YAKIMA/KLICKITAT FISHERIES PROJECT MONITORING AND EVALUATION
Yakima Subbasin

PROJECT NUMBER 1995-063-25
Report covers work performed under BPA contract #00054321
Report was completed under BPA contract #00056662 REL 11/22

FINAL REPORT
For the Performance Period
May 1, 2012 through April 30, 2013

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

Submitted: August 30, 2013

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the authors' and do not necessarily represent the views of BPA.

This report should be cited as follows:
Sampson, M.R., D.E. Fast, and W.J. Bosch (editors). Yakima-Klickitat Fisheries Project Monitoring and Evaluation – Yakima Subbasin, Final Report for the performance period May/2012-April/2013, Project number 1995-063-25, 241 electronic pages.

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Acknowledgements

Monitoring and evaluation efforts in the Yakima River Basin are the result of a cooperative effort by many individuals from a variety of agencies including the Yakama Nation Fisheries Program, the Washington Department of Fish and Wildlife, the United States Fish and Wildlife Service, the National Oceanic and Atmospheric Administration Fisheries department as well as some consultants and contractors. We also wish to acknowledge and thank the Yakama Nation Tribal Council, U.S. Bureau of Reclamation, Yakima Subbasin Fish and Wildlife Recovery Board, Pacific States Marine Fisheries Commission, U.S. Forest Service Naches Ranger District, Columbia River Inter-Tribal Fish Commission, University of Idaho, Mobrand, Jones, and Stokes, University of Washington, and Central Washington University for their many contributions to this project including both recommendations and data services.

The core project team includes the following individuals: Mel Sampson, Dave Fast, Mark Johnston, Bill Bosch, David Lind, Paul Huffman, Jeff Trammel, Joe Hoptowit, Bill Fiander, Todd Newsome, Melinda Davis, Michael Porter, Sara Sohappy, Chris Frederiksen, Jim Matthews, and a number of technicians from the YN; Charles Strom and a number of assistants from the CESRF; Joe Blodgett and the crew at the Prosser Hatchery; John Easterbrooks, Andrew Murdoch, 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; Joy Evered, Susan Gutenberger and assistants from the USFWS; and Don Larsen, Andy Dittman, and assistants from NOAA Fisheries.

Special acknowledgement and recognition is owed to all of the dedicated Yakama Nation and YKFP personnel working on various tasks including Ray Decoteau, Joe Yallup, Leroy Senator, Sy Billy, Wayne Smartlowit, Morales Ganuelas, Pharamond Johnson, Steve Salinas, Shiela Decoteau, Jimmy Joe Olney, Joe Jay Pinkham III, Conan Northwind, Quincy Wallahee, Andrew Lewis, Nate Pinkham, Gene Sutterlick Germaine Hart, Jamie Bill, Nate Pinkham, William Manuel, Terrance Compo, Levi Piel, Winna Switzler, Florence Wallahee, Steve Blodgett and Arnold Barney. The accomplishments and achievements documented here are a direct result of their dedication and desire to seek positive results for the betterment of the resource. Also, these achievements are attainable because of the efficient and essential administrative support received from all of the office and administrative support personnel for the YKFP including: Ida Ike, Rachel Castilleja, and Adrienne Wilson.

We would especially like to thank former contributors to the Yakima/Klickitat Fisheries Project including Bruce Watson, Joel Hubble, Steve Schroder, Todd Pearsons, Craig Busack, Ray Brunson, and Bill Hopley. 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.

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

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 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 2001-2012 average of approximately 11,400 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 2000-2012 average of nearly 3,200 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 200 summer-run Chinook passed above Prosser Dam in 2012, the first adults to return to the Yakima Basin in over 40 years. Adult coho returns averaged about 3,900 fish from 1997-2012 (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 we have not yet observed the high spawner escapements we have 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 the past thirteen years, annual abundance estimates of juvenile smolts migrating downstream at Prosser Dam averaged 202,550 wild/natural spring Chinook, 305,130 CESRF-origin spring Chinook, 25,390 wild/natural-origin coho, and 264,000 hatchery-origin coho. Preliminary smolt-to-adult survival indices averaged approximately 2.3% for both natural-origin spring Chinook and coho. 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. Analysis of trends in smolt-to-adult survival indices for coho at McNary or Prosser Dams suggests that factors complicating SAR analyses are not specific to the Yakima River. 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 substantially.

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 75 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 since 2004.

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 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 80% 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 (2005-2012) have not changed significantly in either the supplemented Upper Yakima or Naches control systems relative to the pre-supplementation period (1982-2004). However, the mean natural-origin return in the post-supplementation period increased in the upper Yakima and decreased in the Naches system relative to the pre-supplementation period. Results in the published literature for the spring Chinook program suggest that a single generation of state-of-the-art conservation hatchery propagation can produce fish with reproductive traits and spawning success similar to those of wild fish, given comparable body size. 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 12-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.

The Yakama Nation Fisheries Program (YNFP) has been working for the past decade or more to develop, maintain, and improve its data management, networking, and sharing capabilities. A comprehensive network of data management systems and the ykfp.org project web site have been constructed. The Yakama Nation has collaborated in numerous regional data management processes. We are working with the Columbia River Inter-Tribal Fish Commission (CRITFC) to implement a tribal data network that will facilitate better sharing of data collected and reported by Yakama Nation fisheries projects as envisioned in preliminary regional data sharing strategies circulated for review.

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, predation, and data management. 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) 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 project 1997-051-00 (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).

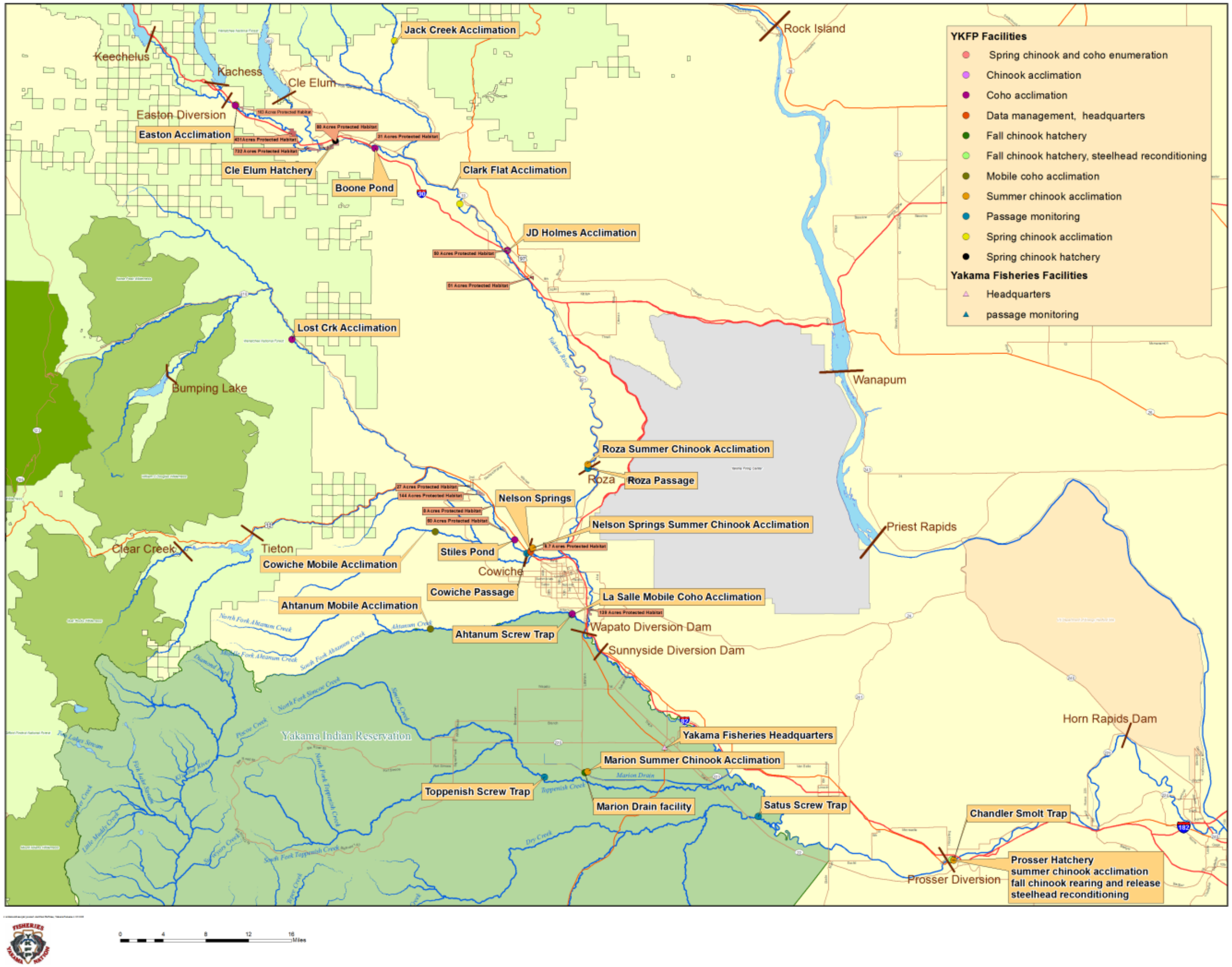


Figure 1. Yakima River Basin and Yakama Nation/YKFP-related artificial production and monitoring facilities (map provided by Paul Huffman).

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, 522). 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 (monitoringmethods.org method 987). 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 341).

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:

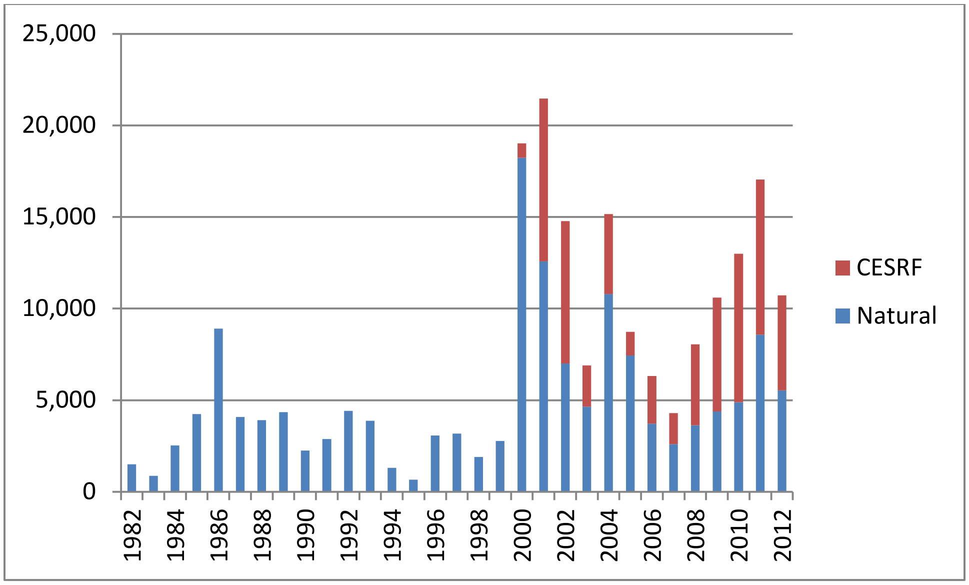


Figure 2. Estimated counts of natural- and Cle Elum Supplementation and Research Facility (CESRF-) origin spring Chinook (adults and jacks) at Prosser Dam, 1982-present.

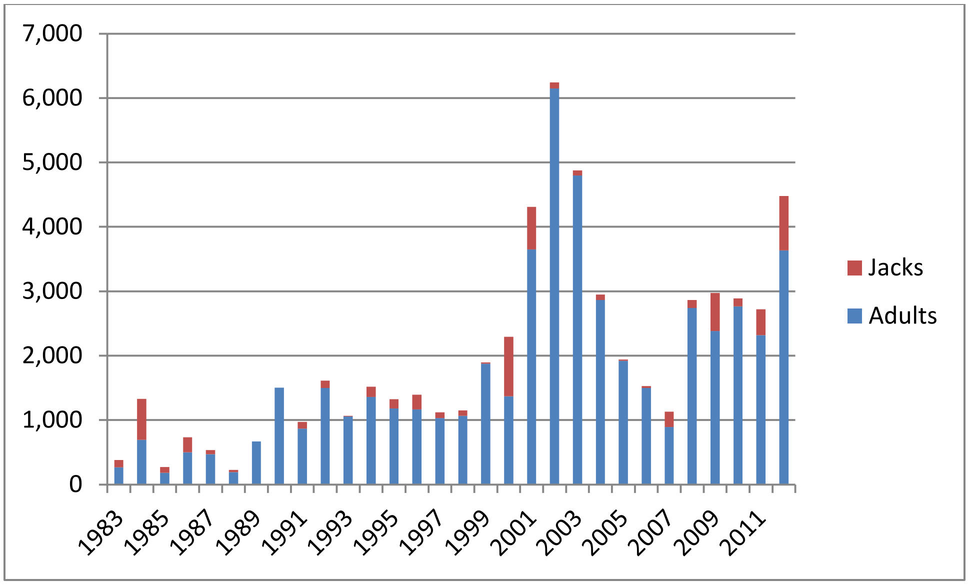


Figure 3. Estimated counts of adult and jack summer/fall run Chinook at Prosser Dam, 1982-present.

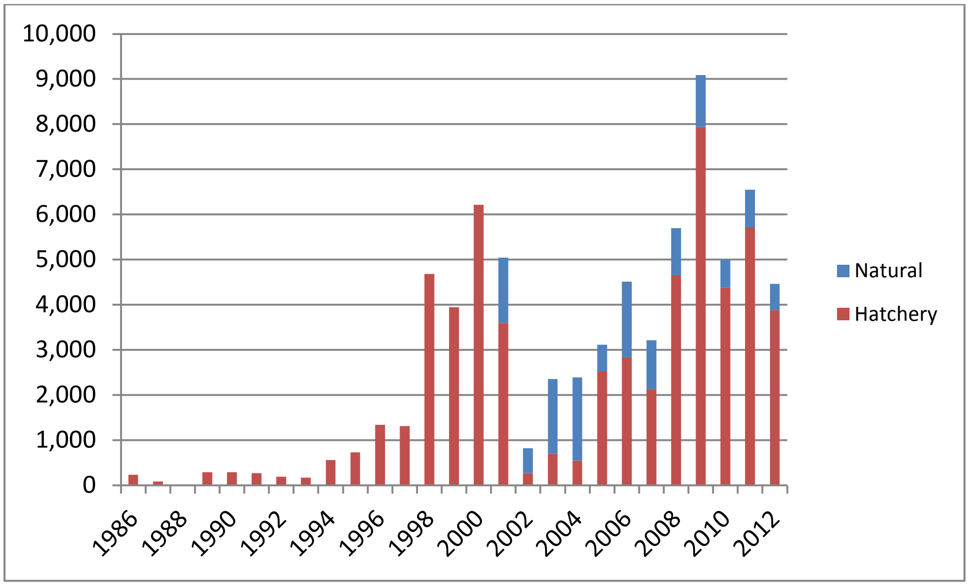


Figure 4. Estimated counts of hatchery- and natural-origin Coho (adults and jacks) at Prosser Dam 1986-present.

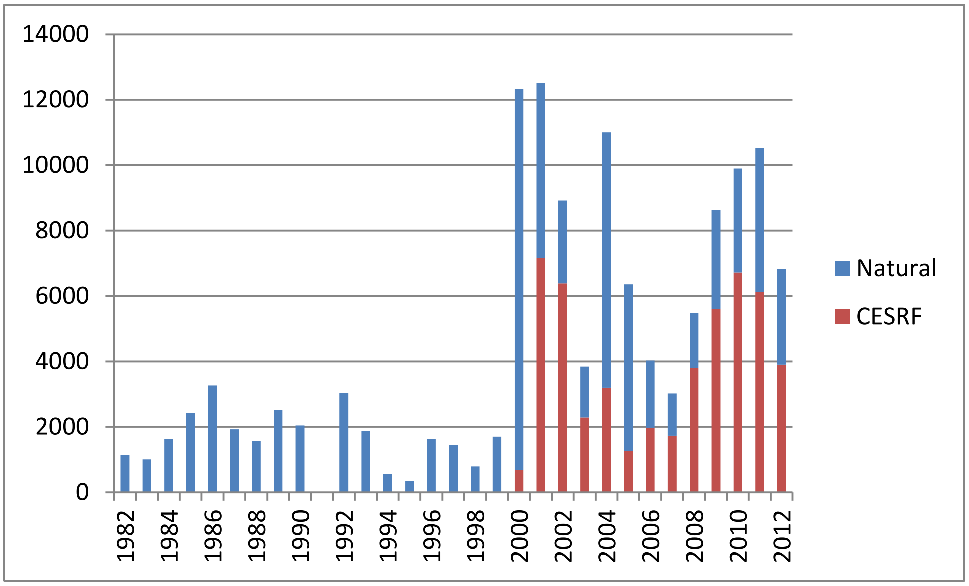


Figure 5. Estimated counts of natural- and Cle Elum Supplementation and Research Facility (CESRF-) origin spring Chinook (adults and jacks) at Roza Dam, 1982-present.

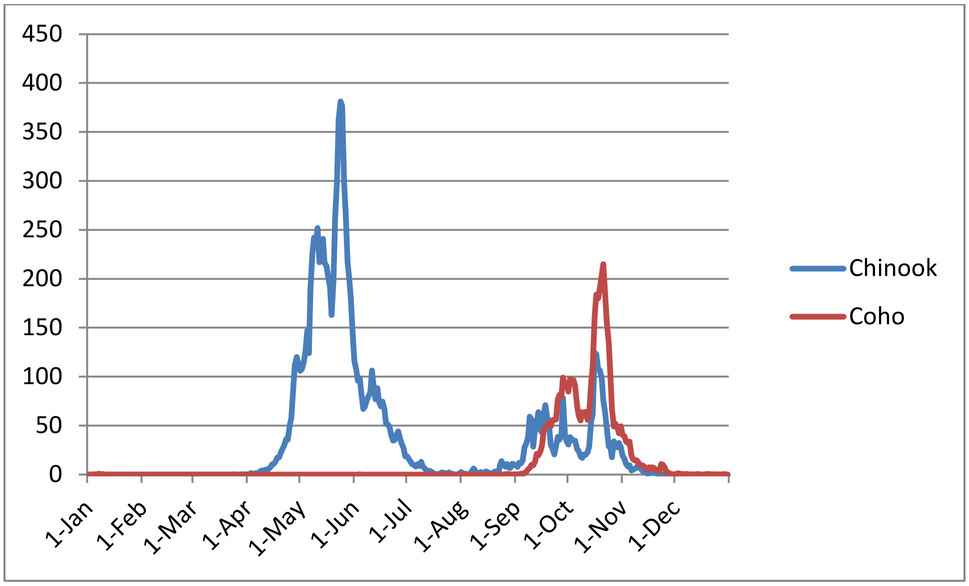


Figure 6. Average daily passage of Chinook and Coho (adults and jacks) at Prosser Dam, 2003-2012.

Discussion:

Annual abundance of spring Chinook at Prosser Dam has increased from a 1982-2000 average of about 4,000 fish to a 2001-2012 average of approximately 11,400 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 2001-2012 average of approximately 7,600 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 averaging 1.6 million Upriver Brights from the Prosser Hatchery which have occurred since 1983 (Yakama Nation 2012). Annual abundance of fall Chinook at Prosser Dam has increased from a 1983-1999 average of just over 1,000 fish to a 2000-2012 average of nearly 3,200 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.

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 3,900 fish from 1997-2012 (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).

Summer-run Chinook were extirpated from the Yakima Basin by 1970. To re-establish this run, the program began releases of Wells Hatchery summer-run Chinook in the Yakima River Basin in 2009. The major objectives of this effort are to increase the temporal (Figure 6) and spatial distribution of summer/fall run Chinook in the Yakima River Subbasin (Yakama Nation 2012). Over 200 summer-run

Chinook passed above Prosser Dam in 2012, the first adult return year for 2009 releases (Figure 7).

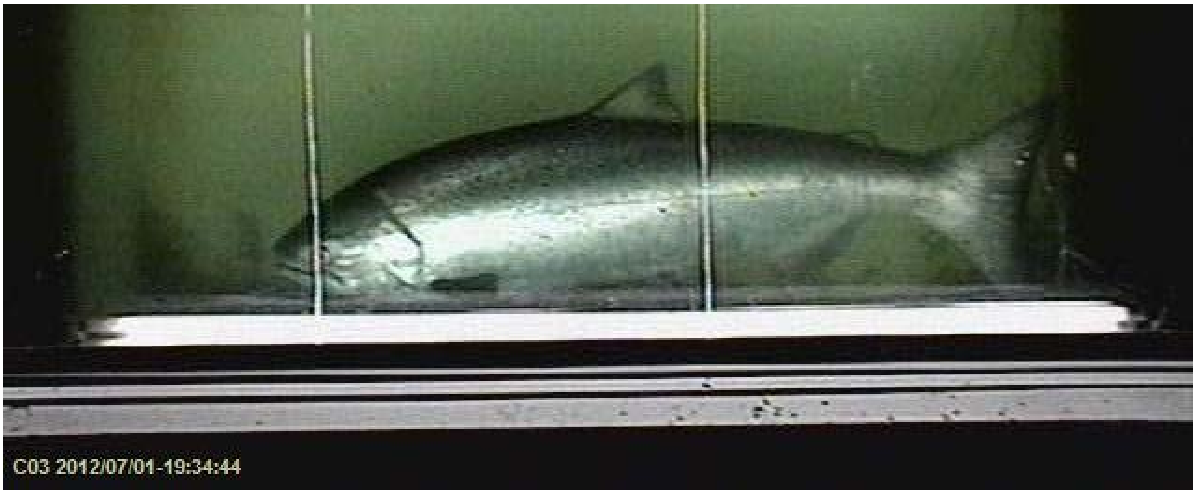


Figure 7. One of the first adult summer-run Chinook to pass upstream at Prosser Dam in over 40 years. From PIT release and detection data, this is a 3-ocean fish returning from the 2009 subyearling release and passing Prosser on July 1, 2012.

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 (monitoring methods.org method 421; 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 (monitoring methods.org method 421; 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.

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	Estimated	Estimated Yakima R. Mouth Returns				Returns/
Year	Spawners	Age-3	Age-4	Age-5	Total	Spawner
1982[1]	1,280	324	4,016	411	4,751	3.71
1983[1]	1,125	408	1,882	204	2,494	2.22
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[2]	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	3,409			
2009	7,056	283				
2010	8,383					
2011	8,584					
2012	5,483					
Mean[3]	4,114	325	2,866	119	3,307	1.80

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. The mean jack proportion of spawning escapement from 1999-2012 was 0.22 (geometric mean 0.16).
3. 1984-present.

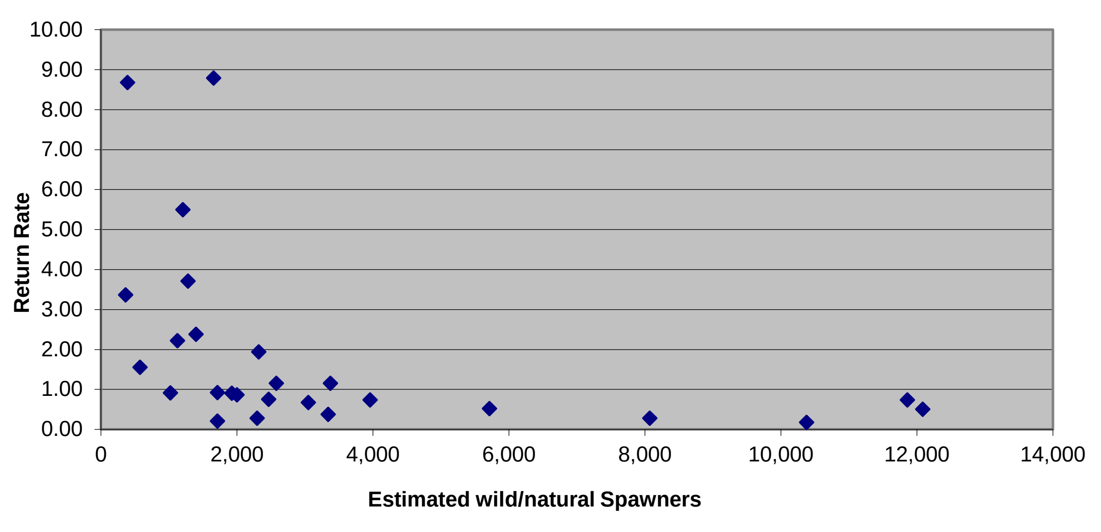


Figure 8. Upper Yakima wild/natural spring Chinook return rate per spawner, brood years 1982-2007.

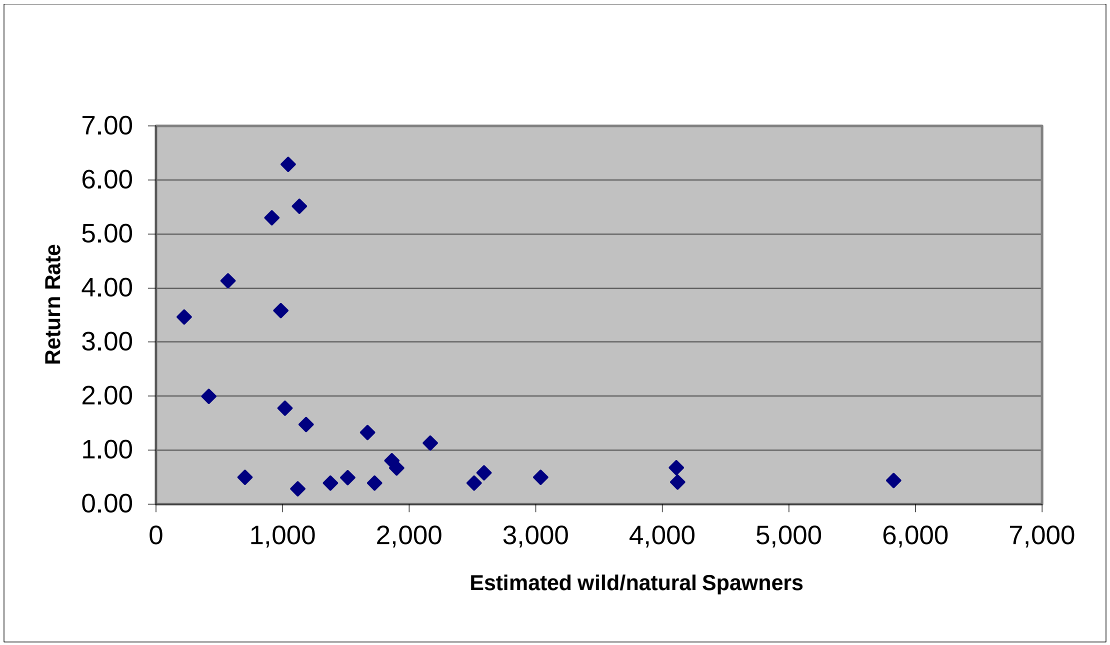


Figure 9. Naches subbasin spring Chinook return rate per spawner, brood years 1984-2007.

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	
1982[1]	108	127	1,274	601	0	2,002	18.54
1983[1]	232	190	1,257	1,257	8	2,713	11.68
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[2]	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[3]	0	1,264	0.66
2006	1,672	237	1,215[3]	759	0	2,211	1.32
2007	986	182[3]	2,239	1,112		3,533	3.58
2008	1,578	653	1,183				
2009	1,117	144					
2010	1,491						
2011	3,060						
2012	1,900						
Mean[4]	1,825	152	1,144	786	9	2,059	1.77

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. The mean jack proportion of spawning escapement from 1999-2011 was 0.08 (geometric mean 0.09).
3. Age composition using only Naches survey samples in 2010 return year.
4. 1984-present.

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	31	4,388	8.60
2006	419	3,038	5,802	264	9,104	21.73
2007	449	1,277	5,174	108	6,558	14.61
2008	457	2,344	4,567			
2009	486	461				
2010	336					
2011	377					
2012	374					
Mean	478	1,024	3,773	134	4,790	7.12[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
Mean			0.92	0.98

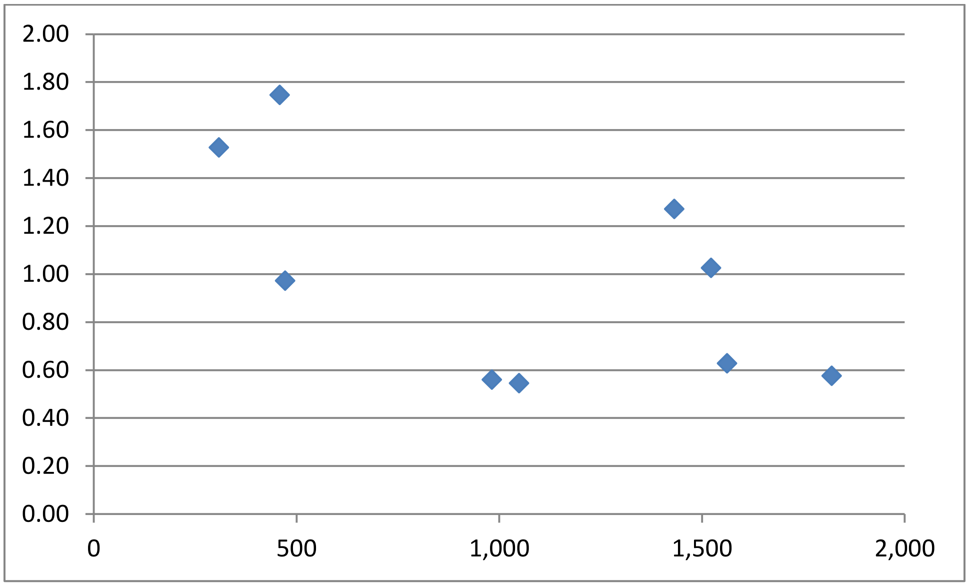


Figure 10. Productivity indices for age-3 natural-origin coho, brood years 2001-2009.

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. Trends in adult productivity indices for natural-origin coho (Figure 10) are not as clear and we have not yet observed the high spawner escapements we have 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 (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. 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).

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 549, 583, 977, 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 422, 512, and 519.

Results and Discussion:

For migration years 2000 to present, annual abundance estimates of juvenile smolts migrating downstream at Prosser Dam (Figure 1) averaged 202,550 wild/natural spring Chinook, 305,130 CESRF-origin spring Chinook, 25,390 wild/natural-origin coho, and 264,000 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.

	Smolt	Spring Chinook		Coho	
Brood Year	Migr. Year	Wild/ Natural	Hatchery (CESRF)	Wild/ Natural	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	129,695	283,376	18,787	148,810
2003	2005	144,873	212,771	31,631	204,728
2004	2006	157,699	272,629	8,298	204,602
2005	2007	145,203	362,663	20,131	260,455
2006	2008	115,602	247,476	43,046	416,708
2007	2009	240,606	395,890	25,108	496,594
2008	2010	167,883	407,412	35,158	341,145
2009	2011	355,214	387,817	24,108	333,891
2010	2012	215,225	396,596		244,503
	Mean	202,554	305,131	25,392	263,997

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 439, 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-G.

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. 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 11 of the 14 outmigration years (Figure 11). The pooled survival and weighted survival estimates over years were significantly higher for the natural-origin smolts (Appendix C). Survival analyses for additional spring Chinook treatments are presented in Appendices D and E.

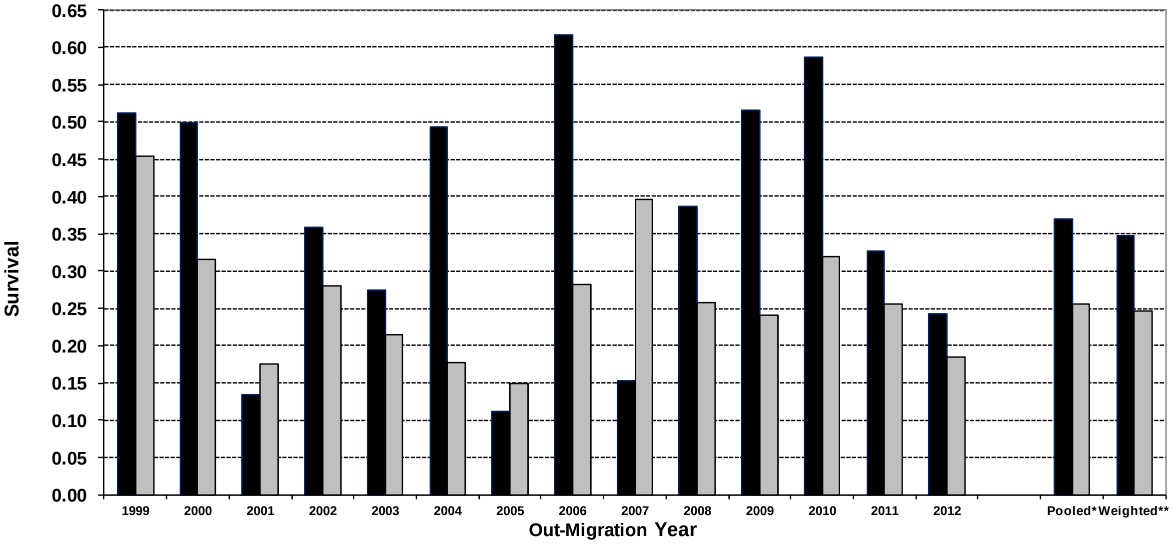


Figure 11. Upper-Yakima Spring-Chinook Roza-to-McNary Smolt Survival for late-migrating (>March 15) Natural- (dark-colored bars) and Hatchery-origin (light-colored bars) Smolts.

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 2012 (Appendix F). Summer-run Chinook subyearlings were released from Stiles pond in outmigration-years 2009 and 2011, from Nelson Springs (Buckskin Slough) in 2011 and 2012, and from Marion Drain in 2012 (Figure 1). In 2012 the Stiles releases were discontinued and shifted to Prosser.

Estimates for release-to-McNary survival from Stiles and Prosser are presented in Figure 12. 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 F), and

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

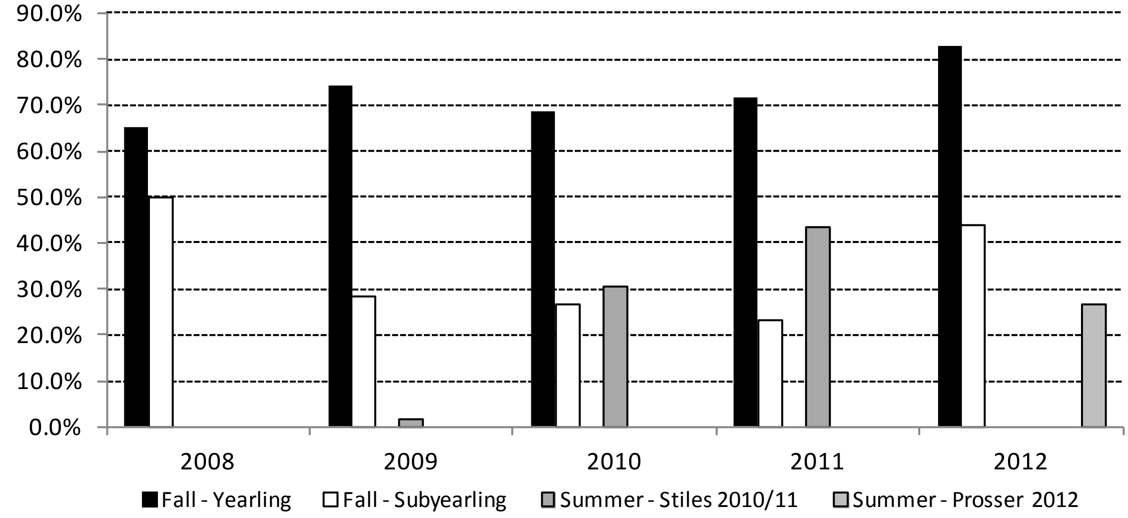


Figure 12. Estimated smolt survival to McNary Dam of summer- and fall-run Chinook that were PIT-tagged and detected at release from various sites in the Yakima River, 2008-2012.

For coho, we estimated survival (Appendix G) 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 15 paired-releases (Figure 13 and Appendix G).

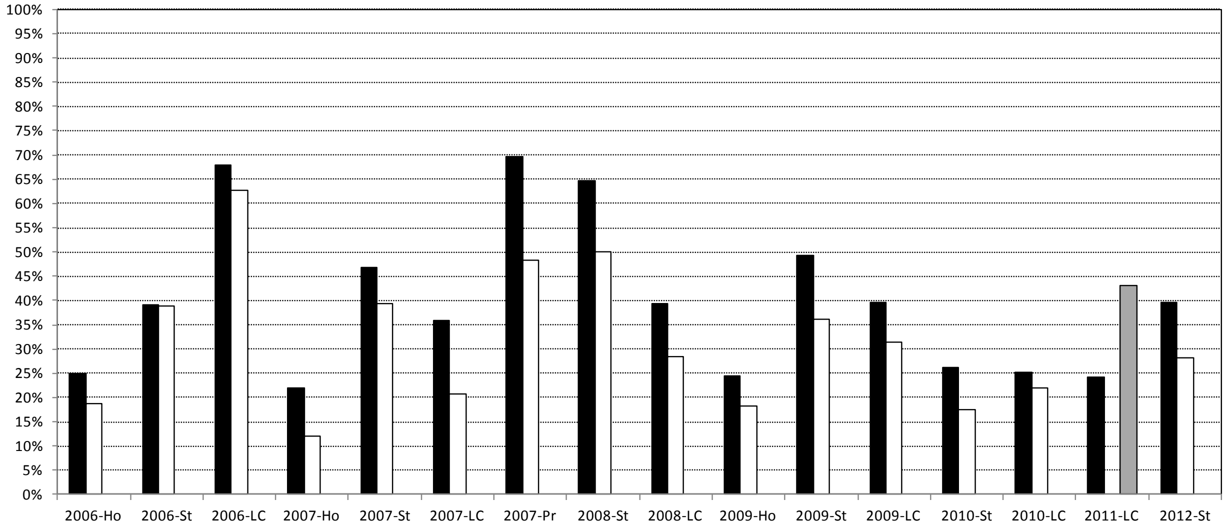


Figure 13. Estimated smolt survival to McNary Dam of Yakima (black), Eagle Creek (white), and a Yakima/Eagle Creek cross (gray) brood source coho that were PIT-tagged and detected at release from various sites (Holmes-Ho, Stiles-St, Lost Creek-LC, and Prosser-Pr; Figure 1) in the Yakima River, 2006-2012.

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 (monitoring methods.org method 421; 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%	8,240	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	129,695	283,376	33.9%	3,743	2,300	2.9%	0.8%
2003	2005	1285	144,873	212,771	25.8%	2,746	932	1.9%	0.4%
2004	2006	5652	157,699	272,629	34.7%	2,802	4,022	1.8%	1.5%
2005	2007	4551	145,203	362,663	42.2%	4,201	4,378	2.9%	1.2%
2006	2008	4298	115,602	247,476	38.5%	6,099	9,114	5.3%	3.7%
2007	2009	5784	240,606	395,890	51.3%	8,030	6,558	3.3%	1.7%
2008	2010	3592	167,883	407,412	48.0%	6,380[6]	6,911[6]	3.8%[6]	1.7%[6]
2009	2011	9414	355,214	387,817	46.6%				
2010	2012	8556	215,225	396,596	49.9%				

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. Preliminary; data do not include age-5 adult returns.

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 1988-2012.

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	2,226,311	2,972	0.13%
2010	2,206,186	2,888	0.14%
2011	3,064,288	2,718	0.17%
2012	2,641,000	4,477	0.26%
Average	1,728,155	2,225	0.12%

[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 2000-2011.

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	1.07%	37,359	1,432	3.83%
2001	134,574	166	0.12%	40,605	309	0.76%
2002	155,814	669	0.43%	19,859	1,523	7.67%
2003	139,135	505	0.36%	9,092	1,820	20.02%
2004	148,810	2,405	1.62%	18,787	472	2.51%
2005	204,728	2,646	1.29%	31,631	1,562	4.94%
2006	204,602	2,203	1.08%	8,298	1,049	12.64%
2007	260,455	4,132	1.59%	20,131	459	2.28%[c]
2008	416,708	8,835	2.12%	43,046	982	2.28%[c]
2009	496,594	5,153	1.04%	25,108	573	2.28%[c]
2010	341,145	7,216	2.12%	35,158	802	2.28%[c]
2011	333,891	4,948	1.48%	24,108	550	2.28%[c]
Mean	263,997	3,535	1.20%	25,392	961	5.31%

[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.

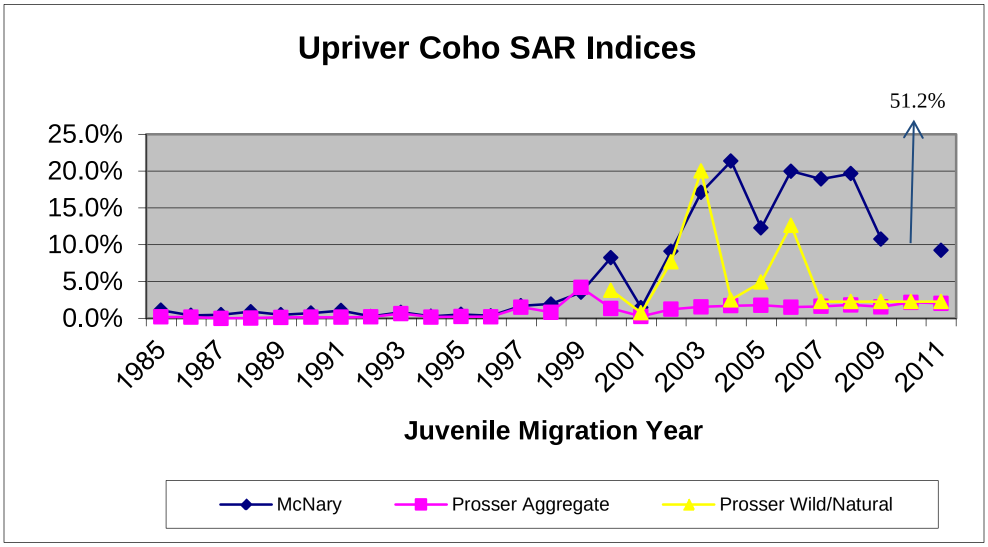


Figure 14. Aggregate smolt-to-adult survival (SAR) indices at Chandler/Prosser and McNary Dams for mid- and upper-Columbia (Yakima, Snake, and Upper Columbia) coho reintroduction programs, juvenile migration years 1985 to 2011 and Yakima natural-origin SAR indices for juvenile migration years 2000-2011 (McNary Dam data courtesy of Fish Passage Center and Univ. of Washington Data Access in Real Time).

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 indicate 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.

The difference in observed trends for coho smolt-to-adult survival indices measured at McNary or Prosser Dams (Figure 14) suggests that factors complicating SAR analyses are not specific to the Yakima River. 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 are presented in Appendix B.

Status and Trend of Spatial Distribution (Redd Counts)

Methods: Regular foot and/or boat surveys (monitoringmethods.org methods 30, 97, 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:

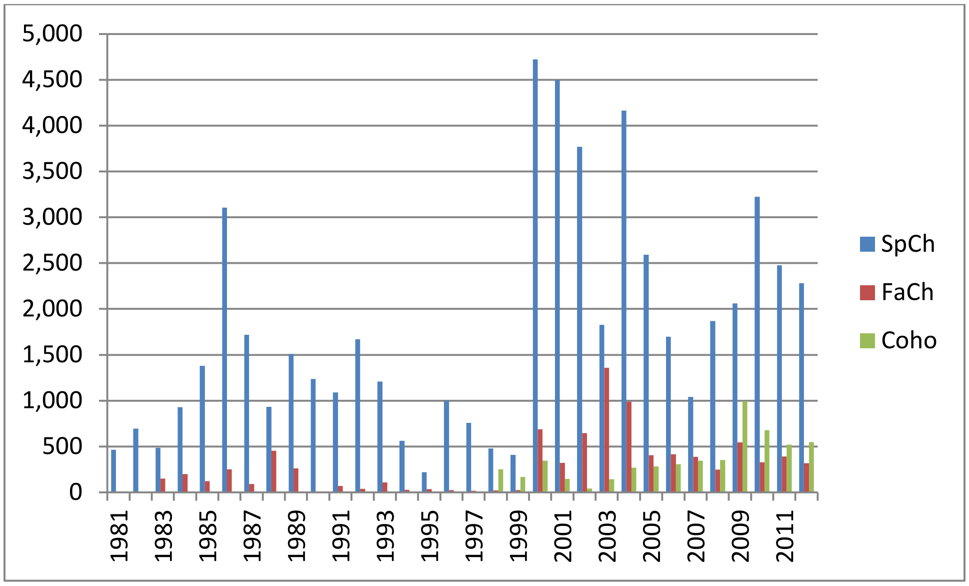
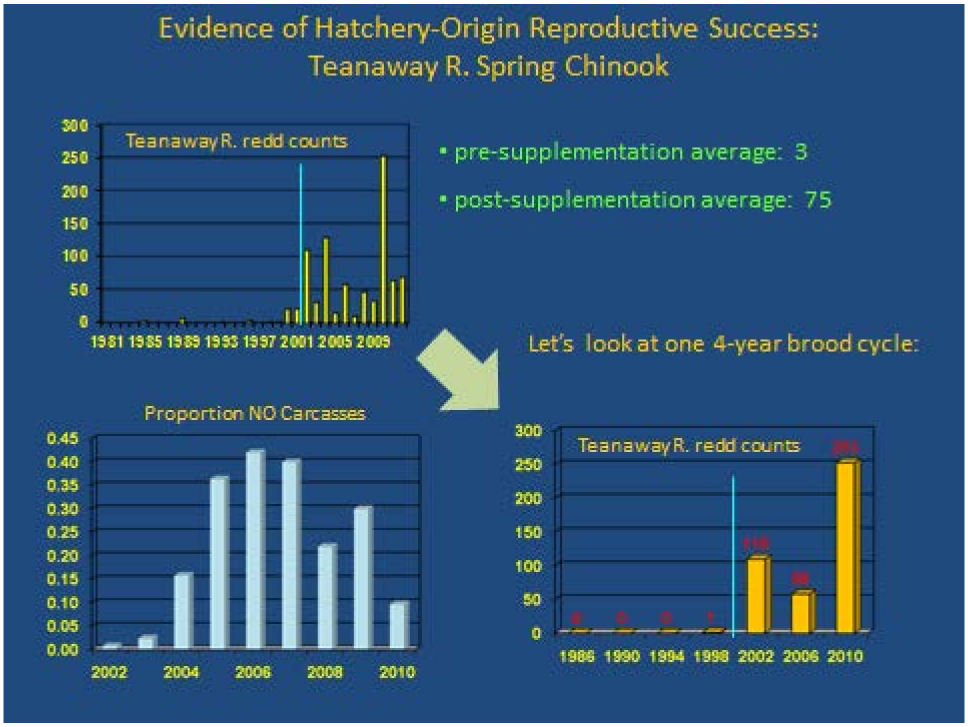


Figure 15. Redd Counts upstream of Prosser Dam in the Yakima River Basin by species, 1981-present.

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
Mean	1,087	131	27	1,245	164	178	116	49	507

[1] Including minor tributaries.

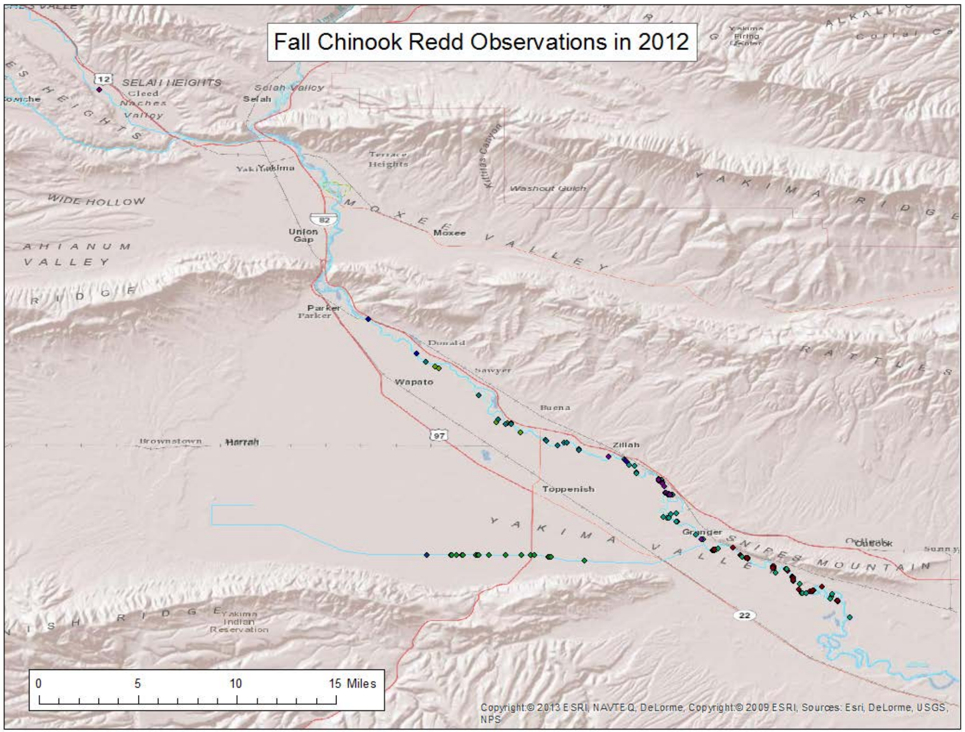


Evidence of Hatchery-Origin Reproductive Success:
Teanaway R. Spring Chinook

- pre-supplementation average: 3
- post-supplementation average: 75

Let's look at one 4-year brood cycle:

Figure 16. Teanaway River Spring Chinook redd counts, 1981-2012 (blue lines denote pre- and post-supplementation periods) and the proportion of natural-origin (NO) carcasses observed in intensive spawning ground surveys, 2002-2010.



C:\avdata\FallChinookRedds\fallchinook2012.mxd Paul Huffman, Yakama Fisheries, 5/15/2013

Figure 17. Distribution of fall Chinook redds in the Yakima River Basin (above Prosser Dam) in 2012.

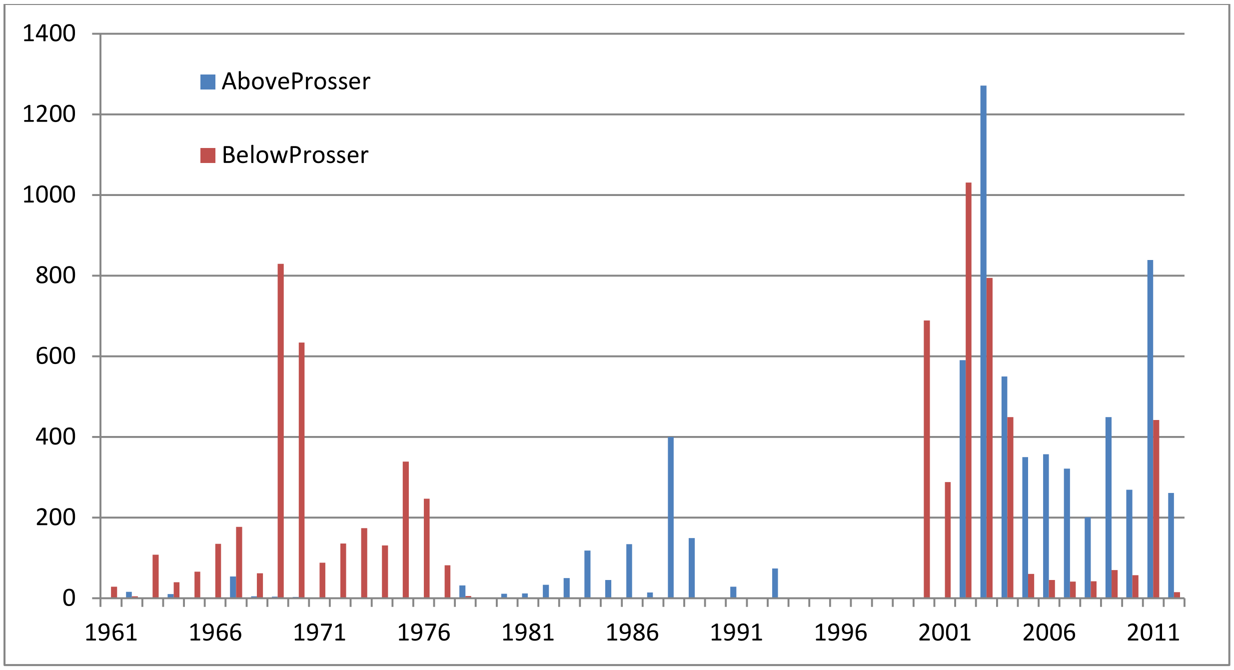


Figure 18. Fall Chinook redd counts above and below Prosser Dam, 1961-present, for years in which surveys were conducted and data are available. Data from YN, WDFW, and Pacific Northwest National Laboratory files; survey data are partial or incomplete for most years prior to 2000.

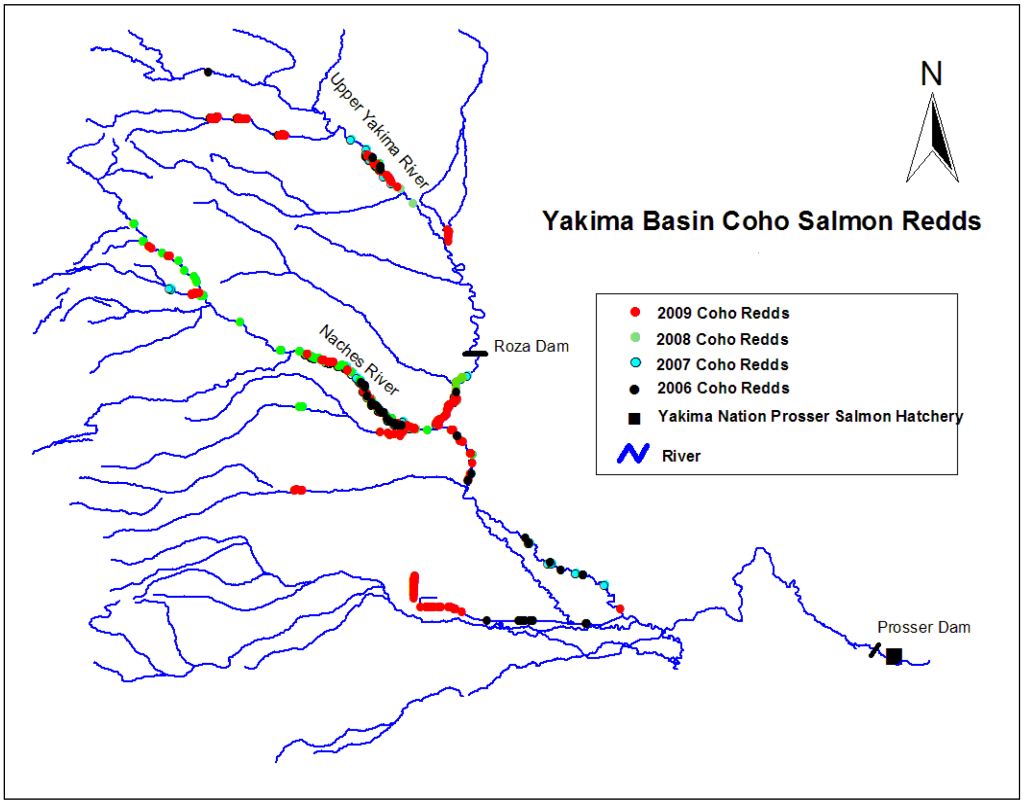


Figure 19. Distribution of coho redds in the Yakima River Basin.

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

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 16). 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 75 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 77 percent (range 55 to 89 percent) of surveyed fall Chinook redds have been located above Prosser Dam (Figure 18). 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 expects to expand 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 17; Yakama Nation 2012).

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 have observed large increases in tributary spawning. Tributary spawning has averaged over 200 redds annually since 2004, a marked increase over the prior five years (Table 10). Coho are volunteering into many tributaries, and the fidelity of adults from the summer parr plants is showing good results. We also observed our first natural returns from the Taneum Creek adult out-plant study. Redd counts and spawner distribution have increased substantially (Table 10 and Figure 19). 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.

Status and Trend of Diversity Metrics

Methods:

Diversity metrics at this time mainly apply to the Cle Elum Supplementation and Research Facility spring Chinook program in the Upper Yakima River. This program is attempting to use supplementation to maintain or increase the natural population of spring Chinook in the Upper Yakima Basin while minimizing risk to non-target populations. The Naches subbasin spring Chinook population is being used as a control for this study. Diversity metrics include monitoring of a large number of 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 are documented in the YKFP Monitoring Plan (Busack et al. 1997), in our FY2010 proposal, the project's

"Supplementation Monitoring Plan" (Chapter 7 in 2005 annual report on project genetic studies), and in numerous manuscripts in the published literature (see Results and References).

Diversity metrics for coho and summer/fall Chinook have been and will be collected at the Prosser Dam denil fish trap and in spawning operations. Methods and results for these programs will be included in future reports and publications as they become more mature.

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).

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.

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 2012. 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 be incorporated in future analyses of "extrinsic" factors on natural production in the Yakima Basin.

Results and Discussion:

Little Naches

A total of 95 McNiel core samples were collected and processed from 8 spawning reaches in the Little Naches drainage this past year. The reach on Pyramid Creek was not sampled this past year due to road being decommissioned. Other means for accessing the Pyramid Creek reach need to be found. With this year's monitoring work, the data set for the Little Naches drainage now covers a time period of 28 years for the two historical reaches, and 21 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 has gone down from the previous year (cumulative average of 7.9% for 2012 compared to 9.0% for 2011). This compares to recent years when overall fine sediment conditions in the Little Naches drainage ranged from about 10.5% to 12% fines (Figure 20). 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. It is not surprising that fine sediment conditions have been fairly low and stable as little anthropogenic disturbance has been taking place in the drainage other than recreational activities. 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 roughly the past 15 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. Localized sediment delivery and loss of riparian vegetation from recreational use has been observed.

Stream flows may be having an effect on observed fine sediment levels. The Little Naches River has experienced some larger flood events in recent years. The U.S. Bureau of Reclamation maintains a stream gauge on the Little Naches River near its confluence. Annual maximum daily flows from 1992 to 2011 were evaluated along with fine sediment conditions observed later in the year. Generally observed fine sediment levels have been decreasing as peak flows have been elevating. Regression analysis was performed to further evaluate this relationship. Regression output indicated that peak flows explain some of the variability found in fine sediment levels ($R^2 = 0.3397$; $p = 0.007$). A downward trend in fine sediment was apparent as peak flows increase. Higher flows can flush fine sediment out of spawning gravels, especially if incoming sediment delivery sources are stable or decreasing. Conversely, larger peak flows can also have major consequences if incubating eggs and fry are scoured from the substrate. Peak flow conditions warrant further attention and monitoring to determine what effect they may be having on salmonid production in the watershed.

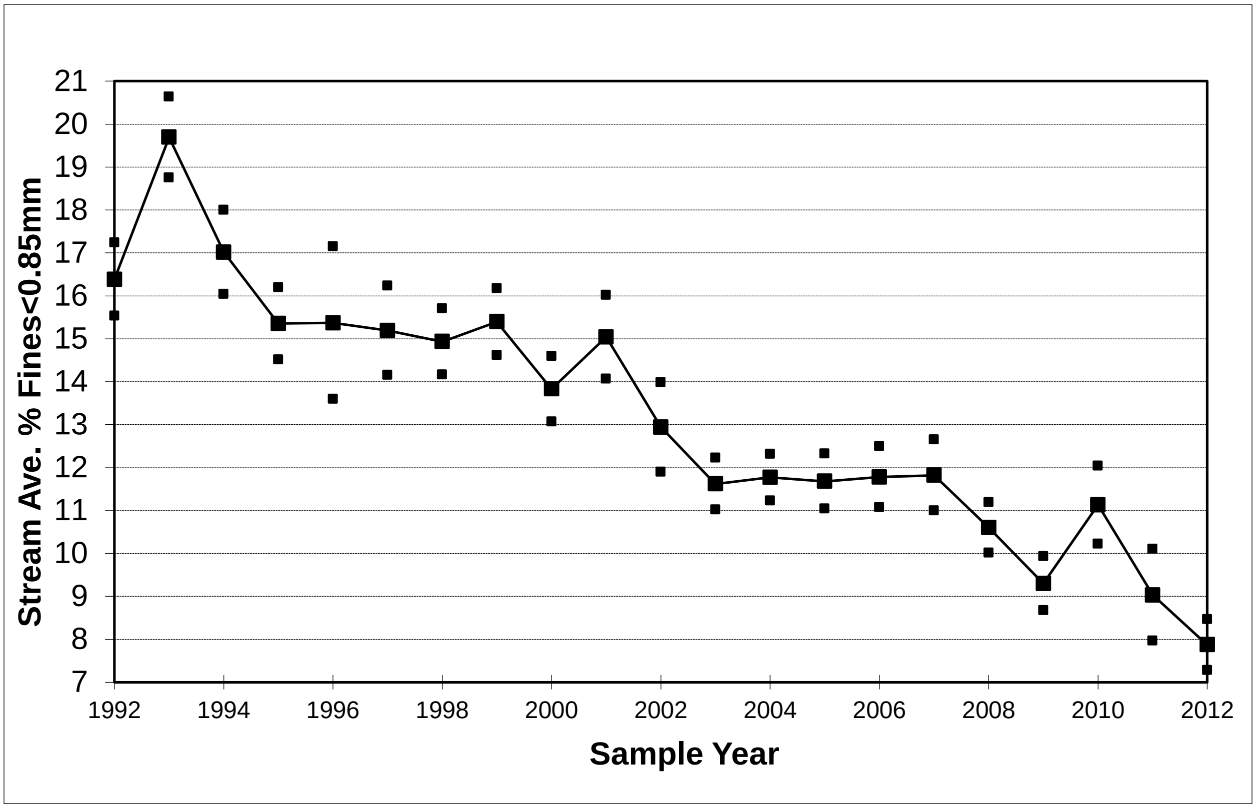


Figure 20. Overall Fine Sediment (<0.85mm) Trends with 95% confidence bounds in the Little Naches River Drainage, 1992-2012.

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 14 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. The 2012 sediment rates, though increased from 2011, are still below the mean for sediment levels for the 14-year sampling period (Figure 21).

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 16 years. Although average fine sediment levels in the Easton and Elk Meadows reaches increased from 2011, overall average percent fine sediment less than 0.85mm for the combined Upper Yakima drainage was again the lowest observed over the sixteen years of sampling (Figure 22).

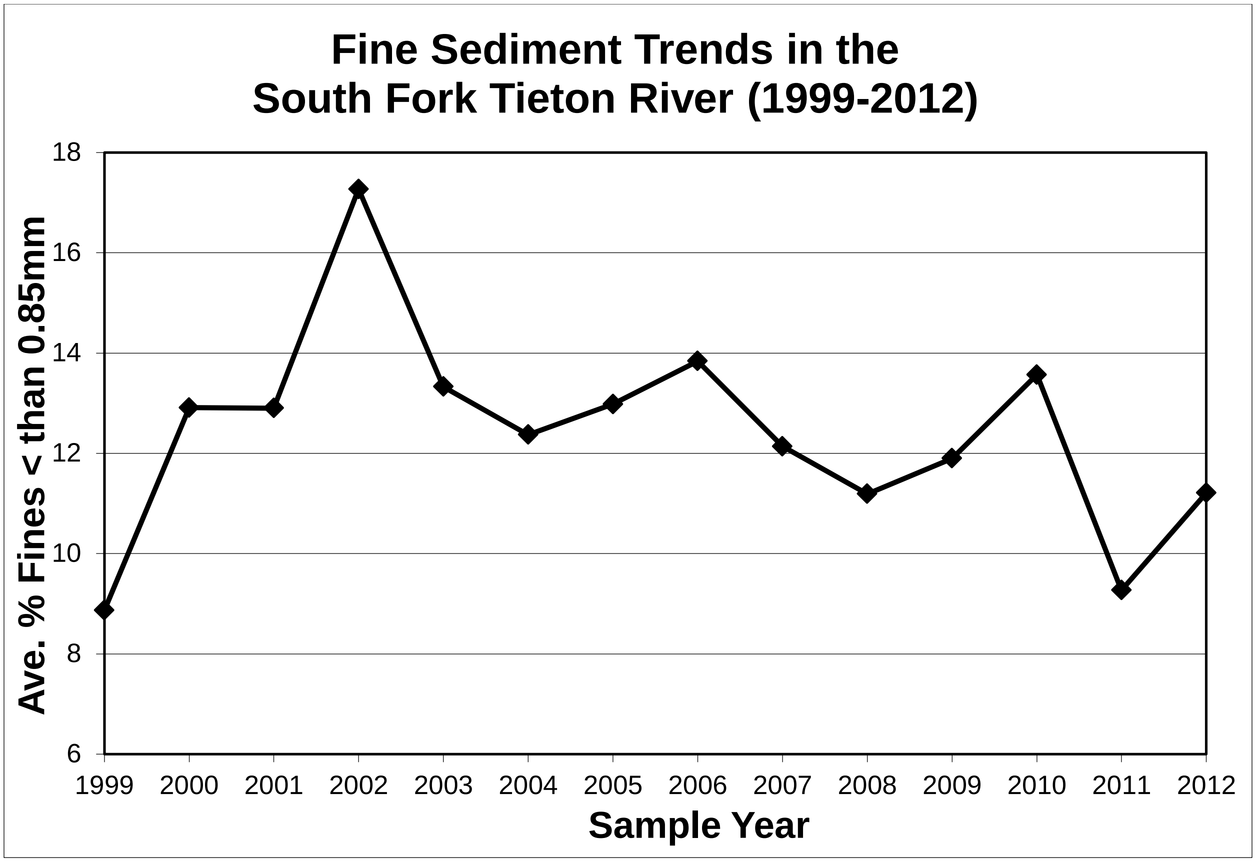


Figure 21. Fine Sediment Trends in the South Fork Tieton River, 1999-2012. Note: Data for 2007 were collected from only 1 Riffle.

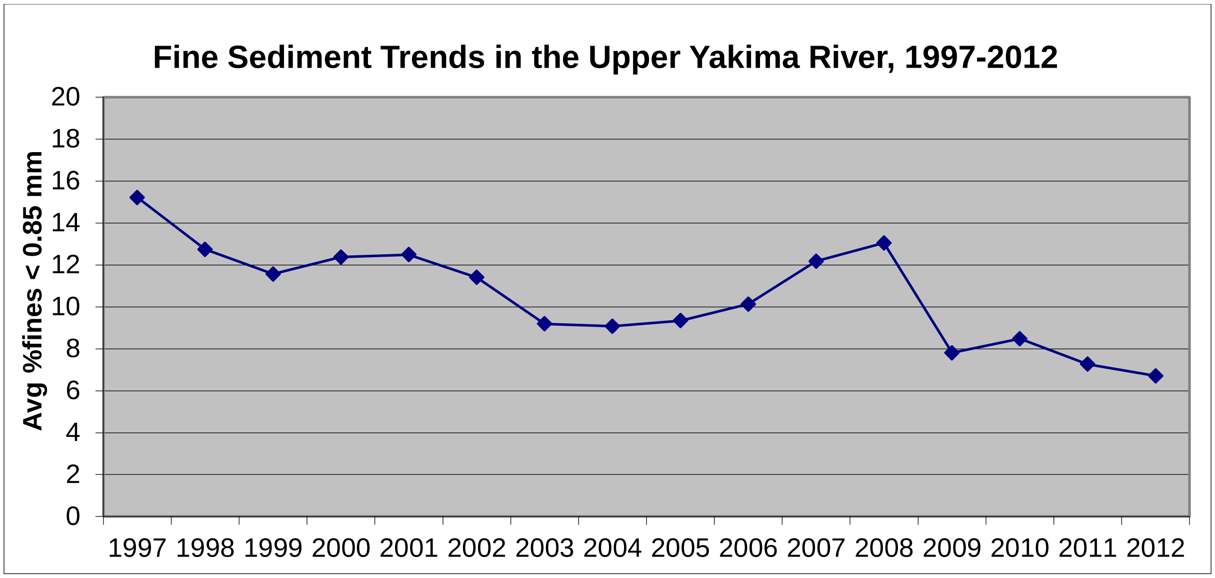


Figure 22. Overall average percent fine sediment (< 0.85 mm) in spawning gravels of the Upper Yakima River, 1997-2012.

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, though increased from 2011, are still below the mean for sediment levels for the 14-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 (monitoring methods.org method 421; 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 11. Marine and freshwater recoveries of CWTs from brood year 1997-2007 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) 12 Dec 2012.

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	328	4.1%	16	1211	1.3%
2007[1]	8	141	5.4%	13	1106	1.2%

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 2007 are considered preliminary or incomplete. CWT recovery data for brood year 2008 were considered too incomplete to report at this time.

Table 12. Estimated run size, harvest, and harvest rates of Yakima Basin spring Chinook in Columbia River mainstem and terminal area fisheries, 1983-present.

Year	Columbia R. Mouth Run Size	Col. R. Mouth to BON Harvest	BON to McNary Harvest	Yakima R. Mouth Run Size	Yakima River Harvest	Columbia Basin Harvest Summary			Col. Basin Harvest Rate	
						Total	Wild	CESRF	Total	Wild
1983	2,470	119	99	1,441	84	302	302		12.2%	
1984	3,890	135	258	2,658	289	682	682		17.5%	
1985	5,274	192	179	4,560	865	1,236	1,236		23.4%	
1986	13,480	279	781	9,439	1,340	2,400	2,400		17.8%	
1987	6,165	96	372	4,443	517	986	986		16.0%	
1988	5,610	359	371	4,246	444	1,174	1,174		20.9%	
1989	8,936	213	668	4,914	747	1,628	1,628		18.2%	
1990	6,967	353	457	4,372	663	1,472	1,472		21.1%	
1991	4,611	183	277	2,906	32	492	492		10.7%	
1992	6,226	103	375	4,599	345	823	823		13.2%	
1993	5,135	44	312	3,919	129	485	485		9.4%	
1994	2,228	86	107	1,302	25	219	219		9.8%	
1995	1,375	1	68	666	79	148	148		10.8%	
1996	5,790	6	303	3,179	475	784	784		13.5%	
1997	5,235	3	350	3,173	575	928	928		17.7%	
1998	2,825	3	142	1,903	188	332	332		11.8%	
1999	3,944	4	182	2,781	604	790	790		20.0%	
2000	29,115	59	1,770	19,100	2,458	4,287	4,163	124	14.7%	
2001	31,220	1,002	4,078	23,265	4,630	9,710	5,595	4,116	31.1%	29.8%
2002	23,954	1,269	2,553	15,099	3,108	6,930	2,606	4,324	28.9%	24.9%
2003	9,759	296	766	6,957	440	1,502	914	589	15.4%	14.6%
2004	22,026	1,011	1,904	15,289	1,679	4,594	2,568	2,026	20.9%	16.3%
2005	11,888	335	740	8,758	474	1,549	1,222	328	13.0%	12.2%
2006	11,588	304	762	6,314	600	1,665	948	717	14.4%	12.8%
2007	5,055	178	348	4,303	279	805	391	414	15.9%	13.9%
2008	11,492	1,149	1,570	8,598	1,532	4,251	1,199	3,053	37.0%	26.8%
2009	12,980	1,139	1,116	12,120	2,353	4,607	1,261	3,346	35.5%	26.1%
2010	17,686	1,518	2,620	13,142	1,741	5,878	1,348	4,531	33.2%	22.1%
2011	22,354	975	1,643	17,960	4,380	6,998	2,401	4,597	31.3%	22.4%
2012[1]	15,931	757	1,478	12,053	3,320	5,554	2,220	3,334	34.9%	28.2%
Mean	10,292	395	868	7,267	1,123	2,386	1,370	2,614	19.7%	17.7%

1. Preliminary.

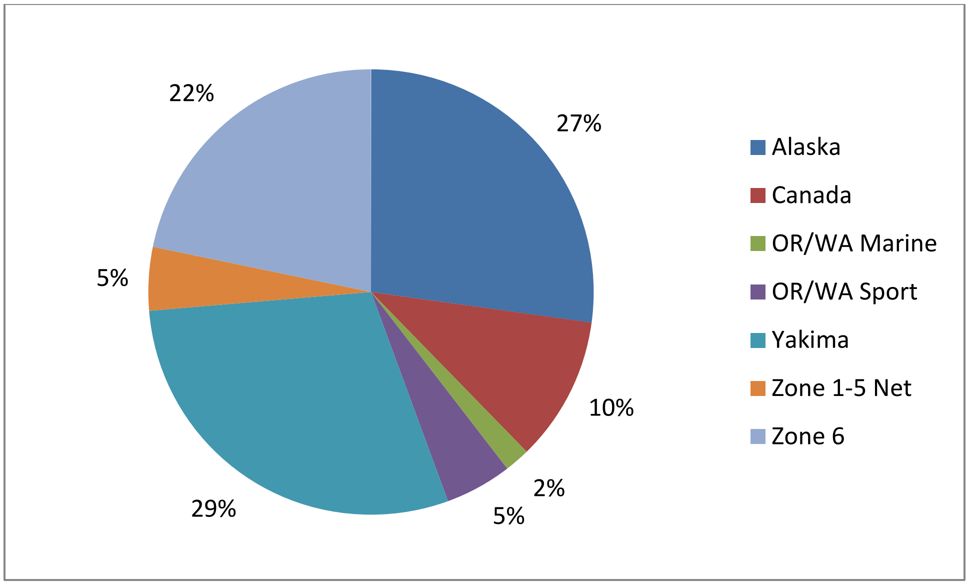


Figure 23. Distribution of coded-wire tag recoveries of Yakima Basin summer/fall run Chinook releases in marine, mainstem Columbia River, and Yakima Basin fisheries. Data retrieved from the regional mark information system (RMIS) for brood year 1997-2007 recoveries.

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 11). Adult returns of spring Chinook from the CESRF appear to be making substantial contributions to Columbia Basin fisheries (Table 12).

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 23). 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, 461, 790, and 960.

Results:

Table 13. 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%
Mean	610	620	576	102	1,186	663	1,123	13.3%

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 14. Estimated fall Chinook return, escapement, and harvest in the Yakima River, 1998-2012. 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%

Table 15. Estimated Coho return, escapement, and harvest in the Yakima River, 1999-2012. 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%

Discussion:

Adult returns of spring Chinook from the CESRF have substantially increased fishing opportunity for all fishers in the Yakima Basin (Table 13) 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 14). Tribal fishers harvest a substantial, but unquantified number of Yakima Basin-destined fall Chinook (Figure 23) 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 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?

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 24) 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 24). 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 findings described below are preliminary. We are working with WDFW to incorporate additional out-of-basin control populations in this evaluation and intend to publish more complete findings in the literature when results are considered mature.

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).

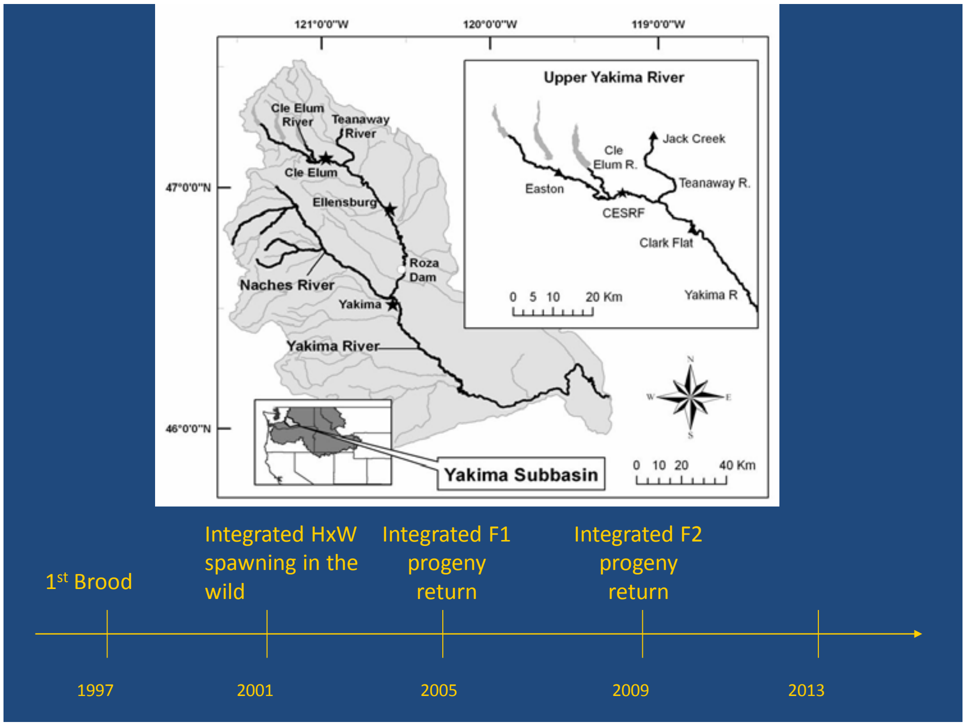
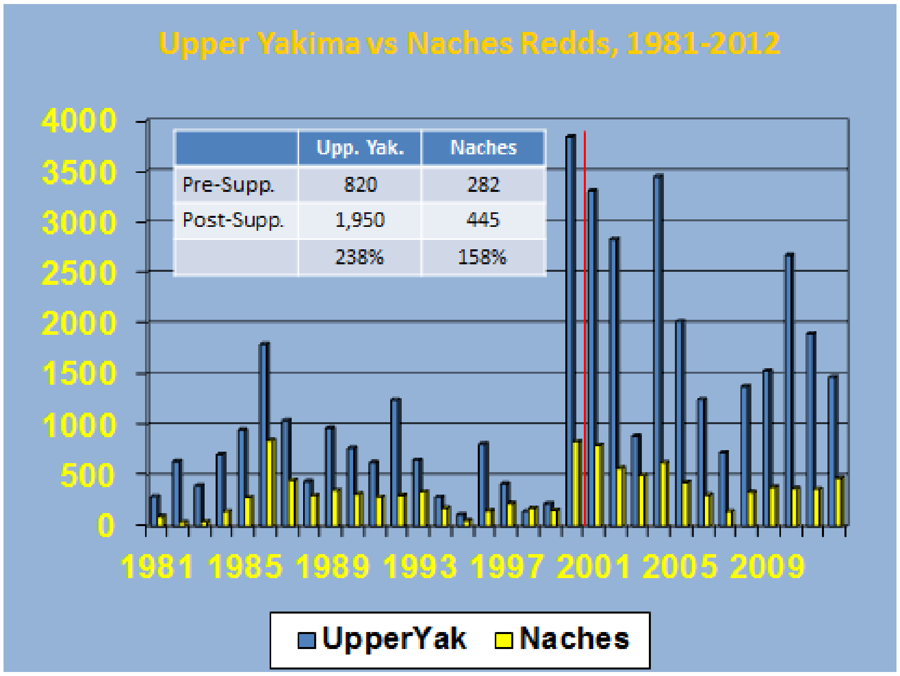


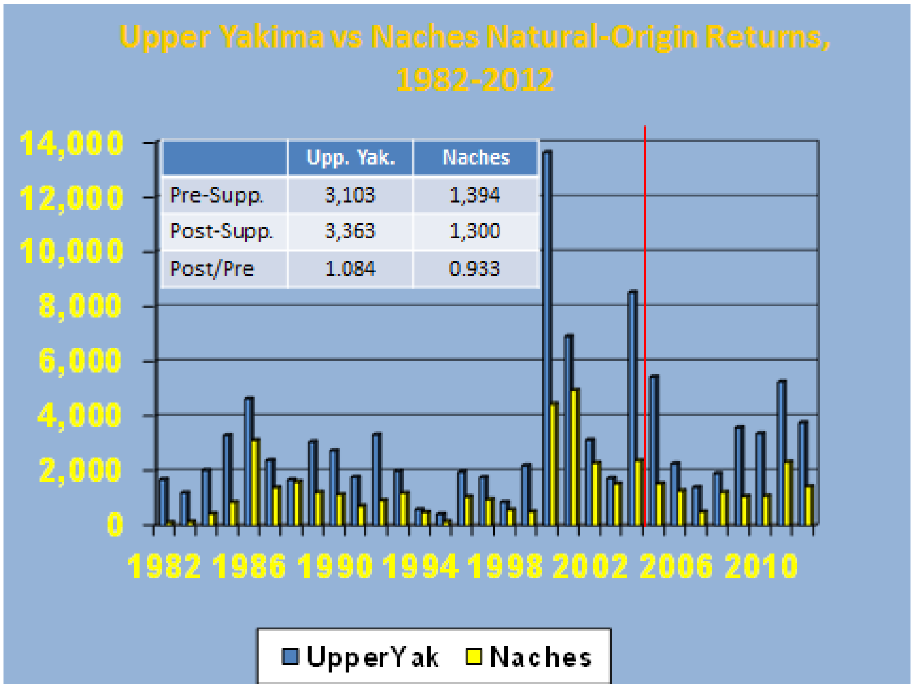
Figure 24. Map of the Yakima River Basin, Cle Elum Supplementation and Research Facility (CESRF) locations, and timeline of the spring Chinook supplementation program.

Results:



	Upp. Yak.	Naches
Pre-Supp.	820	282
Post-Supp.	1,950	445
	238%	158%

Figure 25. Spring Chinook redd counts in the supplemented Upper Yakima (blue bar) relative to the un-supplemented Naches (control; yellow bar) for the pre- (1981-2000) and post-supplementation (2001-2012) periods.



	Upp. Yak.	Naches
Pre-Supp.	3,103	1,394
Post-Supp.	3,363	1,300
Post/Pre	1.084	0.933

Figure 26. 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 (2005-2012) periods.

Discussion:

Supplementation has increased spring Chinook redd abundance in the Upper Yakima relative to the Naches control system (Figure 25). Redd counts in the post-supplementation period (2001-2012) have increased significantly in both the supplemented Upper Yakima and un-supplemented Naches control systems relative to the pre-supplementation period (1981-2000), but the average increase in redd counts in the upper Yakima (238%; P=0.001) was about 80% greater than that observed in the Naches system (158%; P=0.036). 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 16).

Supplementation has not increased natural-origin spring Chinook returns in the Upper Yakima relative to the Naches control system (Figure 26). Natural-origin returns in the post-supplementation period (2005-2012) have not changed significantly in either the supplemented Upper Yakima or Naches control systems relative to the pre-supplementation period (1982-2004). However, the mean natural-origin return in the post-supplementation period increased in the upper Yakima (~ 8%; P=0.815; Figure 26) and decreased in the Naches system (~ -7%; P=0.843; Figure 26) relative to the pre-supplementation period. 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.

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).

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. YKFP 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 3,900 fish from 1997-2011 (an order of magnitude greater than the average for years prior to the project) including estimated returns of wild/natural coho averaging about 1,000 fish 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 a tool for evaluating hatchery programs (C. Busack, NOAA Fisheries, unpublished, but see descriptions available at Busack 2013 and Mobrand et al. 2005). The equation describing PNI is given as PNI equals the proportion of natural-origin brood-stock (PNOB) divided by PNOB plus the proportion of hatchery-origin spawners (PHOS). For the CESRF program PNOB equals 1.0 as only natural-origin fish are used for supplementation line brood-stock.

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 16. 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%
Mean[3]	2,688	357	3,045	2,814	798	3,611	5,357	1,189	6,546	56.2%	64.8%

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 12-year mean annual PNI of 65% (range 57-84%; Table 16). 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.

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 17) 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 17. 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 (Holmes) were surveyed for piscivorous birds in 2008 (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 27). 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.

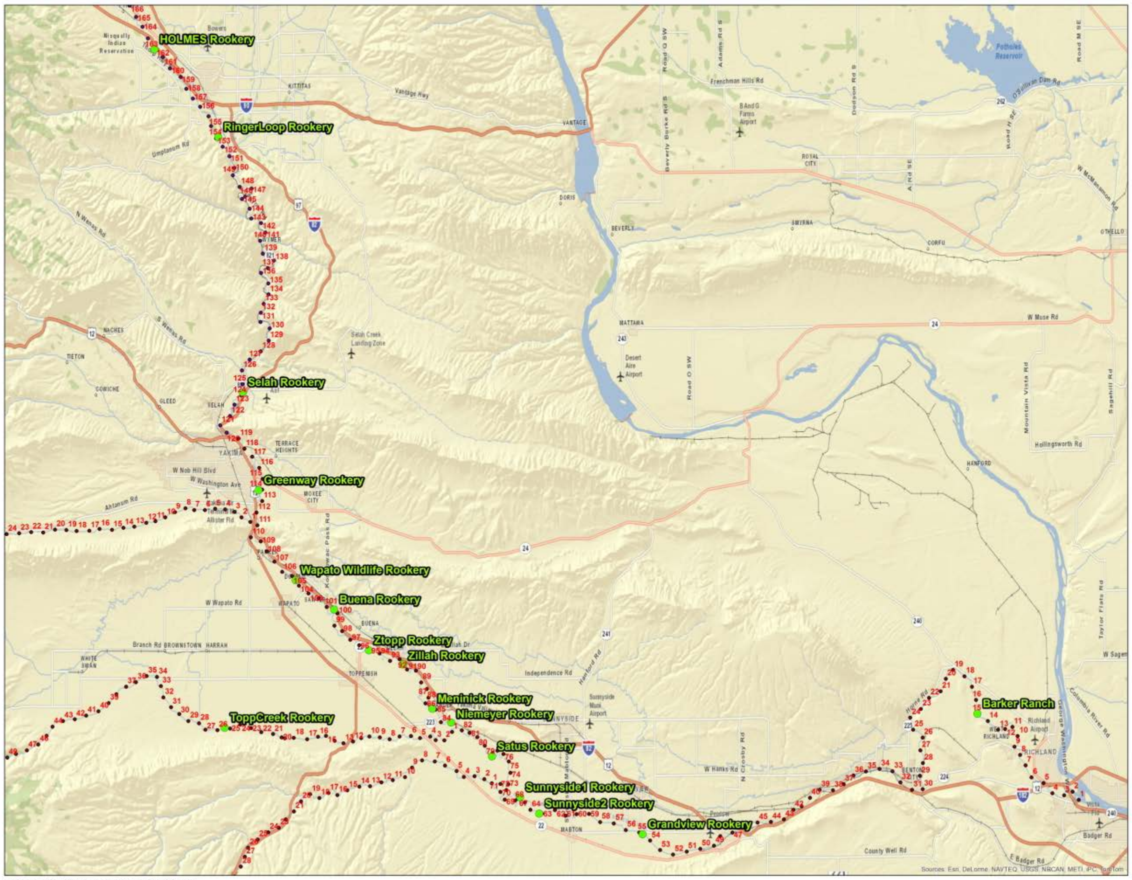


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Figure 27. Map of Yakima Basin Heron Rookeries.

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

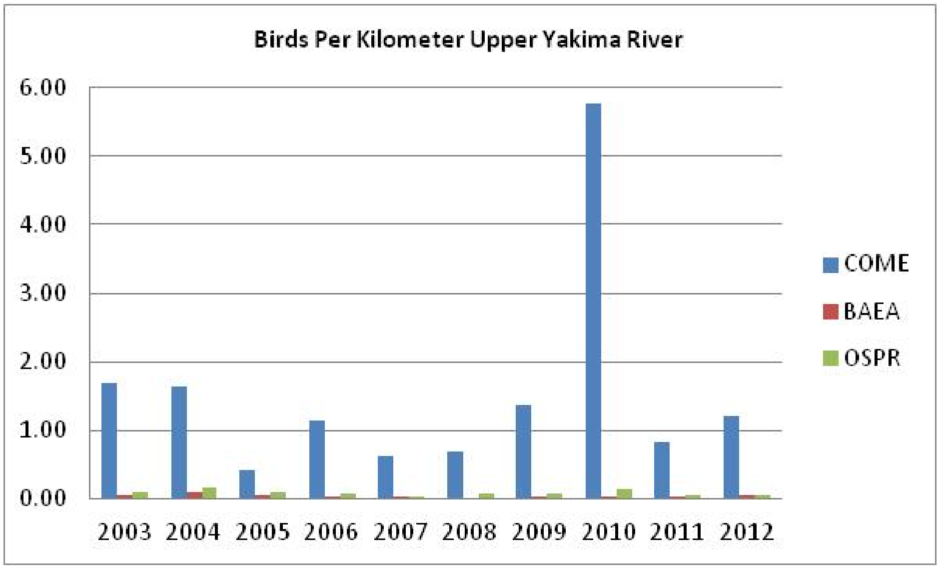


Figure 28. Upper Yakima piscivorous birds per kilometer (Common Merganser-COME, Bald Eagle-BAEA, and Osprey-OSPR).

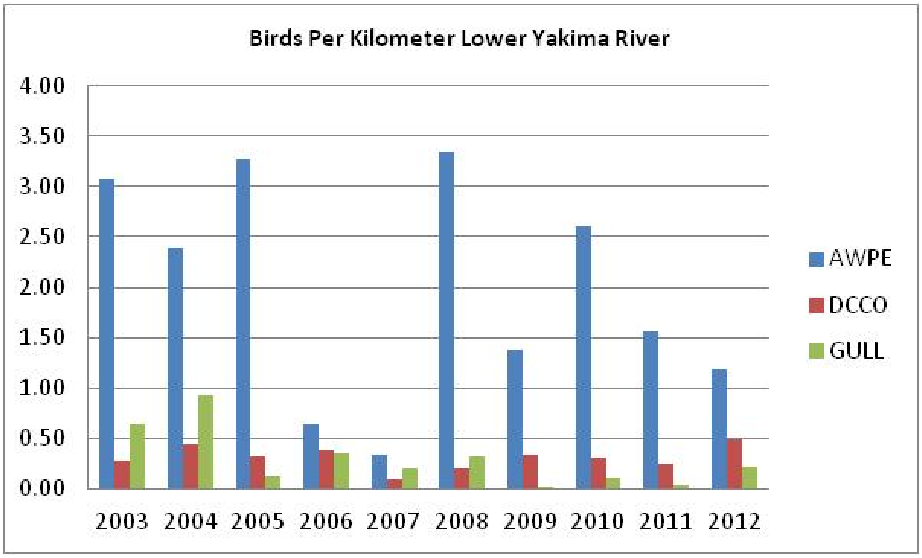


Figure 29. Lower Yakima piscivorous birds per kilometer (American White Pelican-AWPE, Double Crested Cormorant-DCCO, and Gulls-GULL).

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.

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 28).

American White Pelicans numbers remain consistently high in the lower Yakima River and in the Wapato Reach of the Yakima River (Figure 29). Gull and Double Crested Cormorant numbers remain relatively low in the Yakima River Basin.

Acclimation Sites Surveys

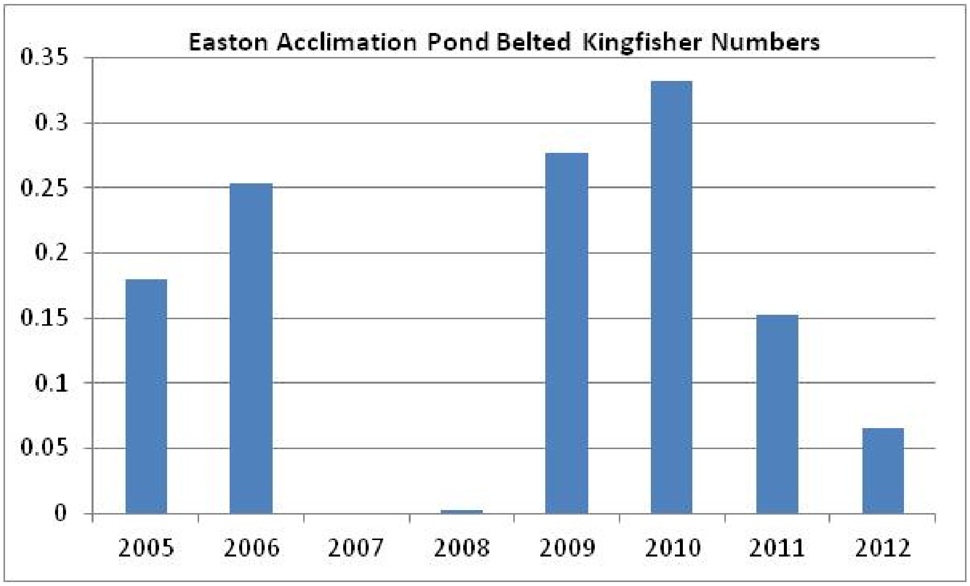


Figure 30. Average number of Belted King Fishers observed per day at the Easton spring Chinook acclimation site between 2005 and 2012 when fish were present.

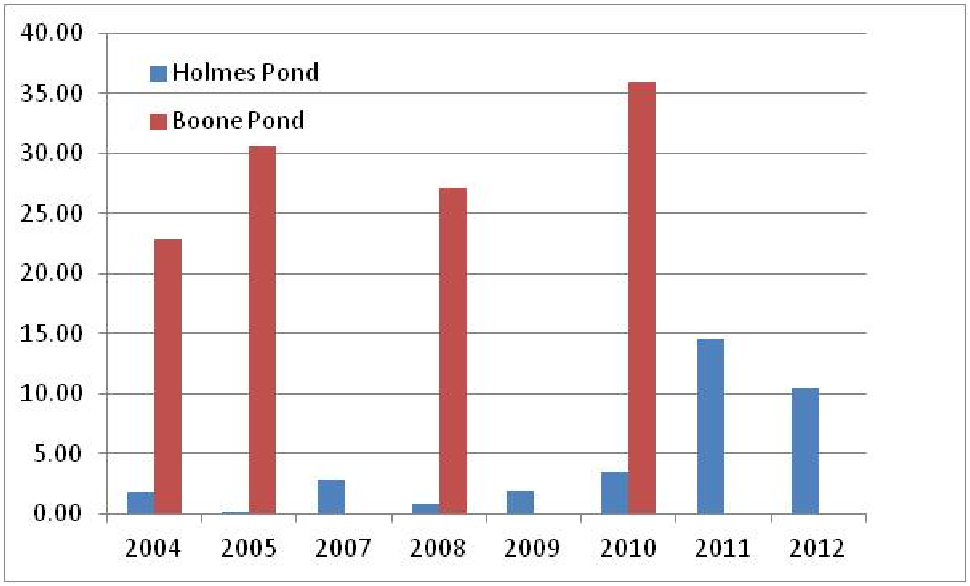


Figure 31. Average number of Common Mergansers observed per day at the Boone and Holmes Pond Coho acclimation sites between 2004 and 2012 when fish were present.

Acclimation site bird numbers 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 30).

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 31). From 2004 to 2012 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 was not used in several recent years. Easton pond was used consistently as a Coho acclimation site from 2004 to 2012. 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.

Great Blue Heron Rookeries

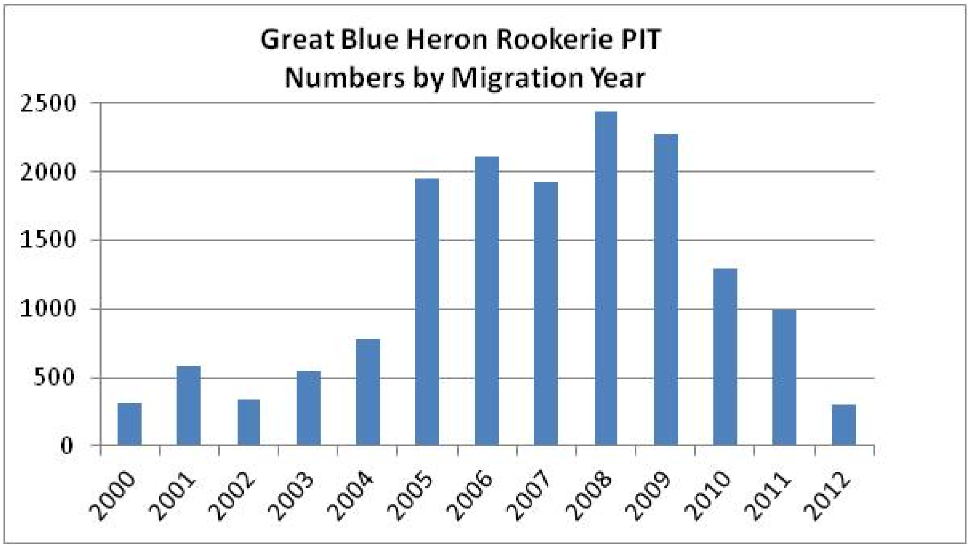


Figure 32. Number of PIT tags recovered at Yakima Basin Great Blue Heron rookery sites during surveys conducted from 2008-2012. Tags were from juvenile salmonids migrating downstream between 2000 and 2012. Total PIT tags recovered are shown by their corresponding migration year.

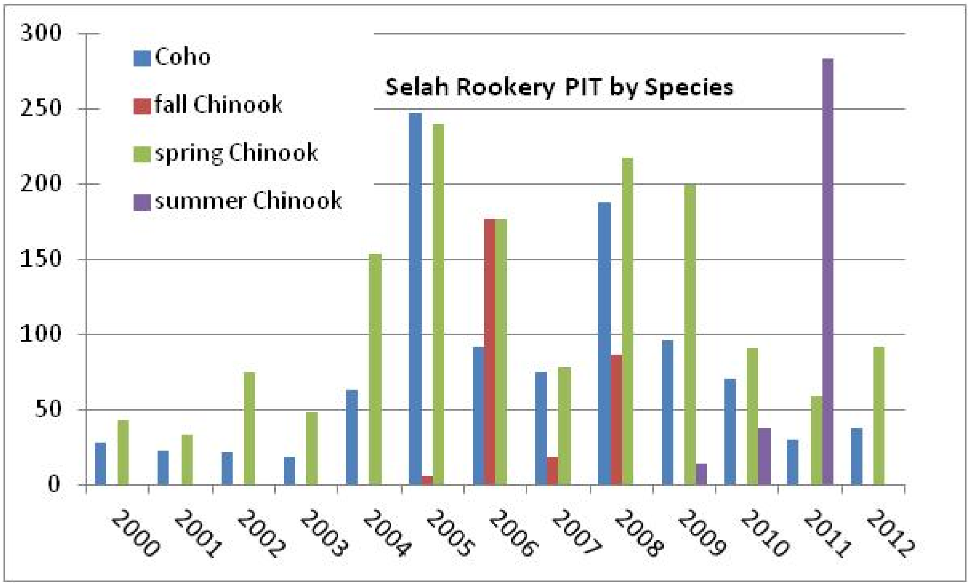


Figure 33. Number of PIT tags recovered at the Selah Great Blue Heron rookery during surveys conducted from 2008-2012. Tags were from juvenile salmonids migrating downstream between 2000 and 2012. Total PIT tags recovered are shown by species and their corresponding migration year.

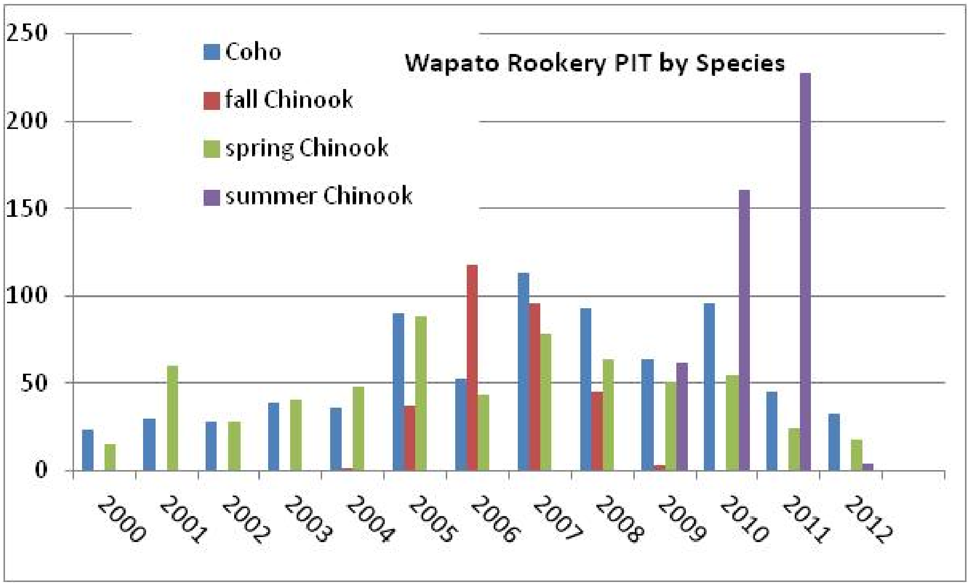


Figure 34. Number of PIT tags recovered at the Wapato Wildlife Area Great Blue Heron rookery during surveys conducted from 2008-2012. Tags were from juvenile salmonids migrating downstream between 2000 and 2012. Total PIT tags recovered are shown by species and their corresponding migration year.

Surveys of the Yakima Basin Great Blue Heron rookery sites between 2008 and 2012 recovered approximately 16,000 salmonid related PIT tags (Figure 32). 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.

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 33). 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 33). This is likely the product of summer Chinook acclimation at the nearby Stiles pond, as these fish would not travel the Yakima River adjacent to the rookery but would enter the Yakima from the Naches River below the 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 34). 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 wild 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 118 and 120. 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 dc 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 method 1712) 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 35). 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.

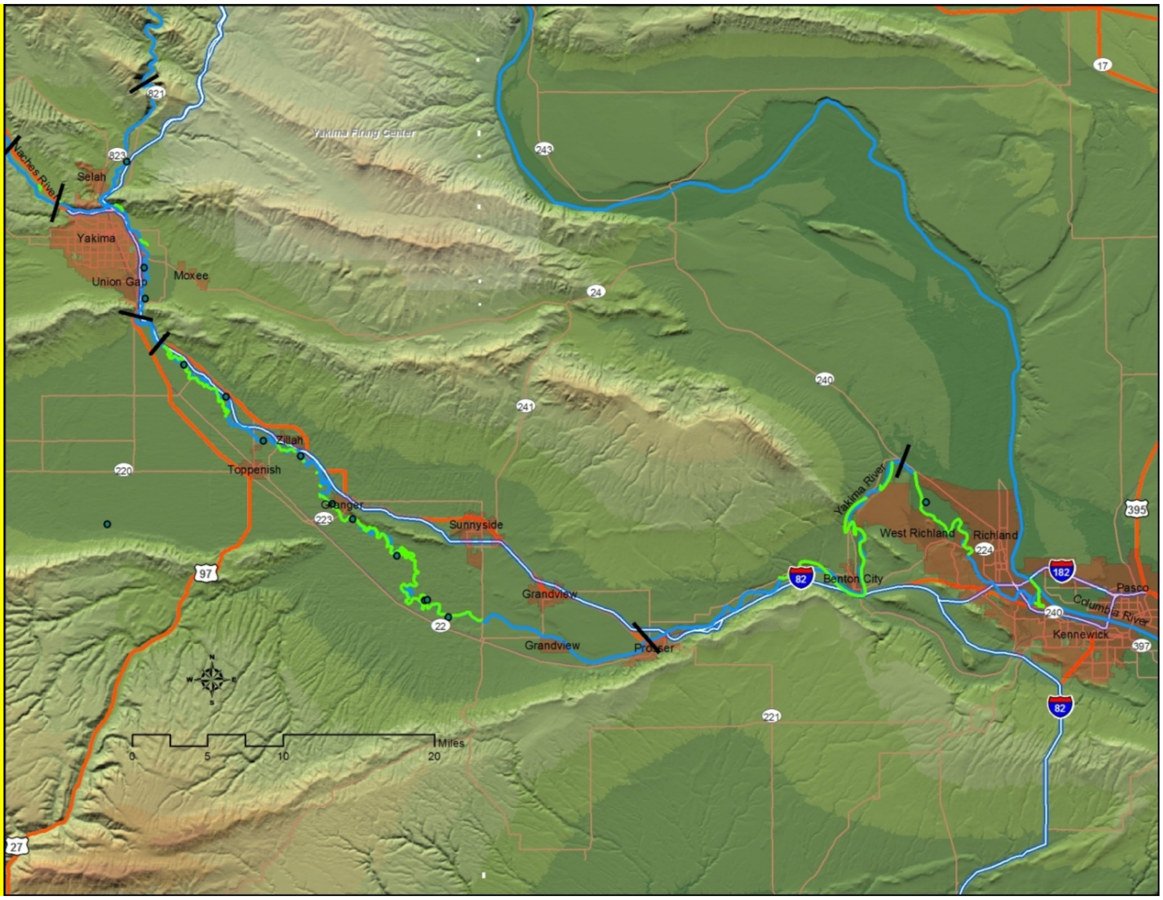


Figure 35. Map of Yakima River Piscivorous Fish Populations Study Areas.

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 1286). NPM stomachs with fish present were further analyzed to determine the number and types of species consumed (monitoringmethods.org method 1287). This analysis was performed using diagnostic bones which allows determination of species (though for salmonids this is more difficult) and approximate body length.

Results and Discussion:

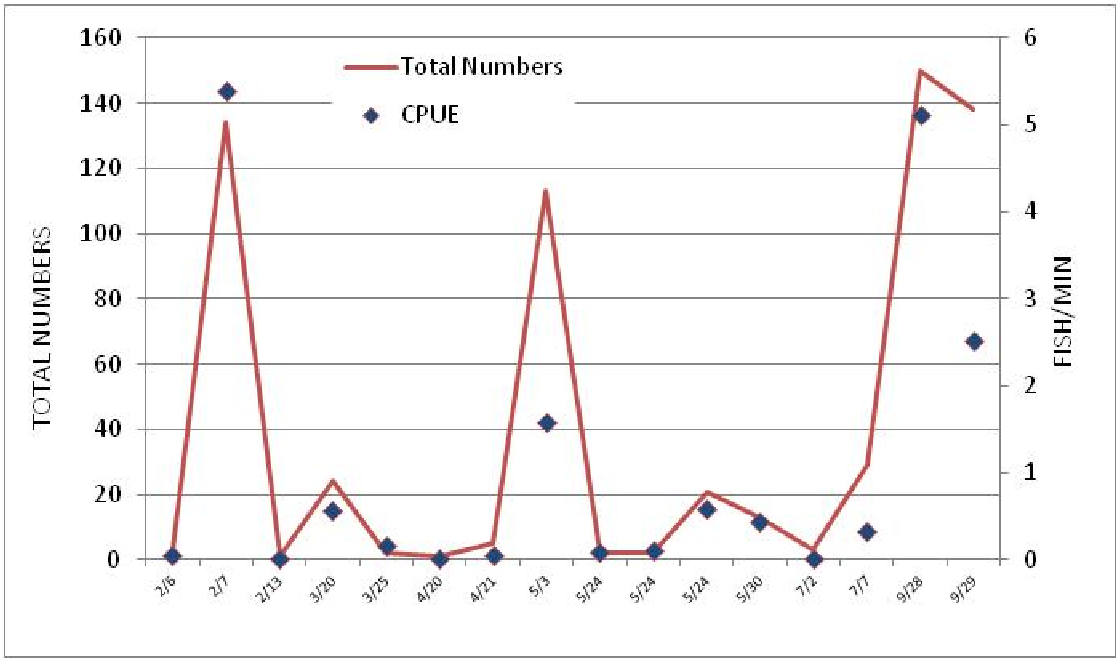


Figure 36. Number and Catch per Unit Effort (CPUE) of Northern Pike Minnow observed in surveys of the Yakima River Wapato Reach. Data are from combined 2011 and 2012 surveys to display NPM presence over varying seasons.

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 36). While numbers vary over seasons it is evident that Northern Pikeminnow populations remain in high numbers over the course of the year.

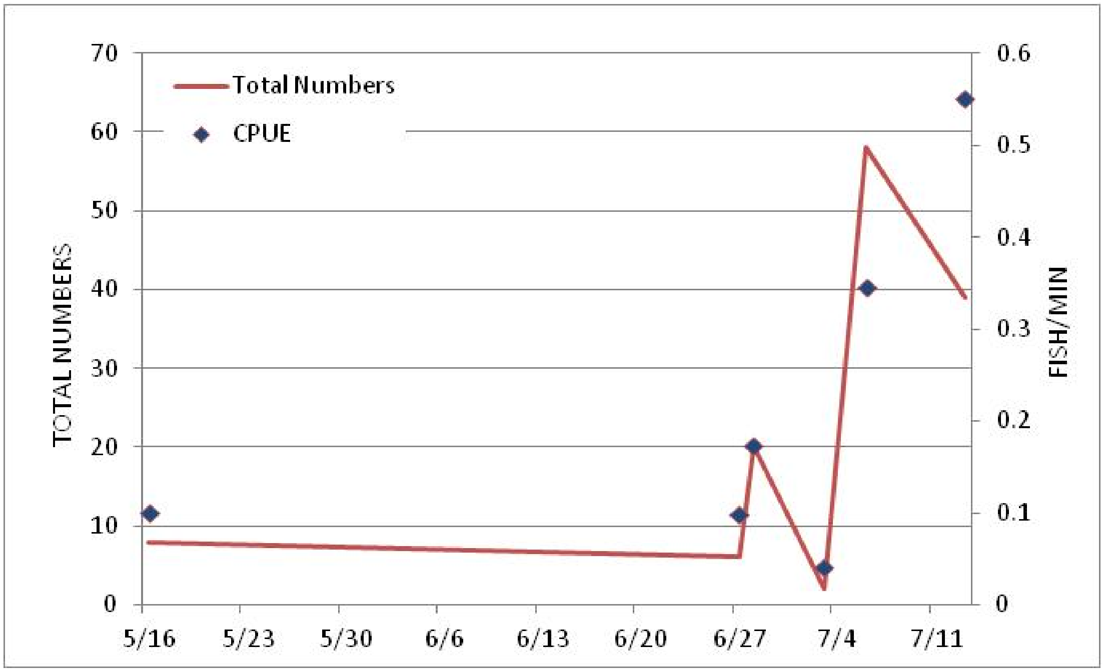


Figure 37. Number and Catch per Unit Effort (CPUE) of Smallmouth Bass observed in 2012 surveys of the Lower Yakima River from Benton to the River Mouth.

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.

Smallmouth Bass were found in higher numbers in the lower river with a spike in presence during their spawning periods (Figure 37). Catch and catch per unit effort began to rise in late June during the 2012 survey period as Smallmouth bass began their migration from the Columbia River upstream in the Yakima River to spawn.

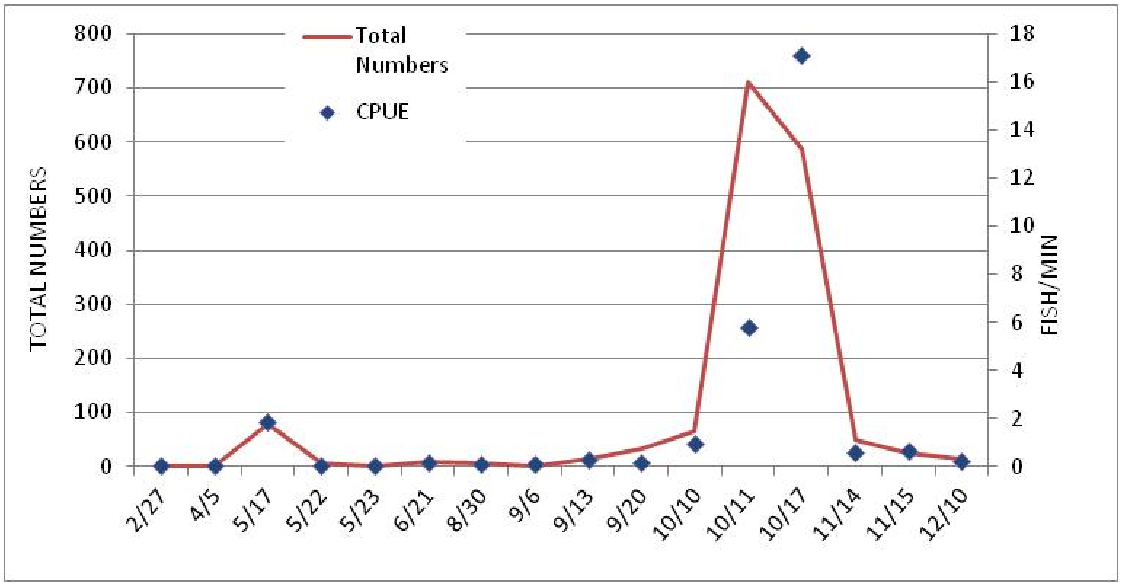


Figure 38. Number and Catch per Unit Effort (CPUE) of Smallmouth Bass observed in surveys of the Yakima River Delta area (West of the Bateman Island Causeway).

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 has produced extremely high numbers of Smallmouth Bass and also produce extremely high CPUE's of up to 17 fish caught per minute (Figure 38).

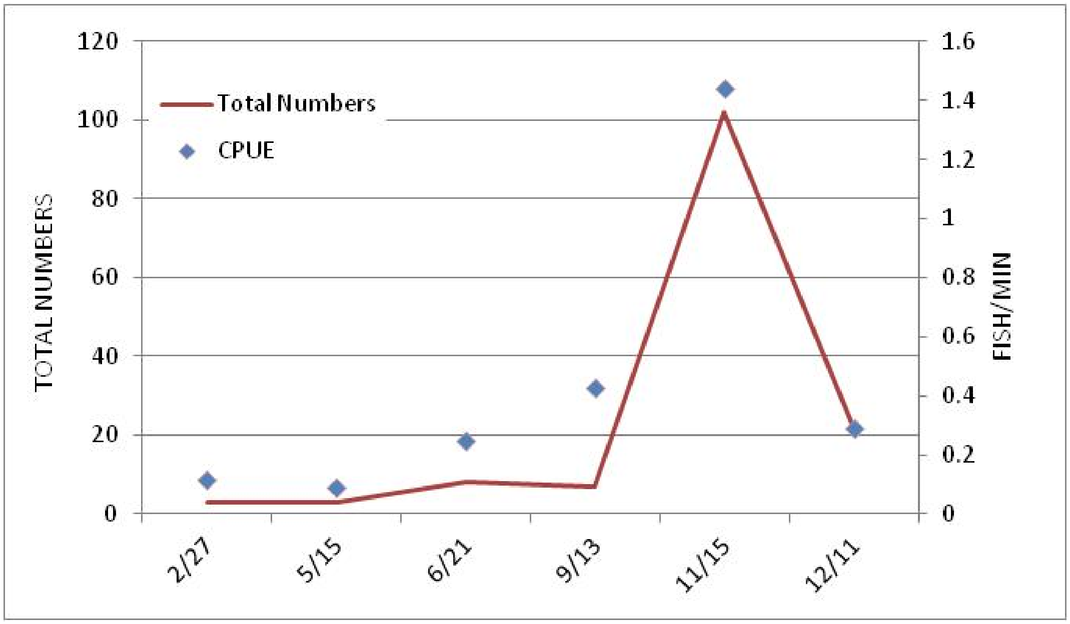


Figure 39. Number and Catch per Unit Effort (CPUE) of Smallmouth Bass observed in surveys of the Yakima River Delta area (East of the Bateman Island Causeway).

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 39), 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.

Coordination and Data Management

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 a comprehensive network of data management systems described as follows.

The Yakama Nation Fisheries Program (YNFP) has been working for the past decade or more to develop, maintain, and improve its data management, networking, and sharing capabilities. Dedicated data stewards have been employed under Yakima-Klickitat Fisheries Project Data, Management, and Habitat contracts for the Yakima Basin (BPA project No. 198812025) since 2000 and for the Klickitat Basin (BPA project No. 198812035) since 2003. Detailed information management plans for these two basins have been developed and are available upon request (Yakima Basin, contact Bill Bosch, bbosch@yakama.com; Klickitat Basin, contact Michael Babcock, mbabcock@ykfp.org). A general data flow diagram for Yakima River Basin data management activities is presented in Figure 40.

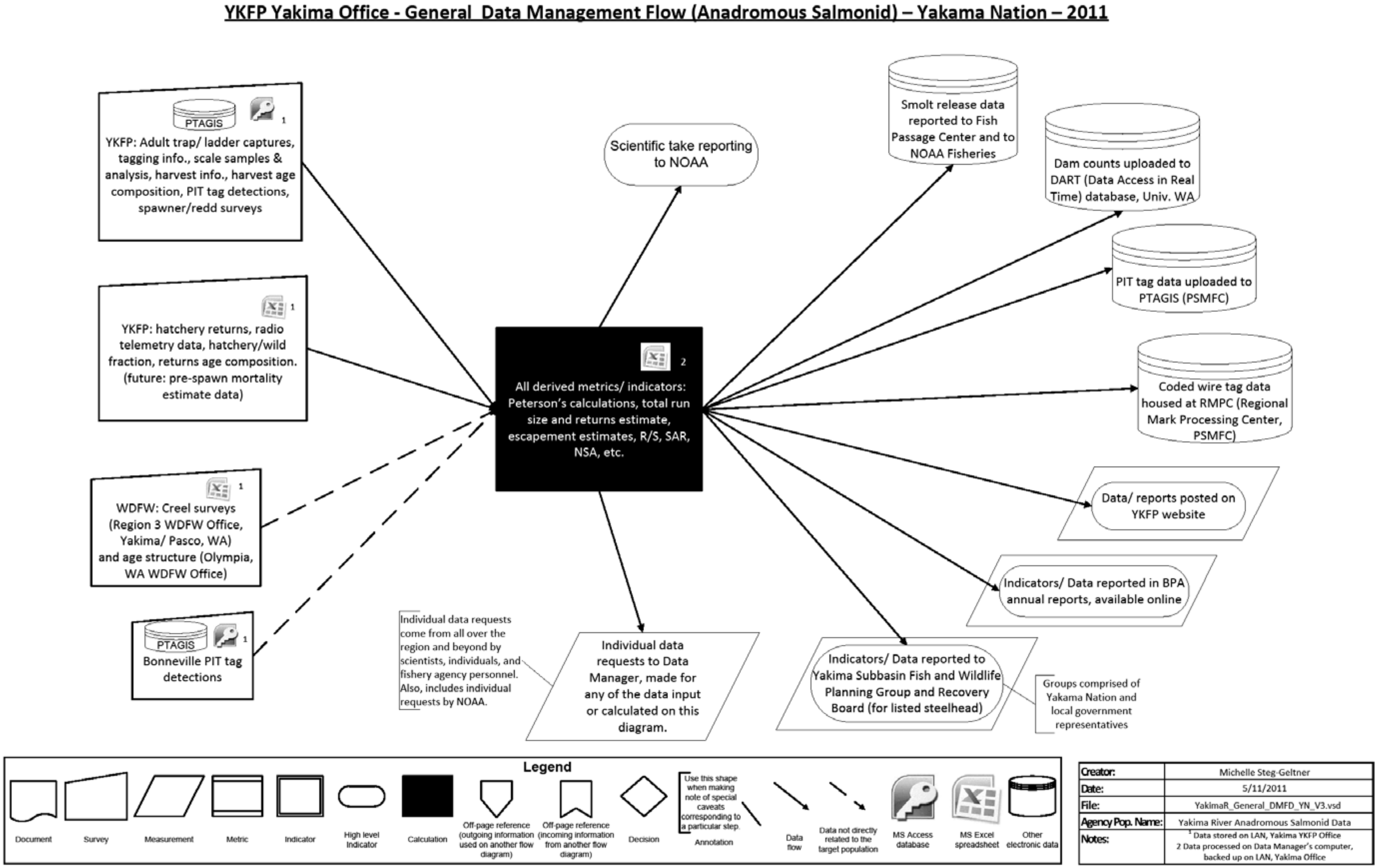
Major YNFP data management accomplishments to date include:

- Development and maintenance of ykfp.org web site to host information relating to Yakima and Klickitat Basin project activities including: redd counts, juvenile and adult migration counts, technical reports and publications, project review/conference information, etc.
- Comprehensive VSP accounting and reporting for Yakima Basin spring Chinook (see Appendix B in this report)
- Automated integration of Prosser and Roza dam daily count data with DART
- Integration of PIT and CWT release and recovery data with PTAGIS, RMPC, 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)
- Development and maintenance of databases to support the following M&E data collection activities: Prosser and Roza video counts; Prosser denil and Roza adult trap sampling; Yakima Basin juvenile migration timing and biological data sampling; juvenile PIT tagging operations at all subbasin locations; Cle Elum spring Chinook spawning and rearing; Cle Elum facility water usage, temperature, and flow monitoring; Prosser steelhead kelt reconditioning; spawner surveys at all subbasin locations; scale sampling; age and sex composition; radio telemetry and tracking; Klickitat habitat surveys; Lyle Falls adult trap counts; Klickitat smolt trap counts; Klickitat stream temperature and sediment data; Zone 6 and tributary harvest accounting; and Zone 6 Treaty commercial fish ticket accounting
- Development of GIS maps as needed to support YNFP activities
- Development and maintenance of spreadsheets to summarize and track annual trends in above data
- Maintenance of hardware and software necessary to support the above

The Yakama Nation has participated in the Collaborative System-wide Monitoring and Evaluation Project (CSMEP), Streamnet, and Northwest Environmental Data Network (NED) projects, and continues to participate in the Coordinated Assessments process and the Pacific Northwest Aquatic Monitoring Program (PNAMP). We are working with the Columbia River Inter-Tribal Fish Commission (CRITFC) to implement a tribal data network that will facilitate sharing of data collected and reported by Yakama Nation fisheries projects as envisioned in preliminary regional data sharing strategies circulated for review. However, it is important to note that additional resources will be required to achieve the regional vision for data sharing as presently described (see Columbia River Basin Collaborative Data Sharing Strategy). With existing staff and budgets, the Yakama Nation is essentially in maintenance mode using all of our current resources to maintain products (described above) that we have already developed.

In addition, 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 (see 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 7 Nov 2012). We can document several recent examples of misuse of project data obtained from existing regional databases.


YKFP Yakima Office - General Data Management Flow (Anadromous Salmonid) – Yakama Nation – 2011

Creator:	Michelle Steg-Geltner
Date:	5/11/2011
File:	YakimaR_General_DMFD_YN_V3.vsd
Agency Pop. Name:	Yakima River Anadromous Salmonid Data
Notes:	[1] Data stored on LAN, Yakima YKFP Office 2 Data processed on Data Manager's computer, backed up on LAN, Yakima Office

Figure 40. General data flow diagram for data collected and reported by the Yakama Nation in the Yakima River Basin.

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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: Smolt Survival to McNary Dam of 1999-2012 PIT-tagged Spring Chinook released or detected at Roza Dam

D. 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 2012

E. IntStats, Inc. Annual Report: Comparisons between Smolt Measures of Hatchery x Hatchery- and Natural x Natural-Brood Stock for Brood-Years 2002-2010 Upper Yakima Spring Chinook

F. IntStats, Inc. 2012 Annual Report: Smolt-to-Smolt Survival to McNary Dam of Yakima Fall and Summer Chinook

G. Intstats, Inc. Annual Report: 2012 Coho Smolt-to-Smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin

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
BPA Fish and Wildlife publication page
PTAGIS Website

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 can document several recent examples of 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

2012 Annual Report

July 2, 2013

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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.

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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

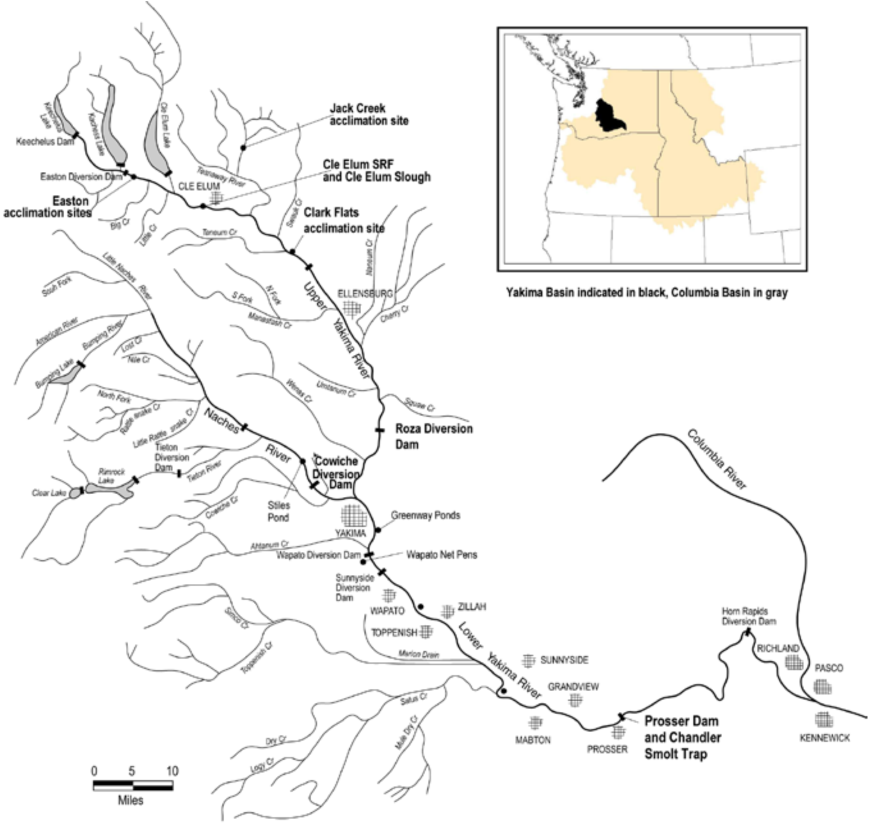
Returning adult spring Chinook are monitored at the Roza adult trapping facility located on the Yakima River (Rkm 205.8). This facility provides the means to monitor every fish returning to the upper Yakima Basin and to collect adults for the CESRF program. All returning CESRF fish (adipose-clipped fish) 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).

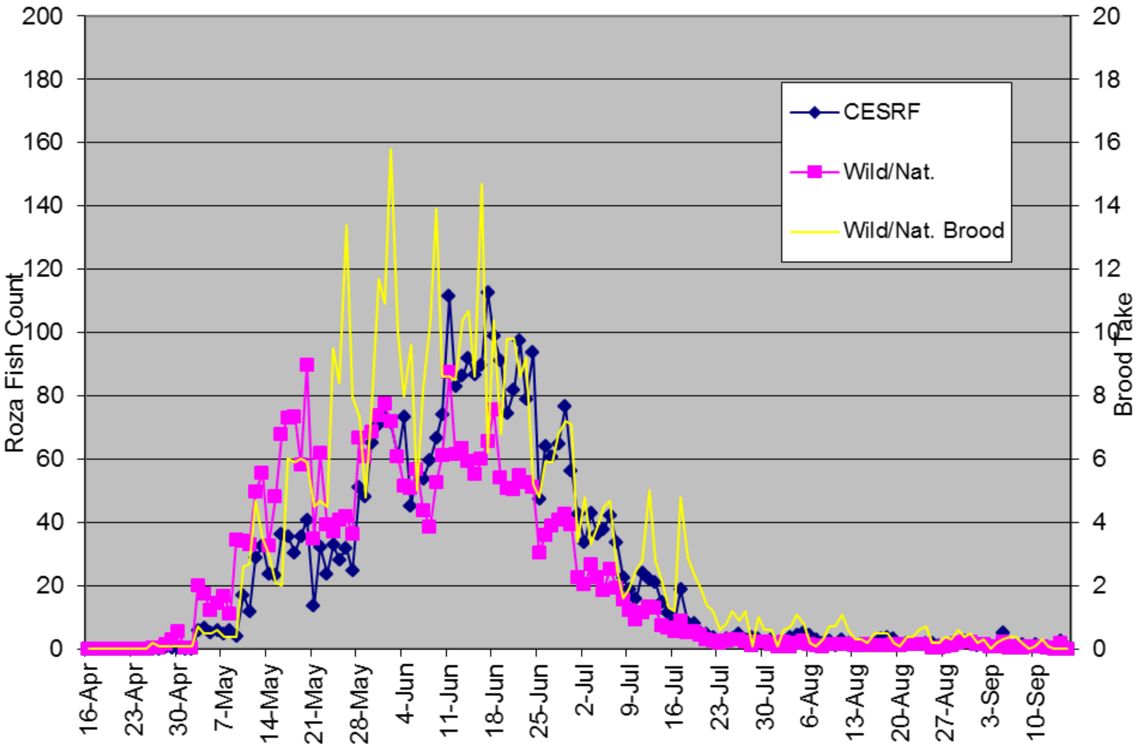


Figure 2. Mean spring Chinook run timing and broodstock collection at Roza Dam, 2003-2012.

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.

	Trap	Brood	Brood	Portion of run collected:[1]			Portion of collection from:[2]		
Year	Count	Take	%	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%

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%
Mean[3]	2,688	357	3,045	2,814	798	3,611	5,357	1,189	6,546	56.2%	64.8%

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, 1986-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
1986	8,841	598	9,439	530	8,909	810	709	3,267	16	3,251	4,123	1,472	1,313
1987	4,187	256	4,443	359	4,084	158	269	1,928	194	1,734	1,729	903	677
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
Mean[6]	8,538	2,011	10,549	469	10,080	1,211	27	6,961	1,090	5,871	1,882	1,724	591

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 (2003-2012).

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
1982[1]	1,280	324	4,016	411	4,751	3.71
1983[1]	1,125	408	1,882	204	2,494	2.22
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[2]	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	3,409			
2009	7,056	283				
2010	8,383					
2011	8,584					
2012	5,483					
Mean[3]	4,114	325	2,866	119	3,307	1.80

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. The mean jack proportion of spawning escapement from 1999-2012 was 0.22 (geometric mean 0.16).
3. 1984-present.

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	Estimated	Estimated Yakima R. Mouth Returns					Returns/
Year	Spawners	Age-3	Age-4	Age-5	Age-6	Total	Spawner
1982[1]	86	85	1,275	324	0	1,683	19.57
1983[1]	131	123	928	757	10	1,818	13.83
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[2]	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	518		2,292	4.95
2008	1,074	414	823				
2009	903	84					
2010	1,207						
2011	2,476						
2012	1,537						
Mean[3]	1,293	104	927	409	3	1,428	1.81

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. The mean jack proportion of spawning escapement from 1999-2012 was 0.08 (geometric mean 0.085).
3. 1984-present.

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

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns					Returns/ Spawner
		Age-3	Age-4	Age-5	Age-6	Total	
1982[1]	22	42	223	248	0	513	23.32
1983[1]	101	67	359	602	0	1,028	10.21
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[2]	0	515	1.11
2006	509	45	172[2]	451	0	668	1.31
2007	523	57[2]	645	668		1,369	2.62
2008	504	239	286				
2009	213	60					
2010	285						
2011	584						
2012	363						
Mean[3]	532	48	256	336	1	627	1.81

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. No survey samples in 2010 return year; data approximated using 2007-09, 2011 survey samples.
3. 1984-present.

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
1982[1]	108	127	1,274	601	0	2,002	18.54
1983[1]	232	190	1,257	1,257	8	2,713	11.68
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[2]	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[3]	0	1,264	0.66
2006	1,672	237	1,215[3]	759	0	2,211	1.32
2007	986	182[3]	2,239	1,112		3,533	3.58
2008	1,578	653	1,183				
2009	1,117	144					
2010	1,491						
2011	3,060						
2012	1,900						
Mean[4]	1,825	152	1,144	786	9	2,059	1.77

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. The mean jack proportion of spawning escapement from 1999-2011 was 0.08 (geometric mean 0.09).
3. Age composition using only Naches survey samples in 2010 return year.
4. 1984-present.

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 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	31	4,388	8.60
2006	419	3,038	5,802	264	9,104	21.73
2007	449	1,277	5,174	108	6,558	14.61
2008	457	2,344	4,567			
2009	486	461				
2010	336					
2011	377					
2012	374					
Mean	478	1,024	3,773	134	4,790	7.12[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 2011, age composition of American River spring Chinook has averaged 1, 41, 56, and 2 percent age-3, -4, –5, and -6, respectively (Table 9). Naches system spring Chinook averaged 2, 60, 38 and 0.5 percent age-3, -4, –5 and -6, respectively (Table 10). The upper Yakima River natural origin fish averaged 8, 87, and 5 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	Males					Females					Total			
Year	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		4		25.0	75.0		16		30.0	70.0	
Mean	2.5	46.1	51.0	0.4			39.4	59.0	1.6		0.9	40.7	56.9	1.4

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	11.1	44.4	44.4		9		63.9	36.1		36	2.2	60.0	37.8	
Mean	4.8	64.8	29.6	0.8		0.6	55.8	43.2	0.4		2.3	59.6	37.6	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					No carcasses were sampled						
Mean	15.8	80.5	3.6		1.3	93.2	5.5		8.3	87.0	4.7

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 19, 80, and 1 percent age-3, -4, and –5, respectively (Table 12) from 2001-2011 compared to 12, 83, and 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 Year	Males				Females				Total		
	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		2		100.0		3		100.0	
Mean	36.7	62.4	1.0		0.5	97.5	1.6		17.1	81.7	1.2

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 Year	Males				Females				Total		
	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
Mean	19.7	75.9	4.5		0.3	94.0	5.8		9.6	85.3	5.1

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	Males				Females				Total		
Year	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
Mean	24.1	71.2	4.7			93.8	6.0		10.5	84.2	5.3

Sex Composition

In the American River, the mean proportion of males to females in wild/natural carcasses sampled on the spawning grounds from 1986-2012 was 44:56 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 26:74 for age-5 fish (Table 16). In the upper Yakima River, the mean proportion of males to females was 34:66 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 1997-2012, the mean proportion of males to females was 38:62 and 35:65 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 34:66 and 42:58 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			33.3	66.7	14.3	85.7		
mean			43.5	56.5	31.5	68.5		

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	100.0		14.8	85.2	23.5	76.5		
mean			41.4	58.6	25.7	74.3		

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	No carcasses were sampled					
mean	85.9	14.1	34.3	65.7	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			40.0	60.0		
mean	96.5	3.5	29.7	70.3		

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
mean	97.8	2.2	37.6	62.4	34.1	65.9

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
mean	98.9	1.1	34.7	65.3	42.3	57.7

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 40, 62, and 78 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 1996-2012 (Table 21). In the Naches River, mean POHP lengths averaged 43, 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 60 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 2001-2012, 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			2	74.5	2	76.0			4	62.5	12	73.8		
Mean[2]		40.3		62.0		77.8				62.7		73.4		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 1996-2012 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	1	55.0	4	64.8	4	78.5					23	61.4	13	72.1		
Mean[2]		42.8		60.9		76.2		78.0		41.0		61.2		73.1		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 1996-2012 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			No samples						No samples			
Mean[1]		44.2		59.8		71.9		45.5		59.6		69.1

[1] Mean of mean values for 1996-2012 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			2	64.5					3	59.3		
Mean		44.3		59.9		69.2				59.5		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
Mean		43.1		59.6		70.3				59.9		68.5

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
Mean		41.2		59.3		73.4				59.4		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 age, 1997-present.

Return	Age 2		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP
1997			4	39.6	202	60.5	12	71.0
1998			37	42.8	309	59.1	24	67.3
1999			352	40.7	336	60.0	30	68.0
2000			41	41.4	499	60.3	5	73.1
2001			32	42.9	482	61.4	52	72.4
2002			45	42.1	525	60.8	29	71.1
2003			55	43.5	314	62.3	63	72.4
2004	2	15.5	41	43.4	515	59.8	3	69.3
2005			35	43.2	441	60.9	11	71.0
2006			28	41.5	413	58.9	49	70.9
2007	2	14.5	32	43.2	363	60.6	52	69.8
2008			38	45.8	394	61.0	16	70.8
2009			39	45.8	422	62.4	12	70.4
2010			40	43.9	427	62.7	2	72.0
2011			44	47.0	389	61.6	13	75.8
2012			27	43.6	315	60.4	6	67.2
Mean				43.1		60.8		70.8

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 age, 2000-present.

Return	Age 2		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2000	66	15.9	633	38.3				
2001	893	15.2	474	40.0	2343	59.3		
2002	475	15.2	26	38.7	1535	59.2	34	67.0
2003	137	15.7	394	41.8	255	60.6	215	71.4
2004	83	15.5	49	40.4	451	59.5	2	71.0
2005	137	15.6	98	40.4	218	59.3	18	70.1
2006	26	14.5	26	40.4	407	57.6	2	70.5
2007	54	15.5	175	41.4	231	59.4	19	70.4
2008	11	15.4	95	45.0	251	60.3	1	67.0
2009	12	15.1	255	43.6	290	62.1	11	67.5
2010	22	15.9	107	42.7	557	61.5	3	67.0
2011	2	15.0	157	43.0	411	61.3	21	73.4
2012	2	15.5	46	40.7	381	59.7	9	68.0
Mean		15.4		41.3		60.0		69.4

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).

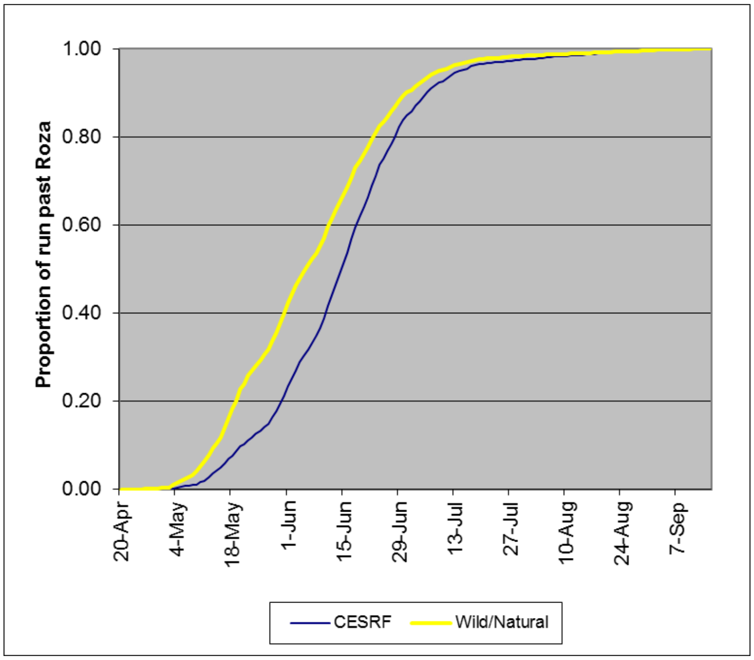


Figure 3. Proportionate passage timing at Roza Dam of wild/natural and CESRF adult spring Chinook (including jacks), 2003-2012.

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

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
Mean	14-Aug	11-Sep	24-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
Mean	1,087	131	27	1,245	164	178	116	49	507

[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 December 2012 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%	4,388			3,052		
2006	459	3	0.65%	9,119			5,802		
2007[2]	238	1	0.42%	6,536	5	0.08%	5,174	1	0.02%
2008[3]	213			6,933			4,589		
2009[4]	21								

[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	788,604	3.8%	725,095	98.2%			
Mean	501	54	89.3%	136	220	5.7%	786,527	735,868	6.7%	704,412	98.2%	667,940	95.1%	93.4%

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 BY2011 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%	94,332	98.8%			
Mean	150	14	90.5%	30	49	0.9%	183,722	92,248	6.0%	93,563	98.4%	88,722	96.0%	94.4%

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.

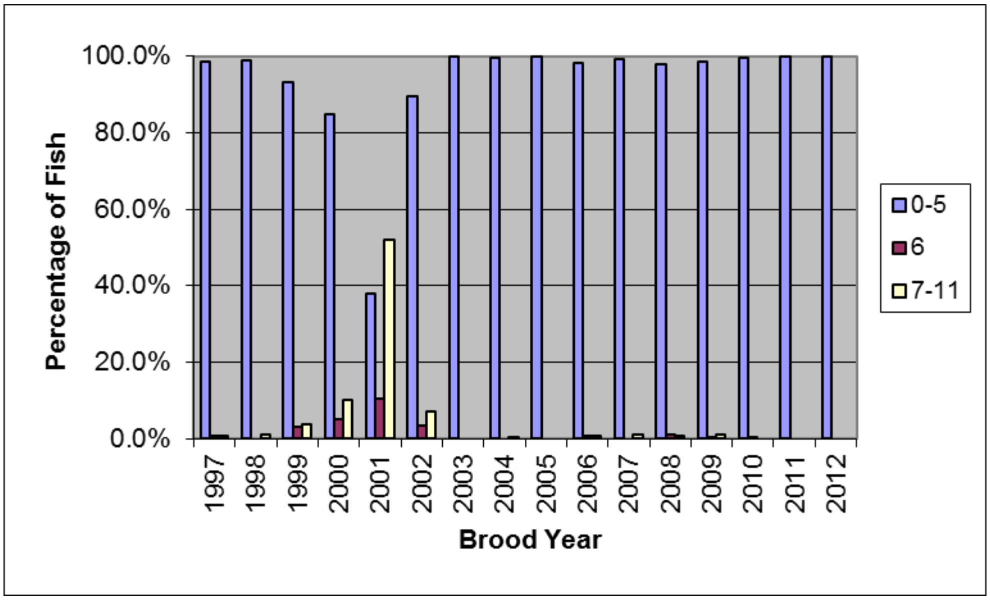


Figure 4. Proportion of wild/natural females spawned at CESRF by BKD rank, 1997 – present.

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			177	3,917.1	5	4,982.8			41	3,537.4	1	3,900.5
Mean				3,859.8		4,708.7				3,745.9		4,384.0

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	
Mean	0.9	0.9	1.1	1.0	1.2	1.1	2.0	1.2	1.6	0.2	1.1	1.1	0.6

Length and Weight Growth Profiles

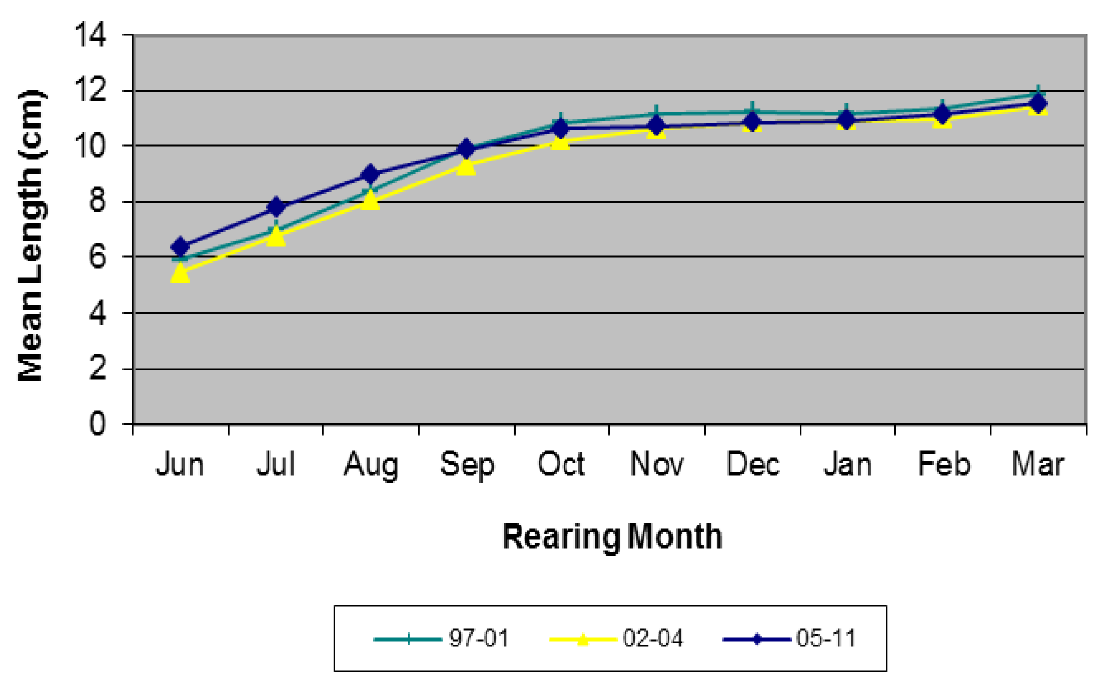


Figure 5. Mean length (cm) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.

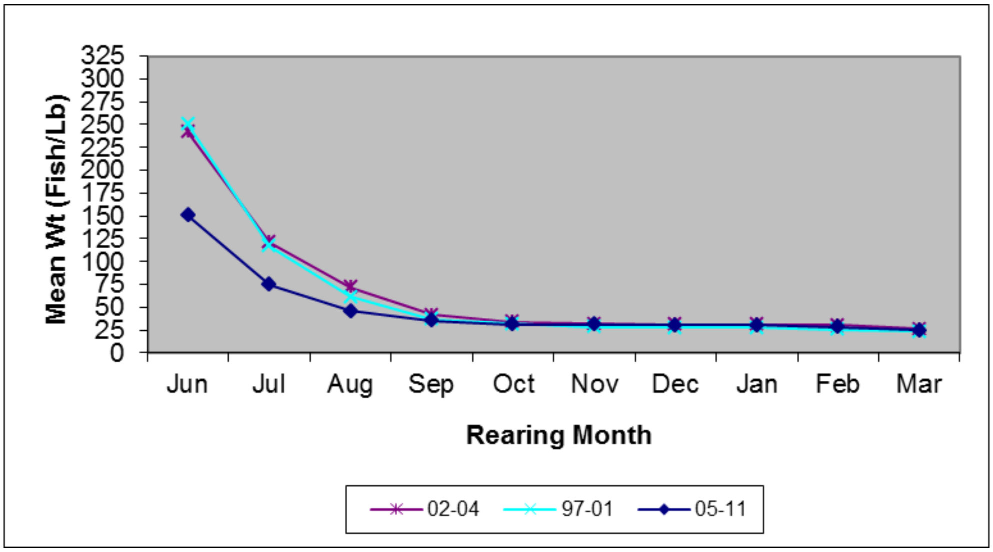


Figure 6. Mean Weight (fish/lb) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.

Juvenile Fish Health Profile

Approximately 30-60 fish from each acclimation site pond are sacrificed for juvenile fish health samples in the spring (usually in March) of their release year. Tissue samples from these fish are 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 for additional discussion). Fish are 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 are 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).

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

	Brood Year[1]												
Raceway	1997	1998	2000	2001[2]	2002	2003	2006	2007	2008	2009	2010	2011	Mean
CFJ01	0.80	0.53	2.17	1.90	0.28	0.28	2.10	1.57	1.93	1.77	1.20	1.57	1.34
CFJ02	1.08	1.88	1.33	1.10	0.18	0.25	1.87	1.50	1.73	2.53	0.40	1.17	1.25
CFJ03	2.38	0.82	1.50		0.22	0.28	1.79	1.70	1.97	2.13	0.97	1.50	1.39
CFJ04	1.15	0.58	1.18		0.16	0.14	1.96	1.87	2.57	2.27	1.60	1.20	1.33
CFJ05	0.85	0.78	1.20		0.06	0.75	2.34	1.50	2.10	2.10	1.53	1.47	1.34
CFJ06	1.05	0.70	1.02		0.21	0.02	1.71	1.73	1.97	3.27	1.53	1.77	1.36
ESJ01	2.03	0.50	1.97	1.19	0.10	0.55	1.73	1.10	1.47	2.63	1.63	0.37	1.27
ESJ02	1.68	0.53	1.17	1.50	0.05	0.43	1.63	0.97	0.97	2.83	1.90	1.03	1.22
ESJ03	2.23	1.37	2.47	0.86	0.07	0.33	1.97	1.13	1.57	2.47	1.40	0.13	1.33
ESJ04	1.33	0.55	1.35	0.79	0.15	0.60	1.41	1.87	1.47	1.60	1.53	0.87	1.13
ESJ05		1.15	3.12	0.73	0.04	0.68	2.07	1.30	1.63	2.30	2.27	1.03	1.48
ESJ06		0.67	1.30	0.80	0.05	0.23	2.05	1.40	1.93	3.10	2.13	0.97	1.33
JCJ01		0.67	1.93	1.47	0.04	0.10	1.43	2.03	1.90	2.83	1.80	0.93	1.38
JCJ02		0.48	1.30	1.52	0.19	0.08	2.00	1.73	2.37	2.90	2.20	1.17	1.45
JCJ03		0.33	1.45	1.62	0.06	0.20	1.66	1.87	2.03	2.53	1.90	0.33	1.27
JCJ04		0.62	1.50	1.56	0.05	0.13	1.40	1.67	2.10	2.53	1.97	0.93	1.31
JCJ05			1.55	1.67	0.00	1.35	1.83	1.77	2.17	2.30	2.20	0.57	1.54
JCJ06			1.25	1.46	0.03	0.10	1.31	1.97	1.93	3.13	1.77	0.97	1.39
Clark Flat	1.22	0.88	1.40	1.50	0.18	0.29	1.96	1.64	2.04	2.34	1.21	1.44	1.34
Easton	1.81	0.80	1.89	0.98	0.08	0.47	1.81	1.29	1.51	2.49	1.81	0.73	1.31
Jack Creek		0.53	1.50	1.55	0.06	0.33	1.61	1.84	2.08	2.71	1.97	0.82	1.36
All Ponds	1.46	0.76	1.60	1.30	0.11	0.36	1.79	1.59	1.88	2.51	1.66	1.00	1.33

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
Mean	365,718	361,372	259,393	256,255	263,849	727,090

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

Brood	Treatment		Acclimation Site		
Year	Control[1]	Treatment[2]	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
Mean	43,507	42,891	43,043	43,642	43,287

1. Brood years 1997-2001: Optimum Conventional Treatment (OCT). Brood Years 2002-2004: Normal (High) growth. Brood Years 2005-2008: 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, 2007-2008: 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.

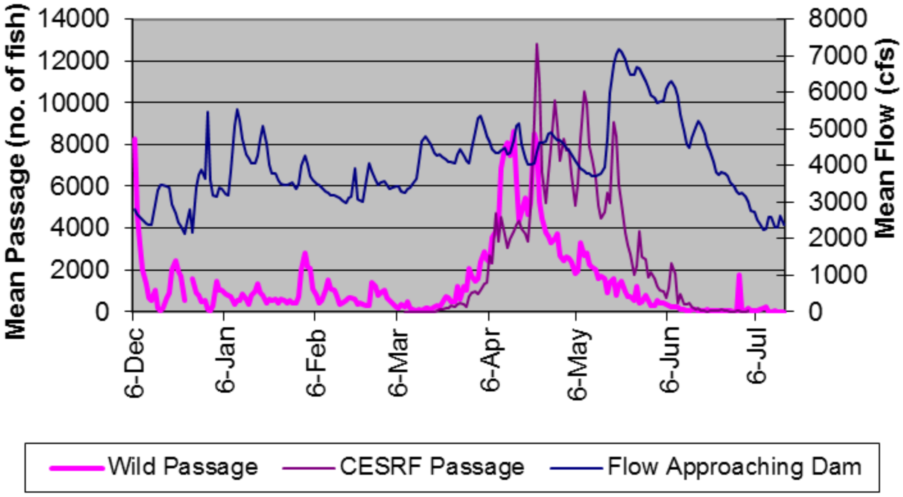


Figure 7. Mean flow approaching Prosser Dam versus mean estimated smolt passage at Prosser of aggregate wild/natural and CESRF spring Chinook for outmigration years 1999-2012.

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- 2012)

Prior to releases in 2007, 2009- 2012, 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 and 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. Analysis of juvenile migrant PIT detections at Roza Dam indicate that approximately 85% of natural-origin spring Chinook migrated in the fall or winter as juveniles (before any CESRF fish would have the opportunity). Comparison of SAR data for non-contemporaneously migrating juveniles may be invalid.

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%	8,240	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	129,695	283,376	33.9%	3,743	2,300	2.9%	0.8%
2003	2005	1285	144,873	212,771	25.8%	2,746	932	1.9%	0.4%
2004	2006	5652	157,699	272,629	34.7%	2,802	4,022	1.8%	1.5%
2005	2007	4551	145,203	362,663	42.2%	4,201	4,378	2.9%	1.2%
2006	2008	4298	115,602	247,476	38.5%	6,099	9,114	5.3%	3.7%
2007	2009	5784	240,606	395,890	51.3%	8,030	6,558	3.3%	1.7%
2008	2010	3592	167,883	407,412	48.0%	6,380[6]	6,911[6]	3.8%[6]	1.7%[6]
2009	2011	9414	355,214	387,817	46.6%				
2010	2012	8556	215,225	396,596	49.9%				

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. Preliminary; data do not include age-5 adult returns.

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[1]	6	47	2	55	1.45%
2008	105	0	1			
2009	2,087	0				
2010	2,640					

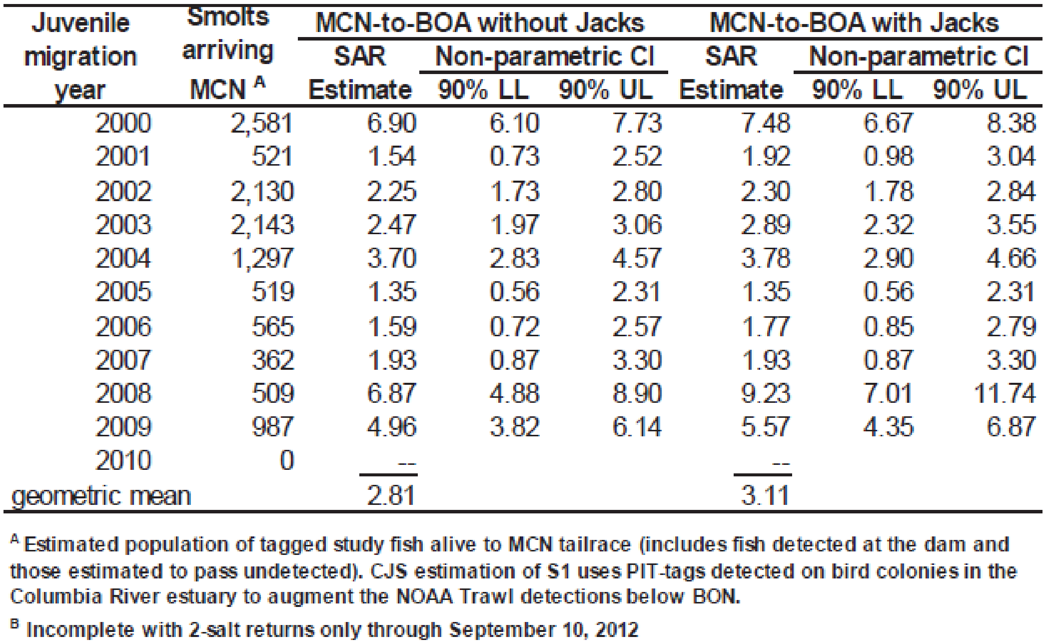
1. Includes 1752 fish tagged and released in late August and early Sept.

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			
2009	3,641	2				
2010	3,831					

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 PIT tagged fish (Table 4.23 in Tuomikoski et al. 2012). McNary smolts to Bonneville Dam adult returns.

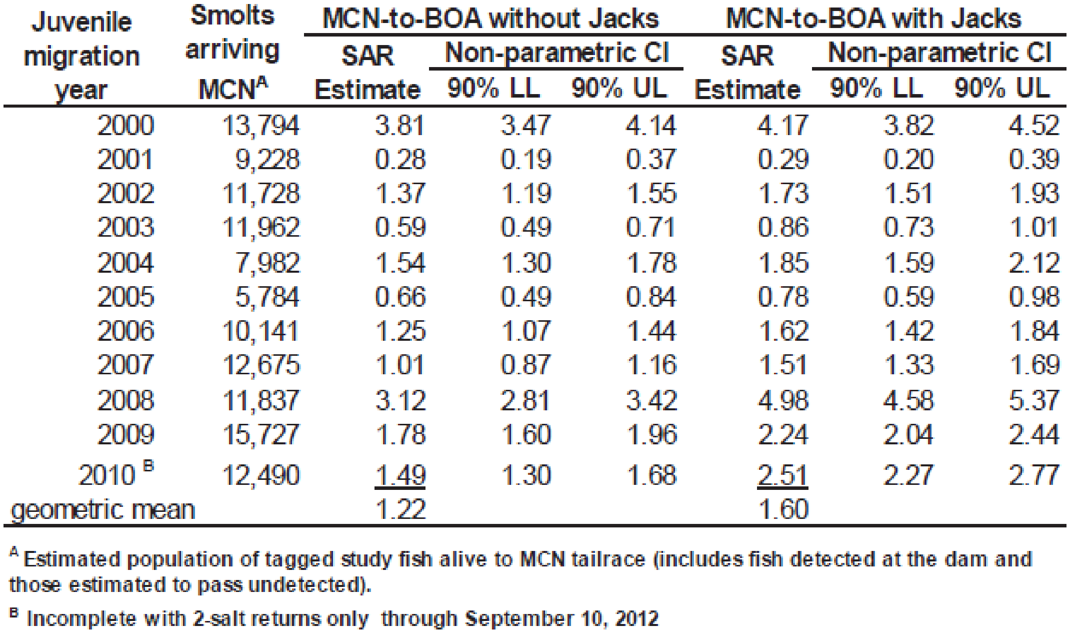


Juvenile migration year	Smolts arriving MCN [A]	MCN-to-BOA without Jacks			MCN-to-BOA with Jacks		
		SAR Estimate	Non-parametric CI 90% LL	Non-parametric CI 90% UL	SAR Estimate	Non-parametric CI 90% LL	Non-parametric CI 90% UL
2000	2,581	6.90	6.10	7.73	7.48	6.67	8.38
2001	521	1.54	0.73	2.52	1.92	0.98	3.04
2002	2,130	2.25	1.73	2.80	2.30	1.78	2.84
2003	2,143	2.47	1.97	3.06	2.89	2.32	3.55
2004	1,297	3.70	2.83	4.57	3.78	2.90	4.66
2005	519	1.35	0.56	2.31	1.35	0.56	2.31
2006	565	1.59	0.72	2.57	1.77	0.85	2.79
2007	362	1.93	0.87	3.30	1.93	0.87	3.30
2008	509	6.87	4.88	8.90	9.23	7.01	11.74
2009	987	4.96	3.82	6.14	5.57	4.35	6.87
2010	0	--			--		
geometric mean		2.81			3.11		

[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 to augment the NOAA Trawl detections below BON.

[B] Incomplete with 2-salt returns only through September 10, 2012

Table 44. Overall CESRF smolt-to-adult return rates (SAR) based on juvenile and adult detections of PIT tagged fish (Table 4.25 in Tuomikoski et al. 2012). 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 Estimate	Non-parametric CI 90% LL	Non-parametric CI 90% UL	SAR Estimate	Non-parametric CI 90% LL	Non-parametric CI 90% UL
2000	13,794	3.81	3.47	4.14	4.17	3.82	4.52
2001	9,228	0.28	0.19	0.37	0.29	0.20	0.39
2002	11,728	1.37	1.19	1.55	1.73	1.51	1.93
2003	11,962	0.59	0.49	0.71	0.86	0.73	1.01
2004	7,982	1.54	1.30	1.78	1.85	1.59	2.12
2005	5,784	0.66	0.49	0.84	0.78	0.59	0.98
2006	10,141	1.25	1.07	1.44	1.62	1.42	1.84
2007	12,675	1.01	0.87	1.16	1.51	1.33	1.69
2008	11,837	3.12	2.81	3.42	4.98	4.58	5.37
2009	15,727	1.78	1.60	1.96	2.24	2.04	2.44
2010 [B]	12,490	1.49	1.30	1.68	2.51	2.27	2.77
geometric mean		1.22			1.60		

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

[B] Incomplete with 2-salt returns only through September 10, 2012

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

Brood	Number	Adult Detections at Bonn. Dam					Adult Detections at Roza Dam				
Year	Tagged[1]	Age3	Age4	Age5	Total	SAR	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	262	11	459	1.19%
2007	38,618	73	279	3	355	0.92%	53	182	3	238	0.62%
2008	39,013	135	192				81	132			
2009	36,239	32					21				

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	Number	Adult Detections at Roza Dam				
Year	Tagged[1]	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	34	6,348	0.77%
2006	604,200	2,384	6,417	287	9,087	1.50%
2007	732,647	1,024	5,645	87	6,757	0.92%
2008	810,292	1,552	3,680			
2009	796,702	391				

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			Harvest
Year	CESRF	Wild	CESRF	Wild	CESRF	Wild	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%
Mean	610	620	576	102	1,186	663	1,123	13.3%

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.

Year	Columbia R. Mouth Run Size	Col. R. Mouth to BON Harvest	BON to McNary Harvest	Yakima R. Mouth Run Size	Yakima River Harvest	Columbia Basin Harvest Summary			Col. Basin Harvest Rate	
						Total	Wild	CESRF	Total	Wild
1983	2,470	119	99	1,441	84	302	302		12.2%	
1984	3,890	135	258	2,658	289	682	682		17.5%	
1985	5,274	192	179	4,560	865	1,236	1,236		23.4%	
1986	13,480	279	781	9,439	1,340	2,400	2,400		17.8%	
1987	6,165	96	372	4,443	517	986	986		16.0%	
1988	5,610	359	371	4,246	444	1,174	1,174		20.9%	
1989	8,936	213	668	4,914	747	1,628	1,628		18.2%	
1990	6,967	353	457	4,372	663	1,472	1,472		21.1%	
1991	4,611	183	277	2,906	32	492	492		10.7%	
1992	6,226	103	375	4,599	345	823	823		13.2%	
1993	5,135	44	312	3,919	129	485	485		9.4%	
1994	2,228	86	107	1,302	25	219	219		9.8%	
1995	1,375	1	68	666	79	148	148		10.8%	
1996	5,790	6	303	3,179	475	784	784		13.5%	
1997	5,235	3	350	3,173	575	928	928		17.7%	
1998	2,825	3	142	1,903	188	332	332		11.8%	
1999	3,944	4	182	2,781	604	790	790		20.0%	
2000	29,115	59	1,770	19,100	2,458	4,287	4,163	124	14.7%	
2001	31,220	1,002	4,078	23,265	4,630	9,710	5,595	4,116	31.1%	29.8%
2002	23,954	1,269	2,553	15,099	3,108	6,930	2,606	4,324	28.9%	24.9%
2003	9,759	296	766	6,957	440	1,502	914	589	15.4%	14.6%
2004	22,026	1,011	1,904	15,289	1,679	4,594	2,568	2,026	20.9%	16.3%
2005	11,888	335	740	8,758	474	1,549	1,222	328	13.0%	12.2%
2006	11,588	304	762	6,314	600	1,665	948	717	14.4%	12.8%
2007	5,055	178	348	4,303	279	805	391	414	15.9%	13.9%
2008	11,492	1,149	1,570	8,598	1,532	4,251	1,199	3,053	37.0%	26.8%
2009	12,980	1,139	1,116	12,120	2,353	4,607	1,261	3,346	35.5%	26.1%
2010	17,686	1,518	2,620	13,142	1,741	5,878	1,348	4,531	33.2%	22.1%
2011	22,354	975	1,643	17,960	4,380	6,998	2,401	4,597	31.3%	22.4%
2012[1]	15,931	757	1,478	12,053	3,320	5,554	2,220	3,334	34.9%	28.2%
Mean	10,292	395	868	7,267	1,123	2,386	1,370	2,614	19.7%	17.7%

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 47 gives the results of a query of the RMIS database run on Dec. 12, 2012 for CESRF spring Chinook CWTs released in brood years 1997-2007. 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 2008 were considered too incomplete to report at this time.

Table 49. Marine and freshwater recoveries of CWTs from brood year 1997-2007 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) 12 Dec, 2012.

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	328	4.1%	16	1211	1.3%
2007[1]	8	141	5.4%	13	1106	1.2%

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 2007 are considered preliminary or incomplete.

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Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2002-2011.

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]
2002	CLE01	JCJ06	HI	WW	2.0	Right	Green	Anal Fin	3/15/2004	5/14/2004	613400	2,222	45,007	46,875
2002	CLE02	JCJ05	LO	WW	2.0	Left	Green	Adipose Fin	3/15/2004	5/14/2004	613401	2,222	46,273	46,588
2002	CLE03	ESJ03	HI	WW	1.6	Right	Orange	Anterior Dorsal	3/15/2004	5/14/2004	613402	2,222	49,027	50,924
2002	CLE04	ESJ04	LO	WW	1.6	Left	Orange	Posterior Dorsal	3/15/2004	5/14/2004	613403	2,222	50,347	52,115
2002	CLE05	CFJ05	LO	WW	2.2	Left	Red	Adipose Fin	3/15/2004	5/14/2004	613404	2,222	45,816	46,584
2002	CLE06	CFJ06	HI	WW	2.2	Right	Red	Anal Fin	3/15/2004	5/14/2004	613405	2,222	46,468	48,496
2002	CLE07	ESJ05	LO	WW	1.9	Left	Orange	Adipose Fin	3/15/2004	5/14/2004	613406	2,222	45,047	45,491
2002	CLE08	ESJ06	HI	WW	1.9	Right	Orange	Anal Fin	3/15/2004	5/14/2004	613407	2,222	48,293	50,316
2002	CLE09	JCJ03	LO	WW	1.8	Left	Green	Anterior Dorsal	3/15/2004	5/14/2004	613408	2,222	41,622	43,512
2002	CLE10	JCJ04	HI	WW	4.9	Right	Green	Posterior Dorsal	3/15/2004	5/14/2004	613409	2,222	46,346	48,279
2002	CLE11	ESJ02	LO	WW	1.9	Left	Orange	Right Cheek	3/15/2004	5/14/2004	613410	2,222	43,619	45,594
2002	CLE12	ESJ01	HI	WW	1.9	Right	Orange	Left Cheek	3/15/2004	5/14/2004	613411	2,222	44,091	46,112
2002	CLE13	JCJ01	HI	WW	1.8	Right	Green	Right Cheek	3/15/2004	5/14/2004	613412	2,222	44,379	46,327
2002	CLE14	JCJ02	LO	WW	1.8	Left	Green	Left Cheek	3/15/2004	5/14/2004	613413	2,222	46,241	48,208
2002	CLE15	CFJ01	LO	HH	1.3	Left	Red	Snout	3/15/2004	5/14/2004	613414	2,222	42,192	44,184
2002	CLE16	CFJ02	HI	HH	1.3	Right	Red	Snout	3/15/2004	5/14/2004	613415	2,222	41,702	43,653
2002	CLE17	CFJ03	HI	WW	1.6	Right	Red	Anterior Dorsal	3/15/2004	5/14/2004	613416	2,222	37,769	39,782
2002	CLE18	CFJ04	LO	WW	1.6	Left	Red	Posterior Dorsal	3/15/2004	5/14/2004	613417	2,222	42,066	43,864

[1] HI = normal growth or LO = slowed growth for brood years 2002 – 2004. 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 2002-2011.

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]
2003	CLE01	CFJ02	HI	WW	0.2	Left	Red	Anal Fin	3/9/2005	4/27/2005	610126	2,222	43,712	45,785
2003	CLE02	CFJ01	LO	WW	0.2	Right	Red	Adipose Fin	3/9/2005	4/27/2005	610127	2,222	42,730	44,551
2003	CLE03	ESJ04	LO	WW	0.1	Right	Green	Left Cheek	3/9/2005	4/27/2005	610128	2,222	41,555	43,544
2003	CLE04	ESJ03	HI	WW	0.1	Left	Green	Right Cheek	3/9/2005	4/27/2005	610129	2,222	43,159	45,215
2003	CLE05	JCJ02	LO	WW	0.2	Right	Orange	Anal Fin	3/9/2005	4/27/2005	610130	2,222	45,401	47,443
2003	CLE06	JCJ01	HI	WW	0.2	Left	Orange	Adipose Fin	3/9/2005	4/27/2005	610131	2,222	46,079	48,095
2003	CLE07	ESJ02	LO	WW	0.3	Right	Green	Anal Fin	3/9/2005	4/27/2005	610132	2,222	43,418	45,464
2003	CLE08	ESJ01	HI	WW	0.3	Left	Green	Adipose Fin	3/9/2005	4/27/2005	610133	2,222	43,261	45,310
2003	CLE09	ESJ06	LO	WW	0.2	Right	Green	Posterior Dorsal	3/9/2005	4/27/2005	610134	2,222	43,410	45,402
2003	CLE10	ESJ05	HI	WW	0.2	Left	Green	Anterior Dorsal	3/9/2005	4/27/2005	610135	2,222	44,255	42,776
2003	CLE11	CFJ04	LO	HH	0.1	Right	Red	Snout	3/9/2005	4/27/2005	610136	2,222	41,017	43,021
2003	CLE12	CFJ03	HI	HH	0.1	Left	Red	Snout	3/9/2005	4/27/2005	610137	2,222	43,680	45,712
2003	CLE13	JCJ04	LO	WW	0.2	Right	Orange	Left Cheek	3/9/2005	4/27/2005	610138	2,222	44,569	46,413
2003	CLE14	JCJ03	HI	WW	0.2	Left	Orange	Right Cheek	3/9/2005	4/27/2005	610139	2,222	45,218	47,079
2003	CLE15	CFJ06	LO	WW	0.1	Right	Red	Posterior Dorsal	3/9/2005	4/27/2005	610140	2,222	45,697	47,468
2003	CLE16	CFJ05	HI	WW	0.1	Left	Red	Anterior Dorsal	3/9/2005	4/27/2005	610141	2,222	44,815	46,840
2003	CLE17	JCJ06	LO	WW	0.1	Right	Orange	Posterior Dorsal	3/9/2005	4/27/2005	610142	2,222	45,375	47,211
2003	CLE18	JCJ05	HI	WW	0.1	Left	Orange	Anterior Dorsal	3/9/2005	4/27/2005	610143	2,222	45,420	47,363

[1] HI = normal growth or LO = slowed growth for brood years 2002 – 2004. 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 2002-2011.

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]
2004	CLE01	CFJ03	HI	WW	0.3	Right	Red	Snout	3/15/2006	5/15/2006	610156	2,222	44,771	46,906
2004	CLE02	CFJ04	LO	WW	0.3	Left	Red	Snout	3/15/2006	5/15/2006	610157	2,222	43,957	46,030
2004	CLE03	ESJ03	HI	WW	0.4	Right	Orange	Snout	3/15/2006	5/15/2006	610158	2,222	43,991	46,083
2004	CLE04	ESJ04	LO	WW	0.4	Left	Orange	Snout	3/15/2006	5/15/2006	610159	2,222	43,045	45,155
2004	CLE05	JCJ03	HI	WW	0.3	Right	Green	Snout	3/15/2006	4/28/2006	610160	2,222	45,803	2,248[3]
2004	CLE06	JCJ04	LO	WW	0.3	Left	Green	Snout	3/15/2006	4/28/2006	610161	2,222	43,843	45,920
2004	CLE07	ESJ05	HI	WW	0.3	Right	Orange	Snout	3/15/2006	5/15/2006	610162	2,222	43,913	46,035
2004	CLE08	ESJ06	LO	WW	0.3	Left	Orange	Snout	3/15/2006	5/15/2006	610163	2,222	42,560	44,668
2004	CLE09	JCJ05	LO	WW	0.4	Left	Green	Snout	3/15/2006	4/28/2006	610164	2,222	42,416	44,485
2004	CLE10	JCJ06	HI	WW	0.4	Right	Green	Snout	3/15/2006	4/28/2006	610165	2,222	43,842	45,942
2004	CLE11	JCJ01	HI	WW	0.3	Right	Green	Snout	3/15/2006	4/28/2006	610166	2,222	45,892	47,993
2004	CLE12	JCJ02	LO	WW	0.3	Left	Green	Snout	3/15/2006	4/28/2006	610167	2,222	42,749	44,822
2004	CLE13	ESJ01	HI	WW	0.3	Right	Orange	Snout	3/15/2006	5/15/2006	610168	2,222	44,887	46,981
2004	CLE14	ESJ02	LO	WW	0.3	Left	Orange	Snout	3/15/2006	5/15/2006	610169	2,222	42,451	44,518
2004	CLE15	CFJ01	HI	HH	0.3	Right	Red	Posterior Dorsal	3/15/2006	5/15/2006	610170	2,222	45,790	47,920
2004	CLE16	CFJ02	LO	HH	0.3	Left	Red	Posterior Dorsal	3/15/2006	5/15/2006	610171	2,222	44,364	46,419
2004	CLE17	CFJ05	HI	WW	0.4	Right	Red	Snout	3/15/2006	5/15/2006	610172	2,222	46,512	48,632
2004	CLE18	CFJ06	LO	WW	0.4	Left	Red	Snout	3/15/2006	5/15/2006	610173	2,222	42,578	44,691

[1] HI = normal growth or LO = slowed growth for brood years 2002 – 2004. 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.

[3] At the Jack Creek acclimation site raceway 3 suffered mechanical failures resulting in the loss of about 45,000 high-growth (control) fish.

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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]
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

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[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.

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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]**
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

[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 2002-2011.

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.

[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 2002-2011.

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]
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.

[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 2002-2011.

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]*
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.

[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 2002-2011.

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 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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Appendix C

Annual Report: Smolt Survival to McNary Dam of 1999-2012 PIT-tagged Spring Chinook released or detected at Roza Dam

Doug Neeley, Consultant to the Yakama Nation

Introduction

As in previous years, survivals to McNary Dam of hatchery-brood PIT-Tagged smolt released into the Roza Dam bypass are compared to survivals of natural-brood smolt PIT-tagged and released contemporaneously with hatchery smolt. These contemporaneously Roza-passing natural outmigrants are referred to as “late” natural smolt, and it is the survival to McNary of these smolt that are compared to the survival of the hatchery releases at Roza.

The survival of the late natural smolt is also compared to the McNary survival of “early” natural smolt that are tagged and released at Roza prior to hatchery-smolt passage.

All smolt releases in this study were originally collected in the Roza bypass system, PIT-tagged if not previously PIT-tagged, and then all PIT-tagged fish are released back into the bypass.

If the tagged detected smolt could not be assigned to a given release, they were omitted from the data set.

Methodology

All smolt included in the analysis were grouped into seven-day intervals. Thus all smolt tagged between Julian dates 1 and 7 were treated as one release group, those between Julian dates 8 and 14 were treated as another group, etc. The last Julian date of a grouping was always evenly divisible by seven. This was done to have a sufficiently large number of released smolt per grouping. If there still were not a sufficient number, then adjacent groups were combined into a common group. Separate McNary survival estimates were made for each group, each group serving as a “block or replicate”. Conceptual survival estimation procedures are discussed in Appendix A. Weighted logistic analyses of variation were used to analyze proportion surviving to McNary, the weights being the number of fish used to estimate the proportions. Comparisons of late-natural and hatchery smolt were treated as paired comparisons with the release-group

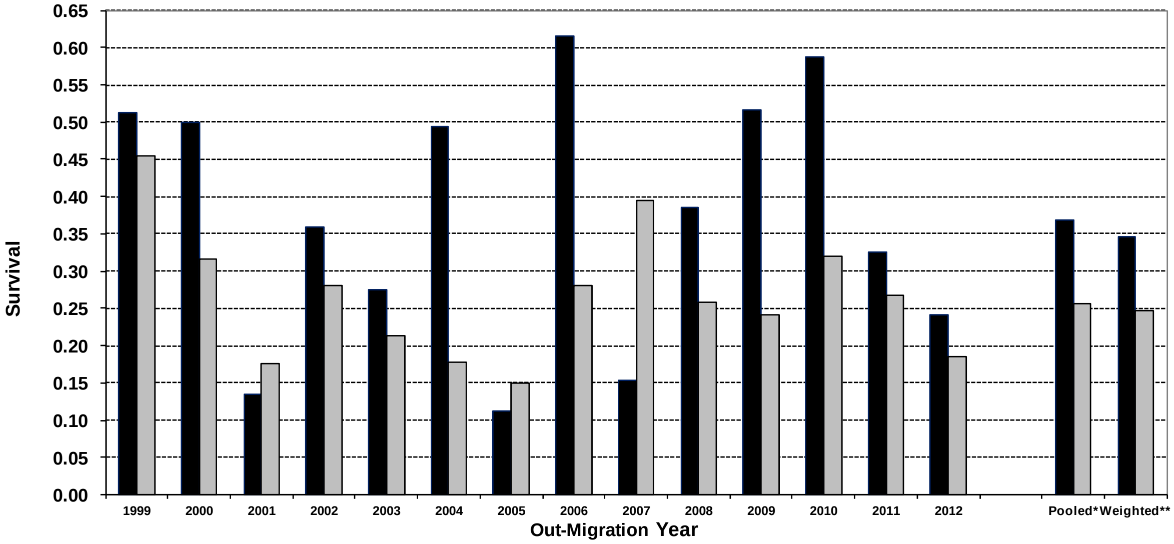
Roza Julian-Date intervals treated as blocks. Comparisons between early and late natural smolt proportions were treated as independent comparisons since they involved different groupings.

Note that plots of individual group survivals within years are given in Appendix B.1 and the means over groups are given in Appendix B.2 for the early natural, the late natural, and hatchery releases.

Comparison of Natural- and Hatchery-Origin Smolt Survival to McNary from Contemporaneous Roza Releases

As was the case in the majority of the previous Roza-release years, late naturally spawned smolt released at Roza in 2012 had a higher mean survival rate to McNary than hatchery smolt. Figure 1 presents the late-natural- and hatchery-smolt survivals to McNary from the 1999 through 2012 Roza releases.

Figure 1. Upper-Yakima Spring-Chinook Roza-to-McNary Smolt Survival for Late Natural Smolt (Dark-Colored Bars) and Hatchery Smolt (Light-Colored Bars)



Because naturally-spawned smolt will have survived the in-stream environment longer than hatchery-spawned smolt, it has always been hypothesized that, for smolt contemporaneously released at Roza, the survival to McNary of naturally-spawned-smolt would be greater than that of hatchery-spawned smolt even though the hatchery tend to be larger; therefore, one-sided tests for the hypotheses for

natural survival – hatchery survival > 0

are performed for the natural–hatchery differences in mean survivals based on the null hypotheses of no differences in survivals. Table 1 presents individual-year mean differences and statistical within-year test summaries as well estimates combined over years with their statistical associated test summaries.

As can be seen from Figure 1 and Table 1, the late natural smolt survival exceeded that of the hatchery smolt in 11 of the 14 outmigration years. Of those 11 years, 9 were significant at the 5% level (Table 1).   Note that the pooled survival and weighted survival estimates over years were significantly higher for the natural smolt [P = 0.0041 and P = 0.0099 respectively in Table 1]).

Table 1. Upper-Yakima Spring Chinook Roza-to-McNary Smolt Survival for Late Naturally Spawned and Hatchery-spawned Smolt

		Outmigration Year						
Stock	**Measure**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Natural	**Survival**	**0.5122**	**0.4987**	**0.1339**	**0.3584**	**0.2750**	**0.4935**	**0.1122**
(Nat)	Released	133	3196	1424	2114	1190	74	45
Hatchery	**Survival**	**0.4540**	**0.3155**	**0.1759**	**0.2803**	**0.2137**	**0.1768**	**0.1494**
(Hat)	Released	675	2999	1744	1503	2146	2201	1344
Difference	**Nat-Hat**	**0.0582**	**0.1832**	**-0.0420**	**0.0781**	**0.0613**	**0.3167**	**-0.0371**
		Type 1 Error P						
(1-sided)	**(Nat > Hat)**	**0.0378**	**0.0000**	0.6312	**0.0433**	**0.0374**	**0.0122**	0.7353

		Outmigration Year								
Stock	**Measure**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Pooled***	**Weighted****
Natural	**Survival**	**0.6160**	**0.1529**	**0.3857**	**0.5161**	**0.5874**	**0.3260**	**0.2419**	**0.3692**	**0.3469**
(Nat)	Released	500	336	421	172	105	956	193	10859	
Hatchery	**Survival**	**0.2810**	**0.3955**	**0.2573**	**0.2405**	**0.3196**	**0.2679**	**0.1849**	**0.2562**	**0.2461**
(Hat)	Released	3802	2477	4406	2334	1130	3103	4405	34269	
Difference	**Nat-Hat**	**0.3350**	**-0.2426**	**0.1284**	**0.2756**	**0.2678**	**0.0581**	**0.0570**	**0.1131**	**0.1009**
		Type 1 Error P								
(1-sided)	**(Nat > Hat)**	**0.0003**	0.5088	**0.0048**	**0.0182**	**0.0108**	0.0559	0.1598	**0.0041**	**0.0099**

*** Pooled using yearly release number as a weighting variable of survival proportions**

**** Pooled using yearly (release-number/error-mean deviance) as a weighting variable of survival proportions**

The analyses on which individual-year significance levels in Table 1 are based are presented in Appendix C.1, and the analyses on which the combined-survival-over-years significance levels (pooled and weighted[1]) were based are presented in Appendix C.2.

Comparison of Early and Late Natural-Origin Smolt Survival to McNary

Beginning in outmigration-year 2000, Roza trapping operations began early enough to permit survival to McNary passage comparisons between early and late arriving natural smolt. In 1999 and 2010, no naturally spawned smolt were tagged at Roza prior to Roza passage of hatchery smolt. Figure 2 presents the naturally-spawned early- and late-smolt survivals from Roza to

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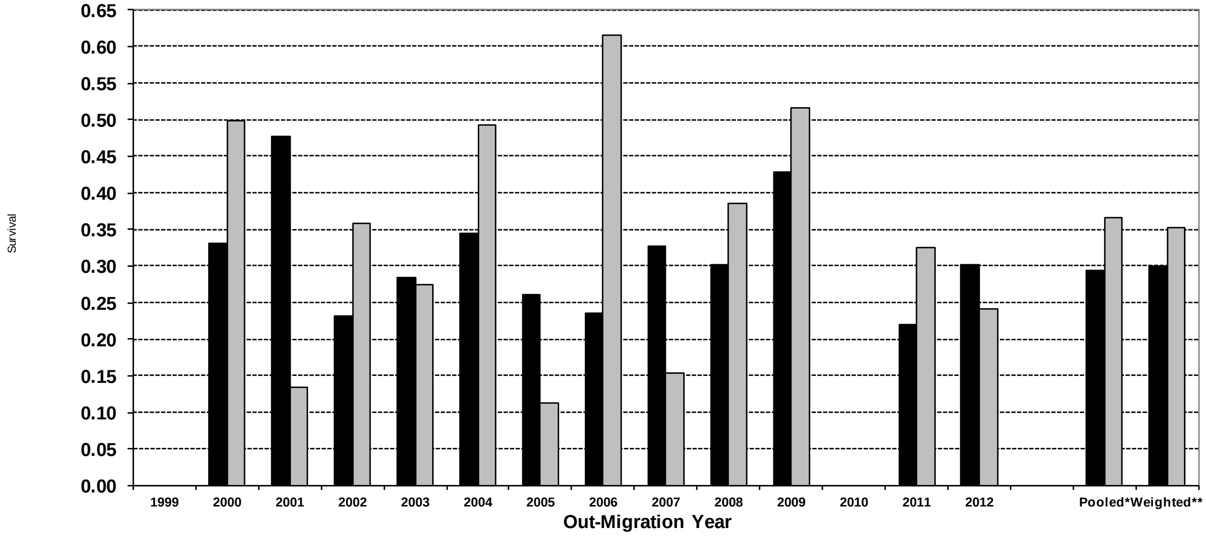
[1] For the "pooled" logistic analysis of variation, the release survivals are effectively weighted by the number of smolt. Such an analysis assumes that there is a constant variance in survivals within each year (homogenous variability). However this is not the case; therefore the for "weighted" logistic analysis of variance , the survivals are weighted by the inverse of the of the variance of the survival, this variance being estimated by the mean deviance divided by the number of smolt released.

McNary for the 2000 through 2009, 2011, and 2012 releases. Table 2 presents the associated survival estimates.

Of the twelve years of early releases, only seven had the highest Roza-to-McNary survival associated with the late releases, and three of the four significant releases were associated with the late releases, and the other was associated with the early release. Because of the great variation in treatment differences over years, the combined analyses indicated that the late release and early release differences were not significant (pooled P = 0.1635 and weighted P = 0.3901 in Table 2).

The analyses on which individual-year significance levels in Table 1 were based are presented in Appendix D.1 and on which the combined-survival-over-years significance levels (pooled and weighted[2]) were based are presented in Appendix D.2.

Figure 2. Upper-Yakima Spring-Chinook Roza-to-McNary Smolt Survival Indices for Early (Dark Bars) and Late (Light-Colored Bars) Natural Smolt



* Pooled using yearly release number as a weighting variable of survival proportions

** Pooled using yearly (release-number/error-mean deviance) as a weighting variable of survival proportions

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[2] For the "pooled" logistic analysis of variation, the release survivals are effectively weighted by the number of smolt. Such an analysis assumes that there is a constant variance in survivals within each year (homogenous variability). However this is not the case; therefore for "weighted" logistic analysis of variation, the survivals are weighted by the inverse of the variance of the survival, this variance being estimated by the mean deviance divided by the number of smolt released.

Table 2. Upper-Yakima Spring-Chinook Roza-to-McNary Smolt Survival Indices for Early and Late Natural Smolt

Natural		Outmigration Year						
Stock	**Measure**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Natural	**Survival**	**no**	**0.3307**	**0.4771**	**0.2314**	**0.2837**	**0.3442**	**0.2608**
Early	Released	**release**	3013	755	6604	6614	3857	1688
Natural	**Survival**	**Table 1**	**0.4987**	**0.1339**	**0.3584**	**0.2750**	**0.4935**	**0.1122**
Late	Released		3196	1424	2114	1190	74	45
Difference	**Early-Late**		**-0.1679**	**0.3432**	**-0.1270**	**0.0087**	**-0.1493**	**0.1485**
(2-sided)	**Early-Late**		**0.0000**	**0.0001**	**0.0004**	0.8230	0.4903	0.4035

		Outmigration Year								
Stock	**Measure**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Pooled***	**Weighted****
Natural	**Survival**	**0.2361**	**0.3273**	**0.3020**	**0.4286**	**no**	**0.2200**	**0.2419**	**0.2942**	**0.3003**
Early	Released	1833	1072	1254	1804	**release**	985	193	29672	
Natural	**Survival**	**0.6160**	**0.1529**	**0.3857**	**0.5161**	**Table 1**	**0.3260**	**0.2419**	**0.3653**	**0.3525**
Late	Released	500	336	421	172		956	193	10621	
Difference	**Early-Late**	**-0.3799**	**0.1744**	**-0.0837**	**-0.0875**		**-0.1060**	**0.0000**	**-0.0711**	**-0.0522**
		Type 1 Error P								
(2-sided)	**Early-Late**	**0.0010**	0.0889	0.2458	0.7590		0.2176	0.5212	**0.1635**	**0.3901**

*** Pooled using yearly release number as a weighting variable of survival proportions**

**** Pooled using yearly (release-number/error-mean deviance) as a weighting variable of survival proportions**

Appendix A. Conceptual Computation

The smolt-to-smolt survival to McNary estimation method involves:

1. Identifying time-of-passage strata within which estimated daily McNary detection rates are reasonably homogeneous. (Daily McNary detection rate is the proportion of all[3] Yakima PIT-tagged Spring Chinook passing McNary Dam for each day of McNary detections)
2. Estimating the McNary detection rate for each stratum
3. Expanding (dividing) the given Roza group's release number of smolt detected at McNary during the stratum by the stratum's detection rate.
4. Totaling the group's release expanded McNary-detection numbers over all strata
5. Taking that release's expanded total over strata and dividing it by the appropriate group's release number at Roza

The methods of identifying strata and estimating the individual stratum detection rates at McNary are discussed in my 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.

Equation 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 2.

$$\text{Smolt-to-Smolt Survival to McNary for a given group} = \frac{\sum_{\text{strata}} \text{For Stratum}\left[\dfrac{\text{Number McNary Detections from Group}}{\text{Stratum's McNary Detection Rate (Equation 1)}}\right]}{\text{Number of Smolt in Group Released at Roza}}$$

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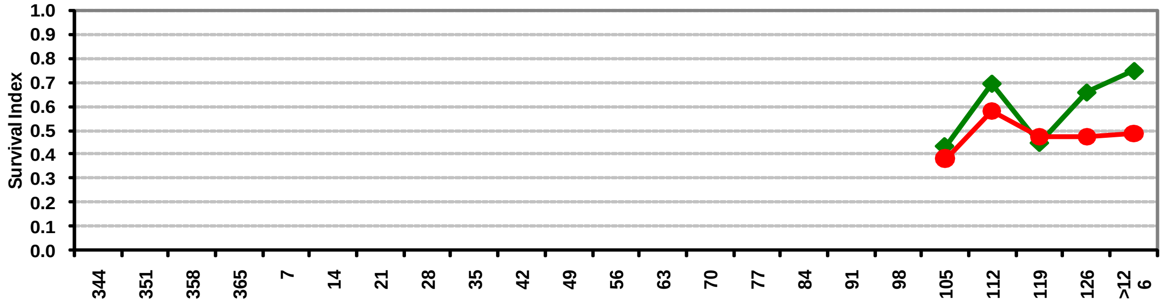
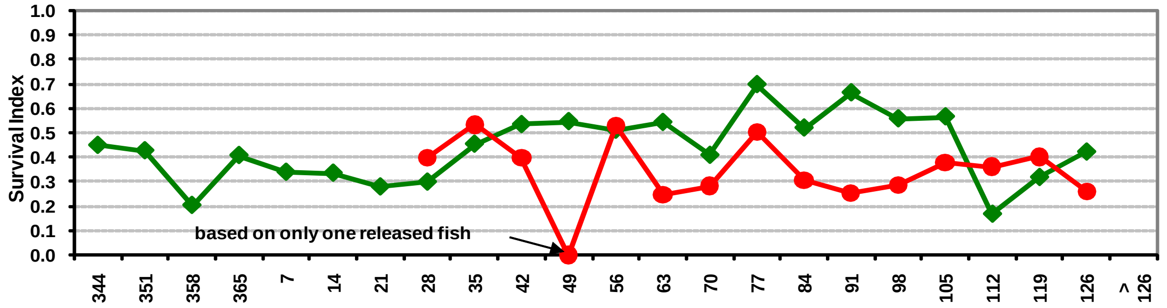
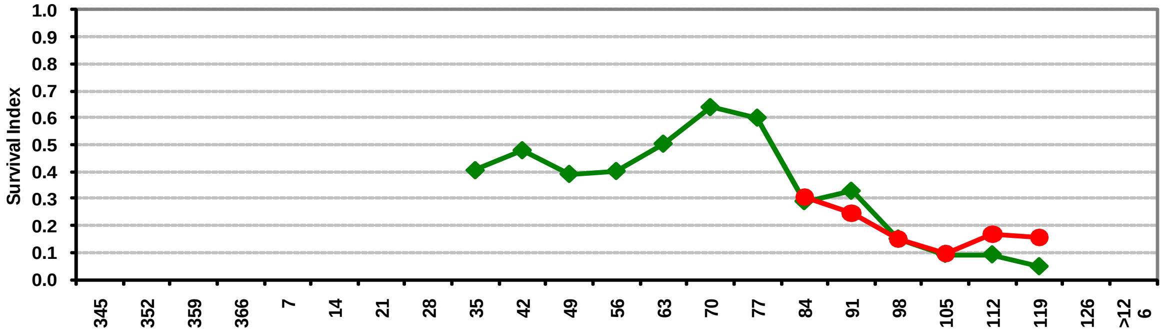
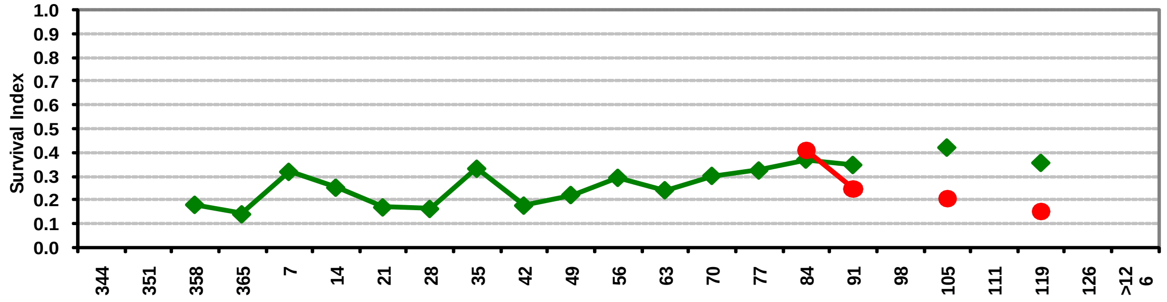
[3] All smolt PIT-tagged in the Yakima Basin, nor merely those PIT-tagged at Roza

Appendix B.1. Plotted McNary Smolt Survival of Roza-Released Upper-Yakima Natural- (diamonds) and Hatchery-Brood (circles) Spring Chinook


a) 1999 Outmigration Year (1997 Brood)


b) 2000 Outmigration Year (1998 Brood)

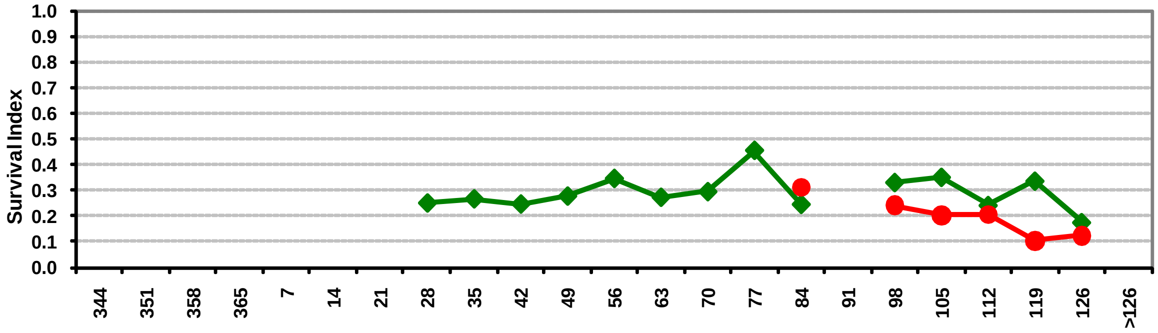

c) 2001 Outmigration Year (1999 Brood)


d) 2002 Outmigration Year (2000 Brood)

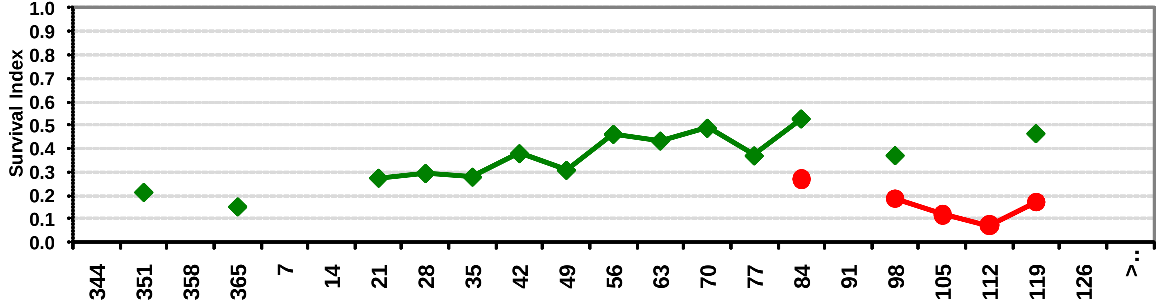
Note: The screens at the acclimation sites are generally pulled on March 15. In 2000 there was leakage that resulted in many of the hatchery smolt leaving earlier.

Appendix B.1. (continued)

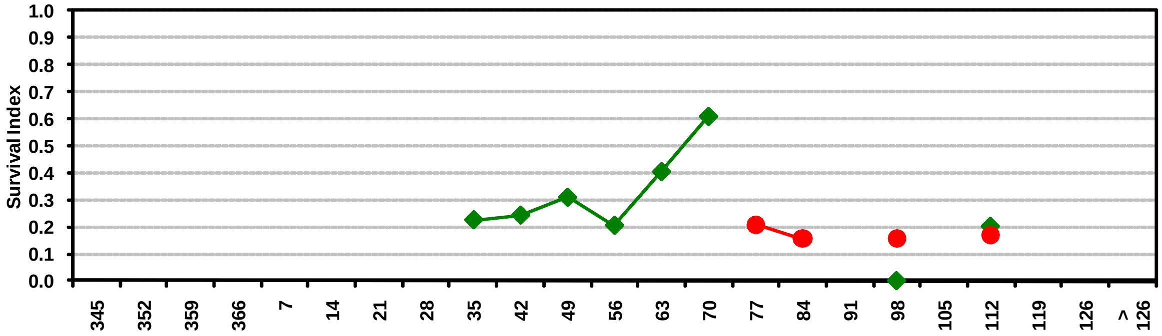
e) 2003 Outmigration Year (2001 Brood)



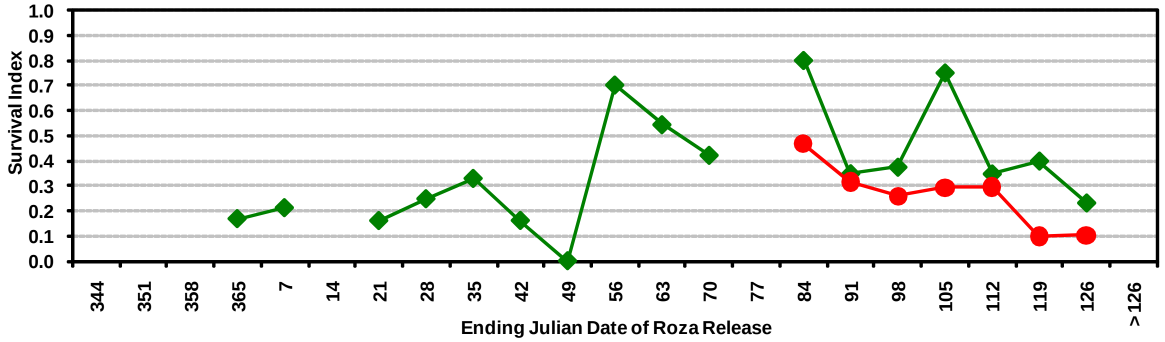
f) 2004 Outmigration Year (2002 Brood)



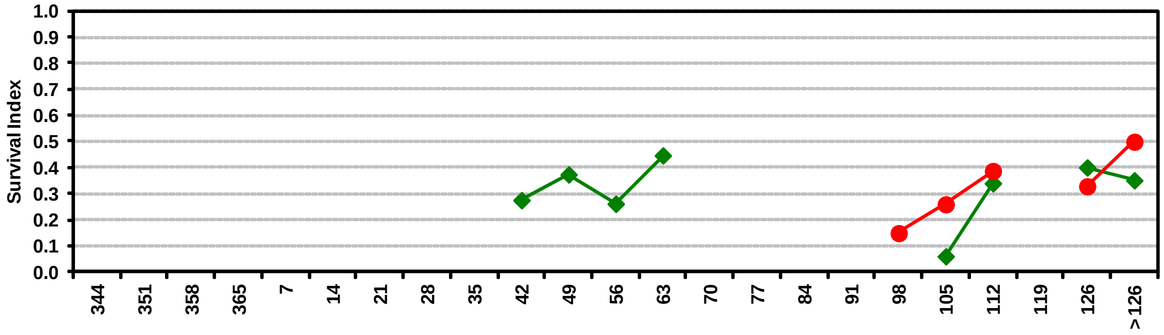
g) 2005 Outmigration Year (2003 Brood)



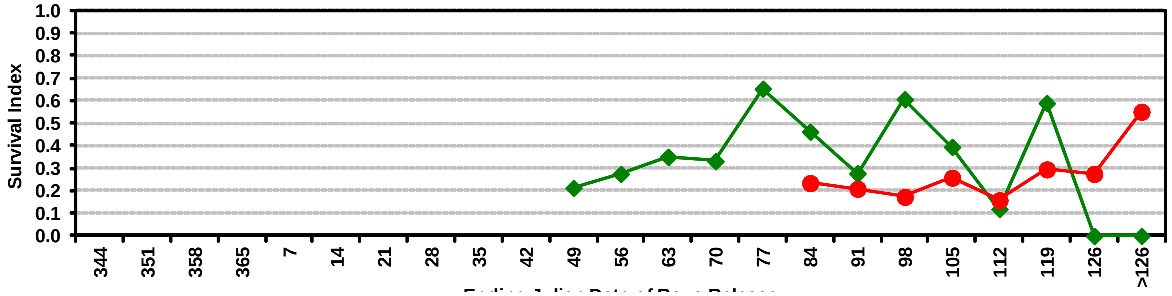
h) 2006 Outmigration Year (2004 Brood)



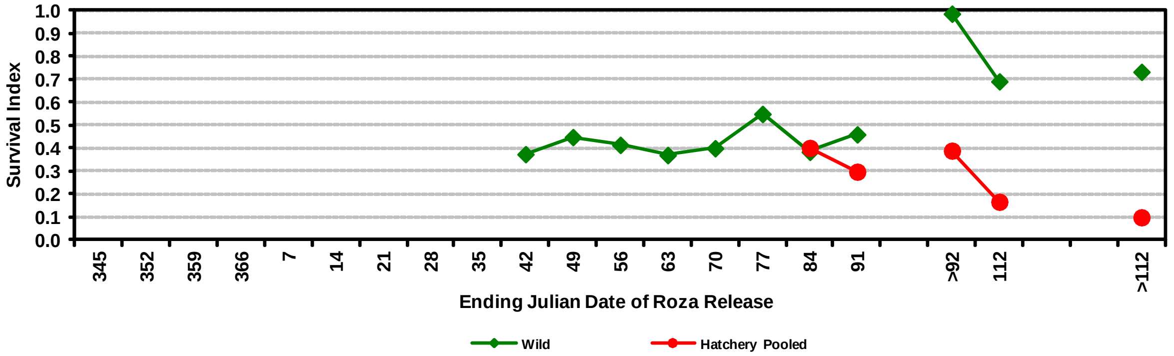
Appendix B.1. (continued)



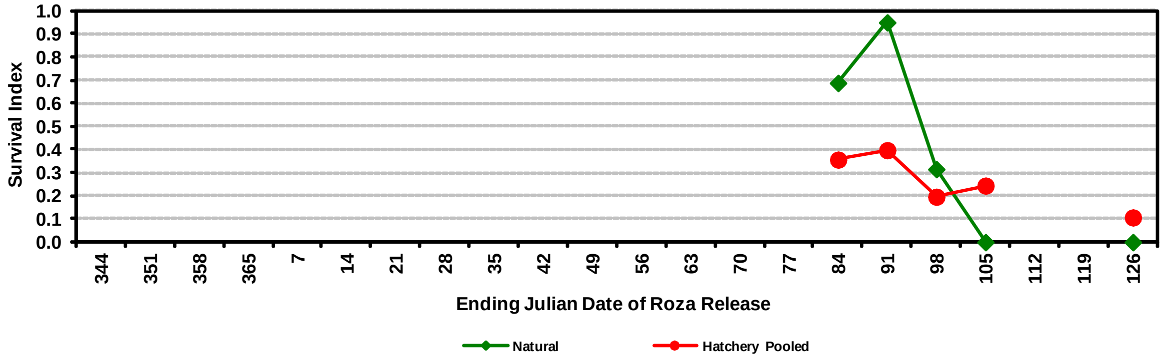
i) 2007 outmigration Year (2005 Brood)



j) 2008 Outmigration Year (2006 Brood)

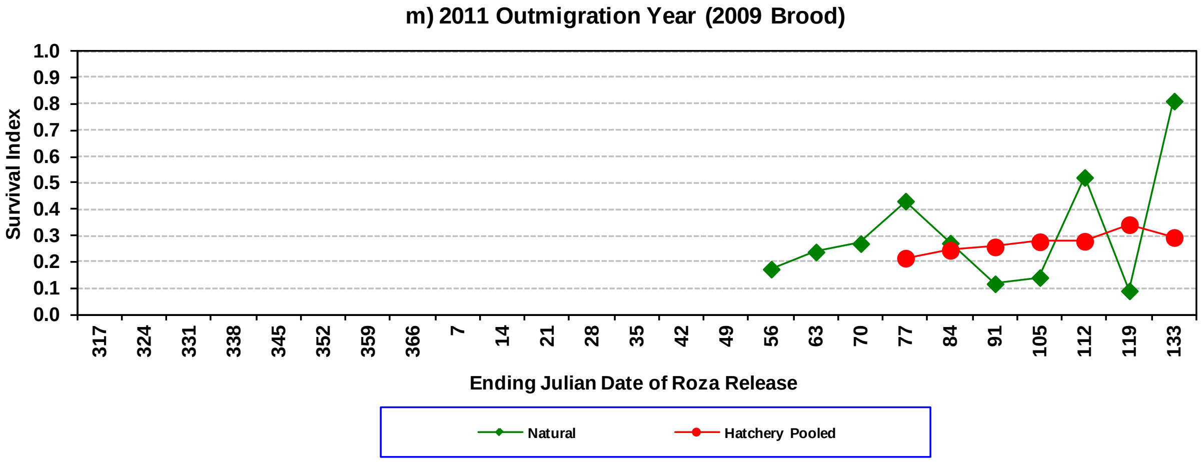


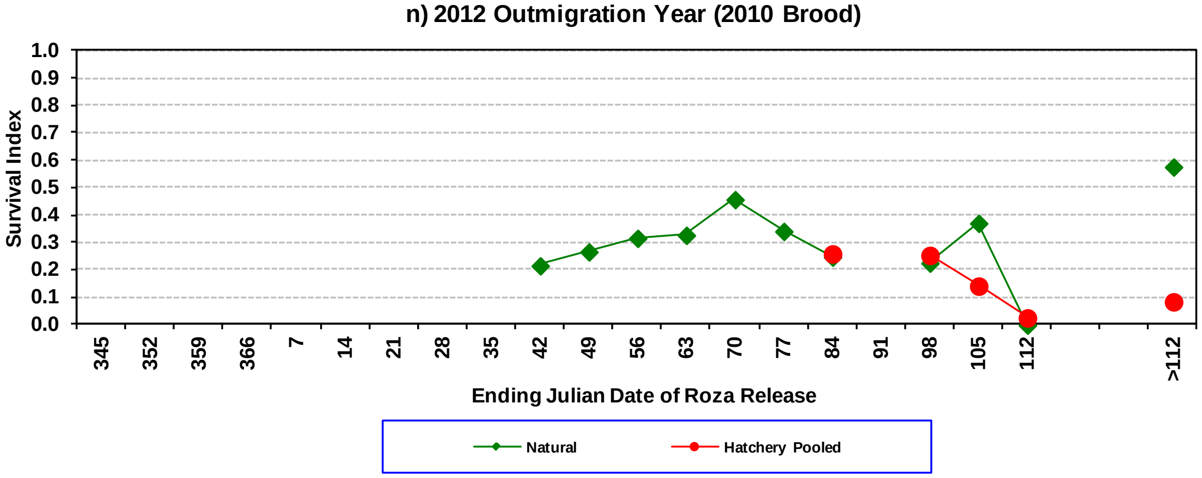
k) 2009 Outmigration Year (2007 Brood)



l) 2010 Outmigration Year (2008 Brood)

Appendix B.1. (continued)





Appendix B.2. Estimated McNary Smolt Survival of Roza-Released Upper-Yakima Natural- and Hatchery-Brood Spring Chinook

a. 1999 Outmigration Year (Brood 1997)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)			04/15/99
Ending Week (ending date of week)			
Natural Origin	Number Released		133
	Expanded McNary Passage Number		68.1
	Survival-Index Estimate		**0.5122**
Hatchery Pooled	Number Released		675
	Expanded McNary Passage Number		306.4
	Survival-Index Estimate		**0.4540**

b. 2000 Outmigration Year (Brood 1998)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		12/10/99	01/28/00
Ending Week (ending date of week)		01/27/00	
Natural Origin	Number Released	3013	3196
	Expanded McNary Passage Number	996.5	1593.8
	Survival-Index Estimate	**0.3307**	**0.4987**
Hatchery Pooled	Number Released		2999
	Expanded McNary Passage Number		946.1
	Survival-Index Estimate		**0.3155**

c. 2001 Outmigration Year (Brood 1999)

		Hatchery	Hatchery
Beginning Week (ending date of week)		02/04/01	03/25/01
Ending Week (ending date of week)		03/24/01	
Natural Origin	Number Released	755	1424
	Expanded McNary Passage Number	360.2	190.6
	Survival-Index Estimate	**0.4771**	**0.1339**
Hatchery Pooled	Number Released		1744
	Expanded McNary Passage Number		306.7
	Survival-Index Estimate		**0.1759**

d. 2002 Outmigration Year (Brood 2000)

		Hatchery	Hatchery
Beginning Week (ending date of week)		12/24/01	03/25/02
Ending Week (ending date of week)		03/24/02	
Natural Origin	Number Released	6604	2114
	Expanded McNary Passage Number	1528.3	757.6
	Survival-Index Estimate	**0.2314**	**0.3584**
Hatchery Pooled	Number Released		1503
	Expanded McNary Passage Number		421.3
	Survival-Index Estimate		0.2803

e. 2003 Outmigration Year (Brood 2001)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		01/28/03	03/25/03
Ending Week (ending date of week)		03/24/03	
Natural Origin	Number Released	6614	1190
	Expanded McNary Passage Number	1876.5	327.2
	Survival-Index Estimate	**0.2837**	**0.2750**
Hatchery Pooled	Number Released		2146
	Expanded McNary Passage Number		458.5
	Survival-Index Estimate		**0.2137**

f. 2004 Outmigration Year (Brood 2002)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		12/10/03	03/24/04
Ending Week (ending date of week)		03/17/04	
Natural Origin	Number Released	3857	74
	Expanded McNary Passage Number	1327.7	36.5
	Survival-Index Estimate	**0.3442**	**0.4935**
Hatchery Pooled	Number Released		2201
	Expanded McNary Passage Number		389.2
	Survival-Index Estimate		**0.1768**

Appendix B.2. (Continued)

g. 2005 Outmigration Year (Brood 2003)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		12/24/04	03/18/05
Ending Week (ending date of week)		03/11/05	
Natural Origin	Number Released	1688	45
	Expanded McNary Passage Number	440.2	5.1
	Survival-Index Estimate	**0.2608**	**0.1122**
Hatchery Pooled	Number Released		1344
	Expanded McNary Passage Number		200.7
	Survival-Index Estimate		**0.1494**

h. 2006 Outmigration Year (Brood 2004)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		12/31/05	03/18/06
Ending Week (ending date of week)		03/11/06	
Natural Origin	Number Released	1833	500
	Expanded McNary Passage Number	432.8	308.0
	Survival-Index Estimate	**0.2361**	**0.6160**
Hatchery Pooled	Number Released		3802
	Expanded McNary Passage Number		1068.2
	Survival-Index Estimate		**0.2810**

i. 2007 Outmigration Year (Brood 2005)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		02/11/07	04/08/07
Ending Week (ending date of week)		03/04/07	
Natural Origin	Number Released	1072	336
	Expanded McNary Passage Number	350.9	51.4
	Survival-Index Estimate	**0.3273**	**0.1529**
Hatchery Pooled	Number Released		2477
	Expanded McNary Passage Number		979.6
	Survival-Index Estimate		**0.3955**

j. 2008 Outmigration Year (Brood 2006)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		02/18/08	03/24/08
Ending Week (ending date of week)		03/17/08	
Natural Origin	Number Released	1254	421
	Expanded McNary Passage Number	378.7	162.4
	Survival-Index Estimate	**0.3020**	**0.3857**
Hatchery Pooled	Number Released		4406
	Expanded McNary Passage Number		1133.7
	Survival-Index Estimate		**0.2573**

k. 2009 Outmigration Year (Brood 2007)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		02/11/09	03/25/09
Ending Week (ending date of week)		03/18/09	
Natural Origin	Number Released	1804	172
	Expanded McNary Passage Number	773.2	88.8
	Survival-Index Estimate	**0.4286**	**0.5161**
Hatchery Pooled	Number Released		2334
	Expanded McNary Passage Number		561.3
	Survival-Index Estimate		**0.2405**

l. 2010 Outmigration Year (Brood 2008)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)			03/25/10
Ending Week (ending date of week)			
Natural Origin	Number Released		105
	Expanded McNary Passage Number		61.7
	Survival-Index Estimate		**0.5874**
Hatchery Pooled	Number Released		1130
	Expanded McNary Passage Number		361.2
	Survival-Index Estimate		**0.3196**

Appendix B.2. (Continued)

m. 2011 Outmigration Year (Brood 2009)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		02/25/12	03/17/12
Ending Week (ending date of week)		03/10/12	
Natural Origin	Number Released	985	956
	Expanded McNary Passage Number	216.7	311.7
	Survival-Index Estimate	**0.2200**	**0.3260**
Hatchery Pooled	Number Released		3103
	Expanded McNary Passage Number		831.4
	Survival-Index Estimate		**0.2679**

n. 2012 Outmigration Year (Brood 2010)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		02/25/12	03/17/12
Ending Week (ending date of week)		03/10/12	
Natural Origin	Number Released	2482	193
	Expanded McNary Passage Number	748.5	46.7
	Survival-Index Estimate	**0.3016**	**0.2419**
Hatchery Pooled	Number Released		4405
	Expanded McNary Passage Number		814.3
	Survival-Index Estimate		**0.1849**

Appendix C.1. Weighted* Logistic Analyses of Variance for Roza-to-McNary Survival of Hatchery** Spawned Smolt Passing Roza contemporaneously with Naturally Spawned Smolt (Late Passage) (<u>non-shaded-analysis</u> is basis of test)

a) 1999 Outmigration (1997 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p^4
Block[1]	32.55	4	8.14	0.93	0.4943	
Natural Origin versus Hatchery Origin[1]	20.15	1	20.15	2.29	0.1683	
Tagged vs Untagged Hatchery Origin1	8.26	1	8.26	0.94	0.3606	
Error(1)	70.26	8	8.7825			
Natural Origin versus Hatchery Origin[2]	20.15	1	20.15	2.35	0.1511	0.0755
Tagged vs Untagged Hatchery Origin[2]	8.26	1	8.26	0.96	0.3455	
Error(2)[3]	102.81	12	8.57			

b) 2000 Outmigration (1998 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p^4
Block[1]	177.90	14	12.71	3.90	0.0017	
Natural Origin versus Hatchery Origin[1]	135.38	1	135.38	41.51	0.0000	0.0000
Tagged vs Untagged Hatchery Origin[1]	0.16	1	0.16	0.05	0.8266	
Error(1)	78.27	24	3.26			
Natural Origin versus Hatchery Origin[2]	135.38	1	135.38	20.08	0.0001	
Tagged vs Untagged Hatchery Origin[2]	0.16	1	0.16	0.02	0.8784	
Error(2)[3]	256.17	38	6.74			

c) 2001 Outmigration (1999 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p^4
Block[1]	119.01	5	23.80	11.89	0.0006	
Natural Origin versus Hatchery Origin[1]	0.87	1	0.87	0.43	0.5246	0.2623
Tagged vs Untagged Hatchery Origin[1]	1.78	1	1.78	0.89	0.3679	
Error(1)	20.02	10	2.002			
Natural Origin versus Hatchery Origin[2]	0.87	1	0.87	0.09	0.7635	
Tagged vs Untagged Hatchery Origin[2]	1.78	1	1.78	0.19	0.6675	
Error(2)[3]	139.03	15	9.27			

* Weight is Number Released, Block being Late-Release Week

** Roza-Dam-Release to McNary-Dam -Detection Smolt-to-Smolt Survival

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[1] Block, Wild versus Hatchery, Tagged versus Untagged Hatchery tested against Error(1)

[2] Block, Wild versus Hatchery, Tagged versus Untagged Hatchery tested against Error(2)

[3] Error (2) is pooling of Error(1) and Block. Analysis is based on Error(1) if Block Type 1 Error P < 0.2, otherwise analysis based on Error(2) is used

[4] One-sided test for Hatchery Survival < Wild Survival

Appendix C.1. Weighted* Logistic Analyses of Variance for Roza-to-McNary Survival** of Hatchery Spawned Smolt Passing Roza contemporaneously with Naturally Spawned Smolt (continued)

d) 2002 Outmigration (2000 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p[4]
Block[1]	41.93	4	10.48	1.34	0.3553	
Natural Origin versus Hatchery Origin[1]	19.10	1	19.10	2.45	0.1689	
Tagged vs Untagged Hatchery Origin1	3.00	1	3.00	0.38	0.5582	
Error(1)	46.86	6	7.81			
Natural Origin versus Hatchery Origin[2]	19.10	1	19.1	2.15	0.1732	0.0866
Tagged vs Untagged Hatchery Origin[2]	3.00	1	3.00	0.34	0.5739	
Error(2)[3]	88.79	10	8.88			

e) 2003 Outmigration (2001 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p[4]
Block[1]	46.25	5	9.25	1.83	0.1953	
Natural Origin versus Hatchery Origin[1]	12.33	1	12.33	2.43	0.1498	0.0749
Tagged vs Untagged Hatchery Origin[1]	0.62	1	0.62	0.12	0.7337	
Error(1)	50.65	10	5.07			
Natural Origin versus Hatchery Origin[2]	12.33	1	12.33	1.91	0.1873	
Tagged vs Untagged Hatchery Origin[2]	0.62	1	0.62	0.10	0.7610	
Error(2)[3]	96.90	15	6.46			

f) 2004 Outmigration (2002 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p[4]
Block[1]	87.14	4	21.79	6.15	0.0257	
Natural Origin versus Hatchery Origin[1]	21.55	1	21.55	6.08	0.0487	0.0243
Tagged vs Untagged Hatchery Origin[1]	21.85	1	21.85	6.17	0.0476	
Error(1)	21.25	6	3.54			
Natural Origin versus Hatchery Origin[2]	21.55	1	21.55	1.99	0.1889	
Tagged vs Untagged Hatchery Origin[2]	21.85	1	21.85	2.02	0.1861	
Error(2)[3]	108.39	10	10.84			

* Weight is Number Released, Block being Late-Release Week

** Roza-Dam-Release to McNary-Dam -Detection Smolt-to-Smolt Survival

---

[1] Block, Wild versus Hatchery, Tagged versus Untagged Hatchery tested against Error(1)

[2] Block, Wild versus Hatchery, Tagged versus Untagged Hatchery tested against Error(2)

[3] Error (2) is pooling of Error(1) and Block. Analysis is based on Error(1) if Block Type 1 Error P < 0.2, otherwise analysis based on Error(2) is used

[4] One-sided test for Hatchery Survival < Wild Survival

Appendix C.1. Weighted* Logistic Analyses of Variance for Roza-to-McNary Survival** of Hatchery Spawned Smolt Passing Roza contemporaneously with Naturally Spawned Smolt (continued)

g) 2005 Outmigration (2003 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p[4]
Block[1]	15.16	3	5.05	0.98	0.4345	
Natural Origin versus Hatchery Origin[1]	0.03	1	0.03	0.01	0.9427	
Tagged vs Untagged Hatchery Origin[1]	0.01	1	0.01	0.00	0.9669	
Error(1)	20.54	4	5.135			
Natural Origin versus Hatchery Origin[2]	0.03	1	0.03	0.01	0.9410	0.5295
Tagged vs Untagged Hatchery Origin[2]	0.01	1	0.01	0.00	0.9659	
Error(2)[3]	35.70	7	5.10			

h) 2006 Outmigration (2004 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p[4]
Block[1]	378.21	6	63.04	10.55	0.0003	
Natural Origin versus Hatchery Origin[1]	105.84	1	105.84	17.71	0.0012	0.0006
Tagged vs Untagged Hatchery Origin[1]	0.16	1	0.16	0.03	0.8727	
Error(1)	71.71	12	5.98			
Natural Origin versus Hatchery Origin[2]	105.84	1	105.84	4.23	0.0544	
Tagged vs Untagged Hatchery Origin[2]	0.16	1	0.16	0.01	0.9371	
Error(2)[3]	449.92	18	25.00			

i) 2007 Outmigration (2005 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p[4]
Block[1]	236.27	4	59.07	12.32	0.0028	
Natural versus Hatchery[1]	32.50	1	32.50	6.78	0.0352	0.0176
Tagged vs Untagged Hatchery	25.61	1	25.61	5.34	0.0541	
Error(1)	33.56	7	4.79			
Natural versus Hatchery[2]	32.50	1	32.5	1.32	0.2741	
Tagged vs Untagged Hatchery[2]	25.61	1	25.61	1.04	0.3288	
Error(2)3	269.83	11	24.53			

* Weight is Number Released, Block being Late-Release Week

** Roza-Dam-Release to McNary-Dam -Detection Smolt-to-Smolt Survival

---

[1] Block, Wild versus Hatchery, Tagged versus Untagged Hatchery tested against Error(1)

[2] Block, Wild versus Hatchery, Tagged versus Untagged Hatchery tested against Error(2)

[3] Error (2) is pooling of Error(1) and Block. Analysis is based on Error(1) if Block Type 1 Error P < 0.2, otherwise analysis based on Error(2) is used

[4] One-sided test for Hatchery Survival < Wild Survival

Appendix C.1. Weighted* Logistic Analyses of Variance for Roza-to-McNary Survival** of Hatchery Spawned Smolt Passing Roza contemporaneously with Naturally Spawned Smolt (continued)

j) 2008 Outmigration (2006 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p^4
Block[1]	272.61	7	38.94	5.84	0.0025	
Natural Origin versus Hatchery Origin[1]	46.66	1	46.66	7.00	0.0192	0.0096
Tagged vs Untagged Hatchery Origin[1]	0.78	1	0.78	0.12	0.7374	
Error(1)	93.33	14	6.67			
Natural Origin versus Hatchery Origin[2]	46.66	1	46.66	2.68	0.1167	
Tagged vs Untagged Hatchery Origin[2]	0.78	1	0.78	0.04	0.8345	
Error(2)[3]	365.94	21	17.43			

k) 2009 Outmigration (2007 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p^4
Block[1]	152.80	5	30.56	4.44	0.0258	
Natural Origin versus Hatchery Origin[1]	28.47	1	28.47	4.13	0.0726	0.9637
Tagged vs Untagged Hatchery Origin[1]	8.52	1	8.52	1.24	0.2950	
Error(1)	62.01	9	6.89			
Natural Origin versus Hatchery Origin[2]	28.47	1	28.47	1.86	0.1947	
Tagged vs Untagged Hatchery Origin[2]	8.52	1	8.52	0.56	0.4685	
Error(2)[3]	214.81	14	15.34			

l) 2010 Outmigration (2008 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p^4
Block[1]	68.48	4	17.12	3.10	0.0913	
Natural Origin versus Hatchery Origin[1]	33.57	1	33.57	6.08	0.0431	0.0216
Tagged vs Untagged Hatchery Origin[1]	1.92	1	1.92	0.35	0.5739	
Error(1)	38.65	7	5.52			
Natural Origin versus Hatchery Origin[2]	33.57	1	33.57	3.45	0.0903	
Tagged vs Untagged Hatchery Origin[2]	1.92	1	1.92	0.20	0.6656	
Error(2)[3]	107.13	11	9.74			

* Weight is Number Released, Block being Late-Release Week

** Roza-Dam-Release to McNary-Dam -Detection Smolt-to-Smolt Survival

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[1] Block, Wild versus Hatchery, Tagged versus Untagged Hatchery tested against Error(1)

[2] Block, Wild versus Hatchery, Tagged versus Untagged Hatchery tested against Error(2)

[3] Error (2) is pooling of Error(1) and Block. Analysis is based on Error(1) if Block Type 1 Error P < 0.2, otherwise analysis based on Error(2) is used

[4] One-sided test for Hatchery Survival < Wild Survival

Appendix C.1. Weighted* Logistic Analyses of Variance for Roza-to-McNary Survival of Hatchery Spawned Smolt Passing Roza contemporaneously with Naturally Spawned Smolt (Late Passage) (non-shaded-analysis is basis of test)

m) 2011 Outmigration (2009 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p^4
Block[1]	32.96	6	5.49	0.39	0.8684	
Natural Origin versus Hatchery Origin[1]	17.51	1	17.51	1.25	0.2867	
Tagged vs Untagged Hatchery Origin[1]	28.31	1	28.31	2.03	0.1822	
Error(1)	153.60	11	13.96			
Natural Origin versus Hatchery Origin[2]	17.51	1	17.51	1.60	0.2236	0.1118
Tagged vs Untagged Hatchery Origin[2]	28.31	1	28.31	2.58	0.1267	
Error(2)[3]	186.56	17	10.97			

n) 2012 Outmigration (20010 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p^4
Block[1]	323.24	4	80.81	19.51	0.0030	
Natural Origin versus Hatchery Origin[1]	1.03	1	1.03	0.25	0.6392	0.3196
Tagged vs Untagged Hatchery Origin[1]	2.7	1	2.7	0.65	0.4561	
Error(1)	20.71	5	4.14			
Natural Origin versus Hatchery Origin[2]	1.03	1	1.03	0.03	0.8732	
Tagged vs Untagged Hatchery Origin[2]	2.70	1	2.70	0.07	0.7964	
Error(2)[3]	343.95	9	38.22			

[4] One-sided test for Hatchery Survival < Wild Survival

* Weight is Number Released, Block being Late-Release Week

** Roza-Dam-Release to McNary-Dam -Detection Smolt-to-Smolt Survival

---

[1] Block, Wild versus Hatchery, Tagged versus Untagged Hatchery tested against Error(1)

[2] Block, Wild versus Hatchery, Tagged versus Untagged Hatchery tested against Error(2)

[3] Error (2) is pooling of Error(1) and Block. Analysis is based on Error(1) if Block Type 1 Error P < 0.2, otherwise analysis based on Error(2) is used

[4] One-sided test for Hatchery Survival < Wild Survival

Appendix C.2. Weighted* Logistic Analyses of Variance over Years of Roza-to-McNary Survival of Contemporaneously Naturally-Spawned and Hatchery-Spawned Pooled Roza-to-McNary Survival of Early and Late Naturally Spawned Smolt Passing Roza

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P (Nat ≠ Hat)	Type 1 Error P (Nat > Hat)
Nat vs Hat Stock (adjusted for Years)	315.8	1	315.80	9.73	0.0081	0.0041
Among Years (adjusted for stock)	1363.45	13	104.88	3.23	0.0217	
Stock x Year Interaction	421.85	13	32.45			

* Pooled (Weight = number of given stock released in given year.)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error (Nat ≠ Hat)	Type 1 Error (Nat > Hat)
Nat vs Hat Stock (adjusted for Years)	56.78	1	56.78	7.05	0.0198	0.0099
Among Years (adjusted for stock)	405.78	13	31.21	3.88	0.0103	
Stock x Year Interaction	104.71	13	8.05			

* Weight = [number of given stock released in given year]/[Error Mean Deviance in Tables in Appendix C.1)] to account for differences in Mean Deviances (measure of error variation) over years.

Appendix D.1. Weighted* Logistic Analyses of Variance for Roza-to-McNary Survival of naturally-Spawned Smolt Passing Roza before (Early) and contemporaneously (Late) with Hatchery Spawned Smolt

a) 1999 Outmigration (1997 Brood Year)

[No Roza Tagging prior to Hatchery-Release Passage at Roza]

b) 2000 Outmigration (1998 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error	Highest Survival Estimate:
Natural Origin Early versus Late	181.10	1	181.10	31.62	0.0000	Late
Error	114.54	20	5.73			

c) 2001 Outmigration (1999 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural Origin Early versus Late	297.69	1	297.69	34.62	0.0001	Early
Error	94.60	11	8.60			

d) 2002 Outmigration (2000 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural Origin Early versus Late	161.77	1	161.77	20.03	0.0004	Late
Error	121.16	15	8.08			

e) 2003 Outmigration (2001 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural Origin Early versus Late	0.38	1	0.38	0.05	0.8230	Early
Error	87.28	12	7.27	0.00		

f) 2004 Outmigration (2002 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural Origin Early versus Late	6.81	1	6.81	0.51	0.4903	Late
Error	161.35	12	13.45			

* Weight is Number Released

** Roza-Dam-Release to McNary-Dam -Detection Smolt-to-Smolt Survival

*** "Late" Outmigrating means migrating contemporaneously with Hatchery-produced Fish and "Early" means oumigrating before Hatchery-produced Fish

Appendix D.1. (Continued)

g) 2005 Outmigration (2003 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural Origin Early versus Late	5.98	1	5.98	0.81	0.4035	Late
Error	44.43	6	7.41			

h) 2006 Outmigration (2004 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural Origin Early versus Late	246.57	1	246.57	17.31	0.0010	Late
Error	199.40	14	14.24			

i) 2007 Outmigration (2005 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural-Origin Early versus Late	41.69	1	41.69	4.11	0.0889	Early
Error	60.82	6	10.14			

j) 2008 Outmigration (2006 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural Origin Early versus Late	9.91	1	9.91	1.50	0.2458	Late
Error	72.51	11	6.59			

k) 2009 Outmigration (2007 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural Origin Early versus Late	0.42	1	0.42	0.10	0.7590	Late
Error	37.78	9	4.20			

l) 2010 Outmigration (2008 Brood Year)
[No Roza Tagging prior to Hatchery-Release Passage at Roza]

* Weight is Number Released
** Roza-Dam-Release to McNary-Dam -Detection Smolt-to-Smolt Survival
*** "Late" Outmigrating means migrating contemporaneously with Hatchery-produced Fish and "Early" means oumigrating before Hatchery-produced Fish

Appendix D.1. (Continued)

m) 2011 Outmigration (2009 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural Origin Early versus Late	27.63	1	27.63	1.79	0.2176	Late
Error	123.43	8	15.43			

n) 2012 Outmigration (2009 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Devivance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Wild Early versus Late	3.17	1	3.17	0.45	0.5212	Early
Error	64.04	9	7.12			

* Weight is Number Released

** Roza-Dam-Release to McNary-Dam -Detection Smolt-to-Smolt Survival

*** "Late" Outmigrating means migrating contemporaneously with Hatchery-produced Fish and "Early" means oumigrating before Hatchery-produced Fish

Appendix D.2. Weighted* Logistic Analyses of Variance over Years for Pooled Roza-to-McNary Survival of Early and Late Naturally Spawned Smolt Passing Roza

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Early vs Late Natually Spawned Brood (adjusted for Years)	160.7	1	160.70	2.2296	0.1635
Among Years (adjusted for Brood)	663.47	11	60.32	0.8368	0.6136
Brood x Year Interaction	792.85	11	72.08		

* Weight = number of given stock released in given year.

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Early vs Late Natually Spawned Brood (adjusted for Years)	0.69	1	0.69	0.80	0.3901
Among Years (adjusted for Brood)	6.48	11	0.59	0.68	0.7307
Brood x Year Interaction	9.48	11	0.86		

* Weight = [number of given stock released in given year]/[Error Mean Deviance in Tables in Appendix D.1)] to account for differences in Mean Deviances (measure of error variation) over years.

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Appendix D
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 2012

Doug Neeley, Consultant to Yakama Nation

Introduction

For hatchery releases of Spring Chinook smolt released in 2007 and 2009 through 2012, two feed treatments were allocated to raceways within adjacent raceway pairs. Fish from each raceway within the pairs were fed Vita prior to smoltification, then the Vita feed for one of the paired raceways was supplemented with Saltwater Transfer Feed (STF) and the other was not. The intent of the experiment was to determine whether the STF-supplement treatment increased the rate of smoltification and survival, the unsupplemented treatment serving as the control. The treatment effects on five evaluated juvenile measures were compared and are presented herein: 1) mean pre-release fish size (assessed from individual fish samples taken by NOAA Fisheries), 2) mean volitional release date, 3) mean McNary Dam (McNary) smolt-passage date, 4) mean proportion of PIT tagged fish detected volitionally leaving the acclimation ponds, 5) mean smolt-smolt survival from volitional release to McNary.

In addition, the treatment effects on two adult measures were estimated: 6) smolt-release to adult-survivals to Roza Dam (Roza) on the Upper Yakima and 7) the age-3 proportions of adults sampled at Roza from brood years 2005, 2007 and 2008 (respectively release years 2007, 2009, and 2010). Brood-year2008 smolt-to-adult survival analysis and age-3 proportion are based on only age-3 and age-4 fish, the age-5 adults have not yet returned, so the results for that brood should be regarded as underestimates[1]. Further, incorporation of additional data from PIT-tagged fish needs to incorporated into the assessment for all brood years, therefore, all summaries presented herein, should be regarded as somewhat tentative.

---

[1] Historically, only a small proportion of adult returns are age-5 fish; therefore general conclusions about the 2008 brood are unlikely to change substantially.

Summary

With the exception of Juvenile Volitional Release Date, no other Transfer–Control juvenile-measure mean differences were significant or substantial when averaged over years. As will be seen even for the exception, the difference was nearly inconsequential.

Juvenile Measures

Tables 1 through 5 and associated Figures are presented in the order of: 1. mean pre-release weight, 2. mean volitional release date, 3. mean juvenile McNary passage date, 4. mean proportion of PIT-tagged fish detected volitionally leaving pond, and 5. mean volitional-release-to-McNary smolt-to-smolt survival.

Table 1. **Brood-Year 2005, 2007-2010 Mean pre-release Weight (grams) for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed (STF) supplement to the control feed (Vita = Control and Vita + STF)**

Brood Year Release Year	2005 2007	2007 2009	2008 2010	2009 2011	2010 2012*	Over Years
Vita + STF	**14.4**	**16.3**	**16.7**	**17.1**	**17.2**	**16.2**
Number Weighed	480	540	480	480	120	2100
Vita	**15.0**	**16.5**	**16.9**	**16.7**	**17.3**	**16.3**
Number Weighed	480	419	476	480	120	1975
Difference	**-0.6**	**-0.3**	**-0.2**	**0.4**	**-0.1**	**-0.1**

* Only Clark Flat Raceways were sampled

Figure 1. **Brood-Year 2005, 2007-2010 Mean pre-release Weight (grams) for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed (STF) supplement to the control feed (Vita = Control and Vita + STF)**

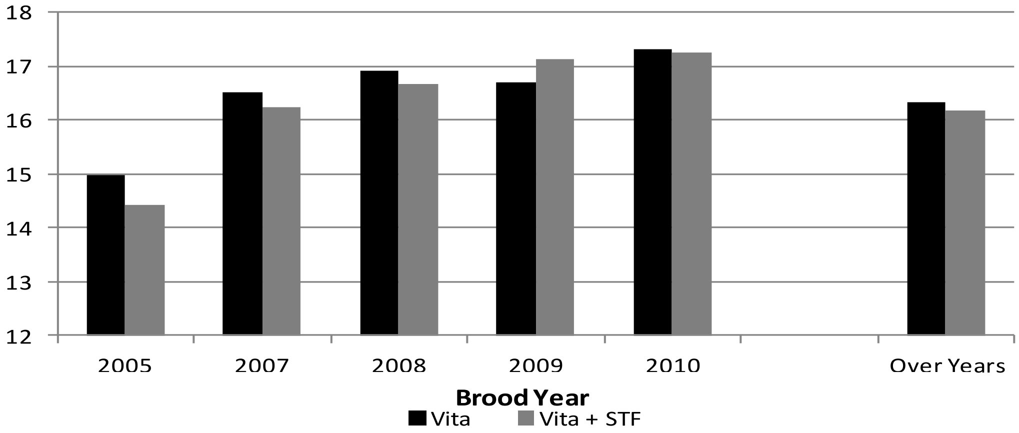
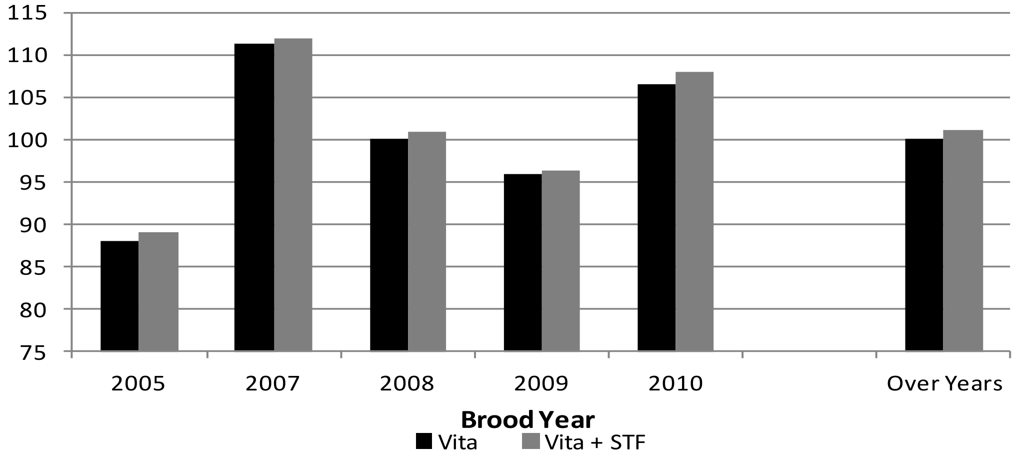


Table 2. Brood-Year 2005, 2007-2010 Mean Julian Release Date for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites Transfer Feed supplement (Vita = Control and Vita + STF)

Brood Year Release Year	2005 2007	2007 2009	2008 2010	2009 2011	2010 2012	Over Years
Vita + STF	**89.0**	**111.9**	**100.9**	**96.3**	**108.0**	**101.0**
Release Detections	17426	15589	15579	13941	15474	78009
Vita	**88.0**	**111.3**	**100.0**	**95.8**	**106.4**	**100.1**
Release Detections	17370	15633	15577	14459	15518	78557
Difference	**1.0**	**0.6**	**0.9**	**0.5**	**1.6**	**0.9**

Figure 2. Brood-Year 2005, 2007-2010 Mean Julian Release Date for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites Transfer Feed supplement (Vita = Control and Vita + STF)



The STF effect was significant (P = 0.013, Appendix Table A.2.); however, the STF-supplemented fish mean date of volitional release was less than a day later then the unsupplemented fish. Since the small delays were consistent over years, the small difference over all years turned out to be out to be significant.

Table 3. **Brood-Year 2005, 2007-2010 Mean Julian Date of McNary Passage for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)**

Brood Year Release Year	2005 2007	2007 2009	2008 2010	2009 2011	2010 2012	Over Years
Vita + STF	**126.4**	**134.8**	**132.5**	**134.8**	**134.7**	**132.6**
McNary Detections	5474	6290	5053	4121	6058	26997
Vita	**126.4**	**134.8**	**132.0**	**134.2**	**134.6**	**132.5**
McNary Detections	5465	6218	4659	4480	6021	26842
Difference	**-0.1**	**0.0**	**0.4**	**0.6**	**0.1**	**0.2**

Figure 3. **Brood-Year 2005, 2007-2010 Mean Julian Date of McNary Passage for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)**

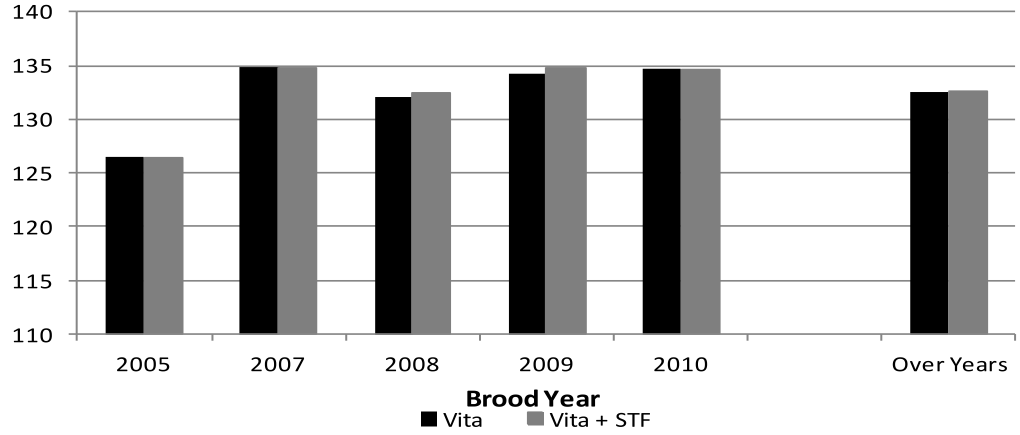


Table 4. **Brood-Year 2005, 2007-2010 Proportion of Spring Chinook Smolt leaving Acclimation Sites at Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)**

Brood Year Release Year	2005 2007	2007 2009	2008 2010	2009 2011	2010 2012	Over Years
Vita + STF	**98.03%**	**97.43%**	**97.37%**	**87.13%**	**96.71%**	**95.39%**
Number tagged	17776	16001	16000	16000	16000	81777
Vita	**97.67%**	**97.65%**	**97.36%**	**90.36%**	**96.97%**	**96.04%**
Number tagged	17785	16010	16000	16001	16003	81799
Difference	**0.36%**	**-0.22%**	**0.01%**	**-3.23%**	**-0.26%**	**-0.64%**

Figure 4. **Release Year 2007, 2009-2012 Proportion of Spring Chinook Smolt leaving Acclimation Sites at Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)**

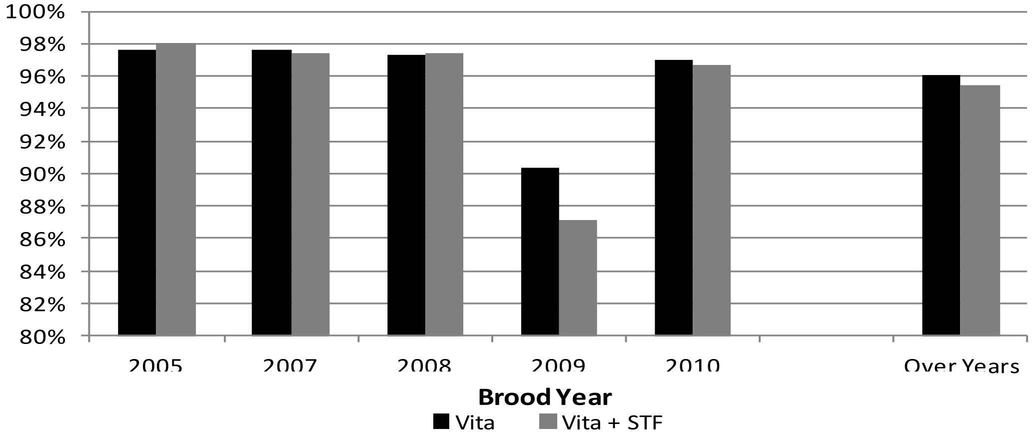
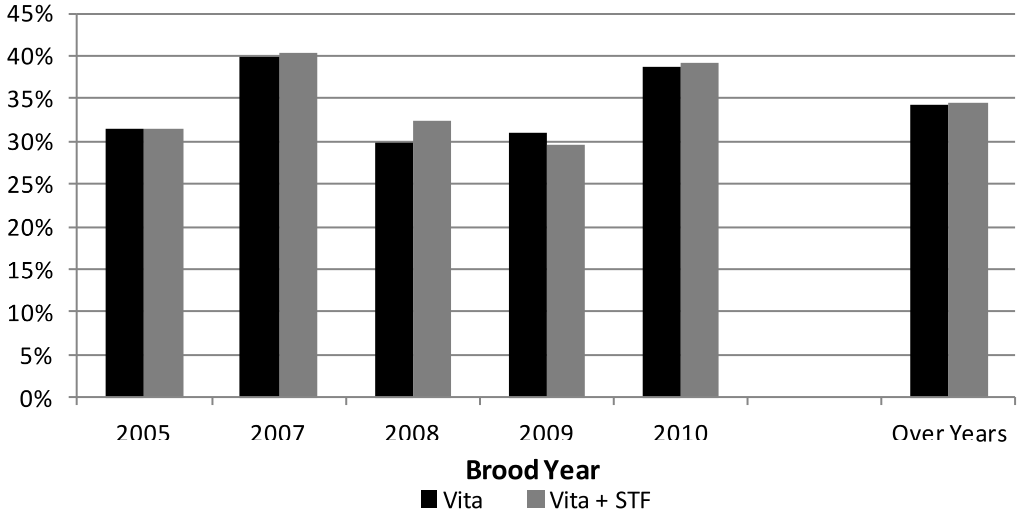


Table 5. Brood-Year 2005, 2007-2010 Mean Release-to-McNary Smolt-to-Smolt survival for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)

Brood Year Release Year	2005 2007	2007 2009	2008 2010	2009 2011	2010 2012	Over Years
Vita + STF	**31.41%**	**40.35%**	**32.43%**	**29.56%**	**39.15%**	**34.61%**
Number Released	17426	15589	15579	13941	15474	78009
Vita	**31.46%**	**39.77%**	**29.91%**	**30.98%**	**38.80%**	**34.17%**
Number Released	17370	15633	15577	14459	15518	78557
Difference	**0.0%**	**0.6%**	**2.5%**	**-1.4%**	**0.4%**	**0.44%**

Figure 5. Brood-Year 2005, 2007-2010 Mean Release-to-McNary Smolt-to-Smolt survival for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)



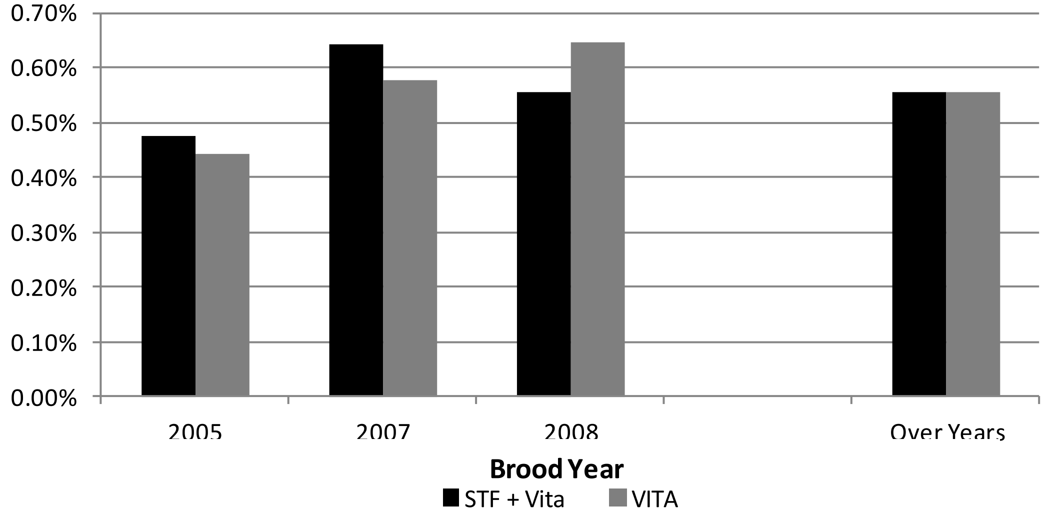
Adult Measures

The mean difference over years of two adult traits measured, Smolt-to-McNary Survival and Age-3 Proportion of all Rosa returns were not significant different. There was a significant interaction in the HxH-STF differences with years.

Table 6. Brood-Year 2005, 2007 and 2008 Survival from Acclimation-Site Volitional Juvenile-Release to Roza Dam Adult Recovery for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)

Brood Year		STF + Vita	VITA	Difference
2005	**Survival**	**0.475%**	**0.443%**	**0.032%**
	Released	383565	385920	
2007	**Survival**	**0.641%**	**0.576%**	**0.065%**
	Released	337173	339429	
2008	**Survival**	**0.554%**	**0.647%**	**-0.092%**
	Released	381123	375327	
Over Years	**Survival**	**0.167%**	**0.157%**	**0.010%**
	Released	1101861	1100676	

Figure 6. Brood-Year 2005, 2007 and 2008 Survival from Acclimation-Site Volitional Juvenile-Release to Roza Dam Adult Recovery for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)

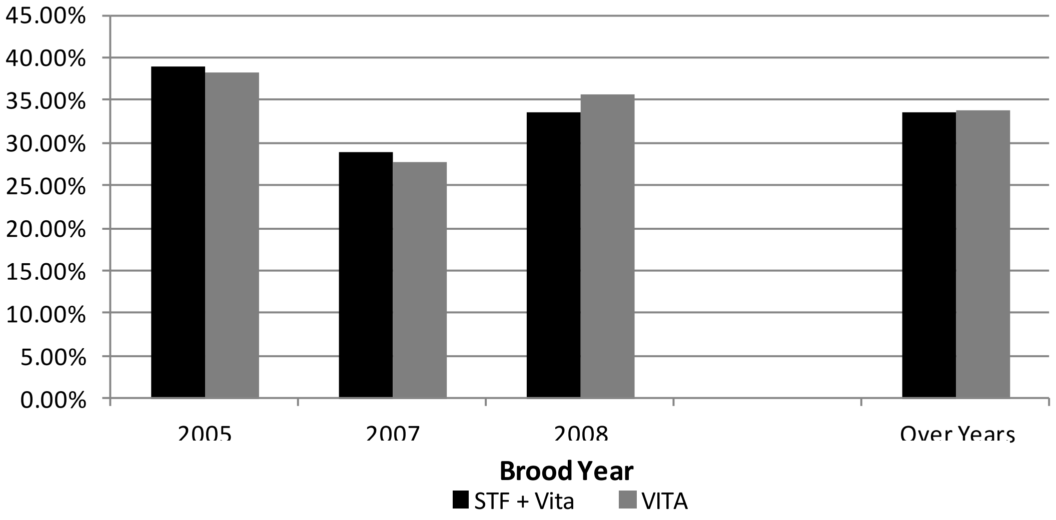


The negative Brood-Year 2008 STF difference was sufficiently larger in absolute value than the positive differences of the 2005 and 2007 brood years to give a significant interaction (P = 0.0002, Appendix Table A.6) and to result in main-effect means that were almost identical.

Table 7. **Brood-Year 2005, 2007 and 2008 Proportion Three-Year Old Returns for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)**

Brood Year		STF + Vita	VITA	Difference
2005	**Survival**	**0.475%**	**0.443%**	**0.032%**
	Released	383565	385920	
2007	**Survival**	**0.641%**	**0.576%**	**0.065%**
	Released	337173	339429	
2008	**Survival**	**0.554%**	**0.647%**	**-0.092%**
	Released	381123	375327	
Over Years	**Survival**	**0.167%**	**0.157%**	**0.010%**
	Released	1101861	1100676	

Figure 7. **Brood-Year 2005, 2007 and 2008 Proportion Three-Year Old Returns for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita = Control and Vita + STF)**



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

Table A.1. Weighted* Least Squares Analysis of Variance of pre-release Size (gram/fish) for Spring Chinook smolt receiving and not receiving STF-supplement.

Source	Squares (SS)	Degrees of Freedom (DF)	Square = SS/DF	F-Ratio	Estimated Type 1 Error	Denominator Mean Dev Source
Year	2736.80	3	912.27	17.20	**0.0000**	Main-Plot Error
Site	588.00	2	294.00	2.31	0.1798	Year x Site
Year x Site	762.00	6	127.00	2.40	**0.0659**	Main-Plot Error
Main-Plot Error	1060.50	20	53.03	2.03	**0.0608**	Subplot Error
Treatment	8.00	1	8.00	0.20	0.6867	Year x Treatment
Year x Treatment	121.40	3	40.47	2.04	0.2098	Year x Treatment x Site
Treatment x Site	24.00	2	12.00	0.61	0.5763	Year x Treatment x Site
Year x Treatment x Site	119.00	6	19.83	0.76	0.6099	Subplot Error
Subplot Error	522.30	20	26.12			

* Number Weighed

Table A.2. Weighted* Least Squares Analysis of Variance of Julian Volitional-Release Date for Spring Chinook Smolt receiving and not receiving STF-supplement.

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square = SS/DF	F-Ratio	Estimated Type 1 Error	Denominator Mean Dev Source
Year	10825558	4	2706390	58.84	**0.0000**	Main-Plot Error
Site	40000	2	20000	0.09	0.9145	Year x Site
Year x Site	1770879	8	221360	4.81	**0.0011**	Main-Plot Error
Main-Plot Error	1149851	25	45994	1.69	**0.0985**	Subplot Error
Treatment	30113	1	30113	17.93	**0.0133**	Year x Treatment
Year x Treatment	6717	4	1679	0.07	0.9895	Year x Treatment x Site
Treatment x Site	2162	2	1081	0.04	0.9566	Year x Treatment x Site
Year x Treatment x Site	193919	8	24240	0.89	0.5388	Subplot Error
Subplot Error	680801	25	27232			

* Number of fish detected volitionally leaving the raceways

Table A.3. Weighted* Least Squares Analysis of Variance of Expanded Mean Julian McNary-Dam Passage Date for Spring Chinook Smolt receiving and not receiving STF-supplement

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	F-Ratio	Estimated Type 1 Error	Denominator Mean Dev Source
Year	565076	4	141269	56.10	0.0000	Main-Plot Error
Site	107437	2	53719	2.36	0.1563	Year x Site
Year x Site	181941	8	22743	9.03	**0.0000**	Main-Plot Error
Main-Plot Error	62959	25	2518	1.75	**0.0841**	Subplot Error
Treatment	586	1	586	2.06	0.2246	Year x Treatment
Year x Treatment	1138	4	284	0.13	0.9685	Year x Treatment x Site
Treatment x Site	10887	2	5443	2.43	0.1499	Year x Treatment x Site
Year x Treatment x Site	17930	8	2241	1.56	0.1878	Subplot Error
Subplot Error	35948	25	1438			

*** Expanded Number Released**

Table A.4. 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.

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	F-Ratio	Estimated Type 1 Error	Denominator Mean Dev Source
Year	3796.90	4	949.23	26.97	**0.0000**	Main-Plot Error
Site	1564.79	2	782.40	2.41	0.1512	Year x Site
Year x Site	2592.47	8	324.06	9.21	**0.0000**	Main-Plot Error
Main-Plot Error	880.05	25	35.20	1.34	0.2146	Subplot Error[1]
Treatment	46.27	1	46.27	2.96	0.1605	Year x Treatment
Year x Treatment	62.53	4	15.63	0.74	0.5699	Subplot Error[1]
Treatment x Site	82.17	2	41.09	1.95	0.1558	Subplot Error[1]
Subplot Error[1]	868.39	33	26.31			

[1] Year x Treatment x Site Mean extremely small relative to Subplot Error and was therefore pooled Subplot Error

* Expanded number passing Prosser

Table A.5. 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

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	F-Ratio	Estimated Type 1 Error	Denominator Mean Dev Source
Year	1216.41	4	304.10	29.44	**0.0000**	Main-Plot Error
Site	288.97	2	144.49	8.92	**0.0092**	Year x Site
Year x Site	129.62	8	16.20	1.57	0.1847	Main-Plot Error
Main-Plot Error	258.27	25	10.33	1.92	**0.0548**	Subplot Error
Treatment	2.15	1	2.15	0.25	0.6409	Year x Treatment
Year x Treatment	33.88	4	8.47	0.90	0.5061	Year x Treatment x Site
Treatment x Site	6.00	2	3.00	1.72	0.2392	Year x Treatment x Site
Year x Treatment x Site	75.12	8	9.39	1.74	0.1370	Subplot Error
Subplot Error	134.55	25	5.38			

* Number of PIT-tagged Smolt detected leaving acclimation site

Table A.6. Weighted* Logistic Analysis of the Smolt-to-Adult Survival to Roza 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

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	F-Ratio	Estimated Type 1 Error	Denominator Mean Dev Source
Brood Year	196.93	2	98.47	587.85	**0.0000**	Year x Site x Treatment (Error)
Site	162.89	2	81.45	6.42	**0.0564**	Brood Year x Site
Brood Year x Site	50.71	4	12.68	75.69	**0.0005**	Year x Site x Treatment (Error)
unsupplemented VITA	0.00	1	0.00	0.00	1.0000	Site x Treatment
Year x Treatment	42.04	2	21.02	125.49	**0.0002**	Year x Site x Treatment (Error)
Site x Treatment	3.99	2	2.00	11.91	0.0207	Year x Site x Treatment (Error)
te x Treatment (Error)	0.67	4	0.17			

*Estimated number of total smolt leaving acclamation site

Table A.7. **Weighted* Logistic Analysis of the Proportion of Three-Year Old comprising Spring Chinook Adult Returns at Roza that as Smolt received and not receiving STF-supplement**

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	F-Ratio	Estimated Type 1 Error	Denominator Mean Dev Source
Brood Year	95.54	2	47.77	35.45	**0.0029**	Year x Site x Treatment (Error)
Site	64	2	32.00	0.87	0.4861	Brood Year x Site
Brood Year x Site	147.37	4	36.84	27.34	**0.0036**	Year x Site x Treatment (Error)
STF supplemented vs unsupplemented VITA	0.04	1	0.04	0.03	0.8851	Site x Treatment
Year x Treatment	2.99	2	1.50	1.11	0.4137	Year x Site x Treatment (Error)
Site x Treatment	2.27	2	1.14	0.84	0.4951	Year x Site x Treatment (Error)
Year x Site x Treatment (Error)	5.39	4	1.35			

*Estimated number of returns to Roza Dam fish

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Appendix E
Annual Report: Comparisons between Smolt Measures of Hatchery x Hatchery- and Natural x Natural-Brood Stock for Brood-Years 2002-2010 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) stocks[1] were allocated to Clark Flat acclimation-site raceway pairs, within each of which the two 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 releases are included in the appendix[2].

For brood-years 2002 through 2010 (release-years 2004 through 2012, respectively), the following juvenile traits were analyzed: 1) pre-release weight, 2) proportion males, 3) pre-release proportion of males that are mini-jacks, 4) mean McNary Dam (McNary) passage date, 5) pre-release survival, and 6) volitional-release-to-McNary survival. Brood-year 2008 smolt-to-adult survival analysis proportion is based on only age-3 and age-4 fish, the age-5 adults have not yet returned, so the results for that brood should be regarded as underestimates[3]. Further, incorporation of additional data from PIT-tagged fish may need to be incorporated into the assessment for all brood years, therefore, adult trait analyses presented herein, should be regarded as somewhat tentative.

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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.

[2] For brood-years 2002-2004, the treatments were low (LO) and standard (HI) feed levels with the intent of the LO treatment to produce a smaller fish comparable in size to naturally out-migrating smolt. For brood-years 2005 and 2007 to present, A supplement feed (Saltwater Transfer Feed, STF) was included with the standard feed to determine whether the supplement improved smolt survival by better preparing them for a fresh-to-salt water transition. For the 2006 brood, there was not a sufficient supply of STF, so another feed, RWOS, was substituted for the supplement.

[3] Historically, only a small proportion of adult returns are age-5 fish; therefore general conclusions about the 2008 brood are unlikely to change substantially.

Differences in the HxH and NxN over-year means were either non-significant or small; however there were significant interactions between the stocks with years suggesting that in some years HxH fish have higher measures but that in others the NxN have higher measures.

Design of Experiment

The HxH assignment was superimposed at only the Clark Flat Acclimation Site at which there were three pairs of raceways[4] with the feed treatments allocated to the different raceways within each pair[5]. The HxH Stock was allocated to one of the three pairs of raceways, and the NxN Stock to the other two pairs[6]. 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).

Originally, the same proportion of fish were PIT-tagged within each raceway for the primary purpose of estimating smolt-to-smolt survival from release to McNary passage. 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. (In previous brood years, there were approximately half as many HxH fish tagged as NxN fish at Clark Flat). For the purpose of assessing Male Proportions, Mini-Jack Proportions, and Pre-Release Fish Weights, approximately twice as many fish were sampled from HxH raceways than from NxN raceways to also give an equal number of sampled HxH and NxN fish beginning in brood-year 2003.

Both main effect HxH–NxN differences and the interaction among yearly differences with years were tested at the 5% significance level using either a weighted logistic analyses of variation or least-squares analyses of variance[7]. Year was taken to be a random effect; therefore, the mean HxH-NxN main-effect difference averaged over years was tested against the interaction, and the interaction was tested against the main-plot error (differences among raceway-pair means).

In all table presentations, means over years are not the simple averages of the year data, rather they are the means over all fish assessed over all years. This is consistent with the weighted analyses of variation used. In those tables, which compare the HxH- and NxN-stock means, the

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[4] 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 different 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.

[5] The feed treatments were allocated to the raceways within the one HxH raceway pair and within the two NxN raceway pairs in BY 2005 and 2007-2009.

[6] 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).

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

individual stock means are presented along with their difference, and the largest of the two stocks' means boldfaced.

Mean Pre-Release Smolt Weight

Table 1 presents the individual release-year HxH and NxN stock pre-release fish-weight means. There was no significant main-effect difference between stock (P =0.4568 Appendix Table A.1), nor did the yearly NxN-HxN differences significantly interact with years (P= 0.2764, Appendix Table A.1).

Table 1. Mean <u>Pre-Release Weight</u> (grams/fish) of Natural x Natural and Hatchery x Hatchery Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2010)[8]

Feed Type >	**Low vs High**			**EWOS vs Vita**
Brood Year >	**2002**	**2003**	**2004**	**2006**
Release Year >	**2004**	**2005**	**2006**	**2008**
HxH (HC)	13.02	**13.33**	**13.53**	**15.96**
NxN (SH)	**13.68**	13.18	13.31	14.78
HxH - NxN	-0.67	0.15	0.22	1.18

Feed Type >	**STF+Vita vs Vita**					
Brood Year >	**2005**	**2007**	**2008**	**2009**	**2010**	**Over**
Release Year >	**2007**	**2009**	**2010**	**2011**	**2012**	**Years**
HxH (HC)	**15.84**	16.44	**17.83**	**18.19**	15.77	**15.84**
NxN (SH)	15.30	**18.05**	17.00	17.59	**17.29**	15.57
HxH - NxN	0.54	-1.60	0.82	0.60	-1.52	0.27

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[8] Appendix A.1 presents the associated analysis of variance with the significance levels.

Pre-Release Male Proportion

The male proportions are presented in Table 2. There were neither significant main-effect nor interaction differences between HxH and NxN stock (respectively p = 0.3815 and p = 0.6630, Appendix Table A.2). The mean male proportion over all 4097 fish evaluated in the analysis was 0.532. Although this proportion is not substantially greater than 0.5, it does differ from 0.5 with a high degree of statistical significance (p < 0.0001). Note that only three of the eighteen total Year x Cross entries in Table 2 have estimates less than 0.5.

Table 2. **<u>Male Proportion</u> of Pre-Release Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002-2010)**

Feed Type >	**Low vs High**			**EWOS vs Vita**
Brood Year >	**2002**	**2003**	**2004**	**2006**
Release Year >	**2004**	**2005**	**2006**	**2008**
HxH (HC)	0.4833	**0.5750**	**0.5314**	0.5292
NxN (SH)	**0.5042**	0.5042	0.4917	**0.5458**
HxH - NxN	-0.0208	0.0708	0.0397	-0.0167

Feed Type >	**STF+Vita vs Vita**					
Brood Year >	**2005**	**2007**	**2008**	**2009**	**2010**	**Over**
Release Year >	**2007**	**2009**	**2010**	**2011**	**2012**	**Years**
HxH (HC)	0.5000	**0.5500**	**0.5708**	**0.5375**	0.5667	**0.5393**
NxN (SH)	**0.5458**	0.5458	0.5500	0.4792	0.5667	0.5259
HxH - NxN	-0.0458	0.0042	0.0208	0.0583	0.0000	0.0134

Pre-Release Precocial Proportion of Males

Table 3 presents the individual year and HxH and NxN mean Precocial proportion of males. While the NxN- HxH Mini-Jack Percentage main-effect mean difference over years was not significant at the 5% level (P = 0.277, Appendix Table A.3), the NxN-HxH differences interaction with years was significant (P = 0.0153, Appendix Table A.3).

Table 3. **Precocial Proportion of Pre-Release Male Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2010)**[9]

Feed Type >	**Low vs High**			**EWOS vs Vita**
Brood Year >	**2002**	**2003**	**2004**	**2006**
Release Year >	**2004**	**2005**	**2006**	**2008**
HxH (HC)	0.138	0.116	0.126	0.197
NxN (SH)	**0.446**	**0.231**	**0.288**	**0.244**
HxH-NxN	-0.308	-0.115	-0.162	-0.047

Feed Type >	**STF+Vita vs Vita**					
Brood Year >	**2005**	**2007**	**2008**	**2009**	**2010**	**Over**
Release Year >	**2007**	**2009**	**2010**	**2011**	**2012**	**Years**
HxH (HC)	**0.542**	0.242	0.307	**0.527**	0.426	0.311
NxN (SH)	0.397	**0.420**	**0.318**	0.443	**0.485**	**0.364**
HxH-NxN	0.145	-0.177	-0.012	0.084	-0.059	-0.053

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[9] Appendix A.3 presents the associated analysis of variance with the significance levels.

Mean McNary-Dam Juvenile-Passage Dates

The mean McNary-passage dates are presented in Table 4. The HxH – NxN Main-Effect was not significantly different (P = 0.1699); however, when adjusted for the effect of year[10], the difference was significant (P = 0.0375). The HxH - NxN differences interaction with year was significant (P =0.0454, Appendix A.4). As can be seen in the table, the NxN stock has a higher mean in seven of the nine years. This was sufficient to result in the NxN year-adjusted mean over years to be significantly, although not substantially, later than the HxH year-adjusted mean. The two years of exceptions (Brood Years 2002 and 2008), the later HxH passages contributed to the significant interaction.

Table 4. Mean McNary-Dam Julian Passage Date of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection (brood years 2002 through 2010)[11]

Mean McNary Passage Date

Feed Type >	Low vs High			EWOS vs Vita
Brood Year >	**2002**	**2003**	**2004**	**2006**
Release Year >	**2004**	**2005**	**2006**	**2008**
HxH (HC)	**123.3**	123.2	125.8	122.9
NxN (SH)	121.9	**123.5**	**126.0**	**126.2**
HxH - NxN	1.4	-0.3	-0.2	-3.3

Feed Type >	STF+Vita vs Vita					
Brood Year >	**2005**	**2007**	**2008**	**2009**	**2010**	**Over**
Release Year >	**2007**	**2009**	**2010**	**2011**	**2012**	**Years**
HxH (HC)	133.4	131.0	**128.5**	127.7	127.6	128.2
NxN (SH)	**136.3**	**131.3**	128.1	**134.2**	**131.5**	**129.5**
HxH - NxN	-2.9	-0.2	0.5	-6.5	-3.9	-1.3

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[10] The adjustment for years is an indication some of the treatment effect is associated with year differences. In this experiment, this is attributed to the fact that the weights used are not proportionally equal. Had they been equal, there would be no difference between the unadjusted and adjusted means; therefore no great degree of import is assigned to the adjusted main-effect mean difference.

[11] Appendix A.4 presents the associated analysis of variance with the significance levels.

Mean Proportion 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 assigned to the hatchery-site raceway and is an index of pre-release survival.

Table 5 presents the individual year and mean pre-release survival-index estimates. While the NxN-HxH main effect comparison is not significant at the 5% level, it is nearly so (P = 0.0694, Appendix Table A.5), the comparison's interaction with years is significant (P = 0.0076), Appendix Table A.5). The nature of the interaction is evident from the table. In the first six release years, the NxN pre-release survival index is greater than that of the HxH stock; however, in the last three years the opposite is true

Table 5. Proportion of PIT-Tagged Natural x Natural and Hatchery x Hatchery Upper Yakima Spring Chinook Detected Leaving Acclimation Sites (brood years 2002 through 2010)[12]

Pre-Release Survival

Feed Type >	**Low vs High**			**EWOS vs Vita**
Brood Year >	**2002**	**2003**	**2004**	**2006**
Release Year >	**2004**	**2005**	**2006**	**2008**
HxH (HC)	0.9640	0.9606	0.9696	0.9723
NxN (SH)	**0.9792**	**0.9717**	**0.9732**	**0.9830**
HxH - NxN	-0.0152	-0.0110	-0.0036	-0.0107

Feed Type >	**STF+Vita vs Vita**					
Brood Year >	**2005**	**2007**	**2008**	**2009**	**2010**	**Over**
Release Year >	**2007**	**2009**	**2010**	**2011**	**2012**	**Years**
HxH (HC)	0.9385	0.9244	**0.9819**	**0.9795**	**0.9679**	0.9610
NxN (SH)	**0.9586**	**0.9844**	0.9736	0.9789	0.9600	**0.9738**
HxH - NxN	-0.0201	-0.0600	0.0082	0.0006	0.0079	-0.0128

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[12] Appendix A.5 presents the associated analysis of variance with the significance levels.

Release-to-McNary Smolt-to-Smolt 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.1):

Eq.1.

$$\text{Release - to - McNary Survival} = \frac{\text{Expanded Number of Released Fish Detected at McNary}}{\text{Release Number (detected at release)}}$$[13]

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

Eq.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.3.

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

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

The HxH – NxN main-effect difference was quite not significant at the 5% level (P= 0.0707, Appendix Table A.6), but the differences' interactions with years was significant (p = 0.0271, Appendix Table A.6). The main-effect mean survival rate was highest for the HxH stock.

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[13] 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.

Table 6. Volitional-Release-to-McNary-Dam Smolt-to-Smolt Proportion Survival of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2010)

Feed Type	**Low vs High**			**EWOS vs Vita**
Brood Year >	**2002**	**2003**	**2004**	**2006**
Release Year >	**2004**	**2005**	**2006**	**2008**
HxH (HC)	**0.221**	**0.171**	**0.364**	0.327
NxN (SH)	0.220	0.154	0.304	**0.344**
HxH-NxN	0.002	0.017	0.060	-0.017

Feed Type	**STF+Vita vs Vita**					
Brood Year >	**2005**	**2007**	**2008**	**2009**	**2010**	**Over**
Release Year >	**2007**	**2009**	**2010**	**2011**	**2012**	**Years**
HxH (HC)	0.307	**0.470**	0.324	**0.403**	0.418	**0.349**
NxN (SH)	**0.359**	0.427	**0.331**	0.345	**0.447**	0.322
HxH-NxN	-0.052	0.043	-0.007	0.058	-0.029	0.027

Release-to-Roza Dam Smolt-to-Adult Survival

Return-to-adult survival was based on a multivariate assignment that is described in Appendix B.

Table 7 presents the individual year and over-year main-effect means. The HxH – NxN main-effect difference was not significant at the 5% level (P= 0.588, Appendix Table A.7), but the differences' interactions with years was significant (p = 0.0001, Appendix Table A.7). The main-effect mean survival rate over years was somewhat higher for the HxH stock.

The relation among the significant interactions between the smolt-to-smolt survivals (Table 6) and the smolt-to-adult survivals (Table 7) are interesting. Among the brood years (brood years 2002 through 2008) for which comparisons are possible, the survival differences of the smolt-to-smolt and of the smolt-to-adult are of opposite signs for 7 of the 8 years. In only one year, brood-year 2005, did were the signs the same. For that only brood did the NxN cross have both a higher smolt-to-smolt and smolt-to adult survival.

Table 7. **<u>Volitional-Release-to-Roza-Dam Smolt-to-Adult Proportion Survival</u> of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2008)**

Feed Type	**Low vs High**			**EWOS vs Vita**
Brood Year >	**2002**	**2003**	**2004**	**2006**
Release Year >	**2004**	**2005**	**2006**	**2008**
HxH (HC)	**0.358%**	**0.021%**	**0.372%**	**1.620%**
NxN (SH)	**0.471%**	**0.132%**	**0.722%**	1.363%
HxH-NxN	-0.112%	-0.111%	-0.350%	0.257%

Feed Type	**STF+Vita vs Vita**			
Brood Year >	**2005**	**2007**	**2008**	**Over**
Release Year >	**2007**	**2009**	**2010**	**Years**
HxH (HC)	0.498%	0.751%	**0.777%**	0.598%
NxN (SH)	**0.581%**	**0.759%**	0.634%	**0.640%**
HxH-NxN	-0.083%	-0.008%	0.144%	-0.042%

Appendix A. Analyses of Variation for the Analyzed Measures

Both main-plot and sub-plot analyses are presented, but only the main-plot analyses are referred to in the text. The HxH and NxN means presented in the text represent means over the treatments that were assigned to the raceways within raceway pairs within the given brood-year. 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 set of diallele crosses.

Within each main-plot analysis, the HxH versus (vs) NxN (stock) main-effect comparison source is always tested against Year x Stock interaction source unless the Year x Stock Mean Deviance is less the main-plot Error Deviance, in which case, the Stock main-effect comparison source is tested against main-plot Error Source. Year x Stock interaction is always tested against the among main-plot Error source. Within the sub-plot analysis, given treatment sources (including Stock x Treatment interactions) are tested against the source's interaction with year. Treatment comparisons are discussed in other annual reports.

Table A.1. Weighted Analysis of Variance of <u>Pre-Release Weight</u> (grams/fish) of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2010). Weight is number of fish weighed/raceway.

Source	Sums of Squares	Degrees of Freedom	Mean Square	F-Ratio	Type 1 Error P
Year	11754	8	1469.25	53.07	**0.0000**
HxH vs NxN (Stock unadj1)	72	1	72.00	0.60	0.4568
HxH vs NxN (Stock adj 1)	0	1	0.00	0.00	1.0000
Stock x Year	953	8	119.13	1.51	0.2764
Main Plot Error	711.41983	9	79.05	2.86	**0.0670**

[1] Adjusted and undjusted for year

Subplot Analysis

Source	Deviance	Degrees of Freedom	Mean Deviance	F-Ratio	Type 1 Error P
Hi vs Lo (Treatment)	5135	1	5135.00	272.41	**0.0037**
Hi vs Lo x Year	37.7	2	18.85	0.96	0.5110
Stock x Hi vs Lo	0	1	0.00	0.00	1.0000
Stock x Hi vs Lo x Year	39.4	2	19.70	0.71	0.5165
EWOS vs Bio (Treatment)	0	1	0.00	0.00	1.0000
Stock x EWOS vs Bio	14	1	14.00	0.51	0.4950
STF vs Bio (Treatment)	0	1	0.00	0.00	1.0000
STF vs Bio x Year	144	4	36.00	0.65	0.6419
Stock x STF vs Bio	11	1	11.00	0.20	0.6792
Stock x STF vs Bio x Year	222	4	55.50	2.00	0.1775
Subplot Error	249.18017	9	27.69		

Note: In General, A Treatment Source is tested against a Year x Treatment Source if available

A Stock by Treatment Source is tested against a Year x Stock x Treatment Source if available

In Case of EWOS vs Bio, there was only one year, and absent interaction with year,

all EWOS sources tested against subplot error

Table A.2. Weighted Logistic Analysis of Variation of Male Proportion of Pre-Release Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002-2010).

Weight is number of fish gender-tested/raceway

Source	Deviance	Degrees of Freedom	Mean Deviance	F-Ratio	Type 1 Error P
Year	8.25	8	1.03	1.37	0.3220
HxH vs NxN (Stock unadjusted[1])	0.73	1	0.73	0.86	0.3815
HxH vs NxN (Stock adjusted[1])	0.51	1	0.51	0.60	0.4611
Year x Stock	5	8	0.63	0.73	0.6630
Main Plot Error	7.66	9	0.85	1.13	0.4277

[1] Adjusted and undjusted for year

Subplot Analysis

Source	Deviance	Degrees of Freedom	Mean Deviance	F-Ratio	Type 1 Error P
Hi vs Lo (Treatment)	0.07	1	0.07	0.02	0.8934
Year x Hi vs Lo	6.09	2	3.05	4.14	0.1944
Stock x Hi vs Lo	1.6	1	1.60	2.18	0.2781
Year x Stock x Hi vs Lo	1.47	2	0.73	0.98	0.4125
EWOS vs Bio (Treatment)	0.21	1	0.21	0.28	0.6098
Stock x EWOS vs Bio	0.4	1	0.40	0.53	0.4841
STF vs Bio (Treatment)	2.43	1	2.43	2.09	0.2218
Year x STF vs Bio	4.65	4	1.16	1.84	0.2058
Stock x STF vs Bio	1.32	1	1.32	2.09	0.2221
Year x Stock x STF vs Bio x Year	2.53	4	0.63	0.84	0.5323
Subplot Error	6.76	9	0.75		

Note: In General, A Treatment Source is tested against a Year x Treatment Source if available

A Stock by Treatment Source is tested against a Year x Stock x Treatment Source if available

In Case of EWOS vs Bio, there was only one year, and absent interaction with year,

all EWOS sources tested against subplot error

Table A.3. **Weighted Logistic Analysis of Variation of Mini-Jack Proportion of Pre-Release Male Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2010). Weight is number males from gender-tested/raceway.**

Source	Deviance	Degrees of Freedom	Mean Deviance	F-Ratio	Type 1 Error P
Year	116.86	8	14.61	11.80	**0.0006**
HxH vs NxN (Stock unadjusted[1])	6.89	1	6.89	1.34	0.2769
HxH vs NxN (Stock adjusted[1])	9.31	1	9.31	1.81	0.2114
Year x Stock	41.14	8	5.14	4.80	**0.0153**
Main Plot Error	9.64	9	1.07	0.87	0.5835

[1] Adjusted and undjusted for year

Subplot Analysis

Source	Deviance	Degrees of Freedom	Mean Deviance	F-Ratio	Type 1 Error P
Hi vs Lo (Treatment)	16.02	1	16.02	7.38	0.1130
Year x Hi vs Lo	4.34	2	2.17	1.31	0.4327
Stock x Hi vs Lo	1.9	1	1.90	1.15	0.3961
Year x Stock x Hi vs Lo	3.31	2	1.66	1.34	0.3102
EWOS vs Bio (Treatment)	0.24	1	0.24	0.19	0.6701
Stock x EWOS vs Bio	0.18	1	0.18	0.15	0.7118
STF vs Bio (Treatment)	0	1	0.00	0.00	1.0000
Year x STF vs Bio	0.97	4	0.24	0.33	0.8496
Stock x STF vs Bio	0.82	1	0.82	1.12	0.3490
Year x Stock x STF vs Bio x Year	2.92	4	0.73	0.59	0.6786
Subplot Error	11.14	9	1.24		

Note: In General, A Treatment Source is tested against a Year x Treatment Source if available

A Stock by Treatment Source is tested against a Year x Stock x Treatment Source if available

In Case of EWOS vs Bio, there was only one year, and absent interaction with year,

all EWOS sources tested against subplot error

Table A.4. Weighted Analysis of Variance of McNary-Dam Julian Detection Date of Passage of PIT-tagged Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2010)

Weight is expanded number of PIT-tagged fish passing McNary

Source	Sums of Squares	Degrees of Freedom	Mean Square	F-Ratio	Type 1 Error P
Year	715618611	8	8.95E+07	1.09E+05	**0.0000**
HxH vs NxN (Stock unadjusted[1])	**17633**	**1**	**17633.00**	**2.23**	0.1699
HxH vs NxN (Stock adjusted[1])	**47079**	**1**	**47079.00**	**5.94**	**0.0375**
Year x Stock	**63367**	**8**	**7920.88**	**3.34**	**0.0454**
Main Plot Error	21323.551	9	2369.28	2.88	0.0656

[1] **Adjusted and undjusted for year**

Subplot Analysis

Source	Deviance	Degrees of Freedom	Mean Deviance	F-Ratio	Type 1 Error P
Hi vs Lo (Treatment)	11326.1	1	11326.10	12.58	**0.0711**
Year x Hi vs Lo	1801.228	2	900.61	5.26	0.1596
Stock x Hi vs Lo	251.8	1	251.80	1.47	0.3489
Year x Stock x Hi vs Lo	342.1463	2	171.07	0.21	0.8162
EWOS vs Bio (Treatment)	4139.42	1	4139.42	5.03	0.0517
Stock x EWOS vs Bio	28.26	1	28.26	0.03	0.8571
STF vs Bio (Treatment)	868	1	868.00	0.19	0.6888
Year x STF vs Bio	18705.571	4	4676.39	2.47	0.1201
Stock x STF vs Bio	128	1	128.00	0.07	0.8079
Year x Stock x STF vs Bio x Year	7587.6025	4	1896.90	2.30	0.1373
Subplot Error	7411.0171	9	823.45		

Note: In General, A Treatment Source is tested against a Year x Treatment Source if available

A Stock by Treatment Source is tested against a Year x Stock x Treatment Source if available

In Case of EWOS vs Bio, there was only one year, and absent interaction with year,

all EWOS sources tested against subplot error

Table A.5. Weighted Logistic Analysis of Variation of <u>Proportion Released</u> (Pre-Release Survival) of PIT-tagged Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2010)

Weight is number of fish PIT-tagged/raceway.

Source	Deviance	Degrees of Freedom	Mean Deviance	F-Ratio	Type 1 Error P
Year	476.06	8	59.51	39.04	**0.0000**
HxH vs NxN (Stock unadjusted[1])	**172.86**	**1**	**172.86**	**4.25**	**0.0694**
HxH vs NxN (Stock adjusted[1])	**140.77**	**1**	**140.77**	**3.46**	**0.0959**
Year x Stock	**325.67**	**8**	**40.71**	**5.93**	**0.0076**
Main Plot Error	61.77	9	6.86	4.50	**0.0176**

[1] **Adjusted and undjusted for year**

Subplot Analysis

Source	Deviance	Degrees of Freedom	Mean Deviance	F-Ratio	Type 1 Error P
Hi vs Lo (Treatment)	10.68	1	10.68	28.86	**0.0329**
Year x Hi vs Lo	0.74	2	0.37	0.05	0.9523
Stock x Hi vs Lo	1.58	1	1.58	0.21	0.6890
Year x Stock x Hi vs Lo	14.76	2	7.38	4.84	**0.0374**
EWOS vs Bio (Treatment)	20.13	1	20.13	13.20	0.0055
Stock x EWOS vs Bio	4.22	1	4.22	2.77	0.1305
STF vs Bio (Treatment)	35.74	1	35.74	9.92	**0.0345**
Year x STF vs Bio	14.41	4	3.60	0.53	0.7181
Stock x STF vs Bio	2.31	1	2.31	0.34	0.5917
Year x Stock x STF vs Bio x Year	27.26	4	6.82	4.47	**0.0290**
Subplot Error	13.72	9	1.52		

Note: In General, A Treatment Source is tested against a Year x Treatment Source if available

A Stock by Treatment Source is tested against a Year x Stock x Treatment Source if available

In Case of EWOS vs Bio, there was only one year, and absent interaction with year,

all EWOS sources tested against subplot error

Table A.6. Weighted* Logistic Analysis of Variation of Volitional-Release-to-McNary-Dam Percent Smolt-to-Smolt Survival of PIT-tagged Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2010)

Weight is Number of Fish Detected at Release

Source	Deviance	Degrees of Freedom	Mean Deviance	F-Ratio	Type 1 Error P
Year	4436.37	8	554.55	238.34	**0.0000**
HxH vs NxN (Stock unadjusted[1])	101.57	1	101.57	4.20	**0.0707**
HxH vs NxN (Stock adjusted[1])	7.82	1	7.82	0.32	0.5835
Year x Stock	193.44	8	24.18	4.00	**0.0271**
Main Plot Error	54.47	9	6.05	2.60	**0.0853**

[1] Adjusted and undjusted for year

Subplot Analysis

Source	Deviance	Degrees of Freedom	Mean Deviance	F-Ratio	Type 1 Error P
Hi vs Lo (Treatment)	80.85	1	80.85	7.83	0.1075
Year x Hi vs Lo	20.65	2	10.33	3.70	0.2127
Stock x Hi vs Lo	0.34	1	0.34	0.12	0.7603
Year x Stock x Hi vs Lo	5.58	2	2.79	1.20	0.3454
EWOS vs Bio (Treatment)	5.82	1	5.82	2.50	0.1482
Stock x EWOS vs Bio	5.73	1	5.73	2.46	0.1510
STF vs Bio (Treatment)	1.54	1	1.54	0.10	0.7723
Year x STF vs Bio	64.26	4	16.07	0.80	0.5568
Stock x STF vs Bio	0.43	1	0.43	0.02	0.8910
Year x Stock x STF vs Bio x Year	80.73	4	20.18	8.67	**0.0037**
Subplot Error	20.94	9	2.33		

Note: In General, A Treatment Source is tested against a Year x Treatment Source if available

A Stock by Treatment Source is tested against a Year x Stock x Treatment Source if available

In Case of EWOS vs Bio, there was only one year, and absent interaction with year,

all EWOS sources tested against subplot error

Table A.7. **Weighted Logistic Analysis of Variation of Smolt-to-Adult Survival to Adult Return to Roza Dam for Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2008).**

Weight is Number Released

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance	F-Ratio	P (estimated Type 1 Error P)
Year	3875.49	6	645.92	188.16	**0.0000**
HxH vs NxN	15.62	1	15.62	0.33	0.5881
Year x Cross	286.48	6	47.75	13.91	**0.0001**
Lo vs Hi	31.91	1	31.91	9.30	**0.0111**
EWOS vs Vita	21.06	1	21.06	6.14	0.0307
STF vs Vita	0	1	0.00	0.00	1.0000
Pooled Error[1]	37.76	11	3.43		

[1] Pooled Year x Treatment Interactions Cross x Treatment Interactions and Error because F-ratios of those interactions against pooled error was near or less than 1

Note: In General, A Treatment Source is tested against a Year x Treatment Source if available

A Stock by Treatment Source is tested against a Year x Stock x Treatment Source if available

In Case of EWOS vs Bio, there was only one year, and absent interaction with year,

all EWOS sources tested against subplot error

Replicates had no individual matks, therefore adult main-plot and separate sub-plot partitions not possible

Appendix B. Adult assignment to Brood Year

A portion of adult returns was sampled for scale-age identification. A multivariate approach was used to create a discriminant function. Using the Age-3/Age-4 partition as an example, the discriminant was a weighting of the following standardized variables: fork-length (FL), post-orbital-to-hyperal length (POH), and fish weight (Wt). The standardization being the z-transformation performed for each variable's datum for the combined age-3 and age-4 data within each year:

Eq. B.1.
$$z(\text{within - year for given variable}) = \frac{(\text{datum value}) - \text{mean(age 3 and age 4)}}{\text{standard error (age 3 and 4)}}$$

Within each year, z values were proportionally weighted by common weights and added for each fish separately:

Eq. B.2.
$$\begin{gathered}\text{discriminant} = \text{w}(1) * \text{z(fl)} + \text{w}(2) * \text{z(POH)} + w(3) * z(wt) \\ \text{w}(1) + \text{w}(2) + \text{w}(3) = 1\end{gathered}$$

Each individual's weighted discriminant was assigned to the appropriate age category, and each category's mean and variance was estimated over the assigned values. For age-3 and age-4 fish, the decision was made to exclude any know-age fish of one age group if it had a weighted value that extended beyond the most proximal second quintile of the other age group, treating the excluded fish as an outlier under the assumption that the fish was likely misidentified as to age group. Means and standard deviations were then recalculated The proportional weights that were chosen were those that minimized the estimated probability of erroneously allocating a fish of known-age fish to the wrong age group based on the assumed overlapping normal distributions of the two age groups.

The basis of the selection of the discriminant was not based on normal-distribution probabilities; rather it was based on the actual proportion of known-age adults that were misclassified. It turned out that using FL by itself gave the smallest probability of misclassification in all but two brood years (2006 and 2009), but the misclassification probabilities of the "better" proportional weights differed only marginally from the FL-based discriminant. There were discriminants in several of the brood-years that gave the same probability of misclassification as the FL discriminant. Based on these findings, I decided to use the sole-FL discriminant for all years

There were an insufficient number of known age-5 fish to use this procedure for each brood year separately. I did perform the same within-year z transform (Equation B.1), but then pooled them over brood years and formed a FL discriminant. The discriminant was then retransformed to the specific within-brood-year age-4 and age-5 means and standard deviations; therefore, the discriminant was still unique to the brood year. The discriminant values are given in the following table:

Fork Length Discriminant Values

Return Year	Age 3 and 4 Discriminant	Age 4 and 5 Discriminant
2005	57.34	83.91
2006	55.99	78.30
2007	58.88	83.40
2008	61.62	81.03
2009	62.56	83.04
2010	59.65	81.89
2011	60.25	84.01
2012	57.32	80.89

These discriminates were then used to assign the unknown-age fish to an age group.

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Appendix F

2012 Annual Report: Smolt-to-Smolt Survival to McNary Dam of Yakima Fall and Summer Chinook

Doug Neeley, Consultant to Yakama Nation

Introduction

In out-migration year 2008 through 2012, subyearling and yearling Yakima-stock Fall Chinook were released from Prosser. Summer Chinook subyearlings were released from Stiles pond in outmigration-years 2009 and 2011, from Buckskin Slough in 2011 and 2012, and from Marion Drain in 2012. In 2012 the Stiles releases were discontinued and shifted to Prosser.

The analyses presented in this report are for:

1. Fall Chinook - Estimation of release-year 2008 through 2012 smolt survival and dates of release and of McNary-Dam detection with formal comparisons between the subyearling and yearling estimates.
2. Summer Chinook - Estimation of migration-year 2009 and 2012 smolt survival and of dates-of-release and of McNary-Dam detection of subyearlings.

Levels of significance given in this report are from analyses of variation tables presented in Appendix A. A comparison is referred to as significant if the comparison is significantly different from zero at the 5% level ($p < 0.05$). Estimation procedures are presented in Appendix B.

For releases from ponds with PIT-tag detectors at their outfalls, survival is partitioned into pre-release survival and release-to-McNary survival, the latter being the proportion of fish detected at release that survive to McNary. Comparisons with releases having no estimation of pre-release survival use as a survival measure the proportion of fish tagged that survive to McNary Dam.

Fall and Summer Chinook data summaries are presented in a common section titled Tables and Figures following discussions in separate sections on the fall and summer runs (sections respective titled Subyearling and Yearling Fall Chinook Releases and Summer Chinook Releases**).**

Subyearling and Yearling Fall Chinook Releases

Pre-Release Survival

There was no significant or substantial difference between subyearling and yearling mean Pre-Release Survivals (Figure and Table 1, $p = 0.31$ from Appendix A - Table A.1).

Release-to-McNary Survival

For the 2008 through 2012 releases, the Release-to-McNary survival estimates are given in Figure and Table 2.a and the Tagging-to-McNary Survival estimates are given in Figure 2.b. The yearling-release survival estimates have been consistently and significantly higher than the subyearling-release survival estimates ($p =0.0041$ and $p < 0.0001$ respectively for Release-to-McNary and Tagging-to-McNary survivals from Table A.2.a and A.2.b of Appendix A) with no statistical evidence of interaction with years ($p = 0.77$ and $p = 0.79$ from the same respective tables).

Dates of Release and McNary Passage Dates

While the mean Yearling–Subyearling Julian volitional release dates did not significantly differ (Figure and Table 3.a; $p = 0.21$, Table A 3.a of Appendix A), the sub-yearling Fall Chinook McNary passage dates were consistently later than the yearling (Figure and Table 3.b, $p = 0.0164$ from Table A.3.b), the magnitudes of these differences differing over years (interaction-with-years $p < 0.0001$).

Summer Chinook Releases

Pre-Release Survival

Estimates are presented in Figure and Table 1 for those sites (Stiles and Prosser) having PIT-tag detectors at the site outfalls.

Survival to McNary

Estimates for release-to-McNary survivals from Stiles and Prosser are presented in Table and Figure 2.a. The Summer Chinook, released as subyearlings from Stiles Pond in 2009, had an abysmal release-to-McNary survival rate, 1.8%; whereas there have been substantial increases in survival in subsequent years. The low survivals in 2009 may be attributed to a couple of factors:

- late volitional Summer Chinook release date (June 22 in 2009 versus May dates in subsequent years, given as Julian dates in Table 3.a) and associated later McNary passage in 2009 (Table 3.b), and
- the blockage of some diversion bypasses in 2009 in irrigation canals up-stream of the Prosser project resulting in fish stranding.

Releases were also made into Buckskin Slough in 2011 and 2012 and into Marion Drain in 2012. Release numbers of fish were the number of PIT-tagged fish directly released as opposed to the number of fish detected leaving a rearing pond (which was the case for releases from Stiles Pond and Prosser). For comparisons between the Stiles-Prosser releases and the Buckskin-Marion releases, Tagging-to-McNary Survivals are presented in Figure and Table 2.b. As can be seen, the Buckskin release's survival was slightly higher than the corresponding survival from Stiles in 2011[1], but the survivals from the Buckskin and Marion Drain releases were much higher than the Prosser survivals in 2012[2] (Figure and Table 2.b).

Dates of Release and McNary Passage Dates

Mean dates of release into Buckskin Slough in 2011 were considerably earlier than mean date of volitional release from Stiles pond in 2011 (single Julian Release Date 121 versus mean volitional-release-date 147); however mean date of passage at McNary Dam was considerably later for the Buckskin releases than for the Stiles volitional releases (Julian McNary Passage Date 171 versus 155). It appears that the Buckskin Slough 2011 releases held much longer in the Upper Yakima River than did the Stiles releases[3]. The mean dates of McNary Passage are nearly identical for the Buckskin, Marion Drain, and Prosser releases (Table 3.b).

---

[1] The 2011 Buckskin Tagging-McNary survival estimate being 43.4% compared to 40.3% for Stiles; however the Stiles Release-to-McNary estimate was 43.5%, nearly identical to the Buckskin Tagging-to-McNary estimate.

[2] The 2012 Buckskin and Marion Drain respective Tagging-to-McNary survivals of 37.0% and 35.7% were substantially higher than Prosser's Tagging-to-McNary and Release-to McNary survivals of 20.7% and 26.7%, respectively.

[3] There were two sets of Buckskin Slough releases, one on Julian Date 119 and the other on Julian Date 122; the earlier release's mean McNary Detection date was also earlier (Julian date 170 versus 174 for the later release).

Figures and Tables

Figure 1. 2008-2012 Pre-Release Survival (survival from tagging to release)

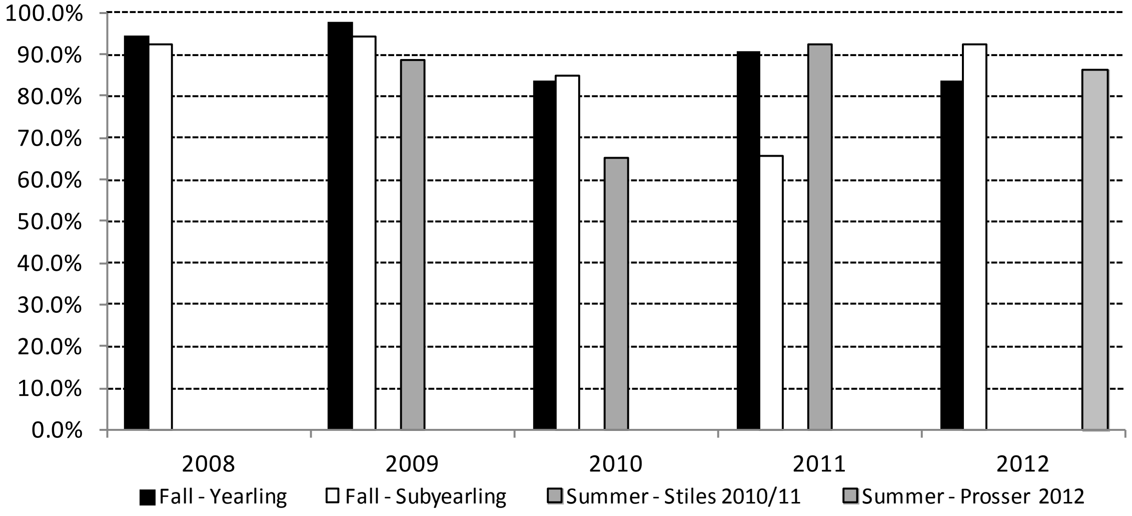

Table 1. 2008-2012 Pre-Release-Survival* (from tagging to release)

Year	Measure	Fall Chinook (Prosser)		Summer Chinook			
		Yearling	Subyearling	(Stiles)	(Buckskin Slough)	(Marion)	(Prosser
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.		
2012	**Pre-Release Survival**	**83.8%**	**90.0%**				**86.5%**
	Number Tagged	19,435	22,790		n.a	n.a	9,999

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

Figures and Tables (continued)

Figure 2.a. 2008-2012 Smolt Survival to McNary of Fish detected at Release

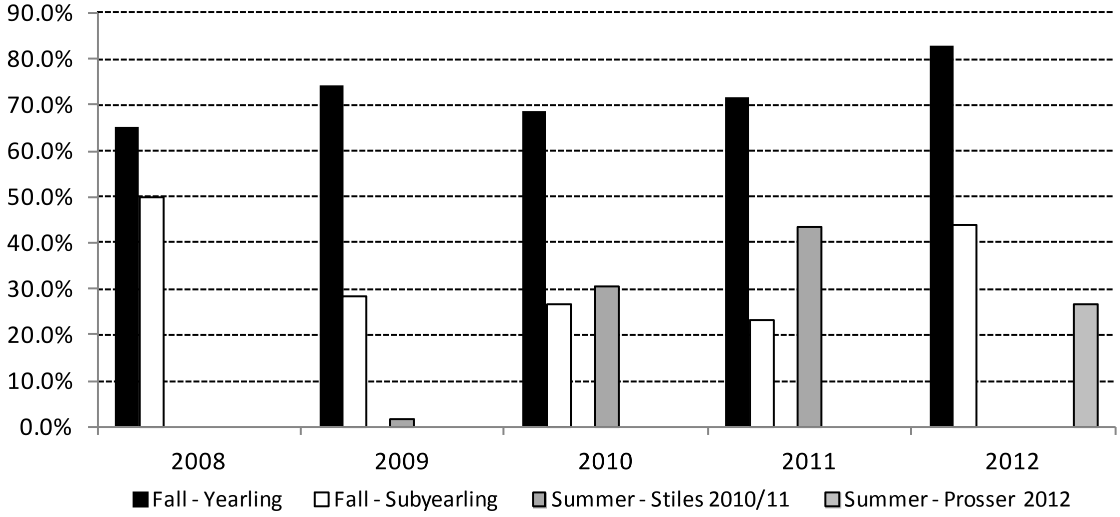

Table 2.a. 2008-2012 Smolt Survival to McNary of Tagged detected at Release

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

Figures and Tables (continued)

Figure 2.b. 2008-2012 Smolt Survival to McNary of all Tagged Fish

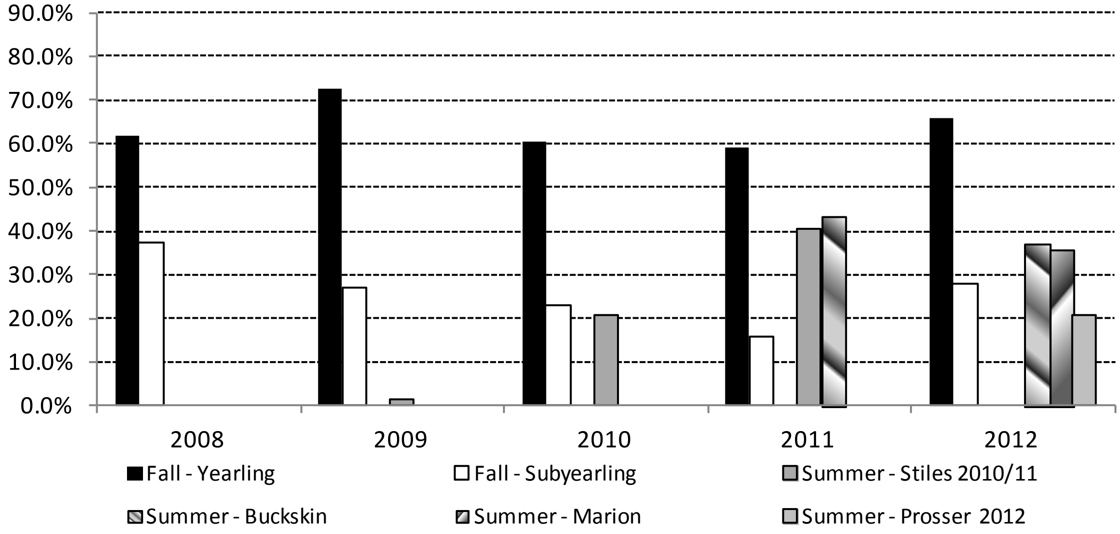

Table 2.b. 2008-2012 Smolt Survival to McNary of all Tagged Fish

		Fall Chinook		Summer Chinook			
		(Prosser)					
Year	**Measure**	**Yearling**	**Subyearling**	**(Stiles)**	**(Buckskin Slough)**	**(Marion)**	**(Prosser)**
2008	**Tagging-to-McNary Survival**	**61.6%**	**37.4%**				
	Number Tagged	1,831	10,003				
2009	**Tagging-to-McNary Survival**	**72.4%**	**26.8%**	**1.5%**			
	Number Tagged	7,516	5,813	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		
2012	**Tagging-to-McNary Survival**	**65.6%**	**27.9%**		**37.0%**	**35.7%**	**20.7%**
	Number Tagged	19,435	19,634		9,999	9,998	9,999

Figures and Tables (continued)

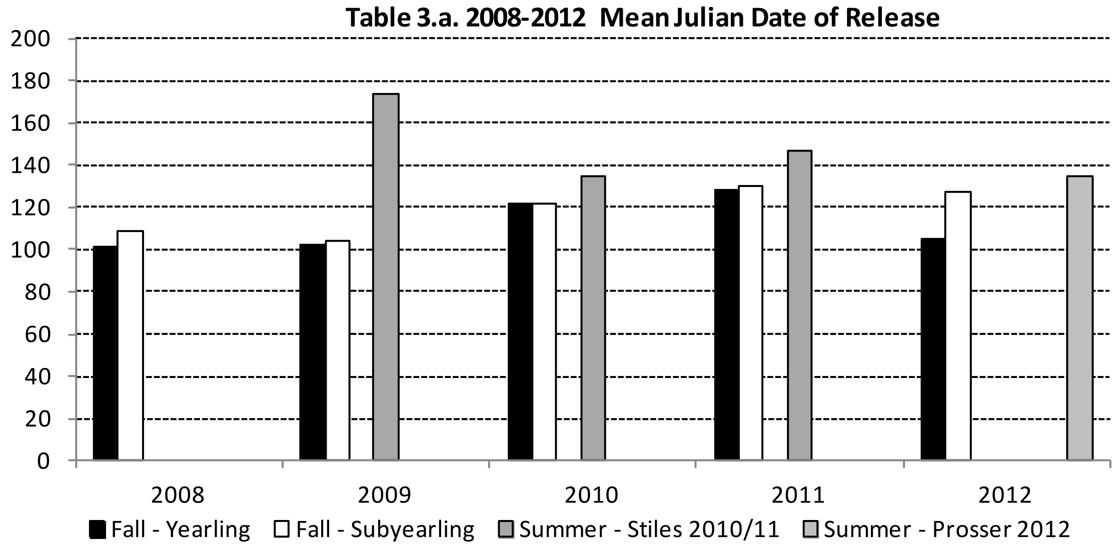
Table 3.a. 2008-2012 Mean Julian Date of Release

Table 3.a. 2008-2012 Mean Julian Date of Release

		Fall Chinook (Prosser)		Summer Chinook			
Year	**Measure**	**Yearling**	**Subyearling**	**(Stiles)**	**(Buckskin Slough)**	**(Marion)**	**(Prosser**
2008	**Mean Release Date**	**101**	**109**				
	Number Released	1706	6187				
2009	**Mean Release Date**	**102**	**104**	**173**			
	Number Released	4659	5777	17054			
2010	**Mean Release Date**	**122**	**122**	**135**			
	Number Released	5327	4324	5669			
2011	**Mean Release Date**	**128**	**130**	**147**			
	Number Released	9442	7007	14748	n.a.		
2012	**Mean Release Date**	**105**	**127**				**135**
	Number Released	9627	3508		n.a.	n.a.	3509

Figures and Tables (continued)

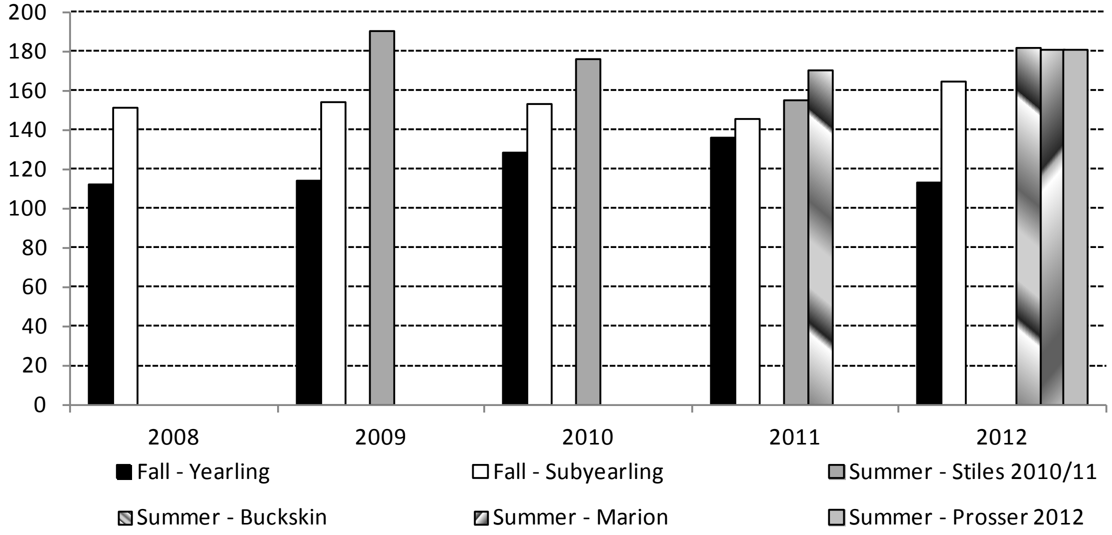

Figure 3.b. 2008-2012 Mean Julian Date of all tagged Smolt detected passing McNary

Table 3.b. 2008-2012 Mean Julian Date* of all Tagged Fish passing McNary

		Fall Chinook (Prosser)		**Summer Chinook**			
Year	**Measure**	**Yearling**	**Subyearling**	**(Stiles)**	**(Buckskin Slough)**	**(Marion)**	**(Prosser**
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		
2012	**Mean McNary Detection Date**	**113**	**164**		**182**	**181**	**181**
	Expanded Passage number	12,752	5,474		3,704	3,565	2,073

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

Appendix A: Logistic Analyses of Variance of Survivals and Least Squares Analyses of Variance of Volitional Dates of Release and McNary Dam Dates of Passage for Fall Chinook

Table A.1. Logistic Analysis of Variation for Pre-Release Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Estimated Type Error P
Year	4417.89	4	1104	0.82	0.54121
Subyearling vs Yearling	1816.63	1	1817	1.35	0.31014 *
Year x (Subyearling vs Yearling)	2886.06	4	722	0.54	0.7131
Residual	13472.75	10	1347		

* Tested against Residual because Year x (Subyearling vs Yearling) interaction F < 1

Table A.2.a. Logistic Analysis of Variation for Release-to-McNary Smolt-to-Smolt Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Estimated Type Error P
Year	2031	4	508	1.88	0.1909
Subyearling vs Yearling	9431	1	9431	34.88	0.0041 *
Year x (Subyearling vs Yearling)	485	4	121	0.45	0.7718
Residual	2704	10	270		

* Tested against Residual because Year x (Subyearling vs Yearling) interaction F < 1

Table A.2.b. Logistic Analysis of Variation for Tagging-to-McNary Smolt-to-Smolt Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Estimated Type Error P
Year	1085	4	271	0.99	0.4558
Subyearling vs Yearling	22323	1	22323	81.55	0.0000 *
Year x (Subyearling vs Yearling)	459	4	115	0.42	0.7916
Residual	2738	10	274		

* Tested against Residual because Year x (Subyearling vs Yearling) interaction F < 1

Table A.3.a. Least Squares Analysis of Variance for Julian Date of Volitional Release

Source	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-Ratio	Estimated Type 1 Error P
Year	5744051	4	1436013	45.29	0.00000
Subyearling vs Yearling	496543	1	496543	2.26	0.20745 *
Year x (Subyearling vs Yearling)	880105	4	220026	6.94	0.0061
Residual	317094	10	31709		

* Tested against Year x (Subyearling versus Yearling) Interaction because Interaction F >1

Appendix A (continued)

Table A.3.b. Least Squares Analysis of Variance for Julian Date of McNary Passage

Source	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-Ratio	Estimated Type 1 Error P
Year	1710000	4	427500	18.84	0.00012
Subyearling vs Yearling	12315659	1	12315659	15.70	0.01664 *
Year x (Subyearling vs Yearling)	3137403	4	784351	34.56	0.0000
Residual	226938	10	22694		

* Tested against Year x (Subyearling versus Yearling) Interaction because Interaction F >1

Appendix B. Estimated Survival Index

Conceptual Computation

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

1. Identifying time-of-passage strata within which estimated daily McNary detection rates of Fall Chinook are reasonably homogeneous. (Daily McNary detection rate is the proportion of all Yakima PIT-tagged Fall Chinook passing McNary Dam for each day that are detected at McNary)

2. Estimating the McNary detection rate for each stratum

3. Expanding (dividing) the given release's number[4] of detected fish not removed for transportation at McNary by the detection rate within the associated stratum and adjusting for the number removed for transportation[5]

4. Totaling the release's expanded numbers over strata

5. Taking that release's expanded total and dividing it by the appropriate "population number[6]"

---

[4] 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.

[5] Adjustments are given in Equation B.2, but so few (usually none) of the fish detected at McNary were transported from 2007 through 2009 that the adjustment was not made.

[6] 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.

The methods of identifying strata and estimating the individual stratum detection rates at McNary are discussed in my 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.)

Equation B.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 B.2.

$$\text{Smolt - to - Smolt Survival to McNary for a given release (Rel)}$$

$$=$$

$$\frac{\sum\limits_{\text{strata}} \text{For Stratum}\left[\dfrac{\text{(McNary Rel Detections - Rel Detections Removed)}}{\text{Stratum's McNary Detection Rate (Equation B.1)}} + \text{Detections Rel Removed}\right]}{\text{Rel Number of Fish Tagged or Released}}$$

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

Equation B.3.

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

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

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

The denominator with [ ] 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 efficiencies estimates based on the expanded detection numbers that resulted in survival estimates slightly exceeding 100%. While this also happened using the unexpanded numbers, the occurrence was even less; therefore the unexpanded numbers were used.

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Appendix G

Annual Report: 2012 Coho Smolt-to-Smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin

Doug Neeley, Consultant to Yakama Nation

Introduction and Summary

In every year since and including 2006 there have been releases of Yakima-Return (Yakima) and Eagle-Creek-Hatchery (Eagle Creek) stock. In 2011 there were three releases of a Yakima x Eagle Creek cross. One of those cross releases (at Stiles) was made with no accompanying Yakima or Eagle Creek stock release. The cross releases in that year at both Easton and Lost Creek were accompanied by a Yakima release and, at Easton, the cross was also accompanied by an Eagle Creek release, the only Eagle Creek release made in that year.

With the 2011 Stiles-release exception, all sites had Yakima releases. All Eagle Creek releases were accompanied by Yakima releases, permitting paired comparisons for each site in each year having an Eagle Creek release.

Survival Estimates based on detected Volitional Releases

In the presence of PIT-tag detectors located in the out-falls from the release sites, it is possible to bifurcate the survival of smolt from the time of tagging to the time of McNary Dam (McNary) passage into two portions: 1) Survival from the time of tagging to the time of release (referred to herein as Pre-release Survival); and 2) survival from time of volitional release to time of McNary passage (referred to herein as Release-to-McNary Survival).

Pre-release Survival

Pre-release survival estimates are the estimated proportions of juveniles that survive from the time of tagging to the time of volitional release. The estimate is the proportion of PIT-tagged smolt detected leaving the pond divided by the pond's detection efficiency. That estimated detection efficiency is the number of McNary-detected smolt previously detected leaving the rearing pond divided by the total number of the McNary-detected smolt tagged.

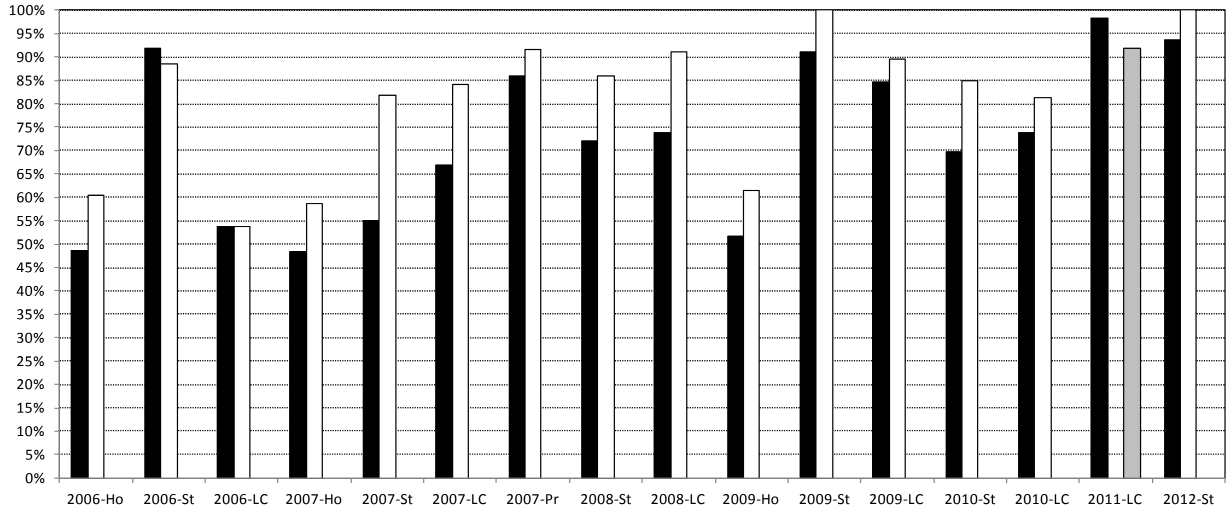
Estimates of pre-release survival are presented in Table 1 for all relevant releases and in Figure 1 for those sites having releases of two or more of the following stock: Yakima, Eagle Creek, or their cross. From Figure 1, it can seen that Eagle-Creek stock had higher Pre-release survivals than Yakima stock in all but 1 of the 15 paired volitional releases measured, the exception being the Stiles releases in 2006, 1/15 being highly significantly less than 0.5 (p = 0.0005). In the only release (2011 at Lost Creek) for which the pre-release survival estimates were possible for both Yakima and Yakima x Eagle Creek Cross, the Yakima Stock had higher pre-release survival.

Table 1. Outmigration-Year 2006-2012 (2004-2010 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	Cle Elum	Taneum Creek	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
	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		

* No viable estimate because of low proportion (3.68%) detected at pond and low number (4) of pond-detected fish detected at McNary Dam

Figure 1. **2006-2012 Outmigration-Year (2004-20010 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)

Volitional-Release to McNary Dam Survival

This is an estimate of the survival of those smolt detected leaving the rearing pond that eventually pass McNary Dam. It is basically[1] the proportion of those PIT-tagged smolt detected leaving the rearing pond that are later detected at McNary Dam divided by McNary's detection efficiency. That estimated detection efficiency is the number of smolt detected passing dams downstream of McNary that were previously detected passing McNary divided by the total number of the smolt passing the downstream dams[2], whether or not the smolt were previously detected at McNary. In this study, Detection efficiencies were based on the detections of all PIT-tagged smolt released into the Yakima basin, not just the smolt associated with the individual release sites.

Estimates of release-to-McNary survival are presented in Table 2 for all releases and in Figure 2 for those sites having two or more of Yakima Stock, Eagle Creek Stock, or their cross. Where Yakima/Eagle Creek paired releases were made, Yakima stock survival was higher than that of Eagle Creek stock for all 15 paired-release sites at which there were PIT-tag detectors[3], 15/15 being highly significantly greater than 0.5 ($p < 0.0001$). In the only release (2011 at Lost Creek) for which the

---

[1] The estimation is somewhat complicated in that detection efficiencies are estimated within time strata, within which days have relatively homogeneous McNary detection efficiencies. Therefore the expansions of the number smolt detected at McNary is performed 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.

[2] John Day and Bonneville Dams

[3] It can be seen that not all sites within a year had paired releases.

survival estimates were possible, the Yakima Stock had a lower survival than did the Yakima x Eagle Creek Cross.

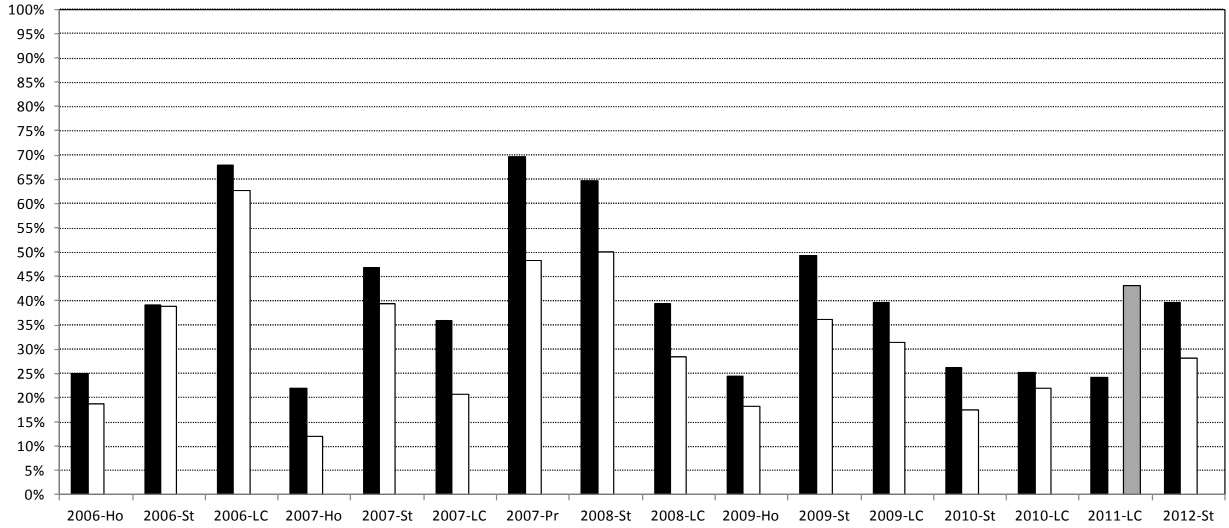
Table 2. Outmigration-Year 2006-2012 (2004-2010 Brood) Release-to-McNary Survival of Pit-Tagged Coho Smolt

			Release-Site Subbasin and Pond within Subbasin					
			Upper Yakima			Naches		Main Stem Yakima
Release Year	Stock	Measure	Holmes	Cle Elum	Taneum Creek	Stiles	Lost Creek	Prosser
2006	**Yakima**	**Survival from Release to McNary**	**25.01%**			**39.15%**	**68.02%**	
		Number Volitionally Released	781			1598	1057	
	Eagle Creek	**Survival from Release to McNary**	**18.62%**			**38.81%**	**62.66%**	**74.78%**
		Number Volitionally Released	636			1974	1663	912
2007	**Yakima**	**Survival from Release to McNary**	**22.01%**			**46.76%**	**35.83%**	**69.75%**
		Number Volitionally Released	920			1204	1671	2112
	Eagle Creek	**Survival from Release to McNary**	**12.02%**			**39.39%**	**20.68%**	**48.35%**
		Number Volitionally Released	1293			1881	2092	1136
2008	**Yakima**	**Survival from Release to McNary**				**64.75%**	**39.25%**	
		Number Volitionally Released				1731	1633	
	Eagle Creek	**Survival from Release to McNary**				**50.09%**	**28.37%**	**5.53%**
		Number Volitionally Released				2110	1956	507
2009	**Yakima**	**Survival from Release to McNary**	**24.38%**	*		**49.24%**	**39.61%**	**58.14%**
		Number Volitionally Released	48	193		696	2053	2299
	Eagle Creek	**Survival from Release to McNary**	**18.29%**			**36.23%**	**31.32%**	
		Number Volitionally Released	130			908	1946	
2010	**Yakima**	**Survival from Release to McNary**				**26.24%**	**25.10%**	**81.15%**
		Number Volitionally Released				1580	1519	1210
	Eagle Creek	**Survival from Release to McNary**				**17.41%**	**21.88%**	
		Number Volitionally Released				1836	1801	
2011	**Yakima**	**Survival from Release to McNary**			**14.46%**		**24.31%**	**36.92%**
		Number Volitionally Released			166 *		1488	2497
	Yakima x Eagle Creek	**Survival from Release to McNary**				**41.30%**	**42.97%**	
		Number Volitionally Released				1184	1374	
2012	**Yakima**	**Survival from Release to McNary**				**39.70%**	**36.59%**	**47.66%**
		Number Volitionally Released				929	1531	731
	Eagle Creek	**Survival from Release to McNary**				**28.06%**		
		Number Volitionally Released				683		

*** No detections at NcNary**

*** Based on low unexpanded number (4) of pond-detected fish detected at McNary**

Figure 2. **2006-2012 Outmigration-Year (2004-20010 Brood-Year) <u>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)

Estimates based on all Releases

Since not all release sites had PIT-tag detectors, the un-bifurcated time-of-tagging-to-McNary survival was also estimated for each release pair. Also the Julian date of McNary passage was estimated using all PIT-tagged smolt detected passing McNary instead of those previously detected leaving rearing ponds. Both of these measures used the same stratified detection-rate procedures described earlier.

Tagging to McNary Dam Survival

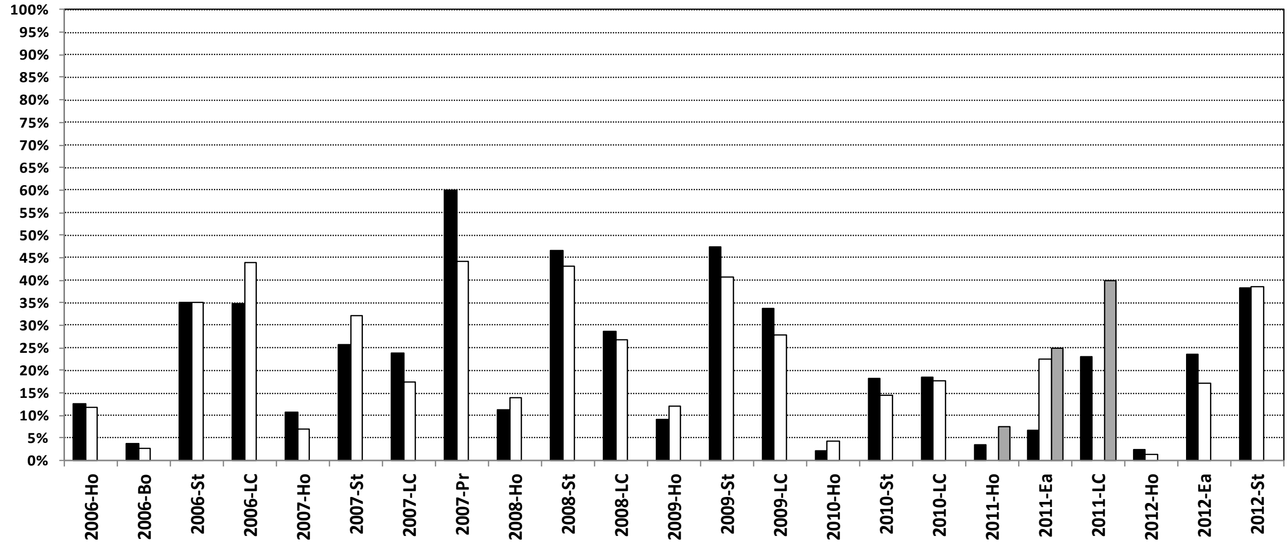
Estimates of Tagging-to-McNary Survival are presented in Table 3 for all releases and in Figure 3 for those sites having two or more of Yakima Stock, Eagle Creek Stock, or their cross. Yakima stock had higher survival than Eagle Creek Stock in only 13 of the 21 paired releases, 13/21 being not significantly greater than 0.5 (p = 0.1917). This is not surprising; recall that, although the Yakima brood had the highest Volitional-Release-to-McNary Survival for all releases, the Eagle Creek brood had the highest Pre-release survival in all but one release for which paired estimates were available. In the two sets of 2011 releases (Lost Creek and Easton) for which the survival estimates were possible, the Yakima Stock had a lower survival than did the Yakima x Eagle Creek cross. For the Easton Site, the Yakima Stock had a much lower survival than did the cross and also a much lower survival than the Eagle Creek stock.

Table 3. Outmigration-Year 2006-2012 (2004-2010 Brood) <u>Time of Tagging-to-McNary Survival</u> of Pit-Tagged Coho Smolt

			Release-Site Subbasin and Pond within Subbasin					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	Marion Drain
2006	**Yakima**	**Tagging-to-McNary Survival**	**12.48%**	**3.69%**				**34.99%**	**34.76%**		
		Number Tagged	2512	2501				2490	2491		
	Eagle Creek	**Tagging-to-McNary Survival**	**11.82%**	**2.57%**				**35.05%**	**43.81%**	**60.52%**	
		Number Tagged	2514	2500				2506	2515	1231	
2007	**Yakima**	**Tagging-to-McNary Survival**	**10.77%**					**25.65%**	**23.94%**	**59.84%**	
		Number Tagged	2460					2449	2501	2499	
	Eagle Creek	**Tagging-to-McNary Survival**	**7.08%**					**32.07%**	**17.39%**	**44.30%**	
		Number Tagged	2504					2513	2511	1246	
2008	**Yakima**	**Tagging-to-McNary Survival**	**11.17%**					**46.59%**	**28.58%**		**26.18%**
		Number Tagged	2493					2492	2499		3013
	Eagle Creek	**Tagging-to-McNary Survival**	**13.89%**				**41.45%**	**43.08%**	**26.76%**	**20.13%**	
		Number Tagged	2508				2500	2453	2524	854	
2009	**Yakima**	**Tagging-to-McNary Survival**	**9.19%**		**0.21%**	**15.67%**		**47.27%**	**33.70%**	**56.76%**	
		Number Tagged	2512		11934	1300		2515	2508	2506	
	Eagle Creek	**Tagging-to-McNary Survival**	**12.01%**				**16.38%**	**40.80%**	**27.76%**		
		Number Tagged	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			

*** Reared at Egle Creek**

Figure 3. **2006-2012 Outmigration-Year (2004-20010 Brood-Year) <u>Time-of-Tagging-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): Holmes (Ho), Boone's Pond ((b0) Stiles (St), and Lost Creek (LC), and Prosser (Pr)

Mean Date of McNary Dam Passage

The weighted mean Julian Date of McNary passage was estimated by weighting the Julian date of detection by the expanded number of all passing 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 detection efficiency associated with that date. These weighted dates were then added over days and then divided by the total of the expanded daily passages.

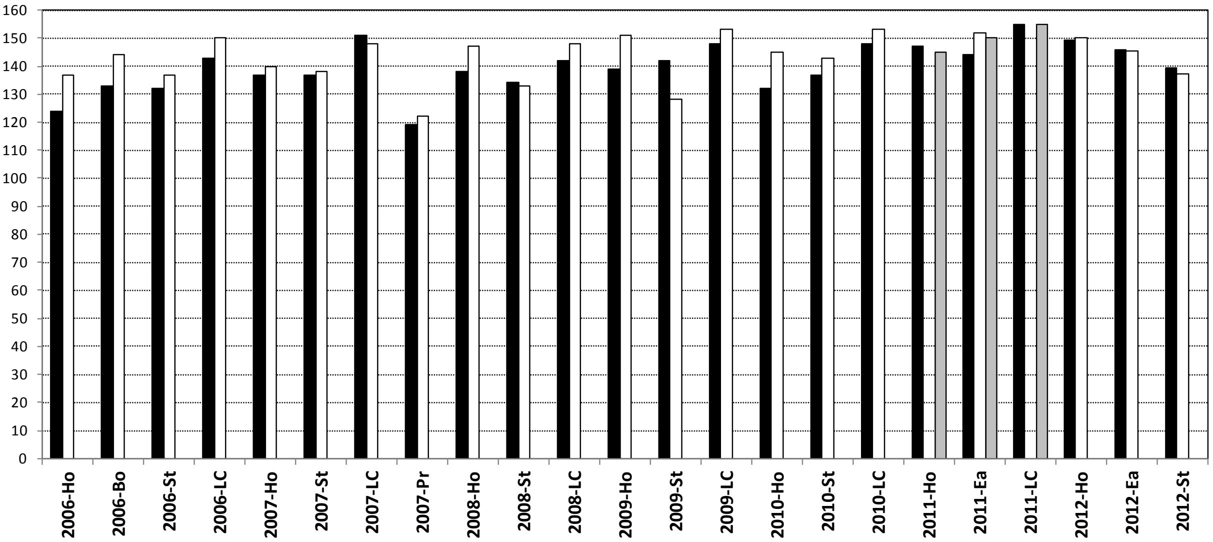
Estimates of Julian Date of McNary passage are presented in Table 4 for all releases and in Figure 4 for those sites having two or more of Yakima Stock, Eagle Creek Stock, or their cross. For 16 out of the 21 paired releases, the Yakima-brood's mean McNary passage date was earlier than the Eagle Creek Stock, 16/21 being significantly greater than 0.5 (p = 0.0133).

Table 4. Outmigration-Year 2006-2012 (2004-2010 Brood) Mean McNary Date of Passage of Pit-Tagged Coho Smolt

			Release-Site Subbasin and Pond within Subbasin					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	Marion Drain
2006	**Yakima**	**Passage Date**	**124**	**133**				**132**	**143**		
		Expanded McNary Passage	313	92				871	865		
	Eagle Creek	**Passage Date**	**137**	**144**				**137**	**150**	**122**	
		Expanded McNary Passage	297	64				878	110	744	
2007	**Yakima**	**Passage Date**	**137**					**137**	**151**	**119**	
		Expanded McNary Passage	265					628	598	1495	
	Eagle Creek	**Passage Date**	**140**					**138**	**148**	**122**	
		Expanded McNary Passage	177					805	436	552	
2008	**Yakima**	**Passage Date**	**138**					**134**	**142**		**122**
		Expanded McNary Passage	278					116	714		788
	Eagle Creek	**Passage Date**	**147**				**135**	**133**	**148**	**142**	
		Expanded McNary Passage	348				1036	105	675	171	
2009	**Yakima**	**Passage Date**	**139**		**164**	**160**		**142**	**148**	**133**	
		Expanded McNary Passage	230		25	204		1188	845	1422	
	Eagle Creek	**Passage Date**	**151**				**147**	**128**	**153**		
		Expanded McNary Passage	171				413	1532	647		
2010	**Yakima**	**Passage Date**	**132**			**168**		**137**	**148**	**118**	
		Expanded McNary Passage	57			185		454	462	980	
	Eagle Creek	**Passage Date**	**145**	**155**			**144**	**143**	**153**		
		Expanded McNary Passage	108	43			143	372	447		
2011	**Yakima**	**Passage Date**	**147**			**162**	**144**		**155**	**124**	
		Expanded McNary Passage	2516			4515	1272		2500	5036	
	Eagle Creek	**Passage Date**					**152**				
		Expanded McNary Passage					2561				
	Yakima x Eagle Creek	**Passage Date**	**145**				**150**	**143**	**155**		
		Expanded McNary Passage	2506				**2522**	2524	2514		
2012	**Yakima**	**Passage Date**	**149**				**146**	**139**	**123**	**124**	
		Expanded McNary Passage	58				538	939	792	484	
	Yakima*	**Passage Date**					**148**				
		Expanded McNary Passage					377				
	Eagle Creek	**Passage Date**	**150**				**146**	**137**			
		Expanded McNary Passage	65				496	1001			

*** Reared at Eagle Creek**

Figure 4. **2006-2012 Outmigration-Year (2004-20010 Brood-Year) <u>Mean Julian Date of Passage</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): Holmes (Ho), Boone's Pond ((b0) Stiles (St), and Lost Creek (LC), and Prosser (Pr)

In-Basin Releases

There were releases of parr and smolt directly into streams and rivers. The method of estimating these survivals to McNary was the same as the method used to estimate the survival of smolt volitionally leaving the rearing ponds except the number released were the number directly released into the streams—the smolt did not volitionally enter the stream. The release-to-McNary survival estimates are given in Table 5.a. and the mean McNary passage dates are given in Table 5.b.

Table 5.a. Outmigration-Year 2010-2011 In-Basin Tagging Release-to-McNary 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	
		Survival from Tagging to McNary	8.18%	12.06%	69.42%	13.79%	23.29%	17.25%	
		Number Tagged	1144	3053	16	3055	1248	3004	
2011	Yakima	File Extender		PLR-Parr	WNL-Parr *	PNL-Parr	MCW-Smolt	PCW-Parr	WCW-Parr
		Survival from Tagging to McNary		7.97%	69.45%	7.46%	31.50%	19.54%	81.99%
		Number Tagged		3000	16	3110	1272	3021	28
2012	Yakima	File Extender	MRS-Smolt	PLR-Parr		PNL-Parr	MCW-Smolt	PCS-Parr	
		Survival from Tagging to McNary	16.22%	8.39%		8.28%	41.05%	11.86%	
		Number Tagged	1274	3006		3017	1277	3024	
		Pooled Survival					20.52%		
		Pooled Number Tagged					4301		

*** High percentage based on very small sample size**

Release Year	Stock	Measure	Ahtanum	Big Creek	Reecer	Little Naches	Lost Creek	Wilson	NF Little Naches
2010	Yakima	File Extender	PAH-Parr	PBG-Parr	PRC-Parr	PLN-Parr		PWL-Parr	PNF-Parr
		Survival from Tagging to McNary	20.18%	10.49%	21.47%	17.87%		11.32%	19.72%
		Number Tagged	3050	3006	3015	3072		3050	3014
2011	Yakima	File Extender	PAH-Parr	PBG-Parr	PRC-Parr	PLN-Parr	WLC-Parr *	PWL-Parr	PNF-Parr
		Survival from Tagging to McNary	18.87%	15.81%	29.61%	9.54%	57.39%	16.93%	17.59%
		Number Tagged	3003	3003	3004	3022	10	2522	3058
2012	Yakima	File Extender	PAL-Parr	PBG-Parr	PRE*-Parr	PLN-Parr		PWI-Parr	PNF-Parr
		Survival from Tagging to McNary	5.42%	11.59%	19.43%	21.91%		11.02%	19.12%
		Number Tagged	4003	3013	3026	3014		3020	3028

*** High percentage based on very small sample size**

Release Year	Stock	Measure	Rock Creek	Buckskin	Quarts	Thorp Bridge	Umtanum Creek	Creek Mark/Recap	Easton Pond
2009	Yakima	File Extender					UMT	TAN	EY1
		Survival from Tagging to McNary					44.32%	15.67%	
		Number Tagged					150	1300	
2010	Yakima	File Extender	WRK-Wild				UMT-Parr	TAN-Parr	
		Survival from Tagging to McNary	0.00%				34.95%	9.89%	
		Number Tagged	78				42	1867	
2011	Yakima	File Extender		WBK-Parr				TAN	
		Survival from Tagging to McNary		37.95%				13.64%	6.74%
		Number Tagged		216				4515	1272
2012	Yakima	File Extender			PQU-Parr	PYA-Parr		COT	
		Survival from Tagging to McNary			12.09%	10.68%		26.48%	
		Number Tagged			3008	2499		1054	

Table 5.b. Outmigration-Year 2010-2011 In-Basin Release Mean Julian Passage Date of Tagged Smolt at McNary Dam

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	
		McNary Julian Detection Date	166	155	171	159	149	166	
		Expanded Passage	94	368	11	421	1248	3004	
2011	Yakima	Expanded Passage		PLR-Parr	WNL-Parr *	PNL-Parr	MCW-Smolt	PCW-Parr	WCW-Parr
		McNary Julian Detection Date		154	165	163	156	162	144
		Expanded Passage		239	11	232	401	590	23
2012	Yakima	File Extender	MRS-Smolt	PLR-Parr		PNL-Parr	MCW-Smolt	PCS-Parr	
		McNary Julian Detection Date	147	155		157	147	155	
		Expanded Passage	207	252		250	524	359	
		Pooled Survival					150		
		Pooled Expanded Passage					883		

Release Year	Stock	Measure	Ahtanum	Big Creek	Reecer	Little Naches	Lost Creek	Wilson	NF Little Naches
2010	Yakima	File Extender	PAH-Parr	PBG-Parr	PRC-Parr	PLN-Parr		PWL-Parr	PNF-Parr
		McNary Julian Detection Date	163	160	145	163		141	160
		Expanded Passage	616	315	647	549		345	594
2011	Yakima	File Extender	PAH-Parr	PBG-Parr	PRC-Parr	PLN-Parr	WLC-Parr *	PWL-Parr	PNF-Parr
		McNary Julian Detection Date	156	156	124	163	136	122	166
		Expanded Passage	567	475	890	288	6	427	538
2012	Yakima	File Extender	PAL-Parr	PBG-Parr	PRE*-Parr	PLN-Parr		PWI-Parr	PNF-Parr
		McNary Julian Detection Date	151	152	145	152		144	146
		Expanded Passage	217	349	588	660		333	579

Release Year	Stock	Measure	Rock Creek	Buckskin	Quarts	Thorp Bridge	Umtanum Creek	Creek Mark/Reca	Easton Pond
2009	Yakima	File Extender					UMT	TAN	
		McNary Julian Detection Date					143	160	
		Expanded Passage					66	204	
2010	Yakima	File Extender	WRK-Wild				UMT-Parr	TAN-Parr	
		McNary Julian Detection Date					137	168	
		Expanded Passage					15	185	
2011	Yakima	File Extender		WBK-Parr				TAN	EY1
		McNary Julian Detection Date		135				94	144
		Expanded Passage		82				615	86
2012	Yakima	File Extender			PQU-Parr	PYA-Parr		COT	
		McNary Julian Detection Date			154	148		146	
		Expanded Passage			364	267		279	