.0	
1993			57.9	42.1	30.0	70.0		
1994			40.0	60.0	22.2	77.8		
1995			33.3	66.7	37.5	62.5		
1996			58.6	41.4		100.0		
1997	100.0		46.2	53.8	28.0	72.0	40.0	60.0
1998			29.4	70.6	27.9	72.1		
1999	100.0		62.5	37.5	25.0	75.0		
2000	100.0		44.1	55.9	25.0	75.0		
2001	100.0		37.4	62.6	24.6	75.4		
2002	100.0		37.4	62.6	20.0	80.0		
2003	83.3	16.7	47.1	52.9	36.1	63.9		
2004	100.0		29.4	70.6	20.0	80.0		
2005			22.5	77.5	25.0	75.0		
2006			50.0	50.0	50.0	50.0		
2007			21.4	78.6	11.1	88.9		
2008	100.0		20.0	80.0	40.0	60.0		
2009	100.0		33.3	66.7	33.3	66.7		
2010			33.3	66.7		100.0		
2011	100.0		58.3	41.7	33.3	66.7		
2012	66.7	33.3	19.4	80.6	34.8	65.2		
2013	100.0		43.8	56.3	36.4	63.6		
2014			35.1	64.9	50.0	50.0		
mean			41.4	58.6	27.3	72.7		

Table 17. Percent of Upper Yakima River wild/natural spring Chinook carcasses sampled on the spawning grounds by age and sex, 1986-present.

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
1986			20.0	80.0		100.0
1987	100.0		35.1	64.9	15.2	84.8
1988	64.3	35.7	43.8	56.3	30.0	70.0
1989	50.0	50.0	34.0	66.0	44.4	55.6
1990	60.0	40.0	31.3	68.7	45.5	54.5
1991	100.0		32.7	67.3	14.3	85.7
1992	100.0		33.1	66.9	62.5	37.5
1993	66.7	33.3	30.4	69.6	27.3	72.7
1994			24.6	75.4		100.0
1995	100.0		25.0	75.0		
1996	87.5	12.5	33.3	66.7	40.0	60.0
1997			31.1	68.9	28.6	71.4
1998	60.0	40.0	35.3	64.7		100.0
1999	100.0		27.7	72.3		100.0
2000	100.0		24.2	75.8		
2001	100.0		24.4	75.6	13.0	87.0
2002	33.3	66.7	32.9	67.1	76.2	23.8
2003	95.8	4.2	44.1	55.9		100.0
2004	100.0		33.9	66.1		100.0
2005	78.6	21.4	34.2	65.8	25.0	75.0
2006	87.5	12.5	34.6	65.4	50.0	50.0
2007	92.9	7.1	37.5	62.5		100.0
2008	100.0		56.6	43.4		100.0
2009	98.1	1.9	57.4	42.6		100.0
2010	100.0		32.4	67.6		
2011	100.0		27.0	73.0		
2012	66.7	33.3	33.3	66.7		
2013				100.0		
2014	100.0	0.0	33.0	67.0		
mean	85.7	14.3	33.0	67.0	22.5	77.5

Table 18. Percent of upper Yakima River CESRF spring Chinook carcasses sampled on the spawning grounds by age and sex, 2001-present.

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
2001	88.9	11.1	19.5	80.5		
2002	100.0		33.0	67.0	33.3	66.7
2003	100.0			100.0		
2004	100.0		27.5	72.5		100.0
2005	90.0	10.0	37.5	62.5		100.0
2006	100.0		20.4	79.6		
2007	100.0		15.4	84.6		
2008				100.0		
2009	100.0		100.0			
2010	100.0		31.3	68.8		
2011	85.7	14.3	32.3	67.7		
2012			18.2	81.8		
2013			12.5	87.5		
2014			24.4	75.6		
mean	96.5	3.5	26.6	73.4		

Table 19. Percent of upper Yakima River wild/natural spring Chinook collected for brood stock at Roza Dam by age and sex, 1997-present.

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
1997	100.0		43.5	56.5	33.3	66.7
1998	100.0		37.4	62.6	28.6	71.4
1999	100.0		35.8	64.2	42.9	57.1
2000	100.0		37.8	62.2	20.0	80.0
2001	90.6	9.4	37.9	62.1	46.2	53.8
2002	94.9	5.1	35.3	64.7	42.9	57.1
2003	100.0		38.9	61.1	39.7	60.3
2004	97.3	2.7	40.1	59.9	33.3	66.7
2005	96.6	3.4	35.7	64.3	36.4	63.6
2006	100.0		43.4	56.6	49.1	50.9
2007	100.0		35.1	64.9	38.0	62.0
2008	100.0		37.9	62.1	31.3	68.8
2009	94.7	5.3	40.4	59.6	27.3	72.7
2010	96.9	3.1	30.3	69.7	50.0	50.0
2011	94.3	5.7	39.7	60.3	10.0	90.0
2012	100.0		32.8	67.2	16.7	83.3
2013	100.0		41.5	58.5	50.0	50.0
2014	100.0		42.9	57.1	55.6	44.4
mean	98.1	1.9	38.1	61.9	36.2	63.8

Table 20. Percent of Upper Yakima River CESRF spring Chinook collected for research or brood stock at Roza Dam by age and sex, 2001-present.

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
2001	100.0	0.0	31.8	68.2		
2002	100.0	0.0	33.5	66.5	33.3	66.7
2003	100.0	0.0	37.9	62.1	44.7	55.3
2004	100.0	0.0	38.1	61.9		
2005	100.0	0.0	39.5	60.5	30.0	70.0
2006	100.0	0.0	42.5	57.5	100.0	
2007	100.0	0.0	38.8	61.3	30.0	70.0
2008	100.0	0.0	26.3	73.7		
2009	93.8	6.3	33.9	66.1	66.7	33.3
2010	100.0	0.0	30.8	69.2		100.0
2011	93.3	6.7	31.6	68.4	66.7	33.3
2012	100.0		31.9	68.1	25.0	75.0
2013	92.3	7.7	37.8	62.2	33.3	66.7
2014	100.0	0.0	48.4	51.6	100.0	0.0
mean	98.5	1.5	35.9	64.1	47.7	52.3

Size at Age

Prior to 1996, samplers were instructed to collect mid-eye to hypural plate (MEHP) lengths from carcasses surveyed on the spawning grounds. From 1996 to present the method was changed and post-eye to hypural plate (POHP) lengths have been recorded. Mean POHP lengths averaged 38, 61, and 77 cm for age-3, -4, and -5 males, and averaged 63 and 73 cm for age-4 and -5 females, respectively, from carcasses sampled on the spawning grounds in the American River from 1996-2014 (Table 21). In the Naches River, mean POHP lengths averaged 42, 61, and 76 cm for age-3, -4, and -5 males, and averaged 61 and 73 cm for age-4 and -5 females, respectively (Table 22). For wild/natural spring Chinook sampled on the spawning grounds in the upper Yakima River, mean POHP lengths averaged 44, 60, and 72 cm for age-3, -4, and -5 males, and averaged 59 and 69 cm for age-4 and -5 females, respectively (Table 23). Beginning in 2012, carcass sampling in the Upper Yakima was scaled back considerably as large numbers of escaping fish are sampled at Roza Dam (Tables 27-28). From 2001-2014, CESRF fish returning to the upper Yakima have been generally smaller in size-at-age than their wild/natural counterparts (Tables 23-28).

Table 21. Counts and mean mid-eye (MEHP) or post-orbital (POHP) to hypural plate lengths (cm) of American River wild/natural spring Chinook from carcasses sampled on the spawning grounds by sex and age, 1986-present.

	Males								Females					
Return	Age 3		Age 4		Age 5		Age 6		Age 4		Age 5		Age 6	
Year	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP
1986			5	57.1	16	80.9			4	65.8	39	75.2	2	74.0
1987			17	58.0	6	80.8	1.0	86.0	9	64.5	12	76.9		
1988					1	79.0			1	63.0				
1989			19	61.1	29	77.4			5	63.0	45	73.5		
1990	1	41.0	10	63.6	29	77.3			13	62.5	33	73.6		
1991			10	59.5	32	77.1			8	65.1	52	73.4		
1992			37	60.6	12	76.2	3.0	86.7	22	64.1	26	76.4		
1993	1	47.0	3	64.0	17	80.2			6	63.7	69	75.5		
1994			8	67.3	10	83.0			15	70.8	14	76.4	1	85.0
1995	1	44.4	1	70.0	4	83.5					12	76.4		
		POHP		POHP		POHP		POHP		POHP		POHP		POHP
1996			2	56.3					5	59.0	1	67.0		
1997[1]			2	62.0	1	63.0			4	62.8	14	64.4	5	71.0
1998			4	58.3	29	79.1			5	64.0	71	73.4		
1999			2	50.5					2	61.0	2	73.0	1	77.0
2000			10	57.9	5	83.2			8	63.9	5	76.2		
2001			59	65.9	31	77.6			72	63.6	34	73.0		
2002	1	40.0	31	63.0	26	77.3			62	64.4	48	74.7		
2003			6	63.0	68	79.4			12	64.3	139	76.7		
2004			3	56.0					1	58.0	4	77.5		
2005			11	60.6	6	80.2			21	62.6	4	74.8		
2006			8	60.8	5	75.4			17	61.8	18	71.7		
2007	2	37.0	6	62.8	11	76.5			21	60.0	27	73.3		
2008			2	67.5	21	83.1			5	67.4	37	78.9		
2009	4	44.0	9	68.3					12	62.6	4	69.8		
2010				No samples						No samples				
2011			4	65.5	6	82.8			12	65.8	7	75.9		
2012			7	64.1	7	77.3			22	63.7	24	74.3		
2013	1	34.0	1	56.0	7	70.1			7	65.7	18	70.3		
2014	1	36.0	14	61.1	3	66.7			30	61.2	3	63.3		
Mean[2]		38.2		61.1		76.5				62.9		72.7		74.0

[1] Carcasses sampled in 1997 had a mix of MEHP and POHP lengths taken. Only POHP samples are given here.

[2] Mean of mean values for 1996-2014 post-eye to hypural plate lengths.

Table 22. Counts and mean mid-eye (MEHP) or post-orbital (POHP) to hypural plate lengths (cm) of Naches River wild/natural spring Chinook from carcasses sampled on the spawning grounds by sex and age, 1986-present.

	Males								Females							
Return	Age 3		Age 4		Age 5		Age 6		Age 3		Age 4		Age 5		Age 6	
Year	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP
1986	1	45.0	12	62.7	6	74.3	1.0	80.0			14	64.5	27	73.6	1	83.5
1987	1	37.0	12	64.2	2	80.5	1.0	94.0			29	67.9	13	75.7		
1988			4	62.0	4	74.6			1	45.0	7	69.1	10	73.6		
1989			33	58.4	14	77.5					22	61.7	40	73.2	1	75.0
1990	3	53.0	20	59.4	10	75.9			3	51.7	16	60.9	9	73.7		
1991	1	31.0	12	56.3	10	72.8					6	62.5	39	71.1		
1992	1	42.0	20	58.8	3	72.3	1.0	83.0			24	62.4	10	71.7		
1993			11	60.0	15	77.7					8	63.3	35	72.5		
1994			2	62.5	2	77.0					3	63.7	7	73.1		
1995			1	59.0	3	73.0					2	64.0	5	73.8		
		POHP		POHP		POHP		POHP		POHP		POHP		POHP		POHP
1996			17	58.1							12	60.3	4	69.6		
1997[1]	1	39.0	24	59.8	4	71.5	2.0	78.0			28	60.0	15	68.6	1	75.0
1998			5	57.8	12	75.0					12	61.1	31	71.6		
1999	1	40.0	5	61.2	2	73.0					3	58.7	6	75.0		
2000	1	35.0	56	58.2	2	84.0					71	59.5	6	72.8		
2001	1	45.0	43	61.4	15	73.4					72	62.2	46	74.5		
2002	1	40.0	37	63.6	9	77.3					62	62.4	36	71.8		
2003	5	41.4	16	62.2	43	79.4			1	41.0	18	62.8	76	75.6		
2004	3	46.0	35	59.8	2	74.5					84	61.5	8	75.8		
2005			9	60.1	2	78.0					31	61.7	6	71.7		
2006			8	56.9	5	76.0					8	63.8	5	71.2		
2007			3	61.3	1	67.0					11	56.9	8	72.1		
2008	4	42.0	5	59.6	2	81.5					20	62.0	3	78.7		
2009	1	43.0	10	67.9	3	76.3					20	63.9	6	73.2		
2010			9	60.3							18	62.6	4	72.0		
2011	3	44.3	21	61.9	2	78.0					15	60.4	4	76.8		
2012	2	51.5	7	67.3	8	75.8			1	41.0	29	61.6	15	71.1		
2013	2	37.0	7	56.1	4	75.0					9	58.7	7	71.3		
2014			13	61.8	2	71.0					24	56.7	2	67.5		
Mean[2]		42.0		60.8		75.7		78.0		41.0		60.9		72.7		75.0

[1] Carcasses sampled in 1997 had a mix of MEHP and POHP lengths taken. Only POHP samples are given here.

[2] Mean of mean values for 1996-2014 post-eye to hypural plate lengths.

Table 23. Counts and mean mid-eye (MEHP) or post-orbital (POHP) to hypural plate lengths (cm) of upper Yakima River wild / natural spring Chinook from carcasses sampled on the spawning grounds by sex and age, 1986-present.

			Males							Females		
Return	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Year	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP
1986			12	60.8					48	58.7	3	70.3
1987	7	45.3	53	58.5	5	73.0			96	59.3	28	70.6
1988	9	40.0	28	59.0	3	79.0	5	52.6	36	59.2	7	70.3
1989	1	50.0	121	59.7	8	70.6	1	40.0	235	58.6	10	67.2
1990	6	47.0	84	58.0	5	77.0	4	51.5	184	59.3	6	72.5
1991	5	39.6	48	56.2	2	67.5			99	57.6	12	68.8
1992	4	43.0	153	58.4	10	71.2			309	58.2	6	69.5
1993	2	44.0	45	60.7	3	75.0	1	56.0	101	59.5	8	70.3
1994			15	62.9					49	61.3	1	72.0
1995	1	43.0	4	62.0					12	61.4	0	
		POHP		POHP		POHP		POHP		POHP		POHP
1996	14	40.9	138	59.1	2	66.5	2	41.0	277	58.6	3	68.0
1997			59	59.3	2	74.0			131	58.6	5	69.4
1998	3	38.7	18	56.4			2	47.0	33	57.5	3	66.7
1999	21	38.8	13	57.4					34	58.9	2	69.8
2000	2	41.0	70	60.3					219	58.3	0	
2001	1	43.0	33	60.7	3	74.7			102	60.6	20	69.8
2002	1	44.0	24	64.9	16	69.3	2	46.0	49	62.5	5	70.2
2003	23	44.4	15	59.8					19	62.4	3	67.8
2004	7	47.3	101	59.9					197	58.7	1	67.0
2005	11	49.2	108	60.6	1	75.0	3	48.7	207	59.5	3	67.3
2006	14	41.8	44	59.4	1	72.0	2	39.5	82	58.3	1	71.0
2007	13	44.2	61	61.7					101	60.6	6	66.0
2008	3	48.3	29	60.5					22	59.7	1	77.0
2009	53	46.8	58	57.6			1	51.0	43	60.2	1	68.0
2010	13	47.7	34	60.5					70	59.5		
2011	6	47.0	10	58.9					27	59.3		
2012	2	44.5	6	58.0			1	47.0	12	57.5		
2013			No samples						8	56.6		
2014	1	45.0	29	61.2					59	61.3		
Mean[1]		44.3		59.8		71.9		45.7		59.4		69.1

[1] Mean of mean values for 1996-2014 post-eye to hypural plate lengths.

Table 24. Counts and mean post-orbital to hypural plate (POHP) lengths (cm) of upper Yakima River CESRF spring Chinook from carcasses sampled on the spawning grounds by sex and age, 2001-present.

	Males						Females					
Return	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2001	8	40.5	25	59.0	1	69.5	1	41.0	107	59.0		
2002	6	47.7	61	61.2	8	68.9			124	60.6	16	71.2
2003	1	42.0							1	69.0		
2004	2	52.0	19	60.8					50	57.9	1	68.0
2005	8	41.8	12	59.9			1	46.0	20	59.6	1	72.0
2006	4	42.3	11	54.0					43	57.0		
2007	4	44.3	2	58.5					11	60.1		
2008	0		0						1	58.0		
2009	3	47.7	2	---								
2010	2	44.0	5	61.8					11	55.5		
2011	6	40.7	10	59.1			1	46.0	21	59.0		
2012			4	63.0			1	50.0	18	57.3		
2013			1	---					7	53.6		
2014			20	60.8					62	59.0		
Mean		44.3		59.8		69.2				58.9		70.4

Table 25. Counts and mean post-orbital to hypural plate (POHP) lengths (cm) of upper Yakima River wild/natural spring Chinook from carcasses sampled at the CESRF prior to spawning by sex and age, 1997-present.

	Males						Females					
Return	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP
1997	4	39.7	81	59.7	3	73.3			105	60.5	6	68.9
1998	28	43.0	95	57.3	6	67.0			161	59.2	15	65.6
1999	124	41.4	75	59.5	10	64.6			199	60.4	16	67.4
2000	19	42.0	145	59.0	1	77.0			263	59.4	3	69.4
2001	17	42.9	115	59.6	14	74.1			196	60.5	19	69.8
2002	23	42.1	113	60.6	5	72.9	1	36.6	233	61.2	9	70.9
2003	37	42.7	92	60.4	19	73.7			164	61.4	31	69.4
2004	18	42.4	108	58.9	1	67.8			225	58.3	2	66.5
2005	19	42.1	113	60.0	2	67.3	1	42.6	223	59.8	5	67.8
2006	17	41.0	82	56.7	20	70.4			197	57.8	24	68.1
2007	20	44.6	108	58.8	17	67.6			181	59.4	24	67.2
2008	17	45.5	121	59.6	4	71.1			209	59.7	11	68.4
2009	16	44.4	122	61.5	3	69.3	1	50.4	206	60.3	6	68.0
2010	9	45.0	88	61.5	1	71.2			192	60.9		
2011	11	47.5	91	60.3	1	75.3	1	52.5	182	60.2	4	72.9
2012	13	43.7	83	59.8	1	62.4			178	59.3	5	66.6
2013	18	45.8	112	59.6	7	70.0			161	58.9	6	69.7
2014	27	43.3	112	61.3	5	70.0			173	59.9	4	63.1
Mean		43.3		59.7		70.3				59.8		68.2

Table 26. Counts and mean post-orbital to hypural plate (POHP) lengths (cm) of upper Yakima River CESRF spring Chinook from carcasses sampled at the CESRF prior to spawning by sex and age, 2001-present.

	Males						Females					
Return	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2001			4	61.3					33	60.4		
2002	2	40.2	25	59.6					63	59.4	2	66.1
2003	17	42.6	16	57.8	15	74.0			31	59.7	19	70.4
2004	6	39.4	9	57.1					42	59.3		
2005	6	37.9	21	58.4	2	68.7			38	58.6	5	68.0
2006[1]			3	57.2					3	56.3		
2007	8	40.4	18	59.3	1	71.4			35	58.2	5	67.6
2008	17	43.8	9	59.1					28	59.4		
2009	5	43.8	11	61.1					32	60.1	1	67.5
2010	11	41.8	18	59.2					40	61.0		
2011	4	43.4	10	62.7	1	79.2			32	60.4	2	71.7
2012	3	39.0	23	59.3	1	73.7			43	59.4	1	67.2
2013	2	45.7	24	60.3					32	57.3		
2014	7	39.2	21	61.8	1	70.2			32	60.5		
Mean		41.4		59.6		72.9				59.3		68.4

[1] Few length samples were collected since these fish were not spawned in 2006.

Table 27. Counts and mean post-orbital to hypural plate (POHP) lengths (cm) of upper Yakima River wild/natural spring Chinook from fish sampled at Roza Dam by sex[1] and age, 1997-present.

	Males						Females					
	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Return Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP
1997	4	39.6	81	60.6	2	73.3			121	60.5	10	70.6
1998	36	42.4	108	58.3	11	67.7	1	58.5	201	59.4	13	67.0
1999	350	40.7	80	59.4	11	67.5	2	46.8	256	60.3	19	68.3
2000	40	41.3	145	60.5	1	77.0	1	46.0	354	60.2	4	72.1
2001	32	42.9	111	61.9	28	73.8			371	61.2	24	70.7
2002	43	41.6	146	61.2	21	71.4	2	52.5	379	60.7	8	70.3
2003	54	43.3	52	64.6	18	75.3	1	51.0	262	61.9	45	71.2
2004	41	43.4	121	61.1	1	69.0			394	59.4	2	69.5
2005	35	43.2	134	61.1	5	74.2			307	60.8	6	68.3
2006	27	41.3	77	59.1	22	72.6	1	47.0	336	58.8	27	69.5
2007	31	42.9	83	60.8	18	69.8	1	50.0	280	60.5	34	69.7
2008	38	45.8	101	61.7	8	72.4			293	60.7	8	69.1
2009	36	45.3	125	63.4	4	71.5	3	52.7	297	61.9	8	69.9
2010	39	43.7	129	62.6	1	74.0	1	51.0	298	62.8	1	70.0
2011	42	46.7	154	61.2	3	77.3	2	53.0	235	61.9	10	75.3
2012	27	43.6	113	60.5	1	63.0			202	60.3	5	68.0
2013	31	45.4	132	59.9	8	70.6			181	59.8	7	70.6
2014	38	44.7	138	62.2	5	72.2			181	61.2	4	65.5
Mean		43.2		61.1		71.8		50.8		60.7		69.8

Table 28. Counts and mean post-orbital to hypural plate (POHP) lengths (cm) of upper Yakima River CESRF spring Chinook from fish sampled at Roza Dam by sex[1] and age, 2001-present.

	Males						Females					
	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Return Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2001	473	39.9	548	59.5			1	58.0	1795	59.2		
2002	26	38.7	383	59.5	19	67.7			1152	59.1	15	66.1
2003	392	41.8	48	61.8	61	73.0	2	47.0	207	60.3	154	70.8
2004	48	40.3	100	60.5			1	44.0	351	59.2	2	71.0
2005	98	40.4	58	60.1	6	73.0			160	59.1	12	68.7
2006	26	40.4	89	58.0					318	57.4	2	70.5
2007	174	41.4	46	60.7	6	71.7	1	47.0	185	59.0	13	69.8
2008	93	44.8	60	60.7			2	54.5	191	60.1	1	67.0
2009	254	43.6	78	62.8	5	65.0	1	50.0	212	61.8	6	69.5
2010	106	42.5	196	61.0	1	67.0	1	60.0	361	61.8	1	72.0
2011	155	42.9	146	60.9	8	73.5	2	57.5	265	61.5	13	73.4
2012	45	40.6	131	59.3	3	65.7	1	45.0	250	59.9	6	69.2
2013	92	44.4	122	59.0	3	70.0			163	58.8	4	69.3
2014	78	42.8	111	61.0	2	71.0			163	60.5	3	71.7
Mean		41.5		60.3		69.8		51.4		59.8		69.9

[1] Sex determined by visual observation prior to 2010 and by ultrasound from 2010 to present.

Migration Timing

Wild/natural spring Chinook adults returning to the upper Yakima River have generally shown earlier passage timing at Roza Dam than CESRF spring Chinook (Figures 2 and 3).

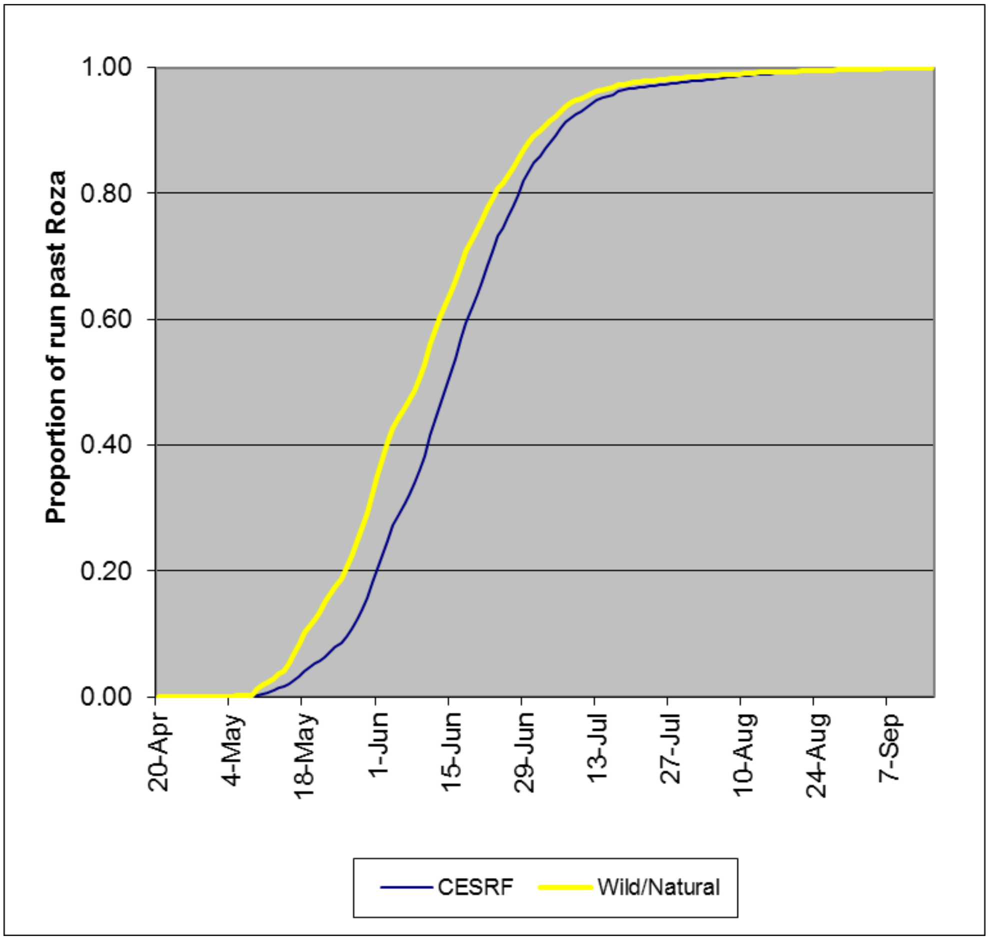


Figure 3. Proportionate passage timing at Roza Dam of wild/natural and CESRF adult spring Chinook (including jacks), 2005-2014.

Table 29. Comparison of 5%, median (50%), and 95% passage dates of wild/natural and CESRF adult spring Chinook (including jacks) at Roza Dam, 1997-Present.

	Wild/Natural Passage			CESRF Passage		
Year	5%	Median	95%	5%	Median	95%
1997	10-Jun	17-Jun	21-Jul			
1998	22-May	10-Jun	10-Jul			
1999	31-May	24-Jun	4-Aug			
2000	12-May	24-May	12-Jul	21-May[1]	15-Jun[1]	27-Jul[1]
2001	4-May	23-May	11-Jul	8-May	28-May	15-Jul
2002	16-May	10-Jun	6-Aug	20-May	13-Jun	12-Aug
2003	13-May	11-Jun	19-Aug	13-May	10-Jun	24-Aug
2004	4-May	20-May	24-Jun	5-May	22-May	26-Jun
2005	9-May	22-May	23-Jun	15-May	31-May	2-Jul
2006	1-Jun	14-Jun	18-Jul	3-Jun	18-Jun	19-Jul
2007	16-May	5-Jun	9-Jul	24-May	14-Jun	19-Jul
2008	27-May	9-Jun	9-Jul	31-May	17-Jun	14-Jul
2009	31-May	14-Jun	17-Jul	2-Jun	19-Jun	17-Jul
2010	11-May	30-May	5-Jul	12-May	2-Jun	9-Jul
2011	6-Jun	23-Jun	16-Jul	9-Jun	24-Jun	15-Jul
2012	30-May	14-Jun	9-Jul	30-May	13-Jun	8-Jul
2013	22-May	4-Jun	3-Jul	24-May	8-Jun	8-Jul
2014	15-May	1-Jun	2-Jul	18-May	5-Jun	8-Jul

1. In 2000 all returning CESRF fish were age-3 (jacks).

Spawning Timing

Median spawn timing for CESRF spring Chinook is earlier than that observed for wild/natural fish in the Upper Yakima River. These differences are due in part to environmental conditions and spawning procedures at the hatchery. It must also be noted that spawning dates in the wild are only a coarse approximation, derived from weekly redd counts not actual dates of redd deposition. A clear delineation of wild/natural spawn timing between subbasins is apparent, with American River fish spawning about 1 month earlier than Naches Basin fish which spawn about 2 weeks earlier than Upper Yakima fish.

Table 30. Median spawn[1] dates for spring Chinook in the Yakima Basin.

Year	American	Naches	Upper Yakima	CESRF
1988	14-Aug	7-Sep	3-Oct	
1989	14-Aug	7-Sep	19-Sep	
1990	14-Aug	12-Sep	25-Sep	
1991	12-Aug	12-Sep	24-Sep	
1992	11-Aug	10-Sep	22-Sep	
1993	9-Aug	8-Sep	27-Sep	
1994	16-Aug	14-Sep	26-Sep	
1995	14-Aug	7-Sep	1-Oct	
1996	20-Aug	18-Sep	23-Sep	
1997	12-Aug	11-Sep	23-Sep	23-Sep
1998	11-Aug	15-Sep	30-Sep	22-Sep
1999	24-Aug	8-Sep	27-Sep	21-Sep
2000	7-Aug	20-Sep	19-Sep	19-Sep
2001	14-Aug	13-Sep	25-Sep	18-Sep
2002	12-Aug	11-Sep	23-Sep	24-Sep
2003	11-Aug	14-Sep	28-Sep	23-Sep
2004	17-Aug	12-Sep	27-Sep	21-Sep
2005	15-Aug	15-Sep	27-Sep	20-Sep
2006	15-Aug	14-Sep	26-Sep	19-Sep
2007	14-Aug	12-Sep	25-Sep	25-Sep
2008	11-Aug	12-Sep	23-Sep	23-Sep
2009	17-Aug	10-Sep	23-Sep	28-Sep
2010	17-Aug	12-Sep	21-Sep	21-Sep
2011	23-Aug	8-Sep	21-Sep	20-Sep
2012	21-Aug	11-Sep	24-Sep	25-Sep
2013	19-Aug	11-Sep	25-Sep	23-Sep
2014	19-Aug	18-Sep	29-Sep	29-Sep
Mean	14-Aug	11-Sep	25-Sep	22-Sep

1. Approximately one-half of the redds in the system were counted by this date and one-half were counted after this date. For the CESRF, approximately one-half of the total broodstock were spawned by this date and one-half were spawned after this date.

Redd Counts and Distribution

Table 31. Yakima Basin spring Chinook redd count summary, 1981 – present.

	Upper Yakima River System				Naches River System				
Year	Mainstem[1]	Cle Elum	Teanaway	Total	American	Naches[1]	Bumping	Little Naches	Total
1981	237	57	0	294	72	64	20	16	172
1982	610	30	0	640	11	25	6	12	54
1983	387	15	0	402	36	27	11	9	83
1984	677	31	0	708	72	81	26	41	220
1985	795	153	3	951	141	168	74	44	427
1986	1,716	77	0	1,793	464	543	196	110	1,313
1987	968	75	0	1,043	222	281	133	41	677
1988	369	74	0	443	187	145	111	47	490
1989	770	192	6	968	187	200	101	53	541
1990	727	46	0	773	143	159	111	51	464
1991	568	62	0	630	170	161	84	45	460
1992	1,082	164	0	1,246	120	155	99	51	425
1993	550	105	1	656	214	189	88	63	554
1994	226	64	0	290	89	93	70	20	272
1995	105	12	0	117	46	25	27	6	104
1996	711	100	3	814	28	102	29	25	184
1997	364	56	0	420	111	108	72	48	339
1998	123	24	1	148	149	104	54	23	330
1999	199	24	1	224	27	95	39	25	186
2000	3,349	466	21	3,836	54	483	278	73	888
2001	2,910	374	21	3,305	392	436	257	107	1,192
2002	2,441	275	110	2,826	366	226	262	89	943
2003	772	87	31	890	430	228	216	61	935
2004	2,985	330	129	3,444	91	348	205	75	719
2005	1,717	287	15	2,019	140	203	163	68	574
2006	1,092	100	58	1,250	136	163	115	33	447
2007	665	51	10	726	166	60	60	27	313
2008	1,191	137	47	1,375	158	165	102	70	495
2009	1,349	197	33	1,579	92	159	163	68	482
2010	2,199	219	253	2,671	173	171	168	40	552
2011	1,663	171	64	1,898	212	145	175	48	580
2012	1,276	125	69	1,470	337	196	189	89	811
2013	552	85	34	671	170	66	85	55	376
2014	962	138	53	1,153	129	65	158	27	379
Mean	1,068	130	28	1,226	163	172	116	49	499

[1] Including minor tributaries.

Homing

A team from NOAA fisheries has conducted studies to determine the spatial and temporal patterns of homing and spawning by wild and hatchery-reared salmon released from CESRF facilities from 2001 to present. These studies collected GPS information on each redd and carcass recovered within a survey reach. Carcass surveys were conducted annually in late-September to early October by NOAA personnel in cooperation with Yakama Nation survey crews over five different reaches of the upper Yakima River and recorded the location of each redd flagged and carcass recovered. For each carcass sex, hatchery/wild, male status (full adult, jack, mini-jack), and CWT location was recorded. Data collected on the body location of CWTs allowed the identification of the release site of some fish. While these studies were not designed to comprehensively map carcasses and redds in all spawning reaches in the upper watershed, preliminary data indicate that fish from the Easton, Jack Creek, and Clark Flat acclimation facilities had distinct spawner distributions. A more complete description of this project is available from NOAA fisheries and in this publication:

Dittman, A. H., D. May, D. A. Larsen, M. L. Moser, M. Johnston, and D. Fast. 2010. Homing and spawning site selection by supplemented hatchery- and natural-origin Yakima River spring Chinook salmon. Transactions of the American Fisheries Society 139:1014-1028.

Straying

The regional PTAGIS (PIT tag) and RMIS (CWT) databases were queried in late December 2014 to determine the number of CESRF releases not returning to the Yakima River Basin. For adult (age-3, -4, or -5) PIT tagged fish, a stray is defined as detection at an out-of-basin facility in the Snake (Ice Harbor or Lower Granite) or Upper Columbia (Priest Rapids, Rock Island, or Wells) without a subsequent detection at Prosser or Roza Dam. For coded-wire tagged fish, a stray is generally defined as a tag recovery in tributaries of the Columbia River upstream (and including the Snake River Basin) of its' confluence with the Yakima River. Marked (adipose fin clipped) fish are occasionally found during carcass surveys in the Naches River system. All marked fish observed in spawning ground carcass surveys in the Naches Basin are assumed to be CESRF fish and are used to estimate in-basin stray rates.

Table 32. Estimated number of PIT- and CWT-tagged CESRF fish not returning to the Yakima River Basin (strays), and marked fish sampled during spawner surveys in the Naches Basin, per number of returning fish, brood years 1997-present.

	CESRF PIT-Tagged Fish			All CESRF Fish			CESRF Age-4 Fish		
Brood Year	Roza Adult Returns	Adult Strays	Stray Rate	Yakima River Mth Return	CWT Strays	Stray Rate	Yak R. MthRtn	In-Basin Strays[1]	Stray Rate
1997	598	2	0.33%	8,670	1	0.01%	7,753		
1998	398	0	0.00%	9,782			7,939	1	0.01%
1999	23	0	0.00%	864			714		
2000	150	4	2.67%	4,819	2	0.04%	3,647	4	0.11%
2001	80	3	3.75%	1,251			845	2	0.24%
2002	97	5	5.15%	2,300			1,886	1	0.05%
2003	31	0	0.00%	932			800		
2004	125	1	0.80%	4,022	4	0.10%	3,101		
2005	142	0	0.00%	4,378			3,052		
2006	460	3	0.65%	9,114			5,812		
2007	238	1	0.42%	6,558	5	0.08%	5,174	1	0.02%
2008	215	0	0.00%	6,976			4,567	1	0.02%
2009[2]	110	0	0.00%	3,123			2,663	1	0.04%
2010[3]	200	5	2.50%						
2011[4]	53	4	7.55%						

[1] All marked fish observed in spawning ground carcass surveys in the Naches Basin are assumed to be CESRF fish.

[2] Age 5 data are preliminary.

[3] Through age 4 only and data are preliminary.

[4] Through age 3 only and data are preliminary.

CESRF Spawning and Survival

As described earlier, a portion of natural- and hatchery-origin (NoR and HoR, respectively) returning adults are captured at Roza Dam during the adult migration and taken to the CESRF for broodstock and/or research purposes. Fish are held in adult holding ponds at the CESRF from capture in the spring and summer until spawning in September through early October. All mortalities during the holding period are documented by sex and origin. During the spawning period data are kept on the number of males and females of each origin used for spawning or other purposes. All females have samples taken that are later evaluated for presence of BKD-causative agents. Eggs from females with high BKD-presence indicators are generally excluded (see Female BKD Profiles). Once fertilized, eggs are placed in holding troughs until shock time. Dead eggs are then sorted and hand-counted. All live eggs are machine counted, sorted into two lots per female (treatment and control) and placed into incubation (heath) trays. Using hand counts of egg samples from a subsample of female egg lots, WDFW staff determined that machine counts are biased and that the best approximation of live egg counts is given by the following equation:

$$\left(\left(\frac{\text{no. eggs in subsample}}{\text{wt. of subsample}} * \text{total egg mass wt}\right) * 0.945\right) - \text{dead eggs}$$

where

the first 3 parameters are from egg samples taken from females at spawn time,
dead eggs are the number of dead or unfertilized eggs counted at shock time, and
the 0.945 value is a correction factor from 1997 and 2000 WDFW studies.

Total egg take is calculated as the total number of live eggs, dead eggs, and all documented egg loss (e.g. spilled at spawn time, etc.). Heath trays are periodically sampled during incubation and dead fry are culled and counted. The number of live eggs less documented fry loss is the estimate of the number of fry ponded. Once fry are ponded, mortalities are counted and recorded daily during the rearing period. Fish are hand counted in the fall prior to their release as they are 100-percent marked. This hand-count less documented mortalities from marking through release is the estimate of smolts released. Survival statistics by origin and life-stage are given in Tables 33 and 34.

Table 33. Cle Elum Supplementation and Research Facility spawning and survival statistics (NoR brood only), 1997 - present.

				No. Fish Spawned[1]										
Brood Year	Total Collected	Total Morts.	PreSpawn Survival	Males[2]	Females	% BKD Loss	Total Egg Take	Live Eggs	% Egg Loss[3]	Fry Ponded[4]	Live-Egg-Fry Survival	Smolts Released	Fry-Smolt Survival	Live-Egg-Smolt Survival
1997	261	23	91.2%	106	132	2.6%	500,750	463,948	7.3%	413,211	98.5%	386,048	93.4%	91.9%
1998	408	70	82.8%	140	198	1.4%	739,802	664,125	10.2%	627,481	98.7%	589,648	94.0%	92.7%
1999	738[5]	24	96.7%	213	222	2.7%	818,816	777,984	5.0%	781,872	97.3%	758,789	97.0%	94.5%
2000	567	61	89.2%	170	278	9.2%	916,292	851,128	7.1%	870,328	97.3%	834,285	95.9%	93.4%
2001	595	171	71.3%	145	223	53.2%	341,648	316,254	7.4%	380,880	98.6%	370,236	97.2%	96.1%
2002	629	89	85.9%	125	261	10.0%	919,776	817,841	11.1%	783,343	98.0%	749,067	95.6%	93.6%
2003	441	54	87.8%	115	200	0.0%	856,574	787,933	8.0%	761,968	98.4%	735,959	96.6%	95.1%
2004	597	70	88.3%	125	245	0.4%	873,815	806,375	7.7%	776,941	97.8%	691,109[6]	89.0%	87.0%
2005	526	57	89.2%	136	241	0.0%	907,199	835,890	7.9%	796,559	98.1%	769,484	96.6%	94.7%
2006	519	45	91.3%	122	239	1.7%	772,357	703,657	8.9%	631,691	97.3%	574,361[7]	90.9%	88.3%
2007	473	49	89.6%	149	216	0.9%	798,729	760,189	4.8%	713,814	98.9%	676,602	94.8%	93.7%
2008	480	38	92.1%	151	253	2.0%	915,563	832,938	9.0%	809,862	99.0%	752,109[8]	97.3%	96.3%
2009	486	57	88.3%	142	219	1.4%	850,404	848,339	0.2%	770,706	98.2%	744,170	96.6%	94.6%
2010	483	20	95.9%	102	193	0.5%	787,953	753,464	4.4%	726,325	98.9%	702,751	96.8%	95.6%
2011	455	28	93.8%	103	197	0.0%	798,229	765,221	4.1%	721,197	98.1%	684,481	94.9%	93.0%
2012	363	14	96.1%	111	209	0.0%	819,775	788,605	3.8%	737,705	98.2%	712,036	96.5%	94.7%
2013	385	15	96.1%	153	179	0.6%	683,484	658,796	3.6%	604,887	98.9%	575,156	95.1%	93.9%
2014	384	39	89.8%	133	188	0.0%	679,374	639,989	5.8%	617,506	96.5%			
Mean	488	51	89.7%	136	216	4.8%	776,697	726,260	6.5%	695,904	98.1%	665,076	95.2%	93.5%

1. Total collected minus total mortalities does not equal total spawned. This is because some fish are used in the spawning channel, some have been released back to the river, and some have not been used.
2. Includes jacks.
3. All documented egg loss at spawn time plus dead eggs counted at shock divided by the estimated total egg take.
4. Based on physical counts at mark time and all documented rearing mortality from ponding to release, except for BY2013 it is live eggs (est.) minus fry loss.
5. Approximately one-half of these were jacks, many of which were not used in spawning.
6. Approximately 45,000 smolts lost at Jack Creek due to frozen equipment in February, 2006.
7. EWOS feed treatment had high mortality and was discontinued in May 2007; resulted in lower survival to release.
8. Approximately 36,000 NoR (Table 33) and 12,000 HoR (Table 34) fish were culled in July 2009 to reduce pond densities; these fish were added back in to fry-smolt and live-egg-smolt survival calculations.
9. Table 34 -- From 2002 to present this is the estimated total egg take from all HxH crosses. Due to the large surplus of eggs over the approximately 100K needed for the HxH line, many surplus fry were planted in nearby land-locked lakes and some surplus eggs were destroyed.
10. Table 34 -- For only those HxH fish which were actually ponded.

Table 34. Cle Elum Supplementation and Research Facility spawning and survival statistics (HoR brood only), 2002 - present.

				No. Fish Spawned[1]										
Brood Year	Total Collected	Total Morts.	PreSpawn Survival	Males[2]	Females	% BKD Loss	Total Egg Take[9]	Live Eggs[10]	% Egg Loss[3]	Fry Ponded[4]	Live-Egg-Fry Survival	Smolts Released	Fry-Smolt Survival	Live-Egg-Smolt Survival
2002	201	22	89.1%	26	72	4.2%	258,226	100,011	7.8%	91,300	98.2%	87,837	96.2%	94.4%
2003	143	12	91.6%	30	51	0.0%	219,901	83,128	7.3%	91,203	98.8%	88,733	97.3%	96.1%
2004	126	19	84.9%	22	49	0.0%	187,406	94,659	5.9%	100,567	98.3%	94,339	93.8%	92.2%
2005	109	6	94.5%	26	45	0.0%	168,160	89,066	12.2%	92,903	98.1%	90,518	97.4%	95.6%
2006	136	21	84.6%	28	41	2.4%	112,576	80,121	8.6%	74,735	97.6%	68,434[7]	91.6%	89.4%
2007	110	15	86.4%	26	35	0.0%	125,755	90,162	3.2%	96,912	99.2%	94,663	97.7%	96.9%
2008	194	10	94.8%	51	67	1.5%	247,503	106,122	5.1%	111,797	98.9%	97,196[8]	97.4%	96.4%
2009	164	24	85.4%	30	38	0.0%	148,593	91,994	0.8%	91,221	98.3%	88,771	97.3%	95.6%
2010	162	9	94.4%	29	55	1.8%	215,814	94,925	8.4%	96,144	97.9%	92,030	95.7%	93.7%
2011	166	7	95.8%	28	49	0.0%	188,075	89,107	4.5%	88,852	98.4%	84,701	95.3%	93.8%
2012	140	8	94.3%	29	42	0.0%	148,932	95,438	2.0%	94,031	98.8%	90,680	96.4%	95.3%
2013	186	5	97.3%	38	43	0.0%	155,383	80,534	2.9%	79,160	98.3%	71,599	90.4%	88.9%
2014	86	11	87.2%	21	29	0.0%	104,121	74,843	1.6%	79,503	96.8%			
Mean	148	13	90.8%	30	47	0.8%	175,419	90,008	5.4%	91,410	98.3%	87,458	95.6%	94.0%

See footnotes for Table 33 above.

Female BKD Profiles

Adults used for spawning and their progeny are tested for a variety of pathogens accepted as important in salmonid culture (USFWS Inspection Manual, 2003), on a population or "lot" basis. At the CESRF, and in the Columbia Basin it has been accepted that the most significant fish pathogen for spring Chinook is *Renibacterium salmoninarum*, the causative agent of Bacterial Kidney Disease (BKD). All adult females and 60 juveniles from each acclimation pond are individually tested for levels of *Renibacterium salmoninarum* using ELISA (Enzyme linked Immuno-sorbant Assay). ELISA data are reported annually to CESRF and YKFP staff for management purposes, eventual data entry and comparisons of ponds and rearing parameters. To date, no significant occurrences of other pathogens have been observed. Periodic field exams for external parasites and any signs of disease are performed on an "as needed" basis. Facility staff have been trained to recognize early signs of behavior changes or diseases and would report any abnormalities to the USFWS, Olympia Fish Health Center for further diagnostic work.

Adult females are ranked from 0 to 13 based on the relative amounts of BKD in the tissue samples of the tested fish. All BKD ranks below 5 are considered low risk for transferring significant BKD organisms through the egg to cause significant disease in progeny receiving proper care. The progeny of adults with BKD rank 6 are considered to be moderate risk and those with BKD rank 7 or greater are considered to be high risk. Given these data, the CESRF chose to rear only the progeny of females with a BKD rank of 6 or less through brood year 2001. Beginning with brood year 2002, the progeny of fish with BKD rank 6 (moderate risk) or greater (high risk) have not been used for production purposes at the CESRF. For additional information, see Appendix B.

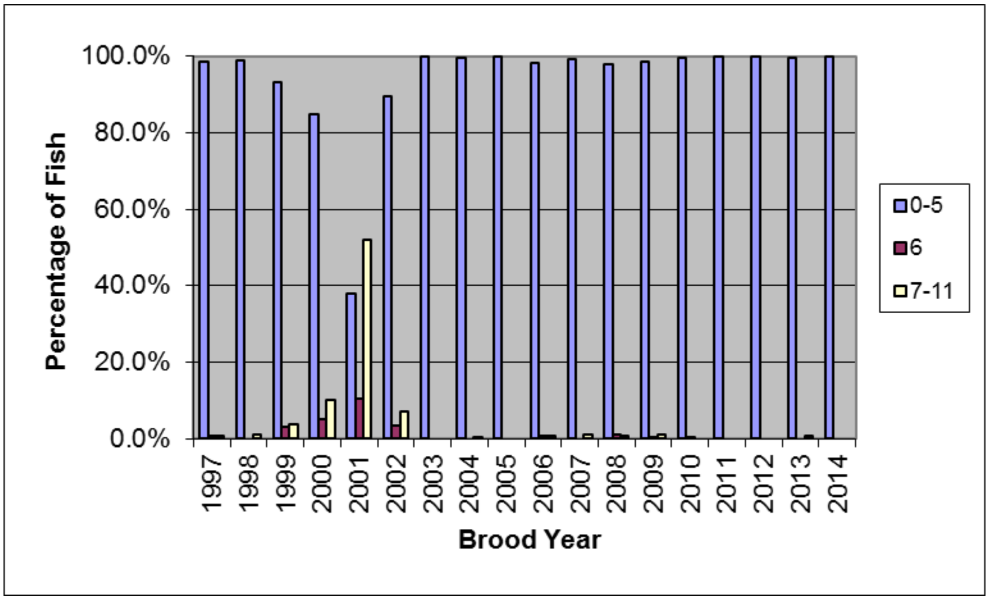


Figure 4. Proportion of wild/natural females spawned at CESRF by BKD rank, 1997 – present.

Fecundity

Fish collected at Roza Dam are taken to the CESRF for spawning and/or research purposes. Egg loss due to spill or other reasons at spawn time is documented. When eggs are shocked, unfertilized (dead) eggs are hand-counted and remaining eggs are machine counted. Due to error associated with machine counts, average fecundity is calculated using spawn-time egg sample data (see discussion above under CESRF Spawning and Survival) and adding in documented egg loss for all females divided by the number of females (N) in the sample.

Table 35. Mean fecundity by age of adult females (BKD rank < 6) spawned at CESRF, 1997-present.

	Wild/Natural (SN)						CESRF (HC)					
Brood	Age-3		Age-4		Age-5		Age-3		Age-4		Age-5	
Year	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity
1997			105	3,842.0	4	4,069.9						
1998	2[1]	3,908.9	161	3,730.3	15	4,322.5						
1999	3[1]	4,470.4	183	3,968.1	14	4,448.6						
2000			224	3,876.5	2	5,737.9						
2001			72	3,966.9	9	4,991.2			18	4,178.9		
2002	1	1,038.0	205	3,934.7	7	4,329.4			60	3,820.0	1	4,449.0
2003			163	4,160.2	31	5,092.8			30	3,584.1	19	5,459.9
2004			224	3,555.4	2	4,508.3			42	3,827.2		
2005	1	1,769.0	218	3,815.5	5	4,675.1			38	3,723.9	5	4,014.7
2006			196	3,396.4	24	4,338.9			36	3,087.3		
2007			178	3,658.3	24	4,403.3			33	3,545.2	2	4,381.9
2008			207	3,814.0	10	4,139.9			58	3,898.0		
2009	1	2,498.2	195	4,018.9	6	4,897.1			34	3,920.3		
2010			185	4,103.0					54	3,996.6		
2011	1[1]	3,853.1	179	4,000.1	4	5,692.1			41	3,843.3	2	4,098.2
2012			186	3,901.0	5	4,982.8			41	3,537.4	1	3,900.5
2013			159	3,760.3	6	5,068.0			36	3,498.7	2	4,955.3
2014			171	3,889.4	4	4,599.5			25	3,627.1	1	5,335.8
Mean				3,855.1		4,723.4				3,719.7		4,574.4

1. Given their length and fecundity, these fish may have been incorrectly aged.

Juvenile Salmon Evaluation

Food Conversion Efficiency

At the end of each month that fish are in the rearing ponds at the CESRF or the acclimation sites, a sample of fish are weighed and measured to estimate growth. These data, in addition to monthly mortality and pond feed data are entered into the juvenile growth and survival tracking database. Hatchery managers monitor food conversion (total pounds fed during a month divided by the total pounds gained by the fish) to track how well fish are converting feed into body mass and to evaluate the amount of feed that needs to be provided on a monthly basis. Average monthly food conversion and growth statistics for the CESRF facilities by brood year are provided in the following tables and figures.

Table 36. Mean food conversion (lbs fed/lbs gained) of CESRF juveniles by brood year and growth month, 1997 – present.

Brood Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1997	2.2		1.1	0.8	1.2	0.8	1.5	1.5		1.9		5.3	0.7
1998		1.0	0.9	1.0	0.9	0.8	2.4	1.4	2.1	-0.3	1.0	1.2	0.8
1999		1.0	1.1	1.1	1.2	1.5	1.8	1.0		-0.5	0.3	1.7	0.7
2000	0.8	0.8	1.0	1.5	1.2	1.4	2.2	2.0	1.6	2.1	2.5	2.4	
2001	1.1	1.1	2.6	1.1	1.3	1.2	1.6	2.0	2.3	2.5	2.8	0.9	
2002	0.9	1.0	1.4	1.2	1.4	1.1	1.5	2.2	4.0	-1.4	2.9	1.0	
2003	0.6	1.0	0.9	1.4	1.2	1.2	4.6	0.7	0.9	-0.2	1.8	1.0	
2004	0.9	1.0	1.2	1.6	2.4	1.2	1.7	2.0	2.8	0.9	-2.6	1.1	
2005	0.8	0.7	1.3	1.0	1.3	1.2	1.5	-0.8	0.4	-0.4	2.2		
2006	0.8	0.7	0.6	0.9	0.8	1.0	1.6	-1.0		-2.6	0.6	0.6	
2007	0.7	0.7	0.9	0.9	1.0	0.8	2.2	-1.6	1.9	2.0	0.7	0.9	0.4
2008	0.5	0.6	0.9	0.9	1.0		0.8	1.7	-1.1	0.9	0.9	0.6	
2009	0.5	1.2	1.0	0.7	1.1	1.0	1.5	4.1	0.6	-2.8	0.8	0.9	
2010	0.6	0.8	1.3	0.8	0.8	1.8	2.8	1.3		0.8	0.8	0.7	
2011	0.9	0.6	0.8	0.7	1.1	0.9		0.7		0.6	0.9	1.0	
2012	0.8	1.4	1.1	0.8	1.3	1.4	1.0	1.1		1.0	3.1	1.2	0.5
2013	0.6	0.9	0.7	0.9	1.0	1.1	2.7	1.4		0.4	0.8	2.5	
Mean	0.9	0.9	1.1	1.0	1.2	1.2	2.0	1.2	1.6	0.3	1.2	1.2	0.6

Length and Weight Growth Profiles

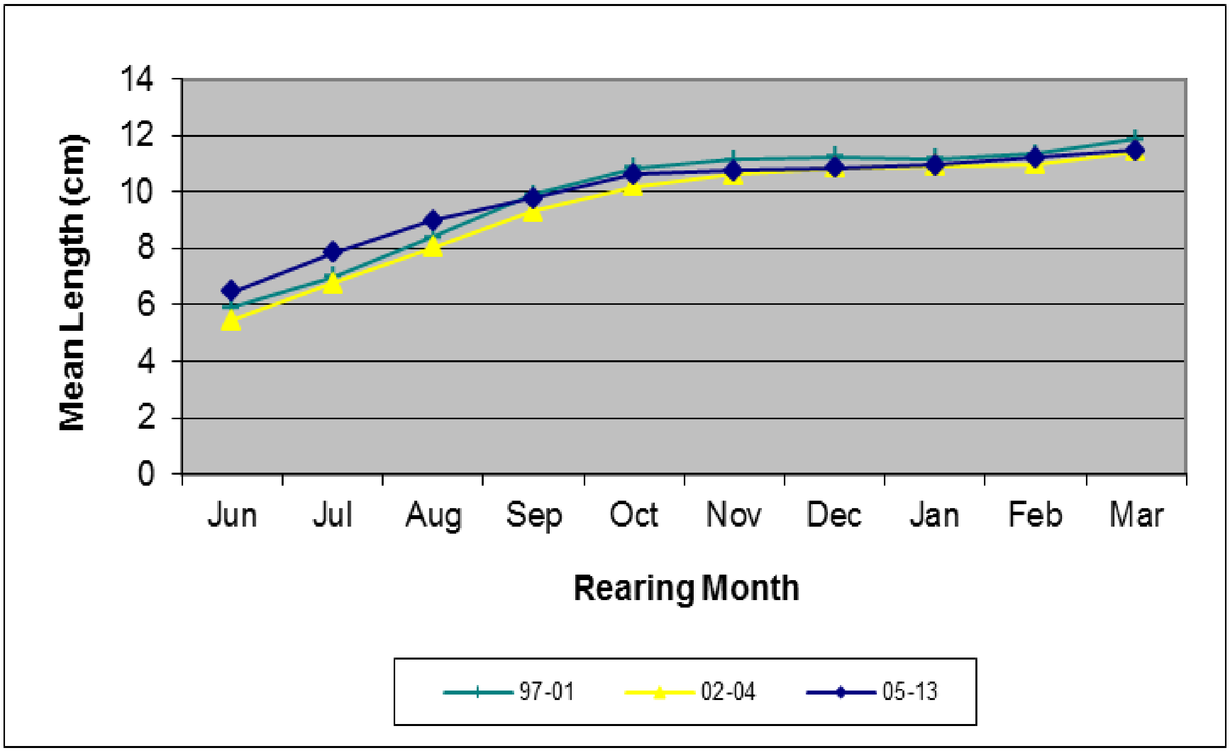


Figure 5. Mean length (cm) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.

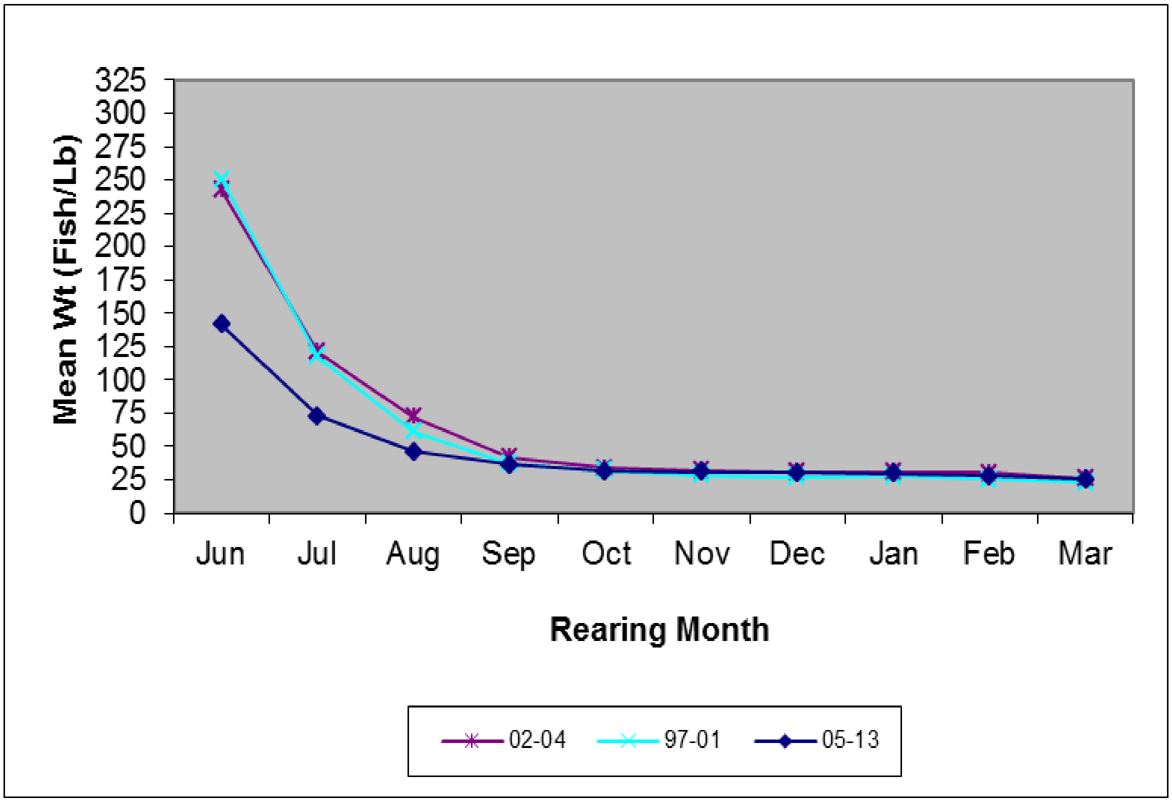


Figure 6. Mean Weight (fish/lb) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.

Juvenile Fish Health Profile

Approximately 5-60 fish from each acclimation site pond were sacrificed for juvenile fish health samples in the spring (usually in March) of their release year. Tissue samples from these fish were processed at USFWS laboratories in Olympia, Washington for presence of bacterial kidney disease (BKD) using enzyme-linked immunosorbent assay (ELISA) tests (see Female BKD Profiles and Appendix B for additional discussion). Fish were ranked from 0 to 13 based on the relative amounts of BKD in the tissue samples of the tested fish. Based on empirical evidence, fish with BKD ranks of 0-5 were considered to be low risk for incidence of BKD in the presence of a good fish culture and rearing environment (i.e., water temperature and flows, nutrition, densities, etc. all must be conducive to good fish health). Mean BKD ranks for all juvenile fish sampled ranged from 0.11 to 3.32 for the 14 brood years when adequate samples were available (Table 37), indicating that juvenile fish released from the CESRF appear to be well within the low risk category for all release years to date.

Table 37. Mean BKD rank of juvenile fish sampled at CESRF acclimation sites by brood year, 1997-present.

Brood Year	Acclimation Site Clark Flat	Easton	Jack Cr.	Pooled Mean
1997	1.22	1.81		1.46
1998	0.88	0.80	0.53	0.76
1999		No Samples		
2000	1.40	1.89	1.50	1.60
2001	1.50	0.98	1.55	1.30
2002	0.18	0.08	0.06	0.11
2003	0.29	0.47	0.33	0.36
2004		No Samples		
2005		No Samples		
2006	1.96	1.81	1.61	1.79
2007	1.64	1.29	1.84	1.59
2008	2.04	1.51	2.08	1.88
2009	2.34	2.49	2.71	2.51
2010	1.21	1.81	1.97	1.66
2011	1.44	0.73	0.82	1.00
2012	2.33	2.52	2.61	2.49
2013	2.76	4.10	3.07	3.32

1. For the 1999, 2004 and 2005 broods, antibody problems were encountered and the USFWS was unable to process the samples.
2. High BKD incidence in adult broodstock reduced production to just 9 ponds (Clark Flat 1-2, Jack Creek, and Easton). Easton samples were for predator avoidance trained (PAT) fish and were the cumulative equivalent of one Cle Elum pond (i.e., ~6,500 fish per pond).

Incidence of Precocialism

For brood years 2002-2004, the YKFP tested two different feeding regimes to determine whether a slowed-growth regime reduces the incidence of precocialism without a reduction in post-release survival. The two growth regimes tested were a normal (High) growth regime resulting in fish which were about 30/pound at release and a slowed growth regime (Low) resulting in fish which were about 45/pound at release. As a critical part of this study, a team from NOAA Fisheries conducted research to characterize the physiology and development of wild and hatchery-reared spring Chinook salmon in the Yakima River Basin. While precocious male maturation is a normal life-history strategy, the hatchery environment may be potentiating this developmental pathway beyond natural levels resulting in potential loss of anadromous adults, skewing of sex ratios, and negative genetic and ecological impacts on wild populations. Previous studies have indicated that age of maturation is significantly influenced by endogenous energy stores and growth rate at specific times of the year. These studies will help direct rearing strategies at the CESRF to allow production of hatchery fish with physiological and life-history attributes that are more similar to their wild cohorts.

Relevant Publications:

Larsen, D. A., B. R. Beckman, K. A. Cooper, D. Barrett, M. Johnston, P. Swanson, and W. W. Dickhoff. 2004. Assessment of High Rates of Precocious Male Maturation in a Spring

Chinook Salmon Supplementation Hatchery Program. Transactions of the American Fisheries Society 133:98-120.

Beckman, B.R. and Larsen D.A. 2005. Upstream Migration of Minijack (Age-2) Chinook Salmon in the Columbia River: Behavior, Abundance, Distribution, and Origin. Transactions of the American Fisheries Society 134:1520–1541.

Larsen, D.A., B.R. Beckman, C.R. Strom, P.J. Parkins, K.A. Cooper, D.E. Fast, W.W. Dickhoff. 2006. Growth Modulation Alters the Incidence of Early Male Maturation and Physiological Development of Hatchery-reared Spring Chinook Salmon: a Comparison with Wild Fish. Transactions of the American Fisheries Society 135:1017-1032.

Larsen, D.A., B.R. Beckman, and K.A. Cooper. 2010. Examining the Conflict between Smolting and Precocious Male Maturation in Spring (Stream-Type) Chinook Salmon. Transactions of the American Fisheries Society 139: 564-578.

Larsen, D.A., D.L. Harstad, C.R. Strom, M.V. Johnston, C.M. Knudsen, D.E. Fast, T.N. Pearsons, and B.R. Beckman. 2013. Early Life History Variation in Hatchery- and Natural-Origin Spring Chinook Salmon in the Yakima River, Washington. Transactions of the American Fisheries Society 142:2, 540-555.

Pearsons, T.N., C.L. Johnson, B.B. James, and G.M. Temple. 2009. Abundance and Distribution of Precociously Mature Male Spring Chinook Salmon of Hatchery and Natural Origin in the Yakima River. North American Journal of Fisheries Management 29:778-790.

CESRF Smolt Releases

The number of release groups and total number of fish released diverged from facility goals in some years. In brood year 1997, the Jack Creek acclimation facility was not yet complete and project policy and technical teams purposely decided to under-collect brood stock to allow a methodical testing of the new facility's operations with less risk to live fish, which resulted in the stocking of only 10 of the 18 raceways. In brood year 1998, the project did not meet facility release goals due to a biological specification that no more than 50% of returning wild fish be taken for brood stock. As a result only 16 raceways were stocked with progeny of the 1998 brood. In the same year, raceway 4 at the Jack Creek acclimation site suffered mechanical failures causing loss of flow and reduced oxygen levels and resulted in the loss of approximately one-half the fish in this raceway prior to release. In the drought year of 2001, a large number of returning adults presented with high enzyme-linked immunosorbent assay (ELISA) levels of *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease (BKD). The progeny of these females were purposely destroyed. As a result, only nine raceways were stocked with fish. The project decided to use the fish from an odd raceway for a predator avoidance training sub-experiment (these fish were subsequently acclimated and released from the Easton acclimation site).

Table 38. CESRF total releases by brood year, treatment, and acclimation site.

Brood			Acclimation Site			
Year	Control[1]	Treatment[2]	CFJ	ESJ	JCJ	Total
1997	207,437	178,611	229,290	156,758		386,048
1998[3]	284,673	305,010	221,460	230,860	137,363	589,683
1999	384,563	374,226	232,563	269,502	256,724	758,789
2000	424,554	409,731	285,954	263,061	285,270	834,285
2001[4]	183,963	186,273	80,782	39,106	250,348	370,236
2002	420,764	416,140	266,563	290,552	279,789	836,904
2003	414,175	410,517	273,377	267,711	283,604	824,692
2004[5]	378,740	406,708	280,598	273,440	231,410	785,448
2005	431,536	428,466	287,127	281,150	291,725	860,002
2006	351,063	291,732	209,575	217,932	215,288	642,795
2007	387,055	384,210	265,907	254,540	250,818	771,265
2008	421,290	428,015	280,253	287,857	281,195	849,305
2009	418,314	414,627	279,123	281,395	272,423	832,941
2010	395,455	399,326	264,420	264,362	265,999	794,781
2011	382,195	386,987	255,290	248,454	265,438	769,182
2012	401,059	401,657	256,732	276,210	269,774	802,716
2013	No Experiment		215,933	214,745	216,077	646,755
Mean	367,927	363,890	246,173	242,214	253,328	726,813

Table 39. CESRF average pond densities at release by brood year, treatment, and acclimation site.

Brood Year	Treatment Control[1]	Treatment[2]	Acclimation Site CFJ	ESJ	JCJ
1997	41,487	35,722	38,215	39,190	
1998[3]	35,584	38,126	36,910	38,477	34,341
1999	42,729	41,581	38,761	44,917	42,787
2000	47,173	45,526	47,659	43,844	47,545
2001[4]	41,116	41,667	40,391	6,518	41,725
2002	46,752	46,238	44,427	48,425	46,632
2003	46,019	45,613	45,563	44,619	47,267
2004[5]	42,082	45,190	46,766	45,573	38,568
2005	47,948	47,607	47,855	46,858	48,621
2006	39,007	32,415	34,929	36,322	35,881
2007	43,006	42,690	44,318	42,423	41,803
2008	46,810	47,557	46,709	47,976	46,866
2009	46,479	46,070	46,521	46,899	45,404
2010	43,939	44,370	44,070	44,060	44,333
2011	42,466	42,999	42,548	41,409	44,240
2012	44,562	44,629	42,789	46,035	44,962
2013	No Experiment		35,989	35,791	36,013
Mean	43,573	43,000	42,613	41,137	42,937

1. Brood years 1997-2001: Optimum Conventional Treatment (OCT). Brood Years 2002-2004: Normal (High) growth. Brood Years 2005-2012: Normal feed at Cle Elum or accl. sites.
2. Brood years 1997-2001: Semi-natural Treatment (SNT). Brood Years 2002-2004: Slowed (Low) growth. Brood Year 2005, 2007-2012: saltwater transition feed at accl. sites. Brood Year 2006: EWS diet at CESRF through May 3, 2007.
3. At the Jack Creek acclimation site only 4 of 6 raceways were stocked, and raceway 4 suffered mechanical failures resulting in the loss of about 20,000 OCT (control) fish.
4. High BKD incidence in adult broodstock reduced production to just 9 ponds (Clark Flat 1-2, Jack Creek, and Easton). Easton ponds were used for predator avoidance trained (PAT) fish and a single Cle Elum pond was spread between 6 ponds at Easton with crowders used to simulate pond densities for fish at other acclimation sites. These releases were excluded from mean pond density calculations by treatment.
5. At the Jack Creek acclimation site raceway 3 suffered mechanical failures resulting in the loss of about 45,000 high-growth (control) fish.

Mean length and weight at release by brood year are shown in Figures 5 and 6 under Juvenile Salmon Evaluation, length and weight growth profiles. Mark information and volitional release dates are given in Appendix A.

Smolt Outmigration Timing

The Chandler Juvenile Monitoring Facility (CJMF) located on the fish bypass facility of Chandler Canal at Prosser Dam (Rkm 75.6; Figure 1) serves as the cornerstone facility for estimating smolt production in the Yakima Basin for several species and stocks of salmonids. Daily species counts in the livebox at the CJMF are expanded by the canal entrainment, canal survival, and sub-sampling rates in order to estimate daily passage at Prosser Dam (Neeley 2000). Expansion techniques for deriving Chandler smolt passage estimates are continually being reviewed and revised to incorporate new information. A subset of fish passing through the CJMF is sampled for presence of internal (CWT or PIT) or external (fin-clip) marks. All fish with marks are assumed to be of hatchery origin; otherwise, fish are presumed to be of natural origin.

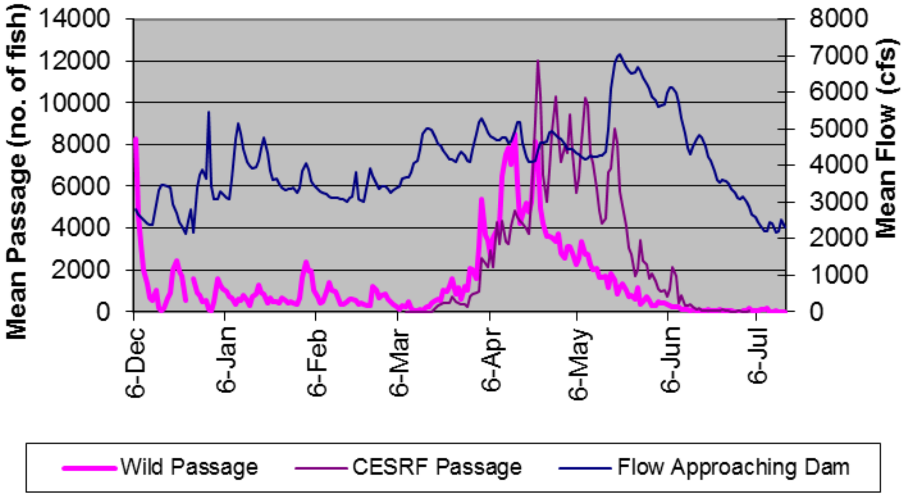


Figure 7. Mean flow approaching Prosser Dam versus mean estimated smolt passage at Prosser of aggregate wild/natural and CESRF spring Chinook for outmigration years 1999-2014.

Smolt-to-Smolt Survival

OCT-SNT Treatment (Brood Years 1997-2001, Migration Years 1999-2003)

Results of this experiment have been published:

Fast, D. E., D. Neeley, D.T. Lind, M. V. Johnston, C.R. Strom, W. J. Bosch, C. M. Knudsen, S. L. Schroder, and B.D. Watson. 2008. Survival Comparison of Spring Chinook Salmon Reared in a Production Hatchery under Optimum Conventional and Seminatural Conditions. Transactions of the American Fisheries Society 137:1507–1518.

Abstract — We found insufficient evidence to conclude that seminatural treatment (SNT; i.e., rearing in camouflage-painted raceways with surface and underwater structures and underwater feeders) of juvenile Chinook salmon *Oncorhynchus tshawytscha* resulted in higher survival indices than did optimum conventional treatment (OCT; i.e., rearing in concrete raceways with surface feeding) for the specific treatments and environmental conditions tested. We reared spring Chinook salmon from fry to smolt in paired raceways under the SNT and OCT rearing treatments for five consecutive years. For four to nine SNT and OCT raceway pairs annually, we used passive integrated transponder, coded wire, and visual implant elastomer tags to compare survival indices for juvenile fish from release at three different acclimation sites 340–400 km downstream to passage at McNary Dam on the Columbia River, and for adults from release to adult return to Roza Dam in the upper Yakima basin. The observed differences in juvenile and adult survival between the SNT and OCT fish were either statistically insignificant, conflicting in their statistical significance, or explained by significant differences in the presence of the causative agents of bacterial kidney disease in juvenile fish at release.

High-Low Growth Treatment (Brood Years 2002-04, Migration Years 2004-2006)

Two early-rearing nutritional regimes were tested using hatchery-reared Yakima Upper spring Chinook for brood years 2002 through 2004. A low nutrition-feeding rate (low treatment or low) was administered at the Cle Elum Hatchery through early rearing to determine whether that treatment would reduce the proportion of precocials produced compared to a conventional feeding rate during early rearing. The conventional feeding rate, which served as a control treatment, is referred to here as a high nutrition-feeding rate (high treatment or high). Feed was administered at a rate of 10 grams/fish for the low treatment and 15 grams/fish for the high treatment through mid-October, after which sufficient feed was administered to both sets of treated fish to meet their feeding demands. The treatments were allocated within pairs of raceways (blocks), there being a total of nine pairs. The Low nutritional feed (Low) had a significantly lower release-to-McNary survival than did the High nutritional feed (High), respective survivals being 18.1% and 21.2% ($P < 0.0001$; D. Neeley, Appendix B of 2008 annual report). The Low survival to McNary was consistently lower than the High at all sites in all years. Low-treated fish were smaller fish at the time of release and had somewhat later McNary passage times than high-treated fish.

Control versus Saltwater Transfer Treatment (Brood Years 2005, 2007- 2010; Migration Years 2007, 2009- 2013)

Prior to releases in 2007, 2009- 2013, two feed treatments were allocated to raceways within adjacent raceway pairs. Fish from each raceway within the pairs were fed BioVita prior to smoltification, then the BioVita feed for one of the raceway pairs was supplemented with a BioTransfer diet and the other was not. The intent of the experiment was to determine whether the Transfer-supplemented-feed treatment increased the rate of smoltification, the non-supplemented treatment serving as the control. Analyses indicated no significant or substantial differences between the supplemented and non-supplemented feed when averaged over years. See Appendix D of this annual report for additional detail.

Control (Bio-Oregon) versus EWOS Feed Comparison (Brood Year 2006, Migration Year 2008)

This experimental design was similar to that described above for the Control versus saltwater transfer treatment study, with the standard Bio-Oregon pellets fed to half of the rearing ponds and an EWOS (www.ewos.com) diet fed to the other ponds. The different feed treatments only lasted about 6 weeks from the time of initial ponding as we found substantially higher mortalities for fish receiving the EWOS feed. From May 7, 2007 until these fish were released in 2008 all fish in this study received the Bio-Oregon diet. For the parameters of interest, we found no significant or substantial differences between the two feeding treatments (Appendix B of 2008 annual report).

Smolt-to-Adult Survival

Calculation of smolt-to-adult survival rates for Yakima River spring Chinook is complicated by the following factors:

1) Downstream of the confluence of the Yakima and Naches rivers the three populations of spring Chinook (Upper Yakima, Naches, and American) are aggregated. A subsample of the

aggregate wild/natural populations is PIT-tagged as part of the Chandler juvenile sampling operation but their origin is not known at the time of tagging. Through 2003, the primary purpose of this subsampling effort was to derive entrainment and canal survival estimates (see 2 below). Due to issues such as tag retention and population representation, adult detections of smolts PIT-tagged at Chandler cannot be used in any valid smolt-to-adult survival analyses.

2) Smolt accounting at Prosser is based on statistical expansion of Chandler smolt trap sampling data using available flow data and estimated Chandler entrainment rates. Chandler smolt passage estimates are prepared primarily for the purpose of comparing relative wild versus CESRF passage estimates and not for making survival comparisons. While these Chandler smolt passage estimates represent the best available data, there may be a relatively high degree of error associated with these estimates due to inherent complexities, assumptions, and uncertainties in the statistical expansion process. Therefore, these estimates are subject to revision. We are in the process of developing methods to subdivide the wild/natural outmigration into Upper Yakima, Naches, and American components based on DNA samples of juveniles taken at Chandler since 1998.

3) Installation of adult PIT detection equipment at all three ladders at Prosser Dam was not completed until the fall of 2005. Therefore, detection of upstream-migrating PIT-tagged adult spring Chinook at Prosser Dam was not possible for all returning fish until the spring of 2006. Periods of high flow may preclude use of automated detection gear so 100% detection of upstream migrants is not possible in all years.

4) Through 2006, detection of upstream-migrating PIT-tagged adult spring Chinook at Roza Dam occurred at an approximate 100% rate only for marked CESRF fish and wild/natural fish taken for broodstock. The majority of wild/natural fish were passed directly back to the river without PIT interrogation.

5) For the 1997 brood (1999 out-migration), 400 Khz PIT-tags were used. Mainstem detection facilities were not configured to detect these tags at nearly the efficiency that they can detect the newer 134.2 kHz ISO tags. Although all marked adult fish are trapped and hand-wanded for PIT detections of adults at Roza Dam, the reliability of the 400kHz detection gear and problems with hand-sampling in general likely precluded a complete accounting of all 1997 brood PIT returns.

6) All CESRF fish are adipose-fin clipped and subjected to higher harvest rates than unmarked wild/natural fish in marine and Columbia River mark-selective fisheries. No adjustments have yet been made in the following tables to account for differential harvest rates in these mark-selective fisheries.

7) PIT tag retention is a factor in estimating survival rates (Knudsen et al. 2009). No attempt has been made to correct the data in the following tables for estimates of tag retention.

8) The ISAB has indicated that "more attention should be given to the apparent documentation that PIT-tagged fish do not survive as well as untagged fish. This point has major implications for all uses of PIT-tagged fish as surrogates for untagged fish." Our data appear

to corroborate this point (Tables 45-46). However, these data are not corrected for tag loss. If a fish loses its PIT tag after detection upon leaving the acclimation site, but before it returns as an adult to Roza Dam, it would be included only as a release in Table 45 and only as an adult return in Table 46. Knudsen et al. (2009) found that smolt-to-adult return rates (SARS) based on observed PIT tag recoveries were significantly underestimated by an average of 25% and that after correcting for tag loss, SARS of PIT-tagged fish were still 10% lower than SARS of non-PIT-tagged fish. Thus, the data in Table 45 under-represent "true" SARS for PIT-tagged fish and SARS for PIT-tagged and non-PIT-tagged fish are likely closer than those reported in Tables 45 and 46.

9) Due to issues relating to water permitting, size required for tagging, and allowing sufficient time for acclimation, CESRF juveniles are not allowed to migrate until at least March 15 of their smolt year. However, juvenile sampling observations at Roza Dam indicate that a substantial number of wild/natural juveniles migrate downstream during the summer, fall, and winter months prior to their smolt outmigration year (Figure 7). Comparison of SAR data for non-contemporaneously migrating juveniles may be invalid (see Copeland et al. 2015).

Given these complicating factors, Tables 40-46 present available smolt-to-adult survival data for Yakima River CESRF and wild/natural spring Chinook. Unfortunately, true "apples-to-apples" comparisons of CESRF and wild/natural smolt-to-adult survival rates are not possible from these tables due to complexities noted above. The reader is cautioned to correct these data for, or acknowledge the factors noted above prior to any use of these data.

Table 40. Estimated smolt passage at Chandler and smolt-to-adult return indices (Chandler smolt to Yakima R. mouth adult) for Yakima Basin wild/natural and CESRF-origin spring Chinook.

			Estimated Smolt Passage at Chandler			Yakima R. Mouth Adult Returns[4]		Smolt-to-Adult Return Index[4]	
Brood Year	Smolt Migr. Year	Mean Flow[1] at Prosser Dam	Wild/ Natural[2]	CESRF Total	CESRF smolt-to-smolt survival[3]	Wild/ Natural[2]	CESRF Total	Wild/ Natural[2]	CESRF Total
1982	1984	4134	381,857			6,753		1.8%	
1983	1985	3421	146,952			5,198		3.5%	
1984	1986	3887	227,932			3,932		1.7%	
1985	1987	3050	261,819			4,776		1.8%	
1986	1988	2454	271,316			4,518		1.7%	
1987	1989	4265	76,362			2,402		3.1%	
1988	1990	4141	140,218			5,746		4.1%	
1989	1991		109,002			2,597		2.4%	
1990	1992	1960	128,457			1,178		0.9%	
1991	1993	3397	92,912			544		0.6%	
1992	1994	1926	167,477			3,790		2.3%	
1993	1995	4882	172,375			3,202		1.9%	
1994	1996	6231	218,578			1,238		0.6%	
1995	1997	12608	52,028			1,995		3.8%	
1996	1998	5466	491,584			21,151		4.3%	
1997	1999	5925	322,105	97,844	25.3%	12,855	8,670	4.0%	8.9%
1998	2000[5]	4946	91,908	268,660	45.6%	8,228	9,782	9.0%	3.6%
1999	2001	1321	62,759	268,232	35.4%	1,764	864	2.8%	0.3%
2000	2002	5015	474,206	320,866	38.5%	11,434	4,819	2.4%	1.5%
2001	2003	3504	332,323	142,319	38.4%	8,597	1,251	2.6%	0.9%
2002	2004	2439	142,297	256,542	30.7%	3,743	2,300	2.6%	0.9%
2003	2005	1285	166,364	282,649	34.3%	2,746	932	1.7%	0.3%
2004	2006	5652	202,346	446,304	56.8%	2,802	4,022	1.4%	0.9%
2005	2007	4551	118,553	401,101	46.6%	4,201	4,378	3.5%	1.1%
2006	2008	4298	122,867	199,744	31.1%	6,099	9,114	5.0%	4.6%
2007	2009	5784	349,598	416,572	54.0%	7,952	6,558	2.3%	1.6%
2008	2010	3592	153,020	272,007	32.0%	7,385	6,976	4.8%	2.6%
2009	2011	9414	270,507	461,669	55.4%	3,766	3,181	1.4%	0.7%
2010	2012	8556	621,994	622,956	78.4%	6,130[6]	4,677[6]	1.0%[6]	0.8%[6]
2011	2013	4875	317,980	309,368	40.2%				
2012	2014[6]	4923	220,402	329,455	41.0%				

1. Mean flow (cfs) approaching Prosser Dam March 29-July 4 of juvenile migration year. No data available for migration year 1991. In high flow years (flows at or > 5000 cfs) operation of the Chandler smolt sampling facility may be precluded during portions of the outmigration. Data courtesy of U.S. BOR hydromet.
2. Aggregate of Upper Yakima, Naches, and American wild/natural populations.
3. Estimated smolt-to-smolt (release from upper Yakima River acclimation sites to Chandler) survival for CESRF juveniles.
4. Includes combined age-3 through age-5 returns. CESRF adult returns and smolt-to-adult survival values are understated relative to wild/natural values since these figures are not adjusted for differential harvest rates in mark selective fisheries in marine and lower Columbia River fisheries.
5. Available data were not sufficient to estimate juvenile flow-entrainment and passage of wild/natural fish.
6. Data for most recent year are preliminary; return data do not include age-5 adult fish.

Table 41. Estimated wild/natural smolt-to-adult return rates (SAR) based on adult detections of PIT tagged fish. Roza tagged smolts to Bonneville Dam adult returns.

		Wild/Natural smolts tagged at Roza				
		Adult Returns at Age[1]				
Brood Year	Number Tagged	Age 3	Age 4	Age 5	Total	SAR[1]
1997	310	0	1	0	1	0.32%[2]
1998	6,209	15	171	14	200	3.22%
1999	2,179	2	8	0	10	0.46%
2000	8,718	1	51	1	53	0.61%
2001	7,804	9	52	3	64	0.82%
2002	3,931	2	46	4	52	1.32%
2003	1,733	0	6	1	7	0.40%
2004	2,333	1	8	1	10	0.43%
2005	1,200	0	8	0	8	0.67%
2006	1,675	12	33	2	47	2.81%
2007	3,795[a]	6	47	2	55	1.45%
2008	105	0	1	0	1	0.95%
2009	2,087	0	3	1	4	0.19%
2010	2,647	4	22		26	0.98%
2011	2,473	1				

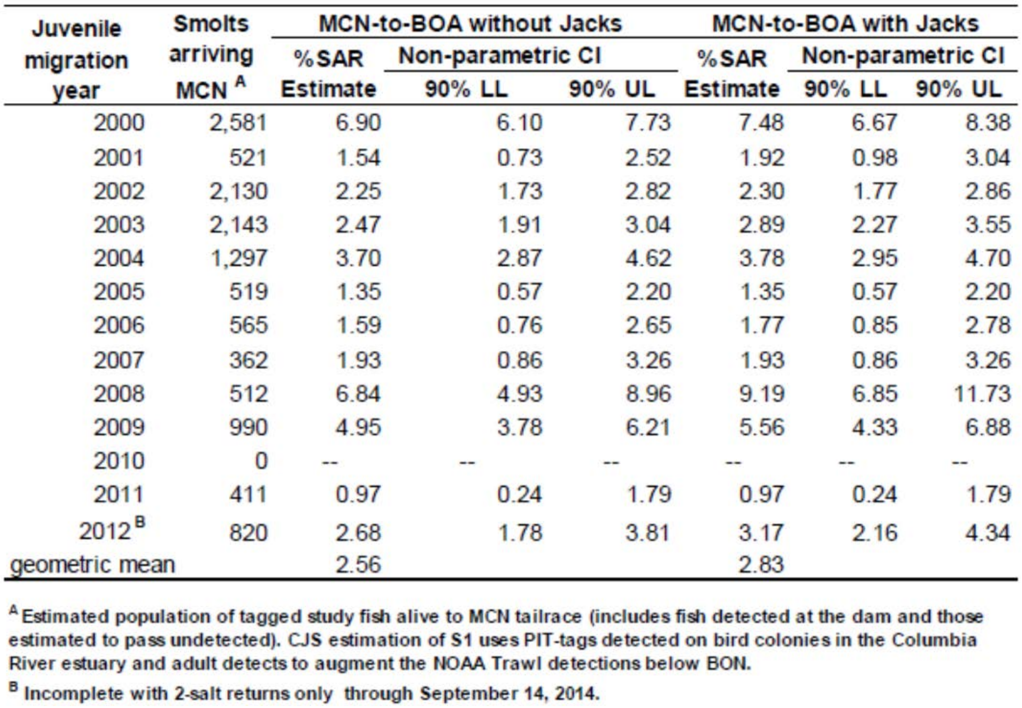
a. Includes 1752 fish tagged and released in late August and early Sept.

Table 42. Estimated CESRF smolt-to-adult return rates (SAR) based on adult detections of PIT tagged fish. Roza tagged smolts to Bonneville Dam adult returns.

		CESRF smolts tagged at Roza				
		Adult Returns at Age[1]				
Brood Year	Number Tagged	Age 3	Age 4	Age 5	Total	SAR[1]
1997	407	0	2	0	2	0.49%[2]
1998	2,999	5	42	2	49	1.63%
1999	1,744	1	0	0	1	0.06%
2000	1,503	0	1	0	1	0.07%
2001	2,146	0	4	0	4	0.19%
2002	2,201	4	5	0	9	0.41%
2003	1,418	0	3	1	4	0.28%
2004	4,194	3	13	0	16	0.38%
2005	2,358	0	3	0	3	0.13%
2006	4,130	32	31	2	65	1.57%
2007	3,736	10	21	0	31	0.83%
2008	1,071	4	3	0	7	0.65%
2009	3,641	2	4	0	6	0.16%
2010	4,064	4	13		17	0.42%
2011	513	0				

1. CESRF adult returns and smolt-to-adult survival values are understated relative to wild/natural values since these figures are not adjusted for differential harvest rates in mark selective fisheries in marine and lower Columbia River fisheries.
2. The reliability of the 400kHz detection gear precluded an accurate accounting of all 1997 brood PIT returns. Therefore, this is not a true SAR. It is presented for relative within-year comparison only and should NOT be compared to SARs for other years.

Table 43. Overall wild/natural smolt-to-adult return rates (SAR) based on juvenile and adult detections of fish PIT-tagged and released at Roza Dam (Table 4.44 in McCann et al. 2014). McNary smolts to Bonneville Dam adult returns.



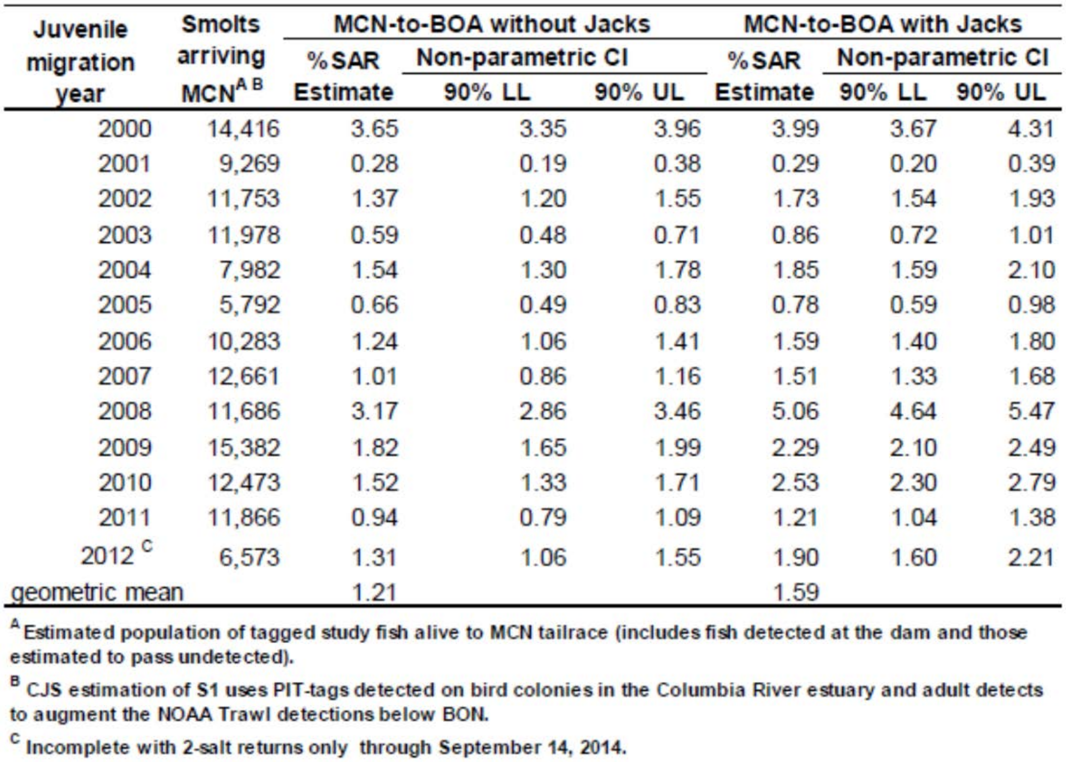
Juvenile migration year	Smolts arriving MCN [A]	MCN-to-BOA without Jacks			MCN-to-BOA with Jacks		
		%SAR	Non-parametric CI		%SAR	Non-parametric CI	
		Estimate	90% LL	90% UL	Estimate	90% LL	90% UL
2000	2,581	6.90	6.10	7.73	7.48	6.67	8.38
2001	521	1.54	0.73	2.52	1.92	0.98	3.04
2002	2,130	2.25	1.73	2.82	2.30	1.77	2.86
2003	2,143	2.47	1.91	3.04	2.89	2.27	3.55
2004	1,297	3.70	2.87	4.62	3.78	2.95	4.70
2005	519	1.35	0.57	2.20	1.35	0.57	2.20
2006	565	1.59	0.76	2.65	1.77	0.85	2.78
2007	362	1.93	0.86	3.26	1.93	0.86	3.26
2008	512	6.84	4.93	8.96	9.19	6.85	11.73
2009	990	4.95	3.78	6.21	5.56	4.33	6.88
2010	0	--	--	--	--	--	--
2011	411	0.97	0.24	1.79	0.97	0.24	1.79
2012 [B]	820	2.68	1.78	3.81	3.17	2.16	4.34
geometric mean		2.56			2.83		

[A] Estimated population of tagged study fish alive to MCN tailrace (includes fish detected at the dam and those estimated to pass undetected). CJS estimation of S1 uses PIT-tags detected on bird colonies in the Columbia River estuary and adult detects to augment the NOAA Trawl detections below BON.

[B] Incomplete with 2-salt returns only through September 14, 2014.

[C] No PIT-tagged smolts released in 2010.

Table 44. Overall CESRF smolt-to-adult return rates (SAR) based on juvenile and adult detections of PIT tagged fish (Table 4.48 in McCann et al. 2014). McNary smolts to Bonneville Dam adult returns.



Juvenile migration year	Smolts arriving MCN [A B]	MCN-to-BOA without Jacks			MCN-to-BOA with Jacks		
		%SAR	Non-parametric CI		%SAR	Non-parametric CI	
		Estimate	90% LL	90% UL	Estimate	90% LL	90% UL
2000	14,416	3.65	3.35	3.96	3.99	3.67	4.31
2001	9,269	0.28	0.19	0.38	0.29	0.20	0.39
2002	11,753	1.37	1.20	1.55	1.73	1.54	1.93
2003	11,978	0.59	0.48	0.71	0.86	0.72	1.01
2004	7,982	1.54	1.30	1.78	1.85	1.59	2.10
2005	5,792	0.66	0.49	0.83	0.78	0.59	0.98
2006	10,283	1.24	1.06	1.41	1.59	1.40	1.80
2007	12,661	1.01	0.86	1.16	1.51	1.33	1.68
2008	11,686	3.17	2.86	3.46	5.06	4.64	5.47
2009	15,382	1.82	1.65	1.99	2.29	2.10	2.49
2010	12,473	1.52	1.33	1.71	2.53	2.30	2.79
2011	11,866	0.94	0.79	1.09	1.21	1.04	1.38
2012 [C]	6,573	1.31	1.06	1.55	1.90	1.60	2.21
geometric mean		1.21			1.59		

[A] Estimated population of tagged study fish alive to MCN tailrace (includes fish detected at the dam and those estimated to pass undetected).

[B] CJS estimation of S1 uses PIT-tags detected on bird colonies in the Columbia River estuary and adult detects to augment the NOAA Trawl detections below BON.

[C] Incomplete with 2-salt returns only through September 14, 2014.

Table 45. Estimated release-to-adult survival of PIT-tagged CESRF fish (CESRF tagged smolts to Bonneville and Roza Dam adult returns).

Brood Year	Number Tagged[1]	Adult Detections at Bonn. Dam Age3	Age4	Age5	Total	SAR	Adult Detections at Roza Dam Age3	Age4	Age5	Total	SAR
1997[2]	39,892	18	182	4	204	0.51%	65	517	16	598	1.50%
1998	37,388	49	478	48	575	1.54%	54	310	34	398	1.06%
1999	38,793	1	25	1	27	0.07%	1	22	0	23	0.06%
2000	37,582	42	159	2	203	0.54%	37	112	1	150	0.40%
2001	36,523	32	71	0	103	0.28%	22	58	0	80	0.22%
2002[3]	39,003	25	119	4	148	0.38%	15	80	2	97	0.25%
2003	38,916	7	37	1	45	0.12%	3	27	1	31	0.08%
2004	36,426	37	123	4	164	0.45%	24	98	3	125	0.34%
2005	39,119	63	126	2	191	0.49%	44	96	2	142	0.36%
2006	38,595	221	354	15	590	1.53%	186	263	11	460	1.19%
2007	38,618	73	279	3	355	0.92%	53	182	3	238	0.62%
2008	39,013	135	192	3	330	0.85%	81	132	2	215	0.55%
2009	36,239	32	110	3	145	0.40%	23	85	2	110	0.30%
2010	38,737	85	187		272	0.70%	61	142		203	0.52%
2011	38,165	77					57				

1. When tag detection data are available, this is the number of unique PIT tags physically detected leaving the acclimation sites. Otherwise, this is the number of fish PIT tagged less documented mortalities of PIT-tagged fish from tagging to release.
2. BY1997 used 400 kHz tags and Bonneville Dam was not fully configured for adult detection of this type of tag; therefore we saw more detections at Roza Dam where fish were manually wanded for adult PIT detections.
3. Includes HxH fish beginning with this brood year.

Table 46. Estimated release-to-adult survival of non-PIT-tagged CESRF fish (CESRF tagged smolts to Roza Dam adult returns).

Brood Year	Number Tagged[1]	Adult Returns to Roza Dam Age3	Age4	Age5	Total	SAR
1997[2]	346,156	623	5,663	120	6,406	1.85%
1998	552,295	936	5,834	534	7,304	1.32%
1999	719,996	103	652	13	768	0.11%
2000	796,703	1,005	2,764	69	3,837	0.48%
2001	333,713	290	791	9	1,091	0.33%
2002[3]	797,901	332	1,771	135	2,238	0.28%
2003	785,776	115	1,568	14	1,696	0.22%
2004	749,022	683	3,688	202	4,574	0.61%
2005	820,883	1,012	5,302	22	6,336	0.77%
2006	604,200	2,384	6,428	287	9,098	1.51%
2007	732,647	1,026	5,645	87	6,758	0.92%
2008	810,292	1,552	3,680	76	5,308	0.66%
2009	796,702	389	3,106	0	3,495	0.44%
2010	756,044	722	3,687		4,409	0.58%
2011	731,017	913				

1. These fish were adipose fin-clipped, coded-wire tagged, and (beginning with 4 of 16 ponds in 1998) elastomer eye tagged. This is the number of fish physically counted at tagging.
2. BY1997 used 400 kHz tags and Bonneville Dam was not fully configured for adult detection of this type of tag; therefore we saw more detections at Roza Dam where fish were manually wanded for adult PIT detections.
3. Includes HxH fish beginning with this brood year.

Harvest Monitoring

Yakima Basin Fisheries

For spring fisheries in the Yakima River Basin, both the WDFW and the Yakama Nation employ two technicians and one biologist to monitor and evaluate in-basin harvest in the respective sport and tribal fisheries. Harvest monitoring consists of on-the-water surveys to collect catch data and to record tag information (e.g., elastomer, CWT, etc.) where possible for adipose-clipped fish. Survey data are expanded for time, area, and effort using standard methods to derive estimates of total in-basin harvest by fishery type (sport and tribal) and catch type (CESRF or wild denoted by adipose presence/absence).

Table 47. Spring Chinook harvest in the Yakima River Basin, 1983-present.

	Tribal		Non-Tribal		River Totals			
Year	CESRF	Wild	CESRF	Wild	CESRF	Wild	Total	Harvest Rate[1]
1983		84		0		84	84	5.8%
1984		289		0		289	289	10.9%
1985		865		0		865	865	19.0%
1986		1,340		0		1,340	1,340	14.2%
1987		517		0		517	517	11.6%
1988		444		0		444	444	10.5%
1989		747		0		747	747	15.2%
1990		663		0		663	663	15.2%
1991		32		0		32	32	1.1%
1992		345		0		345	345	7.5%
1993		129		0		129	129	3.3%
1994		25		0		25	25	1.9%
1995		79		0		79	79	11.9%
1996		475		0		475	475	14.9%
1997		575		0		575	575	18.1%
1998		188		0		188	188	9.9%
1999		604		0		604	604	21.7%
2000	53	2,305		100	53	2,405	2,458	12.9%
2001	572	2,034	1,252	772	1,825	2,806	4,630	19.9%
2002	1,373	1,207	492	36[2]	1,865	1,243	3,108	20.6%
2003	134	306	0	0	134	306	440	6.3%
2004	289	712	569	109[2]	858	820	1,679	11.0%
2005	46	428	0	0	46	428	474	5.4%
2006	246	354	0	0	246	354	600	9.5%
2007	123	156	0	0	123	156	279	6.5%
2008	521	414	586	11[2]	1,107	426	1,532	17.8%
2009	1,089	715	541	8[2]	1,630	722	2,353	19.4%
2010	345	194	1,154	48[2]	1,499	241	1,741	13.2%
2011	1,361	1,261	1,579	179[2]	2,940	1,440	4,380	24.4%
2012	1,220	1,302	735	63[2]	1,955	1,364	3,320	27.5%
2013	846	975	786	46[2]	1,632	1,021	2,653	25.9%
2014	576	715	826	54[2]	1,402	769	2,171	19.2%
Mean	624	634	609	95	1,233	677	1,202	13.8%

1. Harvest rate is the total Yakima Basin harvest as a percentage of the Yakima River mouth run size.
2. Includes estimate of post-release mortality of unmarked fish.

Columbia Basin Fisheries

Standard run reconstruction techniques are employed to derive estimates of harvest from the Columbia River mouth to the Yakima River mouth for spring Chinook. Data from databases maintained by the *United States versus Oregon* Technical Advisory Committee (TAC) are used to obtain harvest rate estimates downstream of the Yakima River for the aggregate Yakima River spring Chinook population and to estimate passage losses from Bonneville through McNary reservoirs. These data, combined with the Prosser Dam counts and estimated harvest below Prosser, are used to derive a Columbia River mouth run size estimate and Columbia River mainstem harvest estimate for Yakima spring Chinook.

Table 48. Estimated run size, harvest, and harvest rates of Yakima Basin spring Chinook in Columbia River mainstem and terminal area fisheries, 1983-present.

						Columbia Basin Harvest Summary			Col. Basin Harvest Rate	
Year	Columbia R. Mouth Run Size	Col. R. Mouth to BON Harvest	BON to McNary Harvest	Yakima R. Mouth Run Size	Yakima River Harvest	Total	Wild	CESRF	Total	Wild
1983	2,470	119	99	1,441	84	302	302	0	12.2%	12.2%
1984	3,890	135	258	2,658	289	682	682	0	17.5%	17.5%
1985	5,274	192	179	4,560	865	1,236	1,236	0	23.4%	23.4%
1986	13,480	279	781	9,439	1,340	2,400	2,400	0	17.8%	17.8%
1987	6,165	96	372	4,443	517	986	986	0	16.0%	16.0%
1988	5,610	359	371	4,246	444	1,174	1,174	0	20.9%	20.9%
1989	8,936	213	668	4,914	747	1,628	1,628	0	18.2%	18.2%
1990	6,870	348	450	4,372	663	1,461	1,461	0	21.3%	21.3%
1991	4,611	183	277	2,906	32	492	492	0	10.7%	10.7%
1992	6,226	103	375	4,599	345	823	823	0	13.2%	13.2%
1993	5,135	44	312	3,919	129	485	485	0	9.4%	9.4%
1994	2,228	86	107	1,302	25	219	219	0	9.8%	9.8%
1995	1,375	1	68	666	79	148	148	0	10.8%	10.8%
1996	5,790	6	303	3,179	475	784	784	0	13.5%	13.5%
1997	5,235	3	350	3,173	575	928	928	0	17.7%	17.7%
1998	2,825	3	142	1,903	188	332	332	0	11.8%	11.8%
1999	3,944	4	182	2,781	604	790	790	0	20.0%	20.0%
2000	28,704	58	1,745	19,100	2,458	4,261	4,138	123	14.8%	14.8%
2001	30,818	943	4,026	23,265	4,630	9,599	5,511	4,087	31.1%	29.8%
2002	23,916	1,235	2,549	15,099	3,108	6,891	2,570	4,321	28.8%	24.7%
2003	9,735	275	764	6,957	440	1,479	891	588	15.2%	14.2%
2004	21,978	967	1,900	15,289	1,679	4,545	2,521	2,025	20.7%	16.1%
2005	11,879	327	740	8,758	474	1,541	1,213	327	13.0%	12.2%
2006	11,583	299	761	6,314	600	1,660	943	717	14.3%	12.7%
2007	4,996	170	344	4,303	279	793	382	411	15.9%	13.8%
2008	11,434	1,152	1,509	8,598	1,532	4,193	1,182	3,011	36.7%	26.5%
2009	12,833	1,171	936	10,726	2,353	4,460	1,238	3,222	34.8%	25.7%
2010	17,406	1,567	2,291	13,142	1,741	5,599	1,305	4,294	32.2%	21.4%
2011	22,193	1,060	1,397	17,960	4,380	6,836	2,374	4,463	30.8%	22.2%
2012	15,716	795	1,347	12,053	3,320	5,462	2,203	3,259	34.8%	28.3%
2013	14,092	839	754	10,245	2,653	4,245	1,679	2,566	30.1%	23.4%
2014[1]	16,461	693	1,778	11,322	2,171	4,642	1,845	2,797	28.2%	21.5%
Mean	10,744	429	879	7,613	1,226	2,534	1,402	1,132	20.2%	17.9%

1. Preliminary.

Marine Fisheries

Based on available CWT information, harvest managers have long assumed that Columbia River spring Chinook are not harvested in any abundance in marine fisheries as the timing of their ocean migration does not generally overlap either spatially or temporally with the occurrence of marine fisheries (TAC 1997). The Regional Mark Information System (RMIS) will be queried regularly for any CWT recoveries of CESRF releases in ocean or Columbia River mainstem fisheries. Table 49 gives the results of a query of the RMIS database run on Dec. 30, 2014 for CESRF spring Chinook CWTs released in brood years 1997-2009. Based on the information reported to RMIS to date, it is believed that marine harvest accounts for about 0-3% of the total harvest of Yakima Basin spring Chinook. CWT recovery data for brood year 2010 were considered too incomplete to report at this time.

Table 49. Marine and freshwater recoveries of CWTs from brood year 1997-2009 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) 30 Dec, 2014.

Brood	Observed CWT Recoveries			Expanded CWT Recoveries		
Year	Marine	Fresh	Marine %	Marine	Fresh	Marine %
1997	5	56	8.2%	8	321	2.4%
1998	2	53	3.6%	2	228	0.9%
1999		2	0.0%		9	0.0%
2000		14	0.0%		34	0.0%
2001		1	0.0%		1	0.0%
2002		7	0.0%		36	0.0%
2003		4	0.0%		10	0.0%
2004	2	154	1.3%	15	526	2.8%
2005	2	96	2.0%	2	304	0.7%
2006	14	329	4.1%	16	1165	1.4%
2007	8	145	5.2%	13	1142	1.1%
2008	5	245	2.0%	7	1629	0.4%
2009[1]	3	87	3.3%	5	467	1.1%

1. Reporting of CWT recoveries to the RMIS database typically lags actual fisheries by one to two years. Therefore, CWT recovery data for brood year 2009 are considered preliminary or incomplete.

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Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2005-2013.

Brood Year	C.E. Pond	Accl. Pond	Treatment[1] /Avg BKD			Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
2005	CLE01	JCJ06	STF	WW	2.4	Left	Orange	Snout	3/15/2007	5/15/2007	613418	2,222	45,991	47,913
2005	CLE02	JCJ05	CON	WW	2.4	Right	Orange	Snout	3/15/2007	5/15/2007	613419	2,222	46,172	48,189
2005	CLE03	JCJ04	STF	WW	2.6	Right	Orange	Snout	3/15/2007	5/15/2007	613420	2,222	47,604	49,605
2005	CLE04	JCJ03	CON	WW	2.6	Left	Orange	Snout	3/15/2007	5/15/2007	613421	2,222	47,852	49,865
2005	CLE05	CFJ06	CON	WW	2.5	Right	Red	Snout	3/15/2007	5/15/2007	613422	2,222	46,258	48,282
2005	CLE06	CFJ05	STF	WW	2.5	Left	Red	Snout	3/15/2007	5/15/2007	613423	2,222	47,129	49,155
2005	CLE07	ESJ06	CON	WW	2.5	Right	Green	Snout	3/15/2007	5/15/2007	613424	2,222	41,808	43,871
2005	CLE08	ESJ05	STF	WW	2.5	Left	Green	Snout	3/15/2007	5/15/2007	613425	2,222	42,094	44,193
2005	CLE09	CFJ02	CON	HH	2.3	Right	Red	Posterior Dorsal	3/15/2007	5/15/2007	613431	2,222	43,580	45,616
2005	CLE10	CFJ01	STF	HH	2.3	Left	Red	Posterior Dorsal	3/15/2007	5/15/2007	613427	2,222	42,971	44,902
2005	CLE11	ESJ02	CON	WW	2.5	Right	Green	Snout	3/15/2007	5/15/2007	613428	2,222	50,108	52,186
2005	CLE12	ESJ01	STF	WW	2.5	Left	Green	Snout	3/15/2007	5/15/2007	613429	2,222	44,487	46,550
2005	CLE13	ESJ04	CON	WW	2.5	Right	Green	Snout	3/15/2007	5/15/2007	613430	2,222	45,040	47,132
2005	CLE14	ESJ03	STF	WW	2.5	Left	Green	Snout	3/15/2007	5/15/2007	613426	2,222	45,132	47,218
2005	CLE15	JCJ02	STF	WW	2.5	Right	Orange	Snout	3/15/2007	5/15/2007	613432	2,222	46,178	48,266
2005	CLE16	JCJ01	CON	WW	2.5	Left	Orange	Snout	3/15/2007	5/15/2007	613433	2,222	45,804	47,887
2005	CLE17	CFJ04	CON	WW	2.5	Right	Red	Snout	3/15/2007	5/15/2007	613434	2,222	46,476	48,508
2005	CLE18	CFJ03	STF	WW	2.4	Left	Red	Snout	3/15/2007	5/15/2007	613435	2,222	48,638	50,664

[1] CON = normal feed or STF = salt-water transition diet at acclimation sites. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. “Avg BKD” denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

[2] The number of fish released is estimated as the total number of fish counted at marking less mortalities documented from mark to release.

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Brood Year	C.E. Pond	Accl. Pond	Treatment[1] /Avg BKD			Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
2006	CLE01	CFJ04	BIO	WW	3.5	Right	Red	Snout	3/15/2008	5/14/2008	190101	2,000	36,945	38,607
2006	CLE02	CFJ03	EWS	WW	3.5	Left	Red	Snout	3/15/2008	5/14/2008	190102	2,000	31,027	32,790
2006	CLE03	ESJ02	BIO	WW	3.2	Right	Green	Snout	3/15/2008	5/14/2008	190103	2,000	36,931	38,762
2006	CLE04	ESJ01	EWS	WW	3.2	Left	Green	Snout	3/15/2008	5/14/2008	190104	2,000	29,635	31,400
2006	CLE05	JCJ02	BIO	WW	3.3	Right	Orange	Snout	3/15/2008	5/14/2008	190105	2,000	36,735	38,383
2006	CLE06	JCJ01	EWS	WW	3.3	Left	Orange	Snout	3/15/2008	5/14/2008	190106	2,000	28,984	30,680
2006	CLE07	ESJ04	BIO	WW	3.4	Right	Green	Snout	3/15/2008	5/14/2008	190107	2,000	38,212	40,006
2006	CLE08	ESJ03	EWS	WW	3.4	Left	Green	Snout	3/15/2008	5/14/2008	190108	2,000	32,726	34,519
2006	CLE09	CFJ02	BIO	WW	3.4	Right	Red	Snout	3/15/2008	5/14/2008	190109	2,000	36,485	38,097
2006	CLE10	CFJ01	EWS	WW	3.4	Left	Red	Snout	3/15/2008	5/14/2008	190110	2,000	29,907	31,647
2006	CLE11	JCJ04	BIO	WW	3.3	Right	Orange	Snout	3/15/2008	5/14/2008	190111	2,000	39,491	40,703
2006	CLE12	JCJ03	EWS	WW	3.3	Left	Orange	Snout	3/15/2008	5/14/2008	190112	2,000	33,418	35,273
2006	CLE13	ESJ06	BIO	WW	3.4	Right	Green	Snout	3/15/2008	5/14/2008	190113	2,000	38,609	39,841
2006	CLE14	ESJ05	EWS	WW	3.4	Left	Green	Snout	3/15/2008	5/14/2008	190114	2,000	31,573	33,404
2006	CLE15	JCJ06	BIO	WW	3.4	Right	Orange	Snout	3/15/2008	5/14/2008	190115	2,000	36,844	38,619
2006	CLE16	JCJ05	EWS	WW	3.4	Left	Orange	Snout	3/15/2008	5/14/2008	190116	2,000	29,857	31,630
2006	CLE17	CFJ06	BIO	HH	3.2	Right	Red	Posterior Dorsal	3/15/2008	5/14/2008	190117	4,000	34,299	38,045
2006	CLE18	CFJ05	EWS	HH	3.2	Left	Red	Posterior Dorsal	3/15/2008	5/14/2008	190118	4,000	26,643	30,389

[1] BIO = BioVita (BioOregon Protein Inc.) or control diet; EWS = EWOS (EWOS Canada Ltd.). All fish were switched to BioVita diet beginning May 3, 2007. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line. “Avg BKD” denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

[2] The number of fish released is estimated as the total number of fish counted at marking less mortalities documented from mark to release.

Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2005-2013.

Brood Year	C.E. Pond	Accl. Pond	Treatment[1] /Avg BKD			Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
2007	CLE01	JCJ06	BIO	WW	2.8	Right	Orange	Snout	3/15/2009	5/15/2009	190151	2,000	38,044	39,840
2007	CLE02	JCJ05	STF	WW	2.8	Left	Orange	Snout	3/15/2009	5/15/2009	190152	2,000	40,066	41,843
2007	CLE03	JCJ04	BIO	WW	2.7	Right	Orange	Snout	3/15/2009	5/15/2009	190153	2,000	40,843	42,647
2007	CLE04	JCJ03	STF	WW	2.7	Left	Orange	Snout	3/15/2009	5/15/2009	190154	2,000	40,196	41,979
2007	CLE05	CFJ06	BIO	WW	2.8	Right	Red	Snout	3/15/2009	5/15/2009	190155	2,000	40,855	42,717
2007	CLE06	CFJ05	STF	WW	2.8	Left	Red	Snout	3/15/2009	5/15/2009	190156	2,000	40,475	42,345
2007	CLE07	ESJ06	BIO	WW	2.6	Right	Green	Snout	3/15/2009	5/15/2009	190157	2,000	42,549	44,387
2007	CLE08	ESJ05	STF	WW	2.6	Left	Green	Snout	3/15/2009	5/15/2009	190158	2,000	43,243	45,080
2007	CLE09	CFJ02	BIO	HH	2.7	Right	Red	Posterior Dorsal	3/15/2009	5/15/2009	190159	4,000	43,803	47,625
2007	CLE10	CFJ01	STF	HH	2.7	Left	Red	Posterior Dorsal	3/15/2009	5/15/2009	190160	4,000	43,256	47,038
2007	CLE11	ESJ02	BIO	WW	2.8	Right	Green	Snout	3/15/2009	5/15/2009	190161	2,000	41,098	42,945
2007	CLE12	ESJ01	STF	WW	2.8	Left	Green	Snout	3/15/2009	5/15/2009	190162	2,001	40,535	42,405
2007	CLE13	ESJ04	BIO	WW	2.7	Right	Green	Snout	3/15/2009	5/15/2009	190163	2,009	39,308	41,190
2007	CLE14	ESJ03	STF	WW	2.7	Left	Green	Snout	3/15/2009	5/15/2009	190164	2,000	36,663	38,533
2007	CLE15	JCJ02	BIO	WW	2.9	Right	Orange	Snout	3/15/2009	5/15/2009	190165	2,000	40,312	42,083
2007	CLE16	JCJ01	STF	WW	2.9	Left	Orange	Snout	3/15/2009	5/15/2009	190166	2,000	40,594	42,426
2007	CLE17	CFJ03	STF	WW	2.8	Right	Red	Snout	3/15/2009	5/15/2009	190167	2,000	40,687	42,561
2007	CLE18	CFJ04	BIO	WW	2.8	Left	Red	Snout	3/15/2009	5/15/2009	190168	2,000	41,704	43,621

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[1] BIO = BioVita (BioOregon Protein Inc.) or control diet; STF = salt-water transition diet at acclimation sites. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. “Avg BKD” denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

[2] The number of fish released is estimated as the total number of fish counted at marking less mortalities documented from mark to release.

Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2005-2013.

Brood Year	***C.E. Pond***	***Accl. Pond***	***Treatment[1] /Avg BKD***			***Tag Information***			***First Release***	***Last Release***	***CWT Code***	***No. PIT***	***No. CWT***	***Est. Tot. Release[2]***
2008	CLE01	ESJ01	STF	WW	3.3	Right	Orange	Snout	3/15/2010	5/11/2010	190191	2,000	44,917	46,704
2008	CLE02	ESJ02	BIO	WW	3.3	Left	Orange	Snout	3/15/2010	5/11/2010	190192	2,000	45,576	47,414
2008	CLE03	CFJ03	STF	WW	3.2	Right	Red	Snout	3/15/2010	5/11/2010	190193	2,000	44,099	45,931
2008	CLE04	CFJ04	BIO	WW	3.2	Left	Red	Snout	3/15/2010	5/11/2010	190194	2,000	42,464	44,271
2008	CLE05	JCJ05	STF	WW	3.0	Right	Green	Snout	3/15/2010	5/11/2010	190195	2,000	46,118	47,936
2008	CLE06	JCJ06	BIO	WW	3.0	Left	Green	Snout	3/15/2010	5/11/2010	190196	2,000	43,708	45,466
2008	CLE07	ESJ05	STF	WW	3.2	Right	Orange	Snout	3/15/2010	5/11/2010	190197	2,000	48,468	50,299
2008	CLE08	ESJ06	BIO	WW	3.2	Left	Orange	Snout	3/15/2010	5/11/2010	190198	2,000	47,611	49,419
2008	CLE09	CFJ05	STF	HH	2.9	Right	Red	Posterior Dorsal	3/15/2010	5/11/2010	190199	4,000	45,169	48,942
2008	CLE10	CFJ06	BIO	HH	2.9	Left	Red	Posterior Dorsal	3/15/2010	5/11/2010	190201	4,000	44,493	48,254
2008	CLE11	JCJ01	STF	WW	3.3	Right	Green	Snout	3/15/2010	5/11/2010	190202	2,000	44,583	46,413
2008	CLE12	JCJ02	BIO	WW	3.3	Left	Green	Snout	3/15/2010	5/11/2010	190203	2,000	45,086	46,856
2008	CLE13	ESJ03	STF	WW	3.1	Right	Orange	Snout	3/15/2010	5/11/2010	190204	2,000	45,518	47,317
2008	CLE14	ESJ04	BIO	WW	3.1	Left	Orange	Snout	3/15/2010	5/11/2010	190205	2,000	44,879	46,704
2008	CLE15	CFJ01	STF	WW	3.2	Right	Red	Snout	3/15/2010	5/11/2010	190206	2,000	45,169	46,893
2008	CLE16	CFJ02	BIO	WW	3.2	Left	Red	Snout	3/15/2010	5/11/2010	190207	2,000	44,149	45,962
2008	CLE17	JCJ03	STF	WW	3.2	Right	Green	Snout	3/15/2010	5/11/2010	190208	2,000	45,807	47,580
2008	CLE18	JCJ04	BIO	WW	3.2	Left	Green	Snout	3/15/2010	5/11/2010	190209	2,000	45,157	46,944

[1] BIO = BioVita (BioOregon Protein Inc.) or control diet; STF = salt-water transition diet at acclimation sites. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. “Avg BKD” denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

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2009	CLE01	CFJ05	STF	HH	3.0	Right	Red	Posterior Dorsal	3/15/2011	5/16/2011	190215	4,000	40,109	43,965
2009	CLE02	CFJ06	BIO	HH	3.0	Left	Red	Posterior Dorsal	3/15/2011	5/16/2011	190216	4,000	41,012	44,806
2009	CLE03	JCJ01	STF	WW	3.0	Right	Orange	Snout	3/15/2011	3/31/2011	190217	2,000	37,245	39,048
2009	CLE04	JCJ02	BIO	WW	3.0	Left	Orange	Snout	3/15/2011	3/31/2011	190218	2,000	42,212	44,053
2009	CLE05	CFJ01	STF	WW	3.2	Right	Red	Snout	3/15/2011	5/16/2011	190219	2,000	47,016	48,761
2009	CLE06	CFJ02	BIO	WW	3.2	Left	Red	Snout	3/15/2011	5/16/2011	190220	2,000	46,733	48,569
2009	CLE07	ESJ05	STF	WW	3.1	Right	Green	Snout	3/15/2011	5/16/2011	190221	2,000	46,302	48,089
2009	CLE08	ESJ06	BIO	WW	3.1	Left	Green	Snout	3/15/2011	5/16/2011	190222	2,000	46,969	48,721
2009	CLE09	ESJ01	STF	WW	3.0	Right	Green	Snout	3/15/2011	5/16/2011	190223	2,000	43,612	45,379
2009	CLE10	ESJ02	BIO	WW	3.0	Left	Green	Snout	3/15/2011	5/16/2011	190224	2,000	43,173	44,962
2009	CLE11	JCJ05	STF	WW	3.1	Right	Orange	Snout	3/15/2011	3/31/2011	190225	2,000	47,585	49,306
2009	CLE12	JCJ06	BIO	WW	3.1	Left	Orange	Snout	3/15/2011	3/31/2011	190226	2,000	47,644	49,434
2009	CLE13	ESJ03	STF	WW	3.2	Right	Green	Snout	3/15/2011	5/16/2011	190227	2,000	45,277	47,036
2009	CLE14	ESJ04	BIO	WW	3.2	Left	Green	Snout	3/15/2011	5/16/2011	190228	2,000	45,529	47,208
2009	CLE15	JCJ03	STF	WW	3.1	Right	Orange	Snout	3/15/2011	3/31/2011	190229	2,000	43,825	45,592
2009	CLE16	JCJ04	BIO	WW	3.1	Left	Orange	Snout	3/15/2011	3/31/2011	190230	2,000	43,209	44,990
2009	CLE17	CFJ03	STF	WW	3.2	Right	Red	Snout	3/15/2011	5/16/2011	190231	2,000	45,587	47,451
2009	CLE18	CFJ04	BIO	WW	3.2	Left	Red	Snout	3/15/2011	5/16/2011	190232	2,000	43,952	45,571

[1] BIO = BioVita (BioOregon Protein Inc.) or control diet; STF = salt-water transition diet at acclimation sites. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. "Avg BKD" denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

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2010	CLE01	CFJ05	STF	WW	4.2	Right	Red	Snout	3/15/2012	5/14/2012	190256	2,000	40,221	41,972
2010	CLE02	CFJ06	BIO	WW	4.2	Left	Red	Snout	3/15/2012	5/14/2012	190257	2,000	40,845	42,664
2010	CLE03	CFJ03	STF	HH	4.0	Right	Red	Posterior Dorsal	3/15/2012	5/14/2012	190258	4,000	43,725	47,415
2010	CLE04	CFJ04	BIO	HH	4.0	Left	Red	Posterior Dorsal	3/15/2012	5/14/2012	190259	4,000	40,976	44,615
2010	CLE05	ESJ01	STF	WW	4.2	Right	Green	Snout	3/15/2012	5/14/2012	190260	2,000	40,710	42,374
2010	CLE06	ESJ02	BIO	WW	4.2	Left	Green	Snout	3/15/2012	5/14/2012	190261	2,000	40,419	42,157
2010	CLE07	JCJ01	STF	WW	4.0	Right	Orange	Snout	3/15/2012	5/14/2012	190262	2,000	43,833	45,471
2010	CLE08	JCJ02	BIO	WW	4.0	Left	Orange	Snout	3/15/2012	5/14/2012	190263	2,000	43,815	45,573
2010	CLE09	ESJ03	STF	WW	4.1	Right	Green	Snout	3/15/2012	5/14/2012	190264	2,000	42,528	44,257
2010	CLE10	ESJ04	BIO	WW	4.1	Left	Green	Snout	3/15/2012	5/14/2012	190265	2,000	42,649	44,443
2010	CLE11	ESJ05	STF	WW	4.2	Right	Green	Snout	3/15/2012	5/14/2012	190266	2,000	43,878	45,633
2010	CLE12	ESJ06	BIO	WW	4.2	Left	Green	Snout	3/15/2012	5/14/2012	190267	2,000	43,750	45,498
2010	CLE13	JCJ03	STF	WW	4.2	Right	Orange	Snout	3/15/2012	5/14/2012	190268	2,000	41,816	43,473
2010	CLE14	JCJ04	BIO	WW	4.2	Left	Orange	Snout	3/15/2012	5/14/2012	190269	2,000	41,052	42,772
2010	CLE15	JCJ05	STF	WW	4.1	Right	Orange	Snout	3/15/2012	5/14/2012	190270	2,000	42,894	44,603
2010	CLE16	JCJ06	BIO	WW	4.1	Left	Orange	Snout	3/15/2012	5/14/2012	190271	2,000	42,371	44,107
2010	CLE17	CFJ01	STF	WW	4.2	Right	Red	Snout	3/15/2012	5/14/2012	190272	2,000	42,329	44,128
2010	CLE18	CFJ02	BIO	WW	4.2	Left	Red	Snout	3/15/2012	5/14/2012	190273	2,000	41,829	43,626

[1] BIO = BioVita (BioOregon Protein Inc.) or control diet; STF = salt-water transition diet at acclimation sites. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. “Avg BKD” denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

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Brood Year	C.E. Pond	Accl. Pond	Treatment[1] /Avg BKD			Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
2011	CLE01	JCJ05	STF	WN	4.1	Right	Orange	Snout	3/15/2013	5/15/2013	190320	2,000	42,452	44,225
2011	CLE02	JCJ06	BIO	WN	4.1	Left	Orange	Snout	3/15/2013	5/15/2013	190321	2,000	42,217	44,056
2011	CLE03	CFJ05	STF	HC	4.0	Right	Red	Posterior Dorsal	3/15/2013	5/15/2013	190322	4,000	38,432	42,092
2011	CLE04	CFJ06	BIO	HC	4.0	Left	Red	Posterior Dorsal	3/15/2013	5/15/2013	190323	4,000	38,743	42,609
2011	CLE05	ESJ01	STF	WN	4.1	Right	Green	Snout	3/15/2013	5/15/2013	190324	2,000	38,404	40,250
2011	CLE06	ESJ02	BIO	WN	4.1	Left	Green	Snout	3/15/2013	5/15/2013	190325	2,000	37,931	39,731
2011	CLE07	CFJ01	STF	WN	4.1	Right	Red	Snout	3/15/2013	5/15/2013	190326	2,000	40,449	42,308
2011	CLE08	CFJ02	BIO	WN	4.1	Left	Red	Snout	3/15/2013	5/15/2013	190327	2,000	39,281	41,088
2011	CLE09	JCJ03	STF	WN	4.0	Right	Orange	Snout	3/15/2013	5/15/2013	190328	2,000	43,588	45,243
2011	CLE10	JCJ04	BIO	WN	4.0	Left	Orange	Snout	3/15/2013	5/15/2013	190329	2,000	41,715	43,288
2011	CLE11	ESJ05	STF	WN	4.0	Right	Green	Snout	3/15/2013	5/15/2013	190330	2,000	40,964	42,610
2011	CLE12	ESJ06	BIO	WN	4.0	Left	Green	Snout	3/15/2013	5/15/2013	190331	2,000	40,905	42,759
2011	CLE13	CFJ03	STF	WN	4.0	Right	Red	Snout	3/15/2013	5/15/2013	190332	2,000	42,298	44,190
2011	CLE14	CFJ04	BIO	WN	4.0	Left	Red	Snout	3/15/2013	5/15/2013	190333	2,000	41,111	43,003
2011	CLE15	JCJ01	STF	WN	3.9	Right	Orange	Snout	3/15/2013	5/15/2013	190334	2,000	42,769	44,590
2011	CLE16	JCJ02	BIO	WN	3.9	Left	Orange	Snout	3/15/2013	5/15/2013	190335	2,000	42,230	44,036
2011	CLE17	ESJ03	STF	WN	4.0	Right	Green	Snout	3/15/2013	5/15/2013	190336	2,000	39,770	41,479
2011	CLE18	ESJ04	BIO	WN	4.0	Left	Green	Snout	3/15/2013	5/15/2013	190337	2,000	39,823	41,625

[1] BIO = BioVita (BioOregon Protein Inc.) or control diet; STF = salt-water transition diet at acclimation sites. All fish are progeny of wild/natural parents unless denoted as HC which designates the hatchery control line beginning with brood year 2002. “Avg BKD” denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

[2] The number of fish released is estimated as the total number of fish counted at marking less mortalities documented from mark to release.

Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2005-2013.

Brood Year	C.E. Pond	Accl. Pond	Treatment[1] /Avg BKD			Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
2012	CLE01	ESJ03	STF	WN	3.7	Right	Green	Snout	3/15/2014	5/15/2014	190367	2,000	44,358	45,902
2012	CLE02	ESJ04	BIO	WN	3.7	Left	Green	Snout	3/15/2014	5/15/2014	190368	2,000	44,999	46,758
2012	CLE03	CFJ03	STF	HC	3.8	Right	Red	Posterior Dorsal	3/15/2014	5/15/2014	190369	4,000	42,147	45,670
2012	CLE04	CFJ04	BIO	HC	3.8	Left	Red	Posterior Dorsal	3/15/2014	5/15/2014	190370	4,000	41,497	45,010
2012	CLE05	ESJ05	STF	WN	3.8	Right	Green	Snout	3/15/2014	5/15/2014	190371	2,000	43,627	45,512
2012	CLE06	ESJ06	BIO	WN	3.8	Left	Green	Snout	3/15/2014	5/15/2014	190372	2,000	44,507	46,420
2012	CLE07	CFJ05	STF	WN	3.7	Right	Red	Snout	3/15/2014	5/15/2014	190373	2,000	41,067	42,932
2012	CLE08	CFJ06	BIO	WN	3.7	Left	Red	Snout	3/15/2014	5/15/2014	190374	2,000	37,499	39,367
2012	CLE09	CFJ01	STF	WN	3.7	Right	Red	Snout	3/15/2014	5/15/2014	190375	2,000	42,001	43,629
2012	CLE10	CFJ02	BIO	WN	3.7	Left	Red	Snout	3/15/2014	5/15/2014	190376	2,000	38,364	40,124
2012	CLE11	JCJ01	STF	WN	3.8	Right	Orange	Snout	3/15/2014	5/15/2014	190377	2,000	41,425	43,279
2012	CLE12	JCJ02	BIO	WN	3.8	Left	Orange	Snout	3/15/2014	5/15/2014	190378	2,000	44,713	46,491
2012	CLE13	ESJ01	STF	WN	3.7	Right	Green	Snout	3/15/2014	5/15/2014	190379	2,000	42,619	44,499
2012	CLE14	ESJ02	BIO	WN	3.7	Left	Green	Snout	3/15/2014	5/15/2014	190380	2,000	45,217	47,119
2012	CLE15	JCJ03	STF	WN	3.7	Right	Orange	Snout	3/15/2014	5/15/2014	190381	2,000	43,330	45,200
2012	CLE16	JCJ04	BIO	WN	3.7	Left	Orange	Snout	3/15/2014	5/15/2014	190382	2,000	42,900	44,729
2012	CLE17	JCJ05	STF	WN	3.7	Right	Orange	Snout	3/15/2014	5/15/2014	190383	2,000	43,240	45,034
2012	CLE18	JCJ06	BIO	WN	3.7	Left	Orange	Snout	3/15/2014	5/15/2014	190384	2,000	43,257	45,041

[1] BIO = BioVita (BioOregon Protein Inc.) or control diet; STF = salt-water transition diet at acclimation sites. All fish are progeny of wild/natural parents unless denoted as HC which designates the hatchery control line beginning with brood year 2002. “Avg BKD” denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

[2] The number of fish released is estimated as the total number of fish counted at marking less mortalities documented from mark to release.

Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2005-2013.

Brood Year	C.E. Pond	Accl. Pond	Treatment[1] /Avg BKD		Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
2013	CLE01	CFJ05	WN	3.8	Right	Red	Snout	3/15/2015	5/6/2015	190401	2,000	36,097	37,928
2013	CLE02	CFJ06	WN	3.8	Left	Red	Snout	3/15/2015	5/6/2015	190402	2,000	34,541	36,343
2013	CLE03	ESJ05	WN	3.7	Right	Green	Snout	3/15/2015	5/6/2015	190403	2,000	33,761	35,473
2013	CLE04	ESJ06	WN	3.7	Left	Green	Snout	3/15/2015	5/6/2015	190404	2,000	34,682	36,295
2013	CLE05	CFJ03	WN	3.9	Right	Red	Snout	3/15/2015	5/6/2015	190405	2,000	34,495	36,240
2013	CLE06	CFJ04	WN	3.9	Left	Red	Snout	3/15/2015	5/6/2015	190406	2,000	32,054	33,823
2013	CLE07	ESJ03	WN	3.8	Right	Green	Snout	3/15/2015	5/6/2015	190407	2,000	32,866	34,672
2013	CLE08	ESJ04	WN	3.8	Left	Green	Snout	3/15/2015	5/6/2015	190408	2,000	34,418	36,130
2013	CLE09	CFJ01	HC	3.8	Right	Red	Posterior Dorsal	3/15/2015	5/6/2015	190409	4,000	32,264	36,029
2013	CLE10	CFJ02	HC	3.7	Left	Red	Posterior Dorsal	3/15/2015	5/6/2015	190410	4,000	31,648	35,570
2013	CLE11	JCJ03	WN	3.7	Right	Orange	Snout	3/15/2015	5/6/2015	190411	2,000	34,948	36,725
2013	CLE12	JCJ04	WN	3.7	Left	Orange	Snout	3/15/2015	5/6/2015	190412	2,000	35,508	37,236
2013	CLE13	ESJ01	WN	3.6	Right	Green	Snout	3/15/2015	5/6/2015	190413	2,000	34,013	35,805
2013	CLE14	ESJ02	WN	3.6	Left	Green	Snout	3/15/2015	5/6/2015	190414	2,000	34,580	36,370
2013	CLE15	JCJ01	WN	3.7	Right	Orange	Snout	3/15/2015	5/6/2015	190415	2,000	32,151	33,810
2013	CLE16	JCJ02	WN	3.7	Left	Orange	Snout	3/15/2015	5/6/2015	190416	2,000	33,703	35,249
2013	CLE17	JCJ05	WN	3.8	Right	Orange	Snout	3/15/2015	5/6/2015	190417	2,000	35,987	37,604
2013	CLE18	JCJ06	WN	3.8	Left	Orange	Snout	3/15/2015	5/6/2015	190418	2,000	33,807	35,453

[1] All fish are progeny of wild/natural parents unless denoted as HC which designates the hatchery control line beginning with brood year 2002. “Avg BKD” denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

[2] The number of fish released is estimated as the total number of fish counted at marking less mortalities documented from mark to release.

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Appendix C
Annual Report: Comparison of Salt-Water-Transfer Supplemented-Feed and Unsupplemented-Feed Treatments evaluated on Natural-Origin Brood, Hatchery-Reared Upper-Yakima Spring Chinook Smolt released in 2007 and 2009 through 2014

Doug Neeley, Consultant to Yakama Nation

Summary

To date, there have been no substantial effects of the Saltwater-Transfer (STF) supplement to standard BioVita feed for any of five juvenile traits assessed: 1) Pre-release weight, 2) Percent of fish detected leaving pond (volitional releases), 3) Mean and median acclimation-pond volitional-release dates, 4) Volitional-release-to-McNary survival, 5) Mean and median McNary Dam (McNary) passage dates.

While the differences were not substantial, the mean volitional-release date adjusted for years was significantly later for the STF-supplement-fed smolt (P = 0.0153), and the mean dates of volitional release were later in each of the seven study years. However, there were no such consistent or significant differences in the median differences. It is noted that STF – Control differences tended to increase over the years for both the means and medians.

The later volitional release dates associated with the supplemented feed were somewhat reflected in mean McNary passage dates with six of the seven years having later passage dates for the STF-supplement fed smolt. However, to date, the mean difference adjusted for years was not yet significant at the 5% level (P = 0.075). All five of the non-zero median differences were associated with later STF-fed smolt, again not yet significant at the 5% level to date (P = 0.0625).

Introduction

For hatchery releases of Spring Chinook smolt released in 2007 and from 2009 through 2014, two feed treatments were allocated to raceways within adjacent raceway pairs. Fish from each raceway pair were fed BioVita feed (Bio-Oregon Inc.; designated Vita in this document) prior to smoltification with one raceway within each pair being allocated the BioTransfer feed supplement

(Bio-Oregon Inc.; designated "Saltwater Transfer Feed" or STF in this document) and the other not. The intent of the experiment was to determine whether the STF-supplemented treatment increased the rate of smoltification and survival, the unsupplemented treatment serving as the control.

There are three pairs of raceways at each of three Upper-Yakima-Basin acclimation sites: Clark Flat, Easton, and Jack Creek. One pair of raceways at Clark Flat is devoted to smolt from Hatchery-origin brood-stock. All eight of the other pairs are from naturally-spawned brood-stock. The analyses in this report are performed only on data gathered from fish from those eight pairs of raceways.

The treatment effects on five evaluated juvenile measures were compared and are presented herein:

1) Mean pre-release weight
2) Mean percent of fish detected leaving pond (volitional release)
3) Mean and median acclimation-pond volitional-release date
4) Mean volitional-release-to-McNary survival of fish detected leaving the raceway
5) Mean and median McNary Dam (McNary) passage date

Analyses presented in past reports were performed on summaries of fish weights and other measures from individual fish sampled by NOAA Fisheries. Beginning in 2012 NOAA ceased collecting these data from two of the acclimation sites (Easton and Jack Creek); in 2014 NOAA then ceased collecting the data from the remaining site (Clark Flat). However, the hatchery staff had been taking pre-release bulk measures of the weight on a fixed number of smolt, computing the number-of-fish/pound. These measures, converted to an average grams/fish are now being used for pre-release weight assessment.

In all table presentations, the stocks' main-effect means over years were adjusted for year effects. These mean estimates are consistent with the analyses of variance/variation comparison; however, they differ slightly from non-adjusted estimates presented in past reports[1].

While medians are generally regarded as more appropriate measures of central tendency for dates of release and passage, medians are usually less powerfully compared than means. It is for this reason that both measures are analyzed for these traits.

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[1] Previous means over years were assessed over all fish over all years (yearly means weighted by the number of fish used to estimate those means). It was stated in previous reports that these were estimates that were consistent with the analyses of variation used. This was not generally this case. The estimates presented in this report are now consistent with the analyses of variation used to assess significance levels.

Mean Pre-Release Smolt Weight

Figure 1 and Table 1 present the individual release-year STF and control pre-release fish-weight means. There was neither a significant nor substantial difference in the treatments' means adjusted for year effects nor a significant yearly STF – Control difference interaction with years (P =0.1903 and P = 0.8836, respectively, Appendix Table A.1.). Only in release-year 2007 (the 2005 brood) was there a significant difference of one gram, but that was not substantial enough to contribute to a significant feed x year interaction.

Figure 1. **Mean Pre-Release Weight (g) of Juvenile Smolt fed with and without Saltwater Transfer Feed supplement (Vita + STF and Vita = Control)**

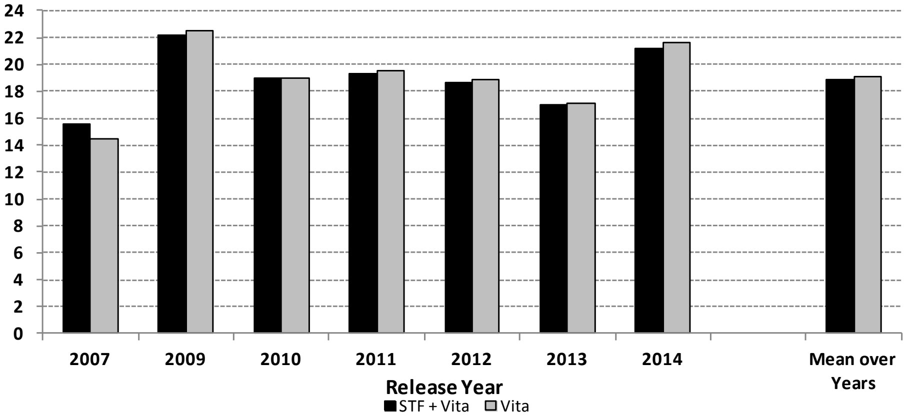


Table 1. **Mean Pre-Release Weight (g) of Juvenile Smolt fed with and without Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)**

		Adjusted* Means within Sites			
	Brood Year	2005	2007	2008	2009
Treatment	Release Year	2007	2009	2010	2011
STF + Vita	Pre-Release Fish Weight	15.5	22.2	19.0	19.3
Vita	Pre-Release Fish Weight	14.5	22.6	19.0	19.6
	Difference	1.0	-0.4	0.0	-0.2
	Estimated Type 1 Error Probabitiy (P)	**0.0000**	0.5324	0.8183	0.2934

		Adjusted* Means within Sites			
	Brood Year	2010	2011	2012	Mean
Treatment	Release Year	2012	2013	2014	over Years
STF + Vita	Pre-Release Fish Weight	18.7	17.0	21.2	18.9
Vita	Pre-Release Fish Weight	18.9	17.1	21.7	19.0
	Difference	-0.3	-0.1	-0.5	-0.2
	Estimated Type 1 Error Probabitiy (P)	0.1485	0.4099	0.4680	0.1903

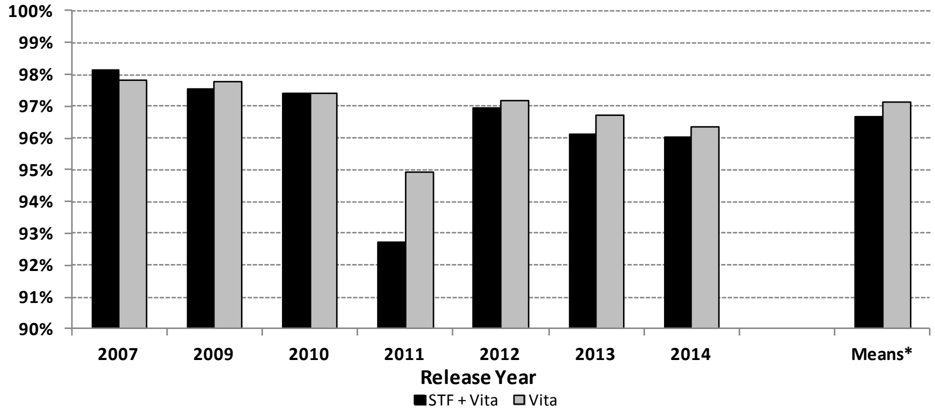
* Adjusted for the significant effects of Sites, Paired Raceways within Year

** Adjusted for the effects of Years, Sites, Year x Site Interaction, and Paired Raceways

Percent of PIT-tagged Fish Detected Leaving Acclimation Ponds

The treatment mean difference adjusted for years was to date not yet significant at the 5% level (P = 0.0963, Appendix Table A.2), the differences in the percentages were small (Figure and Table 2.). As was the case for pre-release weight, only in release-year 2007 (the 2005 brood) was there was a difference significant at the 5% level, but again the mean difference in that year was small and did not contribute to a significant feed x year interaction (P = 0.9848[2], Appendix Table A.2).

Figure 2. **Percent of Spring Chinook Smolt detected leaving Acclimation Sites fed with and without Saltwater Transfer Feed supplement (Vita + STF and Vita = Control)**



*** Means adjusted for the effects of years**

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[2] In last year's annual report, P = .0090 was reported. This was an error, the P value given in the 2013 report was the estimated Type 1 Error probability associated with the feed x site interaction, not the feed x year interaction. The site x interaction P for the current estimated feed x site interaction is P = 0.0028. However, this interaction is not used for testing of the difference in the effect of treatment over years.

Table 2. **Percent of Spring Chinook Smolt detected leaving Acclimation Sites fed with and without Saltwater Transfer Feed supplement (Vita + STF and Vita = Control)**

		Adjusted Means within Sites**			
	Brood Year	**2005**	**2007**	**2008**	**2009**
Treatment	**Release Year**	**2007**	**2009**	**2010**	**2011**
STF + Vita	**Proportion Released***	98.1%	97.6%	97.42%	92.7%
	Number Tagged	17,776	16,001	16,000	16,000
Vita	**Proportion Released***	97.8%	97.8%	97.41%	94.9%
	Number Tagged	17,785	16,010	16,000	16,001
	Difference	0.3%	-0.2%	0.01%	-2.2%
	Estimated Type 1 Error Probabitiy (P)	**0.0286**	0.4849	0.9663	0.4703

		Adjusted Means within Sites**			**Adjusted*****
	Brood Year	**2010**	**2011**	**2012**	**Treatment**
Treatment	**Release Year**	**2012**	**2013**	**2014**	**Means**
STF + Vita	**Proportion Released***	96.9%	96.1%	96.04%	96.7%
	Number Tagged	16,000	16,000	16,003	113,780
Vita	**Proportion Released***	97.2%	96.7%	96.35%	97.1%
	Number Tagged	16,003	15,999	16,000	113,798
	Difference	-0.2%	-0.6%	-0.30%	-0.5%
	Estimated Type 1 Error Probabitiy (P)***	0.6181	0.2742	0.6617	0.0963

*** Number Tagged = n**

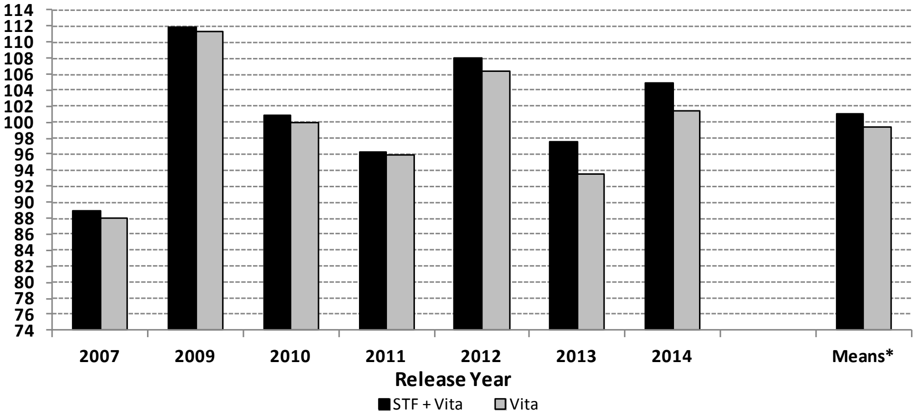
**** Adjusted for the significant effects of Sites, Paired Raceways within Year**

***** Adjusted for the effects of Years, Sites, Year x Site Interaction, and Paired Raceways**

Volitional Release Date

The mean STF release dates were later than the Control in all years (Figure 3.a). With the exceptions of the 2013 and 2014 release (2011 and 2012 brood), yearly differences were less than two days; however, the consistency of the later STF treatment releases resulted in the slightly later adjusted STF mean over years being significant (P =0. 0153, Table 3 and appendix Table A.3.), and the STF – Control interaction being not significant (P = 0.6966) reflecting the consistency of the treatment effect over years.

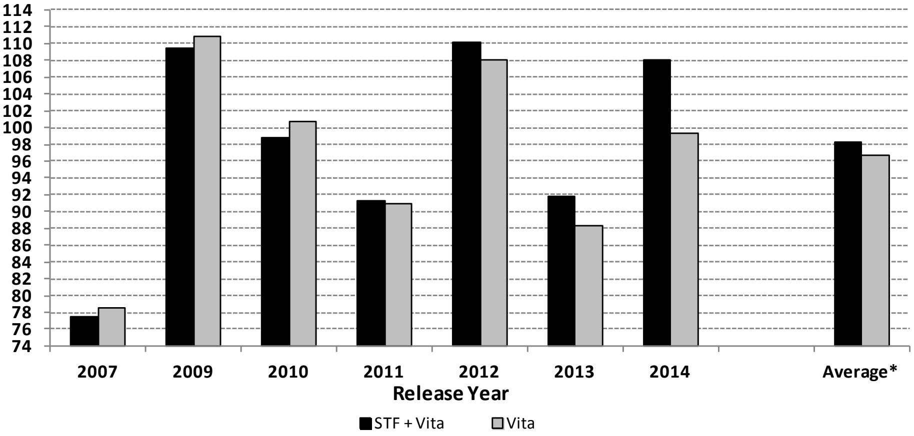
Figure 3.a <u>Mean Julian Release Date</u> **for Spring Chinook Smolt from Acclimation Sites and fed with and without Saltwater Transfer Feed supplement (Vita + STF and Vita = Control)**



*** Means adjusted for the effects of years**

While the differences in means were consistent in sign, the differences in medians were not (Figure 3.b). The Control treatment had later median release dates from 2007 through 2010, but the STF supplement had the later median release dates from 2011 through 2014. A sign test based on the binomial distribution indicated no significant differences in the median release dates (P = 1.0).

Figure 3.b. <u>Median Julian Release Date</u> **for Spring Chinook Smolt from Acclimation Sites and fed with and without Saltwater Transfer Feed supplement (Vita + STF and Vita = Control)**



The tendency of the STF - Control difference for both measures to increase over years is illustrated in Figures 3.c. The significance of the positive trend could be assessed for the means, the trend being nearly significant at the 5% level (P = 0.0544, Appendix Table A.3). The trend with the differences in the medians was even greater.

Figure 3.c. **STF – Control differences in Mean and in Median Smolt Julian Release Dates (Vita + STF and Vita + Control)**

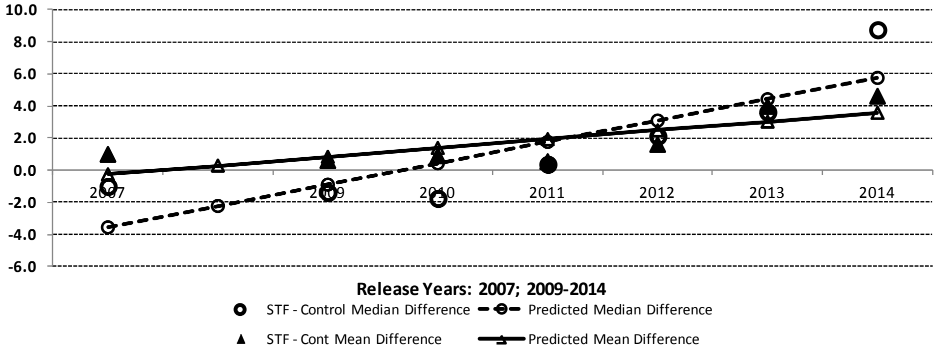


Table 3. **Mean and Median Julian Release Date for Spring Chinook Smolt from Acclimation Sites and fed with and without Saltwater Transfer Feed supplement (Vita + STF and Vita = Control)**

		Adjusted** Means within Sites			
	Brood Year	**2005**	**2007**	**2008**	**2009**
Treatment	**Release Year**	**2007**	**2009**	**2010**	**2011**
STF + Vita	**Julian Release Date**	89.0	111.9	100.9	96.2
	Number Released*	17,426	15,589	15,579	13,941
	Average Median	77.5	109.5	98.9	91.3
Vita	**Julian Release Date**	88.0	111.3	100.0	95.9
	Number Released*	17,370	15,633	15,577	14,459
	Average Median	78.5	110.9	100.6	90.9
	Mean Difference	1.0	0.6	0.9	0.3
	Estimated Type 1 Error Probabitiy (P)	0.9989	0.7128	0.9949	0.9988
	Average Median Difference	-1.00	-1.38	-1.75	0.38

		Adjusted** Means within Sites			Adjusted***
	Brood Year	**2010**	**2011**	**2012**	**Mean**
Treatment	**Release Year**	**2012**	**2013**	**2014**	**over Years**
STF + Vita	**Julian Release Date**	108.0	97.5	104.9	101.1
	Number Released*	15,474	15,329	15,375	108,713
	Average Median	110.1	91.9	108.1	98.2
Vita	**Julian Release Date**	106.4	93.6	101.4	99.4
	Number Released*	15,518	15,432	15,420	109,409
	Average Median	108.0	88.3	99.4	96.6
	Mean Difference	1.6	3.9	3.5	1.7
	Estimated Type 1 Error Probabitiy (P)	0.9887	0.9907	0.9874	**0.0153**
	Average Median Difference	2.13	3.63	8.75	1.5

*** Number detected leaving the acclimation sites = n**

**** Adjusted for the significant effects of Sites, Paired Raceways within Year (for means not medians)**

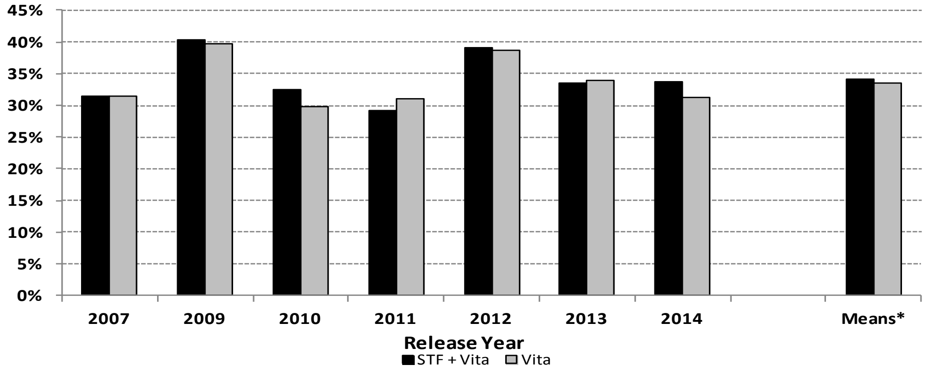
***** Adjusted for the effects of Years, Sites, Year x Site Interaction, and Paired Raceways (for means not medians)**

The average median release date over years is nearly three days earlier than the means for both treatments. Usually a large proportion of smolt volitionally leave the ponds within a very few days of the screens being pulled, tending to skew the distribution of release day to the right, which explains the pooled average of the mean dates of release being later than that of the medians.

Smolt-to-Smolt Survival to McNary Dam

Referring to Figure and Table 4, there was neither a substantial nor significant difference in the year-adjusted smolt-to-smolt survival means of STF-supplemented and unsupplemented treatments nor a significant yearly difference interactions with years (respectively P = 0.3328 and P = 0.3115, Appendix Table A.4).

Figure 4. **<u>Mean Release-to-McNary Smolt-to-Smolt Survival</u> for Spring Chinook Smolt detected leaving Acclimation Sites and fed with and without Saltwater Transfer Feed supplement (Vita + STF and Vita = Control)**



*** Means adjusted for the effects of years**

Table 4. Mean Release-to-McNary Smolt-to-Smolt Survival for Spring Chinook Smolt detected leaving Acclimation Sites and fed with and without Saltwater Transfer Feed supplement (Vita + STF and Vita = Control)

		Adjusted** Means within Sites			
	Brood Year	2005	2007	2008	2009
Treatment	Release Year	2007	2009	2010	2011
STF + Vita	Survival	31.37%	40.3%	32.4%	29.2%
	Number Released*	17,426	15,589	15,579	13,941
Vita	Survival	31.43%	39.7%	29.9%	31.0%
	Number Released*	17,370	15,633	15,577	14,459
	Difference	-0.1%	0.6%	2.5%	-1.8%
	Estimated Type 1 Error Probabitiy (P)***	0.9548	0.5719	0.0541	0.3884

		Adjusted** Means within Sites			Adjusted***
	Brood Year	2010	2011	2012	Treatment
Treatment	Release Year	2012	2013	2014	Means
STF + Vita	Survival	39.1%	33.5%	33.73%	34.2%
	Number Released*	15,474	15,329	15,375	108,713
Vita	Survival	38.7%	34.0%	31.19%	33.6%
	Number Released*	15,518	15,432	15,420	109,409
	Difference	0.4%	-0.4%	2.53%	0.6%
	Estimated Type 1 Error Probabitiy (P)***	0.7650	0.7735	0.2707	0.3228

* Number detected leaving the acclimation sites = n

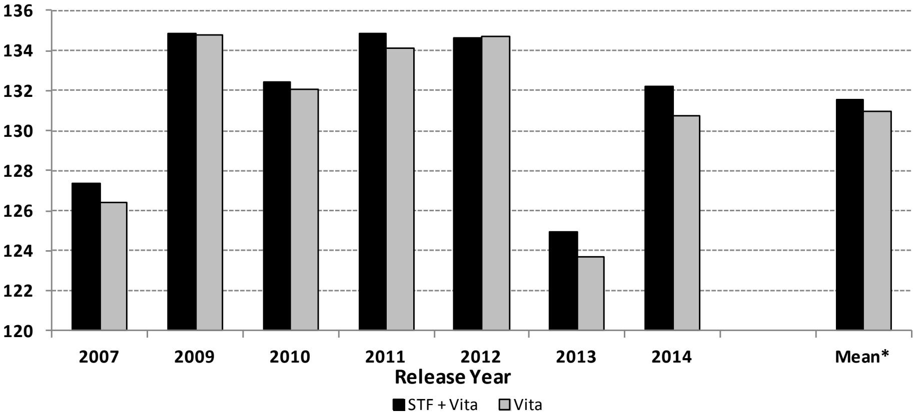
** Adjusted for the significant effects of Sites, Paired Raceways within Year

*** Adjusted for the effects of Years, Sites, Year x Site Interaction, and Paired Raceways

McNary Dam Passage Date

There was neither a significant nor substantial difference between the McNary Dam passage-date means of STF-supplemented and STF-unsupplemented treatments (P = 0.0785, Appendix Table A.5). The individual years treatments' means for each year were nearly equal as was the case for the treatments medians (compare entries in Figures 5.a and 5.b and in Table 5). In the case of medians however, all five of the non-zero differences were associated with a later STF passage date. This approached a significant difference at the 5% level based on the sign test assuming a binomial distribution. (P = 0.0625).

Figure 5.a. **Mean McNary Passage Date Spring Chinook Smolt without and with Saltwater Transfer Feed (STF) supplement and Detected leaving Acclimation Sites**



*** Means adjusted for the effects of years**

Figure 5.b. **Brood-Year 2005, 2007-2011 <u>Median McNary Detection Date</u> for Spring Chinook Smolt fed without and with Saltwater Transfer (STF) supplement**

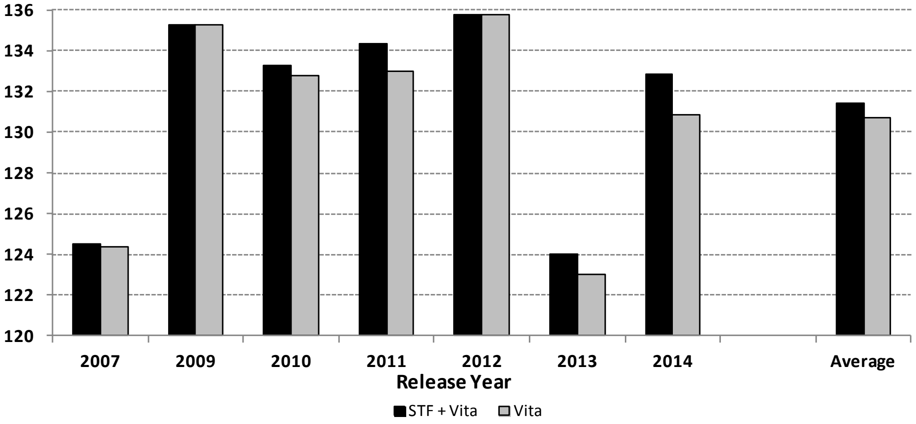


Table 5. **<u>Mean and Median McNary Passage Julian Date</u> for Spring Chinook Smolt detected leaving Acclimation Sites and fed with and without Saltwater Transfer Feed supplement (Vita + STF and Vita = Control)**

		Adjusted** Means within Sites			
	Brood Year	2005	2007	2008	2009
Treatment	Release Year	2007	2009	2010	2011
STF + Vita	Mean Detection Date	127.4	134.9	132.5	134.9
	Estimated Passage*	5,474	6,290	5,053	4,121
	Average Median	124.5	135.3	133.3	134.4
Vita	Mean Detection Date	126.4	134.8	132.1	134.1
	Estimated Passage*	5,465	6,218	4,659	4,480
	Average Median	124.4	135.3	132.8	133.0
Mean Difference		1.0	0.1	0.4	0.8
Estimated Type 1 Error Probabitiy (P)		0.9806	0.7541	0.9907	0.9702
Average Median Difference		0.13	0.00	0.50	1.38

		Adjusted** Means within Sites			Adjusted***
	Brood Year	2010	2011	2012	Mean
Treatment	Release Year	2012	2013	2014	over Years
STF + Vita	Mean Detection Date	134.6	125.0	132.2	131.5
	Estimated Passage*	6,058	5,180	5,204	20,938
	Average Median	135.8	124.0	132.9	131.4
Vita	Mean Detection Date	134.7	123.7	130.7	131.0
	Estimated Passage*	6,021	5,279	4,837	20,822
	Average Median	135.8	123.0	130.9	130.7
Mean Difference		-0.1	1.3	1.5	0.5
Estimated Type 1 Error Probabitiy (P)		0.9988	0.9852	0.9591	0.0785
Average Median Difference		0.00	1.00	2.00	0.7

* Number estimated passing McNary = n

** Adjusted for the significant effects of Sites, Paired Raceways within Year

*** Adjusted for the effects of Years, Sites, Year x Site Interaction, and Paired Raceways

Appendix. Statistical Analysis Tables for the Measures presented in the Text

Table A.1. Least Squares Analysis of Variance of Pre-Release Weight (g) of Spring Chinook Smolt receiving and not receiving STF-supplement

Source	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Square = Dev/DF	F-Ratio	Estimated Type 1 Error (P)	Denominator Mean Deviance Source for F-Ratio
Year (adjusted for Site)	647.80	6	107.97	152.37	**0.0000**	Among Raceway Pairs
Site (adjusted for Year)	13.80	2	6.90	1.77	0.2121	Site x Year
Site x Year	46.80	12	3.90	5.50	**0.0000**	Among Raceway Pairs
Among Raceway Pairs	24.80	35	0.71	1.26	**0.2497**	Residual
Treatment	0.90	1	0.90	1.76	0.1903	Error*
Treatment x Year	1.30	6	0.22	0.38	0.8836	Residual
Treatment x Site	0.10	2	0.05	0.10	0.9070	Treatment x Year x Site
Treatment x Year x Site	6.10	12	0.51	0.90	0.5530	Residual
Residual	19.70	35	0.56			
Error*	27.10	53	0.51			

*** Error = Residual Pooled with the two Treatment x Year interactions because interaction F-Ratios near or less than 1**

Table A.2. Weighted Logistic Analysis of Variation of Proportion of PIT-Tagged Fish detected leaving Acclimation Ponds for Spring Chinook receiving and not receiving STF Supplement Appendix.

(Weight = Number of fish tagged)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	F-Ratio	Estimated Type 1 Error (p)	Denominator Mean Deviance Source for F-Ratio
Year (adjusted for Site)	3842.04	6	640.34	20.22	**0.0000**	Among Raceway Pairs
Site (adjusted for Year)	877.07	2	438.54	1.56	0.2503	Site x Year
Site x Year	3377.89	12	281.49	8.89	**0.0000**	Among Raceway Pairs
Among Raceway Pairs	1108.44	35	31.67	1.17	0.3224	Residual
Treatment	55.24	1	55.24	2.87	0.0963	Error*
Treatment x Year	26.51	6	4.42	0.16	0.9848	Residual
Treatment x Site	78.31	2	39.16	9.94	**0.0028**	Treatment x Year x Site
Treatment x Year x Site	47.25	12	3.94	0.15	0.9995	Residual
Residual	947.39	35	27.07			
Error*	1021.15	53	19.27			

*** Error = Residual Pooled with the two Treatment x Year interactions because interaction F-Ratios near or less than 1**

Table A.3. Weighted Least Squares Analysis of Variance of Julian Volitional-Release Date for Spring Chinook Smolt receiving and not receiving STF-supplement

(Weight = Number of fish detected volitionally leaving the raceways)

Source	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Square = Dev/DF	F-Ratio	Estimated Tye 1 Error (P)	Denominator Mean Deviance Source for F-Ratio
Year (adjusted for Site)	11,787,887	6	1,964,648	33.62	**0.0000**	Among Raceway Pairs
Site (adjusted for Year)	174,764	2	87,382	0.50	0.6205	Site x Year
Site x Year	2,110,958	12	175,913	3.01	**0.0054**	Among Raceway Pairs
Among Raceway Pairs	2,045,113	35	58,432	2.23	**0.0100**	Residual
Treatment (Trt)	151,750	1	151,750	6.28	**0.0153**	Error*
Treatment x Year	92,963	6	15,494	0.64	0.6966	Residual
Trt Difference on Year	*51,668.55*	*1*	*51,669*	*6.26*	***0.0544***	*Remaining Trt x Year*
Remaining Trt x Year	*41,294.45*	*5*	*8,259*	*0.34*	*0.8853*	*Error**
Treatment x Site	12,312	2	6,156	0.27	0.7659	Treatment x Year x Site
Treatment x Year x Site	270,853	12	22,571	0.86	0.5910	Residual
Residual	917,107	35	26,203			
Error*	1,280,923	53	24,168			

*** Error = Residual Pooled with the two Treatment x Year interactions because interaction F-Ratios near or less than 1**

Table A.4. Weighted* Logistic Analysis of the Smolt-to-Smolt Survival to McNary Dam of those PIT-Tagged Fish detected leaving Acclimation Ponds that survived as Adults to Roza Dam for Spring Chinook Smolt receiving and not receiving STF-supplement

(Weight = Expanded number of smolt passing McNary Dam)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	F-Ratio	Estimated Type 1 Error (p)	Denominator Mean Deviance Source for F-Ratio
Year (adjusted for Site)	1279.65	6	213.28	14.72	**0.0000**	Among Raceway Pairs
Site (adjusted for Year)	756.35	2	378.18	19.26	**0.0002**	Site x Year
Site x Year	235.68	12	19.64	1.36	0.2335	Among Raceway Pairs
Among Raceway Pairs	507.24	35	14.49	2.12	**0.0147**	Residual
Treatment	7.40	1	7.40	1.00	0.3228	Error*
Treatment x Year	50.82	6	8.47	1.24	0.3115	Residual
Treatment x Site	23.12	2	11.56	1.34	0.2978	Treatment x Year x Site
Treatment x Year x Site	103.34	12	8.61	1.26	0.2860	Residual
Residual	239.66	35	6.85			
Error*	393.82	53	7.43			

*** Error = Residual Pooled with the two Treatment x Year interactions because interaction F-Ratios near or less than 1**

Table A.5. Weighted Least Squares Analysis of Variance of Expanded Mean Julian McNary-Dam Passage Date for Spring Chinook Smolt receiving and not receiving STF-supplement

(Weight = Number of fish detected volitionally leaving the raceways)

Source	**Sum of Squares (SS)**	**Degrees of Freedom (DF)**	**Mean Square = Dev/DF**	**F-Ratio**	**Estimated Type 1 Error (P)**	**Denominator Mean Deviance Source for F-Ratio**
Year (adjusted for Site)	1,147,655	6	191,276	78.96	**0.0000**	Among Raceway Pairs
Site (adjusted for Year)	89,787	2	44,894	2.11	0.1635	Site x Year
Site x Year	254,822	12	21,235	8.77	**0.0000**	Among Raceway Pairs
Among Raceway Pairs	84,789	35	2,423	1.94	**0.0266**	Residual
Treatment	**5,178**	**1**	**5,178**	**4.49**	**0.0785**	Treatment x Year
Treatment x Year	6,926	6	1,154	0.93	0.4886	Residual
Treatment x Site	**26,130**	**2**	**13,065**	**5.68**	**0.0184**	Treatment x Year x Site
Treatment x Year x Site	**27,597**	**12**	**2,300**	**1.84**	**0.0787**	Residual
Residual	43,646	35	1,247			

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Appendix D
Annual Report: Comparisons between Smolt-Trait Measures of Hatchery x Hatchery- and Natural x Natural-Brood Stock for Brood-Years 2002-2012 Upper Yakima Spring Chinook

Doug Neeley, Consultant to the Yakama Nation

Summary

Hatchery x Hatchery (HxH or Hatchery Control - HC) and Natural x Natural (NxN or Supplemental Hatchery -SH) stock[1] were allocated to Clark Flat acclimation-site raceway pairs. Within each pair, the raceways were assigned different nutritional treatments. This report focuses on the stock comparisons, not the nutrition-treatment comparisons which are presented in different annual reports, although analyses of variation involving nutrition comparisons for Clark Flat are included in the Appendix A.

For brood-years 2002 through 2012 (release-years 2004 through 2014, respectively), the following juvenile traits are analyzed:

1) Pre-release weight
2) Percent of fish detected leaving pond (volitional release)
3) Mean and median acclimation-pond volitional-release date
4) Volitional-release-to-McNary survival
5) Mean and median McNary Dam (McNary) passage date

An incomplete data set for Bacterial Kidney Disease (BKD) incidence levels was also analyzed and is discussed Appendix A.

Of these above enumerated traits, the HxH-NxN main effect differences that were significant at the 5% significance level were:

> The Percent of fish detected leaving the pond, the HxH cross having the lower percentage (and presumably having the lower pre-release survival); and
>
> The McNary mean passage date, the HxH cross having the later date of passage.

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[1] HxH and NxN Stock are part of domestication selection study. The original progenitors of both stocks were wild Upper-Yakima Stock. Both Stocks are reared in the hatchery, but HxH are progeny of hatchery-spawned parents, and NxN are progeny of naturally spawned parents. Protocol dictates that HxH progeny never spawn outside of the hatchery, and NxN progeny are never spawned in the Hatchery.

There was also evidence that the mean date of volitional release from the acclimation ponds was later for the HxH stock.

Introduction

In previous years' annual reports, analyses were summarized for the following traits.

1) Pre-release weight
2) Percent of fish detected leaving pond
3) Mean and median acclimation-pond volitional-release date
4) Volitional-release-to-McNary survival
5) Mean and median McNary Dam (McNary) passage date
7) Pre-release length
8) Pre-release Percent of juveniles that are males
9) Pre-release Percent of males that are precocials (mini-jacks)

NOAA Fisheries had taken prerelease fish samples from which individual fish measures were made on the following of the above: 1) Pre-release weight, 7) Pre-release length, 8) Pre-release percent of juveniles that were males, and 9) Pre-release percent of males that were precocials (mini-jacks). NOAA ceased taking samples from the Cle Elum acclimation ponds beginning with the 2012 brood released in 2014 (they ceased taking samples at two other acclimation sites, Easton and Jack Creek) the year before. However, the hatchery staff has been taking pre-release bulk measures of the weight on a fixed number of smolt, computing number-of-fish/pound. These measures, converted to an average grams/fish are now being used for pre-release weight assessment. The other three traits measured by NOAA Fisheries are no longer included the annual reports.

Further, the analyses presented in this report differ from those in previous reports; those differences are discussed in the next section.

Design of Experiment

The HxH stock assignment was superimposed at only the Clark Flat Acclimation Site at which there were three pairs of raceways[2] with two feed treatments[3] allocated to the different raceways

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[2] Raceways within each pair were similar in that they were physically adjacent to each other and in that they both received progeny from the same sets of diallele crosses, there being different male and female parental sources in diallele crosses assigned to the other raceway pairs. This could result in smolt within raceway pairs being more similar than smolt from different raceway pairs due to genetic and/or parental-effect similarities within pairs.

[3] In every year, two treatments were evaluated. In BY 2002- BY 2004, they were Low and High Nutrition levels (LO and HI), the High level being the standard feed or control. The Low Nutrition was tested to determine whether it would reduce the proportion of male smolt that were sexually mature (mini-jacks). In BY 2005 and 2007 through 2012, the standard feed (Vita) was either supplemented or not supplemented with Salt-

within each pair. The HxH Stock was allocated to one of the three pairs of raceways, and the NxN Stock to the other two pairs[4]. Thus there were twice as many raceways at Clark Flat assigned to the NxN Stock than to the HxH Stock. The design was effectively a Split-Plot design at both the hatchery at Cle Elum and at the acclimation site, Clark Flat, with the Stock assigned to the raceway pairs (main-plot), and the feed levels assigned to raceways within raceway pairs (subplot).

A proportion of fish in each raceway was PIT-tagged for the primary purpose of estimating smolt-to-smolt survival from volitional release to McNary Dam on the Columbia River 70 km below the Yakima River. Beginning with the 2006 brood, there were twice as many HxH fish PIT-tagged per raceway than there were NxN fish to give approximately an equal total number of PIT-tagged fish for both the HxH and NxN stocks at Clark Flat.

Both main effect HxH–NxN differences and the interactions among yearly stock differences with years were tested at the 5% significance level using either a weighted-least-squares analysis of variance or a weighted-logistic-analysis of variation[5]. Year was taken to be a random effect; therefore, the weighted mean HxH-NxN main-effect difference over years was usually tested against the smolt x year interaction, and that interaction was tested against the variation among raceway-pairs within-years.

In all table presentations, the stocks' main-effect means over years were adjusted for year effects. These mean estimates are consistent with the analyses of variance/variation comparison; however, they are not the same mean-over-year estimates presented in past reports[6].

In the past, the analyses included assessments of the effect of the feed treatments as well as their interactions with year and stock effects. In each year, there was a standard feed and a tested feed. Over the eleven years that the HxH/NxN Stock has been conducted there have been changes in the feed used as the tested feed treatment (refer back to footnote 3). There have been some traits for which there have been significant interactions between feed treatment, year, and stock effects. Rather than try to interpret these interactions, the decision was made in this report to use the fish data from only those raceways receiving the standard feed. Analyses are still performed on all treatments, but these analyses are given in the Appendix A. The analyses presented in the main text are those conducted from standard-feed raceways. Two-feed raceway

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water Transfer Feed (STF) to test whether supplementation with STF increased the rate of smoltification. In BY 2006, two feeds (Vita and EWOS) were evaluated.

[4] NxN stock was the only stock used at the other two acclimation sites (i.e., allocated to all three pairs of raceways at both Easton and Jack Creek).

[5] In the case of proportions/percentages, the analysis was a weighted logistic analysis of variation, and for, the other measures, the analysis was a weighted least squares of variance, the weights being the number of observations used to compute the raceway estimates.

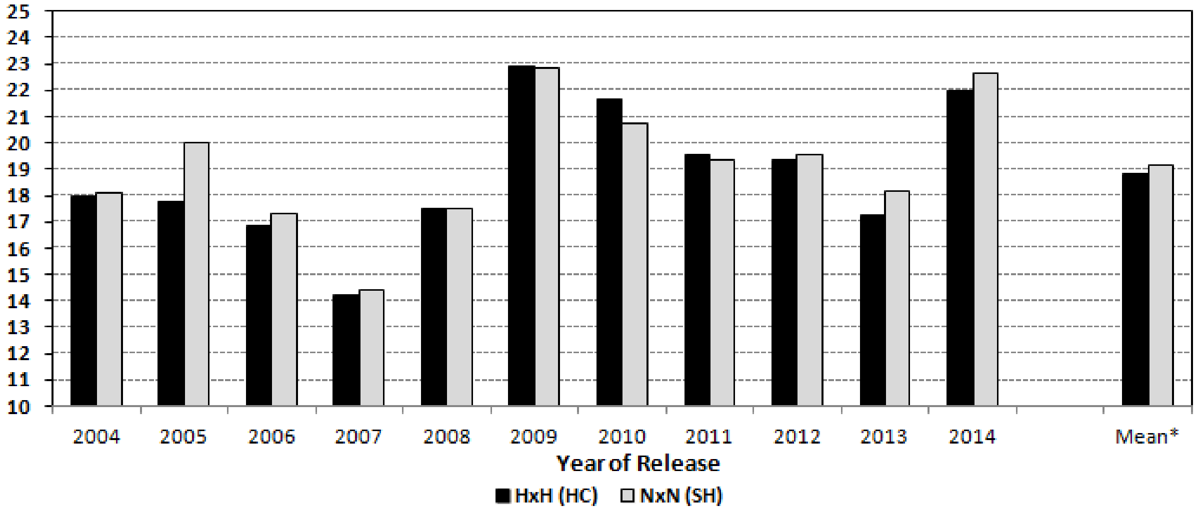
[6] Previous means over years were assessed over all fish over all years (yearly means weighted by the number of fish used to estimate those means). It was stated in previous reports that these were estimates that were consistent with the analyses of variation used. This is not generally this case. The estimates presented in this report are now consistent with the analysis of variation.

analyses are referenced in the main text of this report if there are inconsistencies with the one-feed raceway analysis.

Mean Pre-Release Smolt Weight

Figure 1 and Table 1 present the individual release-year HxH and NxN stock pre-release fish-weight means. There was no significant main-effect difference between stock nor did the yearly HxH-NxN differences significantly interact with years (P =0.2073 and P = 0.1468, respectively, Appendix Table A.1a.).

Figure 1. Mean Pre-Release Weights (g) of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site



* Adjusted for Year Effects

Table 1. Mean Pre-Release Weights (g) of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site

Brood Stock	Brood Year > Release Year >	2002 2004	2003 2005	2004 2006	2005 2007	2006 2008	2007 2009
HxH (HC)	Mean Release Date	17.9	17.8	16.8	14.2	17.5	22.9
NxN (SH)	Mean Release Date	18.1	20.0	17.3	14.4	17.5	22.8
	HxH - NxN Mean Difference	-0.2	-2.3	-0.5	-0.2	0.0	0.1
	Two-Sided Type 1 Error P	0.7636	**0.0024**	0.4192	0.7073	0.9666	0.9134

Brood Stock	Brood Year > Release Year >	2008 2010	2009 2011	2010 2012	2011 2013	2012 2014	Means Adjusted for Years
HxH (HC)	Mean Release Date	21.7	19.5	19.4	17.3	22.0	18.8
NxN (SH)	Mean Release Date	20.7	19.4	19.5	18.2	22.7	19.2
	HxH - NxN Mean Difference	1.0	0.2	-0.1	-0.9	-0.7	-0.3
	Two-Sided Type 1 Error P	0.1197	0.7956	0.8149	0.1454	0.2824	0.2073

Mean Percent of PIT-Tagged fish leaving the Acclimation Site

This measure is simply the ratio between the number of fish detected leaving the acclimation-site raceway and the total number of fish originally tagged and is used here as an index of pre-release survival. This measure is affected by pre-release mortality, pre-release tag-shedding, and the failure of the PIT-tag detector to detect all fish PIT-tagged leaving the pond. The latter can be adjusted for by taking the percent detected leaving the pond and dividing it by a measure of the detection efficiency of the Clark Flat acclimation site's PIT-tag detector. The detection efficiency has been estimated in the past by dividing the number of fish that were jointly detected at Clark Flat and McNary Dam by the total number of Clark Flat Pit-tagged fish detected at McNary. Many of the resulting pre-release survival estimates using this technique were over 100% and converting these to 100% would bias the estimates using logistic regression techniques. Further, the detection deficiencies were always close to 100%. The unadjusted percent of fish detected leaving the pond is now taken as an indicator of pre-release survival. If there is no difference in the PIT-shedding rates between the two stocks and between the rate of the failure of detection between the two stocks, the comparisons between the stocks' percentages should reflect pre-release survival difference.

Figure and Table 2 present the individual year and mean pre-release survival-index (percent released) estimates, The HxH - NxN main effect comparison is negative and significant at the 5% level ($P = 0.0445$, Appendix Table A.2.a). The stock comparisons' interactions with years was not significant at the 5% level but was at the 10% level[7] ($P = 0.0653$, Appendix Table A.2.a). The fact that only one of the eleven stock comparisons within years (brood year 2007, $P = 0.0009$) is significant is not a basis of concern (Table 2.); the fact that, in most years, the HxH stock had a smaller percentage of the fish detected leaving the acclimation ponds is what contributed to the significant main effect difference over years. (Negative differences are boldfaced in addition to the significant levels of $P < 0.05$).

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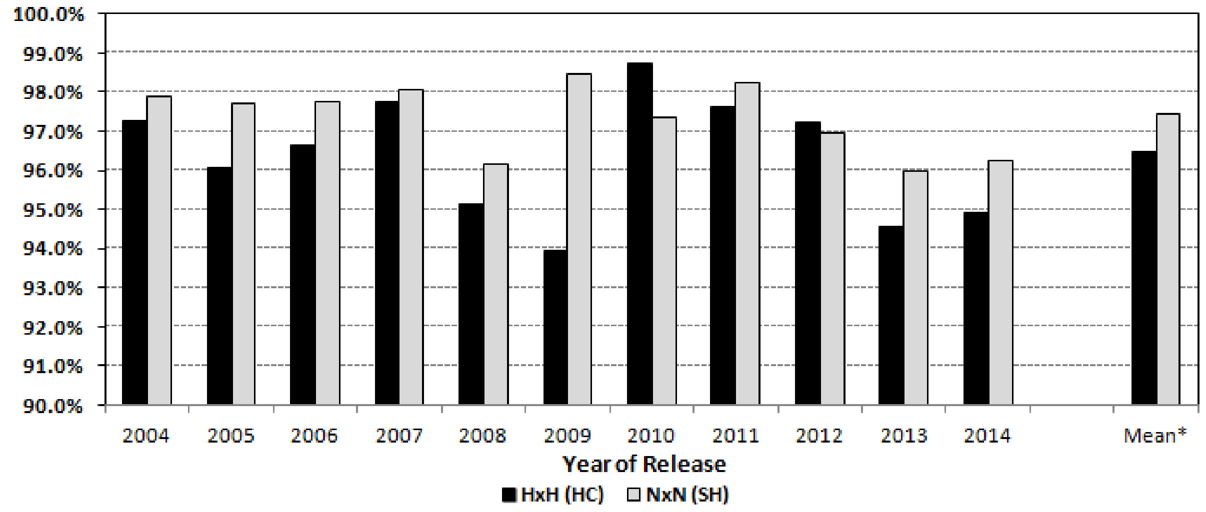
[7] Interactions are less powerfully measured than are main effect comparisons; therefore interaction significance of $P < 0.1$ are noted herein; whereas main effect significance is noted for $P < 0.05$.

Figure 2. Mean Percent of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (single nutrition level)



* Adjusted for Year Effects

Table 2. Mean Percent of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (single nutrition level)

Brood Stock	Brood Year >	2002	2003	2004	2005	2006	2007
	Release Year >	2004	2005	2006	2007	2008	2009
HxH (HC)	Percentage Released	97.3%	96.1%	96.6%	97.7%	95.1%	93.9%
	n (Tagged)	2,223	2,222	2,222	2,222	4,000	4,000
NxN (SH)	Percentage Released	97.9%	97.7%	97.7%	98.1%	96.2%	98.5%
	n (Tagged)	4,446	4,444	4,444	4,450	4,000	4,000
	HxH - NxN Difference	**-0.6%**	**-1.6%**	**-1.1%**	**-0.3%**	**-1.0%**	**-4.6%**
	Type 1 Error P	0.4793	0.1130	0.2452	0.7007	0.3288	**0.0009**

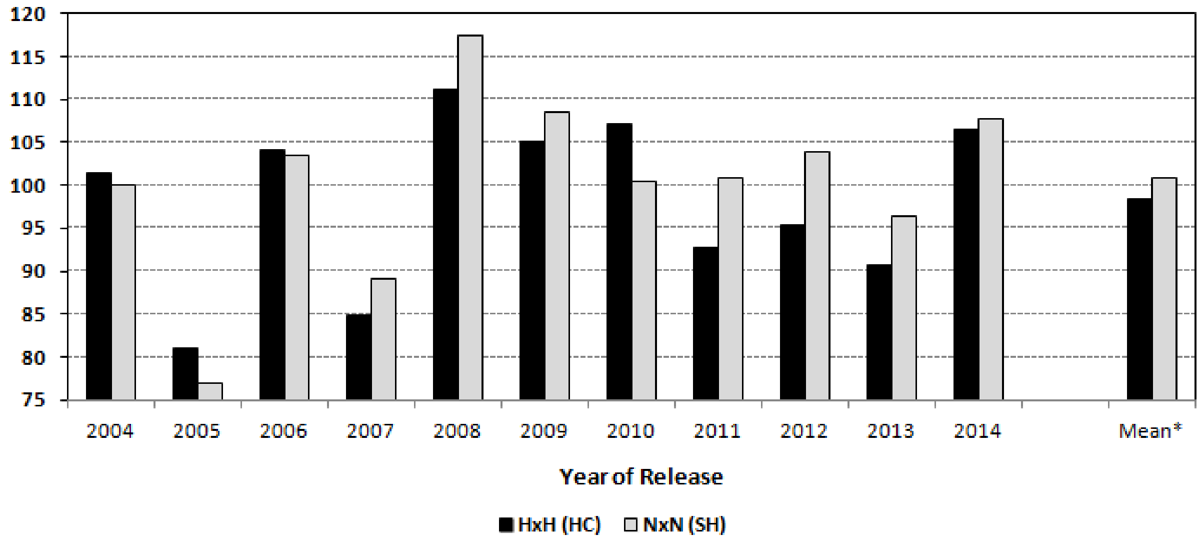
Brood Stock	Brood Year >	2008	2009	2010	2011	2012	Means Adjusted for Years
	Release Year >	2010	2011	2012	2013	2014	
HxH (HC)	Percentage Released	98.7%	97.6%	97.2%	94.6%	94.9%	96.5%
	n (Tagged)	4,000	4,000	4,000	3,999	4,000	
NxN (SH)	Percentage Released	97.3%	98.2%	97.0%	96.0%	96.2%	97.4%
	n (Tagged)	4,000	4,000	4,000	4,000	4,000	
	HxH - NxN Difference	1.4%	**-0.6%**	0.3%	**-1.4%**	**-1.3%**	**-1.0%**
	Type 1 Error P	0.0732	0.4102	0.7668	0.1985	0.2163	**0.0445**

Volitional Release Dates

The mean and median dates of detections of smolt leaving acclimation ponds are given in Figures 3.a and 3.b and are presented in Table 3. Based on means, neither the HxH – NxN Main-Effect-effect nor the HxH – NxN interaction with year were significant (P = 0.1384 and P = 0.1616, respectively; Appendix Table A.3.a.). The less powerful sign test for differences in medians was also not significant (P = 0.2266).

The analysis based on the two levels of feed treatments presented in Appendix 3 resulted in a significant[8] main-effect stock difference (P = 0.0418, Appendix Table A.3.b) with the HxH stock mean release date being a slightly greater number of days later than the NxN stock (2.8 days later, Appendix Table A.3.b) than was the case for the same standard feed analysis (2.5 days later, Table 3). The standard treatment Volitional Release Date results will be discussed further under the McNary Passage Date section.

Figure 3.a. Mean Julian Release Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site



* Adjusted for Year Effects

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[8] The sign-test Type 1 Error P for the sign test for median differences over years was the same for the two feed-treatment treatment analysis (P = 0.2266) and the standard-feed treatment analysis.

Figure 3.b. Median Julian Release Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site

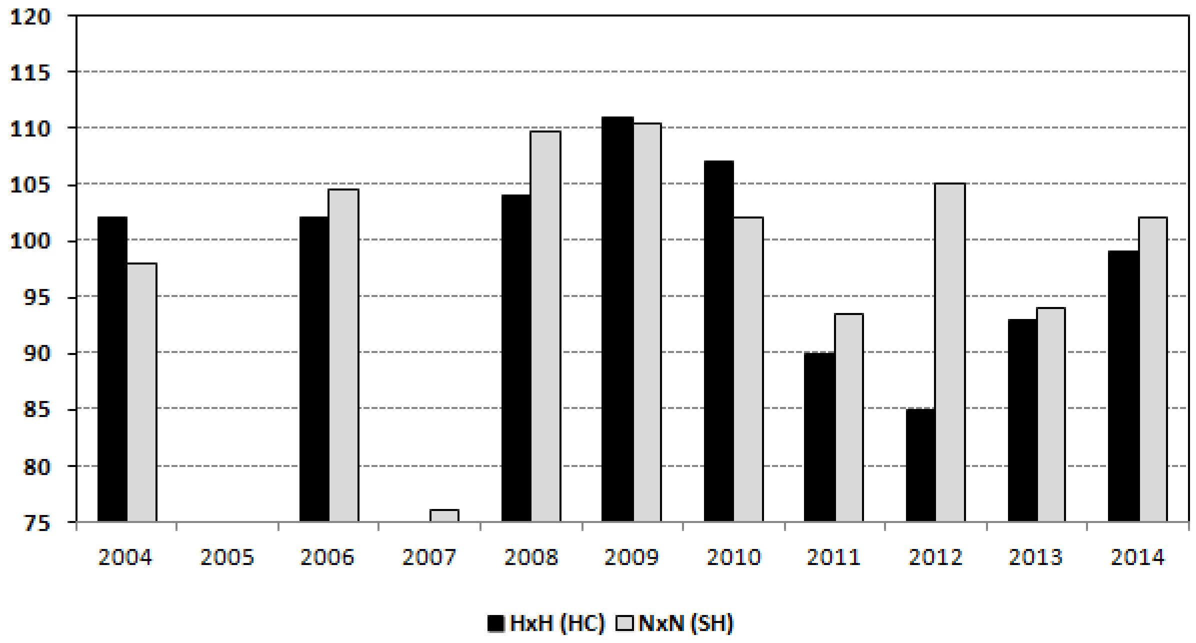


Table 3. Mean and Median Julian Release Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site

Brood	Brood Year >	2002	2003	2004	2005	2006	2007
Stock	Release Year >	2004	2005	2006	2007	2008	2009
HxH (HC)	Mean Release Date	101.5	81.0	104.1	84.9	111.1	105.1
	Median Release Date	102.0	69.0	102.0	74.0	104.0	111.0
	n (Number Released)	2162	2135	2147	2172	3805	3757
NxN (SH)	Mean Release Date	100.0	76.9	103.5	89.1	117.4	108.4
	Median Release Date	98.0	69.0	104.5	76.0	109.7	110.5
	n (Number Released)	4352	4343	4344	4364	3846	3939
	HxH - NxN Mean Difference	1.5	4.1	0.6	**-4.2**	**-6.3**	**-3.3**
	Two-Sided Type 1 Error P	0.7137	0.3406	0.8881	0.3295	0.1081	0.3761
	HxH - NxN Median Difference	4.0	0.0	**-2.5**	**-2.0**	**-5.7**	**0.5**

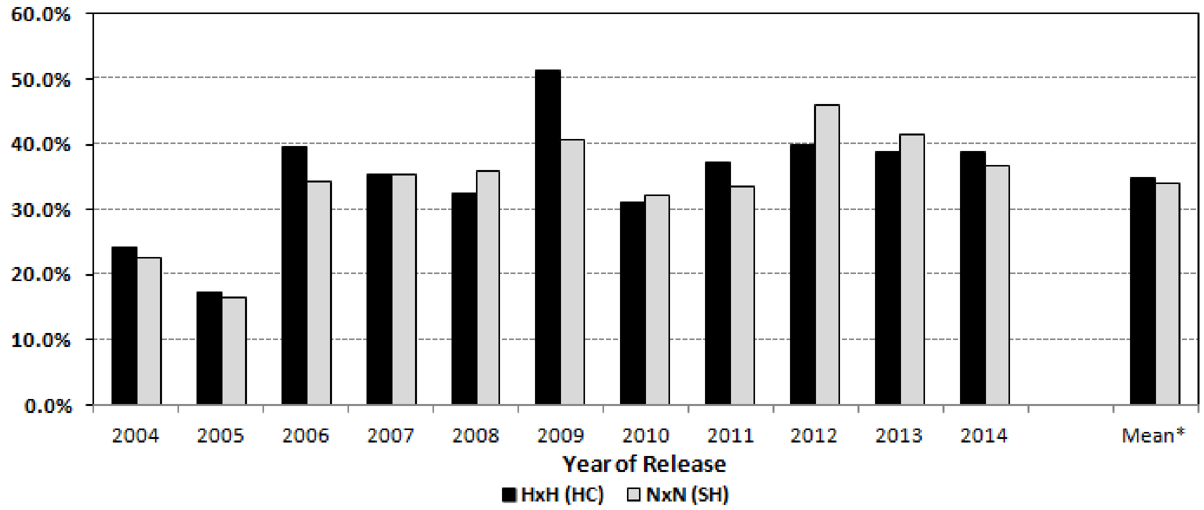
Brood	Brood Year >	2008	2009	2010	2011	2012	Means
Stock	Release Year >	2010	2011	2012	2013	2014	Adjusted for Years
HxH (HC)	Mean Release Date	107.2	92.8	95.3	90.7	106.5	98.4
	Median Release Date	107.0	90.0	85.0	93.0	99.0	
	n (Number Released)	3949	3905	3889	3782	3797	
NxN (SH)	Mean Release Date	100.4	100.8	103.8	96.4	107.8	100.9
	Median Release Date	102.0	93.5	105.0	94.0	102.1	
	n (Number Released)	3894	3929	3879	3840	3850	
	HxH - NxN Mean Difference	6.8	**-8.1**	**-8.5**	**-5.7**	**-1.2**	**-2.5**
	Two-Sided Type 1 Error P	0.0817	**0.0426**	**0.0355**	0.1398	0.7389	0.1384
	HxH - NxN Median Difference	5.0	**-3.5**	**-20.0**	**-1.0**	**-3.1**	

*** Adjusted for Year Effects**

Release-to-McNary Smolt-to-Smolt Survival

The mean Release-to-McNary survival estimates are given in Figure and Table 4. The method of estimating Release-to-McNary Smolt-to Smolt Survival is presented in Appendix B. Neither the HxH – NxN Main-Effect-effect nor the HxH – NxN interaction with year were significant (P = 0.5137 and P = 0.1711, respectively; Appendix Table A.4.a.)

Figure 4. Mean Survival to McNary of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (single nutrition level)



* Adjusted for Year Effects

Table 4. Mean Survival to McNary of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (single nutrition level)

Brood Stock	Brood Year >	2002	2003	2004	2005	2006	2007
	Release Year >	2004	2005	2006	2007	2008	2009
HxH (HC)	Survival Percentage	24.1%	17.4%	39.7%	35.4%	32.4%	51.4%
	n (Detected at Release)	2,162	2,135	2,147	2,172	3,805	3,757
NxN (SH)	Survival Percentage	22.7%	16.6%	34.4%	35.4%	36.0%	40.8%
	n (Detected at Release)	4,352	4,343	4,344	4,364	3,846	3,939
	HxH - NxN Difference	1.4%	0.8%	5.3%	0.0%	-3.5%	10.6%
	Type 1 Error P	0.6724	0.7959	0.1863	0.9988	0.2976	**0.0095**

Brood Stock	Brood Year >	2008	2009	2010	2011	2012	Means Adjusted for Years
	Release Year >	2010	2011	2012	2013	2014	
HxH (HC)	Survival Percentage	31.1%	37.3%	40.0%	38.9%	38.7%	34.9%
	n (Detected at Release)	3,949	3,905	3,889	3,782	3,797	
NxN (SH)	Survival Percentage	32.1%	33.4%	45.9%	41.4%	36.6%	33.9%
	n (Detected at Release)	3,894	3,929	3,879	3,840	3,850	
	HxH - NxN Difference	-1.1%	3.9%	-5.9%	-2.5%	2.1%	0.9%
	Type 1 Error P	0.7364	0.2523	0.1053	0.4672	0.5334	0.5137

Mean McNary-Dam Juvenile-Passage Dates

The mean and median Dates of McNary Passage are given in Figures 5.a. and 5.b and are presented in Table 5. Based on means, both the HxH – NxN Main-Effect-effect difference and the HxH – NxN interaction with year were significant (P = 0.0362 and P = 0.0036, respectively; Appendix Table A.5.a.). The less powerful sign test for differences in medians over years was not significant (P = 0.5588).

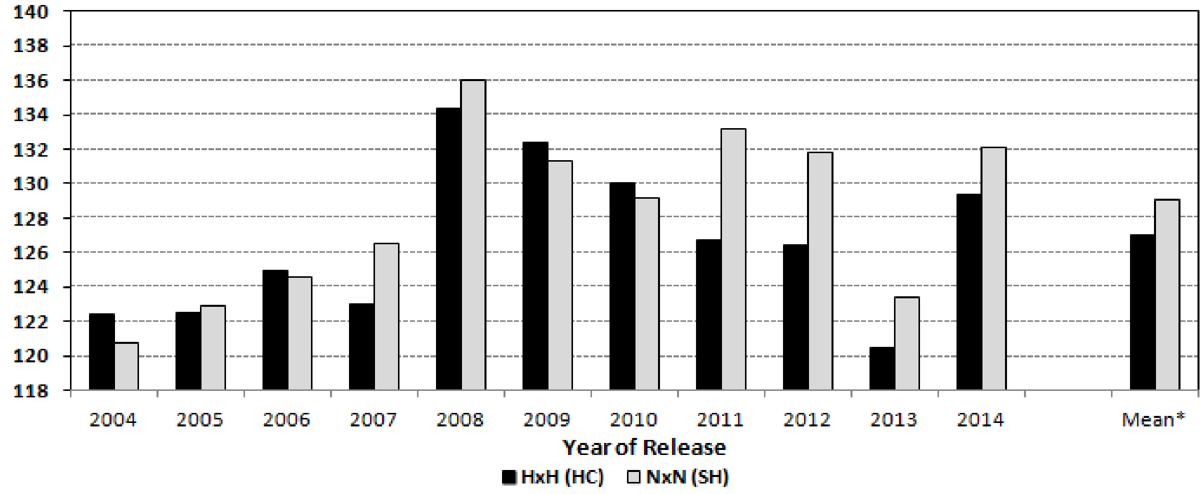
The significant HxH interaction with year reflects the large variation among yearly HxH – NxN differences. While there are years in which the NxN McNary Passage Date is later than that of the HxH stock, there is no indication of significant difference within those years (Table 5). However, among the seven years for which the HxH stock had a later passage date, six had significant differences.

The analyses involving two-feed treatments (Appendix Tables A.5.b. and A.5.c. and Appendix Figures A.5.a and A.5.b) are reasonably consistent with those of the one-treatment analysis presented here except that Main Effect Stock comparison did not quite attain the 5% significance level (P = 0.0503).

The HxH – NxN differences in McNary passage date somewhat mirrors those of the Volitional Release dates. Even though the Release dates didn't result in significant HxH – NxN differences, Pearson's simple linear correlation among the yearly HxH-NxN McNary Passage dates and Volitional Release Date was moderately high and significant (Pearson's correlation coefficient = 0.77, 1-sided P for positive correlation = 0.0028). The correlation among the yearly median differences was even higher (Pearson's correlation coefficient = 0.85).

It is reasonable to conclude that the later HxH McNary Passage Date is largely due to the later Volitional Release Date.

Figure 5.a. Mean Julian McNary-Passage Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site



* Adjusted for Year Effects

Figure 5.b. Median Julian McNary-Passage Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site

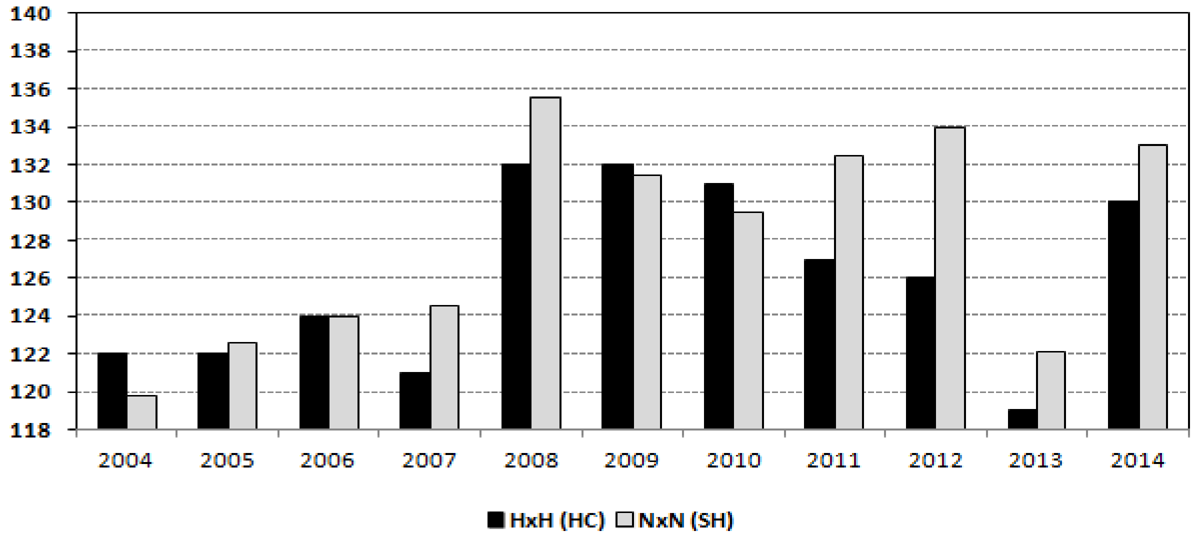


Table 5. Mean and Median Julian McNary-Passage Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site

Brood	Brood Year >	2002	2003	2004	2005	2006	2007
Stock	Release Year >	2004	2005	2006	2007	2008	2009
HxH (HC)	Mean Passage Date	122.4	122.5	125.0	123.0	134.4	132.4
	Median Passage Date	122.0	122.0	124.0	121.0	132.0	132.0
	n (McNary Passage)	521	371	852	769	1234	1930
NxN (SH)	Mean Passage Date	120.7	122.9	124.6	126.5	136.0	131.3
	Median Passage Date	119.8	122.6	124.0	124.5	135.5	131.5
	n (McNary Passage)	987	721	1494	1545	1383	1606
	HxH - NxN Mean Difference	1.7	**-0.3**	0.4	**-3.5**	**-1.7**	1.1
	Two-Sided Type 1 Error	0.3025	0.8555	0.7443	**0.0184**	0.1641	0.2645
	HxH - NxN Median Difference	2.2	**-0.6**	0.0	**-3.5**	**-3.5**	0.5

							Means
Brood	Brood Year >	2008	2009	2010	2011	2012	Adjusted
Stock	Release Year >	2010	2011	2012	2013	2014	for Years
HxH (HC)	Mean Passage Date	130.1	126.7	126.4	120.5	129.4	127.0
	Median Passage Date	131.0	127.0	126.0	119.0	130.0	
	n (McNary Passage)	1226	1455	1556	1473	1470	
NxN (SH)	Mean Passage Date	129.2	133.2	131.8	123.4	132.1	129.1
	Median Passage Date	129.5	132.5	133.9	122.1	133.0	
	n (McNary Passage)	1251	1312	1780	1592	1409	
	HxH - NxN Mean Difference	0.9	**-6.4**	**-5.4**	**-2.9**	**-2.7**	**-2.0**
	Two-Sided Type 1 Error P	0.4548	**0.0001**	**0.0002**	**0.0158**	**0.0265**	**0.0362**
	HxH - NxN Median Difference	1.5	**-5.5**	**-7.9**	**-3.1**	**-3.0**	

Appendix A. Analyses of Variation for the Analyzed Measures

Within each of the measured-trait sections below, the first table presented is the analysis involving only the standard feed-treatment over years. These tables provide the Type 1 Error probabilities given for the main-effect means adjusted for years in the text.

The other tables and the figures presented within the measured-trait sections below relate to the analyses involving the two treatment levels. Both main-plot and sub-plot analyses are presented, but only the main-plot analyses are referred to in the main text. The yearly HxH and NxN means presented in the two-treatment level analyses represent means over the treatments that were assigned to the raceways within raceway pairs. The source of variation in split-plot design analyses that is usually referred to as “Main-Plot Error” is referred to as “Among Raceway Pair” in this report for both the standard-feed and two-level feed analyses (the first two tables within each of the following sections). The source of variation usually referred to as “Subplot Error” in spilt-plot analyses is simply referred to as “Error” in the two-treatment analyses presented in the second of those two tables. The subplot analyses are slightly shaded in those sections.

In each main-plot analysis, the HxH versus (vs) NxN (stock) main-effect comparison is always tested against Year x Stock interaction source. The Year x Stock interaction is tested against the “Among Raceway” source. In the two-treatment analyses, the “Among Raceway Source” is tested against the sub-plot analysis “Error” source. For several traits measured, the “Among Raceway Pair” measure (Mean Square or Mean Deviance) is significantly greater than the “Error” measure. This is discussed in the last section of this appendix (6. Raceway Pair Comparisons) wherein an analysis of BKD load is also discussed.

Appendix A (continued)

1. Fish Weight

Table A.1.a. Mean Pre-Release Weights (g) of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-Reared at the Clark Flat Acclimation Site*

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (DSS/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**181.20**	**10**	**18.12**	**80**	**0.0000**	**Among Raceway Pairs**
Stock	0.80	1	0.80	1.82	0.2073	Stock x Year
Stock x Year	4.40	10	0.44	1.94	0.1468	Among Raceway Pairs
Among Raceway Pairs	2.50	11	0.23			

***Single Feed Treatment Level**

Table. A.1.b. Analysis of Variance of Pre-Release Weight (g) of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared at the Clark Flat Acclimation Site (2nd factor: 2 yearly nutrition levels)

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (DSS/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**443.70**	**10**	**44.37**	**139**	**0.0000**	**Among Raceway Pairs**
Stock	0.10	1	0.10	0.16	0.6987	Stock x Year
Stock x Year	6.30	10	0.63	1.98	0.1389	Among Raceway Pairs
Among Raceway Pairs	3.50	11	0.32	1.05	0.4678	Error
Low-High	**87.95**	**1**	**88**	**105.96**	**0.0093**	**Low-High x Year**
Stock x Low-High	2.10	1	2.10	4.57	0.1661	Stock x Low-High x Year
Low-High x Year: 2004-2006	**1.66**	**2**	**0.83**	**20.75**	**0.0175**	**Error from Low-High Trials**
Stock x Low-High x Year: 2004-2006	**0.92**	**2**	**0.46**	**11.50**	**0.0392**	**Error from Low-High Trials**
EWAS-BIO (2008)	0.51	1	0.51	1.68	0.2209	Error from EWAS - Bio Trial
Stock x EWAS-BIO	0.25	1	0.25	0.83	0.3830	Error from EWAS - Bio Trial
STF-BIO	0.60	1	0.60	0.62	0.4608	STF-BIO x Year
Stock x STF-BIO	0.00	1	0.00	0.00	1.0000	Stock x STF-BIO x Year
STF-BIO x Year: 2007,2009-2014	5.80	6	0.97	2.26	0.1149	Error from STF - Bio Trials
Stock x STF-BIO x Year: 2007,2009-2014	2.60	6	0.43	1.43	0.2865	Error from STF - Bio Trials
Error	3.33	11	0.30			

Appendix A (continued)

Table A.1.c. Mean Pre-Release Weights (g) of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared at the Clark Flat Acclimation Site

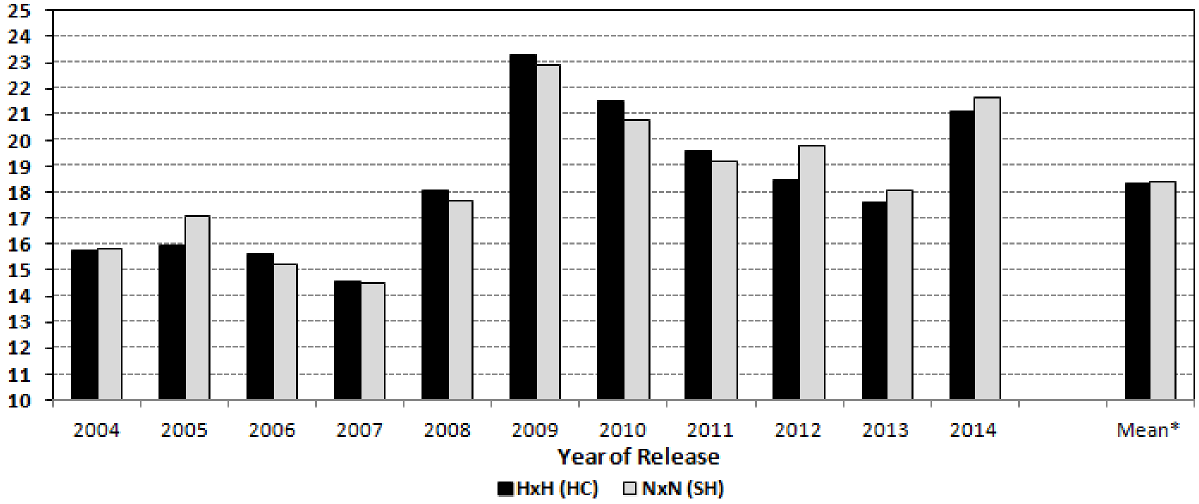
(2nd factor: nutrition levels)

	Brood Year >	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
	Release Year >	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	Nutrition Treatments Assessed >	Low versus (vs) High Nutrtition Level			**STF + VITA vs VITA**	**EWOS vs Vita**	**STF + VITA vs VITA**
HxH (HC)	**Mean Release Date**	15.7	16.0	15.6	14.6	18.1	23.3
NxN (SH)	**Mean Release Date**	15.8	17.1	15.2	14.5	17.7	22.9
	HxH - NxN Mean Difference	-0.1	-1.1	0.4	0.1	0.4	0.4
	Two-Sided Type 1 Error P	0.8105	**0.0441**	0.3819	0.8337	0.4219	0.4219

	Brood Year >	**2008**	**2009**	**2010**	**2011**	**2012**	**Means adjusted for Year Effects**
	Release Year >	**2010**	**2011**	**2012**	**2013**	**2014**	
	Nutrition Treatments Assessed >			**STF + VITA vs VITA**			
HxH (HC)	**Mean Release Date**	21.5	19.6	18.5	17.6	21.1	18.3
NxN (SH)	**Mean Release Date**	20.8	19.2	19.8	18.1	21.6	18.4
	HxH - NxN Mean Difference	0.8	0.4	-1.3	-0.5	-0.5	-0.1
	Two-Sided Type 1 Error P	0.1445	0.4387	**0.0198**	0.3567	0.3012	0.6987

Figure A.1. Mean Pre-Release Weights (g) of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared at the Clark Flat Acclimation Site

(2nd factor: nutrition levels)



* Adjusted for Year Effects

Appendix A (continued)

2. Percent Released

Table. A.2.a. Logistic Analysis of Variation Table for Percent of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site*

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**272.54**	**10**	**27.25**	**5.68**	**0.0041**	**Among Raceway Pairs**
Stock	**66.22**	**1**	**66.22**	**5.28**	**0.0445**	**Stock x Year**
Stock x Year	125.49	10	12.55	2.61	0.0653	Among Raceway Pairs
Among Raceway Pairs	52.82	11	4.80			

***Single Feed Treatment Level**

Table. A.2.b. Logistic Analysis of Variation Table for Percent of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: 2 yearly nutrition levels)

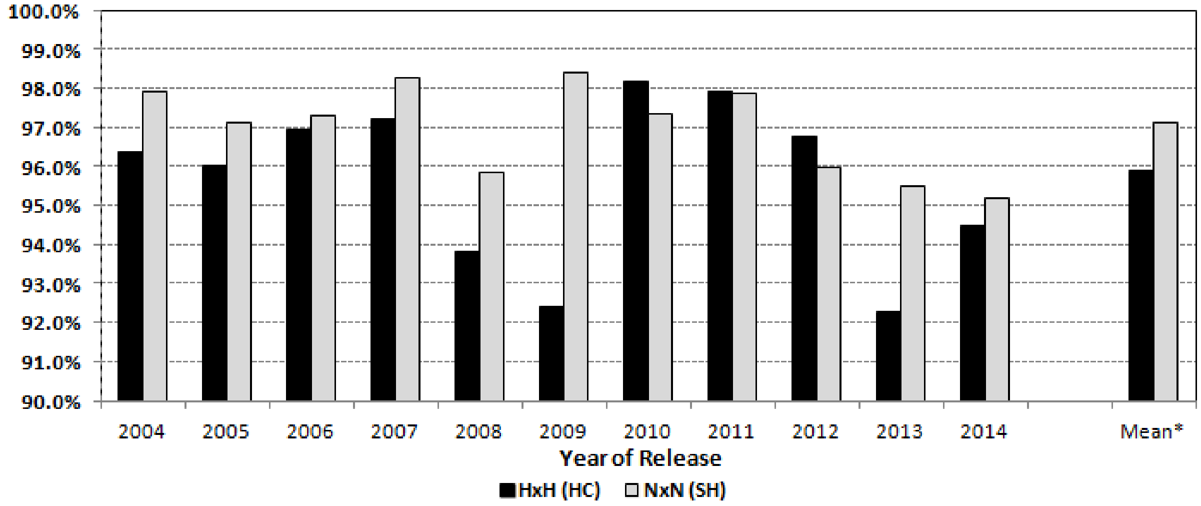
Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**884.21**	**10**	**88.42**	**8.03**	**0.0009**	**Among Raceway Pairs**
Stock	**199.12**	**1**	**199.12**	**5.77**	**0.0372**	**Stock x Year**
Stock x Year	**345.18**	**10**	**34.52**	**3.14**	**0.0370**	**Among Raceway Pairs**
Among Raceway Pairs	**121.08**	**11**	**11.01**	**6.18**	**0.0027**	**Error**
Low-High	**10.69**	**1**	**10.69**	**25.15**	**0.0375**	**Low-High x Year**
Stock x Low-High	1.57	1	1.57	0.21	0.6889	Stock x Low-High x Year
Low-High x Year: 2004-2006	0.85	2	0.425	2.41	0.1359	Error from Low-High Trials
Stock x Low-High x Year: 2004-2006	**14.65**	**2**	**7.325**	**4.11**	**0.0464**	**Error from Low-High Trials**
EWAS-BIO (2008)	**20.13**	**1**	**20.13**	**11.30**	**0.0063**	**Error from EWAS - Bio Trial**
Stock x EWAS-BIO	4.23	1	4.23	2.38	0.1515	Error from EWAS - Bio Trial
STF-BIO	**99.67**	**1**	**99.67**	**27.84**	**0.0019**	**STF-BIO x Year**
Stock x STF-BIO	3.37	1	3.37	0.48	0.5139	Stock x STF-BIO x Year
STF-BIO x Year: 2007,2009-2014	21.48	6	3.58	1.67	0.2191	Error from STF - Bio Trials
Stock x STF-BIO x Year: 2007,2009-2014	**42.04**	**6**	**7.01**	**3.93**	**0.0239**	**Error from STF - Bio Trials**
Error	19.59	11	1.78			

Table 2.c. Mean Percent of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: nutrition levels)

Brood Stock							
	Brood Year >	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
	Release Year >	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	Nutrition Treatments Assessed >	**Low versus (vs) High Nutrtition Level**			**STF + VITA vs VITA**	**EWOS vs Vita**	**STF + VITA vs VITA**
HxH (HC)	**Percentage Released**	96.4%	96.1%	97.0%	97.2%	93.9%	92.4%
	n (Tagged)	4,446	4,444	4,444	4,444	8,000	8,000
NxN (SH)	**Percentage Released**	97.9%	97.2%	97.3%	98.3%	95.9%	98.4%
	n (Tagged)	8,892	8,888	8,888	8,900	8,000	8,000
	HxH - NxN Difference	**-1.5%**	**-1.1%**	**-0.4%**	**-1.1%**	**-2.0%**	**-6.0%**
	Type 1 Error P	0.1493	0.3282	0.7279	0.2461	0.1123	**0.0004**

Brood Stock							**Means adjusted for Year Effects**
	Brood Year >	**2008**	**2009**	**2010**	**2011**	**2012**	
	Release Year >	**2010**	**2011**	**2012**	**2013**	**2014**	
	Nutrition Treatments Assessed >	**STF + VITA vs VITA**					
HxH (HC)	**Percentage Released**	98.2%	98.0%	96.8%	92.3%	94.5%	95.9%
	n (Tagged)	8,000	8,000	8,000	7,998	8,000	
NxN (SH)	**Percentage Released**	97.4%	97.9%	96.0%	95.5%	95.2%	97.1%
	n (Tagged)	8,000	8,000	8,000	8,000	8,000	
	HxH - NxN Difference	0.8%	0.1%	0.8%	**-3.2%**	**-0.7%**	-1.2%
	Type 1 Error P	0.3118	0.9350	0.4386	**0.0271**	0.5656	**0.0372**

Figure A.2. Mean Percent of Hatchery-Brood HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: nutrition levels)



* Adjusted for Year Effects

3. Release Date

Table. A.3.a. Analysis of Variance of Mean McNary Julian Passage Date for Propotrion of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site*

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (DSS/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**6,960,153**	**10**	**696,015**	**28**	**0.0000**	**Among Raceway Pairs**
Stock	117,875	1	117,875	2.59	0.1384	Stock x Year
Stock x Year	454,454	10	45,445	1.86	0.1616	Among Raceway Pairs
Among Raceway Pairs	268,761	11	24,433			

***Single Feed Treatment Level**

Table. A.3.b. Analysis of Variance of Mean Release Date of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: 2 yearly nutrition levels)

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (DSS/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**14,690,619**	**10**	**1,469,062**	**41**	**0.0000**	**Among Raceway Pairs**
Stock	**298,731**	**1**	**298,731**	**5.45**	**0.0418**	**Stock x Year**
Stock x Year	548,292	10	54,829	1.55	0.2418	Among Raceway Pairs
Among Raceway Pairs	389,485	11	35,408	1.95	0.1423	Error
Low-High	**119,981**	**1**	**119,981**	**19.41**	**0.0479**	**Low-High x Year**
Stock x Low-High	16375.00	1	16375.00	0.51	0.5500	Stock x Low-High x Year
Low-High x Year: 2004-2006	12365.00	2	6182.50	0.29	0.7660	Error from Low-High Trials
Stock x Low-High x Year: 2004-2006	64495.70	2	32247.85	1.52	0.3498	Error from Low-High Trials
EWAS-BIO (2008)	574.90	1	574.90	0.03	0.8621	Error from EWAS - Bio Trial
Stock x EWAS-BIO	13135.41	1	13135.41	0.72	0.4136	Error from EWAS - Bio Trial
STF-BIO	71438.00	1	71438.00	3.83	0.0981	STF-BIO x Year
Stock x STF-BIO	1186.00	1	1186.00	0.14	0.7223	Stock x STF-BIO x Year
STF-BIO x Year: 2007,2009-2014	111923.00	6	18653.83	0.99	0.4794	Error from STF - Bio Trials
Stock x STF-BIO x Year: 2007,2009-2014	51277.00	6	8546.17	0.47	0.8172	Error from STF - Bio Trials
Error	200122.19	11	18,192.93			

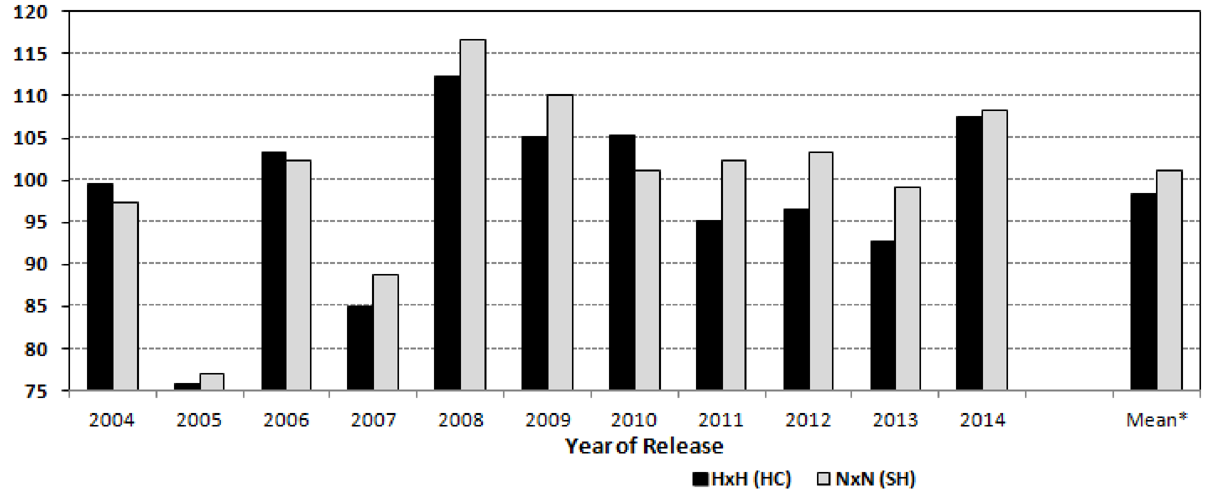
Table A.3.c. Mean and Median Julian Release Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: nutrition levels)

	Brood Year >	2002	2003	2004	2005	2006	2007
	Release Year >	2004	2005	2006	2007	2008	2009
Brood Stock	Nutrition Treatments Assessed >	Low versus (vs) High Nutrtition Level			STF + VITA vs VITA	EWOS vs Vita	STF + VITA vs VITA
HxH (HC)	Mean Release Date	99.5	75.8	103.2	84.9	112.3	105.1
	Median Release Date	99.0	68.5	103.5	74.0	104.5	110.5
	n (Number Released)	4286	4269	4311	4322	7508	7395
NxN (SH)	Mean Release Date	97.3	77.0	102.2	88.8	116.7	110.1
	Median Release Date	96.8	69.0	104.0	75.3	115.4	108.0
	n (Number Released)	8707	8637	8651	8743	7669	7875
	HxH - NxN Mean Difference	2.2	**-1.1**	1.0	**-3.9**	**-4.4**	**-5.0**
	Two-Sided Type 1 Error P	0.5351	0.7509	0.7813	0.2885	0.1767	0.1296
	HxH - NxN Median Difference	2.3	**-0.5**	**-0.5**	**-1.3**	**-10.9**	**2.5**

	Brood Year >	2008	2009	2010	2011	2012	Means adjusted for Year Effects
	Release Year >	2010	2011	2012	2013	2014	
Brood Stock	Nutrition Treatments Assessed >	STF + VITA vs VITA					
HxH (HC)	Mean Release Date	105.2	95.0	96.5	92.8	107.5	98.2
	Median Release Date	106.0	90.5	87.5	94.0	99.5	
	n (Number Released)	7855	7836	7743	7381	7562	
NxN (SH)	Mean Release Date	101.1	102.4	103.4	99.2	108.3	101.0
	Median Release Date	102.8	98.3	106.3	94.2	109.5	
	n (Number Released)	7789	7831	7680	7641	7616	
	HxH - NxN Mean Difference	4.2	**-7.3**	**-6.8**	**-6.4**	**-0.9**	**-2.8**
	Two-Sided Type 1 Error P	0.1949	**0.0332**	**0.0454**	0.0619	0.7821	**0.0418**
	HxH - NxN Median Difference	3.2	**-7.8**	**-18.8**	**-0.3**	**-10.0**	

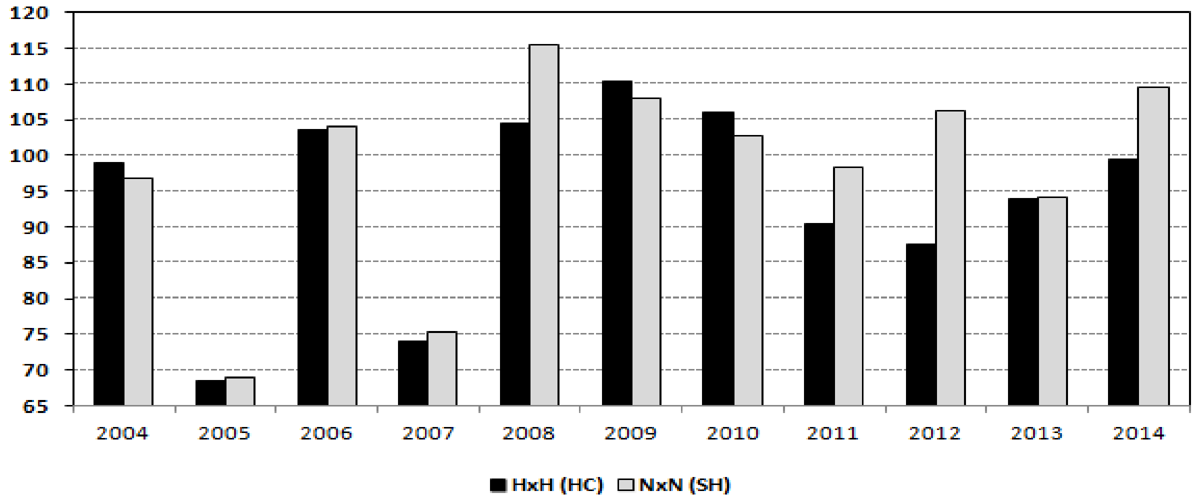
Appendix A (continued)

Figure A.3.a. Mean Julian Release Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: nutrition levels)



* Adjusted for Year Effects

Figure A.3.b. Median Julian Release Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: nutrition levels)



Appendix A (continued)

4. McNary Survival

Table. A.4.a. Logistic Analysis of Variation Table for Survival to McNary of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site*

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**2242.26**	**10**	**224.23**	**25.50**	**0.0000**	**Among Raceway Pairs**
Stock	7.32	1	7.32	0.46	0.5137	Stock x Year
Stock x Year	159.63	10	15.96	1.82	0.1711	Among Raceway Pairs
Among Raceway Pairs	96.73	11	8.79			

***Single Feed Treatment Level**

Table. A.4.b. Logistic Analysis of Variation Table for Survival to McNary of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: 2 yearly nutrition levels)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**4975.04**	**10**	**497.50**	**32.31**	**0.0000**	**Among Raceway Pairs**
Stock	1.63	1	1.63	0.08	0.7865	Stock x Year
Stock x Year	210.61	10	21.06	1.37	0.3067	Among Raceway Pairs
Among Raceway Pairs	169.36	11	15.40	2.53	0.0693	Pooled Error
Low-High	83.96	1	83.96	9.51	0.0910	Low-High x Year
Stock x Low-High	0.23	1	0.23	0.08	0.8012	Stock x Low-High x Year
Low-High x Year: 2004-2006	17.65	2	8.825	1.64	0.2374	Error from Low-High Trials
Stock x Low-High x Year: 2004-2006	5.59	2	2.795	0.46	0.6431	Error from Low-High Trials
EWAS-BIO (2008)	5.82	1	5.82	0.96	0.3489	Error from EWAS - Bio Trial
Stock x EWAS-BIO	5.73	1	5.73	0.94	0.3525	Error from EWAS - Bio Trial
STF-BIO	15.68	1	15.68	1.23	0.3103	STF-BIO x Year
Stock x STF-BIO	2.94	1	2.94	0.20	0.6715	Stock x STF-BIO x Year
STF-BIO x Year: 2007,2009-2014	76.64	6	12.77	1.77	0.1947	Error from STF - Bio Trials
Stock x STF-BIO x Year: 2007,2009-2014	88.83	6	14.81	2.43	0.0954	Error from STF - Bio Trials
Pooled Error	66.89	11	6.08			

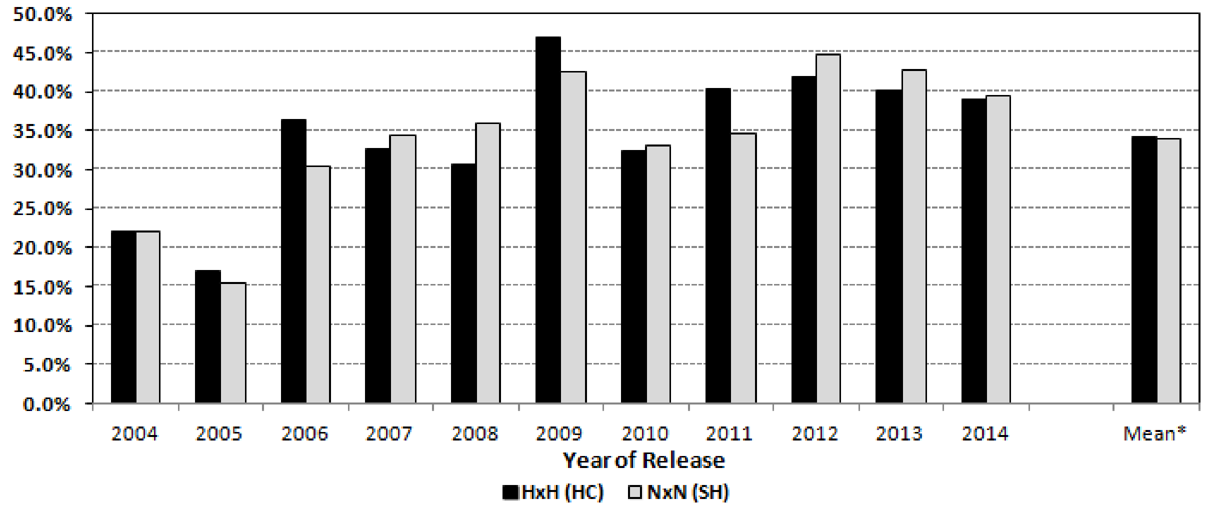
Appendix A (continued)

Table A.4.c. Mean Survival to McNary of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: nutrition levels)

	Brood Year >	2002	2003	2004	2005	2006	2007
	Release Year >	2004	2005	2006	2007	2008	2009
Brood Stock	Nutrition Treatments Assessed >	Low versus (vs) High Nutrition Level			STF + VITA vs VITA	EWOS vs Vita	STF + VITA vs VITA
HxH (HC)	Survival Percentage	22.1%	17.1%	36.4%	32.7%	30.7%	47.0%
	n (Detected at Release)	4,286	4,269	4,311	4,322	7,508	7,395
NxN (SH)	Survival Percentage	22.0%	15.4%	30.4%	34.4%	35.9%	42.7%
	n (Detected at Release)	8,707	8,637	8,651	8,743	7,669	7,875
	HxH - NxN Difference	0.2%	1.7%	6.0%	-1.7%	-5.2%	4.3%
	Type 1 Error P	0.9503	0.5501	0.1101	0.6295	0.1087	0.1972

	Brood Year >	2008	2009	2010	2011	2012	Means adjusted for Year Effects
	Release Year >	2010	2011	2012	2013	2014	
Brood Stock	Nutrition Treatments Assessed >	STF + VITA vs VITA					
HxH (HC)	Survival Percentage	32.4%	40.3%	41.8%	40.2%	39.1%	34.2%
	n (Detected at Release)	7,855	7,836	7,743	7,381	7,562	
NxN (SH)	Survival Percentage	33.1%	34.5%	44.7%	42.9%	39.4%	33.9%
	n (Detected at Release)	7,789	7,831	7,680	7,641	7,616	
	HxH - NxN Difference	-0.7%	5.8%	-2.9%	-2.6%	-0.3%	0.3%
	Type 1 Error P	0.8126	0.0844	0.3799	0.4191	0.9268	0.7865

Figure A.4. Mean Survival to McNary of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: nutrition levels)



* Adjusted for Year Effects

Appendix A (continued)

5. McNary Passage Date

Table. A.5.a. Analysis of Variance of Mean McNary Julian Passage Date for Propotion of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site*

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (DSS/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**481,468**	**10**	**48,147**	**59**	**0.0000**	**Among Raceway Pairs**
Stock	**27,917**	**1**	**27,917**	**5.84**	**0.0362**	**Stock x Year**
Stock x Year	**47,764**	**10**	**4,776**	**5.86**	**0.0036**	**Among Raceway Pairs**
Among Raceway Pairs	8,968	11	815			

***Single Feed Treatment Level**

Table. A.5.b. Analysis of Variance of Mean McNary Julian Passage Date of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: 2 yearly nutrition levels)

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (DSS/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**756,999**	**10**	**75,700**	**40**	**0.0000**	**Among Raceway Pairs**
Stock	43,209	1	43,209	4.95	0.0503	Stock x Year
Stock x Year	**87,329**	**10**	**8,733**	**4.58**	**0.0097**	**Among Raceway Pairs**
Among Raceway Pairs	**20,972**	**11**	**1,907**	**2.83**	**0.0495**	**Error**
Low-High	**12,270**	**1**	**12,270**	**37.83**	**0.0254**	**Low-High x Year**
Stock x Low-High	335.57	1	335.57	2.77	0.2380	Stock x Low-High x Year
Low-High x Year: 2004-2006	648.64	2	324.32	1.03	0.3881	Error from Low-High Trials
Stock x Low-High x Year: 2004-2006	242.40	2	121.20	0.18	0.8379	Error from Low-High Trials
EWAS-BIO (2008)	499.34	1	499.34	0.74	0.4079	Error from EWAS - Bio Trial
Stock x EWAS-BIO	2175.85	1	2175.85	3.23	0.1000	Error from EWAS - Bio Trial
STF-BIO	1534.00	1	1534.00	0.29	0.6096	STF-BIO x Year
Stock x STF-BIO	3779.30	1	3779.30	0.59	0.4729	Stock x STF-BIO x Year
STF-BIO x Year: 2007,2009-2014	**31740.30**	**6**	**5290.05**	**5.88**	**0.0058**	**Error from STF - Bio Trials**
Stock x STF-BIO x Year: 2007,2009-2014	**38679.55**	**6**	**6446.59**	**9.56**	**0.0008**	**Error from STF - Bio Trials**
Error	7419.054	11	674.46			

Appendix 1 (continued)

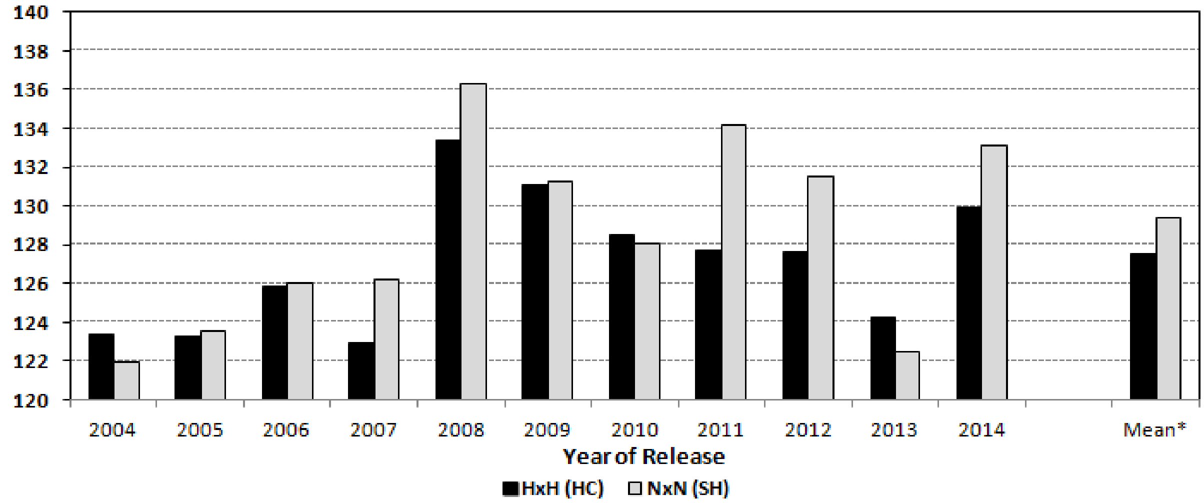
Table A.5.c. Mean and Median Julian Passage Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: nutrition levels)

	Brood Year >	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
	Release Year >	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Brood Stock	**Nutrition Treatments Assessed >**	**Low versus (vs) High Nutrtition Level**			**STF + VITA vs VITA**	**EWOS vs Vita**	**STF + VITA vs VITA**
HxH (HC)	**Mean Passage Date**	123.3	123.2	125.8	122.9	133.4	131.0
	Median Passage Date	122.9	122.5	124.9	121.0	131.5	131.1
	n (McNary Passage)	949	728	1569	1413	2302	3476
NxN (SH)	**Mean Passage Date**	122.0	123.5	126.0	126.2	136.3	131.3
	Median Passage Date	121.3	123.0	125.5	124.0	136.0	131.5
	n (McNary Passage)	1911	1330	2634	3009	2753	3360
	HxH - NxN Mean Difference	1.4	**-0.3**	**-0.2**	**-3.3**	**-2.9**	**-0.2**
	Two-Sided Type 1 Error P	0.4388	0.8865	0.8834	**0.0386**	**0.0383**	0.8259
	HxH - NxN Median Difference	1.6	-0.5	-0.6	-3.0	-4.5	-0.4

	Brood Year >	**2008**	**2009**	**2010**	**2011**	**2012**	**Means adjusted for Year Effects**
	Release Year >	**2010**	**2011**	**2012**	**2013**	**2014**	
Brood Stock	**Nutrition Treatments Assessed >**	**STF + VITA vs VITA**					
HxH (HC)	**Mean Passage Date**	128.5	127.7	127.6	124.2	129.9	127.6
	Median Passage Date	128.4	128.1	128.1	124.0	130.5	
	n (McNary Passage)	2545	3157	3239	2967	2956	
NxN (SH)	**Mean Passage Date**	128.1	134.2	131.5	122.5	133.1	129.4
	Median Passage Date	127.4	134.3	133.5	121.0	136.2	
	n (McNary Passage)	2579	2704	3432	3274	2999	
	HxH - NxN Mean Difference	0.5	**-6.5**	**-3.9**	1.8	**-3.2**	**-1.8**
	Two-Sided Type 1 Error P	0.7086	**0.0001**	**0.0036**	0.1364	**0.0169**	0.0503
	HxH - NxN Median Difference	1.0	-6.2	-5.4	3.0	-5.7	

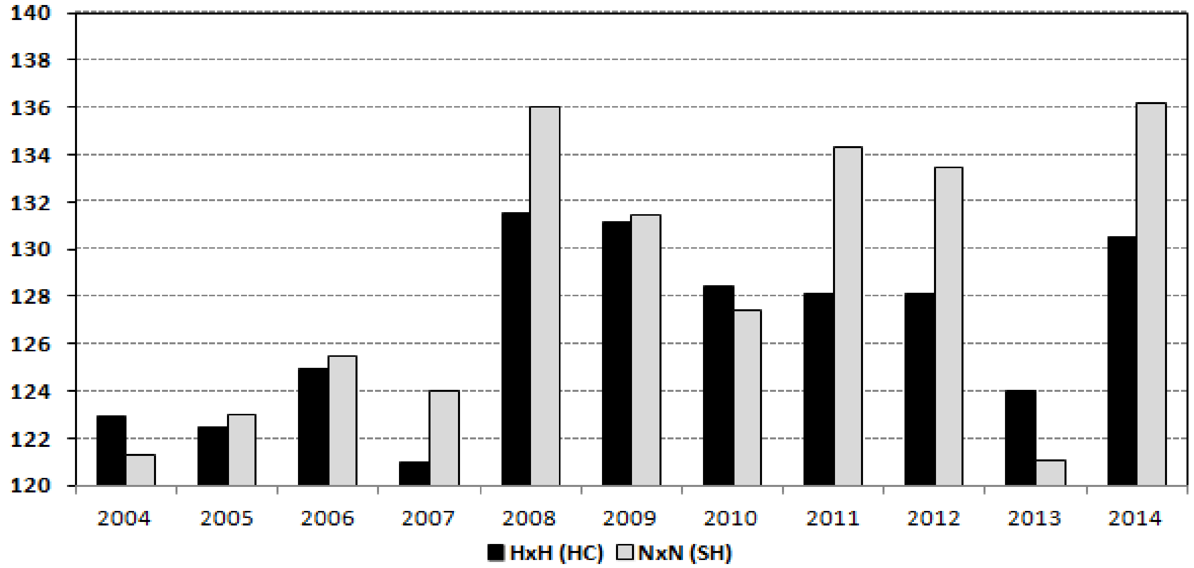
Appendix 1 (continued)

Figure A.5.a. Mean Julian Passage Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: nutrition levels)



* Adjusted for Year Effects

Figure A.5.b. Mean Julian Passage Dates of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared PIT-tagged Smolt Detected Leaving the Clark Flat Acclimation Site (2nd factor: nutrition levels)



Appendix A (continued)

6. Raceway Pair Comparisons

In the analysis of variance and the logistic analysis of variation presented in the second table of each of the above sections in this appendix, the among-raceway variation (Main Plot Error) is taken as the main-plot source of variation that is not affected by the year, stock, treatment among the raceways. Similarly the error variation is taken as a measure of variation between the two raceways within the pairs that is not affected by year, stock, or treatment. In the case of three traits, Percent Released, Release-to-McNary Survival, and McNary Passage Date, the F-ratio of the among-raceway to the within raceway error variation measures is large. What the raceway pairs share in common, besides being physically next to each other, is that they share sets of diallele crosses. If the genetic differences among the sets of diallele crosses assigned to the different raceway pairs were sufficiently large, this might explain the reason for these large ratios; however, there are many diallele crosses within each set, and it is unlikely that ratios of this size would be strictly genetic.

For the 2000 brood release in 2002 (before the HxH and NxN broods were established), there was a relatively high BKD incidence, and the F-ratio of the among-raceway to the within-raceway error BKD variation measures was large, suggesting relatively higher BKD loads for some of the diallele sets than others. For this reason, BKD incidence measures were analyzed for the HxH-NxN stock experiments to see if this trait might explain some of the high-ratios attained for other traits (especially survival measures). Unfortunately, BKD levels were not measured in brood years the 2006 and 2007 releases and individual raceway data were not available for the 2014 release at the time of this report.

A two-treatment level analysis was made on BKD incidence for the available release years and is presented in Table A.6.

Other than for the Year source, there are no significant sources in this table, and the F-ratio of the among-raceway to the within-raceway error BKD variation measures (F = 1.30) was sufficiently near 1 to suggest BKD load would not affect the stock differences that were observed in other traits.

Table. A.6. Analysis of Variance of BKD Load of Hatchery-Brood (HxH) and Natural-Brood (NxN) Hatchery-reared at the Clark Flat Acclimation Site (2nd factor: 2 yearly nutrition levels)

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (DSS/DF)	F-Ratio	Estimated Type 1 Error P	Source of F-Ratio Denominator Mean Deviance
Year	**26.638**	**7**	**3.805**	**39**	**0.0000**	**Among Raceway Pairs**
Stock	0.096	1	0.096	1.55	0.2529	Stock x Year
Stock x Year	0.433	7	0.062	0.63	0.7233	Among Raceway Pairs
Among Raceway Pairs	0.788	8	0.099	1.30	0.3596	Pooled Error
Low-High	0.075	1	0.075	1.69	0.4171	Low-High x Year
Stock x Low-High: 2004-2005	0.029	1	0.029	0.38	0.5952	Error from Low-High Trials*
Low-High x Year: 2004-2005	0.044	1	0.044	0.61	0.5176	Error from Low-High Trials
Stock x Low-High x Year: 2004-2005	0.000	1	0.000	0.00	1.0000	Error from Low-High Trials
EWAS-BIO (2008)	0.079	1	0.079	1.05	0.3361	Error from EWAS - Bio Trial
Stock x EWAS-BIO	0.120	1	0.120	1.58	0.2436	Error from EWAS - Bio Trial
STF-BIO	0.147	1	0.147	0.93	0.3883	STF-BIO x Year
Stock x STF-BIO	0.216	1	0.216	1.69	0.2637	Stock x STF-BIO x Year
STF-BIO x Year: 2009-2013	0.629	4	0.157	1.87	0.2085	Error from STF - Bio Trials
Stock x STF-BIO x Year: 2009-2013	0.512	4	0.128	1.69	0.2445	Error from STF - Bio Trials
Pooled Error	0.606	8	0.076			

* tested against Error from Low-High Trials because Stock x Low-High x Year: 2004-2005 Mean Square = 0

Appendix B. Method of Estimating Volitional Release-to-McNary Survival

For each individual raceway, the survival was based on dividing the total expanded McNary detections of PIT-tagged fish previously detected at acclimation sites by the release number (equation Eq.B.1):

Eq.B.1.

$$\text{Release - to - McNary Survival} = \frac{\text{Expanded Number of Released Fish Detected at McNary}}{\text{Release Number (detected at release)}}$$ [9]

The expanded number of fish detected at McNary (numerator of Eq.B.1) was computed using the following equation (Eq.B.2.)

Eq.B.2.

$$\text{Expanded Number} = \Sigma \frac{\text{Stratum Number Detected}}{\text{Stratum Detection Rate}}$$

The stratum being sequential McNary passage days during which the McNary detection rates are relatively homogeneous, and the Stratum’s detection rate being computed by using the following equation (Eq,3)

Eq.B.3.

$$\text{Stratum Detection Rate} = \frac{\text{Number of Joint Detections at McNary and Downstream Sites within Sratum}}{\text{Total Downstream detections within Stratum}}$$

The downstream sites being Bonneville and John Day Dams, and detections within each stratum being pooled over sites. Note that the detection rates are based on all Yakima detected fish, not just those assigned to the Clark Flat acclimation site.

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[9] Expanded number is the number of fish passing McNary divided by the McNary detection rate. The McNary detection rate is the number of Yakima-origin PIT-tagged fish detected at both McNary and downstream dams (Bonneville and John Day dams) divided by the total number of Yakima-origin PIT-tagged fish detected by those down-stream dams.

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Appendix E
2014 Annual Report: Smolt-to-Smolt Survival to McNary Dam of Yakima Fall and Summer Chinook

Doug Neeley, Consultant to Yakama Nation

Introduction

Paired Subyearling and Yearling Yakima-stock Fall Chinook releases were made from Prosser Diversion Dam (Prosser) in out-migration years 2008 through 2013. Only subyearling Fall Chinook smolt were released in 2014.

Summer Chinook Subyearlings were released from Stiles pond in outmigration-years 2009 and 2011. In 2012 the Stiles releases were discontinued and shifted to Prosser. In 2013 the Prosser releases were discontinued and shifted and released below Roza Dam and a similar release was made in 2014. Subyearlings were also released from Marion Drain in 2012 and from Buckskin Slough from 2011 through 2014, there being two releases from Buckskin Slough in 2014, each on a different starting release date.

The analyses presented in this report are for:

1. Subyearling[1] Fall Chinook: Presented for the 2008 through 2014 Fall Chinook releases are estimates of the proportion detected at release, pre-release survival, survival of smolt from release to McNary Dam (McNary) and from time-of-tagging to McNary, and mean dates of volitional release and of McNary passage

2. Summer Chinook: Presented for 2011 through 2014 Summer Chinook releases are estimates from time-of-tagging to McNary dam and mean dates of McNary-Dam passage. Because of low estimates of survival to McNary of Summer Chinook in 2014, distribution of fish passage of all smolt detected at Roza and of smolt detected at Roza that were subsequently detected at McNary were evaluated to determine what periods in the passage impacted survival.

Regarding juvenile survival estimates, for those releases from acclimation sites with PIT-tag detectors at their outfalls, estimated survival is partitioned into pre-release survival and release-to-McNary survival components, the latter being the proportion of fish detected at release that survived to McNary. Time-of-tagging-to-McNary-passage survival estimates (tagging-to-

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[1] .Formal comparisons between the Subyearling and Yearling estimates were presented in the 2013 Annual Report.

McNary survival), which can be affected by pre-release tag-shedding and mortality as well as in-stream mortality factors, are given for all releases, whether or not there were detectors located at the release sites.

Note: No formal statistical analyses are given in this annual report because releases were not replicated. Analyses comparing Yearling and Subyearling releases of Fall Chinook were presented in the 20013 Annual Report; no Yearling releases were made in 2014.

Because there were some survival issues that were common for Fall and Summer Chinook, these are presented as combined estimates.

Percent Released

The percent released is simply the percent of tagged fish detected leaving the release site. Release site detectors were present at Prosser from where all Fall Chinook have been released. Pre-release estimates were also possible for Summer Chinook released in 2012 from Prosser and for earlier releases of Summer Chinook from Stiles acclimation sites. The estimates are given in Table 1. The percent of Fall Chinook detected leaving the Prosser pond in 2014 was the highest in past five years[2].

Table 1. 2008-2014 Percent of PIT-tagged Smolt detected leaving Site

		Fall Chinook		Summer Chinook					
Release		(Prosser)			(Buckskin Slough)				
Year	Measure	Yearling	Subyearling	(Stiles)	Release 1	Release 2	(Marion)	(Prosser	(Roza)
2008	**Proportion detected at Release**	**93.2%**	**61.8%**						
	Number Tagged	1,831	10,005						
2009	**Proportion detected at Release**	**62.0%**	**76.4%**	**56.8%**					
	Number Tagged	7,516	7,565	30,037					
2010	**Proportion detected at Release**	**43.8%**	**31.6%**	**19.0%**					
	Number Tagged	12,167	13,685	29,865					
2011	**Proportion detected at Release**	**41.5%**	**30.7%**	**73.7%**					
	Number Tagged	22,754	22,790	20,000	n.a.		n.a.	n.a.	n.a
2012	**Proportion detected at Release**	**49.5%**	**17.9%**					**35.1%**	
	Number Tagged	19,435	19,634	n.a.	n.a.		n.a	9,999	n.a
2013	**Proportion detected at Release**	**24.7%**	**0.6%**						
	Number Tagged	22,730	22,966	n.a.	n.a.		n.a.	n.a.	n.a.
2014	**Proportion detected at Release**		**62.0%**						
	Number Tagged		4,025	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Pre-Release Survival

Pre-release survival from Prosser is the percentage of tagged fish detected leaving the pond divided by the detection efficiency of the detector at the outfall from the Prosser rearing ponds. Adjusting for detection efficiency corrects for the failure of those detectors to detect all smolt leaving the ponds. The detection efficiency estimate is the number of smolt detected at McNary Dam that were previously detected leaving the Prosser ponds divided by the number of all tagged Prosser-released smolt detected at McNary under the assumption that survival to McNary is

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[2] It was noted in the 2013 annual report that the detectors were not efficient in that year resulting in less than 1% of the PIT-tagged fish being detected (Table 1.).

independent of whether or not a released fish was previously detected leaving the ponds. The term “pre-release survival” is somewhat of a misnomer since the estimate is adjusted for pre-release tag shedding. The Pre-Release Survival estimates are presented in Table. 2.

Table 2. 2008-2014 Pre-Release-Survival*

		Fall Chinook		Summer Chinook					
Release Year		(Prosser)			(Buckskin Slough)				
	Measure	Yearling	Subyearling	(Stiles)	Release 1	Release 2	(Marion)	(Prosser	(Roza)
2008	**Pre-Release Survival**	**94.6%**	**92.3%**						
	Number Tagged	1,831	10,005						
2009	**Pre-Release Survival**	**97.6%**	**94.3%**	**88.7%**					
	Number Tagged	7,516	7,565	30,037					
2010	**Pre-Release Survival**	**83.8%**	**84.9%**	**65.2%**					
	Number Tagged	12,167	13,685	29,865					
2011	**Pre-Release Survival**	**90.9%**	**65.6%**	**92.4%**					
	Number Tagged	22,754	22,790	20,000	n.a.		n.a	n.a.	n.a
2012	**Pre-Release Survival**	**87.1%**	**90.0%**					**86.5%**	
	Number Tagged	19,435	19,634	n.a.	n.a.		n.a.	9,999	n.a.
2013	**Pre-Release Survival**	**92.4%**	**100.0%**						
	Number Tagged	22,730	22,966	n.a.	n.a.		n.a.	n.a.	n.a.
2014	**Pre-Release Survival**		**82.7%**						
	Number Tagged		4,025	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

*** For each site: [Proportion of PIT-tagged Smolt Detected]/[(Unexpanded McNary Passage of Fish Detected at Release Site)/ [Unexpanded McNary Passage of Tagged Fish)]**

Note: The 100% pre-release survival for sub-yearling Fall Chinook in 2013 is an anomaly. The number of detections at the Prosser site was extremely low. A low percent detected (0.6% from Table 1) divided by a low detection efficiency (0.5%) produced a more than a 100% survival estimate. The true value is probably closer than that for Summer Chinook in that year.

Survival to McNary Dam

For the 2008 through 2014 releases, the Release-to-McNary survival estimates are given in Table 3.a., and the Tagging-to-McNary Survival estimates are given in Table 3.b. Survival-to-McNary estimation procedures are discussed in Appendix A.

Table 3.a. 2008-2014 Smolt Survival to McNary of Tagged fish detected at Release

		Fall Chinook		Summer Chinook					
Release Year	Measure	(Prosser)		(Stiles)	(Buckskin Slough)		(Marion)	(Prosser)	(Roza)
		Yearling	Subyearling		Release 1	Release 2			
2008	**Release-to-McNary Survival**	**65.2%**	**49.9%**						
	Number Released	1,706	6,187						
2009*	**Release-to-McNary Survival**	**74.3%**	**28.4%**	**1.8%**					
	Number Released	4,659	5,777	17,054					
2010	**Release-to-McNary Survival**	**68.6%**	**26.5%**	**30.6%**					
	Number Released	5,327	4,324	5,669					
2011	**Release-to-McNary Survival**	**71.8%**	**23.2%**	**43.5%**					
	Number Released	9,442	7,007	14,748	n.a.		n.a	n.a	n.a
2012	**Release-to-McNary Survival**	**82.7%**	**43.8%**					**26.7%**	
	Number Released	9,627	3,508	n.a.	n.a.		n.a.	3,509	n.a.
2013	**Release-to-McNary Survival**	**74.8%**	**46.5%**						
	Number Released	5,604	141	n.a.	n.a.		n.a.	n.a.	n.a.
2014	**Release-to-McNary Survival**		**28.7%**						
	Number Released		2,497	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

The Tagging-to-McNary Survival estimates (Table 3.b., below) are always more than the Release-to-McNary estimates when available, (Table 3.a., above) because the former have not been adjusted for pre-release mortality.

Table 3.b. 2008-2014 Smolt Survival to McNary of all Tagged Fish

		Fall Chinook		Summer Chinook					
Release Year	Measure	(Prosser)		(Stiles)	(Buckskin Slough)		(Marion)	(Prosser	(Roza)
		Yearling	Subyearling		Release 1	Release 2			
2008	**Tagging-to-McNary Survival**	**61.6%**	**37.4%**						
	Number Tagged	1,831	10,005						
2009	**Tagging-to-McNary Survival**	**72.4%**	**26.8%**	**1.5%**					
	Number Tagged	7,516	7,565	30,037					
2010	**Tagging-to-McNary Survival**	**60.6%**	**22.8%**	**20.5%**					
	Number Tagged	12,167	13,685	29,865					
2011	**Tagging-to-McNary Survival**	**59.2%**	**16.0%**	**40.3%**	**43.4%**				
	Number Tagged	22,754	22,790	20,000	29,894		n.a	n.a	n.a
2012	**Tagging-to-McNary Survival**	**65.6%**	**27.9%**		**37.0%**		**35.7%**	**20.7%**	
	Number Tagged	19,435	19,634	n.a	9,999		9,998	9,999	n.a
2013*	**Tagging-to-McNary Survival**	**55.7%**	**40.0%**		**20.7%**				**29.8%**
	Number Tagged	13,685	22,966	n.a	15,084		n.a	n.a	15,065
2014	**Tagging-to-McNary Survival**		**23.7%**		18.3%	**3.2%**			**4.8%**
	Number Tagged		**4,025**	**n.a**	**10,086**	**10,102**			**10,043**
*** Note: 2013 estimates for Summer Chinook were slightly in error in the 2013 report and have been corrected in this report**			*intial release date 5/2/104		initial release date 5/12/2014	Initial release date 6/5/2015			*initial release date 6/2/205

It can be seen that, while 2014 Tagging-to-McNary Survival of Fall Chinook was down from the previous two years, the survival for 2014 Summer Chinook was abysmal and had never been near this low[3]. The early release (Release 1) of Summer Chinook from Buckskin Slough was the highest of the three Summer Chinook releases but was still lower than previous year survivals from that site.

Below are presented graphs (Figure 1.) of “quartile” relative frequencies (proportions) of 2014 released smolt passing (Summer Chinook) or volitionally leaving (Fall Chinook) Prosser by Prosser detection date. “Quartile” is in parentheses because what is being presented is the estimated proportion based on the cumulative relative frequency of passage at the end of the date when the daily cumulative relative frequency first exceeded 25%, 50% and 75% for respective Quartiles 1, 2, and 3. Those realized end-of-day relative frequencies always exceeded (and are expected to exceed) the actual prescribed 25%, 50%, and 75% relative quartile frequencies[4]. For comparisons presented here, each quartile estimate following the first quartile is obtained by subtracting from the given quartile cumulative relative frequency the previous quartile’s cumulative relative frequency. The actual cumulative relative frequencies are given in Appendix B as well as the computed quartile relative frequencies presented in Figure 1. Also given in Figure 1 are the dates of quartile partitioning for all detected passing smolt.

If McNary survival of fish passing Prosser were uniform over Prosser passage dates, then the two sets of relative frequencies (those for all fish detected at Prosser and those detected at Prosser but subsequently detected at McNary) should be similar.

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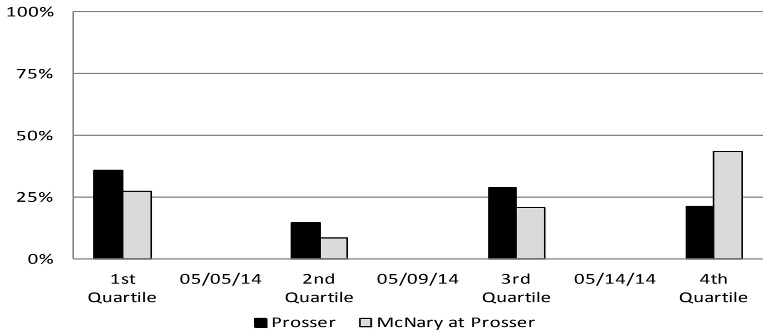
[3] Note that 2013 Tagging-to-McNary Survival estimate for the Summer Chinook were incorrectly computed in the 2013 Annual Report and have been corrected in Table 3.b. The Tagging-to-McNary survival estimates give in that report were 30.1% for the Buckskin Slough release and 21.3% for the Roza release. As can be seen in Table 3.b, the corrected estimates indicate that Roza’s release had the higher survival.

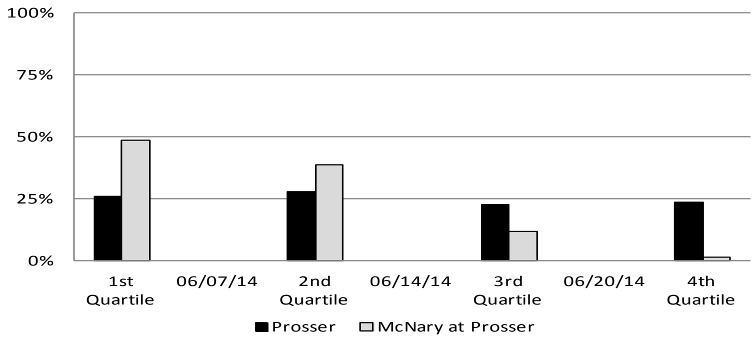
[4] The previous dates’ cumulative frequencies would always be less than the associated 25%, 50%, 75% frequencies.

Figure 1. Approximate quartile percentages for dates of detection at Prosser (black) and realized percentages of fish detected at Prosser that were subsequently detected at McNary Dam (gray)

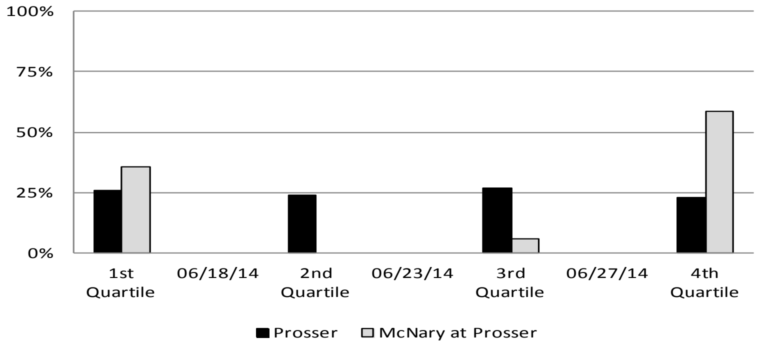
a. Fall Chinook released from Prosser beginning 5/2/2014



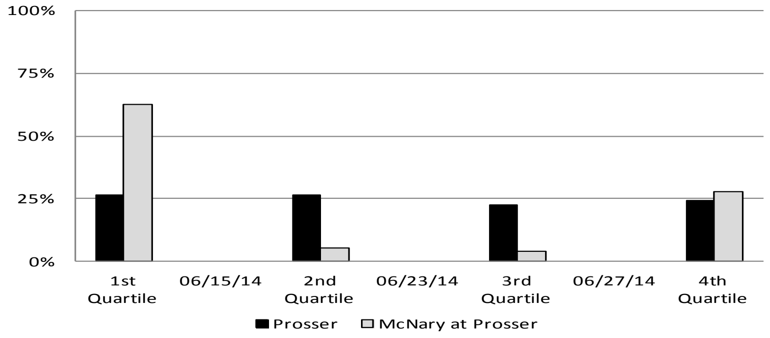
b. Summer Chinook released from Buckskin Slough beginning 5/12/2014



C. Summer Chinook released from Buckskin Slough beginning 6/2/2014



d. Summer Chinook released below Roza Dam beginning 6/5/2014



From Figure 1.a. for Fall Chinook leaving rearing ponds beginning May 2nd, it appears that the two sets of relative frequencies are fairly consistent with slightly lower relative frequencies within the first three quartiles for those fish subsequently detected at McNary but a higher relative frequency within the last quartile suggesting a possibly higher survival for Fall Chinook passing Prosser after May 14th.

The Summer Chinook (Figures 1.b. through 1.d.), which had low survival rates to McNary, show somewhat consistent distribution patterns when the dates of initial release and of quartile partitions are taken into account. Among the three Summer Chinook releases, the one with earliest possible release of the three (May 12th at Buckskin[5], Figure 1.b.) shows higher relative frequencies of smolt subsequently detected at McNary during the 1st and 2nd quartiles and a much lower relative frequency during the 3rd quartile and almost no passage during the 4th quartile. This suggests that survival conditions deteriorated after June 14th. It should be borne in mind that this release had the highest survival to McNary of the three.

The general passage distributions were similar for the later Buckskin release on June 5th and the Roza release on June 2nd (respectively Figures 1.c. and 1.d). The relative frequencies of the 2nd and 3rd quartiles of the smolt subsequently detected at McNary were extremely low but were higher than that for general Prosser passage in the 1st and 4th quartiles--much higher for the Buckskin release in the 4th quartile (Figure 1.c.) and for the Roza release in the 1st quartile (Figure 4.d.). This suggests poor survival after mid-June, as was the case for the earlier Buckskin release (Figure 1.b.), with conditions for survival appearing to improve toward the end of June (June 27 separated the 3rd and 4th quartiles for both the late Buckskin Slough and Roza releases). It should be pointed out that 95% of the Buckskin Slough early release had passed by June 27th, so no meaningful assessment could be made as to whether the survival of that release would have improved at a later date for that release.

These assessments are based on a small number of detections of smolt jointly detected at Prosser and McNary for late-release Summer Chinook. The total number of such detections for Fall Chinook was 117 (rounded expected number of 29 per quartile under the assumption of no effect of Prosser passage time on survival) and for the early Buckskin release the total number was 113 (expected number of 28 per quarter). However, for the late releases at Buckskin Slough and below Roza Dam, the numbers of the joint detections were respectively only 27 and 44 (respective rounded expected numbers of 7 and 11 per quartile), so the evaluations of the two late summer releases should not be regarded as a formal statistical assessment.

It should be noted that the survival estimates from release to Prosser of the Summer Chinook are also low; i.e., 43.3% and 19.8% for the early and late Buckskin Sough releases and 25.0% for the Roza release (Appendix Tables[6] B.2 through B.4). (Note: Appendix Table B.1 gives the survival to Prosser as 85.4%. This is another measure of pre-release survival and is not truly comparable to the Summer Chinook release-to-Prosser survival estimates.)

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[5] The first Buckskin release was ten days later than that for the Fall Chinook which were released at just below the Prosser detection facility. Fall Chinook experienced no downstream challenges above Prosser that Summer Chinook had experienced; therefore their passages at Prosser are not comparable.

Dates of Volitional Release and McNary Passage Dates

Tables 4.a. and 4.b respectively give the estimated mean Julian Release Date for smolt volitionally leaving the facility and the estimated mean passage date of McNary for all PIT-tagged fish passing Prosser.

Table 4.a. 2008-2014 Mean Julian Date of Release

		Fall Chinook		Summer Chinook					
Release		(Prosser)			(Buckskin Slough)				
Year	Measure	Yearling	Subyearling	(Stiles)	Release 1	Release 2	(Marion)	(Prosser	(Roza)
2008	Mean Release Date	101	109						
	Number Released	1,831	10,005						
2009	Mean Release Date	102	104	173					
	Number Released	7,516	7,565	17,054					
2010	Mean Release Date	122	122	135					
	Number Released	12,167	13,685	5,669					
2011	Mean Release Date	128	130	147					
	Number Released	22,754	22,790	14,748	n.a.		n.a	n.a	n.a
2012	Mean Release Date	105	127					135	
	Number Released	19,435	19,634	n.a.	n.a.		n.a.	3,509	n.a
2013	Mean Release Date	88	129						
	Number Released	22,730	22,966	n.a	n.a.		n.a	n.a	n.a
2014	Mean Release Date		132						
	Number Released		2,497	n.a	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4.b. 2008-2014 Mean Julian Date* of all Tagged Fish passing McNary

		Fall Chinook		Summer Chinook					
Release		(Prosser)			(Buckskin Slough)				
Year	Measure	Yearling	Subyearling	(Stiles)	Release 1	Release 2	(Marion)	(Prosser	(Roza)
2008	Mean McNary Detection Date	112	151						
	Expanded Passage number	1,128	3,744						
2009	Mean McNary Detection Date	114	154	190					
	Expanded Passage number	5,442	2,030	459					
2010	Mean McNary Detection Date	128	153	176					
	Expanded Passage number	7,379	3,117	1,735					
2011	Mean McNary Detection Date	136	145	155	171				
	Expanded Passage number	13,465	3,635	8,065	12,989		n.a	n.a	n.a
2012	Mean McNary Detection Date	113	164		182		181	181	
	Expanded Passage number	12,752	5,474	n.a	3,704		3,565	2,073	n.a
2013	Mean McNary Detection Date	101	170		171				166
	Expanded Passage number	12,650	9,188	n.a	3,115		n.a	n.a	4,487
2014	Mean McNary Detection Date		165		166	180			177
	Expanded Passage number		955	n.a	1,845	**321**	n.a	n.a	**487**

*** For each release Site, Mean Julian Date weighted by Expanded Passage of all PIT-Tagged Smolt passing McNary**

It is noted that for subyearling Fall Chinook the mean 2014 date of volitional release was the latest over years and the mean date of McNary detection was latest for all but one year (2013). It is also noted that the earliest 2014 McNary passage date of the three Summer Chinook releases was associated with the first release (Release 1) into Buckskin Slough which had the earliest release date and highest survival of the three 2014 Summer Chinook Releases.

Consideration is being given by the YKFP staff to have an experimental paired sets of PIT-tagged releases in 2015, one being a release at the acclimation site (as is now the case) and one lower in the Yakima River to avoid some of the predator challenges in both time and space.

Appendix A. Estimated Survival Index

Conceptual Computation

The smolt-to-smolt survival to McNary estimation method for Fall Chinook and Summer Chinook involves

1. For each stock, identifying time-of-passage strata for within which estimated daily PIT-tagged McNary detection efficiencies[7] are reasonably homogeneous. (Daily McNary detection rate is the proportion of all Yakima PIT-tagged Fall Chinook passing McNary Dam for each day that fish are detected at McNary)

2. Estimating the McNary detection rate for each stratum

3. Expanding (dividing) the given release's number of detected fish not removed for transportation[8] at McNary by the detection rate within the associated stratum and adjusting for the number removed for transportation[9]

4. Totaling the release's expanded numbers over strata

5. Taking that release's expanded total and dividing it by the appropriate "population number[10]"

The methods of identifying strata and estimating the individual stratum detection rates at McNary are discussed in the annual report *Hatchery x Hatchery and Natural x Natural Smolt-to-Smolt Survivals and Mini-Jack Proportions of Upper Yakima Spring Chinook for Brood-Years 2002-2006*.

The steps given above can be basically summarized in the following equations. (In all of the following equations, the term "detections" is actually the number of detections.)

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[7] Note, detection efficiencies are estimated using all PIT-tagged smolt released in the Yakima under the assumption that they will be well mixed by the time they pass McNary.

[8] Total number of tagged fish detected at McNary within stratum in the case of tagging-to-McNary survival, total number of tagged fish detected at McNary within stratum that were previously detected at acclimation site in case of release-to-McNary survival.

[9] Adjustments for transported smolt are given in Equation A.2, but so few smolt have been detected at McNary as being transported since 2006, the adjustments has not been made since.

[10] Total number of tagged fish in the case of tagging-to-McNary survival, total number of tagged fish detected at acclimation site in case of release-to-McNary survival.

Equation A.1.

$$\text{Stratum McNary detection rate} = \frac{\text{number of joint detections at McNary and downstream dams within Stratum}}{\text{estimated total number of detections at downstream dams within Stratum}}$$

Equation A.2.

$$\text{Smolt - to - Smolt Survival to McNary for a given release (Rel)} = \frac{\sum_{\text{strata}} \text{For Stratum}\left[\frac{\text{(McNary Rel Detections - Rel Detections Removed)}}{\text{Stratum's McNary Detection Rate (Equation A.1)}} + \text{Detections Rel Removed}\right]}{\text{Rel Number of Fish Tagged or Released}}$$

Pre-release survival was estimated using the Equation A.3.

Equation A.3.

$$\text{Pre} - \text{release Survival for a given Release (Rel)} =$$

$$\text{Tagging - to - Release Survival} =$$

$$\frac{\left[\frac{\text{Rel Detections at Acclimation Site}}{\text{Rel Number Tagged}}\right]}{\left[\frac{\text{Total Rel Detections at McNary previously Detected at Acclimation Site}}{\text{Total Rel Detections at McNary}}\right]}$$

The denominator within [ ] in the above equation is a measure of the detection efficiency at the acclimation site for the release in question. In earlier years estimates for this detection efficiency was based on expanded detection numbers using the detection rate in Equation A.1 as the expansion factor rather than the unexpanded detections; however, there were occasional detection efficiency estimates based on the expanded detection numbers that resulted in survival estimates exceeding 100%. While this also happened using the unexpanded numbers, the occurrence was even less; therefore the unexpanded detection numbers are now used.

NOTE FOR 2014 RELEASES: There were no McNary detection-efficiency stratifications of the Fall Chinook and Summer Chinook releases in 2014. Their respective estimated detection efficiency estimates were quite homogeneous over McNary passage. The same was true of Fall Chinook Prosser detection efficiencies at Prosser which is why the estimated percents of Fall Chinook Prosser detected at McNary were the same for the raw detection numbers and expanded passages (last two columns of Table B.1 in Appendix B). There was stratification of the Summer Chinook detection efficiencies at Prosser, therefore the percentages in the last two columns differ within Appendix B Tables B.2, B.3, and B.4.

Appendix B: Passage Distribution of Fish detected at Prosser that were subsequently detected at McNary to that of all Smolt

Table B.1. Fall Chinook released from Prosser beginning 5/2/2014

		1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Total Fish	
2014 Quartile dates* of Prosser Passage		5/5	5/9	5/14		Detected	Expanded**
Quartile Frequency for all Smolt detected at Prosser	Cumulative Upper	35.7%	50.1%	78.8%	100.0%	2,497	3,436
	Quartile	35.7%	14.5%	28.7%	21.2%		
Frequency of Smolt detected at Prosser and McNary	Cumulative Upper	27.4%	35.9%	56.4%	100.0%	117	161
	Quartile	27.4%	8.5%	20.5%	43.6%		
Percent of total Prosser Count and of estimated total Prosser Passage subsequently detected at McNary Dam*** >						4.69%	4.69% (note below)
					Number Tagged >		4025
					Survival from Tagging to Prosser >		85.37%

Note equality of estimates in next-to-last row. For explanation see the last paragraph of Appendix A.

Table B.2. Summer Chinook Releases from Buckskin Slough beginning 5/12/2014

		1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Total Fish	
2014 Quartile dates* of Prosser Passage		6/7	6/14	6/20		Detected	Expanded**
Quartile Frequency for all Smolt detected at Prosser	Cumulative Upper	26.2%	53.9%	76.4%	100.0%	2,044	4,367
	Quartile	26.2%	27.8%	22.5%	23.6%		
Frequency of Smolt detected at Prosser and McNary	Cumulative Upper	48.6%	87.1%	98.7%	100.0%	113	344
	Quartile	48.6%	38.6%	11.6%	1.3%		
Percent of total Prosser Count and of estimated total Prosser Passage subsequently detected at McNary Dam*** >						5.53%	7.88%
					Number Tagged >		10,086
					Survival from Tagging to Prosser >		43.30%

Table B.3. Summer Chinook Released from Buckskin Slough beginning 6/2/2014

		1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Total Fish	
2014 Quartile dates* of Prosser Passage		6/18	6/23	6/27		Detected	Expanded**
Quartile Frequency for all Smolt detected at Prosser	Cumulative Frequency	26.0%	50.0%	77.0%	100.0%	1,428	2,003
	Quartile Difference	26.0%	24.0%	27.0%	23.0%		
Frequency of Smolt detected at Prosser and McNary	Cumulative Frequency	35.8%	35.8%	41.6%	100.0%	27	38
	Quartile Difference	35.8%	0.0%	5.8%	58.4%		
Percent of total Prosser Count and of estimated total Prosser Passage subsequently detected at McNary Dam***						1.89%	1.89%
					Number Tagged >		10,102
					Survival from Tagging to Prosser >		19.83%

Table B.4. Summer Chinook released from below Roza beginning 6/5/2014

		1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Total Fish	
2014 Quartile dates* of Prosser Passage		6/15	6/23	6/27		Detected	Expanded**
Quartile Frequency for all Smolt detected at Prosser	Cumulative Upper	26.7%	53.2%	75.9%	100.0%	1,722	2,511
	Quartile	26.7%	26.5%	22.7%	24.1%		
Frequency of Smolt detected at Prosser and McNary	Cumulative Upper	62.8%	68.1%	72.3%	100.0%		
	Quartile	62.8%	5.3%	4.2%	27.7%		
Percent of total Prosser Count and of estimated total Prosser Passage subsequently detected at McNary Dam***						2.56%	3.17%
					Number Tagged >		10,043
					Survival from Tagging to Prosser >		25.01%

* Dates during which 25%, 50%, and 75% of Prosser passage occurred.

** Based on estimates of Prosser Detection Efficiency from McNary Dam

*** This is not a measure of Prosser-to-McNary Survival which would require expansion for McNary Detection Efficiency.

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Appendix F

Annual Report: 2014 Coho Smolt-to-Smolt Survival of Releases into the Yakima Basin

Doug Neeley, Consultant to Yakama Nation

Introduction and Summary

From 2005 through 2012 there have been releases of Yakima-Return (Yakima) and Eagle-Creek-Hatchery (Eagle Creek) brood Coho smolt from several locations in the Yakima Basin, most of which were paired releases from common sites. In 2012, releases from Yakima and Yakima x Eagle Creek Cross broods were made from three sites with one site also having the Eagle Creek brood release. In 2013 only Yakima-brood Coho smolt were released. In every paired release of Yakima and Eagle Creek broods through 2012, those from the Yakima brood had a higher release-to-McNary-Dam smolt-to-smolt survival[1]. In spite of this higher survival of the Yakima brood, in 2014 there were several sites at which Eagle Creek brood-stock were released. At only one site was there a paired release of both the Yakima and Eagle Creek brood. And, again the Yakima brood's smolt-to-smolt release-to-McNary Dam survival was greater than that of the Eagle Creek brood.

It should be noted for most paired releases, the Eagle Creek brood had a higher survival from tagging to release than that of Yakima brood, suggesting that the Eagle Creek brood tended to have a higher survival in a captive environment than the Yakima brood, but the Yakima brood has to date, always had a higher outmigration survival in the natural environment.

Survival Estimates based on detected Volitional Releases

With PIT-tag detectors located in the outfalls from the release sites, it is possible to partition the survival of smolt from the time of tagging to the time of McNary Dam (McNary) passage into:

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[1] In only 1999, there were paired releases of Yakima and Cascade broods, and the Cascade releases had a higher survival. From 2001 through 2003, there were paired releases of Yakima and Willard brood, and the Yakima brood had the higher survival (in 2000 there were only Willard brood releases). For the 1999-2003 summaries refer to the 2004 annual report. In 2005 there were releases from the Washougal brood as well as from the Yakima and Eagle Creek broods, but only the Washougal and Yakima and the Washougal and the Eagle Creek broods had paired releases. Both the Yakima and Washougal broods had poor release-to-McNary survivals. The Yakima brood and the Eagle Creek brood had higher survival than the Washougal for paired releases. By far the highest survivals were for Eagle Creek. In all subsequent years (2006 to the present, the focus of this report), the Yakima brood has had a higher release-to-McNary survival than the Eagle Creek for every paired release.

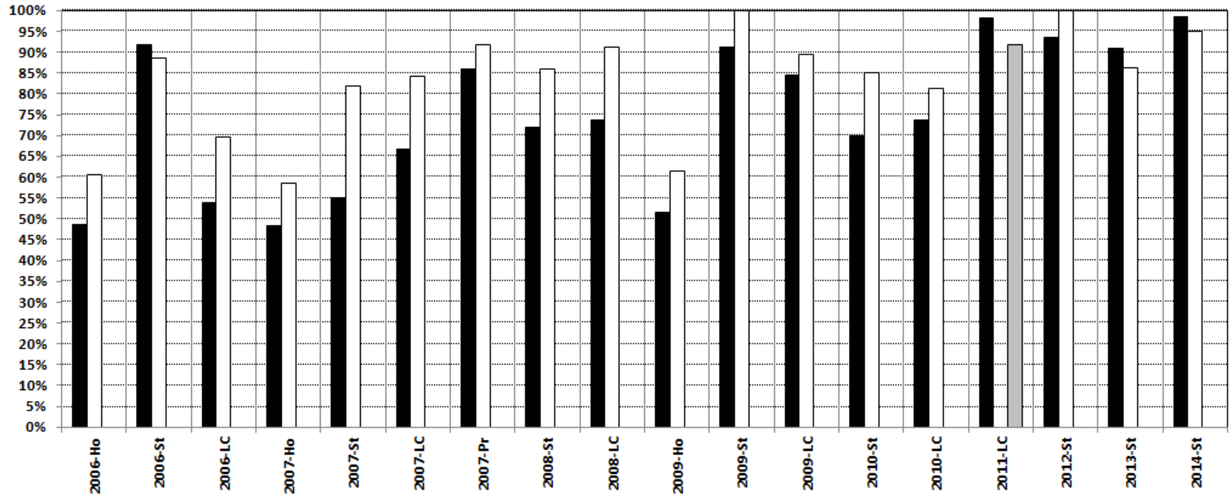
1) Survival from the time of tagging to the time of release (Pre-release Survival); and 2) Survival from time of volitional release to time of McNary passage (Release-to-McNary Survival).

Pre-release Survival

Pre-release survival estimates are the estimated percentages of juveniles that survive from the time of tagging to the time of volitional release. The estimate is the percentage of PIT-tagged smolt detected leaving the pond divided by detection efficiency of the Prosser pond's PIT-tag detector, the detection efficiency being the percentage of all PIT-tagged fish detected leaving the pond divided by the ratio of the estimated passage at McNary of those tagged fish previously detected leaving the ponds and the estimated passage at McNary of all tagged fish.

Pre-Release Survivals are presented in Figure 1 for those sites having two or more of Yakima Stock, Eagle Creek brood, or their cross. Actual estimates are given in Appendix A, Table A.1. In 87.5% (or 14) of the 17 paired releases of Yakima and Eagle Creek brood from the same sites within years, the Eagle Creek brood had the highest pre-release survival. This 87.5% is significantly different than 50%[2] at the 5% level (estimated Type 1 p = 0.012, based on the sign test). The Eagle creek stock, which is a hatchery stock, tends to have a higher survival in the hatchery environment.

Figure 1. **2006-2014 Outmigration-Year (2004-2012 Brood-Year) <u>Pre-Release Coho Survival</u> for Release Sites having two or more of Yakima Stock (black), Eagle Creek Stock (white), or their Cross (gray)***



***Acclimation Sites within Release Year in Order (left to right) with sites identified: Holmes (Ho), Stiles (St), Lost Creek (LC), and Prosser (Pr)

Note: Appendix Table A.1 is the table of all estimates from sites that had at least at least one year of volitional estimates or paired releases.

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[2] If there were equal survival rates, one would expect each of the stock would have having an equal chance of having the larger survival estimate; i.e. a 50% chance.

Volitional-Release to McNary Dam Survival

These are estimates of the survival of those smolt detected leaving the rearing pond that eventually pass McNary Dam. The estimate[3] is basically the percentage of those PIT-tagged smolt detected leaving the rearing pond that are later detected at McNary Dam divided by McNary's detection efficiency[4]. That estimated McNary detection efficiency is the number of smolt detected passing dams downstream of McNary that were previously detected leaving the rearing site divided by the total number of the smolt passing the downstream dams[5], whether or not the smolt were previously detected at the rearing site under the assumption that all Coho PIT-tag releases are well mixed prior to McNary passage.

Volitional Release-to-McNary Survivals are presented in Figure 2 for those sites having two or more of Yakima Stock, Eagle Creek Stock, or their cross. Actual estimates are given in Appendix A, Table A.2.

In all (or 100%) of the 17 paired releases of Yakima and Eagle Creek brood from the same sites within years, the Yakima brood had the highest volitional-release to McNary Dam survival. This 100% is significantly different than 50% at the 5% level (estimated Type 1 $p < 0.0001$), based on the sign test). The Yakima stock's higher release-to-McNary-passage smolt-to-smolt survival indicates better survival in the natural environment for this stock.

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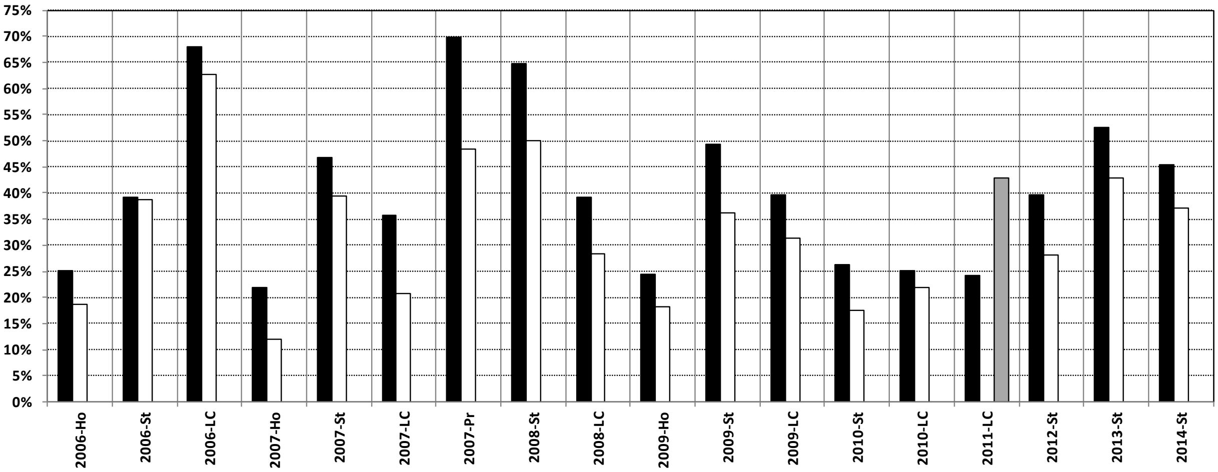
[3] The estimation is somewhat complicated in that detection efficiencies are estimated within time strata, within which there are relatively homogeneous daily detection efficiencies at McNary. Therefore the number of smolt detected at McNary is expanded within each stratum; these expanded stratum passage numbers are then added over strata. The resulting total is then divided by the number of smolt detected leaving the rearing ponds.

[4] The proportion of smolt leaving the pond can be affected by pre-release mortality, pre-release tag-shedding, and the failure of the site's PIT-tag detectors to detect PIT-tagged fish exiting the rearing ponds. The detection efficiency is expected to adjust for differential detection failure but not for differential tag-shedding.

[5] The dams downstream of McNary dams are John Day and Bonneville Dams

Figure 2. 2006-2014 Outmigration-Year (2004-2012 Brood-Year) <u>Volitional Release-to-McNary Coho Survival</u> for Release Sites having two or more of Yakima Stock (black), Eagle Creek Stock (white), or their Cross (gray)*.



*Acclimation Sites within Release Year in Order (left to right) with sites identified: Holmes (Ho), Stiles (St), Lost Creek (LC), and Prosser (Pr)

Note: Appendix Table A.2 is the table of all estimates from sites that had at least at least one year of volitional estimates or paired releases.

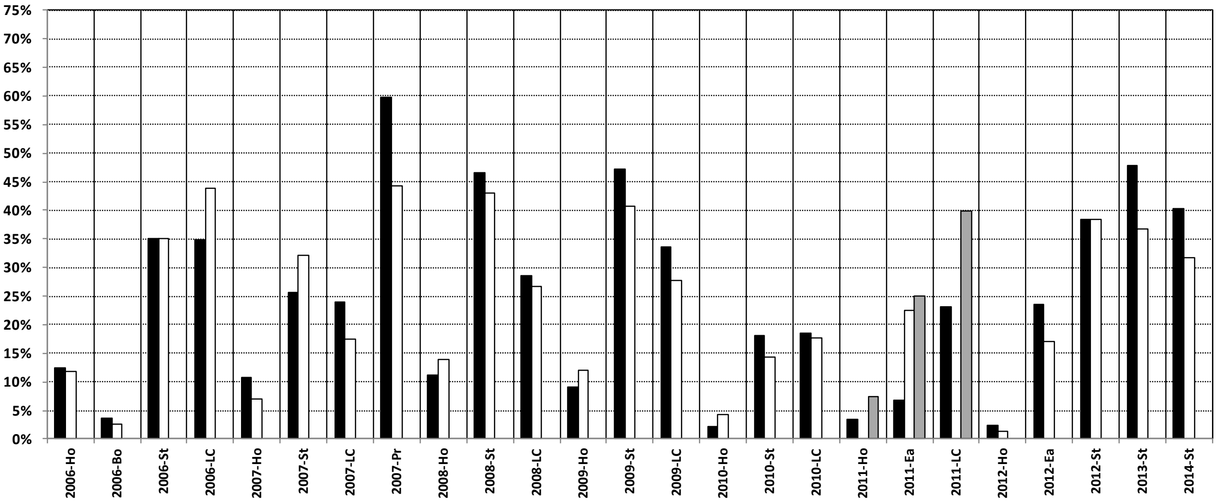
Estimates based on all Releases

Tagging-to-McNary Smolt-to-Smolt Survival

Since not all release sites had PIT-tag detectors, the overall time-of-tagging-to-McNary survival was also estimated for each release as a consistent basis for comparing survival rates from all sites. Tagging-to-McNary Survivals are presented in Figure 3 for those sites having two or more of Yakima Stock, Eagle Creek Stock, or their cross. Actual estimates are given in Appendix A, Table A.3.

In 64 % (or 14) of the 22 paired releases of Yakima and Eagle Creek brood from the same sites within years, the Yakima brood had the highest time-of-tagging-to-McNary smolt-to-smolt survival. This 64% is not significantly different than 50% at the 5% level (estimated Type 1 p = 0.29, based on the sign test). This in contrast to the 100% of the paired releases having the Yakima brood with the highest release-to-McNary-Dam survival. The time-of-tagging survival estimates for most pairs were differentially reduced from the time-of-release-to-McNary-Dam-Passage survival estimates by the lower pre-release mortality experienced by the Eagle Creek brood.

Figure 3. 2006-2014 Outmigration-Year (2004-2012 Brood-Year) Time-of-Tagging-to-McNary Coho Survival for Release Sites having two or more of Yakima Stock (black), Eagle Creek Stock (white), or their Cross (gray)*.



*Acclimation Sites within Release Year in Order (left to right) with sites identified: Holmes (Ho), Stiles (St), Lost Creek (LC), and Prosser (Pr)

Note: Appendix Table A.3 is the table of all estimates from sites that had at least at least one year of volitional estimates or paired releases.

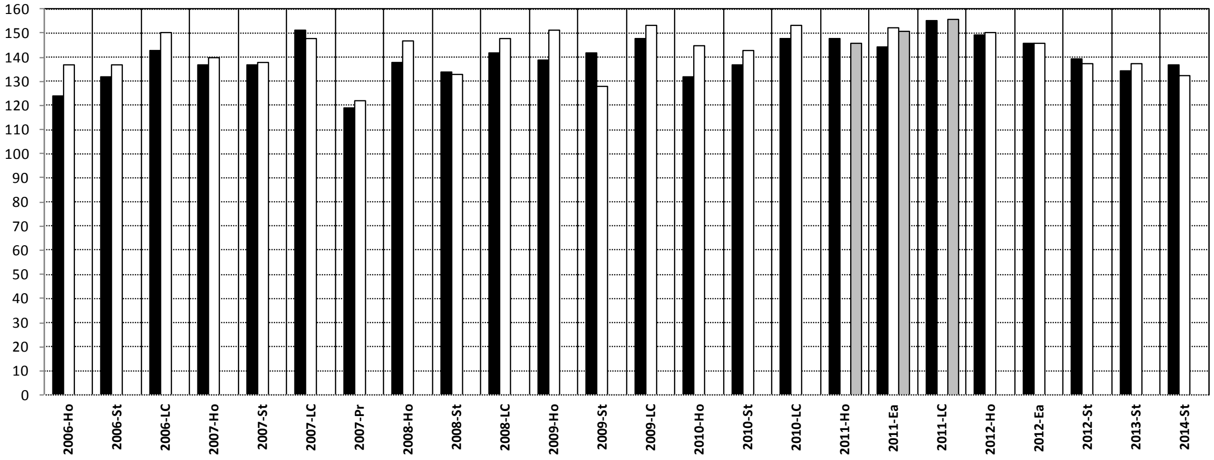
Mean Date of McNary Dam Passage

In Figure 4, the mean Julian date of McNary passage was estimated for each release based on the estimated McNary passage of all PIT-tagged fish. Actual estimates are given in Appendix A, Table A.4.

The mean Julian date of McNary passage was estimated by weighting the Julian date of detection by the expanded number of all passing PIT-tagged smolt (whether or not they were previously detected leaving the rearing ponds). The expanded number being the date's detected passage divided by the McNary's detection efficiency associated with that passage date. These weighted dates were then added over days and then divided by the total of the expanded daily passages.

Estimates of Julian Date of McNary passage are presented in Figure 4 for those sites having two or more of Yakima Stock, Eagle Creek Stock, or their cross. In 73% (or 16) of the 22 paired releases of Yakima and Eagle Creek brood from the same sites within years, the Yakima brood had a later date of Mean McNary Passage. This 73% is not significantly different than 50% at the 5% level (estimated Type 1 p = 0.052, based on the sign test).

Figure 4. 2006-2014 Outmigration-Year (2004-2012 Brood-Year) Mean Julian Date of Passage for Release Sites having two or more of Yakima Stock (black), Eagle Creek Stock (white), or their Cross (gray)*.



*****Acclimation Sites within Release Year in Order (left to right) with sites identified: Holmes (Ho), Stiles (St), Lost Creek (LC), and Prosser (Pr)

Note: Appendix Table A.4 is the table of all estimates from sites that had at least at least one year of volitional estimates or paired releases.

In-Stream and Mobile-Raceway Releases

Scatter-plants of parr and smolt directly into streams and rivers and volitional releases of smolt from mobile acclimation raceways began with outmigration year 2010. There was no detection at release for any of these groups; survival rates were computed for all tagged fish using the same procedures used for the estimates given in Table A.3.

Tagging-to-McNary survival estimates are given in Appendix Table A.5., and mean McNary passage dates are given in Appendix Table A.6.

Appendix A

Table A.1. Outmigration-Year 2006-2014 (2004-2012 Brood) Pre-release Survival of PIT-Tagged Coho Smolt

			Release-Site Subbasin and Pond within Subbasin							
			Upper Yakima					Naches		Main Stem Yakima
Release Year	Stock	Measure	Holmes	Boone	Cle Elum	Taneum Creek	Easton Pond	Stiles	Lost Creek	Prosser
2006	**Yakima**	**Pre-Release Survival**	**48.69%**					**91.75%**	**53.84%**	
		Number Tagged	2512					2490	2491	
	Eagle Creek	**Pre-Release Survival**	**60.50%**					**88.55%**	**69.56%**	**80.82%**
		Number Tagged	2514					2506	2515	1231
2007	**Yakima**	**Pre-Release Survival**	**48.40%**					**54.99%**	**66.81%**	**85.88%**
		Number Tagged	2460					2449	2501	2499
	Eagle Creek	**Pre-Release Survival**	**58.62%**					**81.81%**	**84.26%**	**91.67%**
		Number Tagged	2504					2513	2511	1246
2008	**Yakima**	**Pre-Release Survival**						**71.98%**	**73.82%**	
		Number Tagged						2492	2499	
	Eagle Creek	**Pre-Release Survival**						**86.02%**	**91.13%**	**100.00%**
		Number Tagged						2453	2524	854
2009	**Yakima**	**Pre-Release Survival**	**51.59%**		**0.00%**			**91.12%**	**84.60%**	**97.56%**
		Number Tagged	2512		193			2515	2508	2506
	Eagle Creek	**Pre-Release Survival**	**61.49%**					**100.00%**	**89.56%**	
		Number Tagged	1427					3755	2331	
2010	**Yakima**	**Pre-Release Survival**						**69.82%**	**73.78%**	**88.26%**
		Number Tagged						2501	2505	1371
	Eagle Creek	**Pre-Release Survival**						**85.03%**	**81.33%**	
		Number Tagged						2581	2520	
2011	**Yakima**	**Pre-Release Survival**				*****			**98.26%**	**100.00%**
		Number Tagged				4515			2500	2522
	Eagle Creek	**Pre-Release Survival**								
		Number Tagged								
	Yakima x Eagle Creek	**Pre-Release Survival**						**75.26%**	**91.81%**	
		Number Tagged						1259	1262	
2012	**Yakima**	**Pre-Release Survival**						**93.59%**	**85.71%**	**79.06%**
		Number Tagged						2526	2526	1285
	Eagle Creek	**Pre-Release Survival**						**100.00%**		
		Number Tagged						2543		
2013	**Yakima**	**Pre-Release Survival**						**90.79%**	**80.73%**	**82.83%**
		Number Tagged						2504	2531	2520
	Eagle Creek	**Pre-Release Survival**						**86.19%**		
		Number Tagged						2505		
2014	**Yakima**	**Pre-Release Survival**				**92.97%**		**98.51%**		**0%****
		Number Tagged				**687**		2193		12**
	Eagle Creek	**Pre-Release Survival**						**95.04%**	**63.71%**	
		Number Tagged						2054	1513	

* Only 3.68% detected at pond and, of those, only 4 detected at McNary

**** Only 12 Prosser detections, none of which were detected at McNary**

Table A.2. Outmigration-Year 2006-2014 (2004-2012 Brood) Volitional Release-to-McNary-Passage Survival of PIT-Tagged Coho Smolt

			Release-Site Subbasin and Pond within Subbasin							
			Upper Yakima					Naches		Main Stem Yakima
Release Year	Stock	Measure	Holmes	Boone	Cle Elum	Taneum Creek	Easton Pond	Stiles	Lost Creek	Prosser
2006	Yakima	Survival from Release to McNary	25.01%					39.15%	68.02%	
		Number Detected at Release	781					1598	1057	
	Eagle Creek	Survival from Release to McNary	18.62%					38.81%	62.66%	74.78%
		Number Detected at Release	636					1974	1663	912
2007	Yakima	Survival from Release to McNary	22.01%					46.76%	35.83%	69.75%
		Number Detected at Release	920					1204	1671	2112
	Eagle Creek	Survival from Release to McNary	12.02%					39.39%	20.68%	48.35%
		Number Detected at Release	1293					1881	2092	1136
2008	Yakima	Survival from Release to McNary						64.75%	39.25%	
		Number Detected at Release						1731	1633	
	Eagle Creek	Survival from Release to McNary						50.09%	28.37%	5.53%
		Number Detected at Release						2110	1956	507
2009	Yakima	Survival from Release to McNary	24.38%		*			49.24%	39.61%	58.14%
		Number Detected at Release	48		193			696	2053	2299
	Eagle Creek	Survival from Release to McNary	18.29%					36.23%	31.32%	
		Number Detected at Release	130					908	1946	
2010	Yakima	Survival from Release to McNary						26.24%	25.10%	81.15%
		Number Detected at Release						1580	1519	1210
	Eagle Creek	Survival from Release to McNary						17.41%	21.88%	
		Number Detected at Release						1836	1801	
2011	Yakima	Survival from Release to McNary				14.46%			24.31%	36.92%
		Number Detected at Release				166 *			1488	2497
	Eagle Creek	Survival from Release to McNary								
		Number Detected at Release								
	Yakima x	Survival from Release to McNary						41.30%	42.97%	
	Eagle Creek	Number Detected at Release						1184	1374	
2012	Yakima	Survival from Release to McNary						39.70%	36.59%	47.66%
		Number Detected at Release						929	1531	731
	Eagle Creek	Survival from Release to McNary						28.06%		
		Number Detected at Release						683		
2013	Yakima	Survival from Release to McNary						52.64%	29.47%	89.73%
		Number Detected at Release (reared at Prosser)						2240	1727	112*
	Eagle Creek	Survival from Release to McNary						42.84%		
		Number Detected at Release (reared at Eagle Creek)						2060		
2014	Yakima	Survival from Release to McNary				30.52%		45.44%		0%**
		Number Detected at Release (reared at Prosser)				687		2193		12**
	Eagle Creek	Survival from Release to McNary						37.00%	31.10%	
		Number Detected at Release (reared at Eagle Creek)						2054	1513	
					* No detections at NcNary	* Based on low unexpanded number (4) of pond-detected fish detected at McNary				*Low detection number ** Only 12 Prosser detections, none of which were detected at McNary

Table A.3 Outmigration-Year 2006-2013 (2004-2011 Brood) Time of Tagging-to-McNary-Passage Survival of PIT-Tagged Coho Smolt

			Release-Site Subbasin and Pond within Subbasin								
			Upper Yakima						Naches		Main Stem Yakima
	Stock	Measure	Holmes	Boone	Cle Elum	Taneum Creek	Easton Pond	Rosa Dam	Stiles	Lost Creek	Prosser
2006	**Yakima**	**Tagging-to-McNary Survival**	**12.48%**	**3.69%**					**34.99%**	**34.76%**	
		NumberTagged	2512	2501					2490	2491	
	Eagle Creek	**Tagging-to-McNary Survival**	**11.82%**	**2.57%**					**35.05%**	**43.81%**	**60.52%**
		NumberTagged	2514	2500					2506	2515	1231
2007	**Yakima**	**Tagging-to-McNary Survival**	**10.77%**						**25.65%**	**23.94%**	**59.84%**
		NumberTagged	2460						2449	2501	2499
	Eagle Creek	**Tagging-to-McNary Survival**	**7.08%**						**32.07%**	**17.39%**	**44.30%**
		NumberTagged	2504						2513	2511	1246
2008	**Yakima**	**Tagging-to-McNary Survival**	**11.17%**						**46.59%**	**28.58%**	
		NumberTagged	2493						2492	2499	
	Eagle Creek	**Tagging-to-McNary Survival**	**13.89%**				**41.45%**		**43.08%**	**26.76%**	**20.13%**
		NumberTagged	2508				2500		2453	2524	854
2009	**Yakima**	**Tagging-to-McNary Survival**	**9.19%**		**0.21%**	**15.67%**			**47.27%**	**33.70%**	**56.76%**
		NumberTagged	2512		11934	1300			2515	2508	2506
	Eagle Creek	**Tagging-to-McNary Survival**	**12.01%**				**16.38%**		**40.80%**	**27.76%**	
		NumberTagged	1427				2524		3755	2331	
2010	**Yakima**	**Tagging-to-McNary Survival**	**2.26%**			**9.89%**			**18.17%**	**18.45%**	**71.49%**
		Number Tagged	2516			1867			2501	2505	1371
	Eagle Creek	**Tagging-to-McNary Survival**	**4.29%**	**3.41%**			**9.10%**		**14.43%**	**17.76%**	
		Number Tagged	2504	1265			2532		2581	2520	
2011	**Yakima**	**Tagging-to-McNary Survival**	**3.46%**			**13.64%**	**6.74%**			**23.10%**	**37.19%**
		Number Tagged	2516			4515	1272			2500	5036
	Eagle Creek	**Tagging-to-McNary Survival**					**22.40%**				
		Number Tagged					2561				
	Yakima x Eagle Creek	**Tagging-to-McNary Survival**	**7.42%**				**24.99%**		**28.42%**	**39.85%**	
		Number Tagged	2506				**2522**		2524	2514	
2012	**Yakima**	**Tagging-to-McNary Survival**	**2.31%**			**26.48%**	**23.64%**		**38.38%**	**31.36%**	**37.68%**
		Number Tagged	2508			1054	1258		1285	2526	1285
	Yakima*	**Tagging-to-McNary Survival**					**14.80%**				
		Number Tagged					2547				
	Eagle Creek	**Tagging-to-McNary Survival**	**1.40%**				**17.11%**		**38.49%**		
		Number Tagged	2453				**1294**		1260		
2013	**Yakima**	**Tagging-to-McNary Survival**						**50.89%**	**47.82%**	**23.56%**	**74.32%**
		Number Tagged (reared at Prosser)						1221*	2504	2531	2520
	Eagle Creek	**Tagging-to-McNary Survival**	**38.39%**				**32.85%**		**36.70%**		
		Number Tagged (reared at Eagle Creek)	1263				2495		2505		
2014	**Yakima**	**Tagging-to-McNary Survival**				**11.62%**			**40.39%**		**57.00%**
		Number Tagged				**1941**			2505		3004
	Eagle Creek	**Tagging-to-McNary Survival**	**11.86%**				**11.51%**	**31.86%**	**31.62%**	**29.27%**	
		Number Tagged	2502				2586	1500*	2529	2523	

* Reared at Eagle Creek

* Bypass Release
** Below Dam Release

Table A.4. Outmigration-Year 2006-2014 (2004-2012 Brood) Mean McNary Date of Passage of PIT-Tagged Coho Smolt

			Release-Site Subbasin and Pond within Subbasin								
			Upper Yakima						Naches		Main Stem Yakima
Release Year	Stock	Measure	Holmes	Boone	Cle Elum	Taneum Creek	Easton Pond	Rosa Dam bypass	Stiles	Lost Creek	Prosser
2006	Yakima	Julian Passage Date	124	133					132	143	
		Expanded McNary Passage	313	92					871	865	
	Eagle Creek	Julian Passage Date	137	144					137	150	122
		Expanded McNary Passage	297	64					878	110	744
2007	Yakima	Julian Passage Date	137						137	151	119
		Expanded McNary Passage	265						628	598	1495
	Eagle Creek	Julian Passage Date	140						138	148	122
		Expanded McNary Passage	177						805	436	552
2008	Yakima	Julian Passage Date	138						134	142	
		Expanded McNary Passage	278						116	714	
	Eagle Creek	Julian Passage Date	147				135		133	148	142
		Expanded McNary Passage	348				1036		105	675	171
2009	Yakima	Julian Passage Date	139		164	160			142	148	133
		Expanded McNary Passage	230		25	204			1188	845	1422
	Eagle Creek	Julian Passage Date	151				147		128	153	
		Expanded McNary Passage	171				413		1532	647	
2010	Yakima	Julian Passage Date	132			168			137	148	118
		Expanded McNary Passage	57			185			454	462	980
	Eagle Creek	Julian Passage Date	145	155			144		143	153	
		Expanded McNary Passage	108	43			143		372	447	
2011	Yakima	Julian Passage Date	148			163	144			155	125
		Expanded McNary Passage	2516			4515	1272			2500	5036
	Eagle Creek	Julian Passage Date					152				
		Expanded McNary Passage					2561				
	Yakima x Eagle Creek	Julian Passage Date	146				151		144	156	
		Expanded McNary Passage	2506				**2522**		2524	2514	
2012	Yakima	Julian Passage Date	149			146	146		139	123	124
		Expanded McNary Passage	58			279	538		939	792	484
	Yakima*	Julian Passage Date					148				
		Expanded McNary Passage					377				
	Eagle Creek	Julian Passage Date	150				146		137		
		Expanded McNary Passage	65				**496**		1001		
2013	Yakima	Julian Passage Date						124	134	144	113
		Expanded McNary Passage (reared at Prosser)						621	1197	596	1873
	Eagle Creek	Julian Passage Date	137				140		138		
		Expanded McNary Passage (reared at Eagle Creek)	485				820		919		
2014	Yakima	Julian Passage Date				151		126	137	139	
		Expanded McNary Passage				**226**		478	800	739	
	Eagle Creek	Julian Passage Date	137				142		133		123
		Expanded McNary Passage	297				298		1012		1712

* Reared at Eagle Creek

Table A.5. Outmigration-Year 2010-2014 In-Stream and Mobile-Raceway Date-of-Tagging-to-McNary-Passage Survival

Release Year	Stock	Measure	Little Rattlesnake		Nile		SF Cowiche		Cowiche
2010	**Yakima**	**File Extender**	**MRS-Smolt**	**PRS-Parr**	**WNL-Wild O.Mykiss & Coho ***	**PNL-Parr**	**MCW-Smolt**	**PCW-Parr**	
		Tagging to McNary Survival	**8.18%**	**12.06%**	**69.42%**	**13.79%**	**23.29%**	**17.25%**	
		Number Tagged	1144	3053	16	3055	1248	3004	
		Pooled Survival	**11.00%**		**14.08%**		**19.02%**		
		Pooled Number Tagged	4197		3071		4252		
2011	**Yakima**	**File Extender**		**PLR-Parr**	**WNL-Parr ***	**PNL-Parr**	**MCW-Smolt**	**PCW-Parr**	**WCW-Parr***
		Tagging to McNary Survival		**7.97%**	**69.45%**	**7.46%**	**31.50%**	**19.54%**	**81.99%**
		Number Tagged		3000	16	3110	1272	3021	**28**
		Pooled Survival			**7.78%**		**23.08%**		
		Pooled Number Tagged			3126		4293		
2012	**Yakima**		**Rattlesnake**						
		File Extender	**MRS-Smolt**	**PLR-Parr**		**PNL-Parr**	**MCW-Smolt**	**PCS-Parr**	
		Tagging to McNary Survival	**16.22%**	**8.39%**		**8.28%**	**41.05%**	**11.86%**	
		Number Tagged	1274	3006		3017	1277	3024	
		Pooled Survival	**10.72%**				**20.52%**		
		Pooled Number Tagged	4280				4301		
2013	**Yakima**	**File Extender**	**MRA**	**PRS**		**PNL**	**MCW**		PCW
		Tagging to McNary Survival	**11.34%**	**3.82%**		**4.72%**	**19.87%**		**9.84%**
		Number Tagged	**2506**	**3002**		3033	**3464**		**3003**
		Pooled Survival	**7.24%**						
		Pooled Number Tagged	5508						
2014	**Yakima**	**File Extender**		**PRC**		**PLN**	**MCW**	**PCS**	
		Tagging to McNary Survival		**7.66%**		**9.43%**	**33.98%**	**5.26%**	
		Number Tagged		**3011**		3026	**1249**	**3014**	

*** High percent survival based on very small sample sizes**

Table A.5 (cont) Outmigration-Year 2010-2014 In-Stream and Mobile-Raceway Date-of-Tagging-to-McNary-Passage Survival

Release Year	Stock	Measure	Ahtanum		Big Creek	Reecer	Lost Creek	Umtanum Creek	Wilson	
2010	**Yakima**	**File Extender**		**PAH-Parr**	**PBG-Parr**	**PRC-Parr**		**UMT**	**PWL-Parr**	
		Tagging to McNary Survival		**20.18%**	**10.49%**	**21.47%**		**44.32%**	**11.32%**	
		Number Tagged		3050	3006	3015		150	3050	
2011	**Yakima**	**File Extender**		**PAH-Parr**	**PBG-Parr**	**PRC-Parr**	**WLC-Parr ***	**UMT-Parr ***	**PWL-Parr**	
		Tagging to McNary Survival		**18.87%**	**15.81%**	**29.61%**	**57.39%**	**34.95%**	**16.93%**	
		Number Tagged		3003	3003	3004	10	42	2522	
2012	**Yakima**	**File Extender**	**PAL-Parr**		**PBG-Parr**	**PRE-Parr**			**PWI-Parr**	
		Tagging to McNary Survival	**5.42%**		**11.59%**	**19.43%**			**11.02%**	
		Number Tagged	4003		3013	3026			3020	
									Burried Section-Parr	
									Above	**Below**
2013	**Yakima**	**File Extender**	**PAL-Parr**	**PAM-Parr**	**PBG-Parr**	**PRE-Parr**			**PWA**	**PWB**
		Tagging to McNary Survival	**10.66%**	**6.81%**	**7.45%**	**13.75%**			**4.55%**	**10.71%**
		Number Tagged	600	1213	3028	3032			1518	1502
2014	**Yakima**	**File Extender**	**PAL**	**PAH**	**PBG**	**PRE**			**PWI-Parr**	
		Tagging to McNary Survival	**0.00%**	**0.91%**	**4.80%**	**9.27%**			**10.77%**	
		Number Tagged	672	872	3047	3031			3024	

*** 2011 WLC and UMT high percent based on very small sample size**

Table A.5 (cont) Outmigration-Year 2010-2014 In- Stream and Mobile-Raceway Tagging Release-to-McNary-Passage Survival

Release Year	Stock	Measure	Rock Creek	Buckskin	Quartz Creek	@ Thorp Bridge	Little Naches	NF Little Naches		
2009										
2010	**Yakima**	**File Extender**	**WRK-Wild**				**PLN-Parr**	**PNF-Parr**		
		Tagging to McNary Survival	**0.00%**				**17.87%**	**19.72%**		
		Number Tagged	78				3072	3014		
2011	**Yakima**	**File Extender**		**WBK-Parr**			**PLN-Parr**	**PNF-Parr**		
		Tagging to McNary Survival		**37.95%**			**9.54%**	**17.59%**		
		Number Tagged		216			3022	3058		
2012	**Yakima**	**File Extender**			**PQU-Parr**	**PYA-Parr**	**PLN-Parr**	**PNF-Parr**	**Mercer Creek**	
		Tagging to McNary Survival			**12.09%**	**10.68%**	**21.91%**	**19.12%**	**Burried Section-Parr**	
		Number Tagged			3008	2499	3014	3028	**Above**	**Below**
2013	**Yakima**	**File Extender**			**PQU**		**PLN**	**PNF**	**PMA**	**PMB**
		Tagging to McNary Survival			**4.60%**		**7.48%**	**10.90%**	**15.61%**	**16.46%**
		Number Tagged			3007		3019	3012	1502	1502
2014	**Yakima**	**File Extender**		**MBU-Smolt**	**PQU**		**PLN**			
		Tagging to McNary Survival		**33.97%**	**6.50%**		**9.45%**			
		Number Tagged		1572	3039		3012			

*** 2010 and 2011 WNL high percent based on very small sample size**

Table A.6. Outmigration-Year 2010-2014 In-Stream and Mobile-Raceway <u>Mean Juvenile Detection Date</u>

Release Year	Stock	Measure	Little Rattlesnake		Nile		SF Cowiche		Cowiche
2010	**Yakima**	**File Extender**	**Smolt**	**PRS-Parr**	**WNL-Parr**	**PNL-Parr**	**Smolt**	**PCW-Parr**	
		Mean Detection Date	**166**	**155**	**171**	**159**	**149**	**166**	
		Expanded McNary Passage	94	368	11	421	1248	3004	
		Pooled Date	**157**		**159**		**161**		
		Pooled Passage	462		432		4252		
2011	**Yakima**	**File Extender**		**PLR-Parr**	**WNL-Parr**	**PNL-Parr**	**Smolt**	**PCW-Parr**	**Parr**
		Mean Detection Date		**154**	**165**	**163**	**156**	**162**	**144**
		Expanded McNary Passage		239	11	232	401	590	23
		Pooled Date			**163**		**160**		
		Pooled Passage			243		991		
			Rattlesnake						
2012	**Yakima**	**File Extender**	**MRS-Smolt**	**PLR-Parr**		**PNL-Parr**	**MCW-Smolt**	**PCS-Smolt**	
		Mean Detection Date	**147**	**155**		**157**	**147**	**155**	
		Expanded McNary Passage	207	252		250	524	359	
		Pooled Date					**150**		
		Pooled Passage					883		
2013	**Yakima**	**File Extender**	**MRA**	**PRS**		**PNL**	**Smolt**		**PCW**
		Mean Detection Date	**138**	**143**		**156**	**143**		**153**
		Expanded McNary Passage	2506	3002		3033	3464		3003
		Pooled Survival	**140**						
		Pooled Number Tagged	5508						
2014	**Yakima**	**File Extender**		**PRC**		**PLN**	**MCW**	**PCS**	
		Mean Detection Date		**144**		**148**	**143**	**161**	
		Expanded McNary Passage		3011		3026	1249	3014	
		Pooled Survival							
		Pooled Number Tagged							

Table A.6 (cont) Outmigration-Year 2010-2014 In-Stream and Mobile-Raceway Mean Juvenile Detection Date

Release Year	Stock	Measure	Ahtanum		Big Creek	Reecer	Lost Creek	Umtanum Creek	Wilson	
2010	**Yakima**	**File Extender**	**PAH-Parr**		**PBG-Parr**	**PRC-Parr**		**UMT**	**PWL-Parr**	
		Mean Detection Date	**163**		**160**	**145**		**143**	**141**	
		Expanded McNary Passage	616		315	647		66	345	
2011	**Yakima**	**File Extender**	**PAH-Parr**		**PBG-Parr**	**PRC-Parr**	**WLC-Parr**	**UMT-Parr**	**PWL-Parr**	
		Mean Detection Date	**156**		**156**	**124**	**136**	**137**	**122**	
		Expanded McNary Passage	567		475	890	6	15	427	
2012	**Yakima**	**File Extender**	**PAL-Parr**		**PBG-Parr**	**PRE*-Parr**			**PWI-Parr**	
		Mean Detection Date	**151**		**152**	**145**			**144**	
		Expanded McNary Passage	217		349	588			333	
									Burried Section	
									Above	**Below**
2013	**Yakima**	**File Extender**	**PAL-Parr**	**PAM**	**PBG**	**PRE**			**PWA**	**PWB**
		Mean Detection Date	**121**	**146**	**147**	**140**			**152**	**147**
		Expanded McNary Passage	64	83	225	417			69	161
2014	**Yakima**	**File Extender**	**PAL**	**PAH**	**PBG**	**PRE**			**PWI-Parr**	
		Mean Detection Date	**0**	**141**	**143**	**139**			**140**	
		Expanded McNary Passage	672	872	3047	3031			3024	

Table A.6 (cont) Outmigration-Year 2010-2014 In-Stream and Mobile-Raceway <u>Mean Juvenile Detection Date</u>

Release Year	Stock	Measure	Rock Creek	Buckskin	Quarts	Yakima @ Thorp Bridge	Little Naches	NF Little Naches		
2009		File Extender								
		Mean Detection Date								
		Expanded McNary Passage								
2010	Yakima	File Extender	WRK-Wild				PLN-Parr	PNF-Parr		
		Mean Detection Date	n.a.				163	160		
		Expanded McNary Passage	0				549	594		
2011	Yakima	File Extender		WBK-Parr			PLN-Parr	PNF-Parr		
		Mean Detection Date		135			163	166		
		Expanded McNary Passage		82			288	538		
2012	Yakima	File Extender			PQU-Parr	PYA-Parr	PLN-Parr	PNF-Parr	Mercer Creek	
		Mean Detection Date			154	148	152	146	Burried Section-Parr	
		Expanded McNary Passage			364	267	660	579	Above	Below
2013	Yakima	File Extender					PLN	PNF	PMA	PMB
		Mean Detection Date					153	156	150	140
		Expanded McNary Passage					3019	3012	234	247
2014	Yakima	File Extender		MBU-Smolt	PQU		PLN			
		Mean Detection Date		118	322		154			
		Expanded McNary Passage		1572	3039		3012			

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Appendix G
Annual Report: Comparison of Salt-Water-Transfer Supplemented and Unsupplemented Feed Treatments evaluated on Upper-Yakima Spring Chinook Smolt-to-Adult Survival for 2007 and 2009 through 2011 Smolt Releases

Doug Neeley, Consultant to Yakama Nation

Introduction

For hatchery releases of Spring Chinook smolt released in 2007 and 2009 through 2014, two feed treatments were allocated to raceways within adjacent raceway pairs. Fish from each raceway within the pairs were fed BioVita feed (Bio-Oregon Inc.) prior to smoltification, then one raceway from each pair was allocated the BioTransfer feed supplement (Bio-Oregon Inc.; designated “Saltwater Transfer Feed”, referred to as STF in this document) and the other was not (referred to Control in this report). The intent of the experiment was to determine whether the STF-supplemented treatment increased the rate of smoltification and survival, the unsupplemented treatment serving as the control. This report is the first assessment of survival from acclimation pond release to adult survival to Roza Dam on the Upper Yakima River.

All juvenile fish were tagged as to: Parental source (hatchery-spawned or naturally-spawned parental source), acclimation site (Clark Flat, Easton, and Jack Creek) and treatment (STF or Control). There is now adult scale age information for all adult age groups (age 3, 4, and 5) from the 2007, and 2009 and 2010 releases and for age 3 and 4 adults from the 2011 releases. These serve as the data base for the analyses. There were tagging issues associated with releases in 2007 from the Jack Creek acclimation site; therefore the data from these releases have been excluded from the analyses because of uncertainty as to the assignment of the feed treatments to the raceways.   Although information from age-5 fish released in 2011 releases is not yet available; Age 5 fish represent a small proportion of the adult returns (less than 2.6%. 0.9%, and .7% for the adult returns of the respective 2007, 2009, and 2010 releases); therefore use of all four years are used for a tentative evaluation.

Adult recoveries at Roza Dam were: 1) Assigned to brood years by age at recovery, 2) tallied within age groups within brood year, 3) then adjusted and divided by associated smolt release totals to estimate brood-year survivals using procedures described in Appendix A.

Comparison between the STF and Control Treatments

Analyses of juvenile measures were presented in the annual report entitled *Comparison of Salt-Water-Transfer Supplemented-Feed and Unsupplemented-Feed Treatments evaluated on Natural-Origin Brood, Hatchery-Reared Upper-Yakima Spring Chinook Smolt released in 2007 and 2009 through 2014*. There were neither significant nor substantial differences in STF effects reported on those Juvenile traits[1].

However, the analysis of smolt-to-adult survival revealed that the mean survival of adults receiving pre-release the STF-supplement feed had a higher survival for each of the three years analyzed (Table and Figure 1). The difference when pooled over years was significant at the 5% level (P = 0.0116, Table B.1.a. in Appendix B) based on a one-sided test that the supplement-treated fish would have a higher adult survival than the control. There was no significant interaction of the STF-Control difference with year but there was with site (respectively P = 0.4319 and P = 0.0421 Table B.1.a. in Appendix B). The STF-Control interaction with Site reflects that, of the eleven possible STF-Control paired comparisons presented in Table B.1.b, there were two in which the STF mean did not exceed the Control mean, both of which were associated with Clark Flat (release years 2009 and 2011). This resulted in the Clark Flat STF and Control means over years being nearly identical. Nonetheless, the nine of eleven paired comparisons in which the STF mean exceeded the Control mean was significant based on a one-sided sign test (P = 0.0327).

Table 1. Percent of STF and Control Spring Chinook that survive from Acclimation-Site release to Adult Recovery at Roza Dam by Release Year

	Brood Year	**2005***	**2007**	**2008**	**2009****	
Treatment	**Release Year**	**2007***	**2009**	**2010**	**2011****	**Over Years**
STF	**Survival**	**0.481%**	**0.717%**	**0.671%**	**0.318%**	**0.552%**
	Number Released	282,682	384,210	428,015	399,326	1,494,233
Control	**Survival**	**0.457%**	**0.689%**	**0.607%**	**0.287%**	**0.515%**
	Number Released	285,595	387,055	421,290	395,455	1,489,395
	Difference	**0.024%**	**0.028%**	**0.064%**	**0.031%**	**0.038%**

***Jack Creek omitted because of conflicting tag-position coding**

**** Does not include Age-5 Returns**

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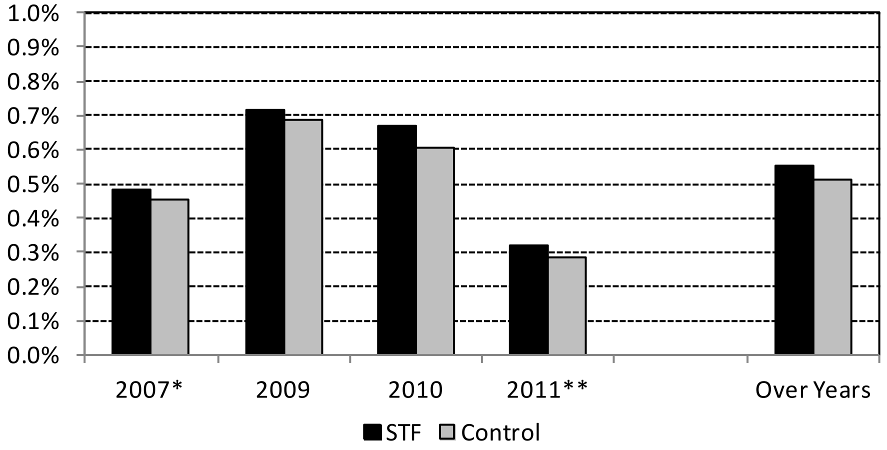
[1] The juvenile analyses excluded hatchery-spawned parental-source returns. This report utilizes returns from both hatchery-spawned and naturally-spawned parental sources; however it is intended to exclude returns from hatchery-spawned parents in future reports. The inclusion of the hatchery-spawned fish is not expected to greatly affect conclusions in the report because it represents one-third of the production from the Clark Flat acclimation site and none of the production from the other two acclimation sites.

Figure 1. Percent of STF and Control Spring Chinook that survive from Acclimation-Site release to Adult Recovery at Roza Dam by Release Year



*** Does not include Jack Creek**

**** Does not include Age-5 Returns**

An analysis was also performed on the percent of Age-3 adults, and the yearly mean percentages are presented in Table and Figure 2. There was no significant difference in the STF and Control means for proportion of fish returning at age-3 over brood years (P= 0.0838, Appendix Table B.2.). Note that the mean estimates for the 2011 release will be biased, the Age-3 mean percentages being too high because they did not include Age-5 returns. It should also be noted that this latter release year was the only one for which the Control mean age-3 percentage exceeded that of the STF. Nevertheless, the STF-Control mean difference in age-3 percent never exceeds 2%.

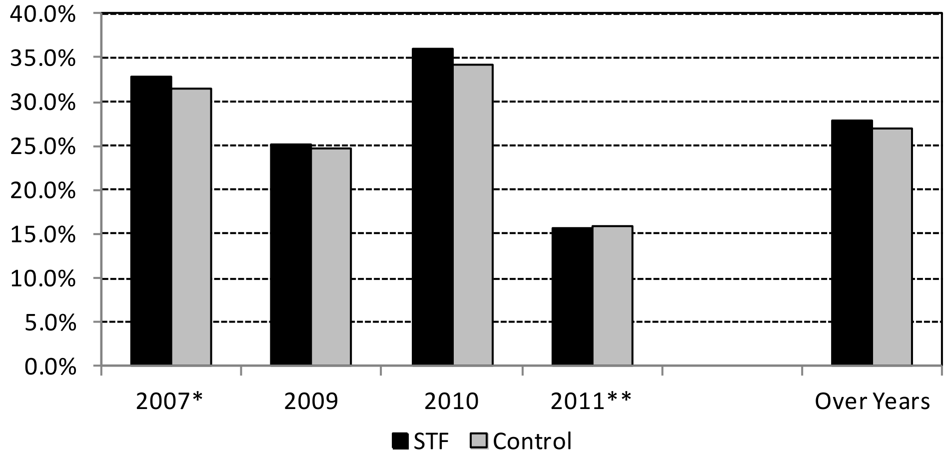
Table 2. Percent of STF- and Control-Treatment Spring Chinook that were classified as Age-3 Adults at Roza Recovery

	Brood Year	**2005***	**2007**	**2008**	**2009****	
Treatment	**Release Year**	**2007***	**2009**	**2010**	**2011****	**Over Years**
STF	**Percent Age-3**	**32.9%**	**25.2%**	**35.9%**	**15.6%**	**27.9%**
	Number of Aduls	2,040	2,753	2,872	1,270	6,895
Control	**Percent Age-3**	**31.4%**	**24.7%**	**34.1%**	**15.9%**	**26.9%**
	Number of Adultls	1,924	2,667	2,559	1,136	6,362
	Difference	**1.4%**	**0.5%**	**1.8%**	**-0.3%**	**1.0%**

***Jack Creek omitted because of conflicting tag-position coding**

**** Does not include Age-5 Returns**

Figure 2. **Percent of STF- and Control-Treatment Spring Chinook that were classified as Age-3 Adults at Roza Recovery by Release Year**



*** Does not include Jack Creek**

**** Does not include Age-5 Returns**

The findings presented herein should be regarded as tentative since very few years for adult-survival analysis are available at this time. At this point, there have been releases made of STF and Control treated smolt through 2014 and more powerful tests over varying yearly conditions will be available as more adults return in future years.

Appendix A. Procedures

A multivariate procedure (a modification of Hotelling's T^2 discriminant) was used to find a weighted index of fish fork-length (FL), post-orbital hypural length (POH) length and weight (Wt) from known-age adult recoveries. This procedure is often used to compare two populations to determine if they differ significantly using these weighted traits. However, the Age-3 and Age-4 populations and Age 4 and Age-5 populations are already known to differ in their traits' distributions. Instead, this index was developed using the measures of known-age fish for the purpose of assigning unknown-age fish to age classes.

Using the age 3 and 4 fish as an example, the index, once established, was applied to each known-age fish's measures, the individual fish being flagged as to age. The index values were sorted, and the sorted value that resulted in the equal numbers of age-3 fish being misclassified as an age-4 fish and of age-4 fish being misclassified as an age-3 fish was determined. That discriminant value was used to classify the unknown-age fish based on their individual index values. For Age-3 and Age-4 fish, discriminant values were estimated separately for each year. In the case of Age-4 and Age-5 fish, the number of known age-5 fish recovered per year was too small for yearly index-value estimation, and it was necessary to pool the age-4 and age-5 fish over years do obtain an estimate. This creates an unavoidable bias when the relative age-4/age-5 distributions differ over years.

The index utilized the standardized[2] z for each trait (Equation Eq. A.1) for the combined age-group pairs (separate indices for the Age-3/Age-4 and the Age-4/Age-5 age groups).

Eq.A.1. z = (Measure – Mean of Measure) **/** (Standard Deviation of Measure)

The index measure's equation is given in equation Eq.A.2.

Eq.A.2. I = W(FL)*z(FL) + W(POH)*z(POH) + W(Wt)*z(Wt) wherein W(FL)+ W(POH)+ W(Wt) = 1

The W() values were chosen so as to maximize equation Eq A.3 for age groups j and k.

Eq. A.3. T^2 = mean^2(difference) **/** Variance(difference), difference = I(age-j) – I(age-k)

It turned out that in no year was the Hotelling discriminant value for Age-3 and Age-4 fish better than a comparable discriminant value based on one of the individual trait measures by itself[3]. Except for brood-year 2002, using fork length alone was as good as a discriminant or better than the Hotelling-based discriminant; i.e., the fork-length equal numbers of misclassified of age -3 and of age-4 fish was the same or smaller than that of the Hotelling-based discriminant except for the one year. In 2002, using fish weight alone was the best discriminant[4]. In all years the Age-4/Age-5 Hotelling discriminant was a weighting of fork length and POH length, but fork length was again a better discriminant than the Hotelling-based discriminant (POH length was slightly better). For the sake of consistency, fork length was used as the discriminator for all years and age classes.

One possible reason for the failure of Hotelling's discriminant to be the best indicator is that it based on the mean and variance which are the two parameters of the normal distribution. The index developed is into the far tail regions of Age-3/Age-4 distributions of known-age fish. Any failure for the actual underlying distributions to follow the normal distribution (e.g., skewness and kurtosis) would be most manifest in the tails.

The Age-3/Age-4 discriminant values used to separate the age classes are given in Table A.1 along with numbers of known-age misclassified fish and the associated misclassification error proportions [(number

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[2] The standardized z is scale independent. If the index measure for length and weight were in inches and pounds, the index created would be inconsistent with an index measure based on centimeters and kilograms.

[3] Hotelling's discriminant would be expected to be the best if the true indices within each group were normally distributed. When identifying the discriminant that results in equal misclassification numbers of the two age groups, the assessment are well into the respective tails of the two distributions (upper tail and lower tail of the respective younger and older age groups), areas likely to be likely to be most impacted by non-normality.

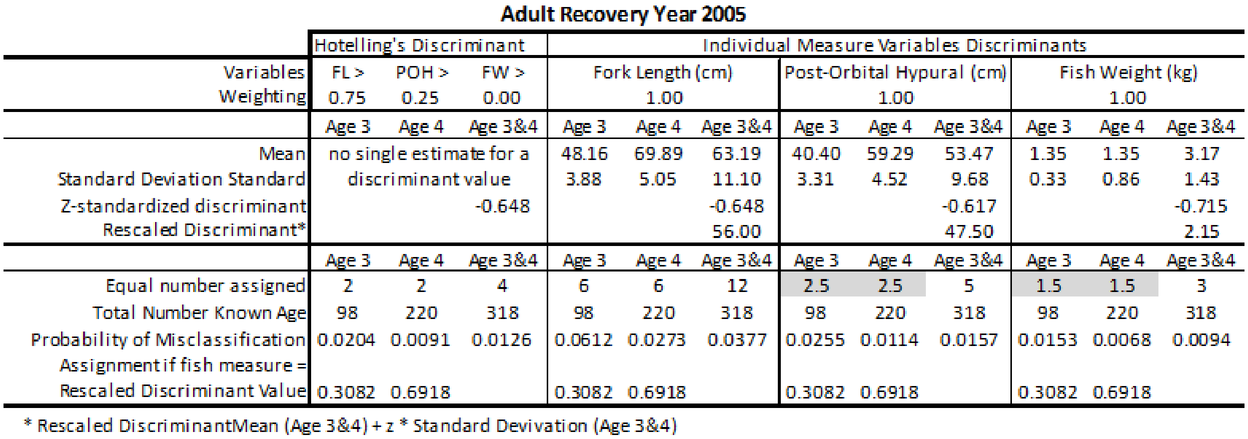
[4] In all years the Hotelling discriminant fore Age-3/Age-4 fish was a weighting of fork length and POH length. In three of the nine years only fork length went into that weighting.

of known-age fish)/(total number of known-age fish)]. Table A.2 presents the same information for the Age-4/Age-5 discriminant. Note that discriminant values with a non-zero decimal value are highlighted in yellow. Occasionally equality values were not realized; for example a discriminant value associated with the sorted trait may have 2 Age-3 fish misclassified as Age-4 and 1 Age -3 fish classified as an Age-4 fish, an adjacent sorted discriminant value may have associated misclassification numbers of 1 Age-3 fish misclassified as Age-4 and 2 Age-3 fish classified as an Age-4 fish. The two sets of numbers straddle the equality numbers. In such cases the two Age-3 misclassification numbers are averaged as are the two Age-4 misclassification numbers; in the example this gives (1+2)/ 2 = (2+1)/2 =1.5. The example given is symmetric: 1 and 2 misclassifications for one of the two respective discriminant values and 2 and 1 for the next straddling value which resulted in equality. Such equality is not guaranteed; however, in all cases involving the averaging of straddling number pairs, equality was realized. When averaging was performed on adjacent straddling numbers, the associated discriminant values were also averaged. If the unknown fish index value exactly equaled the discriminant value, that fish's contribution to the tally was proportionally allocated according to the probability of the estimated probability of error of misclassification, the probability of misclassification and the proportional assignment of the fish being given in Tables A.1 and A.2.

Once a discriminant value was determined, all unknown fish values less than this discriminant value were tallied to get the total for the youngest of the two groups, and all unknown fish values greater than this discriminant value were tallied to get the total of the oldest of the two age groups.

Not all fish could be assigned to a group either because the elastomer tag (identifying the fish as to acclimation site) was missing or unreadable, the tag identifying the fish as being a progeny of parents that were naturally spawned, or the elastomer tag position (left or right eye) identifying the fish as to treatment was unread. To adjust for such tag loss within recovery year, all fish with all tags identifiable were tallied, and this tally was divided by the number of all recovered hatchery fish as an estimate of tag-determination efficiency. This adjustment is made under the assumption that tag-loss/tag-misreading is independent of elastomer-site, eye location, and parental source. The STF and Control tallies were expanded (divided) by this estimate. The tallies within recovery year were then assigned to the appropriate three brood years. The age group tallies were then totaled within STF and Control treated groups within the brood year, and then the respective totals were divided by the respective number of STF and Control smolt released to estimate their survivals.

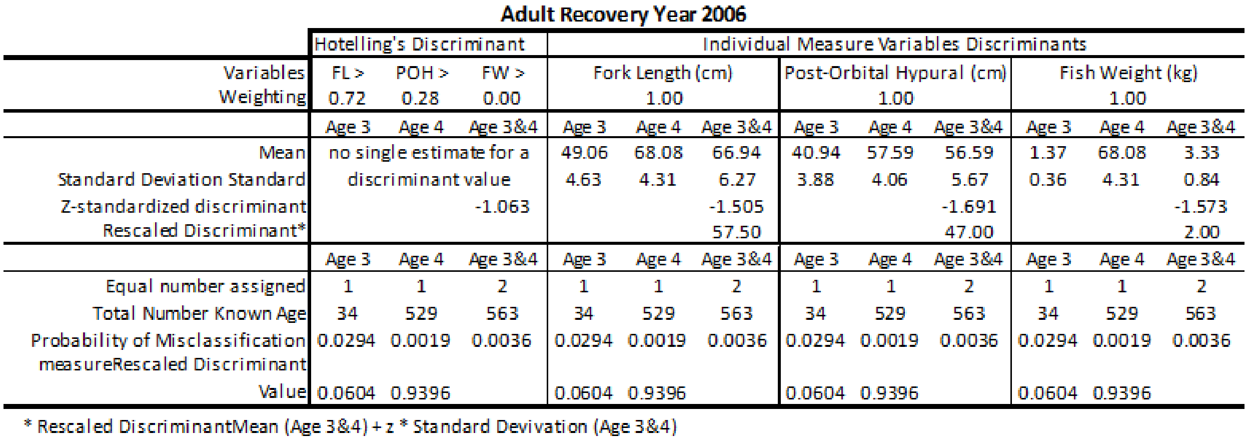
Table A.1. **Information used to discriminate between Age-3 and Age-4 Adults recovered at Roza Dam based on Known-Age Fish for application to Unknown Fish using measured Traits.**



Adult Recovery Year 2005

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.75	0.25	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for a discriminant value			48.16	69.89	63.19	40.40	59.29	53.47	1.35	1.35	3.17
Standard Deviation Standard				3.88	5.05	11.10	3.31	4.52	9.68	0.33	0.86	1.43
Z-standardized discriminant			-0.648			-0.648			-0.617			-0.715
Rescaled Discriminant*						56.00			47.50			2.15
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	2	2	4	6	6	12	2.5	2.5	5	1.5	1.5	3
Total Number Known Age	98	220	318	98	220	318	98	220	318	98	220	318
Probability of Misclassification	0.0204	0.0091	0.0126	0.0612	0.0273	0.0377	0.0255	0.0114	0.0157	0.0153	0.0068	0.0094
Assignment if fish measure = Rescaled Discriminant Value	0.3082	0.6918		0.3082	0.6918		0.3082	0.6918		0.3082	0.6918	

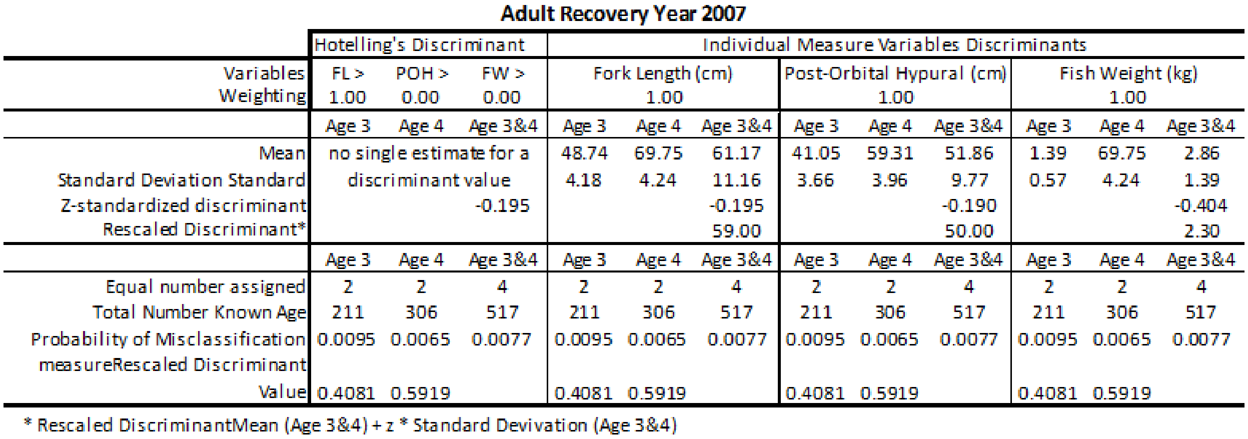
* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)



Adult Recovery Year 2006

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.72	0.28	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for a discriminant value			49.06	68.08	66.94	40.94	57.59	56.59	1.37	68.08	3.33
Standard Deviation Standard				4.63	4.31	6.27	3.88	4.06	5.67	0.36	4.31	0.84
Z-standardized discriminant			-1.063			-1.505			-1.691			-1.573
Rescaled Discriminant*						57.50			47.00			2.00
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	1	1	2	1	1	2	1	1	2	1	1	2
Total Number Known Age	34	529	563	34	529	563	34	529	563	34	529	563
Probability of Misclassification	0.0294	0.0019	0.0036	0.0294	0.0019	0.0036	0.0294	0.0019	0.0036	0.0294	0.0019	0.0036
measureRescaled Discriminant Value	0.0604	0.9396		0.0604	0.9396		0.0604	0.9396		0.0604	0.9396	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)



Adult Recovery Year 2007

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	1.00	0.00	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for a discriminant value			48.74	69.75	61.17	41.05	59.31	51.86	1.39	69.75	2.86
Standard Deviation Standard				4.18	4.24	11.16	3.66	3.96	9.77	0.57	4.24	1.39
Z-standardized discriminant			-0.195			-0.195			-0.190			-0.404
Rescaled Discriminant*						59.00			50.00			2.30
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	2	2	4	2	2	4	2	2	4	2	2	4
Total Number Known Age	211	306	517	211	306	517	211	306	517	211	306	517
Probability of Misclassification	0.0095	0.0065	0.0077	0.0095	0.0065	0.0077	0.0095	0.0065	0.0077	0.0095	0.0065	0.0077
measureRescaled Discriminant Value	0.4081	0.5919		0.4081	0.5919		0.4081	0.5919		0.4081	0.5919	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Table A.1. Information used to discriminate between Age-3 and Age-4 Adults recovered at Roza Dam based on Known-Age Fish for application to Unknown Fish using measured Traits (continue).

Adult Recovery Year 2008

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.41	0.59	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for a			53.63	70.75	66.10	45.06	60.19	56.07	1.91	70.75	3.57
Standard Deviation Standard	discriminant value					8.97			7.96		4.52	1.27
Z-standardized discriminant			-0.609			-0.568			-0.637			-0.684
Rescaled Discriminant*						61.00			51.00			2.70
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	9.5	9.5	19	8.5	8.5	17	8.5	8.5	17	14	14	28
Total Number Known Age	142	380	522	142	380	522	142	380	522	142	380	522
Probability of Misclassification	0.0669	0.0250	0.0364	0.0599	0.0224	0.0326	0.0599	0.0224	0.0326	0.0986	0.0368	0.0536
measureRescaled Discriminant Value	0.2720	0.7280		0.2720	0.7280		0.2720	0.7280		0.2720	0.7280	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Adult Recovery Year 2009

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.76	0.24	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for			51.64	72.96	63.30	43.71	62.10	53.77	1.68	72.96	3.18
Standard Deviation Standard	discriminant value			4.96	4.29	11.58	4.32	3.76	10.00	0.51	4.29	1.53
Z-standardized discriminant			-0.038			-0.026			-0.077			-0.183
Rescaled Discriminant*						63.00			53.00			2.90
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	7	7	14	7	7	14	5	5	10	9	9	18
Total Number Known Age	363	438	801	363	438	801	363	438	801	363	438	801
Probability of Misclassification	0.0193	0.0160	0.0175	0.0193	0.0160	0.0175	0.0138	0.0114	0.0125	0.0248	0.0205	0.0225
measureRescaled Discriminant Value	0.4532	0.5468		0.4532	0.5468		0.4532	0.5468		0.4532	0.5468	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Adult Recovery Year 2010

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	1.00	0.00	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for			49.74	71.90	68.20	42.34	61.46	58.27	1.48	71.90	58.27
Standard Deviation Standard	discriminant value			4.55	4.25	9.32	3.86	3.95	8.15			8.15
Z-standardized discriminant			-0.880			-0.880			-0.892			-1.106
Rescaled Discriminant*						60.00			51.00			49.26
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	4	4	8	4	4	8	4	4	8	4	4	8
Total Number Known Age	153	764	917	153	764	917	153	764	917	153	764	917
Probability of Misclassification	0.0261	0.0052	0.0087	0.0261	0.0052	0.0087	0.0261	0.0052	0.0087	0.0261	0.0052	0.0087
measureRescaled Discriminant Value	0.1668	0.8332		0.1668	0.8332		0.1668	0.8332		0.1668	0.8332	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Table A.1. **Information used to discriminate between Age-3 and Age-4 Adults recovered at Roza Dam based on Known-Age Fish for application to Unknown Fish using measured Traits (continued).**

Adult Recovery Year 2011

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	1.00	0.00	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for			50.77	71.72	66.16	43.14	61.05	56.29	1.59	71.72	56.29
Standard Deviation Standard	discriminant value			4.58	4.35	10.26	3.91	3.97	8.84	0.56	4.35	8.84
Z-standardized discriminant			-0.503			-0.503			-0.598			-0.626
Rescaled Discriminant*						61.00			51.00			50.76
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	7	7	14	7	7	14	7.5	7.5	15	14	14	28
Total Number Known Age	213	589	802	213	589	802	213	589	802	213	589	802
Probability of Misclassification	0.0329	0.0119	0.0175	0.0329	0.0119	0.0175	0.0352	0.0127	0.0187	0.0657	0.0238	0.0349
measureRescaled Discriminant Value	0.2656	0.7344		0.2656	0.7344		0.2656	0.7344		0.2656	0.7344	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Adult Recovery Year 2012

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.63	0.37	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for			48.11	69.99	67.32	40.48	59.40	57.10	1.56	69.99	4.15
Standard Deviation Standard	discriminant value			4.63	4.43	8.43	3.87	4.02	7.37	0.49	4.43	1.29
Z-standardized discriminant			-1.228			-1.224			-1.235			-1.356
Rescaled Discriminant*						57.00			48.00			2.40
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	2	2	4	2	2	4	2	2	4	4	4	8
Total Number Known Age	75	541	616	75	541	616	75	541	616	75	541	616
Probability of Misclassification	0.0267	0.0037	0.0065	0.0267	0.0037	0.0065	0.0267	0.0037	0.0065	0.0533	0.0074	0.0130
measureRescaled Discriminant Value	0.1218	0.8782		0.1218	0.8782		0.1218	0.8782		0.1218	0.8782	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Adult Recovery Year 2013

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.75	0.25	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for			52.33	69.44	64.41	44.59	58.87	54.68	2.03	69.44	3.77
Standard Deviation Standard	discriminant value			4.57	4.71	9.09	3.98	4.23	7.72	0.55	4.71	1.40
Z-standardized discriminant			-0.515			-0.485			-0.476			-0.619
Rescaled Discriminant*						60.00			51.00			2.90
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number missclassified	6	6	12	4	4	8	5	5	10	8	8	16
Total Number Known Age	160	385	545	160	385	545	160	385	545	160	385	545
Probability of Misclassification	0.0375	0.0156	0.0220	0.0250	0.0104	0.0147	0.0313	0.0130	0.0183	0.0500	0.0208	0.0294
measureRescaled Discriminant Value	0.2936	0.7064		0.2936	0.7064		0.2936	0.7064		0.2936	0.7064	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Table A.2. Information used to discriminate between Age-4 and Age-5 Adults recovered at Roza Dam based on Known-Age Fish for application to Unknown Fish using measured Traits.

Adult Recovery Years 2005-2013

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.55	0.00	0.45	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 4	Age 5	Age 4&5	Age 4	Age 5	Age 4&5	Age 4	Age 5	Age 4&5
Mean	no estimates for a			70.66	81.98	70.98	60.08	70.20	60.37	4.17	6.43	4.24
Standard Deviation Standard	single discriminant value			4.65	5.52	5.04	4.27	4.67	4.60	0.89	1.40	0.98
Z-standardized discriminant			2.064			1.987			1.875			2.100
Rescaled Discriminant*						81.00			69.00			1.01
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	59	59	118	51	51	102	50	50	100	61	61	122
Total Number Known Age	4161	123	4284	4161	123	4284	4161	123	4284	4161	123	4284
Probability of Misclassification	0.0142	0.4797	0.0275	0.0123	0.4146	0.0238	0.0120	0.4065	0.0233	0.0147	0.4959	0.0285
measureRescaled Discriminant Value	0.9713	0.0287		0.9713	0.0287		0.9713	0.0287		0.9713	0.0287	

* Rescaled DiscriminantMean (Age 4&5) + z * Standard Devivation (Age 4&5)

Appendix B. Analyses of Variation

Table B.1.a. Logistic Analyses of Variation of Adult Survival from Release from Acclimation Sites to Adult Recovery at Roza Dam for Release Years 2007 and 2009-2011

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P 2-sided*	Type 1 Error P 1-sided**	Base for Test
Year	1539.54	3	513.18	511.14	0.0000		Error
Treatment (Trt)	20.34	1	20.34	18.49	0.0231	0.0116	Year x Trt
Year x Trt	3.3	3	1.10	1.10	0.4319		Error
Site	294.08	2	147.04	8.30	0.0258		Year x Site
Year x Site	88.6	5	17.72	17.65	0.0034		Error
Site x Trt	12.8	2	6.40	6.37	0.0421		Error
Error	5.02	5	1.00				

*** Tests Mean(STF) ≠ Mean (Control)**

**** Tests Mean(STF) > Mean (Control)**

Table B.1.b Percent of STF and Control Spring Chinook tagged as Juveniles before Release from Acclimation Sites that Survive to Adult Recovery at Roza Dam for each Site within each Year

Brood/Release Year	Treatment		Clark Flat	Easton	Jack Creek	Site Means
2005/2007	**STF**	**Survival**	**0.520%**	**0.441%**		**0.481%**
		Number Released	144,721	137,961		282,682
	Control	**Survival**	**0.516%**	**0.398%**		**0.457%**
		Number Released	142,406	143,189		285,595
	STF - Control Survival Difference		**0.004%**	**0.043%**		**0.024%**
2007/2009	**STF**	**Survival**	**0.869%**	**0.560%**	**0.713%**	**0.717%**
		Number Released	131,944	126,018	126,248	384,210
	Control	**Survival**	**0.890%**	**0.532%**	**0.634%**	**0.689%**
		Number Released	133,963	128,522	124,570	387,055
	STF - Control Survival Difference		**-0.021%**	**0.028%**	**0.079%**	**0.028%**
2008/2010	**STF**	**Survival**	**0.739%**	**0.635%**	**0.639%**	**0.671%**
		Number Released	141,766	144,320	141,929	428,015
	Control	**Survival**	**0.711%**	**0.543%**	**0.571%**	**0.607%**
		Number Released	138,487	143,537	139,266	421,290
	STF - Control Survival Difference		**0.028%**	**0.093%**	**0.068%**	**0.064%**
2009/2011*	**STF**	**Survival**	**0.332%**	**0.251%**	**0.370%**	**0.318%**
		Number Released	133,515	132,264	133,547	399,326
	Control	**Survival**	**0.338%**	**0.189%**	**0.335%**	**0.287%**
		Number Released	130,905	132,098	132,452	395,455
	STF - Control Survival Difference		**-0.006%**	**0.062%**	**0.034%**	**0.031%**
Yearly Means	**STF**	**Survival**	**0.648%**	**0.486%**	**0.573%**	**0.569%**
		Number Released	407,225	402,602	401,724	1,211,551
	Control	**Survival**	**0.649%**	**0.424%**	**0.512%**	**0.528%**
		Number Released	403,355	404,157	396,288	1,203,800
	STF - Control Survival Difference		**-0.002%**	**0.062%**	**0.061%**	**0.041%**

*** Based on only Age 3 and 4 Returns**

Table B.2. **Logistic Analyses of Variation of the Age-3 proportion of fish recovered at Roza Dam**

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P	Base for Test
Year	378.72	3	126.24	136.33	0.0000	Error
Treatment (Trt)	1.91	1	1.91	6.51	0.0838	Year x Trt
Year x Trt	0.88	3	0.29	0.32	0.8135	Error
Site	6.85	2	3.43	0.38	0.7011	Year x Site
Year x Site	44.88	5	8.98	9.69	0.0131	Error
Site x Trt	6.84	2	3.42	3.69	0.1035	Error
Error	4.63	5	0.93			

*** Tests Mean(STF) ≠ Mean (Control)**

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Appendix H
Spring Chinook Release-to-Roza-Dam Smolt-to-Adult Survival: Comparison of Hatchery and Natural Origin Brood Stock

Since the onset of the YKFP program, hatchery Spring Chinook of naturally spawned adults have been reared at the Cle Elum hatchery and subsequently transferred to and released from acclimation facilities at Clark Flat, Easton, and Jack Creek. In each year two treatments have been allocated to raceways within adjacent raceway pairs, there being three pairs of raceways at each of the three acclimation sites. The experimental treatments have varied over years. The raceways pairs were similar, not only in that they were adjacent to each other, but also because the raceways within each pair received progeny from the same sets of diallele crosses.

Beginning in Brood-Year 2002, one pair of raceways at the Clark Flat acclimation site was assigned to progeny derived from hatchery-brood crosses (HxH or hatchery-control stock - HC) to assess the long-term effect of using hatchery-brood progeny of each generation to serve as the brood-stock for the subsequent generation. All other raceways continued to use crosses from naturally spawned parents (NxN or supplemented hatchery stock - SH). No HxH hatchery-produced adults are allowed to spawn in the wild.

In this report, only the HxH and NxN stocks released from the Clark Flats acclimation site are being compared.

Adult recoveries at Roza Dam were: 1) Assigned to brood years by age at recovery, 2) tallied within age groups within brood year, 3) then adjusted and divided by associated smolt release totals to estimate brood-year survivals using procedures described in Appendix A.

Comparison between the Hatchery and Natural Crosses

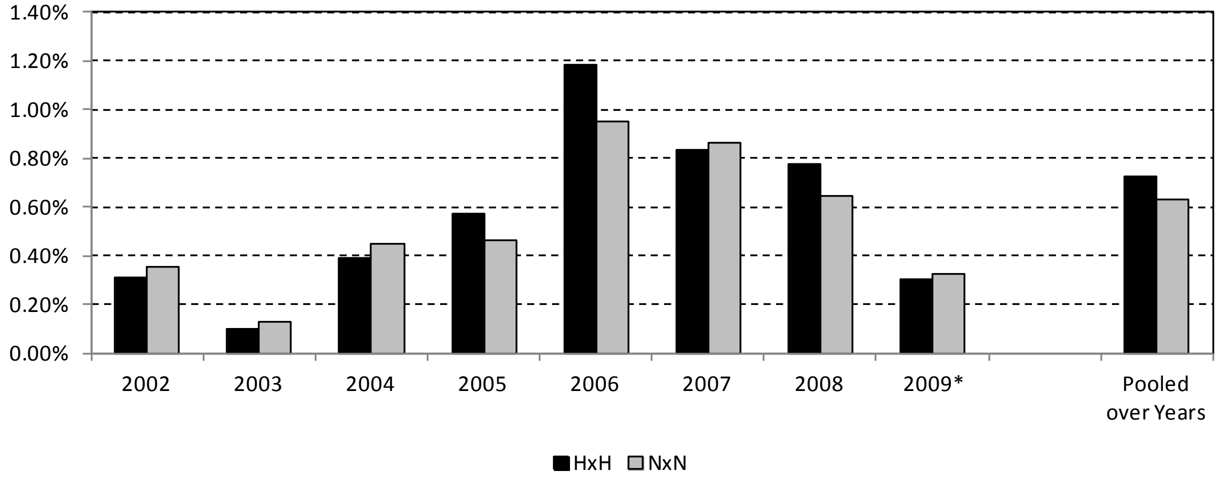
An analysis of smolt-to-adult survival revealed that, although the survival of the HxH-stock over years was higher than that of the NxN stock (respectively 0.73% greater than 0.63%, Table 1. and Figure 1.), the difference was not significant at any reasonable significance level (P = 0.31, Appendix Table B.1.).

Table 1. Percent of HxH and NxN Spring Chinook tagged as Juveniles before Release from Clark Flats that Survive to Adult Recovery at Roza Dam

		Brood Year								Pooled
		2002	2003	2004	2005	2006	2007	2008	2009*	Mean over
HxH	**Percent Survival**	**0.31%**	**0.10%**	**0.39%**	**0.58%**	**1.19%**	**0.83%**	**0.77%**	**0.30%**	**0.73%**
	Number Release	276	90	372	521	812	790	752	269	3,882
NxN	**Percent Survival**	**0.35%**	**0.13%**	**0.45%**	**0.46%**	**0.95%**	**0.86%**	**0.65%**	**0.33%**	**0.63%**
	Number Release	634	235	838	904	1,339	1,479	1,185	591	7,205

*** Does not include Age 5 returns**

Figure 1. Percent of HxH and NxN Spring Chinook tagged as Juveniles before Release from Flats that Survive to Adult Recovery at Roza Dam



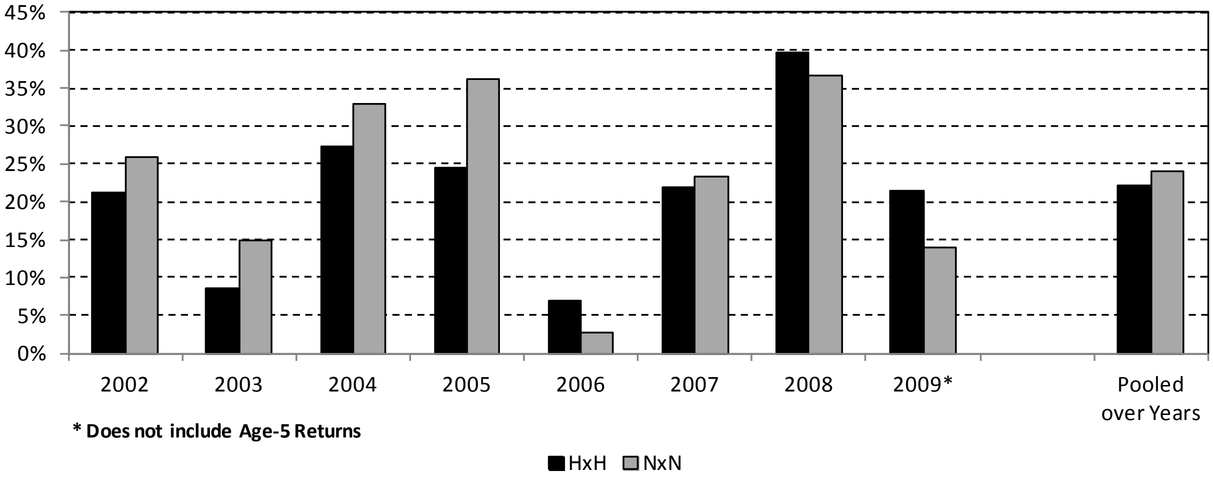
An analysis was also performed on the Age-3 percentages of adult returns. The estimates are presented in Table 2. and Figure 2. The Age-3 percent over years did not differ substantially (22.1% for HxH stock and 24.1% for NxN stock, Table 2 and Figure 2) or differ significantly at any reasonable significance level (P = 0.68, Appendix Table B.2).

Table 2. Percent of Spring Chinook released from Clark Flats' Site as yearlings that were classified as Age-3 Adults at Roza Recovery for HxH and NxN stock

		Brood Year								Pooled
		2002	2003	2004	2005	2006	2007	2008	2009*	Mean over
HxH	**Percent Age 3**	**21.1%**	**8.6%**	**27.3%**	**24.6%**	**6.9%**	**22.0%**	**39.6%**	**21.5%**	**22.1%**
	Number Aged	87,837	88,733	94,339	90,518	68,434	94,663	97,196	88,771	710,491
NxN	**Percent Age 3**	**25.9%**	**14.9%**	**32.9%**	**36.2%**	**2.8%**	**23.4%**	**36.6%**	**13.9%**	**24.1%**
	Number Aged	178,726	184,644	186,259	196,609	141,141	171,244	183,057	180,431	1,422,111

*** Does not include Age 5 returns**

Figure 2. **Percent of Spring Chinook released from Clark Flats' Site as yearlings that were classified as Age-3 Adults at Roza Recovery for HxH and NxN stock**



Appendix A. Procedures

A multivariate procedure (a modification of Hotelling's T^2 discriminant) was used to find a weighted index of fish fork-length (FL), post-orbital hypural length (POH) length and weight (Wt) from known-age adult recoveries. This procedure is often used to compare two populations to determine if they differ significantly using these weighted traits. However, the Age-3 and Age-4 populations and Age 4 and Age-5 populations are already known to differ in their traits' distributions. Instead, this index was developed using the measures of known-age fish for the purpose of assigning unknown-age fish to age classes.

Using the age 3 and 4 fish as an example, the index, once established, was applied to each known-age fish's measures, the individual fish being flagged as to age. The index values were sorted, and the sorted value that resulted in the equal numbers of age-3 fish being misclassified as an age-4 fish and of age-4 fish being misclassified as an age-3 fish was determined. That discriminant value was used to classify the unknown-age fish based on their individual index values. For Age-3 and Age-4 fish, discriminant values were estimated separately for each year. In the case of Age-4 and Age-5 fish, the number of known age-5 fish recovered per year was too small for yearly index-value estimation, and it was necessary to pool the age-4 and age-5 fish over years do obtain an estimate. This creates an unavoidable bias when the relative age-4/age-5 distributions differ over years.

The index utilized the standardized[1] z for each trait (Equation Eq. A.1) for the combined age-group pairs (separate indices for the Age-3/Age-4 and the Age-4/Age-5 age groups).

Eq.A.1. $z = (\text{Measure} - \text{Mean of Measure}) / (\text{Standard Deviation of Measure})$

The index measure's equation is given in equation Eq.A.2.

Eq.A.2. $I = W(FL)*z(FL) + W(POH)*z(POH) + W(Wt)*z(Wt)$ wherein $W(FL)+ W(POH)+ W(Wt) = 1$

The W() values were chosen so as to maximize equation Eq A.3 for age groups j and k.

Eq. A.3. $T^2 = \text{mean}^2(\text{difference}) / \text{Variance}(\text{difference})$, $\text{difference} = I(\text{age-j}) - I(\text{age-k})$

It turned out that in no year was the Hotelling discriminant value for Age-3 and Age-4 fish better than a comparable discriminant value based on one of the individual trait measures by itself[2]. Except for brood-year 2002, using fork length alone was as good as a discriminant or better than the Hotelling-based discriminant; i.e., the fork-length equal numbers of misclassified of age -3 and of age-4 fish was the same or smaller than that of the Hotelling-based discriminant except for the one year. In 2002, using fish weight alone was the best discriminant[3]. In all years the Age-4/Age-5 Hotelling discriminant was a weighting of fork length and POH length, but fork length was again a better discriminant than the Hotelling-based discriminant (POH length was slightly better). For the sake of consistency, fork length was used as the discriminator for all years and age classes.

One possible reason for the failure of Hotelling's discriminant to be the best indicator is that it based on the mean and variance which are the two parameters of the normal distribution. The index developed is into the far tail regions of Age-3/Age-4 distributions of known-age fish. Any failure for the actual underlying distributions to follow the normal distribution (e.g., skewness and kurtosis) would be most manifest in the tails.

The Age-3/Age-4 discriminant values used to separate the age classes are given in Table A.1 along with numbers of known-age misclassified fish and the associated misclassification error proportions [(number of known-age fish)/(total number of known-age fish)]. Table A.2 presents the same information for the Age-4/Age-5 discriminant. Note that discriminant values with a

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[1] The standardized z is scale independent. If the index measure for length and weight were in inches and pounds, the index created would be inconsistent with an index measure based on centimeters and kilograms.

[2] Hotelling's discriminant would be expected to be the best if the true indices within each group were normally distributed. When identifying the discriminant that results in equal misclassification numbers of the two age groups, the assessment are well into the respective tails of the two distributions (upper tail and lower tail of the respective younger and older age groups), areas likely to be likely to be most impacted by non-normality.

[3] In all years the Hotelling discriminant fore Age-3/Age-4 fish was a weighting of fork length and POH length. In three of the nine years only fork length went into that weighting.

non-zero decimal value are highlighted in yellow. Occasionally equality values were not realized; for example a discriminant value associated with the sorted trait may have 2 Age-3 fish misclassified as Age-4 and 1 Age -3 fish classified as an Age-4 fish, an adjacent sorted discriminant value may have associated misclassification numbers of 1 Age-3 fish misclassified as Age-4 and 2 Age-3 fish classified as an Age-4 fish The two sets of numbers straddle the equality numbers. In such cases the two Age-3 misclassification numbers are averaged as are the two Age-4 misclassification numbers; in the example this gives (1+2)/ 2 = (2+1)/2 =1.5. The example given is symmetric: 1 and 2 misclassifications for one of the two respective discriminant values and 2 and 1 for the next straddling value which resulted in equality. Such equality is not guaranteed; however, in all cases involving the averaging of straddling number pairs, equality was realized. When averaging was performed on adjacent straddling numbers, the associated discriminant values were also averaged. If the unknown fish index value exactly equaled the discriminant value, that fish’s contribution to the tally was proportionally allocated according to the probability of the estimated probability of error of misclassification, the probability of misclassification and the proportional assignment of the fish being given in Tables A.1 and A.2.

Once a discriminant value was determined, all unknown fish values less than this discriminant value were tallied to get the total for the youngest of the two groups, and all unknown fish values greater than this discriminant value were tallied to get the total of the oldest of the two age groups.

Not all fish could be assigned to a group either because the elastomer tag (identifying the fish as being from the Clark Flat acclimation site) was missing or unreadable or the tag identifying the fish as being a HxH or NxN fish was missing. To adjust for such tag loss within recovery year, all fish with both tags identifiable were tallied, and this tally was divided by the number of all recovered hatchery fish as an estimate of tag-determination efficiency. This adjustment is made under the assumption that tag-loss/tag-misreading is independent of elastomer-site and HxH/NxN source. The HxH and NxN tallies were expanded (divided) by this estimate. The tallies within recovery year were then assigned to the appropriate three brood years. The age group tallies were then totaled within HxH and NxN stock within the brood year, and then the respective totals were divided by the respective number of HxH and NxN smolt released to estimate their survivals.

Table A.1. Information used to discriminate between Age-3 and Age-4 Adults recovered at Roza Dam based on Known-Age Fish for application to Unknown Fish using measured Traits.

Adult Recovery Year 2005

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.75	0.25	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for a			48.16	69.89	63.19	40.40	59.29	53.47	1.35	1.35	3.17
Standard Deviation Standard	discriminant value			3.88	5.05	11.10	3.31	4.52	9.68	0.33	0.86	1.43
Z-standardized discriminant			-0.648			-0.648			-0.617			-0.715
Rescaled Discriminant*						56.00			47.50			2.15
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	2	2	4	6	6	12	2.5	2.5	5	1.5	1.5	3
Total Number Known Age	98	220	318	98	220	318	98	220	318	98	220	318
Probability of Misclassification	0.0204	0.0091	0.0126	0.0612	0.0273	0.0377	0.0255	0.0114	0.0157	0.0153	0.0068	0.0094
Assignment if fish measure = Rescaled Discriminant Value	0.3082	0.6918		0.3082	0.6918		0.3082	0.6918		0.3082	0.6918	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Adult Recovery Year 2006

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.72	0.28	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for a			49.06	68.08	66.94	40.94	57.59	56.59	1.37	68.08	3.33
Standard Deviation Standard	discriminant value			4.63	4.31	6.27	3.88	4.06	5.67	0.36	4.31	0.84
Z-standardized discriminant			-1.063			-1.505			-1.691			-1.573
Rescaled Discriminant*						57.50			47.00			2.00
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	1	1	2	1	1	2	1	1	2	1	1	2
Total Number Known Age	34	529	563	34	529	563	34	529	563	34	529	563
Probability of Misclassification	0.0294	0.0019	0.0036	0.0294	0.0019	0.0036	0.0294	0.0019	0.0036	0.0294	0.0019	0.0036
measureRescaled Discriminant Value	0.0604	0.9396		0.0604	0.9396		0.0604	0.9396		0.0604	0.9396	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Adult Recovery Year 2007

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	1.00	0.00	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for a			48.74	69.75	61.17	41.05	59.31	51.86	1.39	69.75	2.86
Standard Deviation Standard	discriminant value			4.18	4.24	11.16	3.66	3.96	9.77	0.57	4.24	1.39
Z-standardized discriminant			-0.195			-0.195			-0.190			-0.404
Rescaled Discriminant*						59.00			50.00			2.30
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	2	2	4	2	2	4	2	2	4	2	2	4
Total Number Known Age	211	306	517	211	306	517	211	306	517	211	306	517
Probability of Misclassification	0.0095	0.0065	0.0077	0.0095	0.0065	0.0077	0.0095	0.0065	0.0077	0.0095	0.0065	0.0077
measureRescaled Discriminant Value	0.4081	0.5919		0.4081	0.5919		0.4081	0.5919		0.4081	0.5919	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Table A.1. Information used to discriminate between Age-3 and Age-4 Adults recovered at Roza Dam based on Known-Age Fish for application to Unknown Fish using measured Traits (continue).

Adult Recovery Year 2008

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.41	0.59	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for a discriminant value			53.63	70.75	66.10	45.06	60.19	56.07	1.91	70.75	3.57
Standard Deviation Standard						8.97			7.96		4.52	1.27
Z-standardized discriminant			-0.609			-0.568			-0.637			-0.684
Rescaled Discriminant*						61.00			51.00			2.70
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	9.5	9.5	19	8.5	8.5	17	8.5	8.5	17	14	14	28
Total Number Known Age	142	380	522	142	380	522	142	380	522	142	380	522
Probability of Misclassification	0.0669	0.0250	0.0364	0.0599	0.0224	0.0326	0.0599	0.0224	0.0326	0.0986	0.0368	0.0536
measureRescaled Discriminant Value	0.2720	0.7280		0.2720	0.7280		0.2720	0.7280		0.2720	0.7280	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Adult Recovery Year 2009

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.76	0.24	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for discriminant value			51.64	72.96	63.30	43.71	62.10	53.77	1.68	72.96	3.18
Standard Deviation Standard				4.96	4.29	11.58	4.32	3.76	10.00	0.51	4.29	1.53
Z-standardized discriminant			-0.038			-0.026			-0.077			-0.183
Rescaled Discriminant*						63.00			53.00			2.90
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	7	7	14	7	7	14	5	5	10	9	9	18
Total Number Known Age	363	438	801	363	438	801	363	438	801	363	438	801
Probability of Misclassification	0.0193	0.0160	0.0175	0.0193	0.0160	0.0175	0.0138	0.0114	0.0125	0.0248	0.0205	0.0225
measureRescaled Discriminant Value	0.4532	0.5468		0.4532	0.5468		0.4532	0.5468		0.4532	0.5468	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Adult Recovery Year 2010

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	1.00	0.00	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for discriminant value			49.74	71.90	68.20	42.34	61.46	58.27	1.48	71.90	58.27
Standard Deviation Standard				4.55	4.25	9.32	3.86	3.95	8.15			8.15
Z-standardized discriminant			-0.880			-0.880			-0.892			-1.106
Rescaled Discriminant*						60.00			51.00			49.26
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	4	4	8	4	4	8	4	4	8	4	4	8
Total Number Known Age	153	764	917	153	764	917	153	764	917	153	764	917
Probability of Misclassification	0.0261	0.0052	0.0087	0.0261	0.0052	0.0087	0.0261	0.0052	0.0087	0.0261	0.0052	0.0087
measureRescaled Discriminant Value	0.1668	0.8332		0.1668	0.8332		0.1668	0.8332		0.1668	0.8332	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Table A.1. Information used to discriminate between Age-3 and Age-4 Adults recovered at Roza Dam based on Known-Age Fish for application to Unknown Fish using measured Traits (continued).

Adult Recovery Year 2011

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	1.00	0.00	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for			50.77	71.72	66.16	43.14	61.05	56.29	1.59	71.72	56.29
Standard Deviation Standard	discriminant value			4.58	4.35	10.26	3.91	3.97	8.84	0.56	4.35	8.84
Z-standardized discriminant			-0.503			-0.503			-0.598			-0.626
Rescaled Discriminant*						61.00			51.00			50.76
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	7	7	14	7	7	14	7.5	7.5	15	14	14	28
Total Number Known Age	213	589	802	213	589	802	213	589	802	213	589	802
Probability of Misclassification	0.0329	0.0119	0.0175	0.0329	0.0119	0.0175	0.0352	0.0127	0.0187	0.0657	0.0238	0.0349
measureRescaled Discriminant Value	0.2656	0.7344		0.2656	0.7344		0.2656	0.7344		0.2656	0.7344	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Adult Recovery Year 2012

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.63	0.37	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for			48.11	69.99	67.32	40.48	59.40	57.10	1.56	69.99	4.15
Standard Deviation Standard	discriminant value			4.63	4.43	8.43	3.87	4.02	7.37	0.49	4.43	1.29
Z-standardized discriminant			-1.228			-1.224			-1.235			-1.356
Rescaled Discriminant*						57.00			48.00			2.40
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	2	2	4	2	2	4	2	2	4	4	4	8
Total Number Known Age	75	541	616	75	541	616	75	541	616	75	541	616
Probability of Misclassification	0.0267	0.0037	0.0065	0.0267	0.0037	0.0065	0.0267	0.0037	0.0065	0.0533	0.0074	0.0130
measureRescaled Discriminant Value	0.1218	0.8782		0.1218	0.8782		0.1218	0.8782		0.1218	0.8782	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Adult Recovery Year 2013

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.75	0.25	0.00	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Mean	no single estimate for			52.33	69.44	64.41	44.59	58.87	54.68	2.03	69.44	3.77
Standard Deviation Standard	discriminant value			4.57	4.71	9.09	3.98	4.23	7.72	0.55	4.71	1.40
Z-standardized discriminant			-0.515			-0.485			-0.476			-0.619
Rescaled Discriminant*						60.00			51.00			2.90
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number missclassified	6	6	12	4	4	8	5	5	10	8	8	16
Total Number Known Age	160	385	545	160	385	545	160	385	545	160	385	545
Probability of Misclassification	0.0375	0.0156	0.0220	0.0250	0.0104	0.0147	0.0313	0.0130	0.0183	0.0500	0.0208	0.0294
measureRescaled Discriminant Value	0.2936	0.7064		0.2936	0.7064		0.2936	0.7064		0.2936	0.7064	

* Rescaled DiscriminantMean (Age 3&4) + z * Standard Devivation (Age 3&4)

Table A.2. Information used to discriminate between Age-5 and Age-6 Adults recovered at Roza Dam based on Known-Age Fish for application to Unknown Fish using measured Traits.

Adult Recovery Years 2005-2013

	Hotelling's Discriminant			Individual Measure Variables Discriminants								
Variables	FL >	POH >	FW >	Fork Length (cm)			Post-Orbital Hypural (cm)			Fish Weight (kg)		
Weighting	0.55	0.00	0.45	1.00			1.00			1.00		
	Age 3	Age 4	Age 3&4	Age 4	Age 5	Age 4&5	Age 4	Age 5	Age 4&5	Age 4	Age 5	Age 4&5
Mean	no estimates for a			70.66	81.98	70.98	60.08	70.20	60.37	4.17	6.43	4.24
Standard Deviation Standard	single discriminant value			4.65	5.52	5.04	4.27	4.67	4.60	0.89	1.40	0.98
Z-standardized discriminant			2.064			1.987			1.875			2.100
Rescaled Discriminant*						81.00			69.00			1.01
	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4	Age 3	Age 4	Age 3&4
Equal number assigned	59	59	118	51	51	102	50	50	100	61	61	122
Total Number Known Age	4161	123	4284	4161	123	4284	4161	123	4284	4161	123	4284
Probability of Misclassification	0.0142	0.4797	0.0275	0.0123	0.4146	0.0238	0.0120	0.4065	0.0233	0.0147	0.4959	0.0285
measureRescaled Discriminant Value	0.9713	0.0287		0.9713	0.0287		0.9713	0.0287		0.9713	0.0287	

* Rescaled DiscriminantMean (Age 4&5) + z * Standard Devivation (Age 4&5)

Appendix B. Analyses of Variation

Table B.1. Logistic Analyses of Variation of Adult Survival from Release at Clark Flat to Adult Recovery at Roza Dam for Brood Years 2002-2009

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev	F-Ratio	Type 1 Error
Year	3140.84	7	448.69	53.51	0.0000
Stock (HxH vs NxN)	9.75	1	9.75	1.16	0.3167
Error	58.7	7	8.39		

Table B.2. Logistic Analyses of Variation of the Age-3 proportion of fish recovered at Roza Dam

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev	F-Ratio	Type 1 Error
Year	940.29	7	134.33	16.50	0.0007
Stock (HxH vs NxN)	1.53	1	1.53	0.19	0.6777
Error	57	7	8.14		