# YAKIMA/KLICKITAT FISHERIES PROJECT MONITORING AND EVALUATION
## Yakima Subbasin

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

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# Table of Contents



# List of Tables

## List of Figures

# Acknowledgements

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## Executive Summary

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

The YKFP began a spring Chinook salmon hatchery program at the Cle Elum Supplementation and Research Facility (CESRF) near Cle Elum on the upper Yakima River in 1997. This program is a supplementation effort targeting the upper Yakima River population and is designed to test whether artificial propagation can be used to increase natural production and harvest opportunities while limiting ecological and genetic impacts. It is an integrated hatchery program because only natural-origin brood-stock are used and returning hatchery-origin adults are allowed to spawn in the wild. The program employs "best practice" hatchery management principles including reduced pond densities, strict disease management protocols, random brood-stock selection, and factorial mating to maximize effective population size. Fish are reared at the central facility, but released from three acclimation sites located near the central facility at: Easton approximately 25km upstream of the central facility, Clark Flat about 25km downstream of the central facility, and Jack Creek about 12km upstream from the Teanaway River's confluence with the Yakima River. The CESRF collected its first spring Chinook brood-stock in 1997, released its first fish in 1999, and age-4 adults have been returning since 2001. The first generation of offspring of CESRF and wild fish spawning in the wild returned as adults in 2005. The program uses the adjacent, un-supplemented Naches River population as an environmental and wild control 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 2001-2013 average of approximately 11,200 fish. These increases can be attributed to returns from the Cle Elum supplementation program beginning in 2001, improved freshwater passage conditions, improved marine survival, and habitat restoration and enhancement work. Annual abundance of fall Chinook at Prosser Dam has increased from a 1983-1999 average of just over 1,000 fish to a 2000-2013 average of nearly 3,500 fish. While this increase coincides with improved ocean conditions, some of the increase may also be due to improved passage in the mainstem Columbia River, changes in the lower Yakima River that are making fish seek more amenable spawning areas further upriver, and improvements in spawning and rearing protocols. Over 1,800 summer-run Chinook passed above Prosser Dam in 2013, among the first adults to return to the Yakima Basin in over 40 years. Adult coho returns to Prosser Dam averaged about 3,800 fish from 1997-2013 (an order of magnitude improvement from the average for years prior to the project) including estimated returns of wild/natural coho averaging about 900 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 juvenile migration years 2000-present, annual abundance estimates of juvenile smolts migrating downstream at Prosser Dam averaged 211,200 wild/natural spring Chinook, 283,190 CESRF-origin spring Chinook, 25,220 wild/natural-origin coho, and 278,260 hatchery-origin coho. Preliminary smolt-to-adult survival indices averaged approximately 3.7% and 5.1% for natural-origin spring Chinook and coho, respectively. Because of many complexities associated with the production of smolt indices, these data are useful for analysis of trends but should not be used as direct citations of, or for comparisons of marked and unmarked, smolt-to-adult survival rates. Substantial juvenile mortality occurs as smolts migrate through the Yakima River system. Strategies have been proposed to address limiting factors and improve survival of emigrating Yakima Basin juveniles. As these strategies are implemented, we expect smolt and smolt-to-adult survival to improve.

Spatial distribution of spring Chinook spawners has increased as a result of acclimation site location, salmon homing fidelity and more fully seeding preferred spawning habitats. Spring Chinook redd counts in the Teanaway River increased from a pre-supplementation average of 3 redds per year to a post-supplementation average of 71 redds per year. Fall Chinook redd distribution in the Yakima River Basin appears to be experiencing a transition with an increasing proportion of redds observed above Prosser Dam in the most recent decade. This change is primarily attributed to substantial changes in lower Yakima River habitats in recent years. Redd counts and spatial distribution of coho have increased substantially in recent years, with over 200 redds enumerated annually in tributaries in the upper watersheds in most years since 2004.

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 75% greater than that in the Naches system from the pre- to post-supplementation periods. Natural-origin returns of adult spring Chinook in the post-supplementation period (2005-2013) increased in the supplemented Upper Yakima and decreased in the Naches control systems relative to the pre-supplementation period (1982-2004), but neither change was statistically significant. After three generations of study, the results (many of which are published in the peer-reviewed literature) from the spring chinook supplementation program in the Upper Yakima River demonstrate that a well-designed and carefully managed integrated hatchery program using 100% natural-origin broodstock can produce fish for harvest and return fish to the natural spawning grounds with minimal negative impacts to the target ecosystem. Coho re-introduction research in the published literature suggests that hatchery-origin coho, with a legacy of as many as 10 to 30 generations of hatchery-influence, can reestablish a naturalized population after as few as 3 to 5 generations of outplanting in the wild.

YKFP efforts to monitor and evaluate hatchery reform focus on the CESRF spring Chinook program which was designed explicitly for this purpose from its inception. By designing the program to use only natural-origin fish for brood-stock, the program is meeting or exceeding scientific recommendations for proportionate natural influence (PNI) on an annual basis with a 13-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), on-reservation watersheds (1996-035-01), and Kelt Reconditioning (CRITFC 2008-458-00 and 2007-401-00) projects. WDFW is addressing hatchery uncertainties related to genetic and ecological interactions under project 1995-064-25. YKFP-related habitat activities for the Yakima Subbasin are addressed under projects 1997-051-00 and 1996-035-01 (except for sediment sampling which is addressed here). Hatchery Production Implementation (O&M) is addressed under project 1997-013-25. **Data and findings presented in this report should be considered preliminary until results are published in the peer-reviewed literature.**

*Study Area*

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

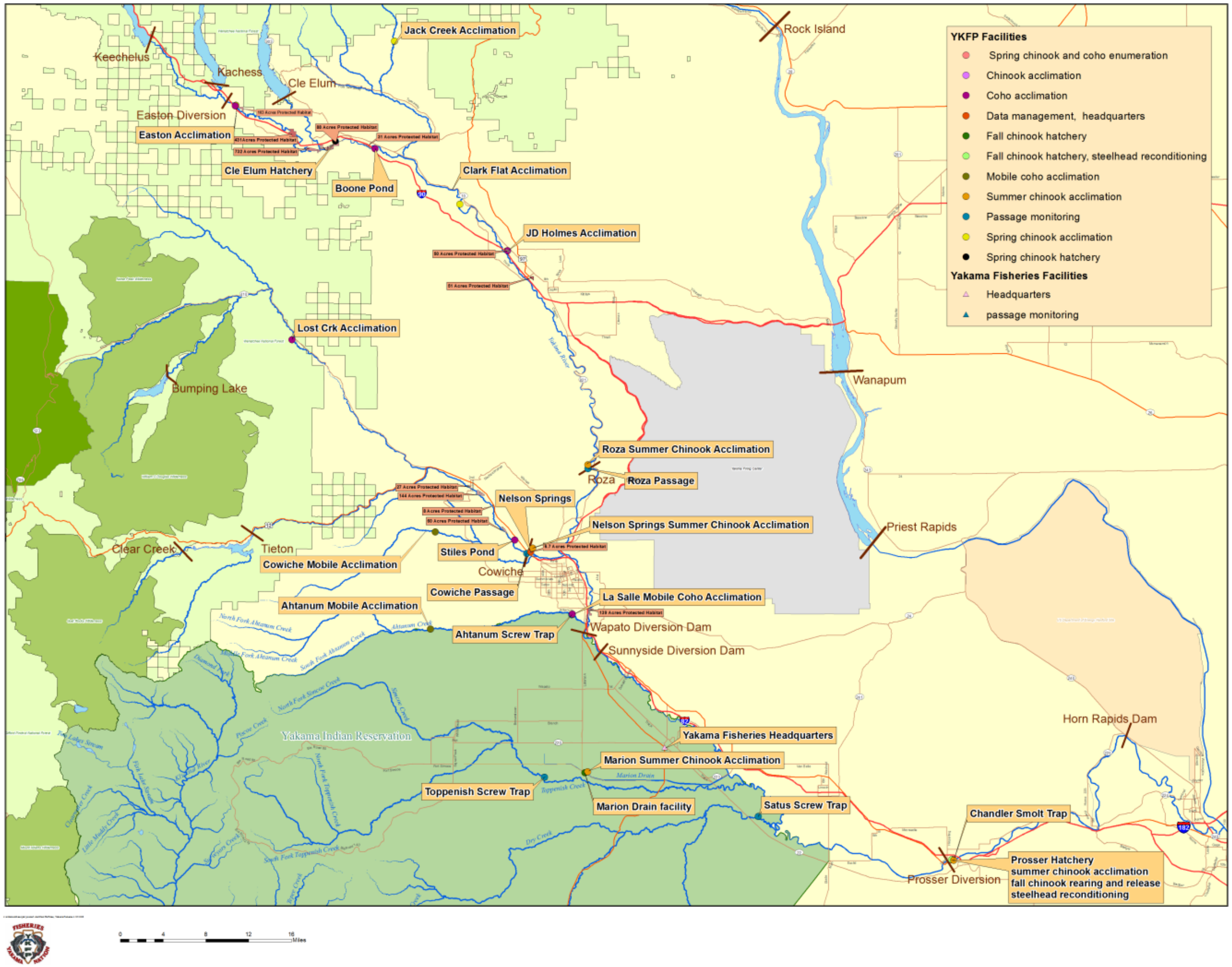



**Figure 1. Yakima River Basin and Yakama Nation/YKFP-related artificial production and monitoring facilities (map provided by Paul Huffman).**

## Fish Population Status Monitoring

### *Status and Trend of Adult Fish Populations (Abundance)*

**Methods:** Adult salmon populations in the Yakima River Basin are enumerated at Prosser Dam using video equipment installed in all three adult fish ladders (monitoringmethods.org methods 143, 144, 307, 418, 515). At both Prosser and Roza Dams, adult fish traps are also used on a seasonal basis for biological sampling and enumeration (monitoringmethods.org methods 135, 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 (see sites RZF and PRO in ptagis.org). For the safety and protection of personnel and equipment, video and PIT-detection equipment are removed during periods of high river flow. In these instances, biologists attempt to extrapolate fish counts using data from before and after the high flow event. Although adult passage over spillways is believed to occur when flows are favorable, Prosser Dam counts are generally considered by Yakama Nation biologists to be within +/- 5% of actual fish passage. Roza Dam counts during trap operation (generally the entire spring Chinook counting period, March-September) are considered virtually 100% accurate; however during the late fall and winter counting period when video equipment is used at least part of the time, accuracy may fall to only 50-75% of actual fish passage based on preliminary evaluation of PIT tag detection data. Fish are denoted as hatchery- or natural-origin based on presence or absence respectively, of observed external or internal marks or tags (monitoringmethods.org method 342). Chinook are denoted as spring-, summer-, or fall-run based on review of PIT-detection data and visual observations of coloration and body morphometry.

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

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

**Results:**

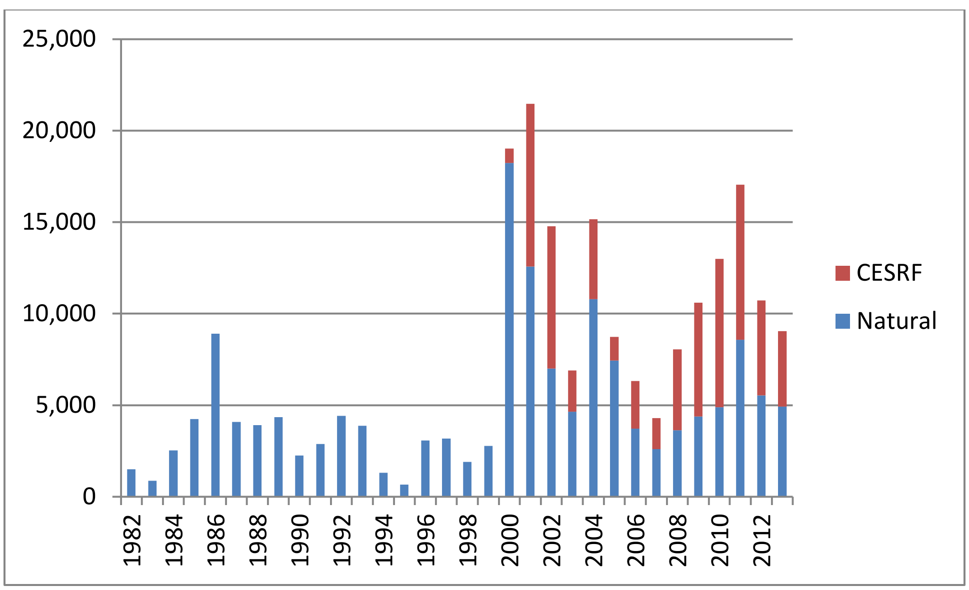



**Figure 2. Estimated counts of natural- and Cle Elum Supplementation and Research Facility (CESRF-) origin spring Chinook (adults and jacks) at Prosser Dam, 1982-present.**

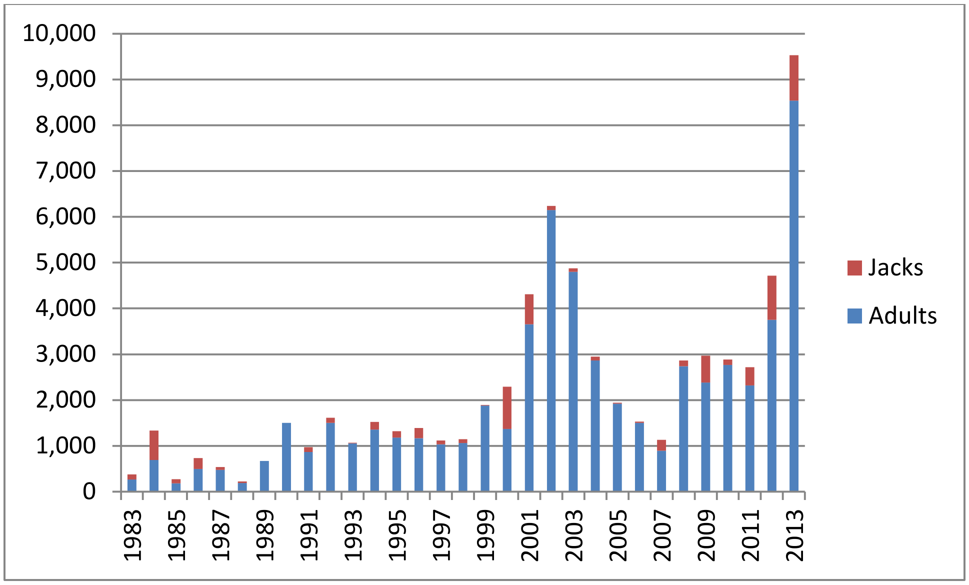



**Figure 3. Estimated counts of adult and jack summer/fall run Chinook at Prosser Dam, 1983-present.**

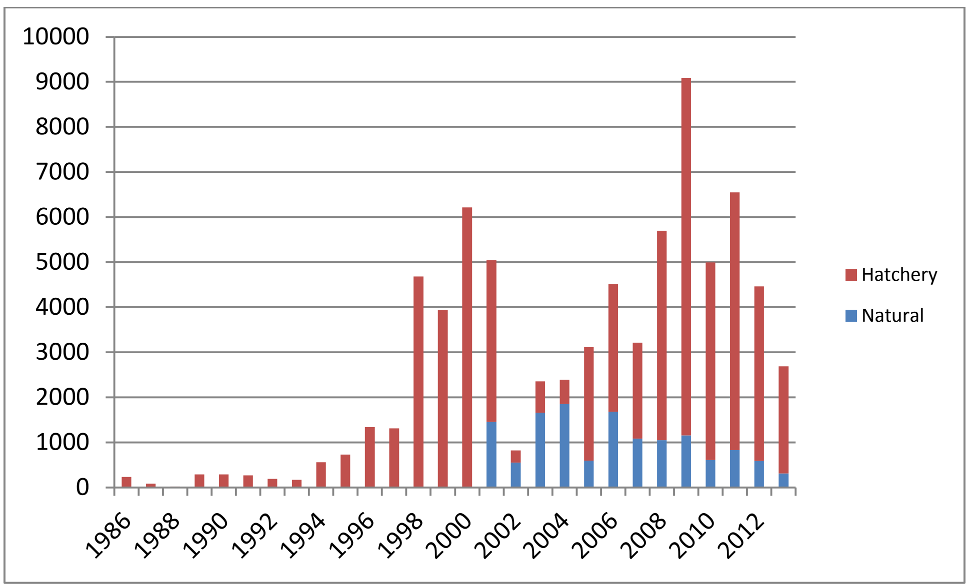



**Figure 4. Estimated counts of hatchery- and natural-origin Coho (adults and jacks) at Prosser Dam 1986-present.**

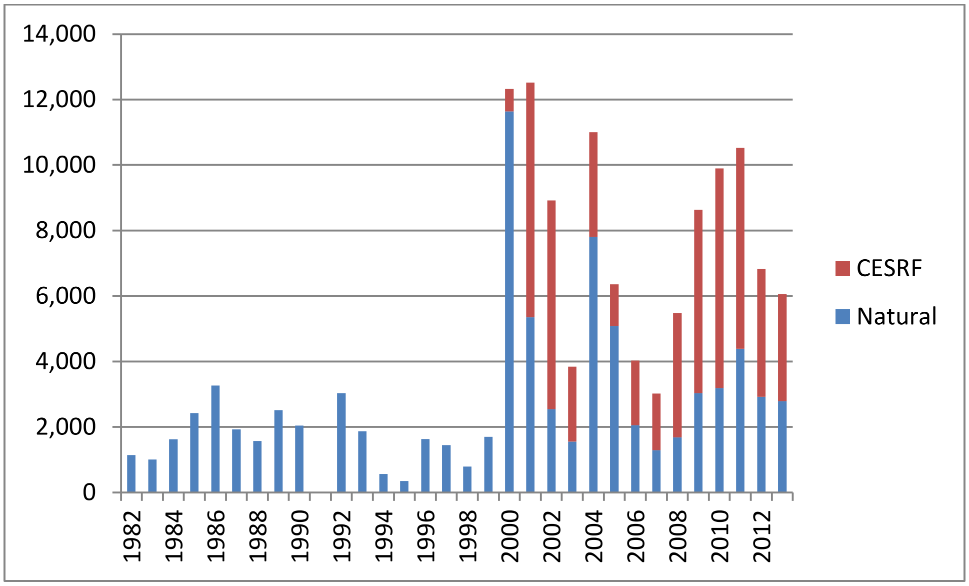



**Figure 5. Estimated counts of natural- and Cle Elum Supplementation and Research Facility (CESRF-) origin spring Chinook (adults and jacks) at Roza Dam, 1982-present.**

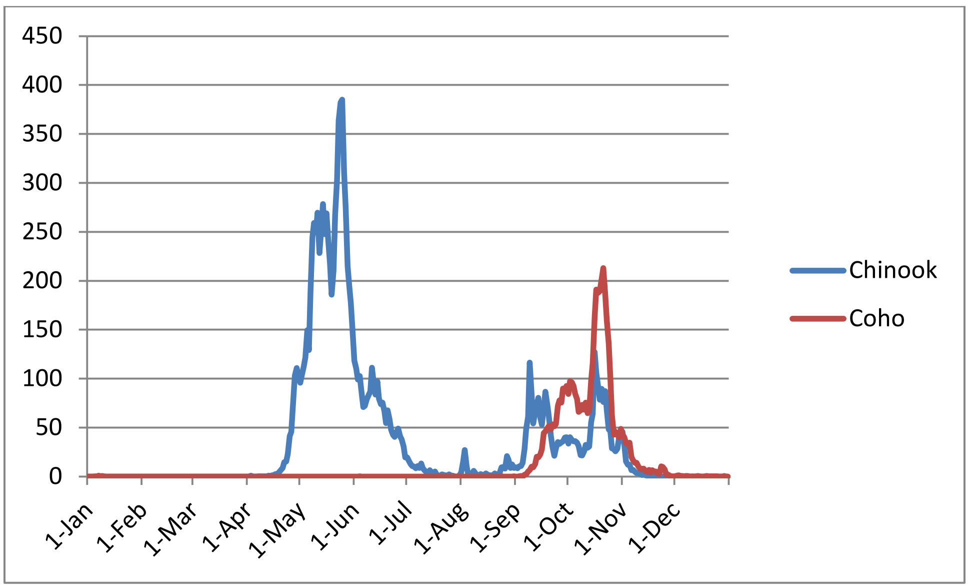



**Figure 6. Average daily passage of Chinook and Coho (adults and jacks) at Prosser Dam, 2004-2013.**

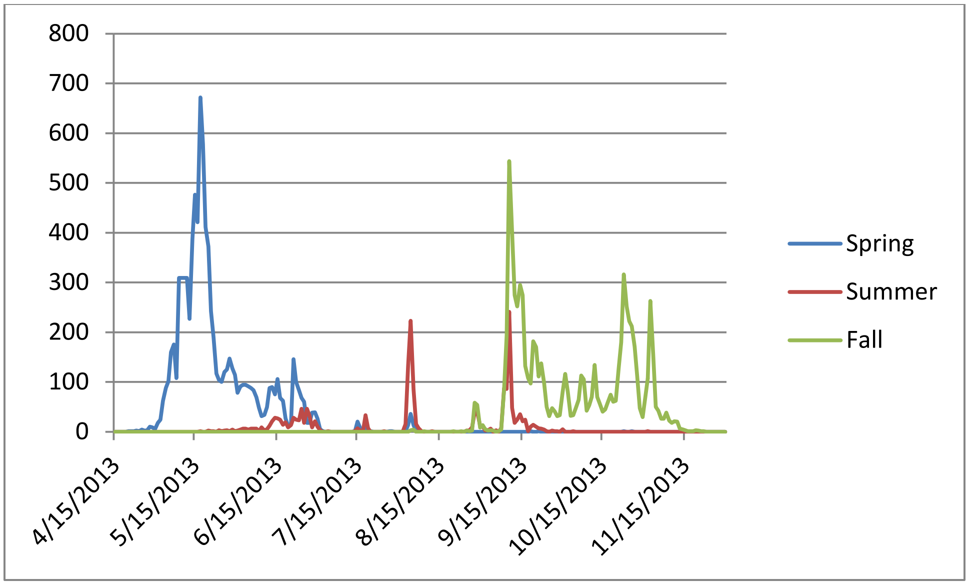



**Figure 7. Passage timing of adult and jack Chinook at Prosser Dam in 2013 by run (see Methods).**

## Discussion:

Annual abundance of spring Chinook at Prosser Dam has increased from a 1982-2000 average of about 4,000 fish to a 2001-2013 average of approximately 11,200 fish (Figure 2). Annual abundance of spring Chinook at Roza Dam has increased from a 1982-2000 average of about 2,300 fish to a 2001-2013 average of approximately 7,500 fish (Figure 5). These increases can be attributed to returns from the Cle Elum supplementation program beginning in 2001, improved freshwater passage conditions, improved marine survival, and habitat restoration and enhancement work. The lowest adult returns since 2000 followed two years after the notable droughts which occurred during smolt outmigration years 2001 and 2005. Discussion of uncertainties relating to the Cle Elum spring Chinook supplementation program is included under Hatchery Monitoring later in this report. Additional data and detail on the Cle Elum spring Chinook supplementation program and the status of natural- and CESRF-origin spring Chinook in the Yakima River Basin are provided in Appendix B.

Although some natural production is occurring, adult returns of fall Chinook to the Yakima River Basin consist mostly of hatchery-origin fish returning from annual releases of Upriver Brights from the Prosser Hatchery which have occurred since 1983 and averaged about 1.9 million since 1999 (Yakama Nation 2012). In addition, the Yakama Nation has a goal of re-establishing Summer-run Chinook which were extirpated from the Yakima Basin by 1970. Pursuant to this goal we began releases of Wells Hatchery summer-run Chinook in the Yakima River Basin in 2009. Annual abundance of summer/fall Chinook at Prosser Dam has increased from a 1983-1999 average of just over 1,000 fish to a 2000-2013 average of over 3,600 fish (Figure 3). While this increase coincides with improved ocean conditions, some of the increase may also be due to improved passage in the mainstem Columbia River, changes (e.g., increased aquatic vegetation like stargrass *Heterantera dubia*, Wise et al. 2009) in the lower Yakima River that are making fish seek more amenable spawning areas further upriver, and improvements in spawning and rearing protocols. By re-establishing the summer-run component we seek to increase the temporal (Figures 6 and 7) and spatial distribution of summer/fall run Chinook in the Yakima River Subbasin (Yakama Nation 2012). Over 1,800 summer-run Chinook were estimated to pass above Prosser Dam in 2013 (Figure 7).

Coho were extirpated from the Yakima Subbasin by the early 1980s. Pursuant to *U.S. v. Oregon* court-mandated agreements, substantial numbers (annual average > 700,000) of hatchery-reared coho salmon were released into the Yakima River since the mid-1980s. Prior to 1996 the primary purpose of releases was harvest augmentation and fish were released in sub-optimal spawning and rearing areas below Wapato Dam. With the inception of the YKFP in 1996, the objective of the coho program became "to determine the feasibility of reestablishing a naturally spawning coho population" and releases were moved upriver to more suitable habitats for natural coho. Monitoring of these efforts to re-introduce a sustainable, naturally spawning coho population in the Yakima Basin have indicated that adult coho returns averaged about 3,800 fish from 1997-2013 (an order of magnitude improvement from the average for years prior to the project) including estimated returns of wild/natural coho averaging about 900 fish annually since 2001 (Figure 4).

## *Status and Trend of Adult Productivity*

**Methods:**

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

*Spring Chinook*

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

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

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

*Coho*

From central British Columbia south, the vast majority of coho salmon adults are 3-year-olds, having spent approximately 18 months in fresh water and 18 months in salt water (Loeffel and Wendler 1968, Wright 1970). Therefore we estimated a natural-origin productivity (recruits per spawner) index by dividing natural-origin returns to Prosser Dam by the estimated returns to Prosser Dam three years prior. We computed this index for both adult and combined adult and jack returns per adult and combined adult and jack spawner.

*Summer/Fall Run Chinook*

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

## Results:

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

| Brood Year | Estimated Spawners | Estimated Yakima R. Mouth Returns Age-3 | Age-4 | Age-5 | Total | Returns/ Spawner |
|---|---|---|---|---|---|---|
| 1984 | 1,715 | 92 | 1,348 | 139 | 1,578 | 0.92 |
| 1985 | 2,578 | 114 | 2,746 | 105 | 2,965 | 1.15 |
| 1986 | 3,960 | 171 | 2,574 | 149 | 2,893 | 0.73 |
| 1987 | 2,003 | 53 | 1,571 | 109 | 1,733 | 0.87 |
| 1988 | 1,400 | 53 | 3,138 | 132 | 3,323 | 2.37 |
| 1989 | 2,466 | 68 | 1,779 | 9 | 1,856 | 0.75 |
| 1990 | 2,298 | 79 | 566 | 0 | 645 | 0.28 |
| 1991 | 1,713 | 9 | 326 | 22 | 358 | 0.21 |
| 1992 | 3,048 | 87 | 1,861 | 95 | 2,043 | 0.67 |
| 1993 | 1,925 | 66 | 1,606 | 57 | 1,729 | 0.90 |
| 1994 | 573 | 60 | 737 | 92 | 890 | 1.55 |
| 1995 | 364 | 59 | 1,036 | 129 | 1,224 | 3.36 |
| 1996 | 1,657 | 1,059 | 12,882 | 630 | 14,571 | 8.79 |
| 1997 | 1,204 | 621 | 5,837 | 155 | 6,613 | 5.49 |
| 1998 | 390 | 434 | 2,803 | 145 | 3,381 | 8.68 |
| 1999 | 1,021[1] | 164 | 722 | 45 | 930 | 0.91 |
| 2000 | 11,864 | 856 | 7,689 | 127 | 8,672 | 0.73 |
| 2001 | 12,084 | 775 | 5,074 | 222 | 6,071 | 0.50 |
| 2002 | 8,073 | 224 | 1,875 | 148 | 2,247 | 0.28 |
| 2003 | 3,341 | 158 | 1,036 | 63 | 1,257 | 0.38 |
| 2004 | 10,377 | 207 | 1,547 | 75 | 1,828 | 0.18 |
| 2005 | 5,713 | 293 | 2,630 | 14 | 2,936 | 0.51 |
| 2006 | 3,378 | 868 | 2,887 | 133 | 3,888 | 1.15 |
| 2007 | 2,322 | 456 | 3,976 | 65 | 4,498 | 1.94 |
| 2008 | 4,343 | 1,135 | 3,410 | 145 | 4,689 | 1.08 |
| 2009 | 7,056 | 283 | 2,551 | | | |
| 2010 | 8,383 | 923 | | | | |
| 2011 | 8,584 | | | | | |
| 2012 | 5,483 | | | | | |
| 2013 | 4,984 | | | | | |
| Mean | 4,143 | 347 | 2,854 | 120 | 3,313 | 1.78 |

1. The mean jack proportion of spawning escapement from 1999-2013 was 0.17 (geometric mean 0.13).

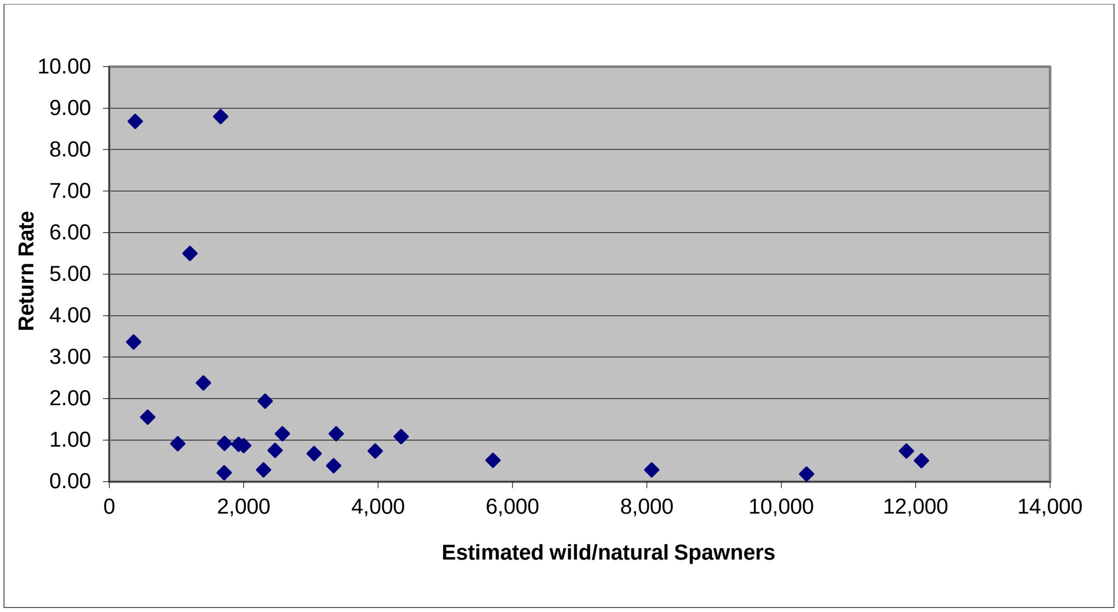



**Figure 8. Upper Yakima wild/natural spring Chinook return rate per spawner, brood years 1984-2008.**

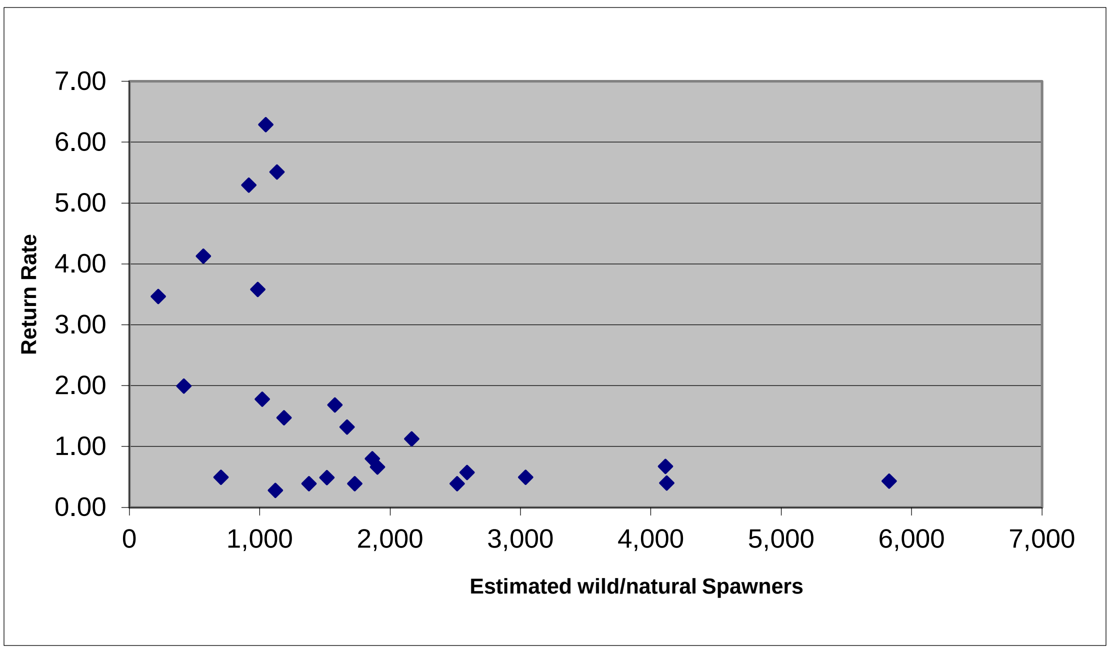



**Figure 9. Naches subbasin spring Chinook return rate per spawner, brood years 1984-2008.**

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

| Brood Year | Estimated Spawners | Estimated Yakima R. Mouth Returns Age-3 | Age-4 | Age-5 | Age-6 | Total | Returns/ Spawner |
|---|---|---|---|---|---|---|---|
| 1984 | 570 | 164 | 1,109 | 1,080 | 0 | 2,354 | 4.13 |
| 1985 | 1,020 | 213 | 667 | 931 | 0 | 1,811 | 1.77 |
| 1986 | 4,123 | 103 | 670 | 852 | 31 | 1,657 | 0.40 |
| 1987 | 1,729 | 39 | 231 | 400 | 0 | 669 | 0.39 |
| 1988 | 2,167 | 51 | 815 | 1,557 | 11 | 2,434 | 1.12 |
| 1989 | 1,517 | 39 | 332 | 371 | 0 | 741 | 0.49 |
| 1990 | 1,380 | 40 | 326 | 168 | 0 | 533 | 0.39 |
| 1991 | 1,121 | 10 | 32 | 144 | 127 | 314 | 0.28 |
| 1992 | 1,188 | 52 | 1,034 | 661 | 0 | 1,747 | 1.47 |
| 1993 | 1,865 | 53 | 603 | 817 | 17 | 1,489 | 0.80 |
| 1994 | 704 | 21 | 160 | 167 | 0 | 348 | 0.49 |
| 1995 | 223 | 73 | 201 | 498 | 0 | 771 | 3.46 |
| 1996 | 1,047 | 209 | 4,010 | 2,359 | 0 | 6,579 | 6.29 |
| 1997 | 1,133 | 220 | 4,644 | 1,377 | 0 | 6,241 | 5.51 |
| 1998 | 917 | 364 | 2,167 | 2,316 | 12 | 4,859 | 5.30 |
| 1999 | 418[1] | 185 | 369 | 279 | 0 | 833 | 1.99 |
| 2000 | 4,112 | 131 | 2,286 | 346 | 0 | 2,762 | 0.67 |
| 2001 | 5,829 | 144 | 1,598 | 785 | 0 | 2,526 | 0.43 |
| 2002 | 3,041 | 78 | 975 | 443 | 0 | 1,496 | 0.49 |
| 2003 | 2,592 | 75 | 387 | 1,028 | 0 | 1,489 | 0.57 |
| 2004 | 2,515 | 227 | 514 | 232 | 0 | 973 | 0.39 |
| 2005 | 1,904 | 246 | 845 | 174 | 0 | 1,264 | 0.66 |
| 2006 | 1,672 | 237 | 1,215 | 759 | 0 | 2,211 | 1.32 |
| 2007 | 986 | 182 | 2,239 | 1,112 | | 3,533 | 3.58 |
| 2008 | 1,578 | 653 | 1,183 | 816 | | 2,652 | 1.68 |
| 2009 | 1,117 | 144 | 529 | | | | |
| 2010 | 1,491 | 381 | | | | | |
| 2011 | 3,060 | | | | | | |
| 2012 | 1,900 | | | | | | |
| 2013 | 1,369 | | | | | | |
| Mean | 1,810 | 160 | 1,121 | 787 | 8 | 2,091 | 1.76 |

1. The mean jack proportion of spawning escapement from 1999-2013 was 0.12 (geometric mean 0.09).

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

| Brood Year | Estimated Spawners | Estimated Yakima R. Mouth Returns Age-3 | Age-4 | Age-5 | Total | Returns/ Spawner |
|---|---|---|---|---|---|---|
| 1997 | 261 | 741 | 7,753 | 176 | 8,670 | 33.22 |
| 1998 | 408 | 1,242 | 7,939 | 602 | 9,782 | 23.98 |
| 1999 | 738[1] | 134 | 714 | 16 | 864 | 1.17 |
| 2000 | 567 | 1,103 | 3,647 | 70 | 4,819 | 8.50 |
| 2001 | 595 | 396 | 845 | 9 | 1,251 | 2.10 |
| 2002 | 629 | 345 | 1,886 | 69 | 2,300 | 3.66 |
| 2003 | 441 | 121 | 800 | 12 | 932 | 2.11 |
| 2004 | 597 | 805 | 3,101 | 116 | 4,022 | 6.74 |
| 2005 | 510 | 1,305 | 3,052 | 21 | 4,378 | 8.58 |
| 2006 | 419 | 3,038 | 5,812 | 264 | 9,114 | 21.75 |
| 2007 | 449 | 1,277 | 5,174 | 108 | 6,558 | 14.61 |
| 2008 | 457 | 2,344 | 4,567 | 66 | 6,977 | 15.27 |
| 2009 | 486 | 461 | 2,662 | | | |
| 2010 | 336 | 1,495 | | | | |
| 2011 | 377 | | | | | |
| 2012 | 374 | | | | | |
| 2013 | 398 | | | | | |
| Mean | 473 | 1,058 | 3,688 | 127 | 4,972 | 7.58[2] |

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

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

| | Prosser Dam Counts | | Return per Spawner Indices | |
|---|---|---|---|---|
| Return Year | Adults | Jacks | With Jacks | Without Jacks |
| 2001 | 1,432 | 21 | | |
| 2002 | 309 | 245 | | |
| 2003 | 1,523 | 135 | | |
| 2004 | 1,820 | 25 | 1.27 | 1.27 |
| 2005 | 472 | 120 | 1.07 | 1.53 |
| 2006 | 1,562 | 114 | 1.01 | 1.03 |
| 2007 | 1,049 | 32 | 0.59 | 0.58 |
| 2008 | 459 | 587 | 1.77 | 0.97 |
| 2009 | 982 | 173 | 0.69 | 0.63 |
| 2010 | 573 | 37 | 0.56 | 0.55 |
| 2011 | 802 | 24 | 0.79 | 1.75 |
| 2012 | 550 | 33 | 0.50 | 0.56 |
| 2013 | 229 | 79 | 0.51 | 0.40 |
| Mean | | | 0.88 | 0.93 |

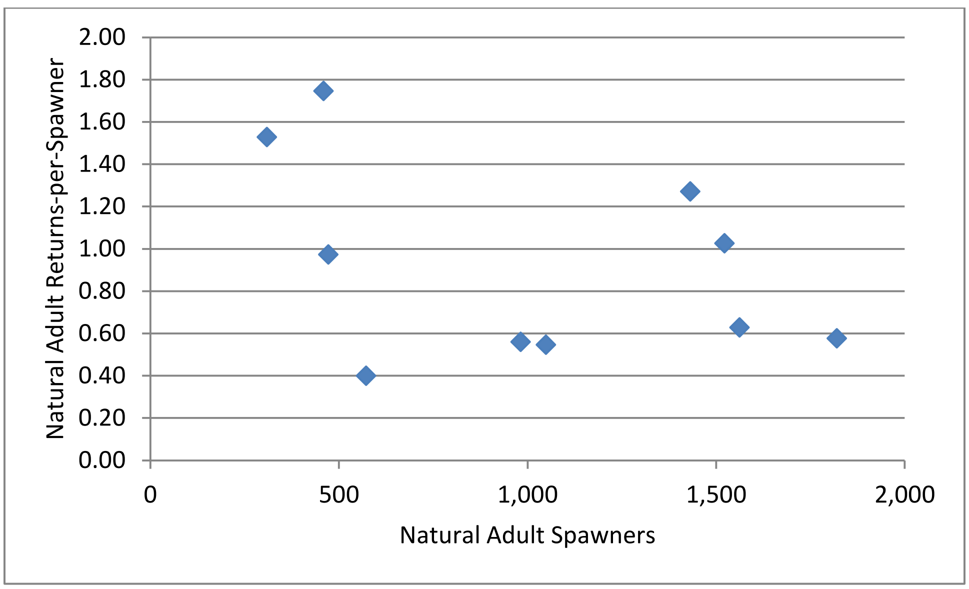



**Figure 10. Productivity indices for age-3 natural-origin coho, brood years 2001-2010.**

## 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 declines as spawner abundance approaches 2,000 fish or greater (Figures 8-9). These data indicate that density-dependent limiting factors (see YSFWPB 2004) depress natural productivity at fairly low population abundance in the Yakima River Basin. Until these factors are fully addressed, supplementation yields higher overall productivity rates and can be used to return adults to fisheries and to augment natural spawning populations (Table 3). While higher spawner abundances under present conditions do not yield increased adult production, these fish still contribute to more fully seeding available habitats, increased spatial and temporal diversity, and nutrient enhancement that should eventually lead to increased natural food supply and higher productivity in the future (NRC 1996, see especially pp. 368-369; Kiffney et al. 2014).

### *Status and Trend of Juvenile Abundance (Chandler smolt estimates)*

**Methods:** Above Prosser Dam, a portion of the river flow is diverted into the Chandler canal to generate electrical power and serve irrigation districts downstream. Juvenile fish are diverted into the Canal (and subsequently the Chandler juvenile monitoring facility-CJMF, Figure 1) at different rates depending on river and canal flow. Smolt sampling efforts at the CJMF near Prosser Dam were conducted annually from early winter through early summer corresponding with salmon smolt out-migrations. A portion of entrained salmon outmigrants (regulated by a timed gate) was manually counted and sampled for biological data on a daily basis and all PIT tagged fish were interrogated. Sampling methods were described in Busack et al. (1997) and were consistent with monitoringmethods.org methods 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 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 211,200 wild/natural spring Chinook, 283,190 CESRF-origin spring Chinook, 25,220 wild/natural-origin coho, and 278,260 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 | 147,486 | 241,078 | 18,787 | 148,810 |
| 2003 | 2005 | 127,945 | 215,578 | 31,631 | 204,728 |
| 2004 | 2006 | 168,972 | 323,490 | 8,298 | 204,602 |
| 2005 | 2007 | 145,203 | 362,663 | 20,131 | 260,455 |
| 2006 | 2008 | 83,329 | 167,682 | 43,046 | 416,708 |
| 2007 | 2009 | 198,966 | 321,594 | 25,108 | 496,594 |
| 2008 | 2010 | 122,954 | 204,812 | 35,158 | 341,145 |
| 2009 | 2011 | 318,800 | 433,654 | 24,108 | 333,891 |
| 2010 | 2012 | 386,121 | 392,963 | 14,675 | 244,503 |
| 2011 | 2013 | 295,849 | 301,059 | NA | 483,122 |
| | Mean | 211,201 | 283,189 | 25,220 | 278,256 |

### *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 (derived using queries of PTAGIS database 7/12/2013). Natural and hatchery-origin smolts contemporaneously migrating past Roza from March 16 on are referred to as "late" migrants.

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

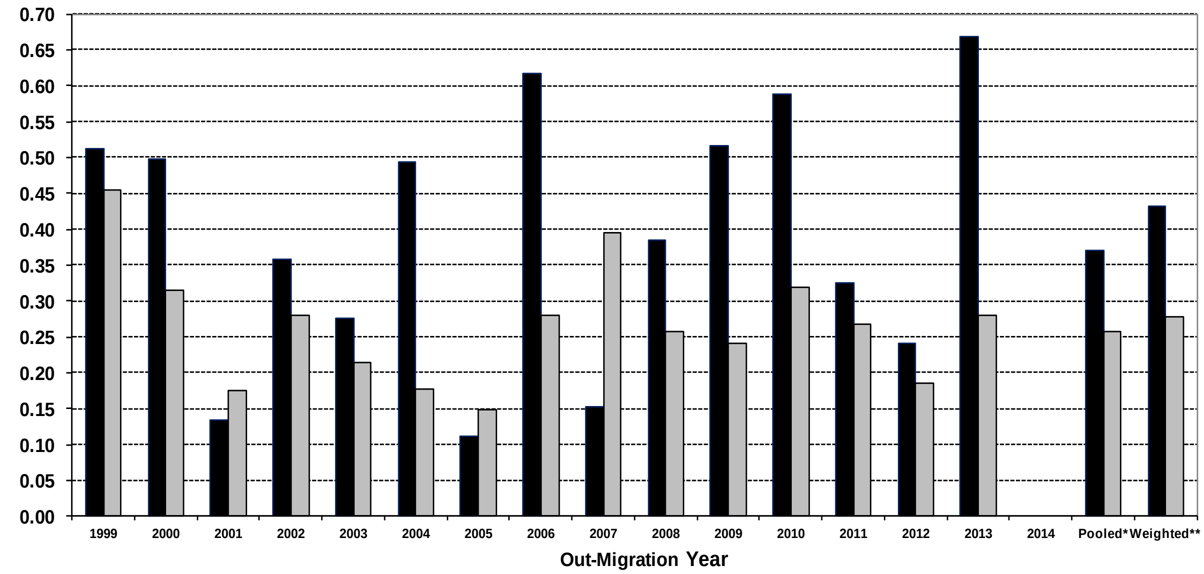



**Figure 11. Upper-Yakima Spring-Chinook Roza-to-McNary Smolt Survival for late-migrating (>March 15) Natural- (dark-colored bars) and Hatchery-origin (light-colored bars) Smolts.**

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 2013. Summer-run Chinook subyearlings were released from Stiles pond in outmigration-years 2009 through 2011, from Nelson Springs (Buckskin Slough) in 2011 and 2012, from Prosser and Marion Drain in 2012, and from Roza Dam in 2013 (Figure 1).

Estimates for release-to-McNary survival from Stiles and Prosser are presented in Figure 12; for complete results see Appendix F. 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.

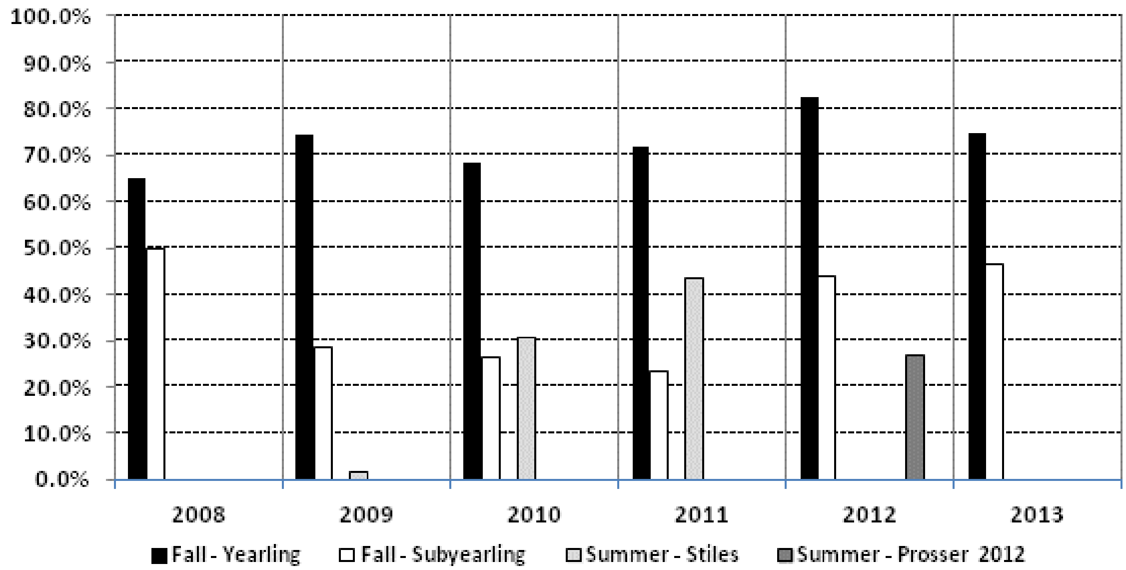



**Figure 12. Estimated smolt survival to McNary Dam of summer- and fall-run Chinook that were PIT-tagged and detected at release from various sites in the Yakima River, 2008-2013.**

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). The 2013 releases consisted of 100% in-basin Yakima River coho. Therefore, the comparison was not in stock but in rearing location (Prosser Hatchery vs. Eagle Creek NFH).

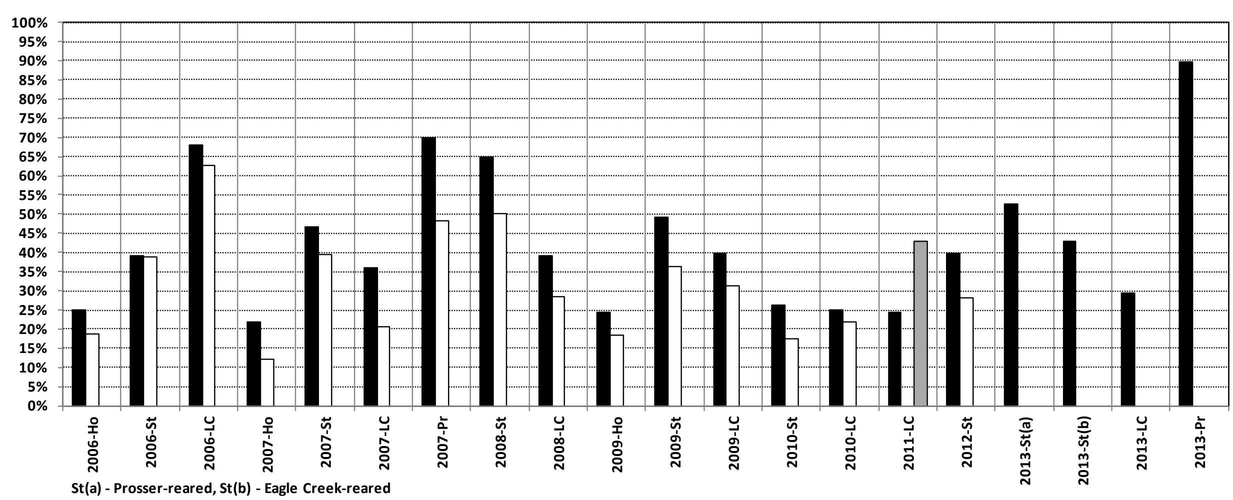



**Figure 13. Estimated smolt survival to McNary Dam of Yakima (black), Eagle Creek (white), and a Yakima/Eagle Creek cross (gray) brood source coho that were PIT-tagged and detected at release from various sites (Holmes-Ho, Stiles-St, Lost Creek-LC, and Prosser-Pr; Figure 1) in the Yakima River, 2006-2013. In 2013, Yakima brood source fish released from Stiles were reared at Prosser (a) and Eagle Creek (b).**

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

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

**Methods:**

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

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

## Results:

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

| | | Mean Flow[1] at Prosser Dam | Estimated Smolt Passage at Chandler | | CESRF smolt-to-smolt survival[3] | Yakima R. Mouth Adult Returns[4] | | Smolt-to-Adult Return Index[4] | |
|---|---|---|---|---|---|---|---|---|---|
| Brood Year | Smolt Migr. Year | | Wild/ Natural[2] | CESRF Total | | 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 | 147,486 | 241,078 | 28.8% | 3,743 | 2,300 | 2.5% | 1.0% |
| 2003 | 2005 | 1285 | 127,945 | 215,578 | 26.1% | 2,746 | 932 | 2.1% | 0.4% |
| 2004 | 2006 | 5652 | 168,972 | 323,490 | 41.2% | 2,802 | 4,022 | 1.7% | 1.2% |
| 2005 | 2007 | 4551 | 145,203 | 362,663 | 42.2% | 4,201 | 4,378 | 2.9% | 1.2% |
| 2006 | 2008 | 4298 | 83,329 | 167,682 | 26.1% | 6,099 | 9,114 | 7.3% | 5.4% |
| 2007 | 2009 | 5784 | 198,966 | 321,594 | 41.7% | 8,030 | 6,558 | 4.0% | 2.0% |
| 2008 | 2010 | 3592 | 122,954 | 204,812 | 24.1% | 7,341 | 6,977 | 6.0% | 3.4% |
| 2009 | 2011 | 9414 | 318,800 | 433,654 | 52.1% | 3,506[6] | 3,123[6] | 1.1%[6] | 0.7%[6] |
| 2010 | 2012 | 8556 | 386,121 | 392,963 | 49.4% | | | | |
| 2011 | 2013[6] | 4875 | 295,849 | 301,059 | 39.1% | | | | |

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

**Table 7. Average combined hatchery- and natural-origin smolt counts at Prosser for fish returning at age-3, -4, and -5, combined adult returns to Prosser Dam of all age classes, and estimated Prosser smolt-to-adult return indices for Yakima River fall Chinook for adult return years 1988-2013.**

| Adult Return Year | Prosser Average Smolts[1] | Prosser Total Adults | Prosser Smolt-to-Adult Return Index (SAR) |
|---|---|---|---|
| 1988 | 1,029,429 | 224 | 0.02% |
| 1989 | 1,469,019 | 670 | 0.05% |
| 1990 | 1,664,378 | 1,504 | 0.09% |
| 1991 | 1,579,989 | 971 | 0.06% |
| 1992 | 1,811,088 | 1,612 | 0.09% |
| 1993 | 2,034,865 | 1,065 | 0.05% |
| 1994 | 1,976,301 | 1,520 | 0.08% |
| 1995 | 1,329,664 | 1,322 | 0.10% |
| 1996 | 1,023,053 | 1,392 | 0.14% |
| 1997 | 1,097,032 | 1,120 | 0.10% |
| 1998 | 1,533,093 | 1,148 | 0.07% |
| 1999 | 1,786,511 | 1,896 | 0.11% |
| 2000 | 1,716,156 | 2,293 | 0.13% |
| 2001 | 1,867,966 | 4,311 | 0.23% |
| 2002 | 1,946,676 | 6,241 | 0.32% |
| 2003 | 2,108,238 | 4,875 | 0.23% |
| 2004 | 2,653,056 | 2,947 | 0.11% |
| 2005 | 2,707,132 | 1,942 | 0.07% |
| 2006 | 2,724,824 | 1,528 | 0.06% |
| 2007 | 2,312,562 | 1,132 | 0.05% |
| 2008 | 2,450,308 | 2,863 | 0.12% |
| 2009 | 2,353,675 | 2,972 | 0.13% |
| 2010 | 2,125,125 | 2,888 | 0.14% |
| 2011 | 1,630,482 | 2,718 | 0.17% |
| 2012 | 1,738,951 | 4,477 | 0.26% |
| 2013 | 1,932,626 | 7,706 | 0.40% |
| Mean | 1,869,315 | 2,436 | 0.13% |

[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 2000-2012.**

| Juvenile | Hatchery-origin | | | Natural-origin | | |
|---|---|---|---|---|---|---|
| Migration Year | Chandler Smolts[a] | Prosser Adults[b] | SAR Index | Chandler Smolts[a] | Prosser Adults[b] | 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] |
| 2012 | 244,503 | 1,865 | 0.76% | 14,675 | 424 | 2.89% |
| Mean | 262,497 | 3,407 | 1.16% | 25,220 | 920 | 5.13% |

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

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

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

## Discussion:

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

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

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

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

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

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

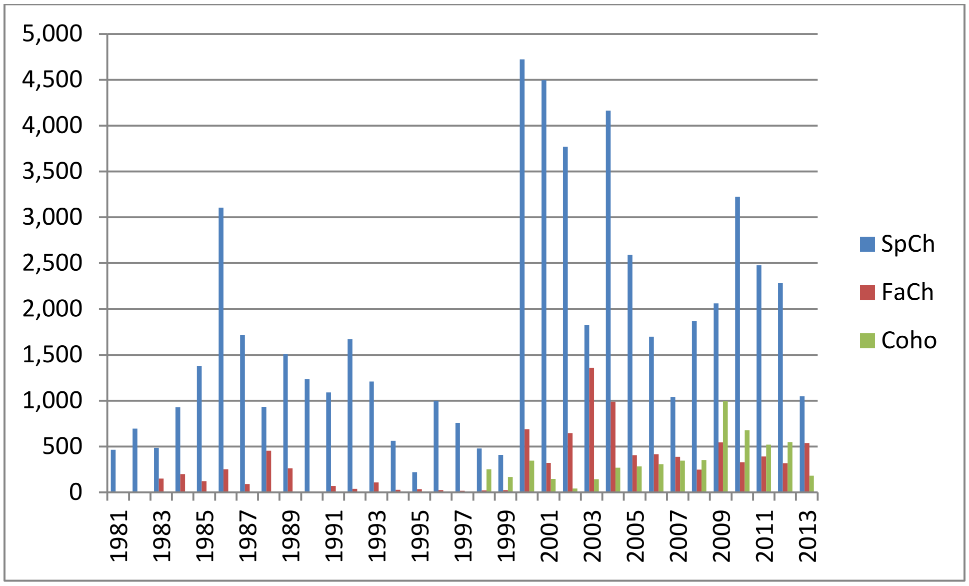



**Figure 14. Redd Counts upstream of Prosser Dam in the Yakima River Basin by species, 1981-present.**

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

| | Upper Yakima River System | | | | Naches River System | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Mainstem[1] | Cle Elum | Teanaway | Total | American | Naches[1] | Bumping | Little Naches | Total |
| 1981 | 237 | 57 | 0 | 294 | 72 | 64 | 20 | 16 | 172 |
| 1982 | 610 | 30 | 0 | 640 | 11 | 25 | 6 | 12 | 54 |
| 1983 | 387 | 15 | 0 | 402 | 36 | 27 | 11 | 9 | 83 |
| 1984 | 677 | 31 | 0 | 708 | 72 | 81 | 26 | 41 | 220 |
| 1985 | 795 | 153 | 3 | 951 | 141 | 168 | 74 | 44 | 427 |
| 1986 | 1,716 | 77 | 0 | 1,793 | 464 | 543 | 196 | 110 | 1,313 |
| 1987 | 968 | 75 | 0 | 1,043 | 222 | 281 | 133 | 41 | 677 |
| 1988 | 369 | 74 | 0 | 443 | 187 | 145 | 111 | 47 | 490 |
| 1989 | 770 | 192 | 6 | 968 | 187 | 200 | 101 | 53 | 541 |
| 1990 | 727 | 46 | 0 | 773 | 143 | 159 | 111 | 51 | 464 |
| 1991 | 568 | 62 | 0 | 630 | 170 | 161 | 84 | 45 | 460 |
| 1992 | 1,082 | 164 | 0 | 1,246 | 120 | 155 | 99 | 51 | 425 |
| 1993 | 550 | 105 | 1 | 656 | 214 | 189 | 88 | 63 | 554 |
| 1994 | 226 | 64 | 0 | 290 | 89 | 93 | 70 | 20 | 272 |
| 1995 | 105 | 12 | 0 | 117 | 46 | 25 | 27 | 6 | 104 |
| 1996 | 711 | 100 | 3 | 814 | 28 | 102 | 29 | 25 | 184 |
| 1997 | 364 | 56 | 0 | 420 | 111 | 108 | 72 | 48 | 339 |
| 1998 | 123 | 24 | 1 | 148 | 149 | 104 | 54 | 23 | 330 |
| 1999 | 199 | 24 | 1 | 224 | 27 | 95 | 39 | 25 | 186 |
| 2000 | 3,349 | 466 | 21 | 3,836 | 54 | 483 | 278 | 73 | 888 |
| 2001 | 2,910 | 374 | 21 | 3,305 | 392 | 436 | 257 | 107 | 1,192 |
| 2002 | 2,441 | 275 | 110 | 2,826 | 366 | 226 | 262 | 89 | 943 |
| 2003 | 772 | 87 | 31 | 890 | 430 | 228 | 216 | 61 | 935 |
| 2004 | 2,985 | 330 | 129 | 3,444 | 91 | 348 | 205 | 75 | 719 |
| 2005 | 1,717 | 287 | 15 | 2,019 | 140 | 203 | 163 | 68 | 574 |
| 2006 | 1,092 | 100 | 58 | 1,250 | 136 | 163 | 115 | 33 | 447 |
| 2007 | 665 | 51 | 10 | 726 | 166 | 60 | 60 | 27 | 313 |
| 2008 | 1,191 | 137 | 47 | 1,375 | 158 | 165 | 102 | 70 | 495 |
| 2009 | 1,349 | 197 | 33 | 1,579 | 92 | 159 | 163 | 68 | 482 |
| 2010 | 2,199 | 219 | 253 | 2,671 | 173 | 171 | 168 | 40 | 552 |
| 2011 | 1,663 | 171 | 64 | 1,898 | 212 | 145 | 175 | 48 | 580 |
| 2012 | 1,276 | 125 | 69 | 1,470 | 337 | 196 | 189 | 89 | 811 |
| 2013 | 552 | 85 | 34 | 671 | 170 | 66 | 85 | 55 | 376 |
| Mean | 1,071 | 129 | 28 | 1,228 | 164 | 175 | 115 | 49 | 503 |

[1] Including minor tributaries.

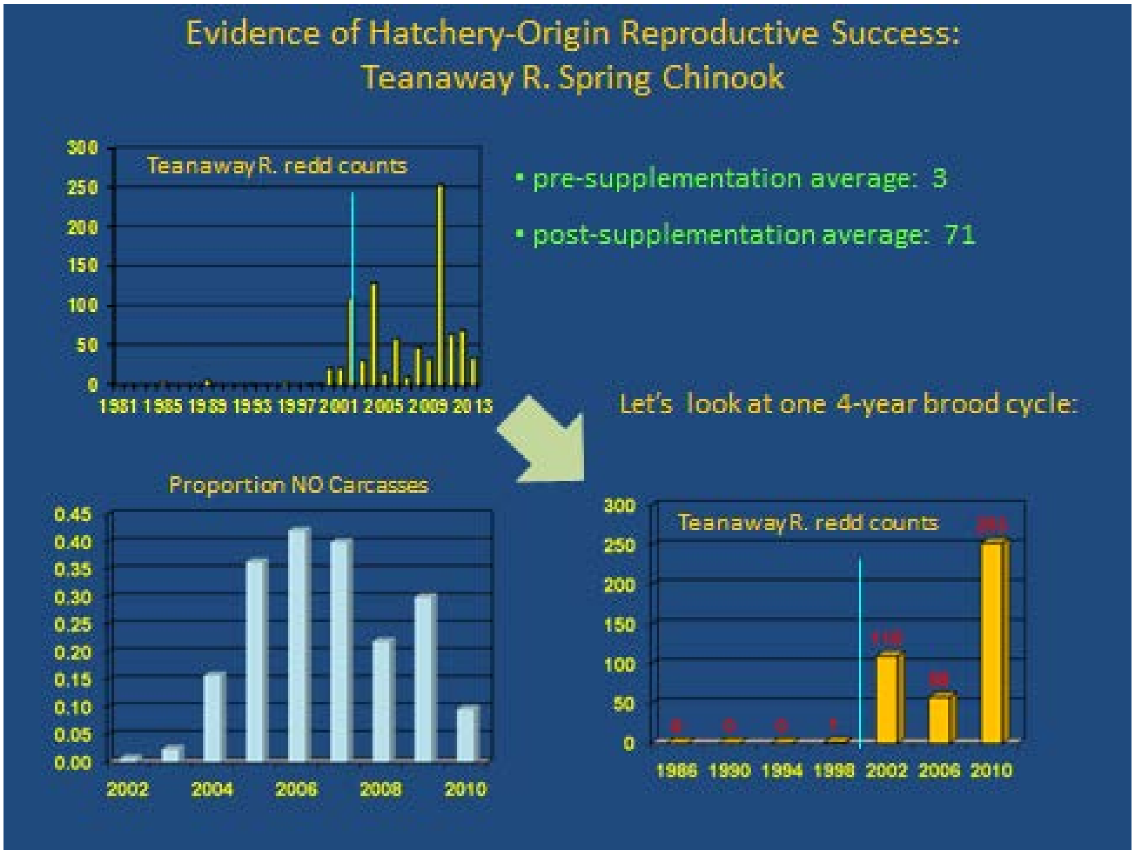
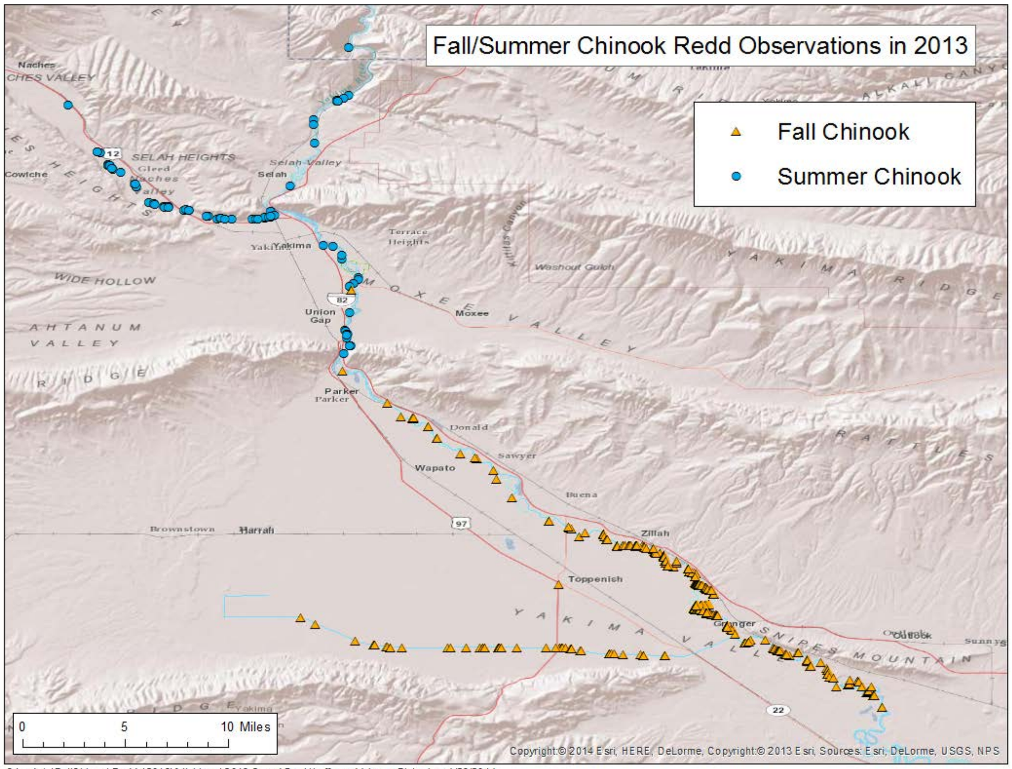



**Figure 15. Teanaway River Spring Chinook redd counts, 1981-2013 (blue lines denote pre- and post-supplementation periods) and the proportion of natural-origin (NO) carcasses observed in intensive spawning ground surveys, 2002-2010.**




C:\avdata\FallChinookRedds\2013\fallchinook2013-2.mxd Paul Huffman, Yakama Fisheries, 4/29/2014

**Figure 16. Distribution of summer and fall run Chinook redds in the Yakima River Basin (above Prosser Dam) in 2013.**

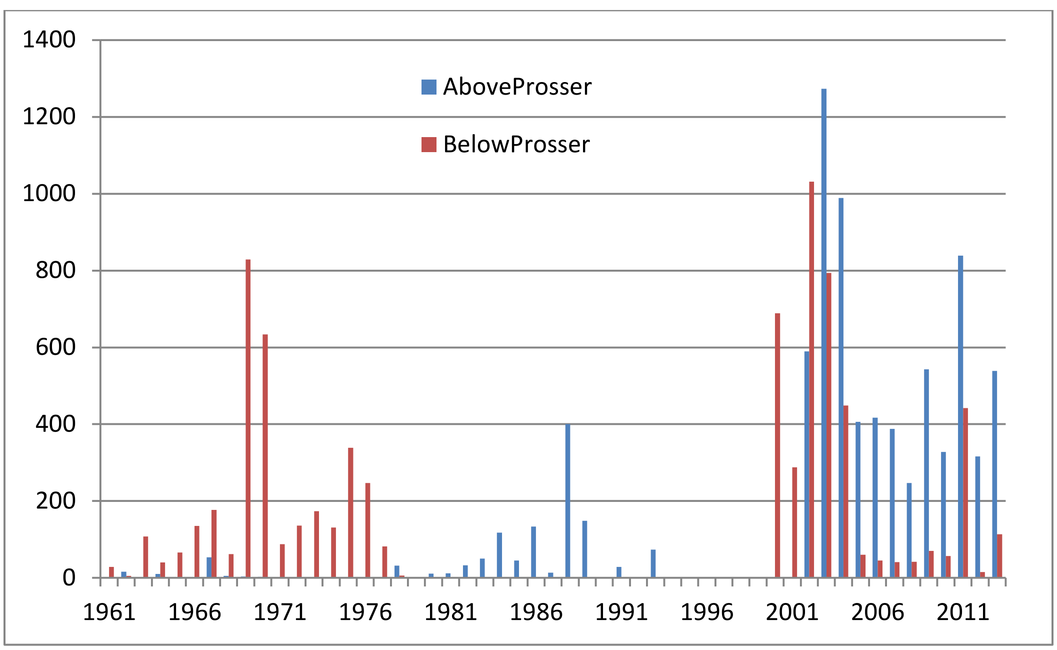



**Figure 17. Fall Chinook redd counts above and below Prosser Dam, 1961-present, for years in which surveys were conducted and data are available. Data from YN, WDFW, and Pacific Northwest National Laboratory files; survey data are partial or incomplete for most years prior to 2000.**

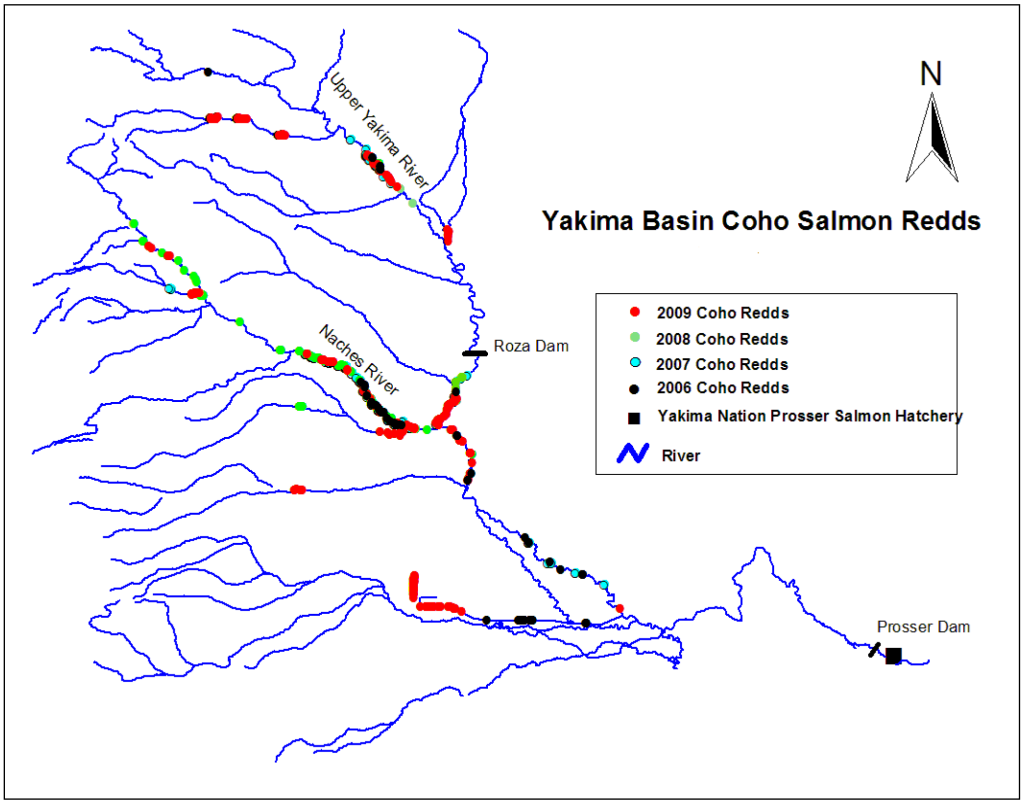



**Figure 18. Distribution of coho redds in the Yakima River Basin.**

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

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

**Discussion:**

Spatial distribution of spring Chinook spawners has increased as a result of acclimation site location, salmon homing fidelity and more fully seeding preferred spawning habitats (Dittman et al. 2010). Redd surveys in the Teanaway River conducted annually by Yakama Nation staff since 1981 demonstrate the benefits of reintroducing salmonids into underutilized habitat (Figure 15). The Jack Creek acclimation site began releasing CESRF spring chinook in 2000, with the first age-4 females returning from these releases in 2002. Redd counts in this tributary have increased from a pre-supplementation average of 3 redds per year to a post supplementation average of 71 redds per year. The proportion of natural-origin carcasses increased from less than one percent in 2002 (when CESRF fish first returned to the natural spawning grounds) to 42% in 2006 when the progeny of the 110 redds produced in 2002 (virtually 100% of which were produced by CESRF-origin fish) returned. These data clearly indicate that naturally-spawning CESRF spring Chinook were successful in returning natural-origin adults back to the Teanaway River.

Fall Chinook redd distribution in the Yakima River Basin appears to be experiencing a major transition in recent years. Historical redd survey data indicates that a substantial number of fall Chinook spawned below Prosser Dam in the lower Yakima River. However, from 2003-present, an average of approximately 80 percent (range 62 to 90 percent) of surveyed fall Chinook redds have been located above Prosser Dam (Figure 17). Biologists and habitat experts in the subbasin at least partially attribute this change in spawning distribution to the invasion of water stargrass (see Wise et al. 2009) in the lower 43 miles of the Yakima River. With the reintroduction of summer run Chinook, the Yakama Nation is expanding the distribution of summer/fall run Chinook spawners and redds into the middle reaches of the Yakima Basin between the town of Wapato upstream to the confluence with the Tieton River in the Naches subbasin and to Roza Dam in the Upper Yakima subbasin (Figures 1 and 16; Yakama Nation 2012). Figure 16 indicates a good distribution of reintroduced summer-run spawners into the intended habitats above Parker Dam in 2013, primarily age-4 fish returning from subyearling releases in 2010. This is the first year of substantial natural summer-run Chinook spawning in these habitats in over 40 years.

Coho redd counts and spawner distribution have increased substantially (Table 10 and Figure 18). Many redds in the mainstem were located intermixed with fall chinook redds, tucked under cut banks or were found in side channels. Tributary redd enumeration and identification continues to be accurate due to the fall low water levels, improving interagency cooperation, and relatively good weather. One of the overall goals during the present implementation phase (Phase II) of the coho program is to evaluate the transition of redds from the mainstem river into historic tributaries. With the beginning of Phase II of the Coho Program we observed large increases in tributary spawning, with an annual average exceeding 200 redds counted in tributaries since 2004 (Table 10). The 2013 redd counts were very low in mainstem and tributaries, due to a relatively poor return and escapement. Coho are volunteering into many tributaries, and the fidelity of adults from the summer parr plants is showing good results. We continue to find natural returns from the Taneum Creek adult out-plant study (Table 11). The study in Taneum Creek was set up to test reintroduction and interactions (Temple et al. 2012); it was not set up for full reintroduction. With implementation of the Coho Master Plan, we expect to double adult out plant numbers, increase escapement into Taneum Creek, and fully seed the available habitat.

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

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

## *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 were documented in: the YKFP Monitoring Plan (Busack et al. 1997), our FY2010 NPCC funding proposal, the project's "Supplementation Monitoring Plan" (Chapter 7 in 2005 annual report on project genetic studies), and numerous manuscripts in the published literature (see Results and References).

Diversity metrics for 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 2013. Each sample was analyzed to estimate the percentage of fine or small particles present (<0.85 mm). The Washington State

Timber, Fish, and Wildlife program established guidelines that specify the impacts that estimated sedimentation levels can have on salmonid egg-to-smolt survival. These impact guidelines will inform future analyses of "extrinsic" factors on natural production in the Yakima Basin.

**Results and Discussion:**

Little Naches

A total of 108 McNiel core samples were collected and processed from 9 spawning reaches in the Little Naches drainage this past year. Pyramid Creek has not been sampled since 2009 when the main road going into the site was 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 29 years for the two historical reaches, and 22 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 up from the previous year (cumulative average of 9.2% for 2013 compared to 7.9% for 2012). This compares to recent years when overall fine sediment conditions in the Little Naches drainage ranged from about 10.5% to 12% fines (Figure 19). Similar trends can be seen when looking at individual reach conditions over the longer term monitoring period since 1992. Most reaches have had a declining level of fine sediment in recent years.

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

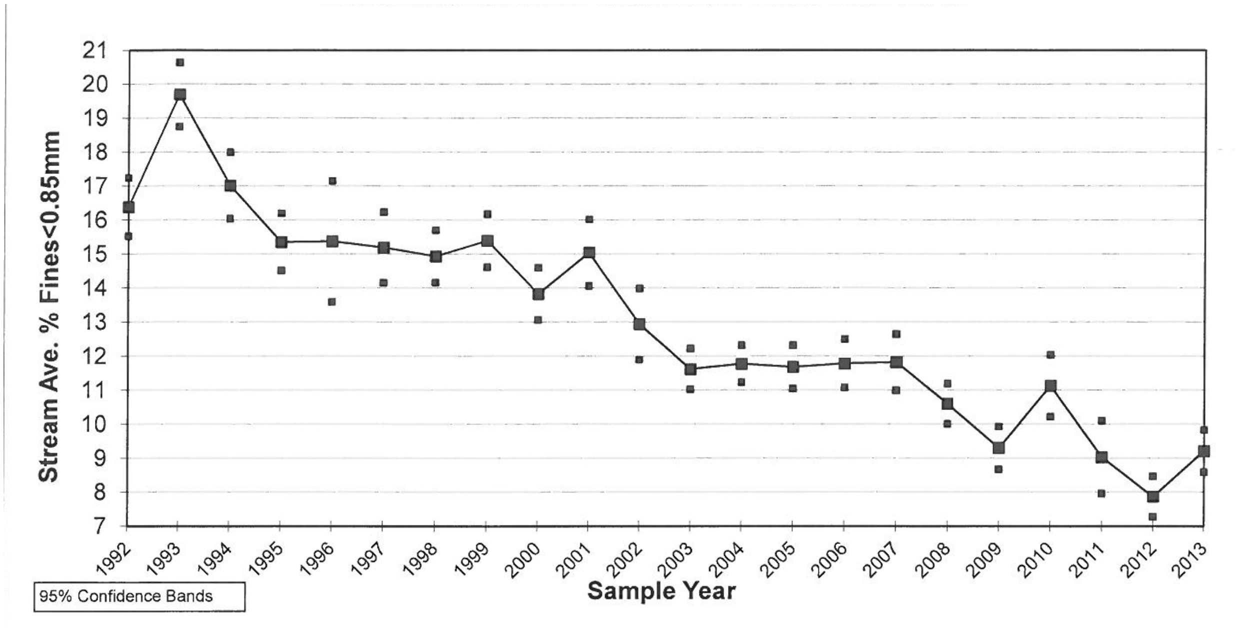



**Figure 19. Overall Fine Sediment (<0.85mm) Trends with 95% confidence bounds in the Little Naches River Drainage, 1992-2013.**

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 15 years that the USFS has been sampling this area. This stream reach typically receives significant bull trout spawning activity and the monitoring efforts provide valuable information on their spawning conditions. Average fine sediment in this reach was 11.1% in 2013, which is very similar to 2012 and below the mean for sediment levels for the 15-year sampling period (Figure 20).

Upper Yakima

A total of 60 samples were collected and processed from the Upper Yakima River drainage this past year (5 reaches, 12 samples from each reach). The same reaches (Stampede Pass, Easton, Camelot to Ensign Ranch, Elk Meadows, and Cle Elum) have been sampled annually for the past 17 years. Although average fine sediment levels in 4 of the 5 reaches increased from 2012, overall average percent fine sediment less than 0.85mm for the combined Upper Yakima drainage was again relatively low (Figure 21).

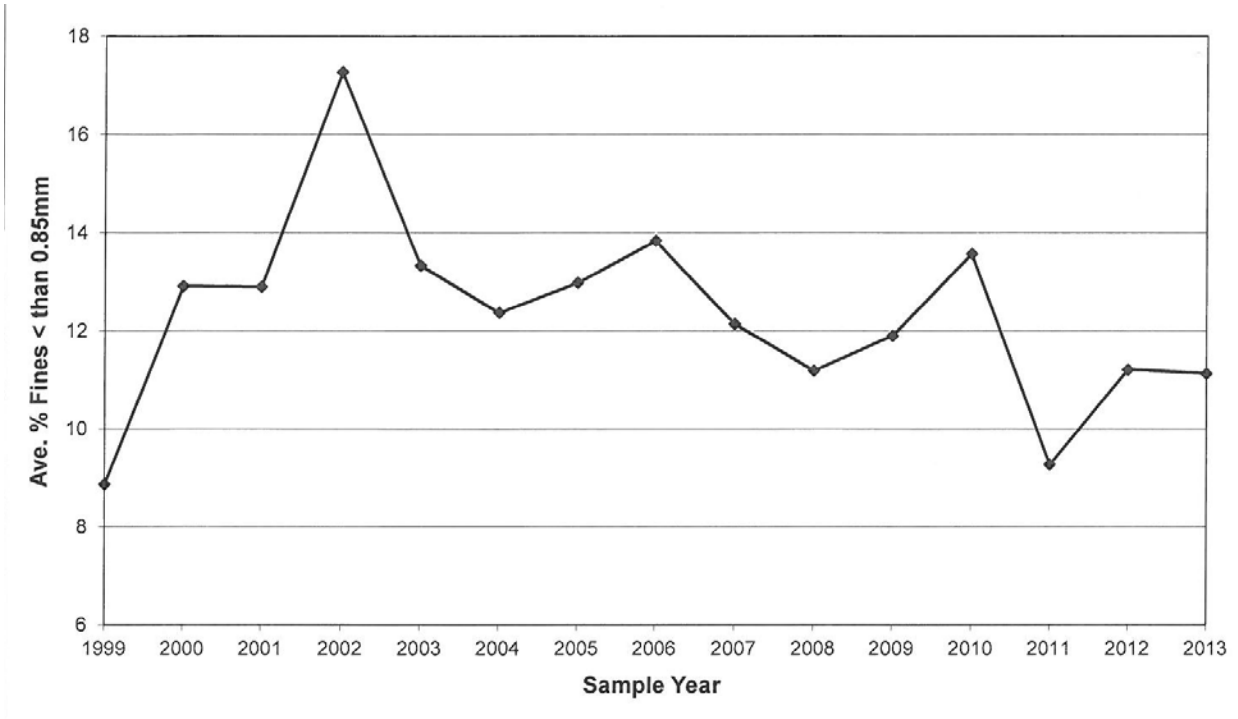



**Figure 20. Fine Sediment Trends in the South Fork Tieton River, 1999-2013. Note: Data for 2007 were collected from only 1 Riffle.**

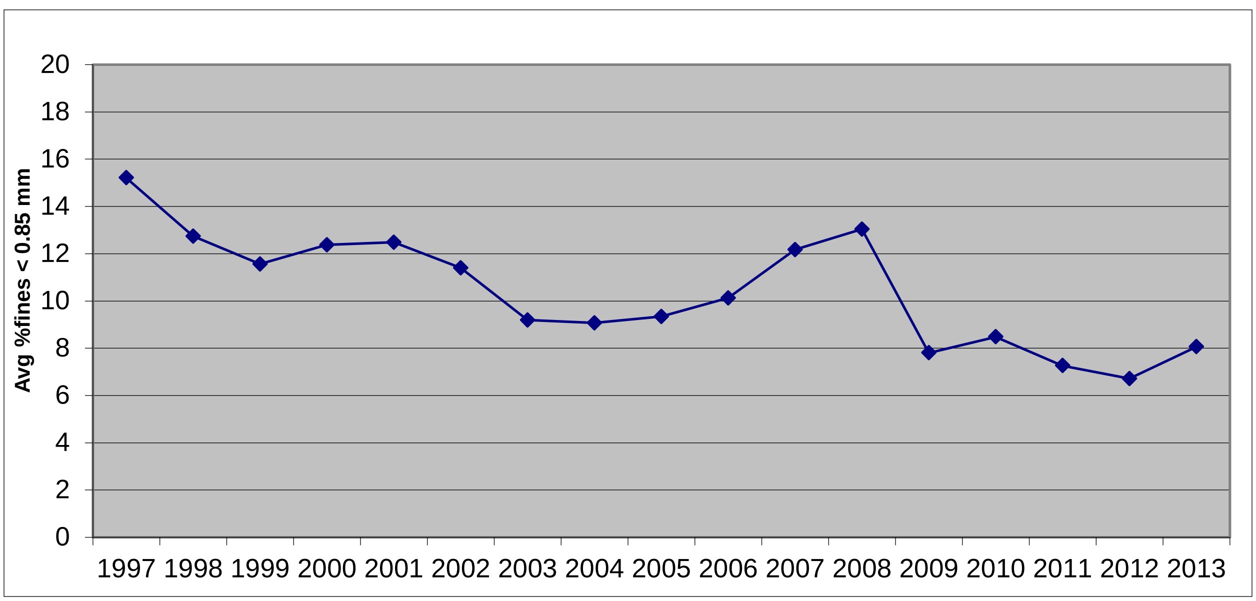



**Figure 21. Overall average percent fine sediment (< 0.85 mm) in spawning gravels of the Upper Yakima River, 1997-2013.**

Summary

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

The results of the USFS sampling in the South Fork Tieton River were very similar to the previous year and below mean sediment levels for the 15-year sampling period. These conditions should still be favorable for early life history survival of bull trout.

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

## Harvest Monitoring

### *Marine and Mainstem Columbia Fisheries*

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

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

## Results:

**Table 12. Marine and freshwater recoveries of CWTs from brood year 1997-2008 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) 7 Jan 2014.**

| Brood | Observed CWT Recoveries | | | Expanded CWT Recoveries | | |
|---|---|---|---|---|---|---|
| Year | Marine | Fresh | Marine % | Marine | Fresh | Marine % |
| 1997 | 5 | 56 | 8.2% | 8 | 321 | 2.4% |
| 1998 | 2 | 53 | 3.6% | 2 | 228 | 0.9% |
| 1999 | | 2 | 0.0% | | 9 | 0.0% |
| 2000 | | 14 | 0.0% | | 34 | 0.0% |
| 2001 | | 1 | 0.0% | | 1 | 0.0% |
| 2002 | | 7 | 0.0% | | 36 | 0.0% |
| 2003 | | 4 | 0.0% | | 10 | 0.0% |
| 2004 | 2 | 154 | 1.3% | 15 | 526 | 2.8% |
| 2005 | 2 | 96 | 2.0% | 2 | 304 | 0.7% |
| 2006 | 14 | 329 | 4.1% | 16 | 1165 | 1.4% |
| 2007 | 8 | 145 | 5.2% | 13 | 1124 | 1.1% |
| 2008[1] | 5 | 240 | 2.0% | 7 | 1608 | 0.4% |

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 2008 are considered preliminary or incomplete.

**Table 13. 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 | 0 | 12.2% | |
| 1984 | 3,890 | 135 | 258 | 2,658 | 289 | 682 | 682 | 0 | 17.5% | |
| 1985 | 5,274 | 192 | 179 | 4,560 | 865 | 1,236 | 1,236 | 0 | 23.4% | |
| 1986 | 13,480 | 279 | 781 | 9,439 | 1,340 | 2,400 | 2,400 | 0 | 17.8% | |
| 1987 | 6,165 | 96 | 372 | 4,443 | 517 | 986 | 986 | 0 | 16.0% | |
| 1988 | 5,610 | 359 | 371 | 4,246 | 444 | 1,174 | 1,174 | 0 | 20.9% | |
| 1989 | 8,936 | 213 | 668 | 4,914 | 747 | 1,628 | 1,628 | 0 | 18.2% | |
| 1990 | 6,870 | 348 | 450 | 4,372 | 663 | 1,461 | 1,461 | 0 | 21.3% | |
| 1991 | 4,611 | 183 | 277 | 2,906 | 32 | 492 | 492 | 0 | 10.7% | |
| 1992 | 6,226 | 103 | 375 | 4,599 | 345 | 823 | 823 | 0 | 13.2% | |
| 1993 | 5,135 | 44 | 312 | 3,919 | 129 | 485 | 485 | 0 | 9.4% | |
| 1994 | 2,228 | 86 | 107 | 1,302 | 25 | 219 | 219 | 0 | 9.8% | |
| 1995 | 1,375 | 1 | 68 | 666 | 79 | 148 | 148 | 0 | 10.8% | |
| 1996 | 5,790 | 6 | 303 | 3,179 | 475 | 784 | 784 | 0 | 13.5% | |
| 1997 | 5,235 | 3 | 350 | 3,173 | 575 | 928 | 928 | 0 | 17.7% | |
| 1998 | 2,825 | 3 | 142 | 1,903 | 188 | 332 | 332 | 0 | 11.8% | |
| 1999 | 3,944 | 4 | 182 | 2,781 | 604 | 790 | 790 | 0 | 20.0% | |
| 2000 | 28,705 | 58 | 1,745 | 19,100 | 2,458 | 4,261 | 4,138 | 123 | 14.8% | |
| 2001 | 30,873 | 990 | 4,033 | 23,265 | 4,630 | 9,654 | 5,564 | 4,090 | 31.3% | 30.0% |
| 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 | 1,503 | 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 | 5,003 | 176 | 344 | 4,303 | 279 | 799 | 388 | 411 | 16.0% | 14.0% |
| 2008 | 11,493 | 1,149 | 1,570 | 8,598 | 1,532 | 4,251 | 1,199 | 3,053 | 37.0% | 26.8% |
| 2009 | 12,979 | 1,138 | 1,116 | 12,120 | 2,353 | 4,606 | 1,260 | 3,346 | 35.5% | 26.1% |
| 2010 | 17,685 | 1,517 | 2,620 | 13,142 | 1,741 | 5,878 | 1,347 | 4,530 | 33.2% | 22.1% |
| 2011 | 22,353 | 975 | 1,643 | 17,960 | 4,380 | 6,997 | 2,400 | 4,597 | 31.3% | 22.4% |
| 2012 | 15,931 | 756 | 1,478 | 12,053 | 3,320 | 5,554 | 2,220 | 3,334 | 34.9% | 28.2% |
| 2013[1] | 14,295 | 684 | 1,117 | 10,245 | 2,653 | 4,454 | 1,697 | 2,756 | 31.2% | 23.7% |
| Mean | 10,389 | 403 | 873 | 7,360 | 1,171 | 2,448 | 1,378 | 2,623 | 20.1% | 17.9% |

1. Preliminary.

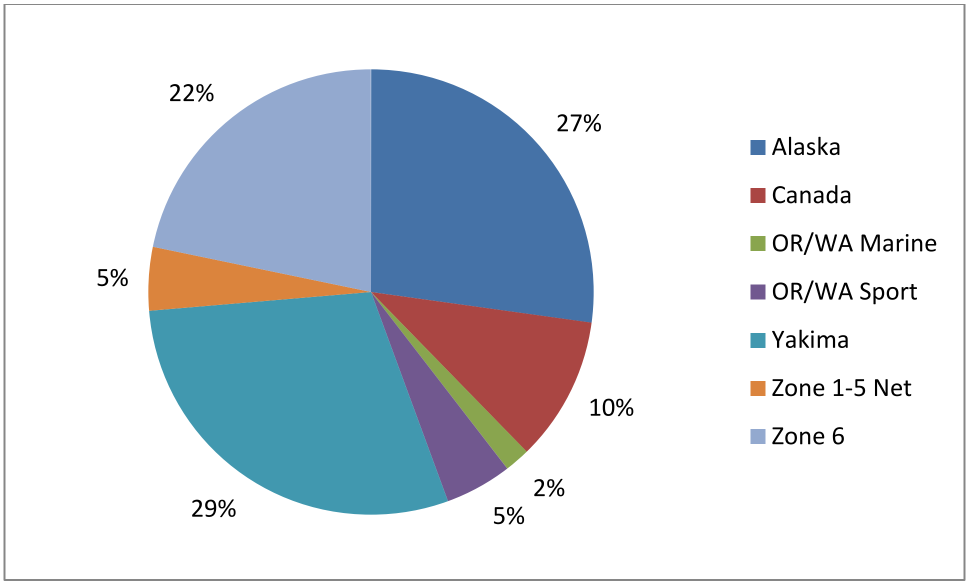



**Figure 22. Distribution of coded-wire tag recoveries of Yakima Basin summer/fall run Chinook releases in marine, mainstem Columbia River, and Yakima Basin fisheries. Data retrieved from the regional mark information system (RMIS) for brood year 1997-2007 recoveries.**

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

## Discussion:

Based on available CWT information, harvest managers have long assumed that Columbia River spring Chinook are not harvested in any abundance in marine fisheries as their ocean migration does not generally overlap either spatially or temporally with the occurrence of marine fisheries (TAC 1997). Harvest recoveries of CESRF spring Chinook as reported to RMIS to date appear to confirm this, as marine harvest apparently accounts for only about 0-3% of the total harvest of Yakima Basin spring Chinook (Table 12). Adult returns of spring Chinook from the CESRF appear to be making substantial contributions to Columbia Basin fisheries (Table 13).

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

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

### *Yakima Subbasin Fisheries*

**Methods:** The two co-managers, Yakama Nation and WDFW, are responsible for monitoring their respective fisheries in the Yakima River. Each agency employs fish monitors dedicated to creel surveys and/or fisher interviews at the most utilized fishing locations and/or boat ramps. From these surveys, standard techniques are employed to expand fishery sample data for total effort and open areas and times to derive total harvest estimates. Fish are interrogated for various marks. Methods are consistent with monitoringmethods.org methods 404, 461, 790, and 960.

## Results:

**Table 14. Spring Chinook harvest in the Yakima River Basin, 1983-present.**

| | Tribal | | Non-Tribal | | River Totals | | | Harvest |
|---|---|---|---|---|---|---|---|---|
| Year | CESRF | Natural | CESRF | Natural | CESRF | Natural | Total | Rate[1] |
| 1983 | | 84 | | 0 | | 84 | 84 | 5.8% |
| 1984 | | 289 | | 0 | | 289 | 289 | 10.9% |
| 1985 | | 865 | | 0 | | 865 | 865 | 19.0% |
| 1986 | | 1,340 | | 0 | | 1,340 | 1,340 | 14.2% |
| 1987 | | 517 | | 0 | | 517 | 517 | 11.6% |
| 1988 | | 444 | | 0 | | 444 | 444 | 10.5% |
| 1989 | | 747 | | 0 | | 747 | 747 | 15.2% |
| 1990 | | 663 | | 0 | | 663 | 663 | 15.2% |
| 1991 | | 32 | | 0 | | 32 | 32 | 1.1% |
| 1992 | | 345 | | 0 | | 345 | 345 | 7.5% |
| 1993 | | 129 | | 0 | | 129 | 129 | 3.3% |
| 1994 | | 25 | | 0 | | 25 | 25 | 1.9% |
| 1995 | | 79 | | 0 | | 79 | 79 | 11.9% |
| 1996 | | 475 | | 0 | | 475 | 475 | 14.9% |
| 1997 | | 575 | | 0 | | 575 | 575 | 18.1% |
| 1998 | | 188 | | 0 | | 188 | 188 | 9.9% |
| 1999 | | 604 | | 0 | | 604 | 604 | 21.7% |
| 2000 | 53 | 2,305 | | 100 | 53 | 2,405 | 2,458 | 12.9% |
| 2001 | 572 | 2,034 | 1,252 | 772 | 1,825 | 2,806 | 4,630 | 19.9% |
| 2002 | 1,373 | 1,207 | 492 | 36[2] | 1,865 | 1,243 | 3,108 | 20.6% |
| 2003 | 134 | 306 | 0 | 0 | 134 | 306 | 440 | 6.3% |
| 2004 | 289 | 712 | 569 | 109[2] | 858 | 820 | 1,679 | 11.0% |
| 2005 | 46 | 428 | 0 | 0 | 46 | 428 | 474 | 5.4% |
| 2006 | 246 | 354 | 0 | 0 | 246 | 354 | 600 | 9.5% |
| 2007 | 123 | 156 | 0 | 0 | 123 | 156 | 279 | 6.5% |
| 2008 | 521 | 414 | 586 | 11[2] | 1,107 | 426 | 1,532 | 17.8% |
| 2009 | 1,089 | 715 | 541 | 8[2] | 1,630 | 722 | 2,353 | 19.4% |
| 2010 | 345 | 194 | 1,154 | 48[2] | 1,499 | 241 | 1,741 | 13.2% |
| 2011 | 1,361 | 1,261 | 1,579 | 179[2] | 2,940 | 1,440 | 4,380 | 24.4% |
| 2012 | 1,220 | 1,302 | 735 | 63[2] | 1,955 | 1,364 | 3,320 | 27.5% |
| 2013 | 846 | 975 | 786 | 46[2] | 1,632 | 1,021 | 2,653 | 25.9% |
| Mean | 628 | 631 | 592 | 98 | 1,220 | 674 | 1,171 | 13.7% |

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 15. Estimated fall Chinook return, escapement, and harvest in the Yakima River, 1998-2013. Data from WDFW and YN databases.**

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

**Table 16. Estimated Coho return, escapement, and harvest in the Yakima River, 1999-2013. Data from WDFW and YN databases.**

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

## Discussion:

Adult returns of spring Chinook from the CESRF have substantially increased fishing opportunity for all fishers in the Yakima Basin (Table 14) 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 15). Tribal fishers harvest a substantial, but unquantified number of Yakima Basin-destined fall Chinook (Figure 22) and coho in commercial gillnet fisheries in the Zone 6 fishing area. Because of the quantity and relatively higher quality of fall Chinook and coho available to tribal fishers in Zone 6 Columbia and Klickitat River fisheries, Yakima River tribal harvest is typically at or near zero even though regulations allowing fall season fisheries in the Yakima River are propagated annually by the Yakama Nation.

## Hatchery Monitoring

### *Effect of Artificial Production on the Viability of Natural Fish Populations*

WDFW is 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 23) in 1997. This program is a supplementation effort targeting the upper Yakima River population and is designed to test whether artificial propagation can be used to increase natural production and harvest opportunities while limiting ecological and genetic impacts (RASP 1992). It is an integrated hatchery program (Mobrand et al. 2005) because only natural-origin brood-stock are used and returning hatchery-origin adults are allowed to spawn in the wild. The program employs "best practice" hatchery management principles (see Cuenco et al. 1993, Mobrand et al. 2005) including reduced pond densities, strict disease management protocols, random brood-stock selection, and factorial mating (Busack and Knudsen 2007) to maximize effective population size. Fish are reared at the central facility, but released from three acclimation sites located near the central facility at: Easton approximately 25km upstream of the central facility, Clark Flat about 25km downstream of the central facility, and Jack Creek about 12km upstream from the Teanaway River's confluence with the Yakima River (Figure 23). The CESRF collected its first spring Chinook brood-stock in 1997, released its first fish in 1999, and age-4 adults have been returning since 2001. The first generation of offspring of CESRF and wild fish spawning in the wild returned as adults in 2005. The program uses the adjacent, un-supplemented Naches River population as an environmental and wild control system.

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

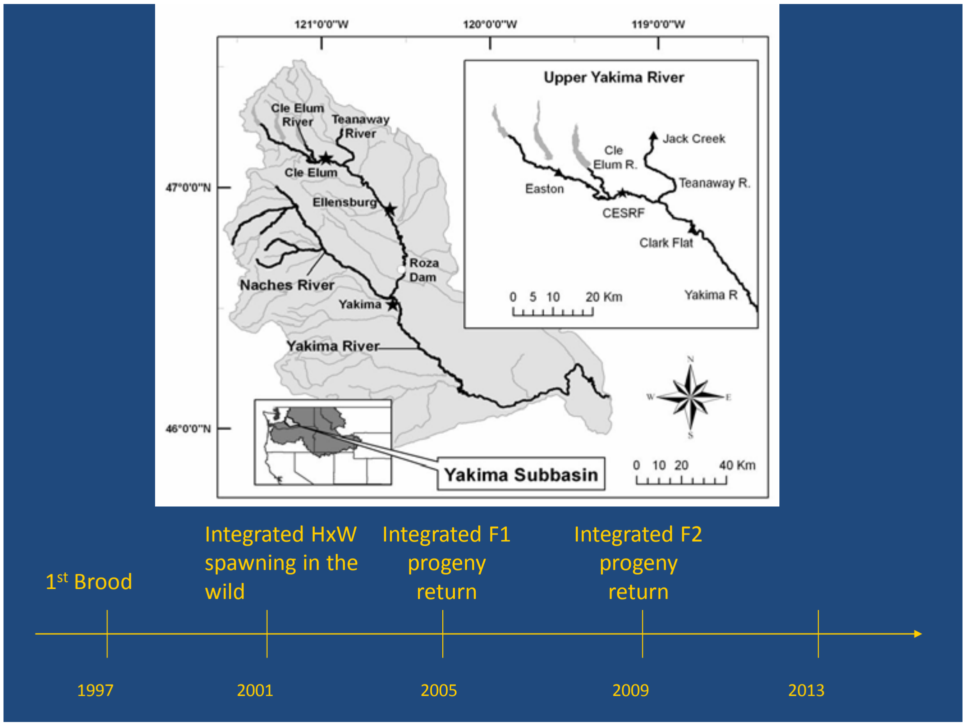



**Figure 23. Map of the Yakima River Basin, Cle Elum Supplementation and Research Facility (CESRF) locations, and timeline of the spring Chinook supplementation program.**

## Results:

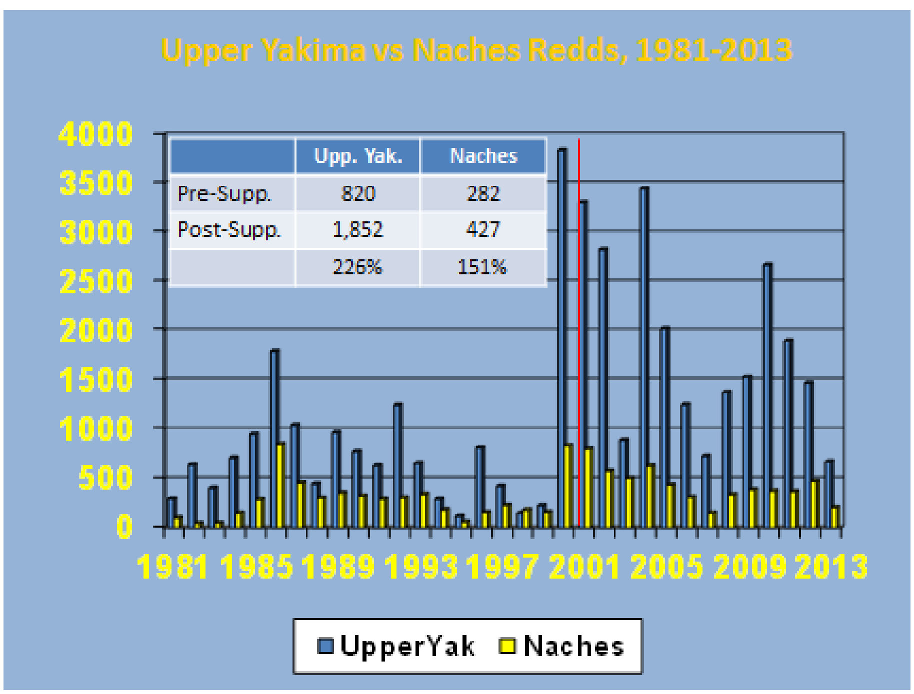



**Figure 24. Spring Chinook redd counts in the supplemented Upper Yakima (blue bar) relative to the un-supplemented Naches (control; yellow bar) for the pre- (1981-2000) and post-supplementation (2001-2013) periods.**

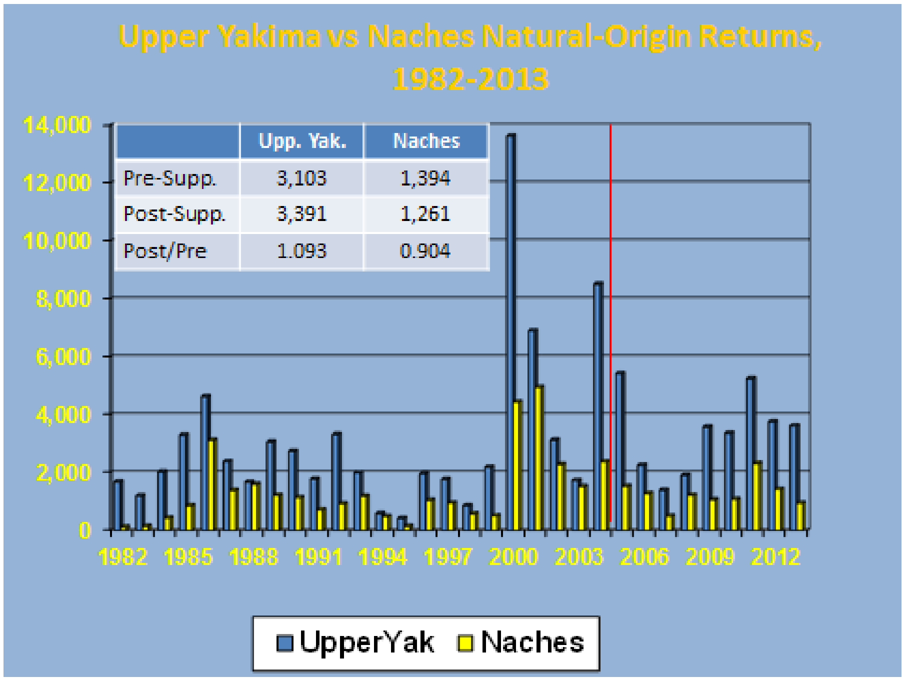



**Figure 25. Natural-Origin returns of Spring Chinook in the supplemented Upper Yakima (blue bar) relative to the un-supplemented Naches (control; yellow bar) for the pre- (1982-2004) and post-supplementation (2005-2013) periods.**

## Discussion:

Supplementation has increased spring Chinook redd abundance in the Upper Yakima relative to the Naches control system (Figure 24). Redd counts in the post-supplementation period (2001-2013) have increased 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 (226%; P=0.002) was about 75% greater than that observed in the Naches system (151%; P=0.056). As noted above, spatial distribution of spring Chinook has also increased as a result of supplementation with dramatic increases in redd abundance observed in the Teanaway River (Figure 15).

The mean natural-origin return in the post-supplementation period (2005-2013) increased in the upper Yakima (~ 9%; P=0.783; Figure 25) and decreased in the Naches system (~ -10%; P=0.766; Figure 25) relative to the pre-supplementation period (1982-2004); neither change was significant. We have already noted that limiting factors appear to be inhibiting natural productivity (see status and trend of adult productivity) throughout the Yakima Basin. It may also be that the post-supplementation time period is not yet long enough to detect a significant change in this natural production parameter. Given the short post-supplementation time series, these findings are preliminary. We will continue to incorporate additional years of data and out-of-basin control populations into this evaluation and publish more complete findings at a later date.

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

The YKFP is presently studying the release of over 1.0 million coho smolts annually from acclimation sites in the Naches and Upper Yakima subbasins. These fish are a combination of in-basin production from brood-stock collected in the vicinity of Prosser Dam plus out-of-basin stock generally reared at Willard or Eagle Creek National Fish Hatcheries and moved to the Yakima Subbasin for final rearing and release. Monitoring of these efforts to re-introduce a sustainable, naturally spawning coho population in the Yakima Basin have indicated that adult coho returns averaged about 3,800 fish from 1997-2013 (an order of magnitude improvement from the average for years prior to the project) including estimated returns of wild/natural coho averaging about 900 fish annually since 2001 (Figure 4). Coho re-introduction research has demonstrated that hatchery-origin coho, with a legacy of as many as 10 to 30 generations of hatchery-influence, can reestablish a naturalized population after as few as 3 to 5 generations of outplanting in the wild (Bosch et al. 2007). The project is working to further develop a locally adapted brood-stock and to establish specific release sites and strategies that optimize natural reproduction and survival.

### *Effectiveness of Hatchery Reform*

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

**Methods:**

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

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

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

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

# Results:

**Table 17. Escapement (Roza Dam counts less brood-stock collection and harvest above Roza) of natural- (NoR) and hatchery-origin (HoR) spring Chinook to the upper Yakima subbasin, 1982 – present.**

| | Wild/Natural (NoR) | | | CESRF (HoR) | | | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Adults | Jacks | Total | Adults | Jacks | Total | Adults | Jacks | Total | PHOS[1] | PNI[1] |
| 1982 | | | 1,146 | | | | | | | | |
| 1983 | | | 1,007 | | | | | | | | |
| 1984 | | | 1,535 | | | | | | | | |
| 1985 | | | 2,331 | | | | | | | | |
| 1986 | | | 3,251 | | | | | | | | |
| 1987 | | | 1,734 | | | | | | | | |
| 1988 | | | 1,340 | | | | | | | | |
| 1989 | | | 2,331 | | | | | | | | |
| 1990 | | | 2,016 | | | | | | | | |
| 1991 | | | *1,583*[2] | | | | | | | | |
| 1992 | | | 3,009 | | | | | | | | |
| 1993 | | | 1,869 | | | | | | | | |
| 1994 | | | 563 | | | | | | | | |
| 1995 | | | 355 | | | | | | | | |
| 1996 | | | 1,631 | | | | | | | | |
| 1997 | 1,141 | 43 | 1,184 | | | | | | | | |
| 1998 | 369 | 18 | 387 | | | | | | | | |
| 1999 | 498 | 468 | 966 | | | | | | | | |
| 2000 | 10,491 | 481 | 10,972 | | 688 | 688 | 10,491 | 1,169 | 11,660 | 5.9% | |
| 2001 | 4,454 | 297 | 4,751 | 6,065 | 982 | 7,047 | 10,519 | 1,279 | 11,798 | 59.7% | 62.6% |
| 2002 | 1,820 | 89 | 1,909 | 6,064 | 71 | 6,135 | 7,884 | 160 | 8,044 | 76.3% | 56.7% |
| 2003 | 394 | 723 | 1,117 | 1,036 | 1,105 | 2,141 | 1,430 | 1,828 | 3,258 | 65.7% | 60.3% |
| 2004 | 6,536 | 671 | 7,207 | 2,876 | 204 | 3,080 | 9,412 | 875 | 10,287 | 29.9% | 77.0% |
| 2005 | 4,401 | 175 | 4,576 | 627 | 482 | 1,109 | 5,028 | 657 | 5,685 | 19.5% | 83.7% |
| 2006 | 1,510 | 121 | 1,631 | 1,622 | 111 | 1,733 | 3,132 | 232 | 3,364 | 51.5% | 66.0% |
| 2007 | 683 | 161 | 844 | 734 | 731 | 1,465 | 1,417 | 892 | 2,309 | 63.4% | 61.2% |
| 2008 | 988 | 232 | 1,220 | 2,157 | 957 | 3,114 | 3,145 | 1,189 | 4,334 | 71.9% | 58.2% |
| 2009 | 1,843 | 701 | 2,544 | 2,234 | 2,260 | 4,494 | 4,077 | 2,961 | 7,038 | 63.9% | 61.0% |
| 2010 | 2,436 | 413 | 2,849 | 4,524 | 1,001 | 5,525 | 6,960 | 1,414 | 8,374 | 66.0% | 60.2% |
| 2011 | 3,092 | 926 | 4,018 | 3,162 | 1,404 | 4,566 | 6,254 | 2,330 | 8,584 | 53.2% | 65.3% |
| 2012 | 2,359 | 191 | 2,550 | 2,661 | 265 | 2,926 | 5,020 | 456 | 5,476 | 53.4% | 65.2% |
| 2013 | 1,708 | 678 | 2,386 | 1,587 | 840 | 2,427 | 3,295 | 1,518 | 4,813 | 50.4% | 66.5% |
| Mean[3] | 2,631 | 376 | 3,007 | 2,719 | 801 | 3,520 | 5,198 | 1,215 | 6,413 | 55.8% | 64.9% |

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 13-year mean annual PNI of 65% (range 57-84%; Table 17). 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 18) 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 18. Avian predation river reach survey start and end locations and total reach length.**

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

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

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

**Acclimation Site Surveys**

Three Spring Chinook acclimation sites in upper Yakima River (Clark Flat, Jack Creek, and Easton) and one Coho site (JD Holmes) were surveyed for piscivorous birds again in 2013 (Figure 1). Surveys were conducted between January 23 and June 10, though dates varied for each site. Three surveys were conducted at the Spring Chinook sites each day, at 8:00 am, 12:00 noon, and 4:00 pm. The Coho site was surveyed once or twice on days hatchery personnel were feeding smolts. Surveys were conducted on foot. All piscivorous birds within the acclimation facility, along the length of the artificial acclimation stream, and 50 meters above and 150 meters below the acclimation stream outlet, into the main stem of the Yakima River or North Fork Teanaway, were recorded.

**Salmon PIT Tag Surveys at Great Blue Heron Rookeries**

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

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

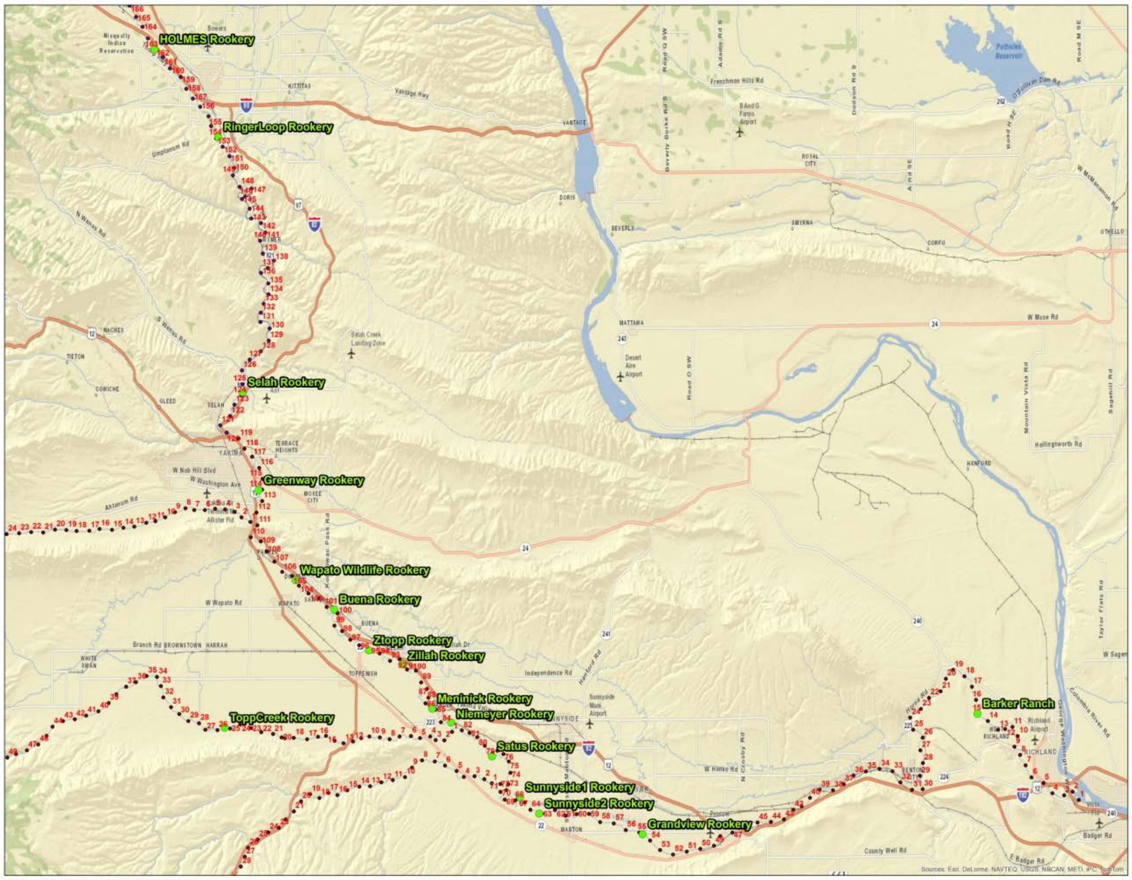



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**Figure 26. Map of Yakima Basin Heron Rookeries.**

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

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

The objectives for the study were:

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

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

## Results and Discussion:

River Reach Surveys

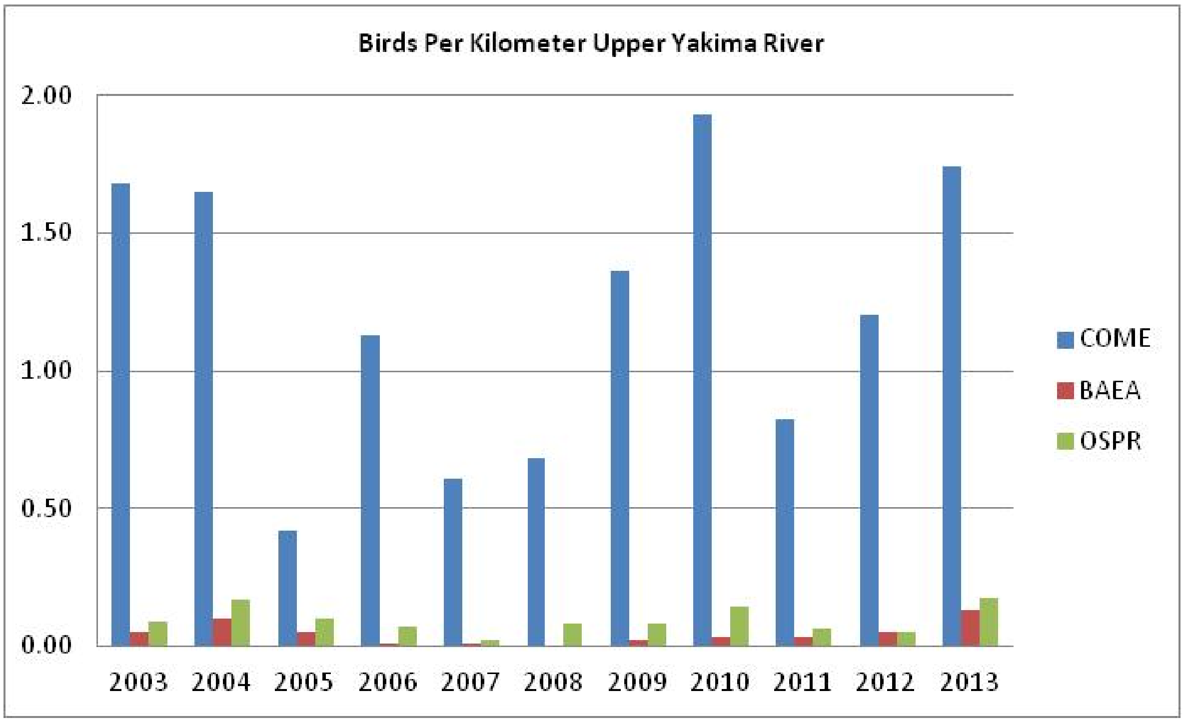


**Figure 27. Upper Yakima piscivorous birds per kilometer (Common Merganser-COME, Bald Eagle-BAEA, and Osprey-OSPR).**

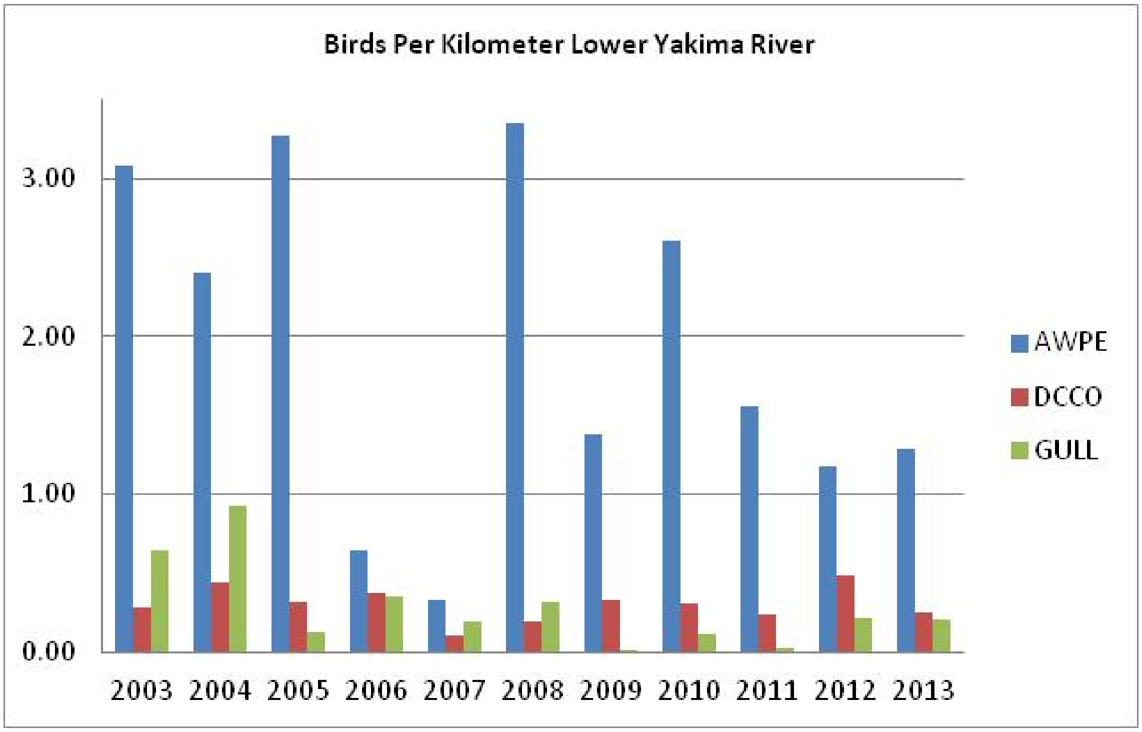


**Figure 28. Lower Yakima piscivorous birds per kilometer (American White Pelican-AWPE, Double Crested Cormorant-DCCO, and Gulls-GULL).**

Thirteen different piscivorous bird species were observed on the Yakima River. These included: American White Pelican, Bald Eagle, Black-crowned Night Heron, Belted Kingfisher, Caspian Tern, Common Merganser, Double-crested Cormorant, Forster's Tern, Great Egret, Great Blue Heron, Gull species, Hooded Merganser, and Osprey. These same 13 species were observed in most survey years.

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

American White Pelicans, the most numerous avian fish predator during smolt out-migration, remain consistently abundant in the lower Yakima River and in the Wapato Reach of the Yakima River (Figure 28). Observations of Double Crested Cormorants and Gulls remain relatively low in the Yakima River Basin.

Acclimation Sites Surveys

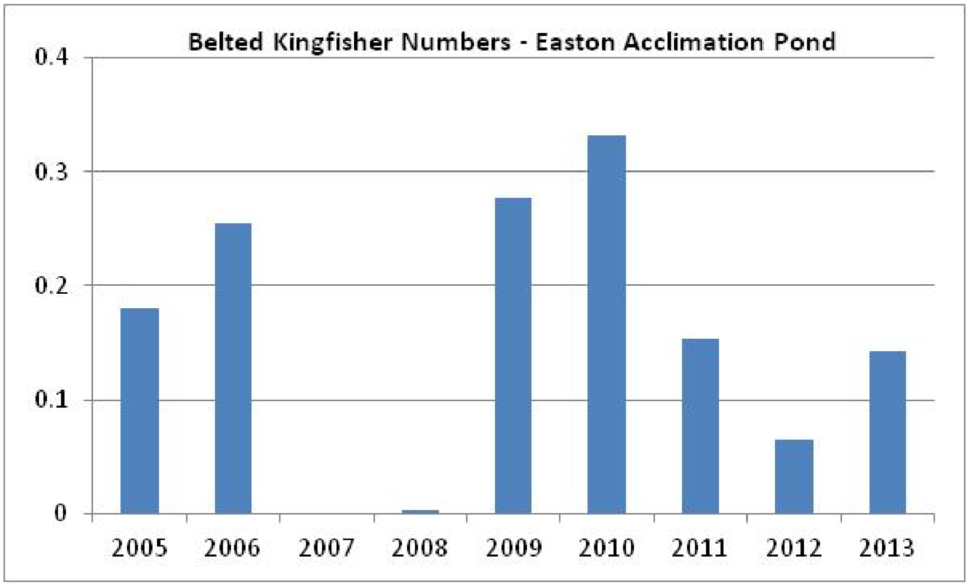


**Figure 29. Average number of Belted King Fishers observed per day at the Easton spring Chinook acclimation site between 2005 and 2013 when fish were present.**

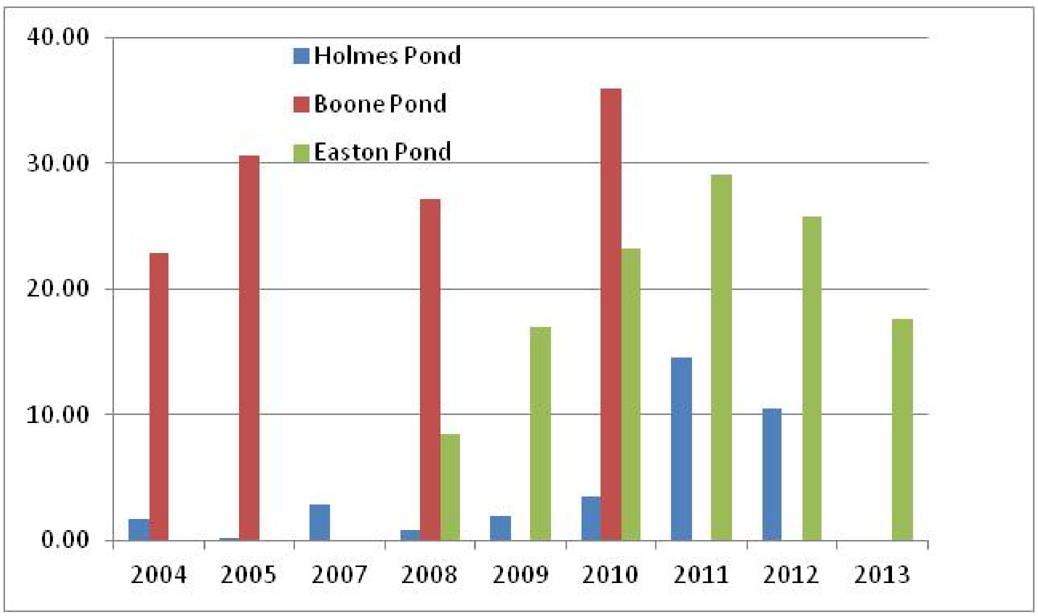


**Figure 30. Average number of Common Mergansers observed per day at the JD Holmes, Boone and Easton Pond Coho acclimation sites between 2004 and 2013 when fish were present.**

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

Coho acclimation was conducted in natural or manmade ponds which were highly accessible to piscivorous birds. The Common Merganser was the most common predator at these Coho acclimation sites (Figure 30). From 2004 to 2013 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 has not been used the past three years. Easton pond was used consistently as a Coho acclimation site from 2004 to 2013. 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.

<u>Great Blue Heron Rookeries</u>

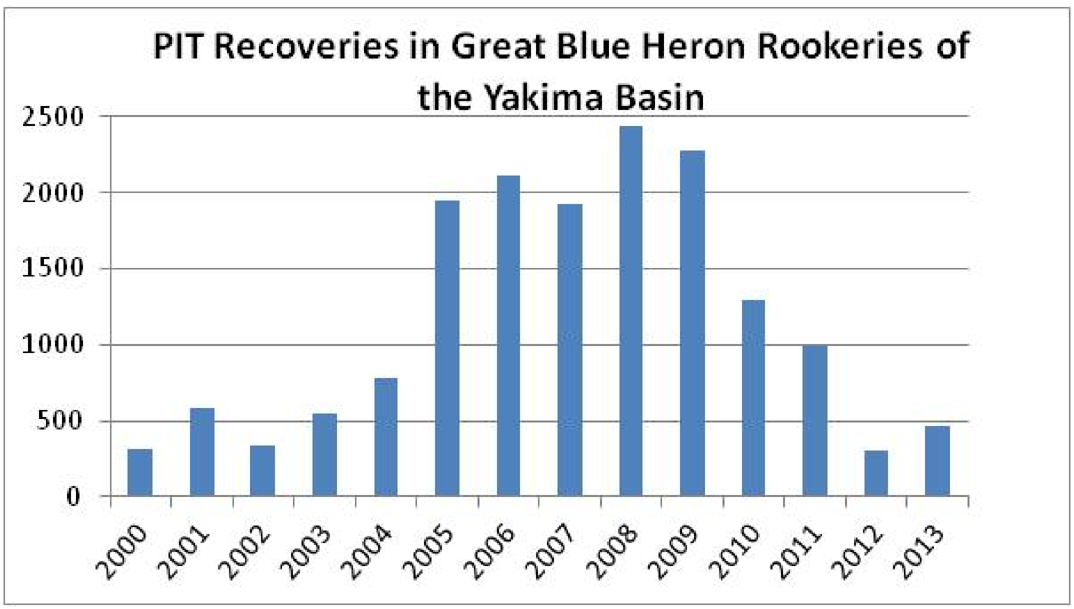


**Figure 31. Number of PIT tags recovered at Yakima Basin Great Blue Heron rookery sites during surveys conducted from 2008-2013. Tags were from juvenile salmonids migrating downstream between 2000 and 2013. Total PIT tags recovered are shown by their corresponding migration year.**

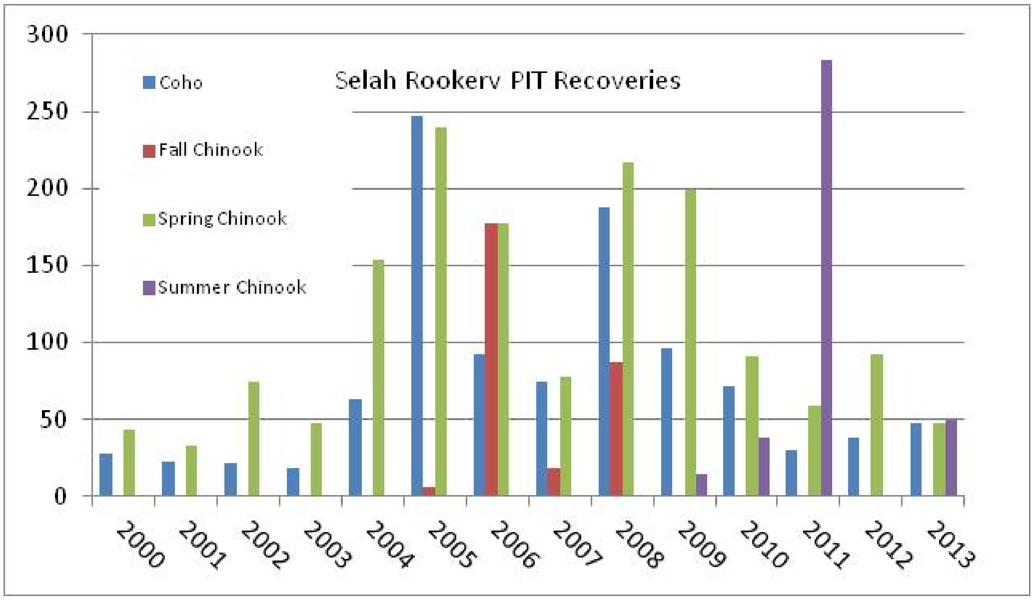


**Figure 32. Number of PIT tags recovered at the Selah Great Blue Heron rookery during surveys conducted from 2008-2013. Tags were from juvenile salmonids migrating downstream between 2000 and 2013. Total PIT tags recovered are shown by species and their corresponding migration year.**

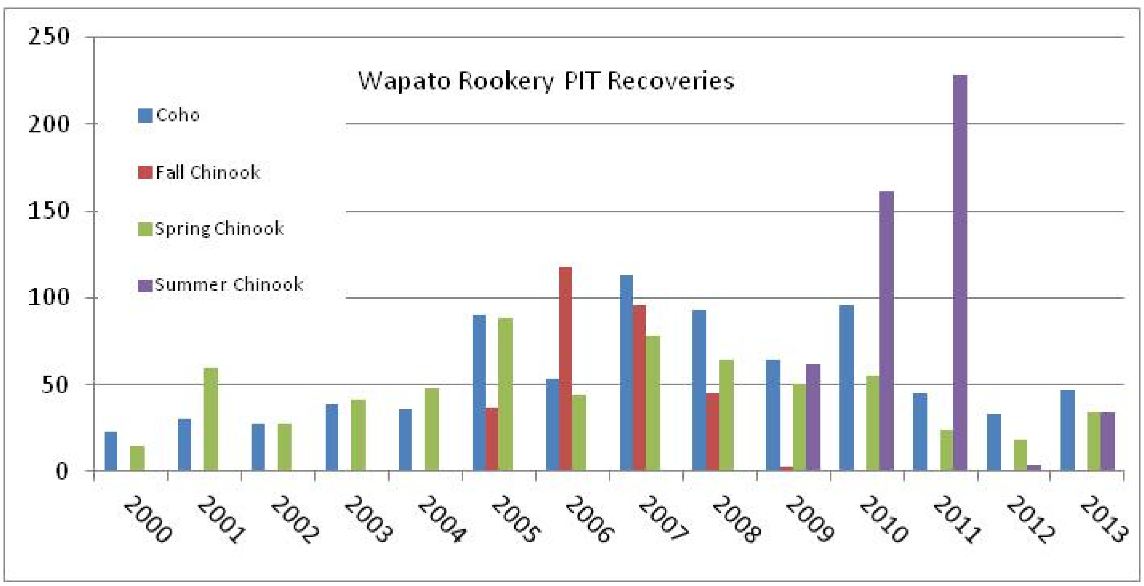


**Figure 33. Number of PIT tags recovered at the Wapato Wildlife Area Great Blue Heron rookery during surveys conducted from 2008-2013. Tags were from juvenile salmonids migrating downstream between 2000 and 2013. Total PIT tags recovered are shown by species and their corresponding migration year.**

Surveys of the Yakima Basin Great Blue Heron rookery sites between 2008 and 2013 recovered approximately 16,500 salmonid related PIT tags (Figure 31). Heron rookery PIT recoveries, when sorted by migration year, show higher mortality rates for juvenile migration years 2005 to 2009. This may correspond to river conditions (e.g., lower flows) that are likely conducive to increased smolt mortalities. For example, the migration year of 2008 was the most prevalent in PIT recoveries which could be related to drought conditions in 2007 when many 2008 migrants were released.

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

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

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

### *Fish Predation Index and Predator Control*

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

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

**Methods:**

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

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

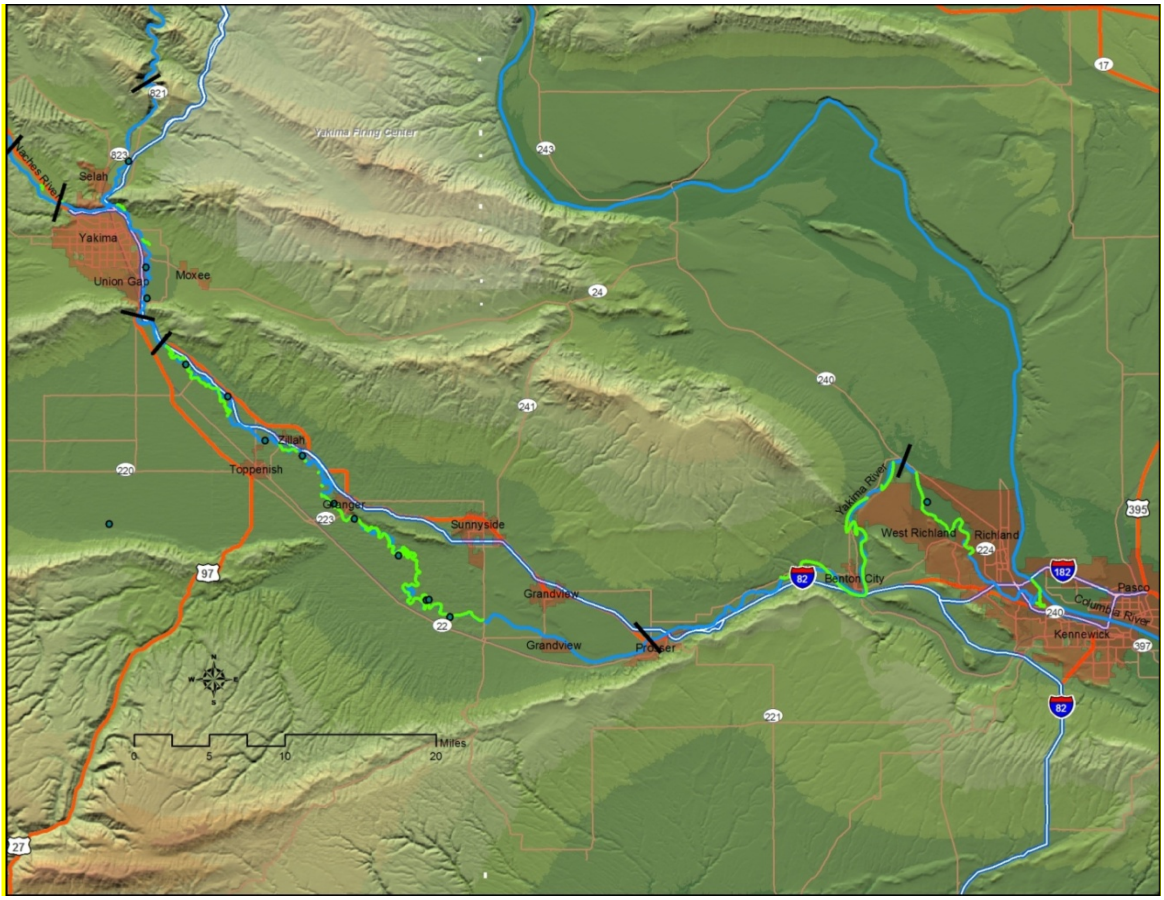


**Figure 34. Map of Yakima River Piscivorous Fish Populations Study Areas.**

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

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

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

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


**Figure 35. Yakima River Delta Survey Areas.**

## Results and Discussion:

Wapato Reach fish species included the piscivorous Northern Pikeminnow and 10 other species of fish (Table 19). Relative catch numbers of the Northern Pikeminnow, for 2010 to present, were small compared to other fish species. Fish from the family *Catostomidae*, or suckers, were the highest relative catch for the Wapato reach (Figure 36). Salmonids were found in high abundance in the Wapato reach; catch abundance was dependent on time of year and is highest during the salmon smolt out-migration through the reach.

**Table 19. Wapato Reach of the Yakima River - Fish Species identified during surveys 2010-2013.**

Wapato Reach Fish Species

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

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

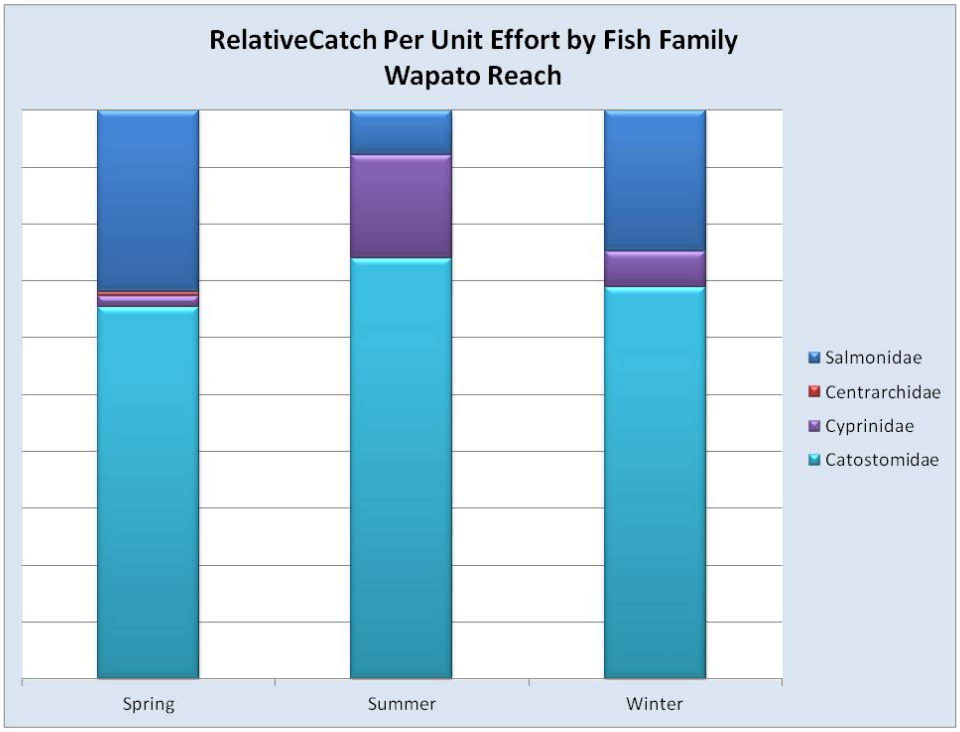


**Figure 36. Wapato Reach of the Yakima River – Relative catch per unit effort by fish family.**

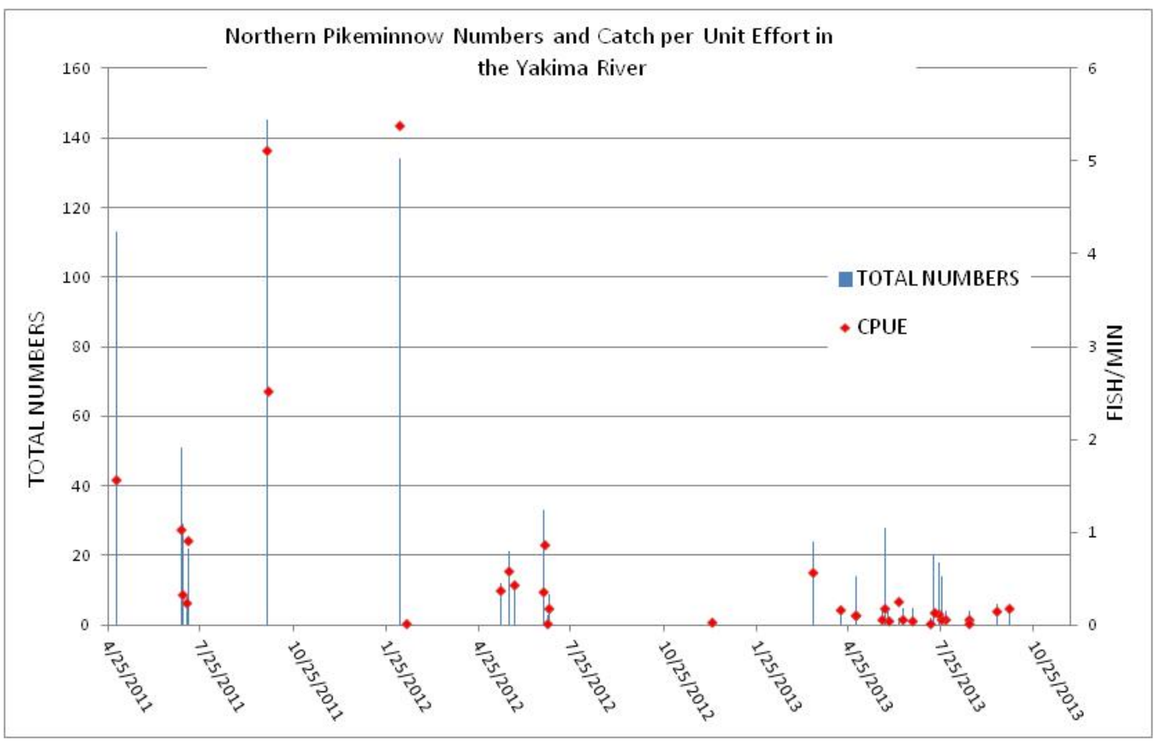


**Figure 37. Number and Catch per Unit Effort (CPUE) of Northern Pike Minnow observed in surveys of the Yakima River Wapato Reach. Data are from 2011-2013 surveys and display NPM presence over varying seasons.**

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

Smallmouth Bass were found in higher numbers in the lower river with a spike in presence during their spawning periods, between April 1 and July 1 (Figure 38). 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. The numbers of Smallmouth Bass observed in the Yakima River increased in 2013 with a high of over 200 fish caught per day and catch per unit effort exceeding 3.5 fish per minute.

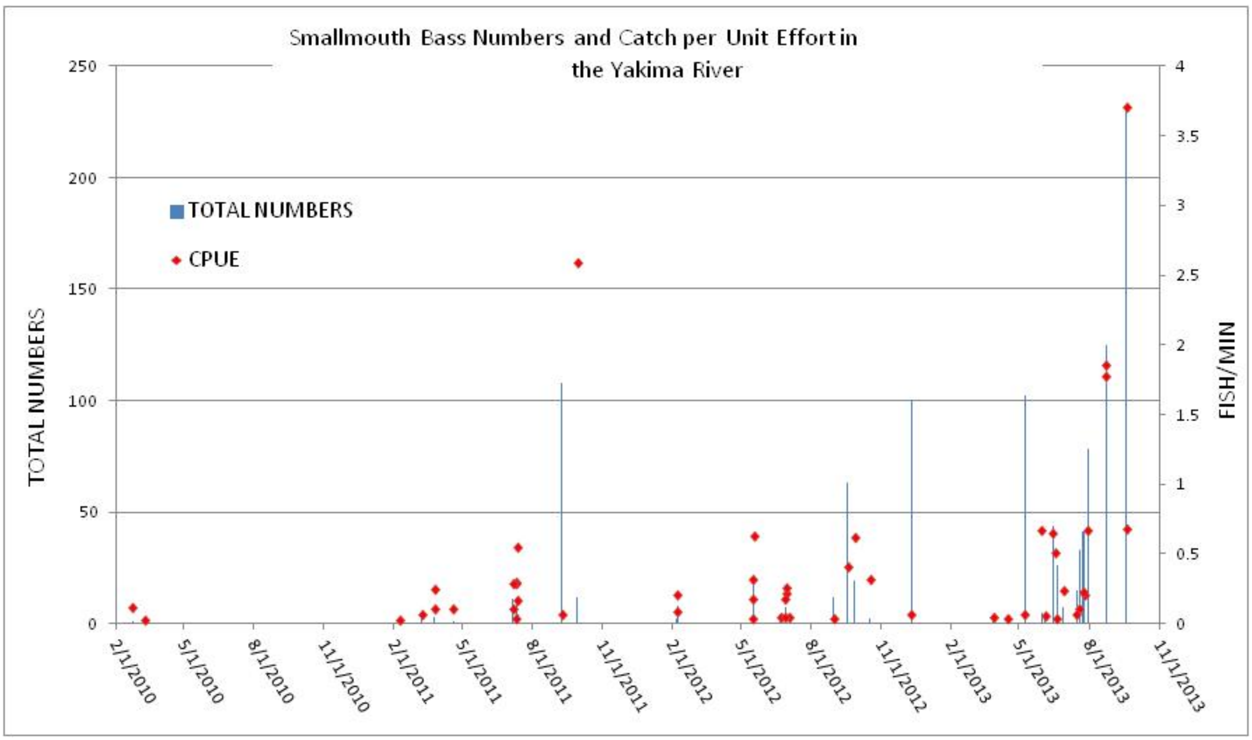


**Figure 38. Number and Catch per Unit Effort (CPUE) of Smallmouth Bass observed in surveys of the Lower Yakima River.**

Yakima River Delta surveys from 2010 to 2013 found 23 different fish species occupied the delta at varying temporal and spatial distributions (Table 20). This is twice the number of fish species in the Delta when compared to the fish species of the Wapato Reach. Many of the fish species in the delta are introduced, non-native fish and are a warm-water species of fish. These introduced fish are adapted to the highly altered water conditions, of increased temperatures and low dissolved oxygen, which the Yakima delta displays. Water temperatures may reach highs of 80 degrees Fahrenheit in the late summer months. Relative catch abundance in the Yakima Delta for the surveys shows a high number of fish from the families of: *Centrarchidae*, *Cyprinidae*, and *Ictaluridae* (Figure 39). These families are highly represented because of large numbers of piscivorous fish present in the delta. Smallmouth Bass, Largemouth Bass, and numerous catfish are present here and use the area for spawning and rearing of juveniles.

**Table 20. Yakima River Delta - Fish Species identified during surveys 2010-2013.**

Yakima River Delta Fish Species

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

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

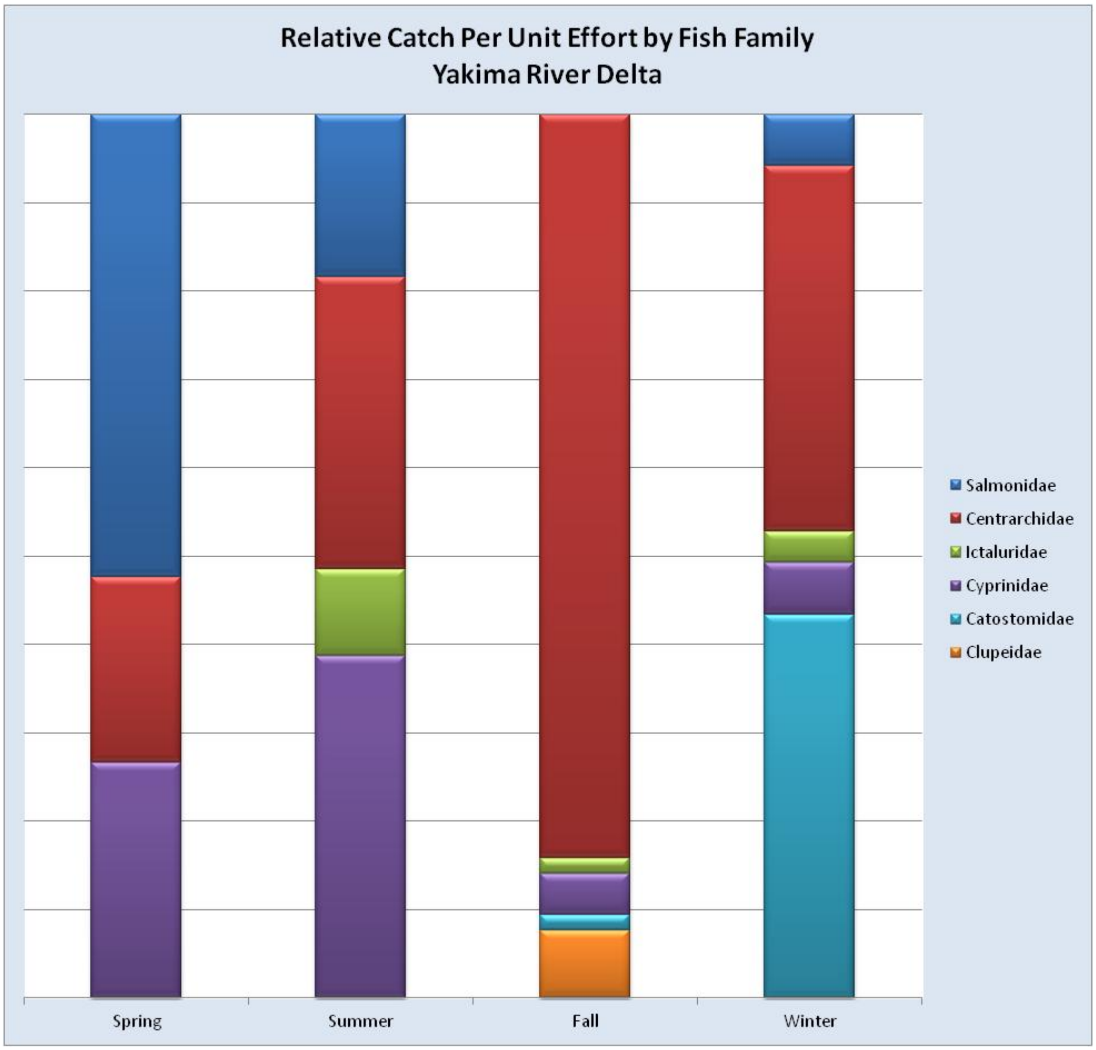


**Figure 39. Yakima River Delta – Relative catch per unit effort by fish family.**

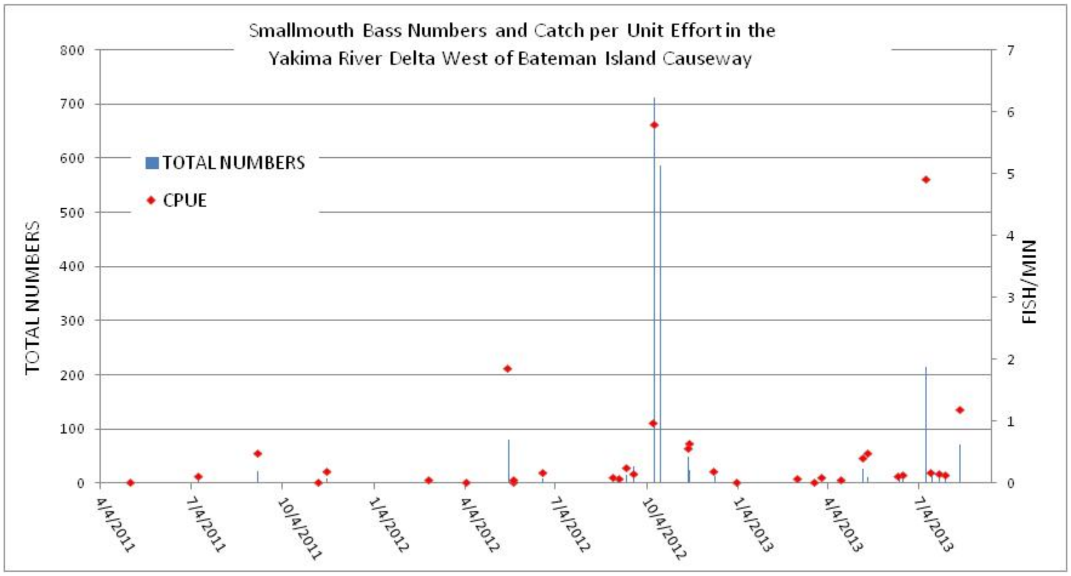


**Figure 40. Number and Catch per Unit Effort (CPUE) of Smallmouth Bass observed in surveys of the Yakima River Delta area (West of the Bateman Island Causeway).**

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

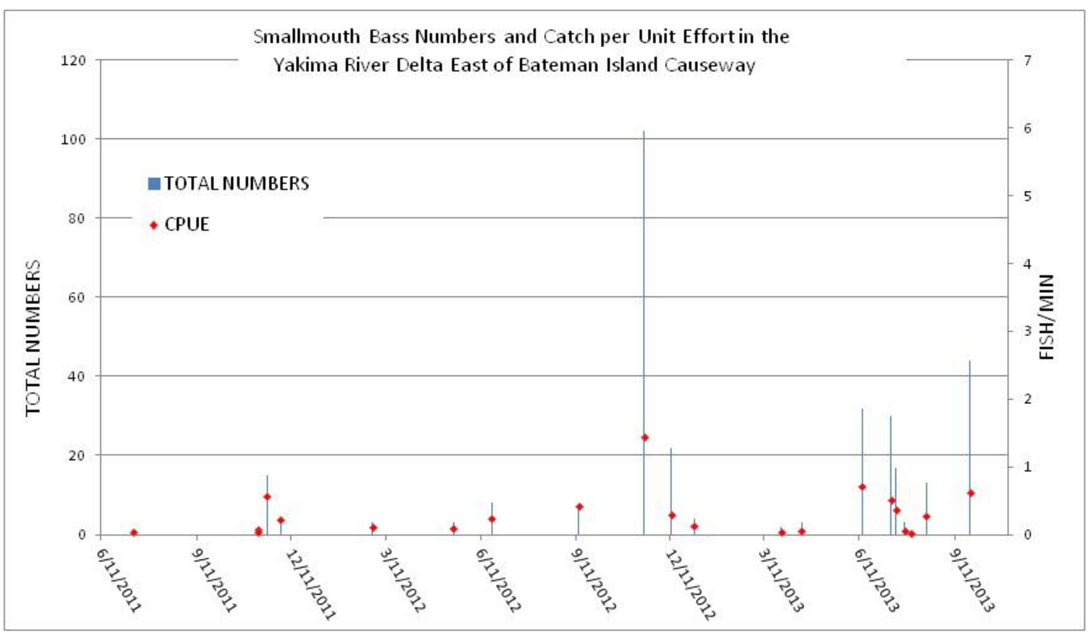


**Figure 41. Number and Catch per Unit Effort (CPUE) of Smallmouth Bass observed in surveys of the Yakima River Delta area (East of the Bateman Island Causeway).**

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

## 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 42.

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.

However, as documented in a letter from Phil Rigdon, Director of Natural Resources for the Yakama Nation to Phil Anderson Director of the Washington Department of Fish and Wildlife, dated 7Nov2012, the Yakama Nation would like to see the region develop strong, enforceable data sharing agreements before we can support broad population and unlimited use of and access to these regional databases with data from

YN/YKFP projects. We remain concerned about the potential for misuse of project data obtained from existing regional databases.

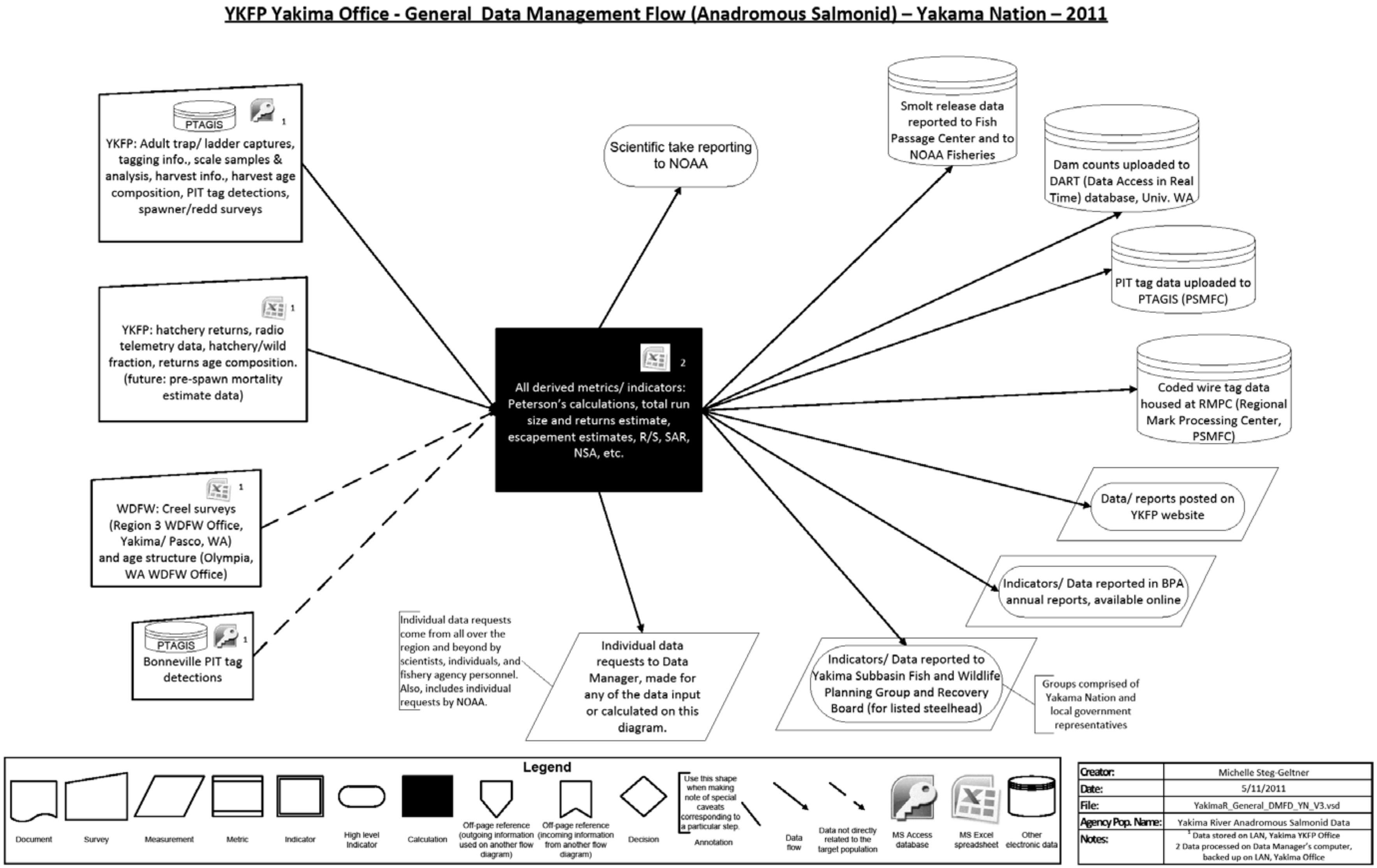


**Figure 42. General data flow diagram for data collected and reported by the Yakama Nation in the Yakima River Basin.**

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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 1999-2013 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 2013

E. IntStats, Inc. Annual Report: Comparisons between Smolt Measures of Hatchery x Hatchery- and Natural x Natural-Brood Stock for Brood-Years 2002-2011 Upper Yakima Spring Chinook

F. IntStats, Inc. 2013 Annual Report: Smolt-to-Smolt Survival to McNary Dam of Yakima Fall and Summer Chinook

G. Intstats, Inc. Annual Report: 2013 Coho Smolt-to-Smolt Survival of 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 remain concerned about the potential for misuse of project data obtained from existing regional databases.

# Appendix B

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

2013 Annual Report

August 12, 2014

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# Acknowledgments

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

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

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

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

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

# Abstract

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

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

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

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

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

# Table of Contents

## List of Tables

## List of Figures



## List of Appendices

# Introduction

## Program Objectives

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

## Facility Descriptions

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

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

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

## Yakima River Basin Overview

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

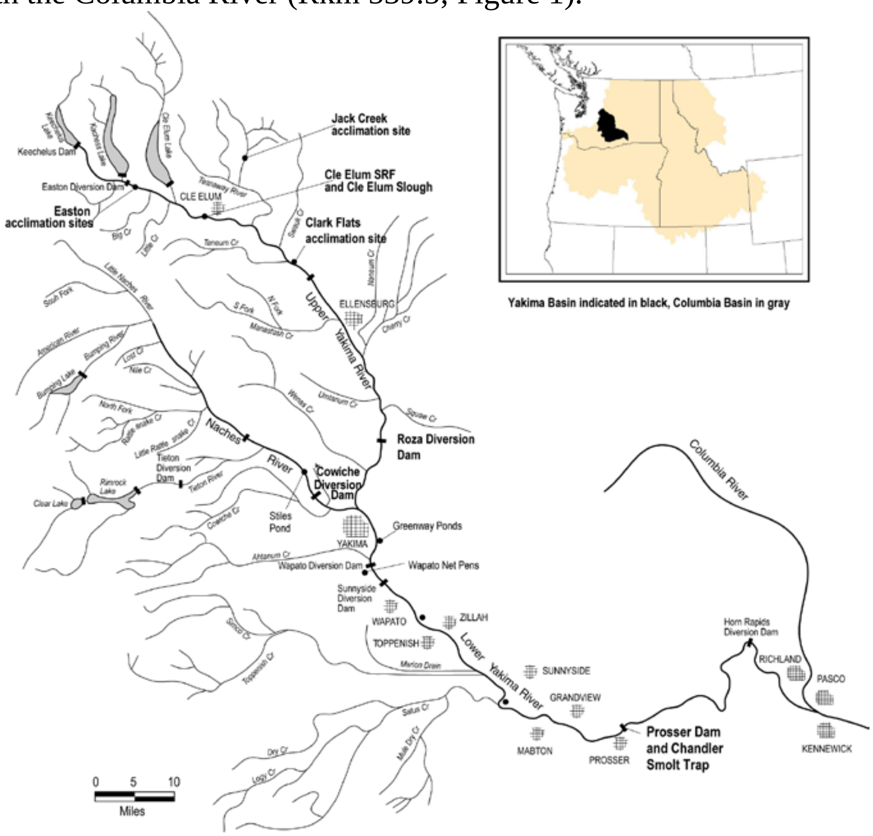


**Figure 1. Yakima River Basin.**

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).

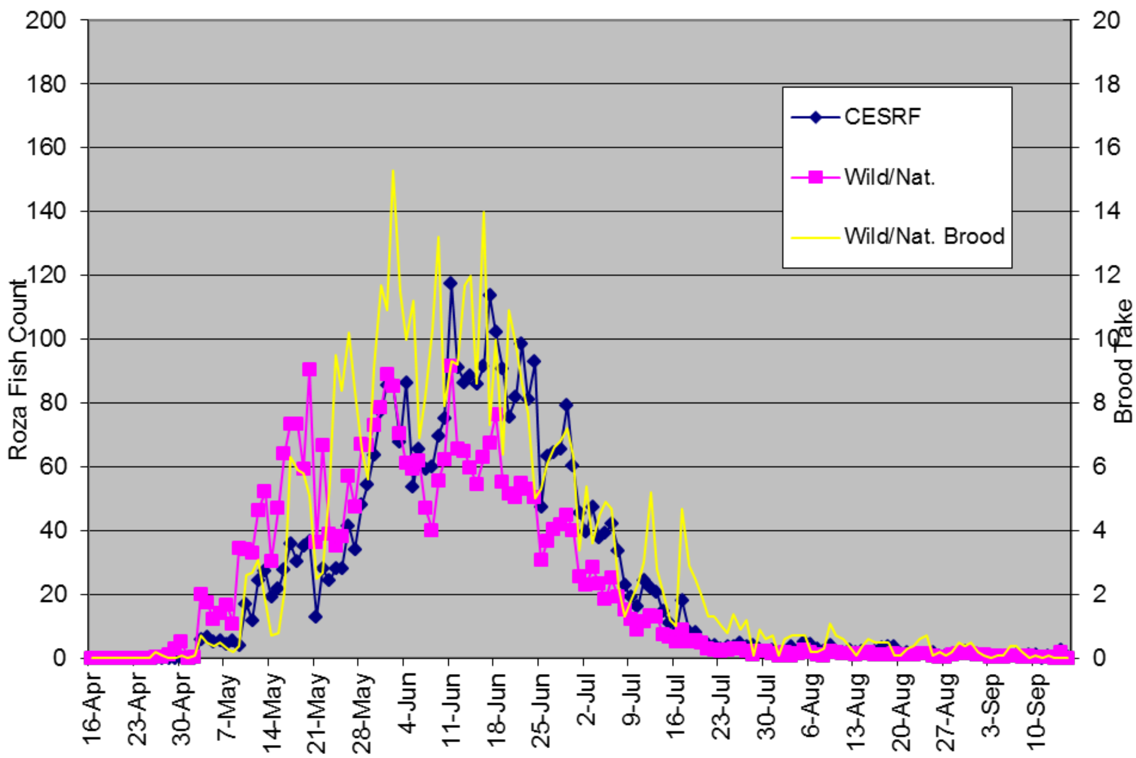


**Figure 2. Mean spring Chinook run timing and broodstock collection at Roza Dam, 2004-2013.**

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% |
| 2013 | 2,784 | 398 | 14.3% | 18.5% | 13.0% | 22.0% | 9.5% | 75.1% | 15.3% |

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

## Natural- and Hatchery-Origin Escapement

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

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

| | Wild/Natural (NoR) | | | CESRF (HoR) | | | Total | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Adults | Jacks | Total | Adults | Jacks | Total | Adults | Jacks | Total | pHOS[1] | PNI[1] |
| 1982 | | | 1,146 | | | | | | | | |
| 1983 | | | 1,007 | | | | | | | | |
| 1984 | | | 1,535 | | | | | | | | |
| 1985 | | | 2,331 | | | | | | | | |
| 1986 | | | 3,251 | | | | | | | | |
| 1987 | | | 1,734 | | | | | | | | |
| 1988 | | | 1,340 | | | | | | | | |
| 1989 | | | 2,331 | | | | | | | | |
| 1990 | | | 2,016 | | | | | | | | |
| 1991 | | | *1,583*[2] | | | | | | | | |
| 1992 | | | 3,009 | | | | | | | | |
| 1993 | | | 1,869 | | | | | | | | |
| 1994 | | | 563 | | | | | | | | |
| 1995 | | | 355 | | | | | | | | |
| 1996 | | | 1,631 | | | | | | | | |
| 1997 | 1,141 | 43 | 1,184 | | | | | | | | |
| 1998 | 369 | 18 | 387 | | | | | | | | |
| 1999 | 498 | 468 | 966 | | | | | | | | |
| 2000 | 10,491 | 481 | 10,972 | | 688 | 688 | 10,491 | 1,169 | 11,660 | 5.9% | |
| 2001 | 4,454 | 297 | 4,751 | 6,065 | 982 | 7,047 | 10,519 | 1,279 | 11,798 | 59.7% | 62.6% |
| 2002 | 1,820 | 89 | 1,909 | 6,064 | 71 | 6,135 | 7,884 | 160 | 8,044 | 76.3% | 56.7% |
| 2003 | 394 | 723 | 1,117 | 1,036 | 1,105 | 2,141 | 1,430 | 1,828 | 3,258 | 65.7% | 60.3% |
| 2004 | 6,536 | 671 | 7,207 | 2,876 | 204 | 3,080 | 9,412 | 875 | 10,287 | 29.9% | 77.0% |
| 2005 | 4,401 | 175 | 4,576 | 627 | 482 | 1,109 | 5,028 | 657 | 5,685 | 19.5% | 83.7% |
| 2006 | 1,510 | 121 | 1,631 | 1,622 | 111 | 1,733 | 3,132 | 232 | 3,364 | 51.5% | 66.0% |
| 2007 | 683 | 161 | 844 | 734 | 731 | 1,465 | 1,417 | 892 | 2,309 | 63.4% | 61.2% |
| 2008 | 988 | 232 | 1,220 | 2,157 | 957 | 3,114 | 3,145 | 1,189 | 4,334 | 71.9% | 58.2% |
| 2009 | 1,843 | 701 | 2,544 | 2,234 | 2,260 | 4,494 | 4,077 | 2,961 | 7,038 | 63.9% | 61.0% |
| 2010 | 2,436 | 413 | 2,849 | 4,524 | 1,001 | 5,525 | 6,960 | 1,414 | 8,374 | 66.0% | 60.2% |
| 2011 | 3,092 | 926 | 4,018 | 3,162 | 1,404 | 4,566 | 6,254 | 2,330 | 8,584 | 53.2% | 65.3% |
| 2012 | 2,359 | 191 | 2,550 | 2,661 | 265 | 2,926 | 5,020 | 456 | 5,476 | 53.4% | 65.2% |
| 2013 | 1,708 | 678 | 2,386 | 1,587 | 840 | 2,427 | 3,295 | 1,518 | 4,813 | 50.4% | 66.5% |
| Mean[3] | 2,631 | 376 | 3,007 | 2,719 | 801 | 3,520 | 5,198 | 1,215 | 6,413 | 55.8% | 64.9% |

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, 1987-present.**

| | River Mouth Run Size[1] | | | Harvest | | Harvest | Spawners | | | Est. Escapement | | Redd Counts | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Below | Prosser | Above | Below | Roza | Roza | | | | |
| Year | Adults | Jacks | Total | Prosser | Count | Prosser | Roza[2] | Count | Removals[3] | Upper Y.R.[4] | Naches[5] | Upper Y.R. | Naches |
| 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 |
| 2013 | 7,101 | 3,144 | 10,245 | 1,191 | 9,054 | 1,462 | 171 | 6,053 | 1,240 | 4,813 | 1,369 | 648 | 376 |
| Mean[6] | 8,762 | 2,116 | 10,878 | 582 | 10,296 | 1,319 | 36 | 7,182 | 1,156 | 6,026 | 1,759 | 1,702 | 535 |

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 (2004-2013).

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

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

| Brood | Estimated | Estimated Yakima R. Mouth Returns | | | | Returns/ |
|---|---|---|---|---|---|---|
| Year | Spawners | Age-3 | Age-4 | Age-5 | Total | Spawner |
| 1984 | 1,715 | 92 | 1,348 | 139 | 1,578 | 0.92 |
| 1985 | 2,578 | 114 | 2,746 | 105 | 2,965 | 1.15 |
| 1986 | 3,960 | 171 | 2,574 | 149 | 2,893 | 0.73 |
| 1987 | 2,003 | 53 | 1,571 | 109 | 1,733 | 0.87 |
| 1988 | 1,400 | 53 | 3,138 | 132 | 3,323 | 2.37 |
| 1989 | 2,466 | 68 | 1,779 | 9 | 1,856 | 0.75 |
| 1990 | 2,298 | 79 | 566 | 0 | 645 | 0.28 |
| 1991 | 1,713 | 9 | 326 | 22 | 358 | 0.21 |
| 1992 | 3,048 | 87 | 1,861 | 95 | 2,043 | 0.67 |
| 1993 | 1,925 | 66 | 1,606 | 57 | 1,729 | 0.90 |
| 1994 | 573 | 60 | 737 | 92 | 890 | 1.55 |
| 1995 | 364 | 59 | 1,036 | 129 | 1,224 | 3.36 |
| 1996 | 1,657 | 1,059 | 12,882 | 630 | 14,571 | 8.79 |
| 1997 | 1,204 | 621 | 5,837 | 155 | 6,613 | 5.49 |
| 1998 | 390 | 434 | 2,803 | 145 | 3,381 | 8.68 |
| 1999 | 1,021[1] | 164 | 722 | 45 | 930 | 0.91 |
| 2000 | 11,864 | 856 | 7,689 | 127 | 8,672 | 0.73 |
| 2001 | 12,084 | 775 | 5,074 | 222 | 6,071 | 0.50 |
| 2002 | 8,073 | 224 | 1,875 | 148 | 2,247 | 0.28 |
| 2003 | 3,341 | 158 | 1,036 | 63 | 1,257 | 0.38 |
| 2004 | 10,377 | 207 | 1,547 | 75 | 1,828 | 0.18 |
| 2005 | 5,713 | 293 | 2,630 | 14 | 2,936 | 0.51 |
| 2006 | 3,378 | 868 | 2,887 | 133 | 3,888 | 1.15 |
| 2007 | 2,322 | 456 | 3,976 | 65 | 4,498 | 1.94 |
| 2008 | 4,343 | 1,135 | 3,410 | 145 | 4,689 | 1.08 |
| 2009 | 7,056 | 283 | 2,551 | | | |
| 2010 | 8,383 | 923 | | | | |
| 2011 | 8,584 | | | | | |
| 2012 | 5,483 | | | | | |
| 2013 | 4,984 | | | | | |
| Mean | 4,143 | 347 | 2,854 | 120 | 3,313 | 1.78 |

1. The mean jack proportion of spawning escapement from 1999-2013 was 0.17 (geometric mean 0.13).

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

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

| Brood Year | Estimated Spawners | Estimated Yakima R. Mouth Returns | | | | | Returns/ Spawner |
|---|---|---|---|---|---|---|---|
| | | Age-3 | Age-4 | Age-5 | Age-6 | Total | |
| 1984 | 383 | 110 | 706 | 564 | 0 | 1,381 | 3.60 |
| 1985 | 683 | 132 | 574 | 396 | 0 | 1,102 | 1.61 |
| 1986 | 2,666 | 68 | 712 | 499 | 15 | 1,294 | 0.49 |
| 1987 | 1,162 | 27 | 183 | 197 | 0 | 407 | 0.35 |
| 1988 | 1,340 | 32 | 682 | 828 | 0 | 1,542 | 1.15 |
| 1989 | 992 | 28 | 331 | 306 | 0 | 665 | 0.67 |
| 1990 | 954 | 24 | 170 | 74 | 0 | 269 | 0.28 |
| 1991 | 706 | 7 | 37 | 121 | 57 | 222 | 0.31 |
| 1992 | 852 | 29 | 877 | 285 | 0 | 1,191 | 1.40 |
| 1993 | 1,145 | 45 | 593 | 372 | 0 | 1,010 | 0.88 |
| 1994 | 474 | 14 | 164 | 164 | 0 | 343 | 0.72 |
| 1995 | 124 | 40 | 164 | 251 | 0 | 455 | 3.66 |
| 1996 | 887 | 179 | 3,983 | 1,620 | 0 | 5,782 | 6.52 |
| 1997 | 762 | 207 | 3,081 | 708 | 0 | 3,996 | 5.24 |
| 1998 | 503 | 245 | 1,460 | 1,128 | 0 | 2,833 | 5.63 |
| 1999 | 358[1] | 113 | 322 | 190 | 0 | 626 | 1.75 |
| 2000 | 3,862 | 71 | 2,060 | 215 | 0 | 2,346 | 0.61 |
| 2001 | 3,912 | 126 | 1,254 | 471 | 0 | 1,850 | 0.47 |
| 2002 | 1,861 | 59 | 753 | 153 | 0 | 965 | 0.52 |
| 2003 | 1,400 | 52 | 237 | 175 | 0 | 464 | 0.33 |
| 2004 | 2,197 | 107 | 875 | 218 | 0 | 1,200 | 0.55 |
| 2005 | 1,439 | 167 | 653 | 119 | 0 | 940 | 0.65 |
| 2006 | 1,163 | 192 | 834 | 254 | 0 | 1,280 | 1.10 |
| 2007 | 463 | 125 | 1,649 | 518 | 0 | 2,292 | 4.95 |
| 2008 | 1,074 | 414 | 823 | 300 | | 1,537 | 1.43 |
| 2009 | 903 | 84 | 437 | | | | |
| 2010 | 1,207 | 209 | | | | | |
| 2011 | 2,476 | | | | | | |
| 2012 | 1,537 | | | | | | |
| 2013 | 1,107 | | | | | | |
| Mean | 1,287 | 108 | 908 | 405 | 3 | 1,440 | 1.80 |

1. The mean jack proportion of spawning escapement from 1999-2013 was 0.12 (geometric mean 0.09).

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

| Brood Year | Estimated Spawners | Estimated Yakima R. Mouth Returns | | | | | Returns/ Spawner |
|---|---|---|---|---|---|---|---|
| | | Age-3 | Age-4 | Age-5 | Age-6 | Total | |
| 1984 | 187 | 54 | 301 | 458 | 0 | 813 | 4.36 |
| 1985 | 337 | 81 | 149 | 360 | 0 | 590 | 1.75 |
| 1986 | 1,457 | 36 | 134 | 329 | 11 | 509 | 0.35 |
| 1987 | 567 | 12 | 71 | 134 | 0 | 216 | 0.38 |
| 1988 | 827 | 19 | 208 | 661 | 5 | 892 | 1.08 |
| 1989 | 524 | 11 | 69 | 113 | 0 | 193 | 0.37 |
| 1990 | 425 | 15 | 113 | 84 | 0 | 213 | 0.50 |
| 1991 | 414 | 3 | 5 | 22 | 0 | 30 | 0.07 |
| 1992 | 335 | 23 | 157 | 237 | 0 | 417 | 1.24 |
| 1993 | 721 | 8 | 218 | 405 | 8 | 639 | 0.89 |
| 1994 | 230 | 7 | 36 | 16 | 0 | 59 | 0.26 |
| 1995 | 98 | 33 | 32 | 98 | 0 | 163 | 1.65 |
| 1996 | 159 | 30 | 176 | 760 | 0 | 967 | 6.07 |
| 1997 | 371 | 13 | 1,543 | 610 | 0 | 2,166 | 5.84 |
| 1998 | 414 | 120 | 766 | 1,136 | 0 | 2,022 | 4.88 |
| 1999 | 61 | 72 | 99 | 163 | 0 | 334 | 5.50 |
| 2000 | 250 | 60 | 163 | 110 | 0 | 333 | 1.33 |
| 2001 | 1,917 | 18 | 364 | 256 | 0 | 638 | 0.33 |
| 2002 | 1,180 | 19 | 279 | 257 | 0 | 555 | 0.47 |
| 2003 | 1,192 | 23 | 183 | 440 | 0 | 646 | 0.54 |
| 2004 | 318 | 121 | 52 | 33 | 0 | 206 | 0.65 |
| 2005 | 464 | 79 | 173 | 263[1] | 0 | 515 | 1.11 |
| 2006 | 509 | 45 | 172[1] | 451 | 0 | 668 | 1.31 |
| 2007 | 523 | 57[1] | 645 | 668 | | 1,369 | 2.62 |
| 2008 | 504 | 239 | 286 | 465 | | 990 | 1.96 |
| 2009 | 213 | 60 | 143 | | | | |
| 2010 | 285 | 172 | | | | | |
| 2011 | 584 | | | | | | |
| 2012 | 363 | | | | | | |
| 2013 | 261 | | | | | | |
| Mean | 523 | 53 | 251 | 341 | 1 | 646 | 1.82 |

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

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

| Brood Year | Estimated Spawners | Estimated Yakima R. Mouth Returns Age-3 | Age-4 | Age-5 | Age-6 | Total | Returns/ Spawner |
|---|---|---|---|---|---|---|---|
| 1984 | 570 | 164 | 1,109 | 1,080 | 0 | 2,354 | 4.13 |
| 1985 | 1,020 | 213 | 667 | 931 | 0 | 1,811 | 1.77 |
| 1986 | 4,123 | 103 | 670 | 852 | 31 | 1,657 | 0.40 |
| 1987 | 1,729 | 39 | 231 | 400 | 0 | 669 | 0.39 |
| 1988 | 2,167 | 51 | 815 | 1,557 | 11 | 2,434 | 1.12 |
| 1989 | 1,517 | 39 | 332 | 371 | 0 | 741 | 0.49 |
| 1990 | 1,380 | 40 | 326 | 168 | 0 | 533 | 0.39 |
| 1991 | 1,121 | 10 | 32 | 144 | 127 | 314 | 0.28 |
| 1992 | 1,188 | 52 | 1,034 | 661 | 0 | 1,747 | 1.47 |
| 1993 | 1,865 | 53 | 603 | 817 | 17 | 1,489 | 0.80 |
| 1994 | 704 | 21 | 160 | 167 | 0 | 348 | 0.49 |
| 1995 | 223 | 73 | 201 | 498 | 0 | 771 | 3.46 |
| 1996 | 1,047 | 209 | 4,010 | 2,359 | 0 | 6,579 | 6.29 |
| 1997 | 1,133 | 220 | 4,644 | 1,377 | 0 | 6,241 | 5.51 |
| 1998 | 917 | 364 | 2,167 | 2,316 | 12 | 4,859 | 5.30 |
| 1999 | 418[1] | 185 | 369 | 279 | 0 | 833 | 1.99 |
| 2000 | 4,112 | 131 | 2,286 | 346 | 0 | 2,762 | 0.67 |
| 2001 | 5,829 | 144 | 1,598 | 785 | 0 | 2,526 | 0.43 |
| 2002 | 3,041 | 78 | 975 | 443 | 0 | 1,496 | 0.49 |
| 2003 | 2,592 | 75 | 387 | 1,028 | 0 | 1,489 | 0.57 |
| 2004 | 2,515 | 227 | 514 | 232 | 0 | 973 | 0.39 |
| 2005 | 1,904 | 246 | 845 | 174[2] | 0 | 1,264 | 0.66 |
| 2006 | 1,672 | 237 | 1,215[2] | 759 | 0 | 2,211 | 1.32 |
| 2007 | 986 | 182[2] | 2,239 | 1,112 | 0 | 3,533 | 3.58 |
| 2008 | 1,578 | 653 | 1,183 | 816 | | 2,652 | 1.68 |
| 2009 | 1,117 | 144 | 529 | | | | |
| 2010 | 1,491 | 381 | | | | | |
| 2011 | 3,060 | | | | | | |
| 2012 | 1,900 | | | | | | |
| 2013 | 1,369 | | | | | | |
| Mean | 1,810 | 160 | 1,121 | 787 | 8 | 2,091 | 1.76 |

1. The mean jack proportion of spawning escapement from 1999-2013 was 0.12 (geometric mean 0.09).
2. Age composition using only Naches survey samples in 2010 return year.

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

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

| Brood Year | Estimated Spawners | Estimated Yakima R. Mouth Returns | | | | Returns/ Spawner |
|---|---|---|---|---|---|---|
| | | Age-3 | Age-4 | Age-5 | Total | |
| 1997 | 261 | 741 | 7,753 | 176 | 8,670 | 33.22 |
| 1998 | 408 | 1,242 | 7,939 | 602 | 9,782 | 23.98 |
| 1999 | 738[1] | 134 | 714 | 16 | 864 | 1.17 |
| 2000 | 567 | 1,103 | 3,647 | 70 | 4,819 | 8.50 |
| 2001 | 595 | 396 | 845 | 9 | 1,251 | 2.10 |
| 2002 | 629 | 345 | 1,886 | 69 | 2,300 | 3.66 |
| 2003 | 441 | 121 | 800 | 12 | 932 | 2.11 |
| 2004 | 597 | 805 | 3,101 | 116 | 4,022 | 6.74 |
| 2005 | 510 | 1,305 | 3,052 | 21 | 4,378 | 8.58 |
| 2006 | 419 | 3,038 | 5,812 | 264 | 9,114 | 21.75 |
| 2007 | 449 | 1,277 | 5,174 | 108 | 6,558 | 14.61 |
| 2008 | 457 | 2,344 | 4,567 | 66 | 6,977 | 15.27 |
| 2009 | 486 | 461 | 2,662 | | | |
| 2010 | 336 | 1,495 | | | | |
| 2011 | 377 | | | | | |
| 2012 | 374 | | | | | |
| 2013 | 398 | | | | | |
| Mean | 473 | 1,058 | 3,688 | 127 | 4,972 | 7.58[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 2013, age composition of American River spring Chinook has averaged 1, 40, 58, and 1 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, 87.5, and 4.5 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 | |
| 2013 | 11.1 | 11.1 | 77.8 | | 9 | | 26.9 | 73.1 | | 26 | 2.9 | 22.9 | 74.3 | |
| Mean | 2.8 | 44.8 | 52.0 | 0.4 | | | 38.9 | 59.5 | 1.5 | | 1.0 | 40.1 | 57.6 | 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 | |
| 2013 | 15.4 | 53.8 | 30.8 | | 13 | | 56.3 | 43.8 | | 16 | 6.7 | 56.7 | 36.7 | |
| Mean | 5.2 | 64.4 | 29.7 | 0.7 | | 0.6 | 55.8 | 43.2 | 0.4 | | 2.4 | 59.5 | 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 | Males | | | | Females | | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 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 | | | | | | |
| 2013 | | | | | | 100.0 | | 8 | | 100.0 | |
| Mean | 15.8 | 80.5 | 3.6 | | 1.3 | 93.4 | 5.3 | | 8.0 | 87.5 | 4.6 |

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 14, 85, and 1 percent age-3, -4, and –5, respectively (Table 12) from 2001-2013 compared to 11, 85, and 4.1 percent respectively for their wild/natural counterparts in the upper Yakima for the same years (Table 11). The observed difference in age distribution between wild/natural and CESRF sampled on the spawning grounds may be due in part to the carcass recovery bias described above. A better comparison of age distribution between upper Yakima wild/natural and CESRF fish is from samples collected at Roza Dam which are displayed in Tables 13 and 14. However, it must be noted that jacks (age-3 males) were collected at Roza in proportion to run size from 1997 to 1999, but from 2000-present we have attempted to collect them at their mean brood representation rate (approximately 7% of the spawning population). Age-3 females do occur rarely in the Upper Yakima population, but it is likely that the data in Table 13 slightly over-represent the proportion of age-3 females due to human error associated with scale collection, handling, processing, and management and entry of these data.

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

| Return | Males | | | | Females | | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 3 | 4 | 5 | n | 3 | 4 | 5 | n | 3 | 4 | 5 |
| 2001 | 23.5 | 76.5 | | 34 | 0.9 | 99.1 | | 108 | 6.3 | 93.7 | |
| 2002 | 8.0 | 81.3 | 10.7 | 75 | | 88.6 | 11.4 | 140 | 2.8 | 86.2 | 11.1 |
| 2003 | 100.0 | | | 1 | | 100.0 | | 1 | 50.0 | 50.0 | |
| 2004 | 9.5 | 90.5 | | 21 | | 98.0 | 2.0 | 51 | 2.8 | 95.8 | 1.4 |
| 2005 | 42.9 | 57.1 | | 21 | | 90.9 | 4.5 | 22 | 23.3 | 74.4 | 2.3 |
| 2006 | 26.7 | 73.3 | | 15 | | 100.0 | | 43 | 6.9 | 93.1 | |
| 2007 | 66.7 | 33.3 | | 6 | | 100.0 | | 11 | 23.5 | 76.5 | |
| 2008 | | | | 0 | | 100.0 | | 1 | | 100.0 | |
| 2009 | 60.0 | 40.0 | | 5 | | | | 0 | 60.0 | 40.0 | |
| 2010 | 28.6 | 71.4 | | 7 | | 100.0 | | 11 | 11.1 | 88.9 | |
| 2011 | 37.5 | 62.5 | | 16 | 4.5 | 95.5 | | 22 | 18.4 | 81.6 | |
| 2012 | | 100.0 | | 2 | | 100.0 | | 3 | | 100.0 | |
| 2013 | | 100.0 | | 1 | | 100.0 | | 7 | | 100.0 | |
| Mean[1] | 33.7 | 65.1 | 1.2 | | 0.6 | 96.9 | 2.0 | | 14.1 | 84.6 | 1.3 |

1. Excludes years where sample size < 5.

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

| Return | Males | | | | Females | | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 3 | 4 | 5 | n | 3 | 4 | 5 | n | 3 | 4 | 5 |
| 1997 | 4.5 | 92.0 | 3.4 | 88 | | 94.6 | 5.4 | 111 | 2.0 | 93.5 | 4.5 |
| 1998 | 22.4 | 73.1 | 4.5 | 134 | | 91.6 | 8.4 | 179 | 9.6 | 83.7 | 6.7 |
| 1999 | 71.1 | 26.1 | 2.8 | 425 | | 92.6 | 7.4 | 215 | 48.8 | 47.0 | 4.2 |
| 2000 | 17.8 | 81.7 | 0.4 | 230 | | 98.7 | 1.3 | 313 | 7.5 | 91.5 | 0.9 |
| 2001 | 12.4 | 77.4 | 10.3 | 234 | 0.9 | 90.5 | 8.5 | 328 | 5.7 | 85.2 | 9.2 |
| 2002 | 16.4 | 78.3 | 5.3 | 226 | 0.6 | 94.8 | 4.7 | 343 | 6.9 | 88.2 | 4.9 |
| 2003 | 27.4 | 60.2 | 12.4 | 201 | | 83.3 | 16.7 | 228 | 12.8 | 72.6 | 14.7 |
| 2004 | 15.1 | 84.5 | 0.4 | 239 | 0.3 | 99.0 | 0.7 | 305 | 6.8 | 92.6 | 0.6 |
| 2005 | 15.5 | 82.3 | 2.2 | 181 | 0.4 | 97.1 | 2.5 | 276 | 6.3 | 91.2 | 2.4 |
| 2006 | 11.1 | 77.4 | 11.5 | 226 | | 89.4 | 10.6 | 255 | 5.2 | 83.8 | 11.0 |
| 2007 | 13.6 | 74.7 | 11.7 | 162 | | 87.8 | 12.2 | 255 | 5.3 | 82.7 | 12.0 |
| 2008 | 20.0 | 77.4 | 2.6 | 190 | | 95.6 | 4.4 | 252 | 8.6 | 87.8 | 3.6 |
| 2009 | 17.4 | 81.2 | 1.4 | 207 | 0.8 | 96.1 | 3.1 | 258 | 8.2 | 89.5 | 2.4 |
| 2010 | 20.0 | 79.4 | 0.6 | 155 | 0.4 | 99.3 | 0.4 | 285 | 7.3 | 92.3 | 0.5 |
| 2011 | 18.1 | 81.3 | 0.5 | 182 | 0.8 | 95.3 | 3.8 | 236 | 8.4 | 89.2 | 2.4 |
| 2012 | 12.5 | 86.5 | 1.0 | 104 | | 97.4 | 2.6 | 189 | 4.4 | 93.5 | 2.0 |
| 2013 | 12.7 | 81.7 | 5.6 | 126 | | 95.5 | 4.5 | 157 | 5.7 | 89.4 | 4.9 |
| Mean | 19.3 | 76.2 | 4.5 | | 0.2 | 94.0 | 5.7 | | 9.4 | 85.5 | 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 |
| 2013 | 17.9 | 80.6 | 1.5 | 67 | 1.1 | 96.7 | 2.2 | 92 | 8.2 | 89.9 | 1.9 |
| Mean | 23.7 | 71.9 | 4.4 | | | 94.1 | 5.7 | | 10.3 | 84.6 | 5.1 |

## Sex Composition

In the American River, the mean proportion of males to females in wild/natural carcasses sampled on the spawning grounds from 1986-2013 was 42:58 for age-4 and 31:69 for age-5 spring Chinook (Table 15). In the Naches River, the mean proportion of males to females was 42:58 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 33:67 for age-4 and 23:77 for age-5 fish (Table 17).

For upper Yakima fish collected at Roza Dam for brood stock or research purposes from 1997-2013, 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 35:65 and 41:59 for age-5 fish from the wild/natural and CESRF populations (excluding years with very small age-5 sample sizes), respectively (Tables 19 and 20). For adult fish, the mean proportion of males to females in spawning ground carcass recoveries was substantially lower than the ratio found at RAMF (Tables 17 and 19), indicating that sex ratios estimated from hatchery origin carcass recoveries were biased due to female carcasses being recovered at higher rates than male carcasses (Knudsen et al, 2003 and 2004). Again, despite these biases, we believe these data are good relative indicators of differences in sex composition between populations and between years.

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

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

| Return | Age-3 | | Age-4 | | Age-5 | | Age-6 | |
|---|---|---|---|---|---|---|---|---|
| Year | M | F | M | F | M | F | M | F |
| 1986 | | | 55.6 | 44.4 | 29.1 | 70.9 | | 100.0 |
| 1987 | | | 65.4 | 34.6 | 33.3 | 66.7 | 100.0 | |
| 1988 | | | 0.0 | 100.0 | 100.0 | 0.0 | | |
| 1989 | | | 79.2 | 20.8 | 39.2 | 60.8 | | |
| 1990 | 100.0 | | 43.5 | 56.5 | 46.8 | 53.2 | | |
| 1991 | | | 55.6 | 44.4 | 38.1 | 61.9 | | |
| 1992 | | | 62.7 | 37.3 | 31.6 | 68.4 | 100.0 | |
| 1993 | 100.0 | | 33.3 | 66.7 | 19.8 | 80.2 | | |
| 1994 | | | 34.8 | 65.2 | 41.7 | 58.3 | | 100.0 |
| 1995 | 100.0 | | 100.0 | 0.0 | 27.8 | 72.2 | | |
| 1996 | | | 28.6 | 71.4 | 0.0 | 100.0 | | |
| 1997 | | | 16.7 | 83.3 | 9.4 | 90.6 | | 100.0 |
| 1998 | | | 44.4 | 55.6 | 29.0 | 71.0 | | |
| 1999 | | | 50.0 | 50.0 | 0.0 | 100.0 | | 100.0 |
| 2000 | | | 55.6 | 44.4 | 50.0 | 50.0 | | |
| 2001 | | | 45.0 | 55.0 | 47.7 | 52.3 | | |
| 2002 | 100.0 | | 33.3 | 66.7 | 35.1 | 64.9 | | |
| 2003 | | | 33.3 | 66.7 | 32.9 | 67.1 | | |
| 2004 | | | 75.0 | 25.0 | 0.0 | 100.0 | | |
| 2005 | | | 34.4 | 65.6 | 60.0 | 40.0 | | |
| 2006 | | | 32.0 | 68.0 | 21.7 | 78.3 | | |
| 2007 | 100.0 | | 22.2 | 77.8 | 28.9 | 71.1 | | |
| 2008 | | | 28.6 | 71.4 | 36.2 | 63.8 | | |
| 2009 | | | 42.9 | 57.1 | 0.0 | 100.0 | | |
| 2010 | | | No carcasses were sampled | | | | | |
| 2011 | | | 25.0 | 75.0 | 46.2 | 53.8 | | |
| 2012 | | | 33.3 | 66.7 | 14.3 | 85.7 | | |
| 2013 | | | 12.5 | 87.5 | 26.9 | 73.1 | | |
| mean | | | 42.3 | 57.7 | 31.3 | 68.7 | | |

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

| Return | Age-3 | | Age-4 | | Age-5 | | Age-6 | |
|---|---|---|---|---|---|---|---|---|
| Year | M | F | M | F | M | F | M | F |
| 1986 | 100.0 | | 46.2 | 53.8 | 18.2 | 81.8 | 50.0 | 50.0 |
| 1987 | 100.0 | | 31.0 | 69.0 | 13.3 | 86.7 | 100.0 | |
| 1988 | | 100.0 | 36.4 | 63.6 | 28.6 | 71.4 | | |
| 1989 | | | 60.0 | 40.0 | 25.9 | 74.1 | | 100.0 |
| 1990 | 50.0 | 50.0 | 55.6 | 44.4 | 52.6 | 47.4 | | |
| 1991 | 100.0 | | 66.7 | 33.3 | 20.4 | 79.6 | | |
| 1992 | 100.0 | | 45.5 | 54.5 | 23.1 | 76.9 | 100.0 | |
| 1993 | | | 57.9 | 42.1 | 30.0 | 70.0 | | |
| 1994 | | | 40.0 | 60.0 | 22.2 | 77.8 | | |
| 1995 | | | 33.3 | 66.7 | 37.5 | 62.5 | | |
| 1996 | | | 58.6 | 41.4 | | 100.0 | | |
| 1997 | 100.0 | | 46.2 | 53.8 | 28.0 | 72.0 | 40.0 | 60.0 |
| 1998 | | | 29.4 | 70.6 | 27.9 | 72.1 | | |
| 1999 | 100.0 | | 62.5 | 37.5 | 25.0 | 75.0 | | |
| 2000 | 100.0 | | 44.1 | 55.9 | 25.0 | 75.0 | | |
| 2001 | 100.0 | | 37.4 | 62.6 | 24.6 | 75.4 | | |
| 2002 | 100.0 | | 37.4 | 62.6 | 20.0 | 80.0 | | |
| 2003 | 83.3 | 16.7 | 47.1 | 52.9 | 36.1 | 63.9 | | |
| 2004 | 100.0 | | 29.4 | 70.6 | 20.0 | 80.0 | | |
| 2005 | | | 22.5 | 77.5 | 25.0 | 75.0 | | |
| 2006 | | | 50.0 | 50.0 | 50.0 | 50.0 | | |
| 2007 | | | 21.4 | 78.6 | 11.1 | 88.9 | | |
| 2008 | 100.0 | | 20.0 | 80.0 | 40.0 | 60.0 | | |
| 2009 | 100.0 | | 33.3 | 66.7 | 33.3 | 66.7 | | |
| 2010 | | | 33.3 | 66.7 | | 100.0 | | |
| 2011 | 100.0 | | 58.3 | 41.7 | 33.3 | 66.7 | | |
| 2012 | 100.0 | | 14.8 | 85.2 | 23.5 | 76.5 | | |
| 2013 | 100.0 | | 43.8 | 56.3 | 36.4 | 63.6 | | |
| mean | | | 41.5 | 58.5 | 26.1 | 73.9 | | |

**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 | | | |
| 2013 | | | | 100.0 | | |
| mean | 85.9 | 14.1 | 32.9 | 67.1 | 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 | | |
| 2013 | | | 12.5 | 87.5 | | |
| mean | 96.5 | 3.5 | 28.4 | 71.6 | | |

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

| Return | Age-3 | | Age-4 | | Age-5 | |
|---|---|---|---|---|---|---|
| Year | M | F | M | F | M | F |
| 1997 | 100.0 | | 43.5 | 56.5 | 33.3 | 66.7 |
| 1998 | 100.0 | | 37.4 | 62.6 | 28.6 | 71.4 |
| 1999 | 100.0 | | 35.8 | 64.2 | 42.9 | 57.1 |
| 2000 | 100.0 | | 37.8 | 62.2 | 20.0 | 80.0 |
| 2001 | 90.6 | 9.4 | 37.9 | 62.1 | 46.2 | 53.8 |
| 2002 | 94.9 | 5.1 | 35.3 | 64.7 | 42.9 | 57.1 |
| 2003 | 100.0 | | 38.9 | 61.1 | 39.7 | 60.3 |
| 2004 | 97.3 | 2.7 | 40.1 | 59.9 | 33.3 | 66.7 |
| 2005 | 96.6 | 3.4 | 35.7 | 64.3 | 36.4 | 63.6 |
| 2006 | 100.0 | | 43.4 | 56.6 | 49.1 | 50.9 |
| 2007 | 100.0 | | 35.1 | 64.9 | 38.0 | 62.0 |
| 2008 | 100.0 | | 37.9 | 62.1 | 31.3 | 68.8 |
| 2009 | 94.7 | 5.3 | 40.4 | 59.6 | 27.3 | 72.7 |
| 2010 | 96.9 | 3.1 | 30.3 | 69.7 | 50.0 | 50.0 |
| 2011 | 94.3 | 5.7 | 39.7 | 60.3 | 10.0 | 90.0 |
| 2012 | 100.0 | | 32.8 | 67.2 | 16.7 | 83.3 |
| 2013 | 100.0 | | 40.7 | 59.3 | 50.0 | 50.0 |
| mean | 98.0 | 2.0 | 37.8 | 62.2 | 35.0 | 65.0 |

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

| Return | Age-3 | | Age-4 | | Age-5 | |
|---|---|---|---|---|---|---|
| Year | M | F | M | F | M | F |
| 2001 | 100.0 | 0.0 | 31.8 | 68.2 | | |
| 2002 | 100.0 | 0.0 | 33.5 | 66.5 | 33.3 | 66.7 |
| 2003 | 100.0 | 0.0 | 37.9 | 62.1 | 44.7 | 55.3 |
| 2004 | 100.0 | 0.0 | 38.1 | 61.9 | | |
| 2005 | 100.0 | 0.0 | 39.5 | 60.5 | 30.0 | 70.0 |
| 2006 | 100.0 | 0.0 | 42.5 | 57.5 | 100.0 | |
| 2007 | 100.0 | 0.0 | 38.8 | 61.3 | 30.0 | 70.0 |
| 2008 | 100.0 | 0.0 | 26.3 | 73.7 | | |
| 2009 | 93.8 | 6.3 | 33.9 | 66.1 | 66.7 | 33.3 |
| 2010 | 100.0 | 0.0 | 30.8 | 69.2 | | 100.0 |
| 2011 | 93.3 | 6.7 | 31.6 | 68.4 | 66.7 | 33.3 |
| 2012 | 100.0 | | 31.9 | 68.1 | 25.0 | 75.0 |
| 2013 | 92.3 | 7.7 | 37.8 | 62.2 | 33.3 | 66.7 |
| mean | 98.4 | 1.6 | 35.0 | 65.0 | 41.2 | 58.8 |

## 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 77 cm for age-3, -4, and -5 males, and averaged 63 and 73 cm for age-4 and -5 females, respectively, from carcasses sampled on the spawning grounds in the American River from 1996-2013 (Table 21). In the Naches River, mean POHP lengths averaged 42, 61, and 76 cm for age-3, -4, and -5 males, and averaged 61 and 73 cm for age-4 and -5 females, respectively (Table 22). For wild/natural spring Chinook sampled on the spawning grounds in the upper Yakima River, mean POHP lengths averaged 44, 60, and 72 cm for age-3, -4, and -5 males, and averaged 59 and 69 cm for age-4 and -5 females, respectively (Table 23). Beginning in 2012, carcass sampling in the Upper Yakima was scaled back considerably as large numbers of escaping fish are sampled at Roza Dam (Tables 27-28). From 2001-2013, 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 | | |
| 2013 | 1 | 34.0 | 1 | 56.0 | 7 | 70.1 | | | 7 | 65.7 | 18 | 70.3 | | |
| Mean[2] | | 40.3 | | 61.7 | | 77.2 | | | | 62.9 | | 73.2 | | 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 1996-2013 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 | | |
| 2013 | 2 | 37.0 | 7 | 56.1 | 4 | 75.0 | | | | | 9 | 58.7 | 7 | 71.3 | | |
| Mean[2] | | 42.3 | | 60.6 | | 76.2 | | 78.0 | | 41.0 | | 61.1 | | 73.0 | | 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 1996-2013 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 | | | |
| 2013 | | | No samples | | | | | | 8 | 56.6 | | |
| Mean[1] | | 44.2 | | 59.8 | | 71.9 | | 45.5 | | 59.4 | | 69.1 |

[1] Mean of mean values for 1996-2013 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 | | |
| 2013 | | | 1 | --- | | | | | 7 | 53.6 | | |
| Mean | | 44.3 | | 59.9 | | 69.2 | | | | 59.0 | | 70.4 |

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

| | Males | | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Return | Age 3 | | Age 4 | | Age 5 | | Age 3 | | Age 4 | | Age 5 | |
| Year | Count | POHP | Count | POHP | Count | POHP | Count | POHP | Count | POHP | Count | POHP |
| 1997 | 4 | 39.7 | 81 | 59.7 | 3 | 73.3 | | | 105 | 60.5 | 6 | 68.9 |
| 1998 | 28 | 43.0 | 95 | 57.3 | 6 | 67.0 | | | 161 | 59.2 | 15 | 65.6 |
| 1999 | 124 | 41.4 | 75 | 59.5 | 10 | 64.6 | | | 199 | 60.4 | 16 | 67.4 |
| 2000 | 19 | 42.0 | 145 | 59.0 | 1 | 77.0 | | | 263 | 59.4 | 3 | 69.4 |
| 2001 | 17 | 42.9 | 115 | 59.6 | 14 | 74.1 | | | 196 | 60.5 | 19 | 69.8 |
| 2002 | 23 | 42.1 | 113 | 60.6 | 5 | 72.9 | 1 | 36.6 | 233 | 61.2 | 9 | 70.9 |
| 2003 | 37 | 42.7 | 92 | 60.4 | 19 | 73.7 | | | 164 | 61.4 | 31 | 69.4 |
| 2004 | 18 | 42.4 | 108 | 58.9 | 1 | 67.8 | | | 225 | 58.3 | 2 | 66.5 |
| 2005 | 19 | 42.1 | 113 | 60.0 | 2 | 67.3 | 1 | 42.6 | 223 | 59.8 | 5 | 67.8 |
| 2006 | 17 | 41.0 | 82 | 56.7 | 20 | 70.4 | | | 197 | 57.8 | 24 | 68.1 |
| 2007 | 20 | 44.6 | 108 | 58.8 | 17 | 67.6 | | | 181 | 59.4 | 24 | 67.2 |
| 2008 | 17 | 45.5 | 121 | 59.6 | 4 | 71.1 | | | 209 | 59.7 | 11 | 68.4 |
| 2009 | 16 | 44.4 | 122 | 61.5 | 3 | 69.3 | 1 | 50.4 | 206 | 60.3 | 6 | 68.0 |
| 2010 | 9 | 45.0 | 88 | 61.5 | 1 | 71.2 | | | 192 | 60.9 | | |
| 2011 | 11 | 47.5 | 91 | 60.3 | 1 | 75.3 | 1 | 52.5 | 182 | 60.2 | 4 | 72.9 |
| 2012 | 13 | 43.7 | 83 | 59.8 | 1 | 62.4 | | | 178 | 59.3 | 5 | 66.6 |
| 2013 | 9 | 46.4 | 92 | 59.1 | 7 | 70.0 | | | 142 | 58.9 | 6 | 69.7 |
| Mean | | 43.3 | | 59.5 | | 70.3 | | | | 59.8 | | 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 |
| 2013 | 2 | 45.7 | 24 | 60.3 | | | | | 32 | 57.3 | | |
| Mean | | 41.6 | | 59.4 | | 73.4 | | | | 59.2 | | 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 |
| 2013 | | | 18 | 44.9 | 264 | 59.5 | 15 | 70.6 |
| Mean | | | | 43.3 | | 60.7 | | 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 |
| 2013 | 18 | 15.8 | 75 | 44.2 | 283 | 58.8 | 7 | 69.6 |
| Mean | | 15.4 | | 41.5 | | 59.9 | | 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).

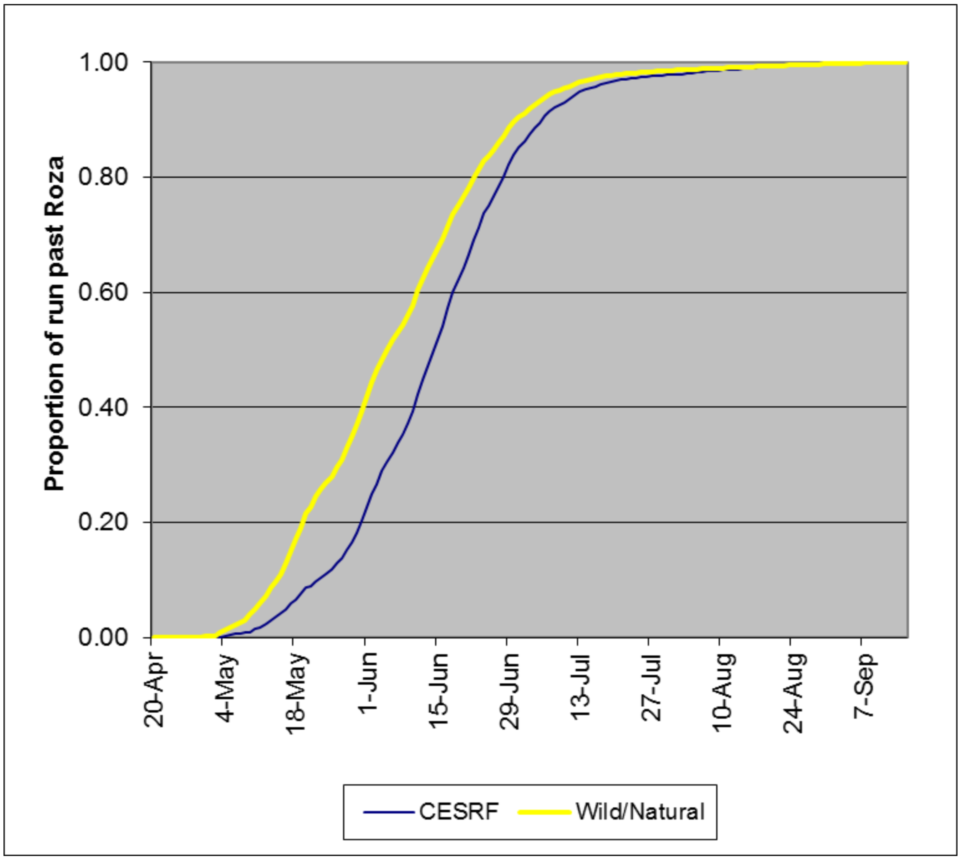


**Figure 3. Proportionate passage timing at Roza Dam of wild/natural and CESRF adult spring Chinook (including jacks), 2004-2013.**

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

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

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

## Spawning Timing

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

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

| Year | American | Naches | Upper Yakima | CESRF |
|---|---|---|---|---|
| 1988 | 14-Aug | 7-Sep | 3-Oct | |
| 1989 | 14-Aug | 7-Sep | 19-Sep | |
| 1990 | 14-Aug | 12-Sep | 25-Sep | |
| 1991 | 12-Aug | 12-Sep | 24-Sep | |
| 1992 | 11-Aug | 10-Sep | 22-Sep | |
| 1993 | 9-Aug | 8-Sep | 27-Sep | |
| 1994 | 16-Aug | 14-Sep | 26-Sep | |
| 1995 | 14-Aug | 7-Sep | 1-Oct | |
| 1996 | 20-Aug | 18-Sep | 23-Sep | |
| 1997 | 12-Aug | 11-Sep | 23-Sep | 23-Sep |
| 1998 | 11-Aug | 15-Sep | 30-Sep | 22-Sep |
| 1999 | 24-Aug | 8-Sep | 27-Sep | 21-Sep |
| 2000 | 7-Aug | 20-Sep | 19-Sep | 19-Sep |
| 2001 | 14-Aug | 13-Sep | 25-Sep | 18-Sep |
| 2002 | 12-Aug | 11-Sep | 23-Sep | 24-Sep |
| 2003 | 11-Aug | 14-Sep | 28-Sep | 23-Sep |
| 2004 | 17-Aug | 12-Sep | 27-Sep | 21-Sep |
| 2005 | 15-Aug | 15-Sep | 27-Sep | 20-Sep |
| 2006 | 15-Aug | 14-Sep | 26-Sep | 19-Sep |
| 2007 | 14-Aug | 12-Sep | 25-Sep | 25-Sep |
| 2008 | 11-Aug | 12-Sep | 23-Sep | 23-Sep |
| 2009 | 17-Aug | 10-Sep | 23-Sep | 28-Sep |
| 2010 | 17-Aug | 12-Sep | 21-Sep | 21-Sep |
| 2011 | 23-Aug | 8-Sep | 21-Sep | 20-Sep |
| 2012 | 21-Aug | 11-Sep | 24-Sep | 25-Sep |
| 2013 | 19-Aug | 11-Sep | 25-Sep | 23-Sep |
| 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 |
| 2013 | 552 | 85 | 34 | 671 | 170 | 66 | 85 | 55 | 376 |
| Mean | 1,071 | 129 | 28 | 1,228 | 164 | 175 | 115 | 49 | 503 |

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

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

| | CESRF PIT-Tagged Fish | | | All CESRF Fish | | | CESRF Age-4 Fish | | |
|---|---|---|---|---|---|---|---|---|---|
| Brood Year | Roza Adult Returns | Adult Strays | Stray Rate | Yakima River Mth Return | CWT Strays | Stray Rate | Yak R. MthRtn | In-Basin Strays[1] | Stray Rate |
| 1997 | 598 | 2 | 0.33% | 8,670 | 1 | 0.01% | 7,753 | | |
| 1998 | 398 | 0 | 0.00% | 9,782 | | | 7,939 | 1 | 0.01% |
| 1999 | 23 | 0 | 0.00% | 864 | | | 714 | | |
| 2000 | 150 | 4 | 2.67% | 4,819 | 2 | 0.04% | 3,647 | 4 | 0.11% |
| 2001 | 80 | 3 | 3.75% | 1,251 | | | 845 | 2 | 0.24% |
| 2002 | 97 | 5 | 5.15% | 2,300 | | | 1,886 | 1 | 0.05% |
| 2003 | 31 | 0 | 0.00% | 932 | | | 800 | | |
| 2004 | 125 | 1 | 0.80% | 4,022 | 4 | 0.10% | 3,101 | | |
| 2005 | 142 | 0 | 0.00% | 4,378 | | | 3,052 | | |
| 2006 | 460 | 3 | 0.65% | 9,114 | | | 5,812 | | |
| 2007 | 238 | 1 | 0.42% | 6,558 | 5 | 0.08% | 5,174 | 1 | 0.02% |
| 2008[2] | 215 | 0 | 0.00% | 6,997 | | | 4,567 | | |
| 2009[3] | 108 | 0 | 0.00% | 3,102 | | | 2,642 | 1 | 0.04% |
| 2010[4] | 61 | 2 | 3.28% | | | | | | |

[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.**

| Brood Year | Total Collected | Total Morts. | PreSpawn Survival | No. Fish Spawned[1] Males[2] | Females | % BKD Loss | Total Egg Take | Live Eggs | % Egg Loss[3] | Fry Ponded[4] | Live-Egg-Fry Survival | Smolts Released | Fry-Smolt Survival | Live-Egg-Smolt Survival |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1997 | 261 | 23 | 91.2% | 106 | 132 | 2.6% | 500,750 | 463,948 | 7.3% | 413,211 | 98.5% | 386,048 | 93.4% | 91.9% |
| 1998 | 408 | 70 | 82.8% | 140 | 198 | 1.4% | 739,802 | 664,125 | 10.2% | 627,481 | 98.7% | 589,648 | 94.0% | 92.7% |
| 1999 | 738[5] | 24 | 96.7% | 213 | 222 | 2.7% | 818,816 | 777,984 | 5.0% | 781,872 | 97.3% | 758,789 | 97.0% | 94.5% |
| 2000 | 567 | 61 | 89.2% | 170 | 278 | 9.2% | 916,292 | 851,128 | 7.1% | 870,328 | 97.3% | 834,285 | 95.9% | 93.4% |
| 2001 | 595 | 171 | 71.3% | 145 | 223 | 53.2% | 341,648 | 316,254 | 7.4% | 380,880 | 98.6% | 370,236 | 97.2% | 96.1% |
| 2002 | 629 | 89 | 85.9% | 125 | 261 | 10.0% | 919,776 | 817,841 | 11.1% | 783,343 | 98.0% | 749,067 | 95.6% | 93.6% |
| 2003 | 441 | 54 | 87.8% | 115 | 200 | 0.0% | 856,574 | 787,933 | 8.0% | 761,968 | 98.4% | 735,959 | 96.6% | 95.1% |
| 2004 | 597 | 70 | 88.3% | 125 | 245 | 0.4% | 873,815 | 806,375 | 7.7% | 776,941 | 97.8% | 691,109[6] | 89.0% | 87.0% |
| 2005 | 526 | 57 | 89.2% | 136 | 241 | 0.0% | 907,199 | 835,890 | 7.9% | 796,559 | 98.1% | 769,484 | 96.6% | 94.7% |
| 2006 | 519 | 45 | 91.3% | 122 | 239 | 1.7% | 772,357 | 703,657 | 8.9% | 631,691 | 97.3% | 574,361[7] | 90.9% | 88.3% |
| 2007 | 473 | 49 | 89.6% | 149 | 216 | 0.9% | 798,729 | 760,189 | 4.8% | 713,814 | 98.9% | 676,602 | 94.8% | 93.7% |
| 2008 | 480 | 38 | 92.1% | 151 | 253 | 2.0% | 915,563 | 832,938 | 9.0% | 809,862 | 99.0% | 752,109[8] | 97.3% | 96.3% |
| 2009 | 486 | 57 | 88.3% | 142 | 219 | 1.4% | 850,404 | 848,339 | 0.2% | 770,706 | 98.2% | 744,170 | 96.6% | 94.6% |
| 2010 | 483 | 20 | 95.9% | 102 | 193 | 0.5% | 787,953 | 753,464 | 4.4% | 726,325 | 98.9% | 702,751 | 96.8% | 95.6% |
| 2011 | 455 | 28 | 93.8% | 103 | 197 | 0.0% | 798,229 | 765,221 | 4.1% | 721,197 | 98.1% | 684,481 | 94.9% | 93.0% |
| 2012 | 363 | 14 | 96.1% | 111 | 209 | 0.0% | 819,775 | 788,605 | 3.8% | 737,705 | 98.2% | 712,036 | 96.5% | 94.7% |
| 2013 | 385 | 15 | 96.1% | 153 | 179 | 0.6% | 683,484 | 658,796 | 3.6% | 604,887 | 98.9% | | | |
| Mean | 494 | 52 | 89.7% | 136 | 218 | 5.1% | 782,421 | 731,334 | 6.5% | 706,493 | 98.2% | 670,696 | 95.2% | 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 BY2013 it is live eggs (est.) minus fry loss.
5. Approximately one-half of these were jacks, many of which were not used in spawning.
6. Approximately 45,000 smolts lost at Jack Creek due to frozen equipment in February, 2006.
7. EWOS feed treatment had high mortality and was discontinued in May 2007; resulted in lower survival to release.
8. Approximately 36,000 NoR (Table 33) and 12,000 HoR (Table 34) fish were culled in July 2009 to reduce pond densities; these fish were added back in to fry-smolt and live-egg-smolt survival calculations.
9. Table 34 -- From 2002 to present this is the estimated total egg take from all HxH crosses. Due to the large surplus of eggs over the approximately 100K needed for the HxH line, many surplus fry were planted in nearby land-locked lakes and some surplus eggs were destroyed.
10. Table 34 -- For only those HxH fish which were actually ponded.

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

| Brood Year | Total Collected | Total Morts. | PreSpawn Survival | No. Fish Spawned[1] Males[2] | Females | % BKD Loss | Total Egg Take[9] | Live Eggs[10] | % Egg Loss[3] | Fry Ponded[4] | Live-Egg-Fry Survival | Smolts Released | Fry-Smolt Survival | Live-Egg-Smolt Survival |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2002 | 201 | 22 | 89.1% | 26 | 72 | 4.2% | 258,226 | 100,011 | 7.8% | 91,300 | 98.2% | 87,837 | 96.2% | 94.4% |
| 2003 | 143 | 12 | 91.6% | 30 | 51 | 0.0% | 219,901 | 83,128 | 7.3% | 91,203 | 98.8% | 88,733 | 97.3% | 96.1% |
| 2004 | 126 | 19 | 84.9% | 22 | 49 | 0.0% | 187,406 | 94,659 | 5.9% | 100,567 | 98.3% | 94,339 | 93.8% | 92.2% |
| 2005 | 109 | 6 | 94.5% | 26 | 45 | 0.0% | 168,160 | 89,066 | 12.2% | 92,903 | 98.1% | 90,518 | 97.4% | 95.6% |
| 2006 | 136 | 21 | 84.6% | 28 | 41 | 2.4% | 112,576 | 80,121 | 8.6% | 74,735 | 97.6% | 68,434[7] | 91.6% | 89.4% |
| 2007 | 110 | 15 | 86.4% | 26 | 35 | 0.0% | 125,755 | 90,162 | 3.2% | 96,912 | 99.2% | 94,663 | 97.7% | 96.9% |
| 2008 | 194 | 10 | 94.8% | 51 | 67 | 1.5% | 247,503 | 106,122 | 5.1% | 111,797 | 98.9% | 97,196[8] | 97.4% | 96.4% |
| 2009 | 164 | 24 | 85.4% | 30 | 38 | 0.0% | 148,593 | 91,994 | 0.8% | 91,221 | 98.3% | 88,771 | 97.3% | 95.6% |
| 2010 | 162 | 9 | 94.4% | 29 | 55 | 1.8% | 215,814 | 94,925 | 8.4% | 96,144 | 97.9% | 92,030 | 95.7% | 93.7% |
| 2011 | 166 | 7 | 95.8% | 28 | 49 | 0.0% | 188,075 | 89,107 | 4.5% | 88,852 | 98.4% | 84,701 | 95.3% | 93.8% |
| 2012 | 140 | 8 | 94.3% | 29 | 42 | 0.0% | 148,932 | 95,438 | 2.0% | 94,031 | 98.8% | 90,680 | 96.4% | 95.3% |
| 2013 | 186 | 5 | 97.3% | 38 | 43 | 0.0% | 155,383 | 80,534 | 2.9% | 79,160 | 98.3% | | | |
| Mean | 153 | 13 | 91.1% | 30 | 49 | 0.8% | 181,360 | 91,272 | 5.7% | 93,606 | 98.4% | 88,900 | 96.0% | 94.5% |

See footnotes for Table 33 above.

**Female BKD Profiles**

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

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

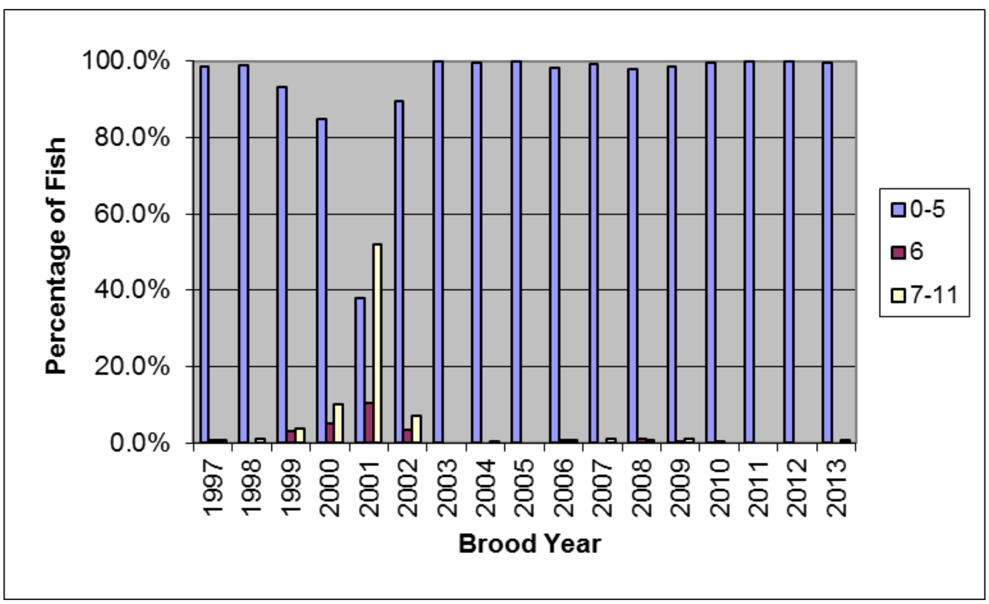


**Figure 4. Proportion of wild/natural females spawned at CESRF by BKD rank, 1997 – present.**

### Fecundity

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

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

| | Wild/Natural (SN) | | | | | | CESRF (HC) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brood | Age-3 | | Age-4 | | Age-5 | | Age-3 | | Age-4 | | Age-5 | |
| Year | N | Fecundity | N | Fecundity | N | Fecundity | N | Fecundity | N | Fecundity | N | Fecundity |
| 1997 | | | 105 | 3,842.0 | 4 | 4,069.9 | | | | | | |
| 1998 | 2[1] | 3,908.9 | 161 | 3,730.3 | 15 | 4,322.5 | | | | | | |
| 1999 | 3[1] | 4,470.4 | 183 | 3,968.1 | 14 | 4,448.6 | | | | | | |
| 2000 | | | 224 | 3,876.5 | 2 | 5,737.9 | | | | | | |
| 2001 | | | 72 | 3,966.9 | 9 | 4,991.2 | | | 18 | 4,178.9 | | |
| 2002 | 1 | 1,038.0 | 205 | 3,934.7 | 7 | 4,329.4 | | | 60 | 3,820.0 | 1 | 4,449.0 |
| 2003 | | | 163 | 4,160.2 | 31 | 5,092.8 | | | 30 | 3,584.1 | 19 | 5,459.9 |
| 2004 | | | 224 | 3,555.4 | 2 | 4,508.3 | | | 42 | 3,827.2 | | |
| 2005 | 1 | 1,769.0 | 218 | 3,815.5 | 5 | 4,675.1 | | | 38 | 3,723.9 | 5 | 4,014.7 |
| 2006 | | | 196 | 3,396.4 | 24 | 4,338.9 | | | 36 | 3,087.3 | | |
| 2007 | | | 178 | 3,658.3 | 24 | 4,403.3 | | | 33 | 3,545.2 | 2 | 4,381.9 |
| 2008 | | | 207 | 3,814.0 | 10 | 4,139.9 | | | 58 | 3,898.0 | | |
| 2009 | 1 | 2,498.2 | 195 | 4,018.9 | 6 | 4,897.1 | | | 34 | 3,920.3 | | |
| 2010 | | | 185 | 4,103.0 | | | | | 54 | 3,996.6 | | |
| 2011 | 1[1] | 3,853.1 | 179 | 4,000.1 | 4 | 5,692.1 | | | 41 | 3,843.3 | 2 | 4,098.2 |
| 2012 | | | 186 | 3,901.0 | 5 | 4,982.8 | | | 41 | 3,537.4 | 1 | 3,900.5 |
| 2013 | | | 141 | 3,753.5 | 6 | 5,068.0 | | | 36 | 3,498.7 | 2 | 4,955.3 |
| Mean | | | | 3,852.6 | | 4,731.1 | | | | 3,726.9 | | 4,465.6 |

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

## Juvenile Salmon Evaluation

### Food Conversion Efficiency

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

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

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

## Length and Weight Growth Profiles

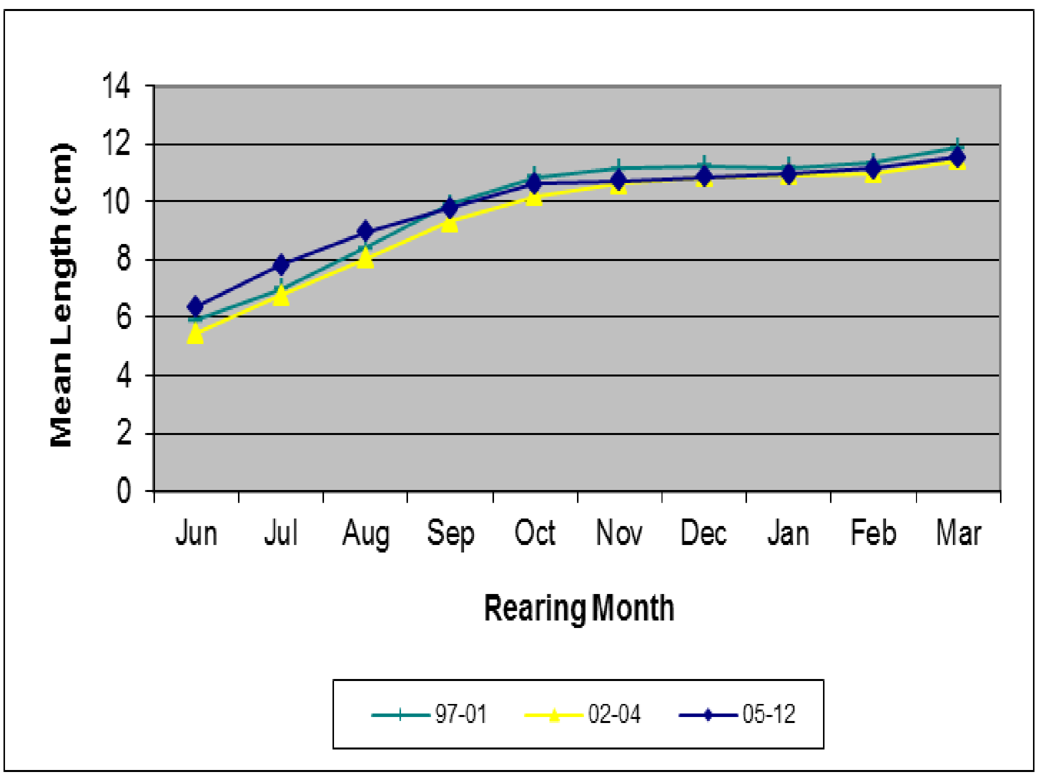


**Figure 5. Mean length (cm) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.**

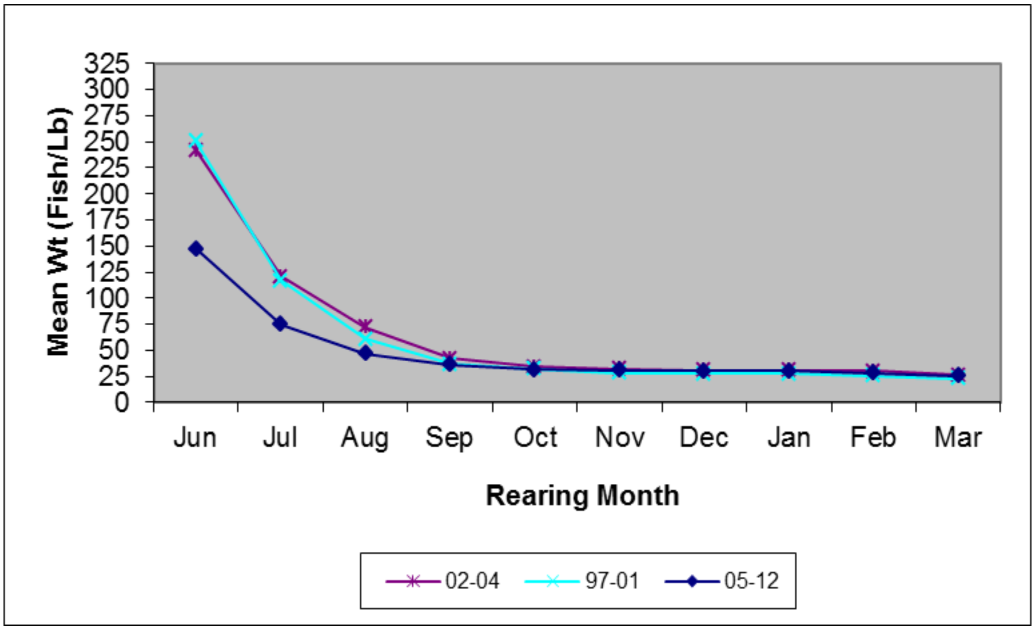


**Figure 6. Mean Weight (fish/lb) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.**

## Juvenile Fish Health Profile

Approximately 10-60 fish from each acclimation site pond were sacrificed for juvenile fish health samples in the spring (usually in March) of their release year. Tissue samples from these fish were processed at USFWS laboratories in Olympia, Washington for presence of bacterial kidney disease (BKD) using enzyme-linked immunosorbent assay (ELISA) tests (see Female BKD Profiles and Appendix B for additional discussion). Fish were ranked from 0 to 13 based on the relative amounts of BKD in the tissue samples of the tested fish. Based on empirical evidence, fish with BKD ranks of 0-5 were considered to be low risk for incidence of BKD in the presence of a good fish culture and rearing environment (i.e., water temperature and flows, nutrition, densities, etc. all must be conducive to good fish health). Mean BKD ranks for all juvenile fish sampled ranged from 0.11 to 2.51 for the 13 brood years when adequate samples were available (Table 37), indicating that juvenile fish released from the CESRF appear to be well within the low risk category for all release years to date.

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

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

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 Year | Control[1] | Treatment[2] | Acclimation Site CFJ | ESJ | JCJ | Total |
|---|---|---|---|---|---|---|
| 1997 | 207,437 | 178,611 | 229,290 | 156,758 | | 386,048 |
| 1998[3] | 284,673 | 305,010 | 221,460 | 230,860 | 137,363 | 589,683 |
| 1999 | 384,563 | 374,226 | 232,563 | 269,502 | 256,724 | 758,789 |
| 2000 | 424,554 | 409,731 | 285,954 | 263,061 | 285,270 | 834,285 |
| 2001[4] | 183,963 | 186,273 | 80,782 | 39,106 | 250,348 | 370,236 |
| 2002 | 420,764 | 416,140 | 266,563 | 290,552 | 279,789 | 836,904 |
| 2003 | 414,175 | 410,517 | 273,377 | 267,711 | 283,604 | 824,692 |
| 2004[5] | 378,740 | 406,708 | 280,598 | 273,440 | 231,410 | 785,448 |
| 2005 | 431,536 | 428,466 | 287,127 | 281,150 | 291,725 | 860,002 |
| 2006 | 351,063 | 291,732 | 209,575 | 217,932 | 215,288 | 642,795 |
| 2007 | 387,055 | 384,210 | 265,907 | 254,540 | 250,818 | 771,265 |
| 2008 | 421,290 | 428,015 | 280,253 | 287,857 | 281,195 | 849,305 |
| 2009 | 418,314 | 414,627 | 279,123 | 281,395 | 272,423 | 832,941 |
| 2010 | 395,455 | 399,326 | 264,420 | 264,362 | 265,999 | 794,781 |
| 2011 | 382,195 | 386,987 | 255,290 | 248,454 | 265,438 | 769,182 |
| 2012 | 401,059 | 401,657 | 256,732 | 276,210 | 269,774 | 802,716 |
| Mean | 367,927 | 363,890 | 259,215 | 257,586 | 264,272 | 731,817 |

**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 |
| 2012 | 44,562 | 44,629 | 42,789 | 46,035 | 44,962 |
| Mean | 43,573 | 43,000 | 43,027 | 43,802 | 43,398 |

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

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

## Smolt Outmigration Timing

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

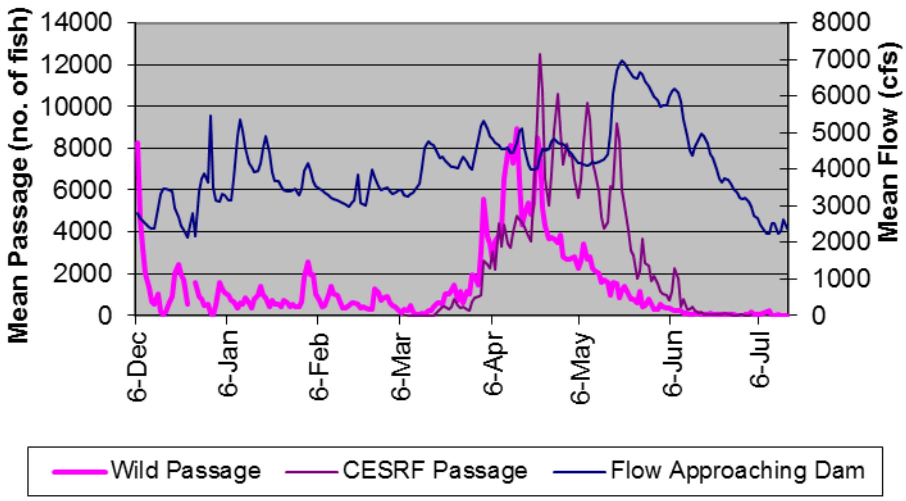


**Figure 7. Mean flow approaching Prosser Dam versus mean estimated smolt passage at Prosser of aggregate wild/natural and CESRF spring Chinook for outmigration years 1999-2013.**

## Smolt-to-Smolt Survival

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

Results of this experiment have been published:

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

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

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

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

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

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

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

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

**Smolt-to-Adult Survival**

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

1) Downstream of the confluence of the Yakima and Naches rivers the three populations of spring Chinook (Upper Yakima, Naches, and American) are aggregated. A subsample of the aggregate wild/natural populations is PIT-tagged as part of the Chandler juvenile sampling

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

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

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

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

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

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

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

8) The ISAB has indicated that "more attention should be given to the apparent documentation that PIT-tagged fish do not survive as well as untagged fish. This point has major implications for all uses of PIT-tagged fish as surrogates for untagged fish." Our data appear to corroborate this point (Tables 45-46). However, these data are not corrected for tag loss.

If a fish loses its PIT tag after detection upon leaving the acclimation site, but before it returns as an adult to Roza Dam, it would be included only as a release in Table 45 and only as an adult return in Table 46. Knudsen et al. (2009) found that smolt-to-adult return rates (SARS) based on observed PIT tag recoveries were significantly underestimated by an average of 25% and that after correcting for tag loss, SARS of PIT-tagged fish were still 10% lower than SARS of non-PIT-tagged fish. Thus, the data in Table 45 under-represent "true" SARS for PIT-tagged fish and SARS for PIT-tagged and non-PIT-tagged fish are likely closer than those reported in Tables 45 and 46.

9) Due to issues relating to water permitting 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 | 147,486 | 241,078 | 28.8% | 3,743 | 2,300 | 2.5% | 1.0% |
| 2003 | 2005 | 1285 | 127,945 | 215,578 | 26.1% | 2,746 | 932 | 2.1% | 0.4% |
| 2004 | 2006 | 5652 | 168,972 | 323,490 | 41.2% | 2,802 | 4,022 | 1.7% | 1.2% |
| 2005 | 2007 | 4551 | 145,203 | 362,663 | 42.2% | 4,201 | 4,378 | 2.9% | 1.2% |
| 2006 | 2008 | 4298 | 83,329 | 167,682 | 26.1% | 6,099 | 9,114 | 7.3% | 5.4% |
| 2007 | 2009 | 5784 | 198,966 | 321,594 | 41.7% | 8,030 | 6,558 | 4.0% | 2.0% |
| 2008 | 2010 | 3592 | 122,954 | 204,812 | 24.1% | 7,341 | 6,977 | 6.0% | 3.4% |
| 2009 | 2011 | 9414 | 318,800 | 433,654 | 52.1% | 3,506[6] | 3,123[6] | 1.1%[6] | 0.7%[6] |
| 2010 | 2012 | 8556 | 386,121 | 392,963 | 49.4% | | | | |
| 2011 | 2013[6] | 4875 | 295,849 | 301,059 | 39.1% | | | | |

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

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

| | | Wild/Natural smolts tagged at Roza | | | | |
|---|---|---|---|---|---|---|
| Brood Year | Number Tagged | Adult Returns at Age[1] Age 3 | Age 4 | Age 5 | Total | SAR[1] |
| 1997 | 310 | 0 | 1 | 0 | 1 | 0.32%[2] |
| 1998 | 6,209 | 15 | 171 | 14 | 200 | 3.22% |
| 1999 | 2,179 | 2 | 8 | 0 | 10 | 0.46% |
| 2000 | 8,718 | 1 | 51 | 1 | 53 | 0.61% |
| 2001 | 7,804 | 9 | 52 | 3 | 64 | 0.82% |
| 2002 | 3,931 | 2 | 46 | 4 | 52 | 1.32% |
| 2003 | 1,733 | 0 | 6 | 1 | 7 | 0.40% |
| 2004 | 2,333 | 1 | 8 | 1 | 10 | 0.43% |
| 2005 | 1,200 | 0 | 8 | 0 | 8 | 0.67% |
| 2006 | 1,675 | 12 | 33 | 2 | 47 | 2.81% |
| 2007 | 3,795[a] | 6 | 47 | 2 | 55 | 1.45% |
| 2008 | 105 | 0 | 1 | 0 | 1 | 0.95% |
| 2009 | 2,087 | 0 | 3 | | | |
| 2010 | 2,640 | 4 | | | | |
| 2011 | 2,481 | | | | | |

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

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

| | | CESRF smolts tagged at Roza | | | | |
|---|---|---|---|---|---|---|
| Brood Year | Number Tagged | Adult Returns at Age[1] Age 3 | Age 4 | Age 5 | Total | SAR[1] |
| 1997 | 407 | 0 | 2 | 0 | 2 | 0.49%[2] |
| 1998 | 2,999 | 5 | 42 | 2 | 49 | 1.63% |
| 1999 | 1,744 | 1 | 0 | 0 | 1 | 0.06% |
| 2000 | 1,503 | 0 | 1 | 0 | 1 | 0.07% |
| 2001 | 2,146 | 0 | 4 | 0 | 4 | 0.19% |
| 2002 | 2,201 | 4 | 5 | 0 | 9 | 0.41% |
| 2003 | 1,418 | 0 | 3 | 1 | 4 | 0.28% |
| 2004 | 4,194 | 3 | 13 | 0 | 16 | 0.38% |
| 2005 | 2,358 | 0 | 3 | 0 | 3 | 0.13% |
| 2006 | 4,130 | 32 | 31 | 2 | 65 | 1.57% |
| 2007 | 3,736 | 10 | 21 | 0 | 31 | 0.83% |
| 2008 | 1,071 | 4 | 3 | 0 | 7 | 0.65% |
| 2009 | 3,641 | 2 | 4 | | | |
| 2010 | 3,831 | 4 | | | | |
| 2011 | 746 | | | | | |

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

**Table 43. Overall wild/natural smolt-to-adult return rates (SAR) based on juvenile and adult detections of fish PIT-tagged and released at Roza Dam (Table 4.35 in Tuomikoski et al. 2013). McNary smolts to Bonneville Dam adult returns.**

| Juvenile migration year | Smolts arriving MCN [A] | MCN-to-BOA without Jacks | | | MCN-to-BOA with Jacks | | |
|---|---|---|---|---|---|---|---|
| | | %SAR | Non-parametric CI | | %SAR | Non-parametric CI | |
| | | Estimate | 90% LL | 90% UL | Estimate | 90% LL | 90% UL |
| 2000 | 2,581 | 6.90 | 6.10 | 7.73 | 7.48 | 6.67 | 8.38 |
| 2001 | 521 | 1.54 | 0.73 | 2.52 | 1.92 | 0.98 | 3.04 |
| 2002 | 2,130 | 2.25 | 1.73 | 2.80 | 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 [C] | 0 | -- | -- | -- | -- | -- | -- |
| 2011 | 411 | 0.73 | 0.20 | 1.50 | 0.73 | 0.20 | 1.50 |
| geometric mean | | 2.49 | | | 2.73 | | |

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

[B] Incomplete with 2-salt returns only through September 15th 2013.

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

**Table 44. Overall CESRF smolt-to-adult return rates (SAR) based on juvenile and adult detections of PIT tagged fish (Table 4.37 in Tuomikoski et al. 2013). McNary smolts to Bonneville Dam adult returns.**

| Juvenile migration year | Smolts arriving MCN [A B] | MCN-to-BOA without Jacks | | | MCN-to-BOA with Jacks | | |
|---|---|---|---|---|---|---|---|
| | | %SAR | Non-parametric CI | | %SAR | Non-parametric CI | |
| | | Estimate | 90% LL | 90% UL | Estimate | 90% LL | 90% UL |
| 2000 | 14,416 | 3.65 | 3.35 | 3.96 | 3.99 | 3.67 | 4.31 |
| 2001 | 9,269 | 0.28 | 0.19 | 0.38 | 0.29 | 0.20 | 0.39 |
| 2002 | 11,753 | 1.37 | 1.19 | 1.55 | 1.73 | 1.53 | 1.94 |
| 2003 | 11,978 | 0.59 | 0.48 | 0.71 | 0.86 | 0.72 | 1.00 |
| 2004 | 7,982 | 1.54 | 1.31 | 1.77 | 1.85 | 1.62 | 2.10 |
| 2005 | 5,791 | 0.66 | 0.48 | 0.85 | 0.78 | 0.58 | 0.98 |
| 2006 | 10,285 | 1.23 | 1.05 | 1.42 | 1.59 | 1.39 | 1.81 |
| 2007 | 12,658 | 1.01 | 0.87 | 1.16 | 1.51 | 1.33 | 1.69 |
| 2008 | 11,683 | 3.16 | 2.85 | 3.45 | 5.05 | 4.67 | 5.45 |
| 2009 | 15,391 | 1.82 | 1.64 | 2.00 | 2.29 | 2.09 | 2.50 |
| 2010 | 12,466 | 1.52 | 1.33 | 1.71 | 2.53 | 2.29 | 2.79 |
| 2011 [C] | 11,832 | 0.91 | 0.77 | 1.07 | 1.18 | 1.01 | 1.35 |
| geometric mean | | 1.19 | | | 1.56 | | |

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

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

[C] Incomplete with 2-salt returns only through September 15th 2013.

**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 | 263 | 11 | 460 | 1.19% |
| 2007 | 38,618 | 73 | 279 | 3 | 355 | 0.92% | 53 | 182 | 3 | 238 | 0.62% |
| 2008 | 39,013 | 135 | 192 | 3 | 330 | 0.85% | 81 | 132 | 2 | 215 | 0.55% |
| 2009 | 36,239 | 32 | 110 | | | | 23 | 85 | | | |
| 2010 | 38,737 | 85 | | | | | 61 | | | | |

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 Returns to 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 | 22 | 6,336 | 0.77% |
| 2006 | 604,200 | 2,384 | 6,428 | 287 | 9,098 | 1.51% |
| 2007 | 732,647 | 1,026 | 5,645 | 87 | 6,758 | 0.92% |
| 2008 | 810,292 | 1,552 | 3,680 | 77 | 5,309 | 0.66% |
| 2009 | 796,702 | 389 | 3,105 | | | |
| 2010 | 756,044 | 611 | | | | |

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% |
| 2013 | 846 | 975 | 786 | 46[2] | 1,632 | 1,021 | 2,653 | 25.9% |
| Mean | 628 | 631 | 592 | 98 | 1,220 | 674 | 1,171 | 13.7% |

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 | 0 | 12.2% | |
| 1984 | 3,890 | 135 | 258 | 2,658 | 289 | 682 | 682 | 0 | 17.5% | |
| 1985 | 5,274 | 192 | 179 | 4,560 | 865 | 1,236 | 1,236 | 0 | 23.4% | |
| 1986 | 13,480 | 279 | 781 | 9,439 | 1,340 | 2,400 | 2,400 | 0 | 17.8% | |
| 1987 | 6,165 | 96 | 372 | 4,443 | 517 | 986 | 986 | 0 | 16.0% | |
| 1988 | 5,610 | 359 | 371 | 4,246 | 444 | 1,174 | 1,174 | 0 | 20.9% | |
| 1989 | 8,936 | 213 | 668 | 4,914 | 747 | 1,628 | 1,628 | 0 | 18.2% | |
| 1990 | 6,870 | 348 | 450 | 4,372 | 663 | 1,461 | 1,461 | 0 | 21.3% | |
| 1991 | 4,611 | 183 | 277 | 2,906 | 32 | 492 | 492 | 0 | 10.7% | |
| 1992 | 6,226 | 103 | 375 | 4,599 | 345 | 823 | 823 | 0 | 13.2% | |
| 1993 | 5,135 | 44 | 312 | 3,919 | 129 | 485 | 485 | 0 | 9.4% | |
| 1994 | 2,228 | 86 | 107 | 1,302 | 25 | 219 | 219 | 0 | 9.8% | |
| 1995 | 1,375 | 1 | 68 | 666 | 79 | 148 | 148 | 0 | 10.8% | |
| 1996 | 5,790 | 6 | 303 | 3,179 | 475 | 784 | 784 | 0 | 13.5% | |
| 1997 | 5,235 | 3 | 350 | 3,173 | 575 | 928 | 928 | 0 | 17.7% | |
| 1998 | 2,825 | 3 | 142 | 1,903 | 188 | 332 | 332 | 0 | 11.8% | |
| 1999 | 3,944 | 4 | 182 | 2,781 | 604 | 790 | 790 | 0 | 20.0% | |
| 2000 | 28,705 | 58 | 1,745 | 19,100 | 2,458 | 4,261 | 4,138 | 123 | 14.8% | |
| 2001 | 30,873 | 990 | 4,033 | 23,265 | 4,630 | 9,654 | 5,564 | 4,090 | 31.3% | 30.0% |
| 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 | 1,503 | 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 | 5,003 | 176 | 344 | 4,303 | 279 | 799 | 388 | 411 | 16.0% | 14.0% |
| 2008 | 11,493 | 1,149 | 1,570 | 8,598 | 1,532 | 4,251 | 1,199 | 3,053 | 37.0% | 26.8% |
| 2009 | 12,979 | 1,138 | 1,116 | 12,120 | 2,353 | 4,606 | 1,260 | 3,346 | 35.5% | 26.1% |
| 2010 | 17,685 | 1,517 | 2,620 | 13,142 | 1,741 | 5,878 | 1,347 | 4,530 | 33.2% | 22.1% |
| 2011 | 22,353 | 975 | 1,643 | 17,960 | 4,380 | 6,997 | 2,400 | 4,597 | 31.3% | 22.4% |
| 2012 | 15,931 | 756 | 1,478 | 12,053 | 3,320 | 5,554 | 2,220 | 3,334 | 34.9% | 28.2% |
| 2013[1] | 14,295 | 684 | 1,117 | 10,245 | 2,653 | 4,454 | 1,697 | 2,756 | 31.2% | 23.7% |
| Mean | 10,389 | 403 | 873 | 7,360 | 1,171 | 2,448 | 1,378 | 2,623 | 20.1% | 17.9% |

1. Preliminary.

## Marine Fisheries

Based on available CWT information, harvest managers have long assumed that Columbia River spring Chinook are not harvested in any abundance in marine fisheries as the timing of their ocean migration does not generally overlap either spatially or temporally with the occurrence of marine fisheries (TAC 1997). The Regional Mark Information System (RMIS) will be queried regularly for any CWT recoveries of CESRF releases in ocean or Columbia River mainstem fisheries. Table 49 gives the results of a query of the RMIS database run on Jan. 7, 2014 for CESRF spring Chinook CWTs released in brood years 1997-2008. 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 2009 were considered too incomplete to report at this time.

**Table 49. Marine and freshwater recoveries of CWTs from brood year 1997-2008 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) 7 Jan, 2014.**

| Brood | Observed CWT Recoveries | | | Expanded CWT Recoveries | | |
|---|---|---|---|---|---|---|
| Year | Marine | Fresh | Marine % | Marine | Fresh | Marine % |
| 1997 | 5 | 56 | 8.2% | 8 | 321 | 2.4% |
| 1998 | 2 | 53 | 3.6% | 2 | 228 | 0.9% |
| 1999 | | 2 | 0.0% | | 9 | 0.0% |
| 2000 | | 14 | 0.0% | | 34 | 0.0% |
| 2001 | | 1 | 0.0% | | 1 | 0.0% |
| 2002 | | 7 | 0.0% | | 36 | 0.0% |
| 2003 | | 4 | 0.0% | | 10 | 0.0% |
| 2004 | 2 | 154 | 1.3% | 15 | 526 | 2.8% |
| 2005 | 2 | 96 | 2.0% | 2 | 304 | 0.7% |
| 2006 | 14 | 329 | 4.1% | 16 | 1165 | 1.4% |
| 2007 | 8 | 145 | 5.2% | 13 | 1124 | 1.1% |
| 2008[1] | 5 | 240 | 2.0% | 7 | 1608 | 0.4% |

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 2008 are considered preliminary or incomplete.

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## *Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2002-2012.*

| 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 2002-2012.*

| 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 2002-2012.*

| 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.

## *Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2002-2012.*

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

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

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

## *Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2002-2012.*

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

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

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

# *Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2002-2012.*

| 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 2002-2012.*

| 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.

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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] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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.

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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] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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.

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

[1] BIO = BioVita (BioOregon Protein Inc.) or control diet; STF = salt-water transition diet at acclimation sites. All fish are progeny of wild/natural parents unless denoted as 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 B. CESRF - Summary of SCS ELISA data collected from 1997-2014

**Prepared by**
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**Olympia Fish Health Center**
**500 Desmond Drive SE**
**Lacey, WA 98503**

**July 18, 2014**

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Bacterial Kidney Disease (BKD) is a chronic systemic disease caused by the bacterium *Renibacterium salmoninarum* (Rsal). This disease can cause extensive mortality in cultured spring Chinook salmon populations (Raymond 1988). The Cle Elum Supplementation and Research Facility (CESRF) has been reducing the risks of vertical and horizontal transmission of Rsal by using an enzyme-linked immunosorbant assay (ELISA)-based culling program coupled with good fish husbandry and culture practices as outlined in their standard operating procedures. The Olympia Fish Health Center (OFHC) has measured Rsal antigen levels in the kidney tissue of the adult spring Chinook spawning populations and their progeny prior to release since the program began in 1997. Based on the ELISA optical density (OD) values, samples were ranked and grouped into Low (L), Moderate (M) and High (H) risk categories. Risk groups were established based on personal observations and experiences with other spring Chinook populations. These risk groups reflect the likelihood of Bacterial Kidney Disease (BKD) occurrence. Research has demonstrated that progeny of adult females with high ELISA OD values have an increased prevalence of the bacterium Rsal and higher incidences of Bacterial Kidney Disease (Munson et. al. 2010). A summary of the data collected by the OFHC is provided below.

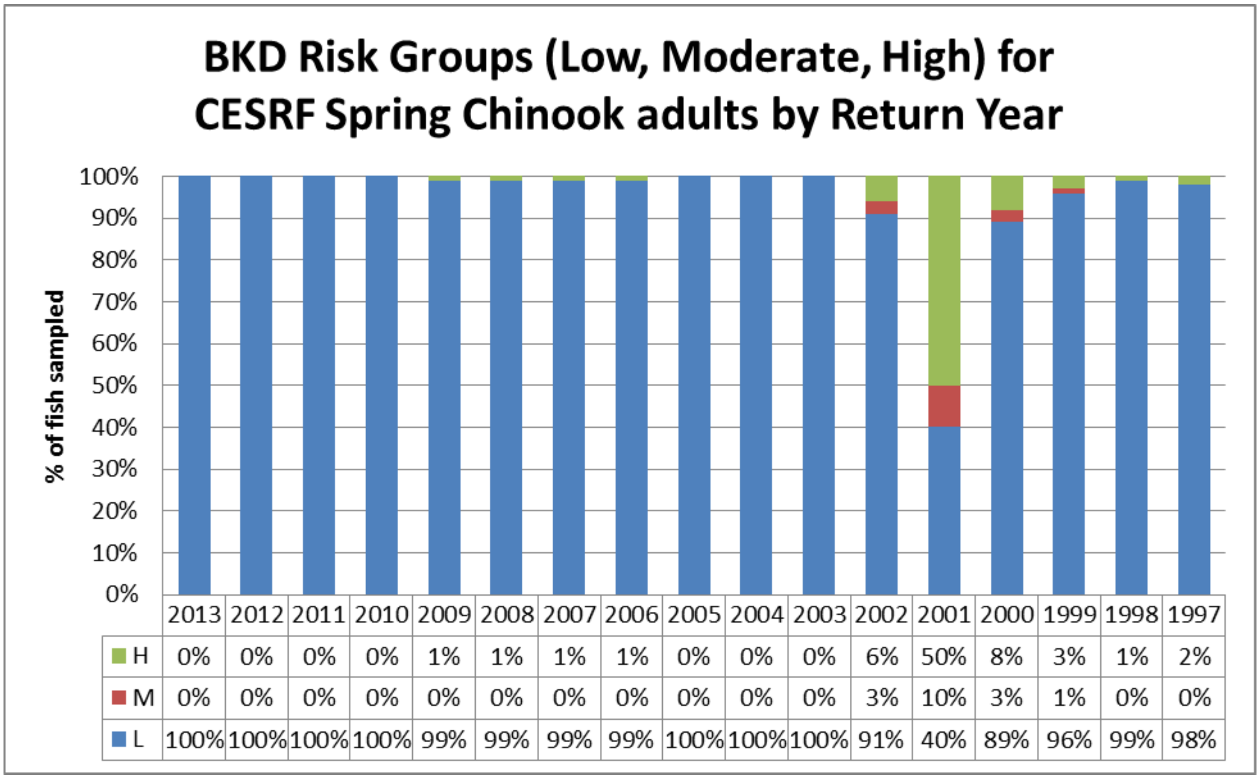
- <u>Spring Chinook adults (RY1997-2013)</u>

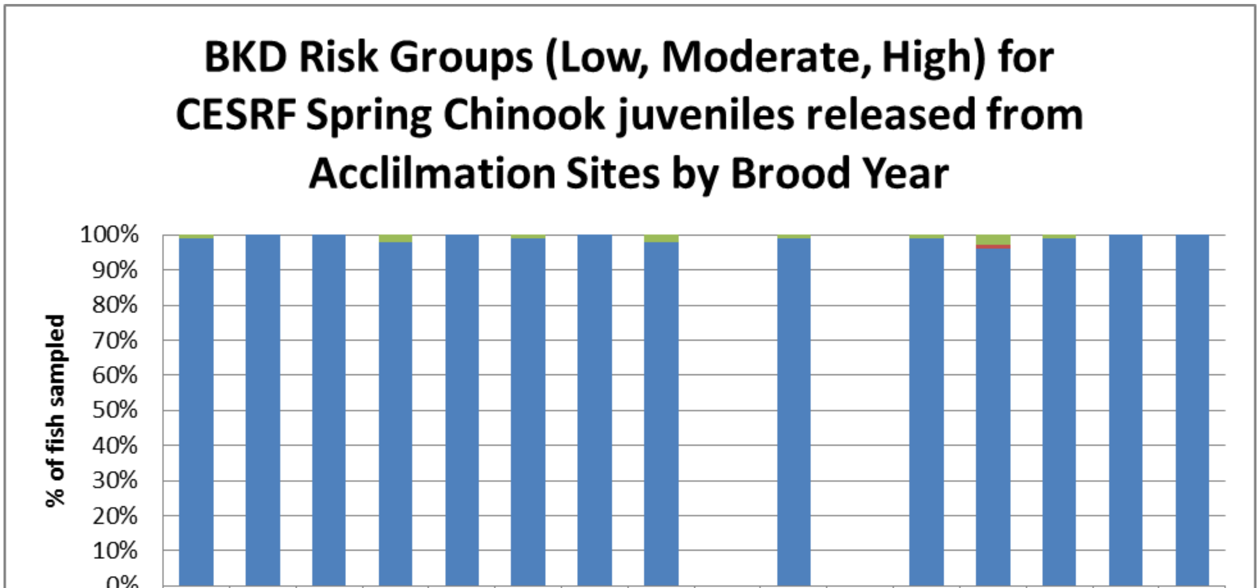
The 17 years of ELISA data collected from the CESRF spawning adult populations (4600 fish) shows that approximately 5% of the adults returned with moderate to high risk profiles. During the first 7 years, approximately 12% of the adults spawned were in the moderate to high risk category. Within the last 10 years, this percentage has declined to less than 1% (approximately 0.4% of the adults falling into the moderate to high risk profile). Fish returning in 2001 had an especially high ELISA rank with 60% of the adults in the moderate to high category. This appears to have been a basin wide "anomaly" that was encountered in several other spring Chinook facilities and stocks in the Columbia River basin. While these adults were held prior to spawning they experienced elevated mortalities due to Bacterial Kidney Disease and Furunculosis (caused by the bacterium *Aeromonas salmonicida*).

- <u>Spring Chinook juveniles (BY1997-2012)</u>

Over the last 16 years, juvenile spring Chinook (9022 fish) have been evaluated for the presence of Rsal using ELISA. This data shows that approximately 99% of the juvenile populations were released with low risk profiles. There have been no disease problems attributed to BKD in the juveniles, except in 1997 and 2001. In 1997, eggs from 3 very "high risk" adult females were kept and reared on station. This resulted in the progeny from these females experiencing an epizootic due to Bacterial Kidney Disease. ELISA testing revealed that 87% of this population ranked as highs and this raceway of fish was euthanized. In 2001-2002, a portion of the 2001 brood year fish were not transferred to the acclimation sites but held on station for a research project. This held population experienced clinical BKD with 36% having elevated ELISA values in the moderate to high range. These were the progeny from the 2001 adults that tested abnormally high for Rsal. These experiences emphasize the importance of not rearing “high risk” groups.

Other than the two cases described above where juveniles from high ELISA value parents were kept, there have been no BKD related problems at CESRF. However, there have been sporadic observations of juveniles with clinical signs of BKD.






| | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | 1% | 0% | 0% | 2% | 0% | 1% | 0% | 2% | 0% | 1% | 0% | 1% | 3% | 1% | 0% | 0% |
| M | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% | 0% |
| L | 99% | 99% | 99% | 98% | 100% | 99% | 100% | 98% | 0% | 99% | 0% | 99% | 96% | 98% | 100% | 100% |

Note: This graph does not include the two cases of clinical BKD described above (BY1997&2001).
There is no data for BY2002 & 2004 due to test failure.

Maintaining a proactive approach to fish health and incorporating a culling program that segregates and/or removes high risk progeny from the population has effectively limited the impacts of Bacterial Kidney Disease at CESRF. While ELISA based BKD management may not completely eliminate Rsal or Bacterial Kidney Disease from a population, it has proven to reduce the overall prevalence and intensity of Rsal infections and thereby helps control disease outbreaks during hatchery rearing.

References:

Munson, A. D., D. G. Elliott and K. Johnson. 2010. Management of Bacterial Kidney Disease in Chinook Salmon Hatcheries Based on Broodstock Testing by Enzyme-Linked Immunosorbent Assay: A Multiyear Study, North American Journal of Fisheries Management, 30:4, 940-955.

Raymond, H. L. 1988. Effects of hydroelectric development and fisheries enhancement on spring and summer Chinook salmon and steelhead in the Columbia River basin. North American Journal of Fisheries Management 8:1-24.

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**Appendix C**
**Annual Report: Smolt Survival to McNary Dam of 1999-2013 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 spring Chinook smolt released in the Roza Dam juvenile bypass system 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 their survival to McNary that is 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 captured, 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 were released back into the bypass.

The Roza Dam juvenile bypass system is not equipped with PIT tag detection; the data set includes only the fish that were captured in the Roza bypass and tagged, or recaptured if already tagged, for this study.

In 2013 there were very few late natural and previously PIT-tagged hatchery spring Chinook smolt captured for re-release at Roza.

## Methodology

In previous years, all smolt releases 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. This was done to have a sufficiently large number of released smolt per grouping. If there still were not a sufficient number, then adjacent seven-day 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 Julian-date intervals treated as blocks. Comparisons between early and late natural smolt proportions were treated as independent comparisons since they involved different groupings.

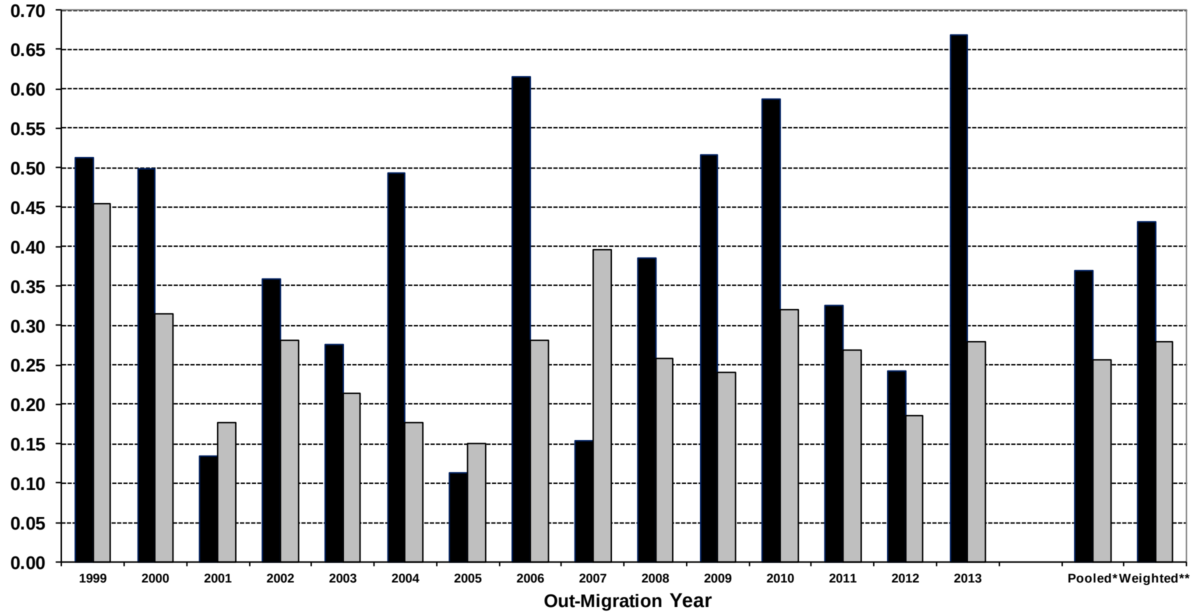
In 2013 this same grouping was used for the early outmigrating natural smolt; however there were few natural-origin smolt available for tagging during the late period. It was necessary to come up with groupings that were meaningful. For the period when hatchery fish were being released, the only two groupings that could be established were those released from Julian dates 98 through 114 and 115 through 125, which are not multiples of seven day groupings. The only reason that two groupings were formed was to obtain an estimate of variation. The only survival estimates provided in tables are for all fish within the late period, not for the two individual 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. Formal statistical analyses for the comparisons of the contemporaneously outmigrating (late) hatchery and natural-origin smolt are presented in Appendices C.1 and C.2. For comparisons of the late and early outmigration natural-origin smolt, analyses are presented in Appendices D1 and D.2.

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

As was the case in previous years, late naturally spawned smolt released at Roza in 2013 had a higher mean Roza-to-McNary survival rate than did hatchery smolt. Figure 1 presents the late-natural- and hatchery-smolt survivals to McNary from the 1999 through 2013 Roza releases.

**Figure 1. Upper-Yakima Spring-Chinook Roza-to-McNary Smolt Survival for Late Natural Smolt (black bars) and Hatchery Smolt (grey bars)**




***  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**

Because naturally-spawned smolt will have survived the in-stream environment longer than hatchery-spawned smolt prior to capture at Roza Dam, 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 smolt tend to be larger. Therefore, one-sided tests for the hypothesis

$$\text{natural survival} - \text{hatchery survival} > 0$$

were 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 as estimates combined over years with their associated statistical test summaries.  Note that the pooled survival and weighted survival estimates over years were significantly higher for the natural smolt (P = 0.0032 and P = 0.0011, respectively from two different tests; Table 1 and Appendix Table C.2).

As can be seen from Figure 1 and Table 1, the late natural smolt survival exceeded that of the hatchery smolt in 12 or 80% of the 15 outmigration years.  Of those 12 years, 9 were significant at the 5% level (Table 1). The analyses on which individual-year significance levels in Table 1 are based are presented in Appendix C.1.

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

| Stock | Measure | 1999 | 2000 | 2001*** | 2002 | 2003 | 2004 | 2005*** | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| | | Outmigration Year | | | | | | | |
| **Natural** | **Survival** | **0.5122** | **0.4987** | **0.1339** | **0.3584** | **0.2750** | **0.4935** | **0.1122** | **0.6160** |
| (Nat) | Released | 133 | 3196 | 1424 | 2114 | 1190 | 74 | 45 | 500 |
| **Hatchery** | **Survival** | **0.4540** | **0.3155** | **0.1759** | **0.2803** | **0.2137** | **0.1768** | **0.1494** | **0.2810** |
| (Hat) | Released | 675 | 2999 | 1744 | 1503 | 2146 | 2201 | 1344 | 3802 |
| **Difference** | **Nat-Hat** | **0.0582** | **0.1832** | **-0.0420** | **0.0781** | **0.0613** | **0.3167** | **-0.0371** | **0.3350** |
| | | **Type 1 Error P** | | | | | | | |
| **(1-sided)** | **(Nat > Hat)** | **0.0378** | **0.0000** | 0.6312 | **0.0433** | **0.0374** | **0.0122** | 0.7353 | **0.0003** |

| Stock | Measure | 2007*** | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Pooled* | Weighted** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Outmigration Year | | | | | | | | |
| **Natural** | **Survival** | **0.1529** | **0.3857** | **0.5161** | **0.5874** | **0.3260** | **0.2419** | **0.6683** | **0.3703** | **0.4319** |
| (Nat) | Released | 336 | 421 | 172 | 105 | 956 | 193 | 38 | 10897 | |
| **Hatchery** | **Survival** | **0.3955** | **0.2573** | **0.2405** | **0.3196** | **0.2679** | **0.1849** | **0.2801** | **0.2566** | **0.2786** |
| (Hat) | Released | 2477 | 4406 | 2334 | 1130 | 3103 | 4405 | 550 | 34819 | |
| **Difference** | **Nat-Hat** | **-0.2426** | **0.1284** | **0.2756** | **0.2678** | **0.0581** | **0.0570** | **0.3882** | **0.1137** | **0.1533** |
| | | **Type 1 Error P** | | | | | | | | 0.69012669 |
| **(1-sided)** | **(Nat > Hat)** | 0.5088 | **0.0048** | **0.0182** | **0.0108** | 0.0559 | 0.1598 | 0.1727 | **0.0032** | **0.0011** |

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

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

***** The three years in which late Natural-brood Survival was less than that of the hatchery-brood**

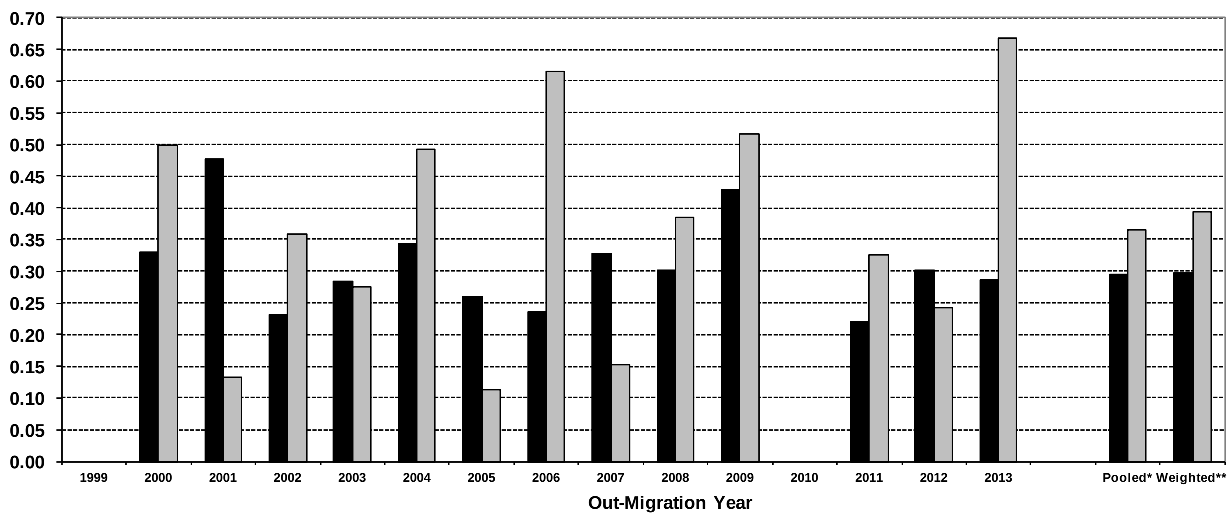
### Comparison of Early and Late Natural-Origin Smolt Survival to McNary

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 and Table 2 present the naturally-spawned early- and late-smolt survivals from Roza to McNary for the outmigration years through 2013 where early and late arriving natural-origin smolt were available for comparison.

The combined analyses over years indicated that the late-release and early-release differences were not significant (P = 0.1385 and P = 0.1363, respectively from two different tests, Table 2 and Appendix Table D.2).

The analyses on which individual-year significance levels in Table 2 are based are presented in Appendix D.1. Of the thirteen years with early releases, late releases had higher Roza-to-McNary survival in eight (62%) of the years, and three of the four significant differences in survival were years where the late releases survived better than the early releases.

**Figure 2. Upper-Yakima Spring-Chinook Roza-to-McNary Smolt Survival Indices for Early (black bars) and Late (grey 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

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

| Natural Stock | Measure | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| | | Outmigration Year | | | | | | | |
| Natural | Survival | no | 0.3307 | 0.4771 | 0.2314 | 0.2837 | 0.3442 | 0.2608 | 0.2361 |
| Early | Released | release | 3013 | 755 | 6604 | 6614 | 3857 | 1688 | 1833 |
| Natural | Survival | 0.0000 | 0.4987 | 0.1339 | 0.3584 | 0.2750 | 0.4935 | 0.1122 | 0.6160 |
| Late | Released | 133 | 3196 | 1424 | 2114 | 1190 | 74 | 45 | 500 |
| Difference | Early-Late | | -0.1679 | 0.3432 | -0.1270 | 0.0087 | -0.1493 | 0.1485 | -0.3799 |
| | | Type 1 Error P | | | | | | | |
| (2-sided) | Early-Late | | 0.0000 | 0.0001 | 0.0004 | 0.8230 | 0.4903 | 0.4035 | 0.0010 |

| Stock | Measure | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Pooled* | Weighted** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Outmigration Year | | | | | | | | |
| Natural | Survival | 0.3273 | 0.3020 | 0.4286 | no | 0.2200 | 0.3016 | 0.2855 | 0.2944 | 0.2983 |
| Early | Released | 1072 | 1254 | 1804 | release | 985 | 2482 | 2435 | 34396 | |
| Natural | Survival | 0.1529 | 0.3857 | 0.5161 | 0.5874 | 0.3260 | 0.2419 | 0.6683 | 0.3664 | 0.3945 |
| Late | Released | 336 | 421 | 172 | 105 | 956 | 193 | 38 | 10659 | |
| Difference | Early-Late | 0.1744 | -0.0837 | -0.0875 | | -0.1060 | 0.0597 | -0.3828 | -0.0720 | -0.0962 |
| | | Type 1 Error P | | | | | | | | |
| (2-sided) | Early-Late | 0.0889 | 0.2458 | 0.7590 | | 0.2176 | 0.5212 | 0.2883 | 0.1385 | 0.1363 |

* 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

NOTE: The years 1999 and 2010 are not used in the pooled estimates because no Early Natural were released

**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 estimated daily proportion of all[1] Yakima PIT-tagged Spring Chinook passing McNary Dam that were subsequently detected at McNary)

2. Estimating the McNary detection rate for each stratum

3. Expanding (dividing) each Roza group's release number of smolt detected at McNary during the stratum by the stratum's detection rate.

4. Totaling each group's release expanded McNary-detection numbers over all strata

5. Taking that release group's expanded total over strata and dividing it by the number of fish initially released 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 summarized in the following equations:

Equation 1.

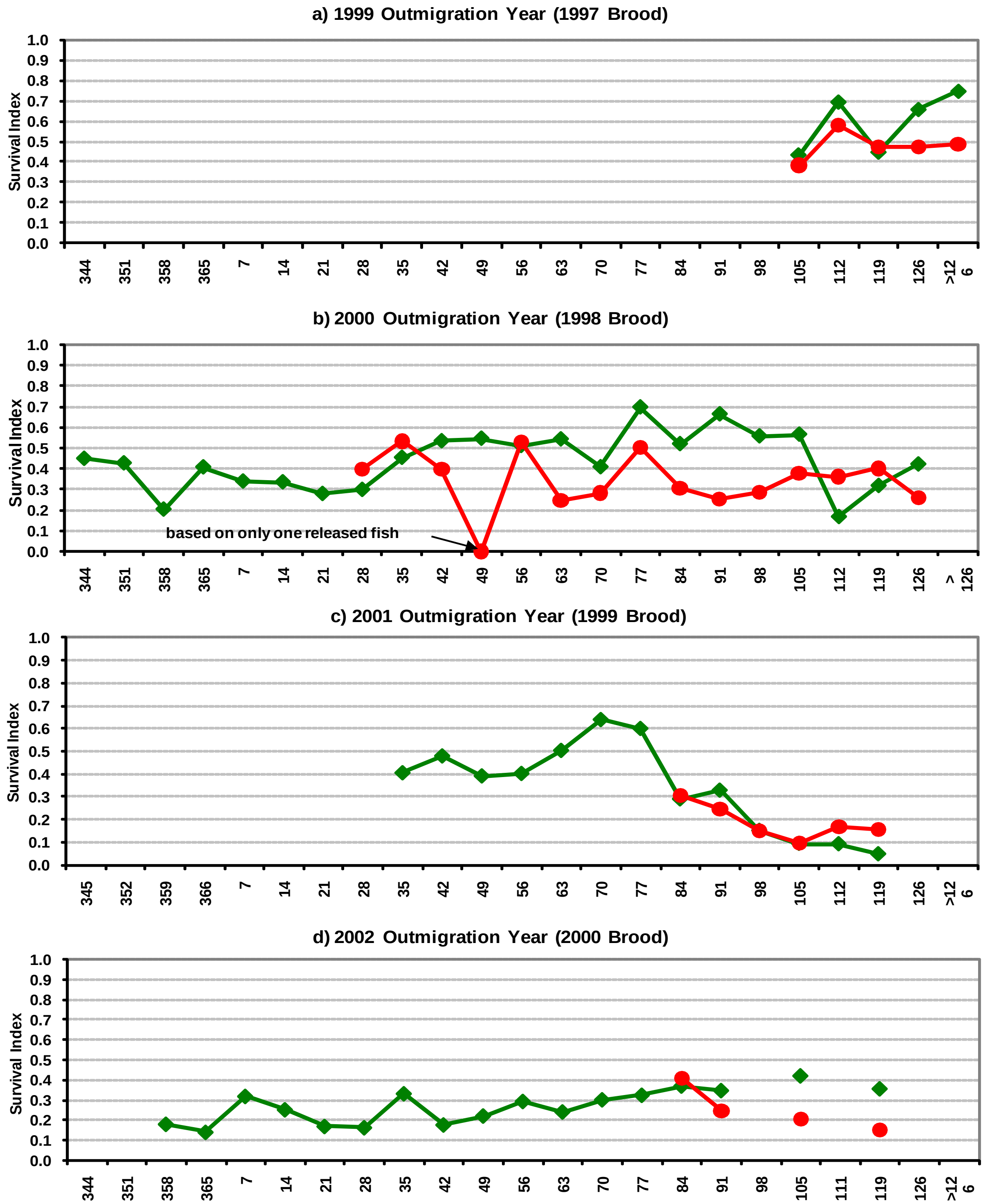
$$\text{Stratum McNary detection rate} = \frac{\text{number of joint detections at McNary and downstream dams within Stratum}}{\text{estimated total number of detections at downstream dams within Stratum}}$$

Equation 2.

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

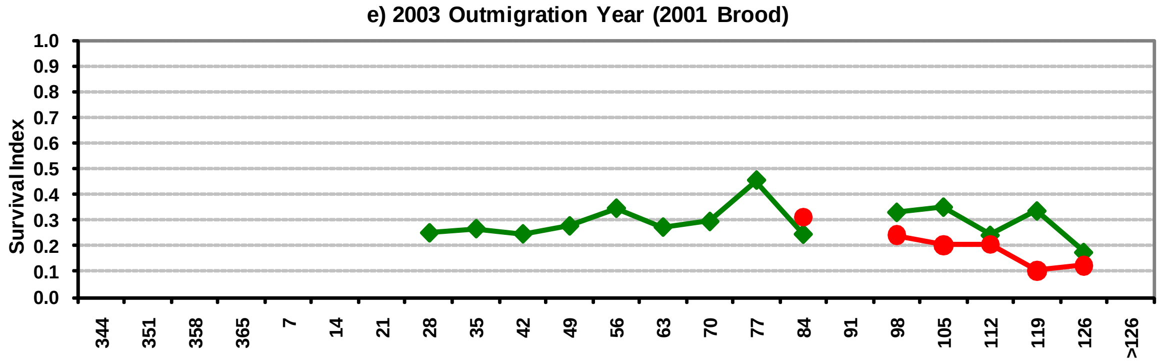
[1] All smolt PIT-tagged in the Yakima Basin, not only those PIT-tagged at Roza

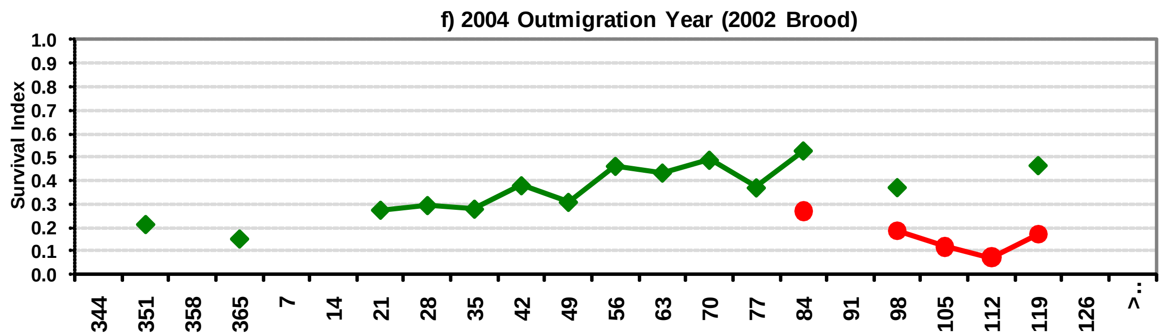
## Appendix B.1. Plotted McNary Smolt Survival of Roza-Released Upper-Yakima Natural- (diamonds) and Hatchery-Brood (circles) Spring Chinook, Plotted on Each Group's Julian Release Date

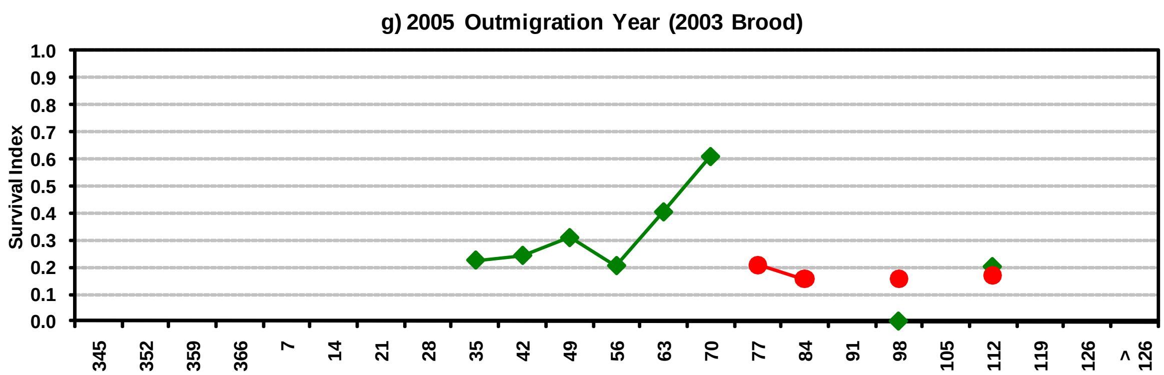


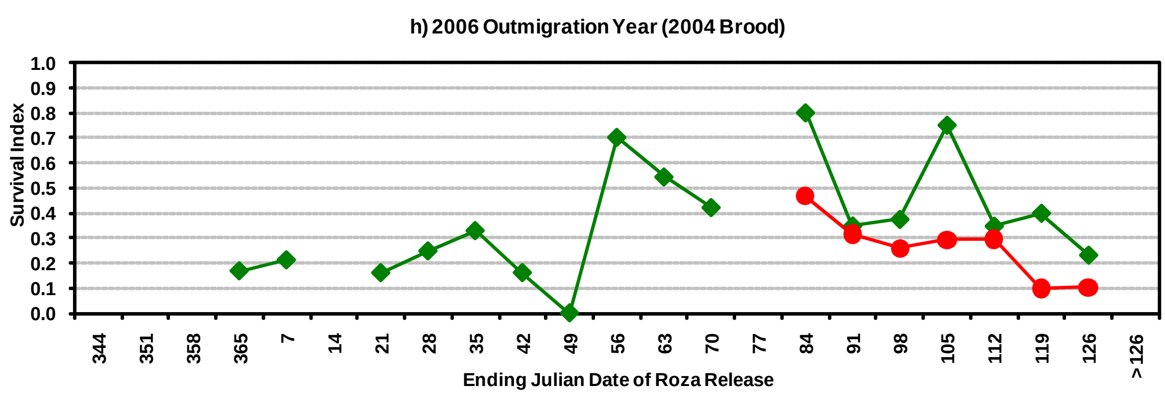

Note: The screens at the acclimation sites are generally pulled on March 15. In 2000 there was leakage that resulted in many of the hatchery smolt leaving before March 15.

**Appendix B.1. (continued)**

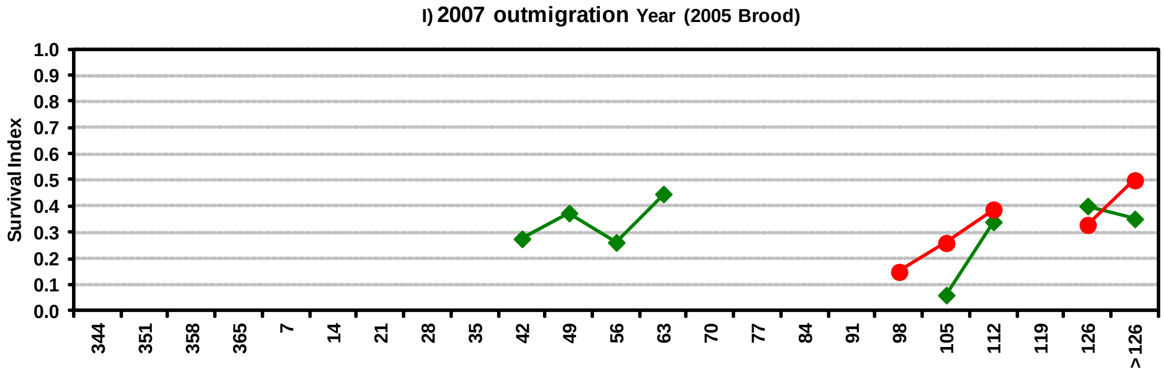


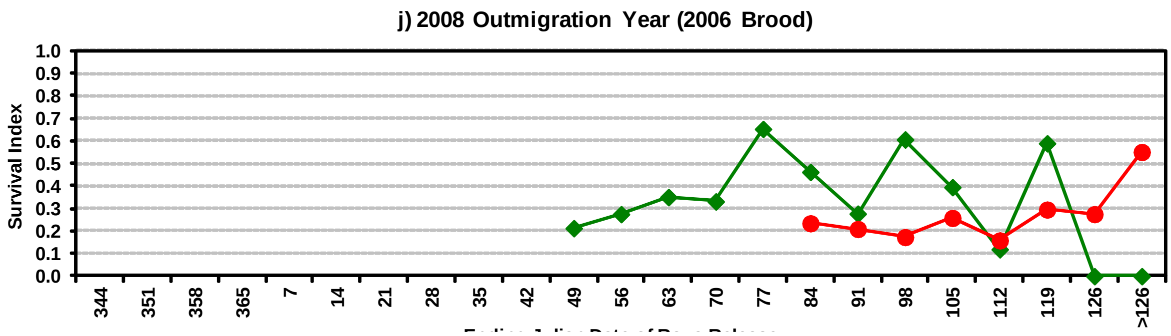



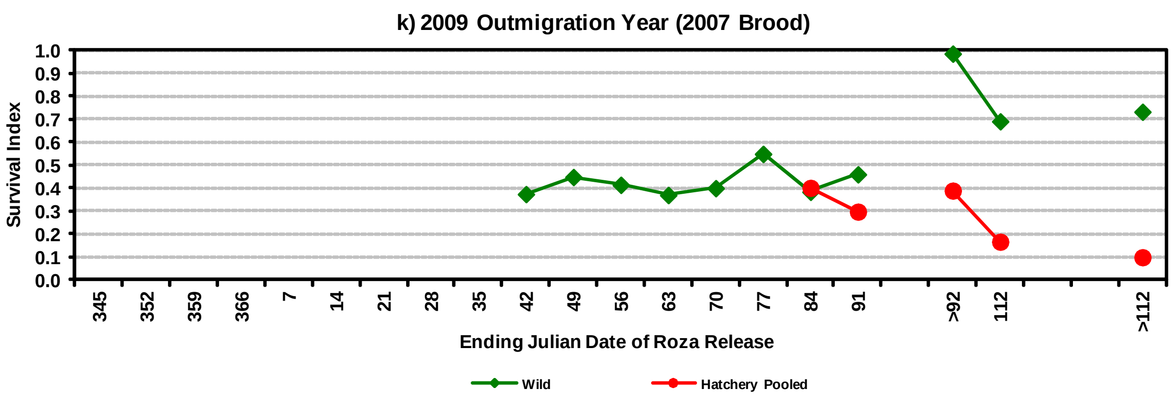



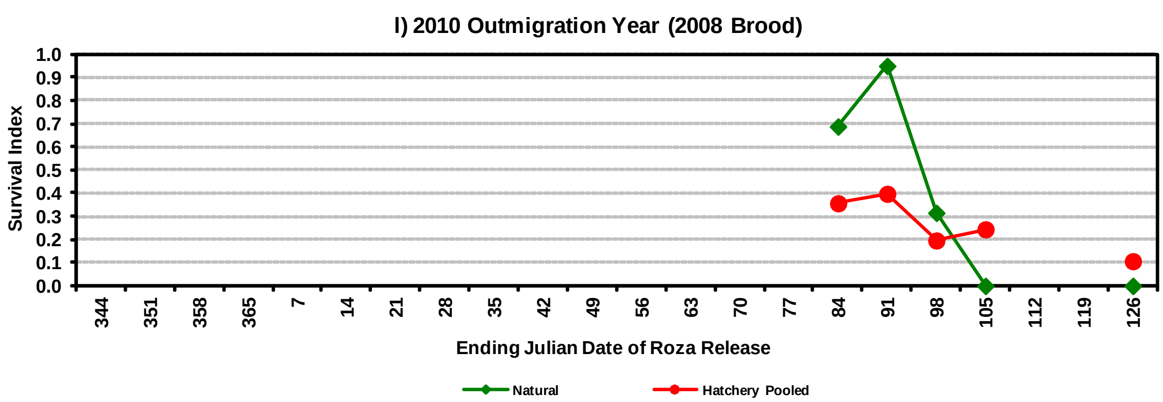



## Appendix B.1. (continued)

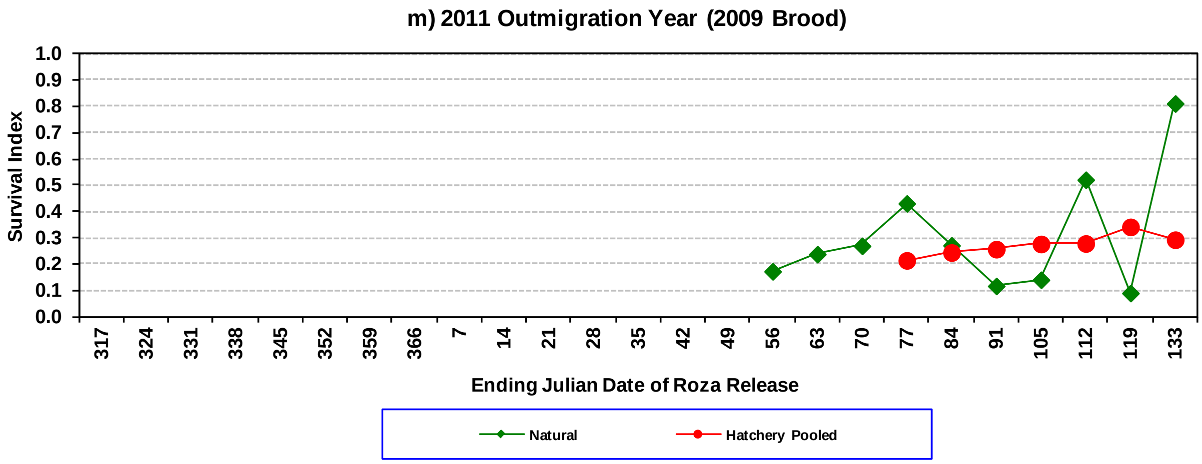


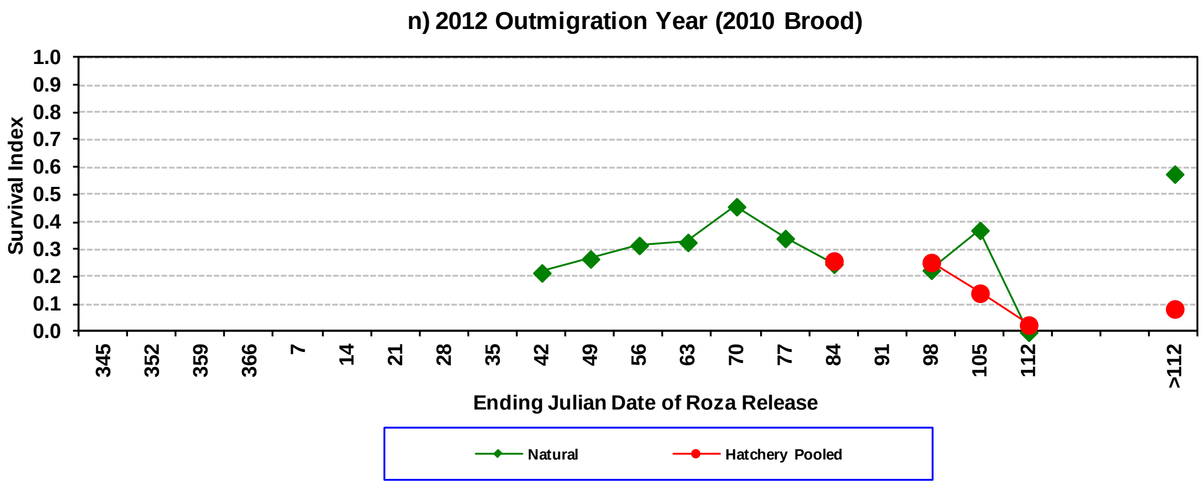



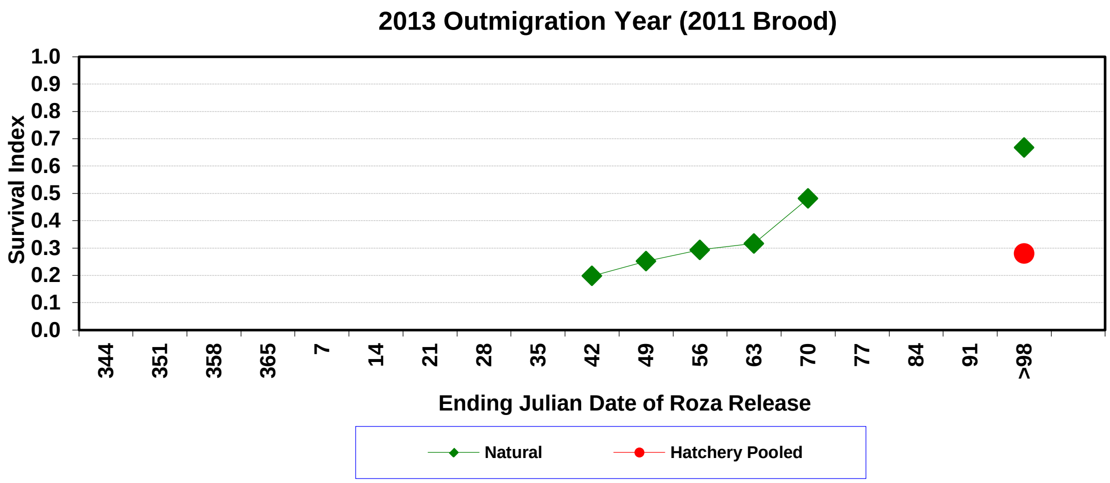



## Appendix B.1. (continued)



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

### 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** |

**n. 2013 Outmigration Year (Brood 2011)**

| | | Before Hatchery Passage | During Hatchery Passage |
|---|---|---|---|
| Beginning Week (ending date of week) | | 02/11/13 | 04/08/13 |
| Ending Week (ending date of week) | | 04/01/13 | |
| **Natural Origin** | Number Released | 2435 | 38 |
| | Expanded McNary Passage Number | 695.1 | 25.4 |
| | **Survival-Index Estimate** | **0.2855** | **0.6683** |
| **Hatchery Pooled** | Number Released | | 550 |
| | Expanded McNary Passage Number | | 154.0 |
| | **Survival-Index Estimate** | | **0.2801** |

## Appendix C.1. Weighted* Logistic Analyses of Variance for Roza-to-McNary Survival of Hatchery** Spawned Smolt Passing Roza Contemporaneously with Late Naturally-Spawned Smolt (<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

[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. (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 | 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. (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 | 0.4845 | |
| 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. (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

[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. (continued)

**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 | | | |

**o) 2013 Outmigration (2011 Brood)**

| Source | Deviance (Dev) | Degrees of Freedom (DF) | Mean Deviance (Dev/DF) | F-Ratio | P | 1-sided Type 1 p4 |
|---|---|---|---|---|---|---|
| Block1 | 23.38 | 1 | 23.38 | 0.79 | 0.5379 | |
| Wild versus All Hatchery[1] | 29.69 | 1 | 29.69 | 1.27 | 0.4621 | |
| Error(1) | 23.38 | 1 | 23.38 | | | |
| Wild versus All Hatchery[2] | 22.84 | 1 | 22.84 | 1.50 | 0.3454 | 0.1727 |
| Error(2)[3] | 30.47 | 2 | 15.24 | | | |

NOTE: In 2013 there too few Tagged for comparision to Untagged Hatchery-Origin Fish

* 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 Pooled over Years of Roza-to-McNary Survival of Contemporaneous Naturally-Spawned (Nat) and Hatchery-Spawned (Hat) Smolt Passing Roza**

**(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 (Nat ≠ Hat) | Type 1 Error P (Nat > Hat) |
|---|---|---|---|---|---|---|
| Nat vs Hat Stock (adjusted for Years) | 318.43 | 1 | 318.43 | 10.21 | 0.0065 | 0.0032 |
| Among Years (adjusted for stock) | 1366.48 | 14 | 97.61 | 3.13 | 0.0205 | |
| Stock x Year Interaction | 436.74 | 14 | 31.20 | | | |

**(Weight = measure of inverse of variation* of estimate)**

| 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) | 5.24 | 1 | 5.24 | 13.95 | 0.0022 | 0.0011 |
| Among Years (adjusted for stock) | 9.83 | 14 | 0.70 | 1.87 | 0.1271 | |
| Stock x Year Interaction | 5.26 | 14 | 0.38 | | | |

$$^{*}\ \text{Weight} = \frac{\text{Expanded Number of Released Fish Detected at McNary for Group}}{\left[\dfrac{\text{Error Mean Deviance for Year (Appendix C.1)}}{\text{Number of Released (for group)}}\right]}$$

## 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 w ith 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)

**n) 2011 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 | 27.63 | 1 | 27.63 | 1.79 | 0.2176 | Late |
| Error | 123.43 | 8 | 15.43 | | | |

**n) 2012 Outmigration (2010 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 | | | |

**o) 2013 Outmigration (2011 Brood Year)**

| Source | Deviance (Dev) | Degrees of Freedom (DF) | Mean Devivance (Dev/DF) | F-Ratio | P | Highest Survival Estimate: |
|---|---|---|---|---|---|---|
| Wild Early versus Late | 23.43 | 1 | 23.43 | 1.41 | 0.2883 | Early |
| Error | 83.05 | 5 | 16.61 | | | |

* Weight is Number Released

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

*** "Late" Outmigrating means migrating contemporaneously w ith 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

**(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 Spaw ned Brood (adjusted for Years) | 169.51 | 1 | 169.51 | 2.5191 | 0.1385 |
| Among Years (adjusted for Brood) | 664.12 | 12 | 55.34 | 0.8225 | 0.6298 |
| Brood x Year Interaction | 807.47 | 12 | 67.29 | | |

**(Weight = measure of inverse of variation* of estimate)**

| Source | Deviance (Dev) | Degrees of Freedom (DF) | Mean Dev (Dev/DF) | F-Ratio | Type 1 Error P |
|---|---|---|---|---|---|
| Early vs Late Natually Spaw ned Brood (adjusted for Years) | 2.66 | 1 | 2.66 | 2.55 | 0.1363 |
| Among Years (adjusted for Brood) | 9.34 | 12 | 0.78 | 0.75 | 0.6901 |
| Brood x Year Interaction | 12.52 | 12 | 1.04 | | |

Note: Weights are (separate yearly numbers of total releases for the stock Mean)/(Mean Deviance)
Year and Stock Tested against Interaction (Denominator Mean Deviance).
Note: In release years 2009 and 2010 there w ere no early Natural releasease

$$* \quad \text{Weight} = \frac{\text{Expanded Number of Released Fish Detected at McNary for Group}}{\left[\dfrac{\text{Error Mean Deviance for Year (Appendix D.1)}}{\text{Number of Released (for group)}}\right]}$$

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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 2013

**Doug Neeley, Consultant to Yakama Nation**

## Introduction

For hatchery releases of Spring Chinook smolt released in 2007 and 2009 through 2013, two feed treatments were allocated to raceways within adjacent raceway pairs. Fish from each raceway within the pairs were fed BioVita feed (Bio-Oregon Inc.) prior to smoltification, then one raceway from each pair was allocated the BioTransfer feed supplement (Bio-Oregon Inc.; designated "Saltwater Transfer Feed" or STF in this document) and the other was not. The intent of the experiment was to determine whether the STF-supplemented treatment increased the rate of smoltification and survival, the unsupplemented treatment serving as the control. The treatment effects on four evaluated juvenile measures were compared and are presented herein:

1) mean and median volitional release (pond outfall detection) date,
2) mean and median McNary Dam (McNary) smolt-passage date,
3) mean proportion of PIT-tagged fish detected leaving the acclimation ponds, and
4) mean smolt-to-smolt survival from volitional release to McNary.

In past reports analyses were performed on summaries of fish weights and other measures from individual fish sampled by NOAA Fisheries. Beginning in 2012 NOAA ceased collecting these data from two of the release sites (Easton and Jack Creek); in 2014 NOAA then ceased collecting the data from the remaining site (Clark Flat). In the future a calibrated fish weight will be used. Hatchery personnel net a sample of fish (typically about 100-200 fish), then the total weight of the sample and the number of fish comprising the sample are assessed.

Previous years' NOAA weight estimates based on raceway means will be regressed on the sample estimates as a calibration measure, and the resulting equation will be applied to sample-based estimates from 2012 onward to obtain estimates more comparable to previous reports.

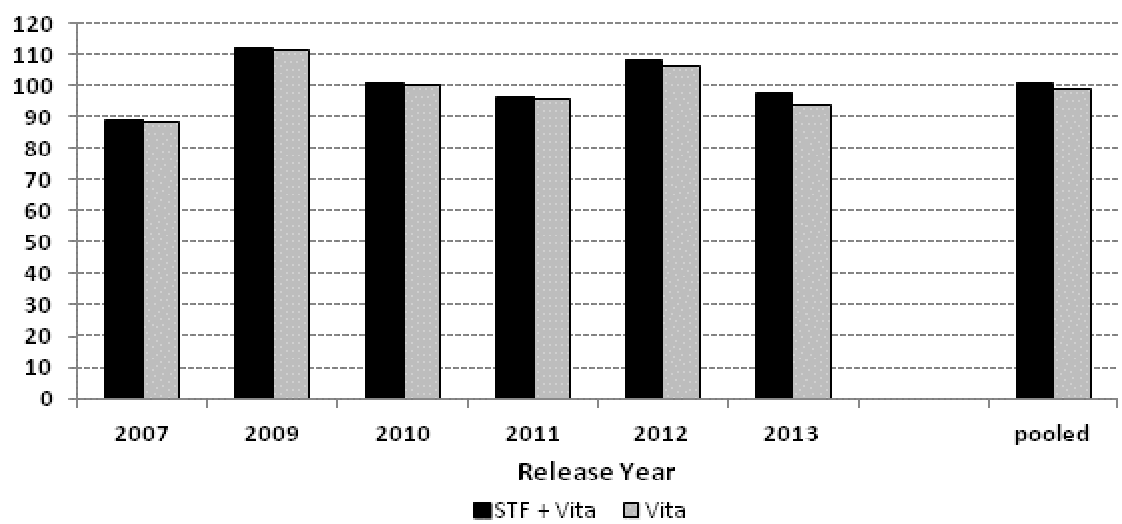
**Volitional Release Date**

The STF effect on mean release date over years was not quite significant at the 5 % level (P = 0.0660, Appendix Table A.1). The mean STF release dates were greater than the Control in all years (Table and Figure 1.a). With the exception of the 2013 release (2011 brood), yearly differences were small. The difference between the pooled means was less than two days.

**Table 1.a.** **Brood-Year 2005, 2007-2011 Mean Julian Release Date for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites Transfer Feed supplement (Vita + STF and Vita = Control)**

| Brood Year<br>Release Year | 2005<br>2007 | 2007<br>2009 | 2008<br>2010 | 2009<br>2011 | 2010<br>2012 | 2011<br>2013 | Over Years |
|---|---|---|---|---|---|---|---|
| STF + Vita Survival<br>Number Released* | 89.0<br>17,426 | 111.9<br>15,589 | 100.9<br>15,579 | 96.3<br>13,941 | 108.0<br>15,474 | 97.6<br>15,355 | 100.4<br>93,364 |
| Vita Survival<br>Number Released* | 88.0<br>17,370 | 111.3<br>15,633 | 100.0<br>15,577 | 95.8<br>14,459 | 106.4<br>15,518 | 93.6<br>15,432 | 99.0<br>93,989 |
| Difference | 1.0 | 0.6 | 0.9 | 0.5 | 1.6 | 4.0 | 1.4 |
| | | | | Estimated Type 1 Error Probabitiy | | | 0.0660 |

**Figure 1.a** **Brood-Year 2005, 2007-2011 Mean Julian Release Date for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites Transfer Feed supplement (Vita + STF and Vita = Control)**

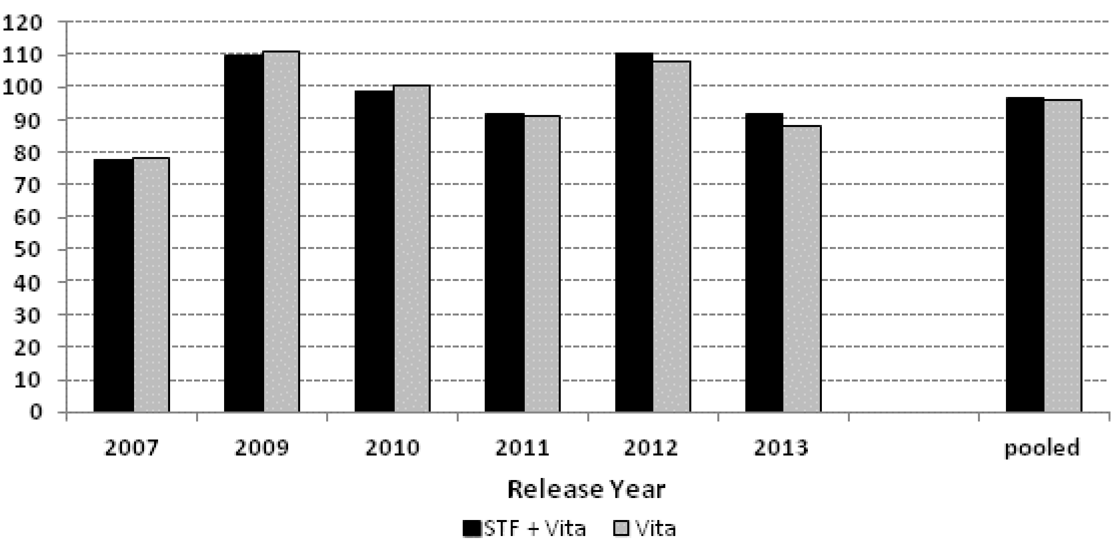


While the differences in means were consistent, the differences in medians were not (Table and Figure 1.b). The Control treatment had later median release dates from 2007 through 2010, but the STF supplement had the later median release dates from 2011 through 2013. With the exception of release year 2011, the STF – Control median difference in release dates was consistently increasing with time[1], although not in a consistent direction over the six years.

**Table 1.b.** **Brood-Year 2005, 2007-2011 Median Julian Release Date for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites Transfer Feed supplement (Vita + STF and Vita = Control)**

| Brood Year > | 2005 | 2007 | 2008 | 2009 | 2010 | 2011 | Medians |
|---|---|---|---|---|---|---|---|
| Release year > | 2007 | 2009 | 2010 | 2011 | 2012 | 2013 | pooled |
| Measure | | | | | | | over Years |
| STF + Vita | 77.5 | 109.4 | 98.9 | 91.6 | 110.2 | 92.0 | 96.3 |
| Vita | 78.5 | 110.8 | 100.6 | 91.0 | 108.0 | 88.2 | 95.9 |
| Difference (STF-Vita) | -1.0 | -1.4 | -1.8 | 0.5 | 2.1 | 3.8 | 0.4 |

**Figure 1.b** **Brood-Year 2005, 2007-2011 Median Julian Release Date for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites Transfer Feed supplement (Vita + STF and Vita = Control)**




The pooled median release date is 3.6 days earlier than the mean. Usually a large proportion of smolt volitionally leave the ponds within a very few days of the screens being pulled, tending to skew the distribution of releases to the right, which explains the pooled average of the mean dates of release being later than that of the medians.

[1] Pearson's correlation coefficient estimate = 0.826, estimated Type 1 Error probability = 0.0426 (2-sided test), weight = mean number of detected releases over treatments within years.

The pooled median release date is 3.6 days earlier than the mean. Usually a large proportion of smolt volitionally leave the ponds within a very few days of the screens being pulled, tending to skew the distribution of release day to the right, which explains the pooled average of the mean dates of release being later than that of the medians.

### McNary Dam Passage Date

There was a neither a significant nor substantial difference between the passage-date means of STF-supplemented and STF-unsupplemented treatments (P = 0.1806, Appendix Table A.2). The individual treatments' mean and median estimates for each year were nearly equal (Compare entries in Table 2.a and Table 2.b and in Figures 2.a. and 2.b.).

**Table 2.a.** **Brood-Year 2005, 2007-2011 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 + STF and Vita = Control)**

| Brood Year<br>Release Year | 2005<br>2007 | 2007<br>2009 | 2008<br>2010 | 2009<br>2011 | 2010<br>2012 | 2011<br>2013 | Over Years |
|---|---|---|---|---|---|---|---|
| STF + Vita Survival<br>McNary Passage | 126.4<br>5,474 | 134.8<br>6,290 | 132.5<br>5,053 | 134.8<br>4,121 | 134.7<br>6,058 | 125.0<br>5,305 | 131.4<br>32,302 |
| Vita Survival<br>McNary Passage | 126.4<br>5,465 | 134.8<br>6,218 | 132.0<br>4,659 | 134.2<br>4,480 | 134.6<br>6,021 | 123.7<br>5,279 | 131.0<br>32,121 |
| Difference | -0.1 | 0.0 | 0.4 | 0.6 | 0.1 | 1.3 | 0.3 |
| | | | | Estimated Type 1 Error Probabitiy | | | 0.1806 |

**Table 2.b.** **Brood-Year 2005, 2007-2011 Median 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 + STF and Vita = Control)**

| Brood Year ><br>Release year ><br>Measure | 2005<br>2007 | 2007<br>2009 | 2008<br>2010 | 2009<br>2011 | 2010<br>2012 | 2011<br>2013 | Medians pooled over Years |
|---|---|---|---|---|---|---|---|
| McN Release Date | 124.5 | 135.2 | 133.1 | 134.7 | 135.7 | 123.9 | 131.2 |
| McN Release Date | 124.5 | 135.3 | 132.7 | 133.4 | 135.7 | 122.8 | 130.7 |
| Difference (STF-Vita) | 0.0 | -0.1 | 0.4 | 1.4 | 0.1 | 1.1 | 0.5 |

**Figure 2.a.** **Brood-Year 2005, 2007-2011 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 + STF and Vita = Control)**

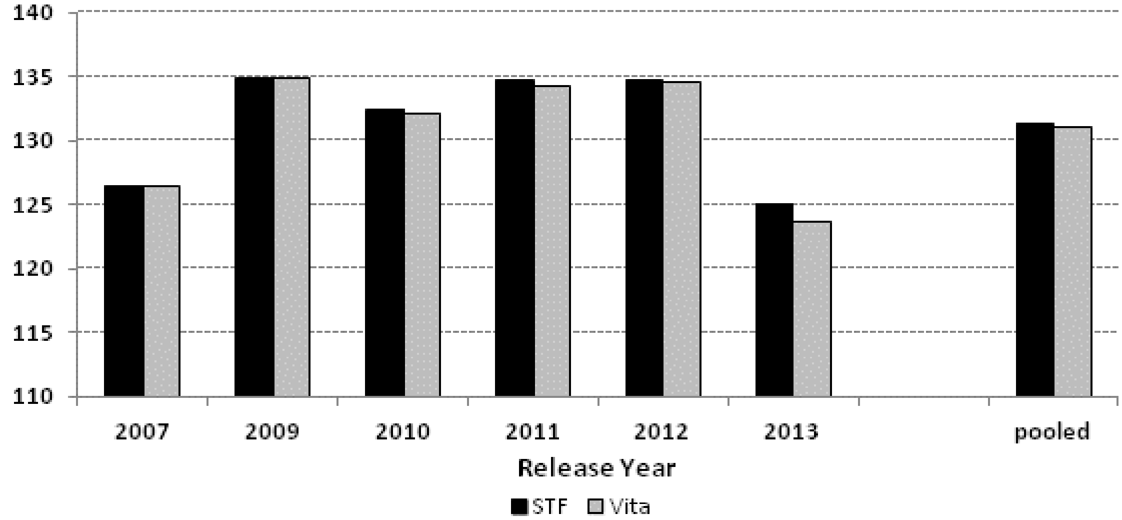
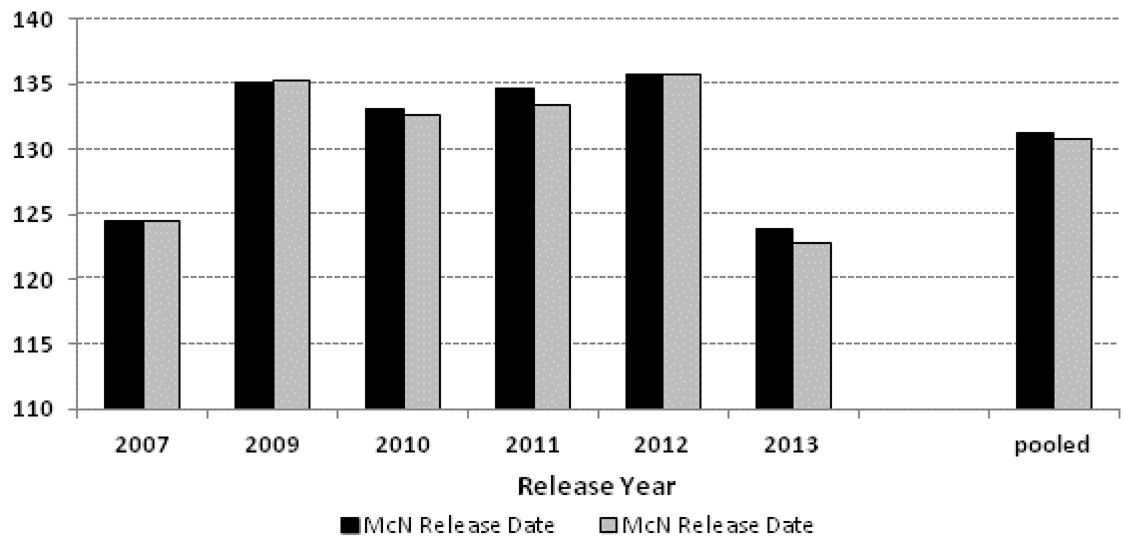



**Figure 2.b.** **Brood-Year 2005, 2007-2011 Median Julian Date of McNary Passage for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and With Saltwater Transfer Feed supplement (Vita + STF and Vita = Control)**



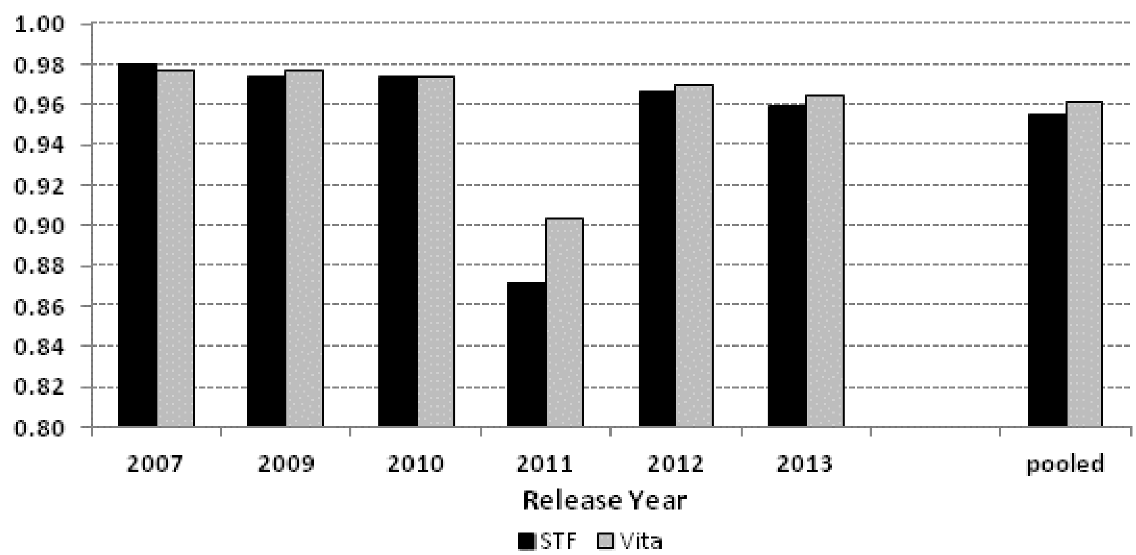
## Proportion of PIT-tagged Fish Detected Leaving Acclimation Ponds

The difference in the pooled proportions over years of STF-supplemented and unsupplemented treatments was small and not significant (P = 0.1708, Appendix Table A.3). The large difference in release year 2011[2], when the detected proportions were relatively low, contributed to a significant interaction of treatment differences with years (P = 0.0090, Appendix Table A.3).

**Table 3.** **Brood-Year 2005, 2007-2011 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 + STF and Vita = Control)**

| Brood Year<br>Release Year | 2005<br>2007 | 2007<br>2009 | 2008<br>2010 | 2009<br>2011 | 2010<br>2012 | 2011<br>2013 | Pooled<br>Mean |
|---|---|---|---|---|---|---|---|
| STF + Vita Survival | 98.0% | 97.4% | 97.4% | 87.1% | 96.7% | 96.0% | 95.5% |
| Number Tagged | 17,776 | 16,001 | 16,000 | 16,000 | 16,000 | 16,000 | 97,777 |
| Vita Survival | 97.7% | 97.6% | 97.4% | 90.4% | 97.0% | 96.5% | 96.1% |
| Number Tagged | 17,785 | 16,010 | 16,000 | 16,001 | 16,003 | 15,999 | 97,798 |
| Difference | 0.4% | -0.2% | 0.0% | -3.2% | -0.3% | -0.5% | -0.6% |
| | | | | Estimated Type 1 Error Probabitiy | | | 0.1708 |

**Figure 3.** **Brood Year 2007, 2009-2011 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 + STF and Vita = Control)**




[2] In spite of this large difference in 2011 relative to the differences in other years, the treatment differences interaction with years was not significant (P=0.9759).

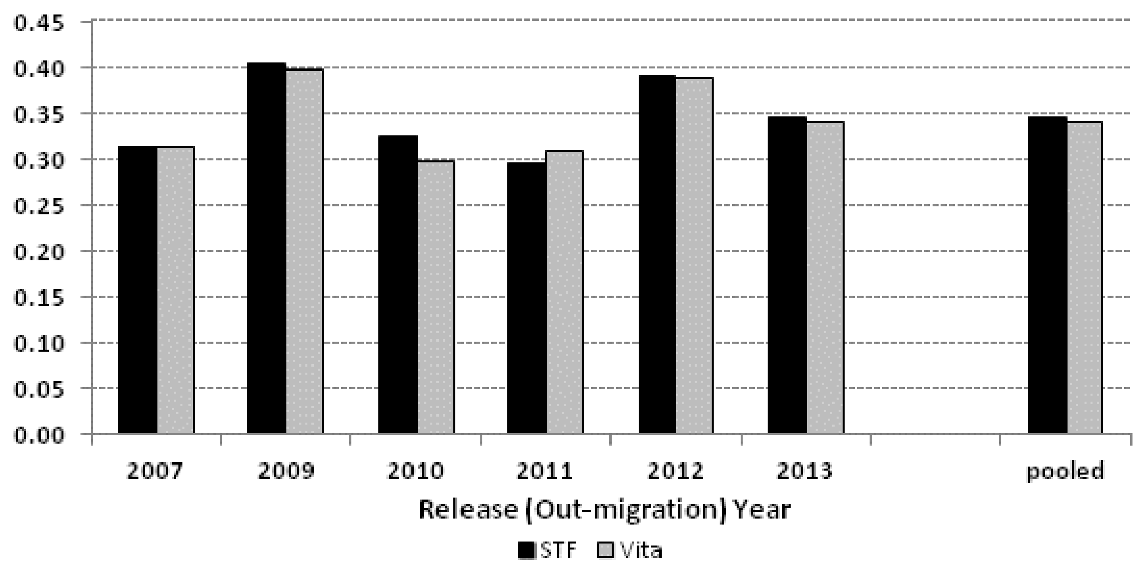
## Smolt-to-Smolt Survival to McNary Dam

Referring to Table and Figure 4, there was neither a substantial nor significant difference in the smolt-to-smolt survival means of STF-supplemented and STF-unsupplemented treatments over years (P = 0.5614, Appendix Table A.4).

**Table 4.** **Brood-Year 2005, 2007-2011 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 > / Measure | 2005 / 2007 | 2007 / 2009 | 2008 / 2010 | 2009 / 2011 | 2010 / 2012 | 2011 / 2013 | Proportions pooled over Years |
|---|---|---|---|---|---|---|---|
| STF | **0.3141** | **0.4035** | **0.3243** | **0.2956** | **0.3915** | **0.3455** | **0.3460** |
| | 17426 | 15589 | 15579 | 13941 | 15474 | 15355 | 93364 |
| Vita | **0.3146** | **0.3977** | **0.2991** | **0.3098** | **0.3880** | **0.3421** | **0.3418** |
| | 17370 | 15633 | 15577 | 14459 | 15518 | 15432 | 93989 |
| Difference (STF-Vita) | **-0.0005** | **0.0058** | **0.0253** | **-0.0142** | **0.0035** | **0.0034** | **0.0042** |
| Type 1 Error | 0.9682 | 0.6760 | 0.0588 | 0.3000 | 0.7991 | 0.8025 | 0.5614 |

**Figure 4.** **Brood-Year 2005, 2007-2011 Median 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)**



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

**Table A.1. Weighted Least Squares Analysis of Variance of Julian Volitional-Release Date for Spring Chinook Smolt receiving and not receiving STF-supplement**

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

| Source | Sums of Squares (SS) | Degrees of Freedom (DF) | Mean Square | F-Ratio | Estimated Type 1 Error (p) | Denominator Mean Square Source for F-Ratio |
|---|---|---|---|---|---|---|
| Year (adjusted for Site) | 11,463,252 | 5 | 2,292,650 | 50.94 | **0.0000** | Among Raceways |
| Site (adjusted for Year) | 88,826 | 2 | 44,413 | 0.24 | 0.7926 | Site x Year |
| Site x Year | 1,866,518 | 10 | 186,652 | 4.15 | **0.0012** | Among Raceways |
| Among Raceways | 1,350,160 | 30 | 45,005 | 1.57 | 0.1111 | Error |
| Treatment | 89,514 | 1 | 89,514 | 3.55 | 0.0660 | Pooled* Error |
| Treatment x Year | 67,534 | 5 | 13,507 | 0.47 | 0.7946 | Error |
| Treatment x Site | 6,127 | 2 | 3,064 | 0.15 | 0.8645 | Treatment x Year x Site |
| Treatment x Year x Site | 207,377 | 10 | 20,738 | 0.72 | 0.6963 | Error |
| Error | 859,727 | 30 | 28,658 | | | |
| Pooled* Error | 1,134,638 | 45 | 25,214 | | | |

* Pooled over Error, Treatment x Year, and Treatment x Year x Site because of small F and large P Values

**Table A.2. Weighted Least Squares Analysis of Variance of Expanded Mean Julian McNary-Dam Passage Date for Spring Chinook Smolt receiving and not receiving STF-supplement**

**(Weight = Expanded number of smolt passing McNary Dam)**

| Source | Sums of Squares (SS) | Degrees of Freedom (DF) | Mean Square | F-Ratio | Estimated Type 1 Error (p) | Denominator Mean Square Source for F-Ratio |
|---|---|---|---|---|---|---|
| Year (adjusted for Site) | 1,151,385 | 5 | 230,277 | 85.46 | **0.0000** | Among Raceways |
| Site (adjusted for Year) | 128,502 | 2 | 64,251 | 3.57 | 0.0675 | Site x Year |
| Site x Year | 179,843 | 10 | 17,984 | 6.67 | **0.0000** | Among Raceways |
| Among Raceways | 80,840 | 30 | 2,695 | 2.03 | **0.0283** | Error |
| Treatment | 2,351 | 1 | 2,351 | 1.87 | 0.1806 | Pooled* Error |
| Treatment x Year | 4,294 | 5 | 859 | 0.65 | 0.6653 | Error |
| Treatment x Site | 21,996 | 2 | 10,998 | 4.29 | **0.0451** | Treatment x Year x Site |
| Treatment x Year x Site | 25,614 | 10 | 2,561 | 1.93 | 0.0799 | Error |
| Error | 39,779 | 30 | 1,326 | | | |
| Pooled* Error | 44,073 | 35 | 1,259 | | | |

* Pooled over Error and Treatment x Year because of small F and large P Values

**Table A.3. Weighted* Logistic Analysis of Variation of Proportion of PIT-Tagged Fish detected leaving Acclimation Ponds for Spring Chinook receiving and not receiving STF Supplement Appendix.**

**(Weight = Number of fish tagged)**

| Source | Deviance (Dev) | Degrees of Freedom (DF) | Mean Dev = Dev/DF | F-Ratio | Estimated Type 1 Error (p) | Denominator Mean Deviance Source for F-Ratio |
|---|---|---|---|---|---|---|
| Year (adjusted for Site) | 3843.83 | 5 | 768.77 | 22.23 | **0.0000** | Among Raceways |
| Site (adjusted for Year) | 1169.77 | 2 | 584.89 | 1.92 | 0.1967 | Site x Year |
| Site x Year | 3043.23 | 10 | 304.32 | 8.80 | **0.0000** | Among Raceways |
| Among Raceways | 1037.64 | 30 | 34.59 | 1.14 | 0.3576 | Error |
| Treatment | 51.12 | 1 | 51.12 | 1.91 | 0.1708 | Pooled* Error |
| Treatment x Year | 23.88 | 5 | 4.78 | 0.16 | 0.9759 | Error |
| Treatment x Site | 57.08 | 2 | 28.54 | 7.82 | **0.0090** | Treatment x Year x Site |
| Treatment x Year x Site | 36.49 | 10 | 3.65 | 0.12 | 0.9994 | Error |
| Error | 907.15 | 30 | 30.24 | | | |
| Pooled* Error | 2005.16 | 75 | 26.74 | | | |

*Pooled over Error, Among Raceways, Treatment x Year, and Tretament x Year x Site because of small F and large P Values

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

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

| Source* | Deviance (Dev) | Degrees of Freedom (DF) | Mean Dev (Dev/DF) | F-Ratio | P(F) | Denominator Mean Deviance Source |
|---|---|---|---|---|---|---|
| Year | 1242.08 | 5 | 248.416 | 15.98 | 0.0000 | Among Raceway Pairs |
| Site | 543.24 | 2 | 271.620 | 13.86 | 0.0013 | Year x Site |
| Year x Site | 196.03 | 10 | 19.603 | 1.26 | 0.2951 | Among Raceway Pairs |
| Among Raceway Pairs | 466.22 | 30 | 15.541 | 2.81 | 0.0030 | Error |
| Treatment | 2.57 | 1 | 2.570 | 0.39 | 0.5614 | Treatment x Year |
| Treatment x Year | 33.24 | 5 | 6.648 | 0.83 | 0.5581 | Treatment x Year x Site |
| Treatment x Site | 10.19 | 2 | 5.095 | 0.63 | 0.5505 | Treatment x Year x Site |
| Treatment x Year x Site | 80.35 | 10 | 8.035 | 1.45 | 0.2066 | Error |
| Error | 166.12 | 30 | 5.537 | | | |

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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 2002-2011 Upper Yakima Spring Chinook

**Doug Neeley, Consultant to the Yakama Nation**

## Summary

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

For brood-years 2002 through 2011 (release-years 2004 through 2013, respectively), the following juvenile traits are analyzed:

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

Of these traits, the only HxH-NxN main effect difference that was significant at the 5% significance level was that for the proportion of fish detected leaving the pond, with the HxH cross having the lower proportion, and presumably having the lower pre-release survival. However, there was a significant interaction of the treatment effects with years.

It is noted that, for mean acclimation-pond volitional-release date (a variable that may be associated with proportion detected leaving the pond), the HxH-NxN main effect difference was

[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.

significant at the 10% level with the HxH stock weighted mean date over years being slightly earlier than that of the NxN stock.

## Design of Experiment

The HxH assignment was superimposed at only the Clark Flat Acclimation Site at which there were three pairs of raceways[2] with feed treatments[3] allocated to the different raceways within each pair. The HxH Stock was allocated to one of the three pairs of raceways, and the NxN Stock to the other two pairs[4]. Thus there were twice as many raceways at Clark Flat assigned to the NxN Stock than to the HxH Stock. The design was effectively a Split-Plot design at both the hatchery at Cle Elum and at the acclimation site, Clark Flat, with the Stock assigned to the raceway pairs (main-plot), and the feed levels assigned to raceways within raceway pairs (subplot).

A proportion of fish in each raceway was PIT-tagged for the primary purpose of estimating smolt-to-smolt survival from volitional release to McNary Dam on the Columbia River 70 km below the Yakima River. Beginning with the 2006 brood, there were twice as many HxH fish PIT-tagged per raceway than there were NxN fish to give approximately an equal total number of PIT-tagged fish for both the HxH and NxN stocks at Clark Flat. For the purpose of assessing Male Proportions, Mini-Jack Proportions, and morphological characteristics, beginning with the 2004 brood, twice as many fish were sampled from HxH raceways than from NxN raceways prior to their release in 2006. Because of budgetary constraints, 2013 was the last year of this pre-release sampling.

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

---

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

[3] In every year, two treatments were evaluated. In BY 2002- BY 2004, they were Low and High Nutrition levels (LO and HI), the High level being the standard feed or control. The Low Nutrition was tested to determine whether it would reduce the proportion of male smolt that were sexually mature (mini-jacks). In BY 2005 and 2007 through 2011, the standard feed (Vita) was either supplemented or not supplemented with Salt-water Transfer Feed (STF) to test whether supplementation with STF increased the rate of smoltification. In BY 2006, two feeds (Vita and EWOS) were evaluated.

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

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

within-years (main-plot error). In the case of the test for main-effect differences in the proportion of males and in the acclimation-pond volitional-release date, the HxH-NxN main-effect differences were tested against a pooled main-plot error which was the combined raceway-pair and Year x Stock interaction sources for reasons explained in their associated analysis of variation tables in Appendix A.

In all table presentations, weighted means over years are not the simple averages of the yearly means, rather they are the means over all fish assessed over all years (yearly means weighted by the number of fish used to estimate those means). This is consistent with the weighted analyses of variation used. In the main text tables, the individual year stock means and mean differences are presented along with the weighted main effect means and their difference.

## Errors discovered in previous Reports

There were some errors in figure and table presentations in the 2012 Annual Report and earlier reports. The BY 2006 estimates were incorrectly listed as BY 2005 estimates and *vice versa* for all estimates in the 2012 report. In 2006, 2007, and 2011, there were tally allocation errors of pre-released fish as to their gender or as to their precocial status, and these errors were reflected in those year's and subsequent annual reports. These have been corrected in this report. Gender and precocial proportion estimates that were changed from previous reports have estimates lightly shaded in tables.

Another error was that standard errors for comparing proportions within years were incorrectly computed in previous annual reports; they were correctly computed for the weighted proportions used to comparing the main HxH and NxN proportions over years.

## Mean Pre-Release Smolt Weight

Figure 1 and Table 1 present the individual release-year HxH and NxN stock pre-release fish-weight means. There was no significant main-effect difference between stock (P =0.7435 Appendix Table A.1), nor did the yearly HxH-NxN differences significantly interact with years (P= 0.2951, Appendix Table A.1).

**Figure 1.** **Mean Pre-Release Weight (grams/fish) of Natural x Natural and Hatchery x Hatchery Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2011)**

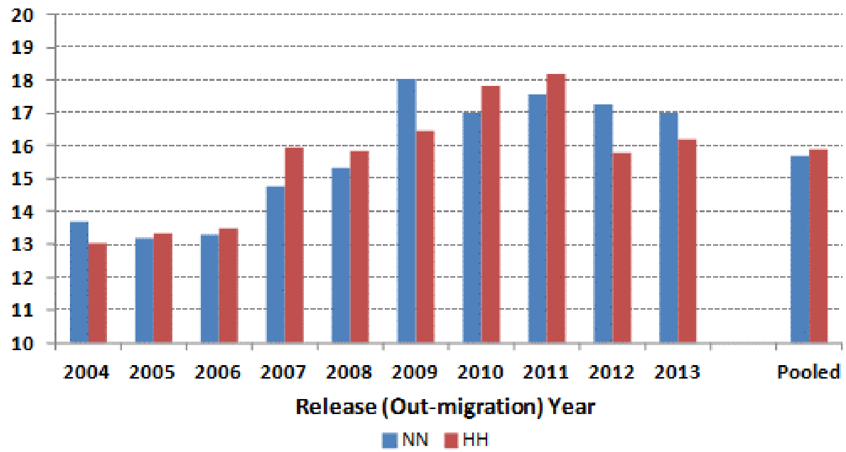



**Table 1.** **Mean Pre-Release Weight (grams/fish) of Natural x Natural and Hatchery x Hatchery Upper-Yakima Spring Chinook Smolt[6]**

| | Brood Year > | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| | Release year > | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| Cross | Measure | Low vs. High | | | STF + VITA vs VITA | EWOS vs. Vita | STF + VITA vs VITA |
| HxH (HC) | Weight | **13.0** | **13.3** | **13.5** | **16.0** | **15.8** | **16.4** |
| | n(sampled) | 120 | 120 | 240 | 240 | 240 | 240 |
| NxN (SH) | Mean | **13.7** | **13.2** | **13.3** | **14.8** | **15.3** | **18.1** |
| | n(sampled) | 240 | 240 | 240 | 240 | 240 | 240 |
| Difference (HxH - NxN) | | -0.7 | 0.2 | 0.2 | 1.2 | 0.5 | -1.6 |
| Type 1 Error | | 0.5234 | 0.8820 | 0.8488 | 0.1806 | 0.5241 | 0.0782 |

| | Brood Year > | 2008 | 2009 | 2010 | 2011 | Means pooled over Years |
|---|---|---|---|---|---|---|
| | Release year > | 2010 | 2011 | 2012 | 2013 | |
| Cross | Measure | STF + VITA vs VITA | | | | |
| HxH (HC) | Weight | **17.8** | **18.2** | **15.8** | **16.2** | **15.9** |
| | n(sampled) | 240 | 240 | 240 | 240 | 2160 |
| NxN (SH) | Mean | **17.0** | **17.6** | **17.3** | **17.0** | **15.7** |
| | n(sampled) | 240 | 240 | 240 | 240 | 2400 |
| Difference (HxH - NxN) | | **0.8** | **0.6** | **-1.5** | **-0.9** | **0.2** |
| Type 1 Error | | 0.3384 | 0.4801 | 0.0937 | 0.3165 | 0.7435 |

6 Appendix Table A.1 presents the associated analysis of variance with the significance levels.

## Mean Pre-Release Smolt Length

Figure 2 and Table 2 present the individual release-year HxH and NxN stock pre-release fish-lengths. There was no significant main-effect difference between stock (P =0.8222 Appendix Table A.2), nor did the yearly HxH-NxN differences significantly interact with years (P= 0.6310 Appendix Table A.2).

**Figure 2.** **Mean <u>Pre-Release Length</u> (millimeters/fish) of Natural x Natural and Hatchery x Hatchery Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2011)**

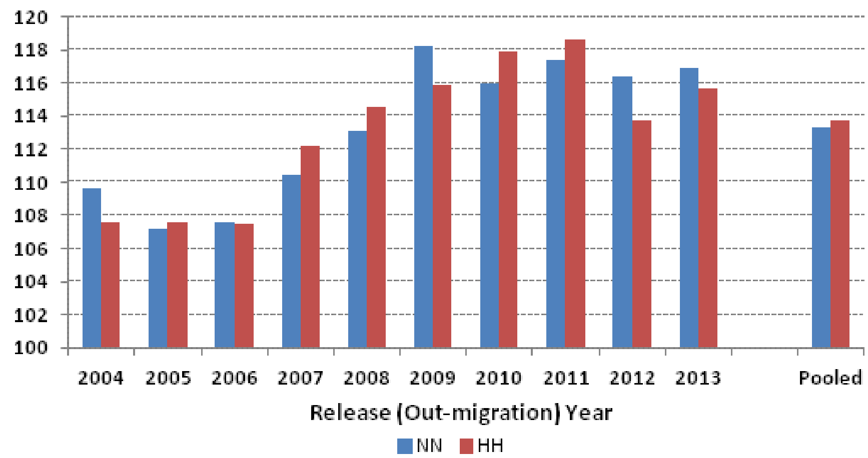



**Table 2.** **Mean <u>Pre-Release Length</u> (millimeters/fish) of Natural x Natural and Hatchery x Hatchery Upper-Yakima Spring Chinook Smolt[7]**

| | Brood Year > | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| | Release year > | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| Cross | Measure | Low vs. High | | | STF + VITA vs VITA | EWOS vs. Vita | STF + VITA vs VITA |
| HxH (HC) | Length | 107.6 | 107.6 | 107.5 | 112.2 | 114.5 | 115.8 |
| | n(sampled) | 240 | 240 | 240 | 240 | 240 | 240 |
| NxN (SH) | Length | 109.6 | 107.2 | 107.6 | 110.5 | 113.1 | 118.2 |
| | n(sampled) | 120 | 120 | 240 | 240 | 240 | 240 |
| Difference (HxH - NxN) | | -2.0 | 0.4 | -0.2 | 1.7 | 1.4 | -2.3 |
| Type 1 Error | | 0.4175 | 0.8810 | 0.9371 | 0.3919 | 0.4844 | 0.2602 |

| | Brood Year > | 2008 | 2009 | 2010 | 2011 | Means pooled over Years |
|---|---|---|---|---|---|---|
| | Release year > | 2010 | 2011 | 2012 | 2013 | |
| Cross | Measure | STF + VITA vs VITA | | | | |
| HxH (HC) | Length | 117.9 | 118.6 | 113.7 | 115.7 | 113.7 |
| | n(sampled) | 240 | 240 | 240 | 240 | 2400 |
| NxN (SH) | Length | 116.0 | 117.4 | 116.4 | 116.9 | 113.3 |
| | n(sampled) | 240 | 240 | 240 | 240 | 2160 |
| Difference (HxH - NxN) | | 1.9 | 1.2 | -2.7 | -1.2 | 0.4 |
| Type 1 Error | | 0.3491 | 0.5442 | 0.1953 | 0.5416 | 0.8222 |

[7] Appendix A.2 presents the associated analysis of variance with significance levels.

### Pre-Release Male Proportion

The pre-release male proportions are presented in Figure 3 and Table 3 for HxH and NxN stock. There were neither significant main-effect nor an HxH-NxN difference interaction with Years (respectively p = 1.000 and p = 0.6111, Appendix Table A.3).

**Figure 3. Male Proportion of Pre-Release Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt**

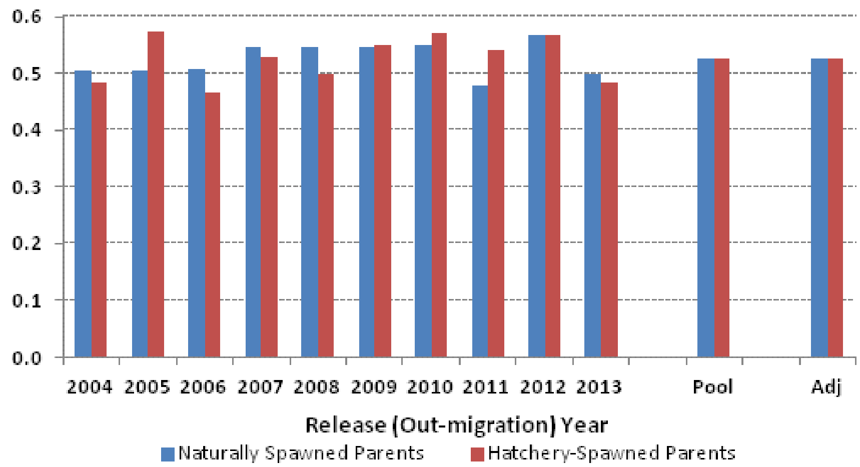



**Table 3. Male Proportion of Pre-Release Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt[8]**

| | Brood Year > | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| | Release year > | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| Cross | Measure | Low vs. High | | | STF + VITA vs VITA | EWOS vs. Vita | STF + VITA vs VITA |
| HxH (HC) | p(males) | 0.483 | 0.575 | 0.467 | 0.529 | 0.500 | 0.550 |
| | n (tested) | 120 | 120 | 240 | 240 | 240 | 240 |
| NxN (SH) | p(males) | 0.504 | 0.504 | 0.508 | 0.546 | 0.546 | 0.546 |
| | n (tested) | 240 | 240 | 240 | 240 | 240 | 240 |
| Difference (HxH - NxN) | | -0.021 | 0.071 | -0.042 | -0.017 | -0.046 | 0.004 |
| Type 1 Error | | 0.6767 | 0.1608 | 0.3096 | 0.6820 | 0.2641 | 0.9182 |

| | Brood Year > | 2008 | 2009 | 2010 | 2011 | Means pooled over Years |
|---|---|---|---|---|---|---|
| | Release year > | 2010 | 2011 | 2012 | 2013 | |
| Cross | Measure | STF + VITA vs VITA | | | | |
| HxH (HC) | p(males) | 0.571 | 0.540 | 0.567 | 0.485 | 0.526 |
| | n (tested) | 240 | 239 | 240 | 239 | 2158 |
| NxN (SH) | p(males) | 0.550 | 0.479 | 0.567 | 0.500 | 0.525 |
| | n (tested) | 240 | 240 | 240 | 240 | 2400 |
| Difference (HxH - NxN) | | 0.021 | 0.061 | 0.000 | -0.015 | 0.001 |
| Type 1 Error | | 0.6071 | 0.1430 | 1.0000 | 0.7198 | 1.0000 |

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

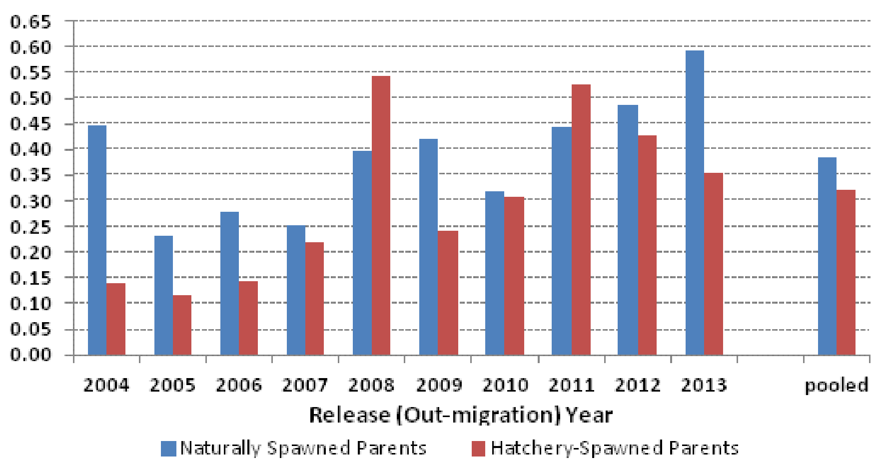
The mean male proportion over all fish is 0.526. While this proportion is not substantially greater than 0.5, its difference from 0.5 is highly significant (p = 0.0005). Note that only four of the twenty[9] total Year x Cross entries in the Table 3 have estimates less than 0.5. No pre-release individual juvenile sampling has been conducted in 2014 nor are any planned in the subsequent years.

### Pre-Release Precocial Proportion of Males

Figure 4 and Table 4 present the individual release-year HxH and NxN stock precocial proportions of pre-release males. While the NxN- HxH Mini-Jack proportion main-effect mean difference over years was not significant at the 5% level (P = 0.1207, Appendix Table A.4), the HxH-NxN difference interaction with years was significant (P = 0.0221, Appendix Table A.4). We note that in eight of the ten years, the precocial proportion of the HxH stock was less than that of the NxN stock and that, of those eight years, four of the HxH and NxN comparisons were significant at the 5% significance level. The possibility that HxH crosses tend to have a lower precocial proportion of males than NxN crosses should not be discounted.

No pre-release individual juvenile sampling has been conducted in 2014 nor are any planned in the future.

**Figure 4. <u>Precocial Proportion</u> of Male Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt**




[9] Chance of this occurring by chance is p = 0.0118.

**Table 4. Precocial Proportion of Male Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt[10]**

| | Brood Year > | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| | Release Year > | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| Cross | Measure | Low vs. High | | | STF + VITA vs VITA | EWOS vs. Vita | STF + VITA vs VITA |
| HxH (HC) | p(Precocial) | 0.138 | 0.116 | 0.143 | 0.220 | 0.542 | 0.242 |
| | n (males) | 58 | 69 | 112 | 127 | 120 | 132 |
| NxN (SH) | p(Precocial) | 0.446 | 0.231 | 0.279 | 0.252 | 0.397 | 0.420 |
| | n (males) | 121 | 121 | 122 | 131 | 131 | 131 |
| Difference (HxH - NxN) | | **-0.308** | -0.115 | **-0.136** | -0.031 | 0.145 | **-0.177** |
| Type 1 Error | | **0.0070** | 0.1211 | **0.0522** | 0.6113 | 0.0708 | **0.0232** |

| | Brood Year > | 2008 | 2009 | 2010 | 2011 | Means pooled over Years |
|---|---|---|---|---|---|---|
| | Release Year > | 2010 | 2011 | 2012 | 2013 | |
| Cross | Measure | STF + VITA vs VITA | | | | |
| HxH (HC) | p(Precocial) | 0.307 | 0.527 | 0.426 | 0.353 | 0.322 |
| | n (males) | 137 | 129 | 136 | 116 | 1136 |
| NxN (SH) | p(Precocial) | 0.318 | 0.443 | 0.485 | 0.592 | 0.386 |
| | n (males) | 132 | 115 | 136 | 120 | 1260 |
| Difference (HxH - NxN) | | -0.012 | 0.084 | -0.059 | **-0.238** | -0.064 |
| Type 1 Error | | 0.8596 | 0.2763 | 0.4097 | **0.0094** | 0.1207 |

## Volitional Release Dates

The mean and median dates of detections of smolt leaving acclimation ponds are given in Figures 5.a and 5.b and are presented in Table 5. Based on means, neither the HxH – NxN Main-Effect-effect nor the HxH – NxN interaction with year were significant (P = 0.0603 and P = 0.6546, respectively; Appendix Table A.5). The less powerful sign test for differences in medians was also not significant (P = .3428). Given that the test for the HxH–NxN main-effect was a two-sided test, a one-sided test for an earlier HxH main effect mean would have been significant at the 5% level, the possibility of a tendency for HxH smolt to leave the acclimation ponds early should not be discounted. However, there were seven of the ten years in which the NxN cross volitional release date exceeded that of the HxH cross.

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

**Figure 5.a.** **<u>Mean Dates of Volitional Release</u> of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection**

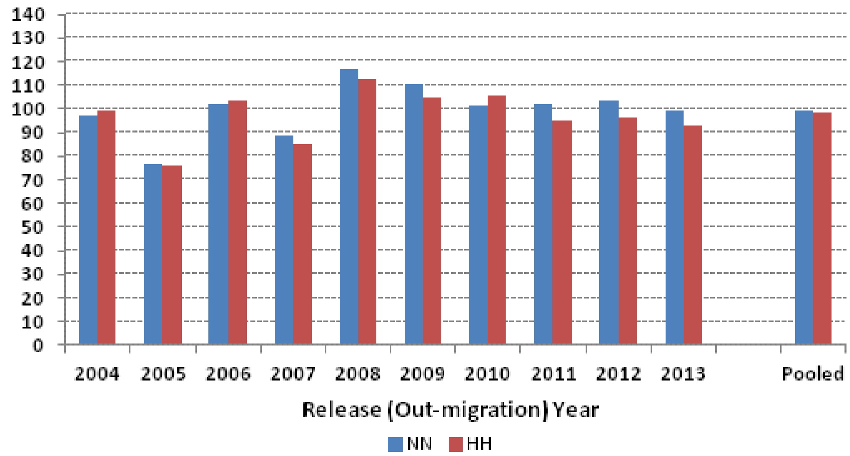



**Figure 5.b.** **<u>Median Dates of Volitional Release</u> of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection**

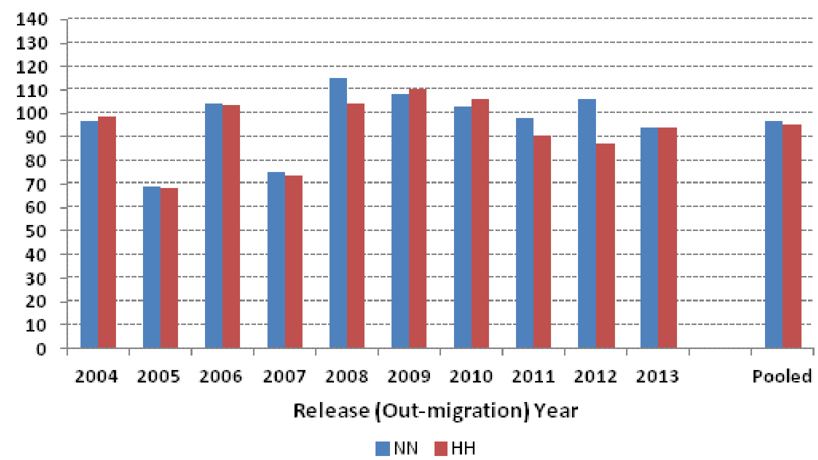


**Table 5. Mean and Median Dates of Volitional Release of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection**[11]

| | Brood Year > | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| | Release year > | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| Cross | Measure | Low vs. High | | | STF + VITA vs VITA | EWOS vs. Vita | STF + VITA vs VITA |
| HxH (HC) | Mean Julian Date | 99.5 | 75.8 | 103.2 | 84.9 | 112.3 | 105.1 |
| | Median Julian Date | 99.0 | 68.5 | 103.5 | 74.0 | 104.5 | 110.5 |
| | n (released) | 4286 | 4269 | 4311 | 4322 | 7508 | 7395 |
| NxN (SH) | Mean Julian Date | 97.3 | 77.0 | 102.2 | 88.8 | 116.7 | 110.1 |
| | Median Julian Date | 96.8 | 69.0 | 104.0 | 75.3 | 115.4 | 108.0 |
| | n (released) | 8707 | 8637 | 8651 | 8743 | 7669 | 7875 |
| Difference (HxH - NxN) in Means | | 2.2 | -1.1 | 1.0 | -3.9 | -4.4 | -5.0 |
| | Type 1 Error | 0.7042 | 0.8465 | 0.8656 | 0.5116 | 0.3990 | 0.3410 |
| Difference (HxH - NxN) in Medians | | 2.3 | -0.5 | -0.5 | -1.3 | -10.9 | 2.5 |

| | Brood Year > | 2008 | 2009 | 2010 | 2011 | Means |
|---|---|---|---|---|---|---|
| | Release year > | 2010 | 2011 | 2012 | 2013 | pooled |
| Cross | Measure | STF + VITA vs VITA | | | | over Years |
| HxH (HC) | Mean Julian Date | 105.2 | 95.0 | 96.5 | 92.8 | 98.3 |
| | Median Julian Date | 106.0 | 90.5 | 87.5 | 94.0 | 95.3 |
| | n (released) | 7855 | 7836 | 7743 | 7381 | 62906 |
| NxN (SH) | Mean Julian Date | 101.1 | 102.4 | 103.4 | 99.2 | 99.4 |
| | Median Julian Date | 102.8 | 98.3 | 106.3 | 94.2 | 96 |
| | n (released) | 7789 | 7831 | 7680 | 7641 | 81223 |
| Difference (HxH - NxN) in Means | | 4.2 | -7.3 | -6.8 | -6.4 | -1.1 |
| | Type 1 Error | 0.4193 | 0.1684 | 0.1987 | 0.2334 | 0.0603 |
| Difference (HxH - NxN) in Medians | | 3.2 | -7.8 | -18.8 | -0.3 | -1.2 |

Note: In previous analyses, only mean volitional release dates were assessed. There was concern that means may not be most appropriate measure of central tendency if the distribution of volitional release time were skewed. While a formal test for a skewed distribution was not conducted, the distribution in some years is highly skewed with a high proportion of smolt leaving the Clark Flat acclimation site within the first couple of days following the pulling of the exit screens. In 2005 the opposite was true when, because of a pessimistic stream flow forecast, a large proportion of the fish had to be forced out several days after the pulling of the screens. The difficulty with using medians is that statistical tests for median differences are generally less powerful than those for means. While there is a great deal of variation in the HxH – NxN means and medians over years, when averaged over all juveniles over all years, the difference between the HxH and NxN mean and median is nearly imperceptible (-1.1 days for means and -1.2 days for medians).

Over the years a large proportion of smolt have volitionally left the Clark Flat ponds within a very few days of the screens being pulled, indicating that the smolt were ready to actively out-

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

migrate. An earlier date for pulling the screens should be considered to give a more reasonable assessment of a volitional release date.

**Mean McNary-Dam Juvenile-Passage Dates**

The mean and median Dates of McNary Passage are given in Figures 6.a. and 6.b and are presented in Table 6. As was the case for dates of volitional release the HxH–NxN Main-Effect-effect was not significant (P = 0.1001, Appendix Table A.6), nor was the sign test for differences in medians (P = 0.17). As was the case for dates of volitional release, the mean dates of McNary Passage for NxN fish were later than HxH fish in seven of the ten years. However, unlike the case of dates of volitional release, there was a significant interaction of HxH – N-N differences with Year (P = 0.0145, Appendix Table A.6). And of the seven years in which the HxH mean McNary Passage dates were earlier, four of them had significant differences. There were no cases of significance for the years in which the NxN had the earlier passage date. As was the case for mean Volitional Release Dates, the possibility of a tendency for HxH smolt to pass McNary earlier than NxN smolt should not be discounted.

The HxH – NxN differences in McNary passage date somewhat mirrors those of the Volitional Release dates, the simple Pearson's correlation coefficient of 0.588 being positive and significant (p = 0.0300, one sided t-test for a positive correlation). In only two years (release years 2006 and 2013) were the signs of the HxH – NxN differences opposite for the McNary Passage and Volitional Release dates. As was the case with the Volitional Release Dates, when passage was pooled over years, the difference between the HxH and NxN mean – median Mary Passage Dated is nearly imperceptible (-1.0 for means and -0.9 for medians).

However, unlike the case with mean and median HxH – NxN comparisons for Volitional Release Date, the direction of the HxH – NxN mean and median differences in McNary Passage Dates over years are consistent (within in a year, they are either both negative or are both positive).

**Figure 6.a.** **<u>Mean McNary-Dam Julian Passage Date</u> of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection)**

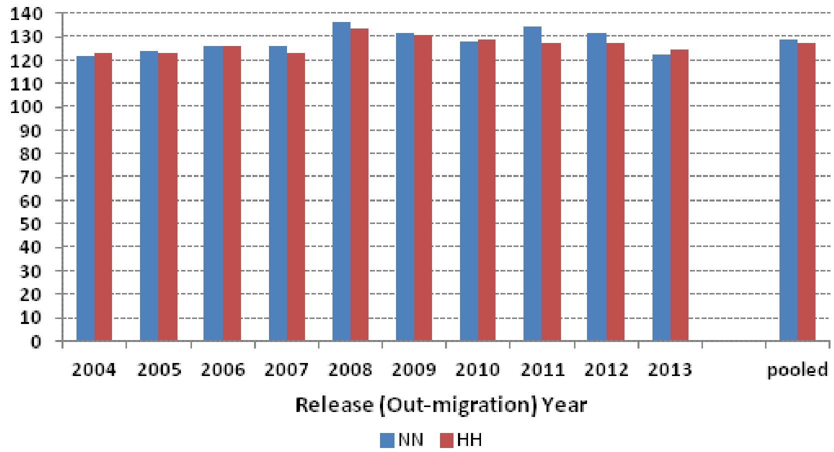



**Figure 6.b.** **<u>Median McNary-Dam Julian Passage Date</u> of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection**

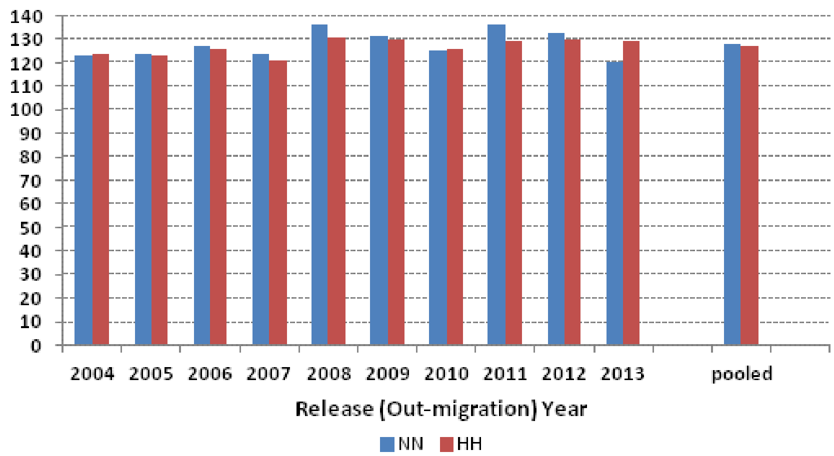


**Table 6. Mean and Median McNary-Dam Julian Passage Date of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection**[12]

| Cross | Brood Year > / Release year > | 2002 / 2004 | 2003 / 2005 | 2004 / 2006 | 2005 / 2007 | 2006 / 2008 | 2007 / 2009 |
|---|---|---|---|---|---|---|---|
| Cross | Measure | Low vs. High | | | STF + VITA vs VITA | EWOS vs. Vita | STF + VITA vs VITA |
| HxH (HC) | Mean Passage Date | 123.3 | 123.2 | 125.8 | 122.9 | 133.4 | 131.0 |
| | Median Passage Date | 122.9 | 122.5 | 124.9 | 121.0 | 131.5 | 131.1 |
| | n(detected*) | 949 | 728 | 1569 | 1413 | 2302 | 3476 |
| NxN (SH) | Mean Passage Date | 121.9 | 123.5 | 126.0 | 126.2 | 136.3 | 131.3 |
| | Median Passage Date | 121.3 | 123.0 | 125.5 | 124.0 | 136.0 | 131.5 |
| | n(detected*) | 1911 | 1330 | 2634 | 3009 | 2753 | 3360 |
| Difference (HxH - NxN) in Means | | 1.4 | -0.3 | -0.2 | **-3.3** | **-2.9** | -0.2 |
| | Type 1 Error | 0.4470 | 0.8896 | 0.8843 | **0.0308** | **0.0306** | 0.8304 |
| Difference (HxH - NxN) in Medians | | 1.6 | -0.5 | -0.6 | -3.0 | -4.5 | -0.4 |

| Cross | Brood Year > / Release year > | 2008 / 2010 | 2009 / 2011 | 2010 / 2012 | 2011 / 2013 | Means pooled over Years |
|---|---|---|---|---|---|---|
| Cross | Measure | STF + VITA vs VITA | | | | |
| HxH (HC) | Mean Passage Date | 128.5 | 127.7 | 127.6 | 124.2 | 127.6 |
| | Median Passage Date | 128.4 | 128.1 | 128.1 | 124.0 | 127.3 |
| | n(detected*) | 2545 | 3157 | 3239 | 2967 | 22345 |
| NxN (SH) | Mean Passage Date | 128.1 | 134.2 | 131.5 | 122.5 | 128.6 |
| | Median Passage Date | 127.4 | 134.3 | 133.5 | 121.0 | 128 |
| | n(detected*) | 2579 | 2704 | 3432 | 3274 | 26986 |
| Difference (HxH - NxN) in Means | | 0.5 | **-6.5** | **-3.9** | 1.8 | -1.0 |
| | Type 1 Error | 0.7177 | **0.0000** | **0.0011** | 0.1333 | 0.1001 |
| Difference (HxH - NxN) in Medians | | 1.0 | **-6.2** | **-5.4** | 3.0 | -0.9 |

* Expanded Detected at McNary, Expansion being estimated Detection Rate at McNary

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

[12] Appendix A.6 presents the associated analysis of variance with the significance levels.

detection between the two stocks, the comparisons between the stocks' proportions should reflect pre-release survival difference.

Figure and Table 7 present the individual year and mean pre-release survival-index estimates, The HxH-NxN main effect comparison is significant (P = 0.0420, Appendix Table A.7) as are the comparisons' interactions with years (P = 0.0053, Appendix Table A.7). The nature of the interaction is evident from the figure and the table. In the first six release years (2004-2009) and in the last release year (2013), the HxH pre-release survival index is less than that of the NxN stock. In the other three years (2010-2012) the opposite is true. However, the absolute values of those three differences are less than those of the other seven, and in none of those three years were the differences significant (Table 7). Of the seven years in which the HxH had the lower proportion released, there were three in which the within-year comparison was significant.

**Figure 7.** **Proportion of PIT-Tagged Natural x Natural and Hatchery x Hatchery Upper Yakima Spring Chinook Detected Leaving Acclimation Sites**

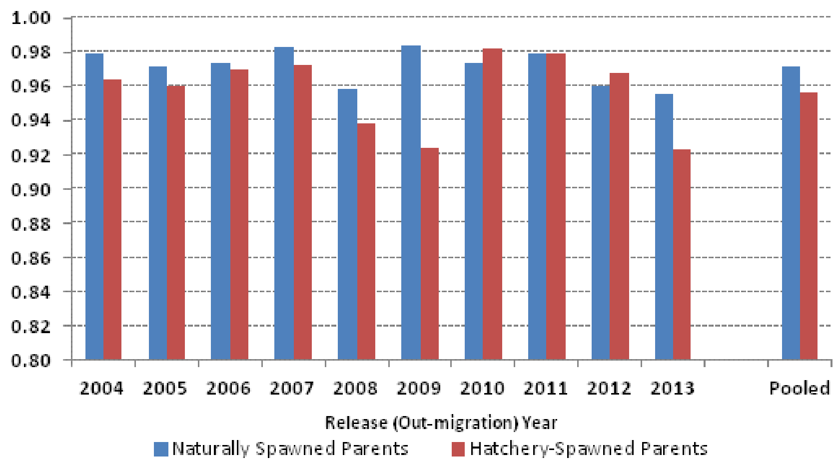


**Table 7. Proportion of PIT-Tagged Natural x Natural and Hatchery x Hatchery Upper Yakima Spring Chinook Detected Leaving Acclimation Sites**[13]

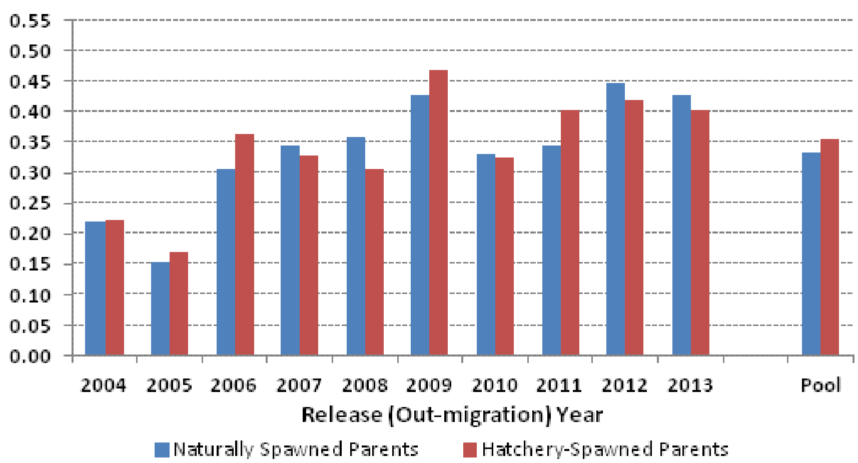
| Cross | Measure | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| | Brood Year > | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
| | Release Year > | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| Cross | Measure | Low vs. High | | | STF + VITA vs VITA | EWOS vs. Vita | STF + VITA vs VITA |
| HxH (HC) | p(released) | 0.964 | 0.961 | 0.970 | 0.972 | 0.939 | 0.924 |
| | n (tagged) | 4446 | 4444 | 4446 | 4445 | 8000 | 8000 |
| NxN (SH) | p(released) | 0.979 | 0.972 | 0.973 | 0.983 | 0.959 | 0.984 |
| | n (tagged) | 8892 | 8889 | 8889 | 8894 | 8000 | 8000 |
| Difference (HxH - NxN) | | -0.015 | -0.011 | -0.004 | -0.011 | -0.020 | -0.060 |
| Type 1 Error | | 0.0676 | 0.2061 | 0.6472 | 0.1364 | 0.0457 | 0.0001 |

| Cross | Measure | 2008 | 2009 | 2010 | 2011 | Means pooled over Years |
|---|---|---|---|---|---|---|
| | Brood Year > | 2008 | 2009 | 2010 | 2011 | |
| | Release year > | 2010 | 2011 | 2012 | 2013 | |
| Cross | Measure | STF + VITA vs VITA | | | | |
| HxH (HC) | p(released) | 0.982 | 0.980 | 0.968 | 0.923 | 0.956 |
| | n (tagged) | 8000 | 8000 | 8000 | 7999 | 65780 |
| NxN (SH) | p(released) | 0.974 | 0.979 | 0.960 | 0.955 | 0.972 |
| | n (tagged) | 8000 | 8000 | 8000 | 8000 | 83564 |
| Difference (HxH - NxN) | | 0.008 | 0.001 | 0.008 | -0.032 | -0.016 |
| Type 1 Error | | 0.1914 | 0.9143 | 0.3131 | 0.0071 | 0.0420 |

## Release-to-McNary Smolt-to-Smolt Survival

The method of estimating Release-to-McNary Smolt-to Smolt Survival is presented in Appendix B. There were neither main effect nor year interaction differences between HxH and NxN stock (respectively p = 0.7663 and p = 0.2144, Appendix Table A.8).

**Figure 8. Volitional-Release-to-McNary-Dam Smolt-to-Smolt Survival of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt**




[13] Appendix A.7 presents the associated analysis of variance with the significance levels.

**Table 8.** **Volitional-Release-to-McNary-Dam Smolt-to-Smolt Survival of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt**[14]

| | Brood Year > | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| | Release Year > | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| Cross | Measure | Low vs. High | | | STF + VITA vs VITA | EWOS vs. Vita | STF + VITA vs VITA |
| HxH (HC) | p(surviving) | 0.221 | 0.171 | 0.364 | 0.327 | 0.307 | 0.470 |
| | n (released) | 4286 | 4269 | 4311 | 4322 | 7508 | 7395 |
| NxN (SH) | p(surviving) | 0.220 | 0.154 | 0.304 | 0.344 | 0.359 | 0.427 |
| | n (released) | 8707 | 8637 | 8651 | 8743 | 7669 | 7875 |
| Difference (HxH - NxN) | | 0.002 | 0.017 | 0.060 | -0.017 | -0.052 | 0.043 |
| Type 1 Error | | 0.9477 | 0.5304 | 0.0969 | 0.6123 | 0.0956 | 0.1786 |

| | Brood Year > | 2008 | 2009 | 2010 | 2011 | Means |
|---|---|---|---|---|---|---|
| | Release Year > | 2010 | 2011 | 2012 | 2013 | pooled |
| Cross | Measure | STF + VITA vs VITA | | | | over Years |
| HxH (HC) | p(surviving) | 0.324 | 0.403 | 0.418 | 0.402 | 0.355 |
| | n (released) | 7855 | 7836 | 7743 | 7381 | 62906 |
| NxN (SH) | p(surviving) | 0.331 | 0.345 | 0.447 | 0.429 | 0.332 |
| | n (released) | 7789 | 7831 | 7680 | 7641 | 81223 |
| Difference (HxH - NxN) | | -0.007 | 0.058 | -0.029 | -0.026 | 0.023 |
| Type 1 Error | | 0.8032 | 0.0735 | 0.3576 | 0.3970 | 0.7663 |

## 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. The source of variation in spilt-plot design analyses that is usually referred to as "Main-Plot Error" is referred to as "Among Raceway Pair" herein.

In 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 Square[15] is less the Among-Raceway-Pair Mean Square, in which case, the Stock main-effect comparison source is tested against a "Pooled Main-Plot Mean Square" which is pooling of the Year x Stock and Among-Raceway-Pair source of variation. Year x Stock interaction is always tested against the Among-Raceway-Pair Mean Square.

In the sub-plot analysis, Treatment and Stock x Treatment sources are tested against what is usually referred to as the "Sub-Plot Error" source, but is referred to herein as "Residual".

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

[15] Note: As a clarification of the term "Mean Square" the actual term refers to a measure of variation estimated using a least squares analysis of variation; however analyses of proportions is actually based on logistic regression, and the analogous term used in the tables in this appendix is "Mean Deviance" and the analogous term "Sums of Squares used in the logistic analyses of variation is "Deviance" is in Logistic Analysis of Variation tables.

Treatment comparisons are discussed in other annual reports. These are not relevant to this report, but are only presented to give a summary of the whole analysis.

**Table A.1. Weighted Analysis of Variance of Pre-Release Weight (grams/fish) of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2011)**
**(Weight is number of fish weighed/raceway)**

| Source* | Sum of Squares (SS) | Degrees of Freedom (DF) | Mean Square (SS/DF) | F-Ratio | Estimated Type 1 Error P(F) | Denominator Mean Square Source of F-Ratio |
|---|---|---|---|---|---|---|
| Year | 12170 | 9 | 1352.22 | 16.84 | 0.0001 | Among Raceway Pairs |
| Stock (HH vs NN) | 13 | 1 | 13.00 | 0.11 | 0.7435 | Year x Stock |
| Year x Stock | 1027 | 9 | 114.11 | 1.42 | 0.2951 | Among Raceway Pairs |
| Among Raceway Pairs | 803 | 10 | 80.30 | 2.68 | 0.0234 | Residual |
| Treatment** | 5183 | 3 | 1727.67 | 57.59 | 0.0000 | Residual |
| Stock x Treatment | 29 | 3 | 9.67 | 0.32 | 0.8092 | Residual |
| Residual | 720 | 24 | 30.00 | | | |

*each source's effects are adjusted for effects of preceding sources

** One pair of treatments tested in BY 2004-2007, another pair in 2008, 2010-2013, another set in 2009

**Table A.2. Weighted Analysis of Variance of Pre-Release Length (millimeters/fish) of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2011)**
**(Weight is number of fish length-measured/raceway)**

| Source* | Sum of Squares (SS) | Degrees of Freedom (DF) | Mean Square (SS/DF) | F-Ratio | Type 1 Error P Estimate of F-Ratio | Denominator Mean Square Source of F-Ratio |
|---|---|---|---|---|---|---|
| Year | 66338 | 9 | 7370.90 | 16.13 | 0.0001 | Among Raceway Pairs |
| Stock (HH vs NN) | 19 | 1 | 19.40 | 0.05 | 0.8222 | Year x Stock |
| Year x Stock | 3262 | 9 | 362.44 | 0.79 | 0.6310 | Among Raceway Pairs |
| Among Raceway Pairs | 4569 | 10 | 456.92 | 3.57 | 0.0052 | Residual |
| Treatment** | 32347 | 3 | 10782.29 | 84.16 | 0.0000 | Residual |
| Stock x Treatment | 275 | 3 | 91.59 | 0.71 | 0.5527 | Residual |
| Residual | 3075 | 24 | 128.11 | | | |

*each source's effects are adjusted for effects of preceding sources

** One pair of treatments tested in BY 2004-2007, another pair in 2008, 2010-2013, another set in 2009

**Table A.3. 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 2002-2011)**
**(Weight is number of fish gender-tested/raceway)**

| Source* | Deviance (Dev) | Degrees of Freedom (DF) | Mean Dev (Dev/DF) | F-Ratio | Estimated Type 1 Error P(F) | Denominator Mean-Square Source to F-Ratio |
|---|---|---|---|---|---|---|
| Year | 13.390 | 9 | 1.49 | 1.89 | 0.1676 | Among Raceway Pairs |
| Stock (HH vs NN)** | 0.000 | 1 | 0.00 | 0.00 | 1.0000 | Pooled Main Plot Error** |
| Year x Stock | 5.820 | 9 | 0.65 | 0.82 | 0.6111 | Among Raceway Pairs |
| Among Raceway Pairs | 7.870 | 10 | 0.79 | 0.85 | 0.5924 | Residual |
| Pooled Main Plot Error** | 13.690 | 19 | 0.72 | 0.77 | 0.7134 | Residual |
| Treatment*** | 3.18 | 3 | 1.06 | 1.14 | 0.3536 | Residual |
| Stock x Treatment | 2.90 | 3 | 0.97 | 1.04 | 0.3936 | Residual |
| Residual | 22.35 | 24 | 0.93 | | | |

*each source's effects are adjusted for effects of preceding sources

** Since F-Ratio Year x Stock < 1, it was pooled with Among Raceway Pairs for base of Stock comparison

*** One pair of treatments tested in BY 2004-2007, another pair in 2008, 2010-2013, another set in 2009

**Table A.4. Weighted Logistic Analysis of Variation of Precocial Proportion of Pre-Release Male Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2011)**
**(Weight is number males from gender-tested/raceway)**

| Source* | Deviance (Dev) | Degrees of Freedom (DF) | Mean Dev (Dev/DF) | F-Ratio | Estimated Type 1 Error P(F) | Denominator Mean-Square Source to F-Ratio |
|---|---|---|---|---|---|---|
| Year | 124.03 | 9 | 13.78 | 10.76 | 0.0005 | Among Raceway Pairs |
| Stock (HH vs NN) | 14.77 | 1 | 14.77 | 2.94 | 0.1207 | Year x Stock |
| Year x Stock | 45.25 | 9 | 5.03 | 3.92 | **0.0221** | Among Raceway Pairs |
| Among Raceway Pairs | 12.81 | 10 | 1.28 | 1.55 | 0.1831 | Residual |
| Treatment** | 19.01 | 3 | 6.34 | 7.66 | 0.0009 | Residual |
| Stock x Treatment | 3.77 | 3 | 1.26 | 1.52 | 0.2352 | Residual |
| Residual | 19.86 | 24 | 0.83 | | | |

*each source's effects are adjusted for effects of preceding sources

** One pair of treatments tested in BY 2004-2007, another pair in 2008, 2010-2013, another set in 2009

**Table A.5. Weighted Analysis of Variance of McNary-Dam Julian Detection Date of Detection at Acclimation Sites of PIT-tagged Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt leaving Ponds (brood years 2002 through 2011)**

**(Weight is number of fish PIT-tagged)**

| Source* | Sum of Squares (SS) | Degrees of Freedom (DF) | Mean Square (SS/DF) | F-Ratio | Estimated Type 1 Error P(F) | Denominator Mean Square Source of F-Ratio |
|---|---|---|---|---|---|---|
| Year | 13,594,752 | 9 | 1,510,528 | 15.89 | 0.0001 | Among Raceway Pairs |
| Stock (HH vs NN)** | 311,502 | 1 | 311,502 | 3.99 | 0.0603 | Pooled Main Plot Error** |
| Year x Stock | 532,676 | 9 | 59,186 | 0.76 | 0.6546 | Among Raceway Pairs |
| Among Raceway Pairs | 950,783 | 10 | 95,078 | 1.22 | 0.3290 | Residual |
| Pooled Main Plot Error** | 1,483,459 | 19 | 78,077 | 9862.33 | 0.0000 | Residual |
| Treatment*** | 84 | 3 | 28.00 | 3.54 | **0.0298** | Residual |
| Stock x Treatment | 13 | 3 | 4.33 | 0.55 | 0.6547 | Residual |
| Residual | 190 | 24 | 7.92 | | | |

*each source's effects are adjusted for effects of preceding sources

** Since F-Ratio Year x Stock < 1, it was pooled with Among Raceway Pairs for base of Stock comparison

*** One pair of treatments tested in BY 2004-2007, another pair in 2008, 2010-2013, another set in 2009

**Table A.6. 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 2011)**

**(Weight is expanded number of PIT-tagged fish passing McNary)**

| Source* | Sum of Squares (SS) | Degrees of Freedom (DF) | Mean Square (SS/DF) | F-Ratio | Estimated Type 1 Error P(F) | Denominator Mean Square Source of F-Ratio |
|---|---|---|---|---|---|---|
| Year | 697142 | 9 | 77460.22 | 36.92 | 0.0000 | Among Raceway Pairs |
| Stock (HH vs NN) | 31354 | 1 | 31354.00 | 3.36 | 0.1001 | Year x Stock |
| Year x Stock | 84018 | 9 | 9335.33 | 4.45 | 0.0145 | Among Raceway Pairs |
| Among Raceway Pairs | 20981.5 | 10 | 2098.15 | 0.67 | 0.7366 | Residual |
| Treatment** | 13123.1 | 3 | 4374.37 | 1.41 | 0.2651 | Residual |
| Stock x Treatment | 7754.4 | 3 | 2584.80 | 0.83 | 0.4898 | Residual |
| Residual | 74628 | 24 | 3109.50 | | | |

*each source's effects are adjusted for effects of preceding sources

** One pair of treatments tested in BY 2004-2007, another pair in 2008, 2010-2013, another set in 2009

**Table A.7. 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 2011)**

**(Weight is number of fish PIT-tagged/raceway)**

| Source* | Deviance (Dev) | Degrees of Freedom (DF) | Mean Dev (Dev/DF) | F-Ratio | Estimated Type 1 Error P(F) | Denominator Mean-Square Source to F-Ratio |
|---|---|---|---|---|---|---|
| **Year** | 783.1 | 9 | 87.01 | 13.81 | 0.0002 | Among Raceway Pairs |
| **Stock (HH vs NN)** | 207.55 | 1 | 207.55 | 5.61 | **0.0420** | Year x Stock |
| **Year x Stock** | 332.88 | 9 | 36.99 | 5.87 | **0.0053** | Among Raceway Pairs |
| **Among Raceway Pairs** | 63.01 | 10 | 6.30 | 1.79 | 0.1174 | Residual |
| **Treatment**** | 112.95 | 3 | 37.65 | 10.70 | 0.0001 | Residual |
| **Stock x Treatment** | 15.6 | 3 | 5.20 | 1.48 | 0.2457 | Residual |
| **Residual** | 84.45 | 24 | 3.52 | | | |

***each source's effects are adjusted for effects of preceding sources**

**** One pair of treatments tested in BY 2004-2007, another pair in 2008, 2010-2013, another set in 2009**

**Table A.8. Weighted* Logistic Analysis of Variation of Proportion of Smolt detected leaving acclimation Sites that survived to McNary-<u>Dam (Smolt-to-Smolt Survival)</u> for Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2011)**

**(Weight is Number of Fish Detected at Released)**

| Source* | Deviance (Dev) | Degrees of Freedom (DF) | Mean Dev (Dev/DF) | F-Ratio | Estimated Type 1 Error P(F) | Denominator Mean-Square Source to F-Ratio |
|---|---|---|---|---|---|---|
| **Year** | 4825.8 | 9 | 536.20 | 38.69 | 0.0000 | Among Raceway Pairs |
| **Stock (HH vs NN)** | 2.19 | 1 | 2.19 | 0.09 | 0.7663 | Year x Stock |
| **Year x Stock** | 209.92 | 9 | 23.32 | 1.68 | 0.2144 | Among Raceway Pairs |
| **Among Raceway Pairs** | 138.59 | 10 | 13.86 | 1.70 | 0.1389 | Residual |
| **Treatment**** | 96.69 | 3 | 32.23 | 3.95 | **0.0201** | Residual |
| **Stock x Treatment** | 6.37 | 3 | 2.12 | 0.26 | 0.8532 | Residual |
| **Residual** | 195.77 | 24 | 8.16 | | | |

***each source's effects are adjusted for effects of preceding sources**

**** One pair of treatments tested in BY 2004-2007, another pair in 2008, 2010-2013, another set in 2009**

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

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

Eq.B.1.

$$\text{Release - to - McNary Survival} = \frac{\text{Expanded Number of Released Fish Detected at McNary}}{\text{Release Number (detected at release)}}$$ [16]

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

Eq.B.2.

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

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

Eq.B.3.

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

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

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

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**Appendix F**
**2013 Annual Report: Smolt-to-Smolt Survival to McNary Dam of Yakima Fall and Summer Chinook**

Doug Neeley, Consultant to Yakama Nation

## Introduction

Paired Subyearling and Yearling Yakima-stock Fall Chinook releases were made from Prosser Hatchery (Prosser) in out-migration years 2008 through 2013.

Summer Chinook Subyearlings were released from Stiles Pond in outmigration-years 2009 and 2011. In 2012 the Stiles releases were discontinued and shifted to Prosser. In 2013 the Prosser releases were discontinued and shifted to mobile raceways located at Roza Dam with releases occurring below the Dam. Subyearlings were also released from mobile raceways into Buckskin Slough from 2011 through 2012 and from Marion Drain Hatchery in 2012.

The analyses presented in this report are for:

1. Fall Chinook - Estimation of release-year 2008 through 2013 pre-release survival, smolt-to-smolt survival to McNary Dam (McNary) on the Columbia River 70 km below the Yakima River, and mean dates of release and of McNary-Dam detection with formal comparisons between the Subyearling and Yearling estimates.

2. Summer Chinook – Similar estimates were made for Summer Chinook. Only subyearlings were released, so there are no within-site comparisons of survival rates.

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 for smolt-to-smolt survival to McNary and for pre-release survival are given in Appendix B.

For releases from ponds with PIT-tag detectors at their outfalls, estimated survival is partitioned into pre-release survival and release-to-McNary survival estimates, the former being the proportion of fish tagged that are detected at release divided by outfall detection efficiency, and the latter being the proportion of fish detected at release that survive to McNary. Time-of-tagging-to-McNary-passage survival estimates (tagging-to-McNary survival), which can be affected by pre-release tag-shedding and mortality as well as in-stream mortality factors, are given for all releases, whether or not there were detectors located at the release sites. Mean dates of release and of McNary passage estimates are also presented.

## Low Detection Efficiencies at Prosser in 2013

Discussions on the fall and summer runs are presented in the next two sections (respectively titled Fall Chinook Releases and Summer Chinook Releases). Following these sections, Fall and Summer Chinook data summaries are presented in a common section titled Tables and Figures.

However, prior to these discussions, it should be pointed out that detection efficiencies of the Prosser ponds' out-fall detector were extremely poor in 2013. Detection efficiencies are estimated by dividing the number of smolt jointly detected at McNary and the Prosser outfall by the total number of Prosser-released smolt detected at McNary. The 2013 detection efficiencies at the Prosser outfall are presented in Table 1 along with percentages of tagged fish detected leaving the pond for Fall Chinook, Coho, and Summer Chinook releases. The reason for including Coho is that they tend to leave their acclimation ponds later than Yearling but earlier than Subyearling Fall Chinook.

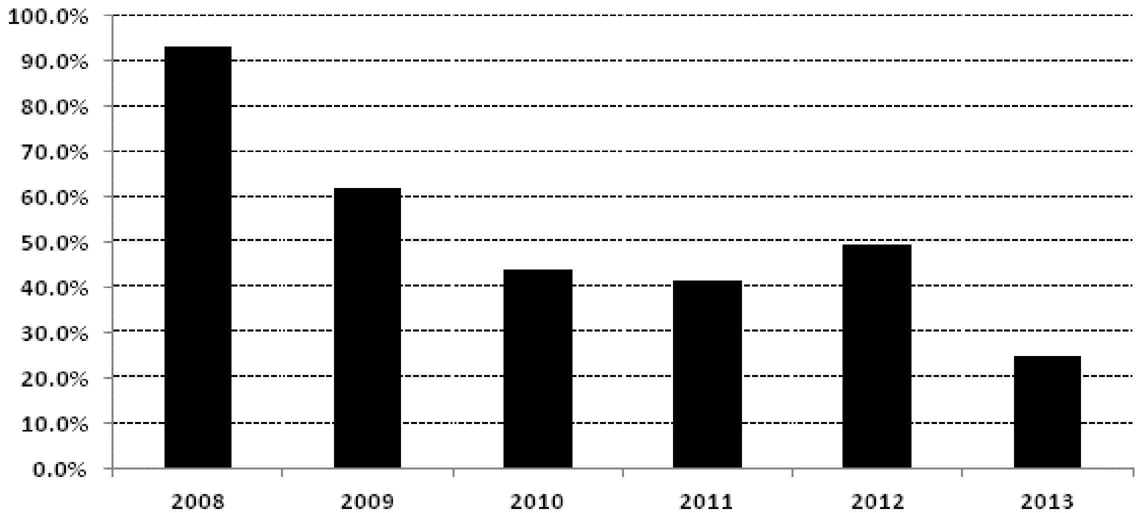
As can be seen in Table 1, the detection efficiency is low for the earliest outfall passage (Fall Chinook) and dramatically decreases with later outfall passages. The same pattern holds true for percentage of fish detected leaving the ponds. Detection efficiency and percentage of fish detected leaving the ponds are separate measures. Their similarity indicates that reduced detection efficiencies, and not pre-release mortality or tag shedding, are the primary reason for the lower percentages detected.

**Table 1. 2013 Detection Efficiency of Prosser Rearing Pond's PIT-Tag Detector**

| | Stock | | |
|---|---|---|---|
| **Measure** | **Fall Yearling** | **Coho** | **Fall Sub-Yearling** |
| **Mean Release Date** | 03/29/13 | 04/24/13 | 05/09/13 |
| **Prosser Detection Efficiency** | 26.68% | 5.37% | 0.53% |
| **Percentage Detected leaving Pond** | 24.65% | 4.44% | 0.61% |

As will be seen in Figure 1, the Fall Chinook percentage detected leaving raceways has been low for several years. This is unrelated to mortality or tag shedding. Relatively inexpensive detection equipment designed for other purposes was adapted to remote, unattended operation, and has not been as reliable as the purpose-built and redundant systems employed at large facilities. In spite of these limitations, detection efficiency has been measurable as described above in most years, allowing the partitioning of pre-release mortality and tag shedding from mortality during outmigration.

**Figure 1. Percent of Tagged Fall Chinook Detected leaving Prosser Raceways**




Pre-release survival is estimated by

$$p = \frac{\text{Percentage Detected Leaving the Pond}}{\text{Prosser Detection Efficiency}}$$

When the denominator percentages are low for the reasons described above, it is possible to get estimates of the pre-release survival (p) that are greater than 100%, which is clearly impossible. When this happens, the estimated p is rounded down to 100%.

## Fall Chinook Releases

### Pre-Release Survival

Pre-release survival is percentage of tagged fish detected leaving the pond divided by the detection efficiency. The term pre-release survival is somewhat of a misnomer since the estimate can be affected by pre-release tag shedding as well as pre-release mortality. There was no significant or substantial difference between Subyearling and Yearling mean Pre-Release Survivals over years (Figure and Table 2.a.; p = 0.4433 from Table A.2.a. of Appendix A). However, in 2011, the Subyearling pre-release survival was substantially less than that of the Yearling (Figure and Table 2.a.). Nonetheless, this notable exception did not trigger a significant year x stock difference interaction (p = 0.4149, Table A.2.a. of Appendix A), probably because of the similarity of the Subyearling and Yearling survivals in the other five years.

## Survival to McNary

For the 2008 through 2013 releases, the Release-to-McNary survival estimates are given in Figure 2.b, and the Tagging-to-McNary Survival estimates are given in Figure 2.c. The Yearling-release survival estimates have been consistently and significantly higher than the Subyearling-release survival estimates ($p < 0.0001$ and $p = 0.0018$ respectively for Release-to-McNary and Tagging-to-McNary survivals from Appendix Tables A.2.b and A.2.c). Given the issues associated with low detection efficiencies and low percentages detected at release, tagging-to-McNary survival may provide a better base of comparison.

## Dates of Release and McNary Passage Dates

While the over-year mean Yearling and Subyearling Julian volitional release dates did not significantly differ (Figure and Table 3.a; $p = 0.1624$, Appendix Table A 3.a), the Subyearling Fall Chinook McNary passage dates were consistently and substantially later than the Yearling (Figure and Table 3.b, $p = 0.0058$ from Appendix Table A.3.b).

Even though there was no over-year significant Yearling–Subyearling difference in release dates, there was a significant interaction of the differences with years ($p = 0.0016$, Table A.3.a of Appendix A. There was a substantially later mean release-date difference for Subyearlings in 2013 (pointed out earlier in Table 1) and a rather substantial one in 2012 (Figure and Table 3.a.).

There was also a significant Yearling–Subyearling McNary-passage-date difference interaction with year ($p < 0.0001$ from Appendix A Table A.3.b.), but in all cases the Subyearling passage at McNary was later than the Yearling. Excluding 2011, the Subyearlings' mean date of McNary passage ranged from 25 days later than the Yearlings in 2010 to 69 days later in 2013, reflecting a longer period of in-stream rearing for the Subyearlings. In 2011, the mean McNary passage date for Subyearlings was only 9 days later than Yearlings.

# Summer Chinook Releases

## Pre-Release Survival

Estimates are presented in Figure and Table 2.a. 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.b. 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 high pre-release survival associated with the Stiles' release in 2009 indicates that the extremely low survival to McNary was due to in-stream factors which may be attributed to a couple of factors:

- Late volitional Stiles 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);

- The blockage of some juvenile fish bypasses in 2009 in irrigation canals up-stream of the Prosser project resulting in fish stranding.

Releases were made into Buckskin Slough in 2011 through 2013 and into Marion Drain in 2012 and below Roza Dam in 2013. Without pond outfall detection, release numbers of these fish were simply the numbers of PIT-tagged fish unlike releases from the Stiles and Prosser ponds. Tagging-to-McNary survivals are presented in Figure and Table 3.b.

**Dates of Release and McNary Passage Dates**

Coho were released into Buckskin Slough in 2011 considerably earlier than estimated mean date of volitional release from Stiles pond (direct Julian release dates were 119 and 122 for Buckskin versus estimated mean volitional Julian release date 147 for Stiles); however estimated mean date of passage at McNary Dam (Figure and Table 3.b.) was considerably later for the Buckskin releases than for the Stiles volitional releases (Julian McNary Passage Date 171[1] versus 155[2]). It appears that the Buckskin Slough 2011 releases held much longer in the Naches and Yakima rivers than did the Stiles releases. The 2012 estimated mean dates of McNary Passage are very similar for the Buckskin, Marion Drain, and Prosser releases (Table 3.b). In 2013, the estimated Buckskin mean McNary Passage Date was somewhat later than that of the Roza-release (Table 3.b).

[1] Recall that were two sets of Buckskin Slough releases in 2011, 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).
[2] Buckskin information given textually. Stiles pond releases are give in Table 3.a. because they were releases from ponds with detectors. Buckskin releases were in-stream releases.

## Figures and Tables

**Figure 2.a. 2008-2013 Pre-Release-Survival* (from tagging to release)**

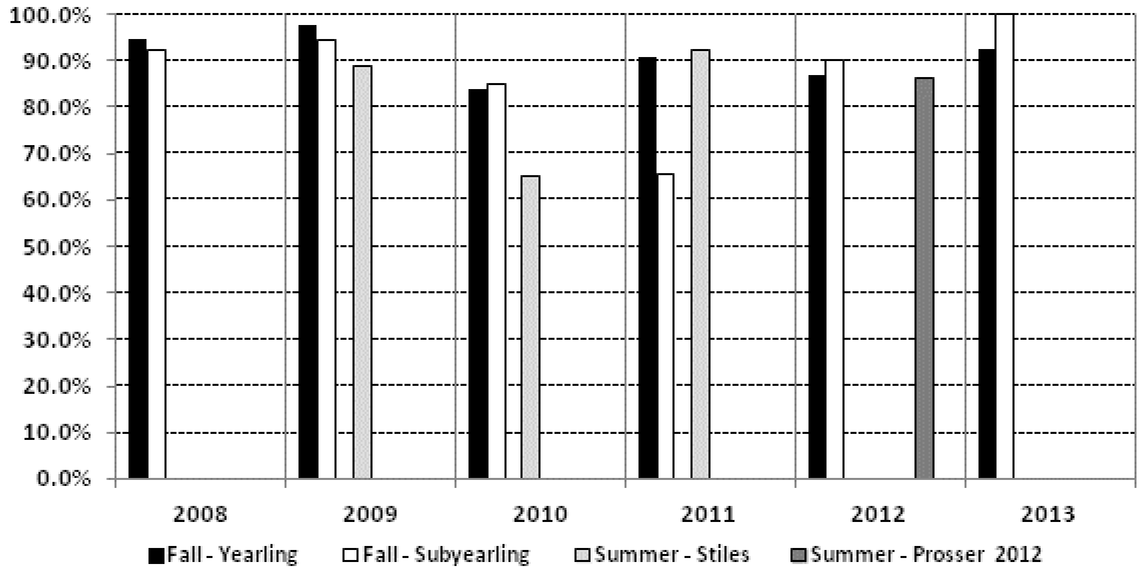
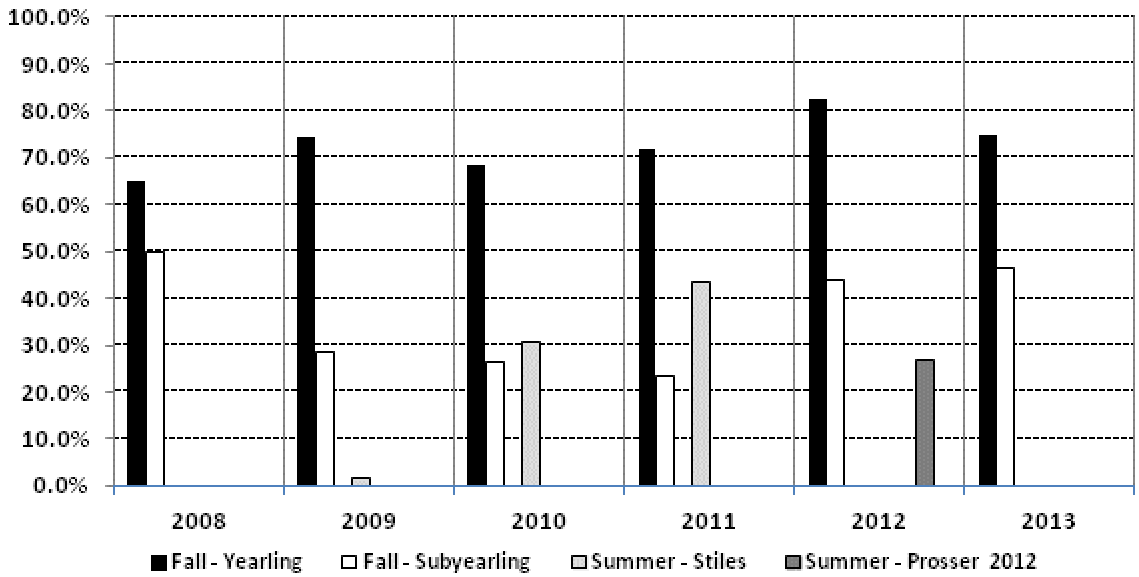



**Table 2.a. 2008-2013 Pre-Release-Survival* (from tagging to release)**

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

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

**Figure 2.b. 2008-2013 Smolt Release-to-McNary Survival of Smolt detected at Release**

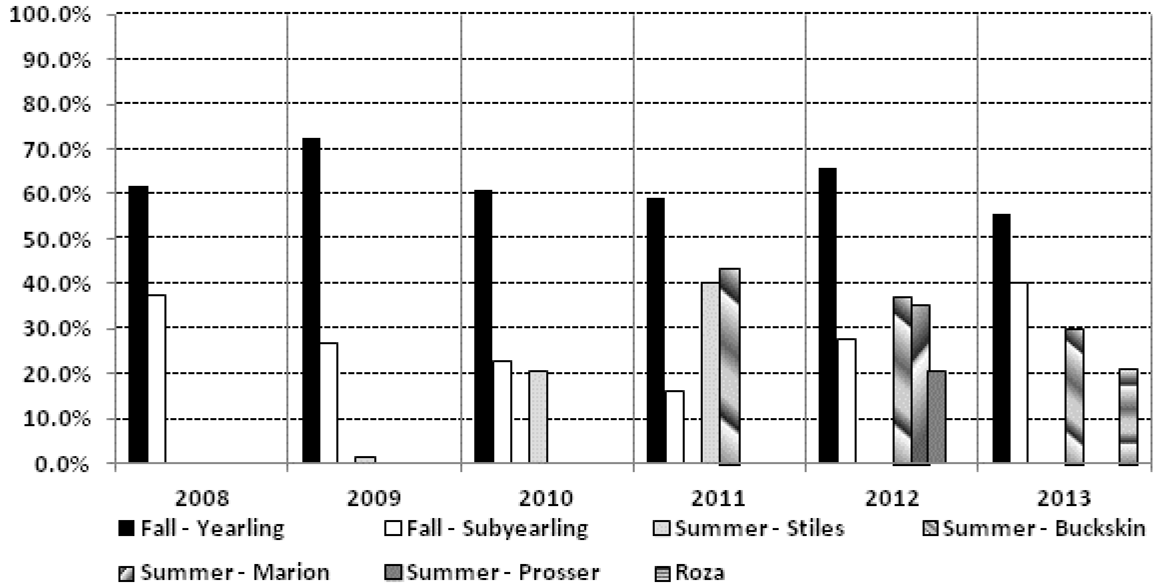



## Table 2.b. 2008-2013 Smolt Release-to-McNary Survival of Smolt detected at Release

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

*** In 2009, Summer Chinook were released from Stiles in June (Table 3.a) and a passage problem was discovered at the Wapato diversion dam juvenile bypass, both of which substantially impacted juvenile survival of Summer Chinook releases that year.**

## Figure 2.c. 2008-2013 Tagging-to-McNary Survival of all Tagged Fish




## Table 2.c. 2008-2013 Tagging-to-McNary Survival of all Tagged Fish

| Year | Measure | Fall Chinook (Prosser) Yearling | Fall Chinook (Prosser) Subyearling | Summer Chinook (Stiles) | Summer Chinook (Buckskin Slough) | Summer Chinook (Marion) | Summer Chinook (Prosser) | Summer Chinook (Roza) |
|---|---|---|---|---|---|---|---|---|
| **2008** | **Tagging-to-McNary Survival** | **61.6%** | **37.4%** | | | | | |
| | Number Tagged | 1,831 | 10,005 | | | | | |
| **2009*** | **Tagging-to-McNary Survival** | **72.4%** | **26.8%** | **1.5%** | | | | |
| | Number Tagged | 7,516 | 7,565 | 30,037 | | | | |
| **2010** | **Tagging-to-McNary Survival** | **60.6%** | **22.8%** | **20.5%** | | | | |
| | Number Tagged | 12,167 | 13,685 | 29,865 | | | | |
| **2011** | **Tagging-to-McNary Survival** | **59.2%** | **16.0%** | **40.3%** | **43.4%** | | | |
| | Number Tagged | 22,754 | 22,790 | 20,000 | 29,894 | n.a | n.a | n.a |
| **2012** | **Tagging-to-McNary Survival** | **65.6%** | **27.9%** | | **37.0%** | **35.7%** | **20.7%** | |
| | Number Tagged | 19,435 | 19,634 | n.a | 9,999 | 9,998 | 9,999 | n.a |
| **2013** | **Tagging-to-McNary Survival** | **55.7%** | **40.0%** | | **30.1%** | | | **21.3%** |
| | Number Tagged | 13,685 | 22,966 | n.a | 15,065 | n.a | n.a | 15,084 |

*** In 2009, Summer Chinook were released in June (Stiles release, Table 3.a) and a passage problem was discovered at the Wapato diversion dam juvenile bypass, both of which substantially impacted juvenile survival of Summer Chinook releases that year.**

**Figure 3.a. 2008-2013 Mean Julian Date of Release**

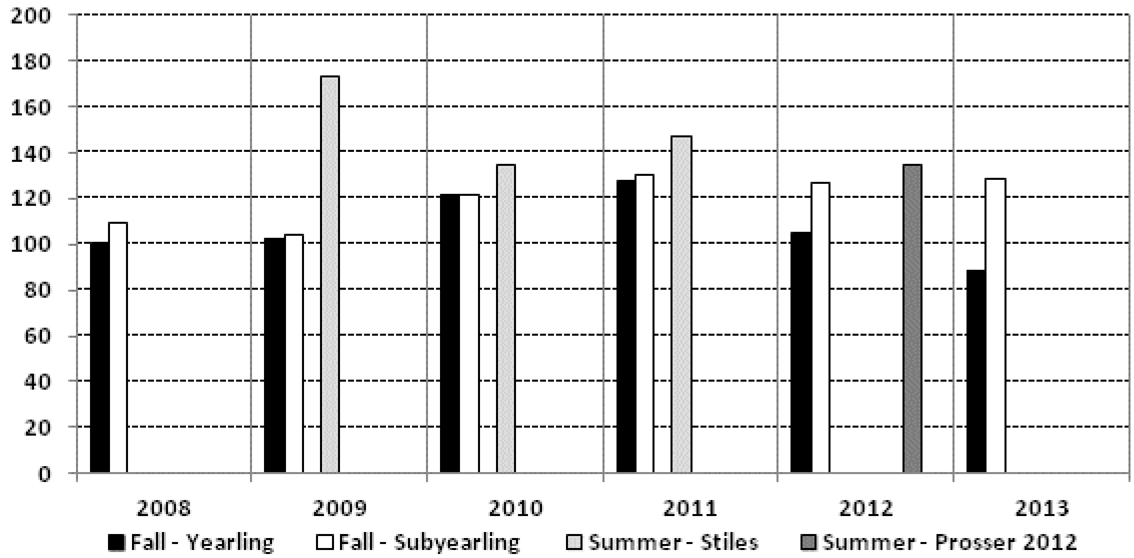



**Table 3.a. 2008-2013 Mean Julian Date of Release**

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

**Table 3.b. 2008-2013 Mean Julian Date* of all Tagged Fish passing McNary**

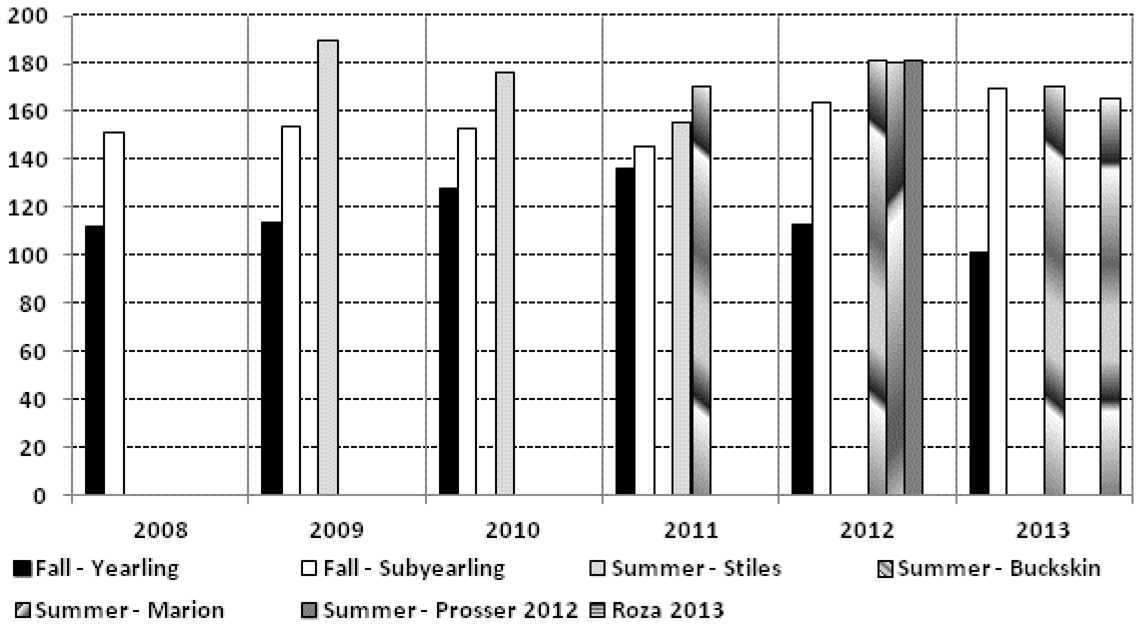



**Table 3.b. 2008-2013 Mean Julian Date* of all Tagged Fish passing McNary**

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

*** 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 Mean Deviance for Proportion Detected**

| Source | Deviance (Dev) | Degrees of Freedom (DF) | Mean Dev (Dev/DF) | F-Ratio | Estimated Type Error P |
|---|---|---|---|---|---|
| Year | 24,220 | 5 | 4,844 | 11.96 | 0.0003 |
| Stock (Subyearling vs Yearling) | 7,066 | 1 | 1,413 | 0.99 | 0.3644 * |
| Year x Stock Interaction | 7,104 | 5 | 1,421 | 3.51 | 0.0348 |
| Residual | 4,860 | 12 | 405 | | |

* Tested against Interaction because Iteraction F > 1 and Interaction p < 0.05

**Table A.2.a. 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 | 9,049 | 5 | 1,810 | 1.53 | 0.2523 |
| Stock (Subyearling vs Yearling) | 748 | 1 | 748 | 0.62 | 0.4433 * |
| Year x Stock Interaction | 6,435 | 5 | 1,287 | 1.09 | 0.4149 |
| Residual | 14,187 | 12 | 1,182 | | |
| Pooled Error | 20,623 | 17 | 1,213 | | |

* Tested against Interaction and Residual pooled because interaction F ≈ 1

**Table A.2.b. 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 | 2,802 | 5 | 560 | 2.49 | 0.0910 |
| Stock (Subyearling vs Yearling) | 9,470 | 1 | 9,470 | 50.30 | 0.0000 * |
| Year x Stock Interaction | 496 | 5 | 99 | 0.44 | 0.8122 |
| Residual | 2,704 | 12 | 225 | | |
| Pooled Error | 3,200 | 17 | 188 | | |

* Tested against Interaction and Residual pooled because interaction F < 1

**Table A.2.c. 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 | 1,497 | 5 | 299 | 1.25 | 0.3450 |
| Stock (Subyearling vs Yearling) | 21,010 | 1 | 21,010 | 36.26 | 0.0018 * |
| Year x Stock Interaction | 2,897 | 5 | 579 | 2.42 | 0.0971 |
| Residual | 2,870 | 12 | 239 | | |

* Tested against Year x Stock interaction becauce interaction F > 1 and Interaction < 0.10

## Appendix A (continued)

**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 | 9,626,159 | 5 | 1,925,232 | 72.74 | 0.0000 |
| Stock (Subyearling vs Yearling) | 564,317 | 1 | 564,317 | 2.68 | 0.1624 * |
| Year x Stock Interaction | 1,051,901 | 5 | 210,380 | 7.95 | 0.0016 |
| Residual | 317,623 | 12 | 26,469 | | |

*** Tested against Interaction because Iteraction F >> 1**

**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 | 1,900,000 | 5 | 380,000 | 15.73 | 0.0001 |
| Stock (Subyearling vs Yearling) | 32,917,919 | 1 | 32,917,919 | 21.23 | 0.0058 * |
| Year x Stock Interaction | 7,752,142 | 5 | 1,550,428 | 64.17 | 0.0000 |
| Residual | 289,939 | 12 | 24,162 | | |

*** Tested against 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[3] 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[4]

[3] 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.

[4] 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.

4. Totaling the release's expanded numbers over strata

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

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.

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

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

Equation B.3.

[5] The total number of tagged fish if estimating tagging-to-McNary survival, or the total number of tagged fish detected at their acclimation site if estimating release-to-McNary survival.

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

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

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

The denominator within brackets ([ ]) 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 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: 2013 Coho Smolt-to-Smolt Survival of Releases into the Yakima Basin

**Doug Neeley, Consultant to Yakama Nation**

### Introduction and Summary

From 2005 through 2012 there have been releases of Yakima-Return (Yakima) and Eagle-Creek-Hatchery (Eagle Creek) brood Coho smolt from several locations in the Yakima Basin, most of which were paired releases from common sites. In 2012 releases from Yakima and Yakima x Eagle Creek Cross broods were made from three sites with one site also having the Eagle Creek brood release. In nearly every paired release of Yakima and Eagle Creek broods, those from the Yakima had a higher smolt-to-smolt survival[1].

In 2013 only Yakima-brood Coho smolt were released. For this reason, there are no formal brood comparisons in this report; those comparisons from previous years are presented in the 2012 annual report. However, the estimates of those paired Yakima and Eagle Creek brood releases are given in figures and tables in this report along with the 2013 Yakima brood survivals.

### Survival Estimates based on detected Volitional Releases

With PIT-tag detectors located in the outfalls from the release sites, it is possible to partition the survival of smolt from the time of tagging to the time of McNary Dam (McNary) passage into: 1) Survival from the time of tagging to the time of release (Pre-release Survival); and 2) Survival from time of volitional release to time of McNary passage (Release-to-McNary Survival).

[1] In 2004 there were releases from Eagle Creek brood; however, Yakima-Return and Washougal brood the two stock that were paired, and the survival of the Yakima brood was higher. For survival estimates from that year, refer to the 2004 annual report. From 2001 through 2003, there were paired releases of Yakima and Willard brood, and the Yakima brood had the higher survival. In 2000 there were only Willard brood releases. In only 1999, there were paired releases of Yakima and Cascade brood, and the Cascade releases had a higher survival. For the 1999-2003 summaries refer to the 2003 annual report.

**Pre-release Survival**

Pre-release survival estimates are the estimated percentages of juveniles that survive from the time of tagging to the time of volitional release from an acclimation site pond. The estimate is the percentage of PIT-tagged smolt detected leaving the pond divided by detection efficiency of that pond's PIT-tag detector.

Prior to discussing individual pre-release survival estimates, it is necessary to discuss the two components going into the estimate of 2013 pre-release survival from Prosser. Table 1 presents the Prosser detection efficiencies, calculated from the percentage of expanded McNary Dam detections for each species that were first detected leaving Prosser ponds. Table 1 presents the percentage of tagged fish detected leaving the Prosser site for the three species of salmonids reared at Prosser. The percentage detected and the detection efficiency estimates mirrored each other for each species, both in the fact that both estimates were similar and low in value for each species and in the fact that the two estimates declined dramatically over the three mean dates[2] of release. This similarity of the estimates within species from Prosser demonstrates that the low and declining percentage detected at release was primarily due to the low detection efficiencies (not pre-release mortality or tag-shedding). The other release sites did not have the low percentage of fish detected leaving the ponds.

**Table 1. Release Dates and Detection Rates for Three Smolt Release Groups from Prosser in 2013**

| | Stock | | |
|---|---|---|---|
| **Measure** | **Fall Yearling** | **Coho** | **Fall Sub-Yearling** |
| **Mean Release Date** | 03/29/13 | 04/24/13 | 05/09/13 |
| **Prosser Detection Efficiency** | 26.68% | 5.37% | 0.53% |
| **Percentage Detected leaving Pond** | 24.65% | 4.44% | 0.61% |

Estimates of pre-release survival are presented in Table 2 and Figure 1 for all releases having release site detections and having releases of two or more of the following stocks: Yakima, Eagle Creek, or their cross.

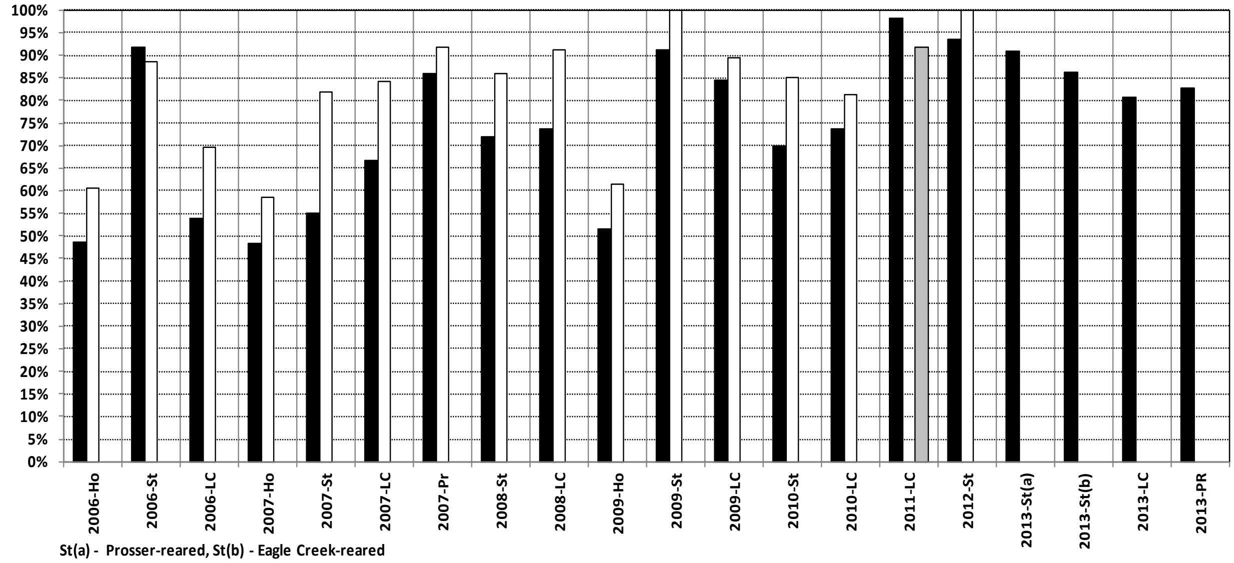
[2] The 2013 detection efficiencies at the Prosser outfall are presented for Fall Chinook and Summer Chinook as well as for Coho releases from Prosser because the fish of the three species tend to leave their acclimation ponds at different times. The low percentage detected and the low detection efficiencies hold for all for all three species, and the detection problems became progressively much worse over time: An approximate five-fold decrease in the detection rate from the Fall Chinook mean detection date to the later Coho mean detection date; and an approximate ten-fold decrease in detection rate from the Coho mean detection date to the later Summer Chinook mean detection date.

## Table 2. Outmigration-Year 2006-2013 (2004-2011 Brood) Pre-release Survival of PIT-Tagged Coho Smolt

| | | | Release-Site Subbasin and Pond within Subbasin | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Upper Yakima | | | | | Naches | | Main Stem Yakima |
| Release Year | Stock | Measure | Holmes | Boone | Cle Elum | Taneum Creek | Easton Pond | Stiles | Lost Creek | Prosser |
| **2006** | **Yakima** | **Pre-Release Survival** | **48.69%** | | | | | **91.75%** | **53.84%** | |
| | | Number Tagged | 2512 | | | | | 2490 | 2491 | |
| | **Eagle Creek** | **Pre-Release Survival** | **60.50%** | | | | | **88.55%** | **69.56%** | **80.82%** |
| | | Number Tagged | 2514 | | | | | 2506 | 2515 | 1231 |
| **2007** | **Yakima** | **Pre-Release Survival** | **48.40%** | | | | | **54.99%** | **66.81%** | **85.88%** |
| | | Number Tagged | 2460 | | | | | 2449 | 2501 | 2499 |
| | **Eagle Creek** | **Pre-Release Survival** | **58.62%** | | | | | **81.81%** | **84.26%** | **91.67%** |
| | | Number Tagged | 2504 | | | | | 2513 | 2511 | 1246 |
| **2008** | **Yakima** | **Pre-Release Survival** | | | | | | **71.98%** | **73.82%** | |
| | | Number Tagged | | | | | | 2492 | 2499 | |
| | **Eagle Creek** | **Pre-Release Survival** | | | | | | **86.02%** | **91.13%** | **100.00%** |
| | | Number Tagged | | | | | | 2453 | 2524 | 854 |
| **2009** | **Yakima** | **Pre-Release Survival** | **51.59%** | | **0.00%** | | | **91.12%** | **84.60%** | **97.56%** |
| | | Number Tagged | 2512 | | 193 | | | 2515 | 2508 | 2506 |
| | **Eagle Creek** | **Pre-Release Survival** | **61.49%** | | | | | **100.00%** | **89.56%** | |
| | | Number Tagged | 1427 | | | | | 3755 | 2331 | |
| **2010** | **Yakima** | **Pre-Release Survival** | | | | | | **69.82%** | **73.78%** | **88.26%** |
| | | Number Tagged | | | | | | 2501 | 2505 | 1371 |
| | **Eagle Creek** | **Pre-Release Survival** | | | | | | **85.03%** | **81.33%** | |
| | | Number Tagged | | | | | | 2581 | 2520 | |
| **2011** | **Yakima** | **Pre-Release Survival** | | | | * | | | **98.26%** | **100.00%** |
| | | Number Tagged | | | | 4515 | | | 2500 | 2522 |
| | **Eagle Creek** | **Pre-Release Survival** | | | | | | | | |
| | | Number Tagged | | | | | | | | |
| | **Yakima x Eagle Creek** | **Pre-Release Survival** | | | | | | **75.26%** | **91.81%** | |
| | | Number Tagged | | | | | | 1259 | 1262 | |
| **2012** | **Yakima** | **Pre-Release Survival** | | | | | | **93.59%** | **85.71%** | **79.06%** |
| | | Number Tagged | | | | | | 2526 | 2526 | 1285 |
| | **Eagle Creek** | **Pre-Release Survival** | | | | | | **100.00%** | | |
| | | Number Tagged | | | | | | 2543 | | |
| **2013** | **Yakima** | **Pre-Release Survival** | | | | | | **90.79%** | **80.73%** | **82.83%** |
| | | Number Tagged | | | | | | 2504 | 2531 | 2520 |
| | **Yakima** | **Pre-Release Survival** | | | | | | **86.19%** | | |
| | | Number Tagged | | | | | | 2505 | | |

*** 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. 2006-2013 Outmigration-Year (2004-2011 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

These are estimates of the survival of those smolt detected leaving the rearing pond that eventually pass McNary Dam (Table 3 and Figure 2). The estimate[3] is basically the percentage of those PIT-tagged smolt detected leaving the rearing pond that are later detected at McNary Dam divided by McNary's detection efficiency. That estimated McNary 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[4], whether or not the smolt were previously detected at McNary under the assumption that all Coho PIT-tag releases are well mixed prior to McNary passage.

With the small number of Coho detected leaving the Prosser Hatchery's raceways in 2013, the pre-release and Release-to-McNary survival rates from Prosser are subject to a greater degree of sampling error than those in previous years or from other release sites.

[3] The estimation is somewhat complicated in that detection efficiencies are estimated within time strata, within which there are relatively homogeneous daily detection efficiencies at McNary. Therefore the number of smolt detected at McNary is expanded within each stratum; these expanded stratum passage numbers are then added over strata. The resulting total is then divided by the number of smolt detected leaving the rearing ponds.

[4] The dams downstream of McNary dams are John Day and Bonneville Dams

## Table 3. Outmigration-Year 2006-2013 (2004-2011 Brood) Release-to-McNary Survival of PIT-Tagged Coho Smolt

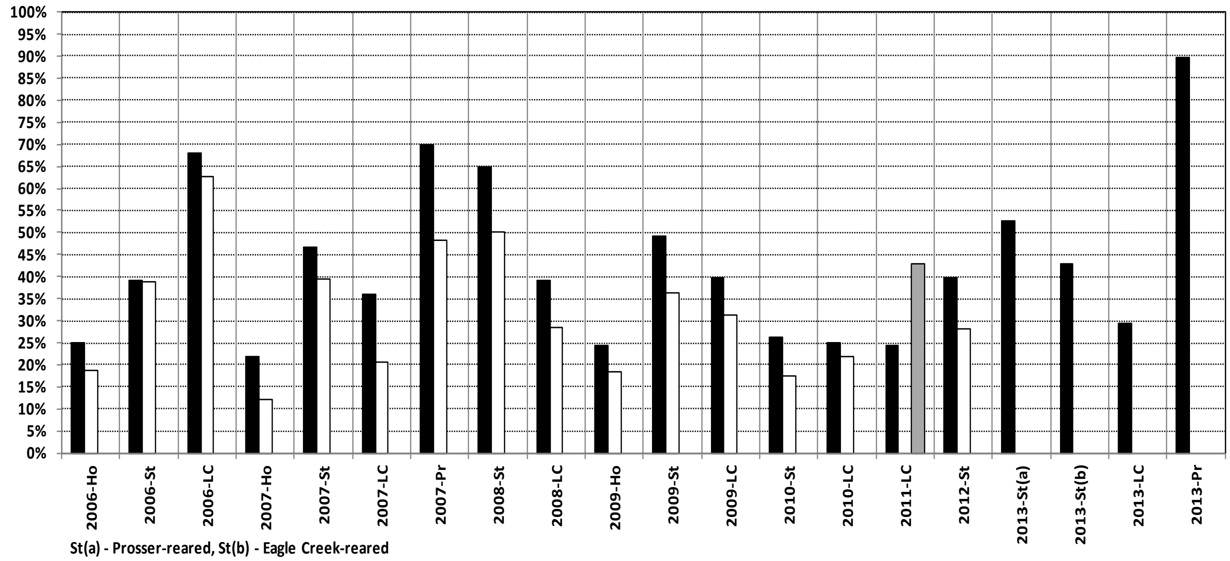
| Release Year | Stock | Measure | Release-Site Subbasin and Pond within Subbasin | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Upper Yakima | | | | | Naches | | Main Stem Yakima |
| | | | Holmes | Boone | Cle Elum | Taneum Creek | Easton Pond | Stiles | Lost Creek | Prosser |
| 2006 | Yakima | Survival from Release to McNary | 25.01% | | | | | 39.15% | 68.02% | |
| | | Number Detected at Release | 781 | | | | | 1598 | 1057 | |
| | Eagle Creek | Survival from Release to McNary | 18.62% | | | | | 38.81% | 62.66% | 74.78% |
| | | Number Detected at Release | 636 | | | | | 1974 | 1663 | 912 |
| 2007 | Yakima | Survival from Release to McNary | 22.01% | | | | | 46.76% | 35.83% | 69.75% |
| | | Number Detected at Release | 920 | | | | | 1204 | 1671 | 2112 |
| | Eagle Creek | Survival from Release to McNary | 12.02% | | | | | 39.39% | 20.68% | 48.35% |
| | | Number Detected at Release | 1293 | | | | | 1881 | 2092 | 1136 |
| 2008 | Yakima | Survival from Release to McNary | | | | | | 64.75% | 39.25% | |
| | | Number Detected at Release | | | | | | 1731 | 1633 | |
| | Eagle Creek | Survival from Release to McNary | | | | | | 50.09% | 28.37% | 5.53% |
| | | Number Detected at Release | | | | | | 2110 | 1956 | 507 |
| 2009 | Yakima | Survival from Release to McNary | 24.38% | | * | | | 49.24% | 39.61% | 58.14% |
| | | Number Detected at Release | 48 | | 193 | | | 696 | 2053 | 2299 |
| | Eagle Creek | Survival from Release to McNary | 18.29% | | | | | 36.23% | 31.32% | |
| | | Number Detected at Release | 130 | | | | | 908 | 1946 | |
| 2010 | Yakima | Survival from Release to McNary | | | | | | 26.24% | 25.10% | 81.15% |
| | | Number Detected at Release | | | | | | 1580 | 1519 | 1210 |
| | Eagle Creek | Survival from Release to McNary | | | | | | 17.41% | 21.88% | |
| | | Number Detected at Release | | | | | | 1836 | 1801 | |
| 2011 | Yakima | Survival from Release to McNary | | | | 14.46% | | | 24.31% | 36.92% |
| | | Number Detected at Release | | | | 166 * | | | 1488 | 2497 |
| | Eagle Creek | Survival from Release to McNary | | | | | | | | |
| | | Number Detected at Release | | | | | | | | |
| | Yakima x | Survival from Release to McNary | | | | | | 41.30% | 42.97% | |
| | Eagle Creek | Number Detected at Release | | | | | | 1184 | 1374 | |
| 2012 | Yakima | Survival from Release to McNary | | | | | | 39.70% | 36.59% | 47.66% |
| | | Number Detected at Release | | | | | | 929 | 1531 | 731 |
| | Eagle Creek | Survival from Release to McNary | | | | | | 28.06% | | |
| | | Number Detected at Release | | | | | | 683 | | |
| 2013 | Yakima | Survival from Release to McNary | | | | | | 52.64% | 29.47% | 89.73% |
| | | Number Detected at Release (reared at Prosser) | | | | | | 2240 | 1727 | 112* |
| | Yakima | Survival from Release to McNary | | | | | | 42.84% | | |
| | | Number Detected at Release (reared at Eagle Creek) | | | | | | 2060 | | |

Cle Elum: * No detections at NcNary

Taneum Creek: * Based on low unexpanded number (4) of pond-detected fish

Prosser: *Low detection number

**Figure 2. 2006-2013 Outmigration-Year (2004-2011 Brood-Year) Release-to-McNary Coho Survival for Release Sites having two or more of Yakima Stock (black), Eagle Creek Stock (white), or their Cross (gray)*.**




*Acclimation Sites within Release Year in Order (left to right) with sites identified: Holmes (Ho), Stiles (St), Lost Creek (LC), and Prosser (Pr).

## Estimates based on all Releases

Since not all release sites had PIT-tag detectors, the overall time-of-tagging-to-McNary survival was also estimated for each release as a consistent basis for comparing survival rates from all sites (Table 4). In Table 5 the mean Julian date of McNary passage was estimated for each release using the estimated McNary passage dates for all PIT-tagged fish. Both the Release-to-McNary and the Tagging-to-McNary survival estimates from respective Tables 2 and 3 use the same stratified detection-efficiency estimates.

## Tagging to McNary Dam Survival

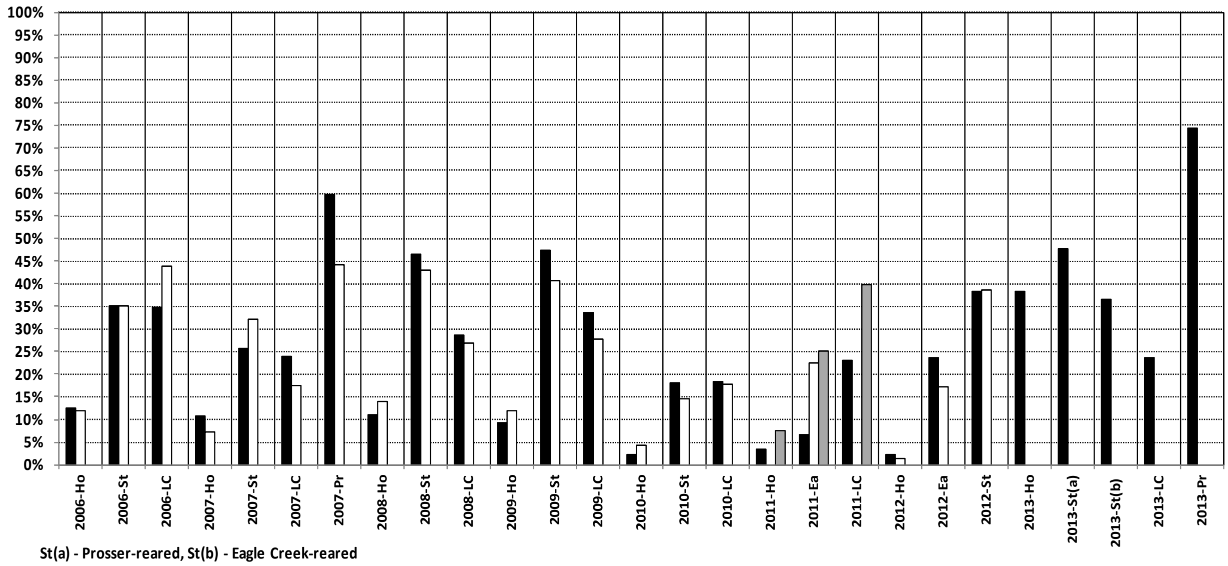
Estimates of Tagging-to-McNary Survival are presented in Table 4 for all releases and in Figure 3 for those sites having two or more of Yakima Stock, Eagle Creek Stock, or their cross.

### Table 4. Outmigration-Year 2006-2013 (2004-2011 Brood) Time of Tagging-to-McNary Survival of PIT-Tagged Coho Smolt

| | | | Release-Site Subbasin and Pond within Subbasin | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Upper Yakima | | | | | | Naches | | Main Stem Yakima |
| | Stock | Measure | Holmes | Boone | Cle Elum | Taneum Creek | Easton Pond | Dam bypass | Stiles | Lost Creek | Prosser |
| 2006 | Yakima | Tagging-to-McNary Survival | 12.48% | 3.69% | | | | | 34.99% | 34.76% | |
| | | NumberTagged | 2512 | 2501 | | | | | 2490 | 2491 | |
| | Eagle Creek | Tagging-to-McNary Survival | 11.82% | 2.57% | | | | | 35.05% | 43.81% | 60.52% |
| | | NumberTagged | 2514 | 2500 | | | | | 2506 | 2515 | 1231 |
| 2007 | Yakima | Tagging-to-McNary Survival | 10.77% | | | | | | 25.65% | 23.94% | 59.84% |
| | | NumberTagged | 2460 | | | | | | 2449 | 2501 | 2499 |
| | Eagle Creek | Tagging-to-McNary Survival | 7.08% | | | | | | 32.07% | 17.39% | 44.30% |
| | | NumberTagged | 2504 | | | | | | 2513 | 2511 | 1246 |
| 2008 | Yakima | Tagging-to-McNary Survival | 11.17% | | | | | | 46.59% | 28.58% | |
| | | NumberTagged | 2493 | | | | | | 2492 | 2499 | |
| | Eagle Creek | Tagging-to-McNary Survival | 13.89% | | | | 41.45% | | 43.08% | 26.76% | 20.13% |
| | | NumberTagged | 2508 | | | | 2500 | | 2453 | 2524 | 854 |
| 2009 | Yakima | Tagging-to-McNary Survival | 9.19% | | 0.21% | 15.67% | | | 47.27% | 33.70% | 56.76% |
| | | NumberTagged | 2512 | | 11934 | 1300 | | | 2515 | 2508 | 2506 |
| | Eagle Creek | Tagging-to-McNary Survival | 12.01% | | | | 16.38% | | 40.80% | 27.76% | |
| | | NumberTagged | 1427 | | | | 2524 | | 3755 | 2331 | |
| 2010 | Yakima | Tagging-to-McNary Survival | 2.26% | | | 9.89% | | | 18.17% | 18.45% | 71.49% |
| | | Number Tagged | 2516 | | | 1867 | | | 2501 | 2505 | 1371 |
| | Eagle Creek | Tagging-to-McNary Survival | 4.29% | 3.41% | | | 9.10% | | 14.43% | 17.76% | |
| | | Number Tagged | 2504 | 1265 | | | 2532 | | 2581 | 2520 | |
| 2011 | Yakima | Tagging-to-McNary Survival | 3.46% | | | 13.64% | 6.74% | | | 23.10% | 37.19% |
| | | Number Tagged | 2516 | | | 4515 | 1272 | | | 2500 | 5036 |
| | Eagle Creek | Tagging-to-McNary Survival | | | | | 22.40% | | | | |
| | | Number Tagged | | | | | 2561 | | | | |
| | Yakima x | Tagging-to-McNary Survival | 7.42% | | | | 24.99% | | 28.42% | 39.85% | |
| | Eagle Creek | Number Tagged | 2506 | | | | **2522** | | 2524 | 2514 | |
| 2012 | Yakima | Tagging-to-McNary Survival | 2.31% | | | 26.48% | 23.64% | | 38.38% | 31.36% | 37.68% |
| | | Number Tagged | 2508 | | | 1054 | 1258 | | 1285 | 2526 | 1285 |
| | Yakima* | Tagging-to-McNary Survival | | | | | 14.80% | | | | |
| | | Number Tagged | | | | | 2547 | | | | |
| | Eagle Creek | Tagging-to-McNary Survival | 1.40% | | | | 17.11% | | 38.49% | | |
| | | Number Tagged | 2453 | | | | **1294** | | 1260 | | |
| 2013 | Yakima | Tagging-to-McNary Survival | | | | | | 50.89% | 47.82% | 23.56% | 74.32% |
| | | Number Tagged (reared at Prosser) | | | | | | 1221 | 2504 | 2531 | 2520 |
| | Yakima | Tagging-to-McNary Survival | 38.39% | | | | 32.85% | | 36.70% | | |
| | | Number Tagged (reared at Eagle Creek) | 1263 | | | | 2495 | | 2505 | | |

* Reared at Egle Creek

**Figure 3. 2006-2013 Outmigration-Year (2004-2011 Brood-Year) Time-of-Tagging-to-McNary Coho Survival for Release Sites having two or more of Yakima Stock (black), Eagle Creek Stock (white), or their Cross (gray)*.**




*Acclimation Sites within Release Year in Order (left to right): Holmes (Ho), Boone's Pond (Bo) 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 PIT-tagged smolt (whether or not they were previously detected leaving the rearing ponds), the expanded number being the date's detected passage divided by the McNary's detection efficiency associated with that passage date. These weighted dates were then added over days and then divided by the total of the expanded daily passages.

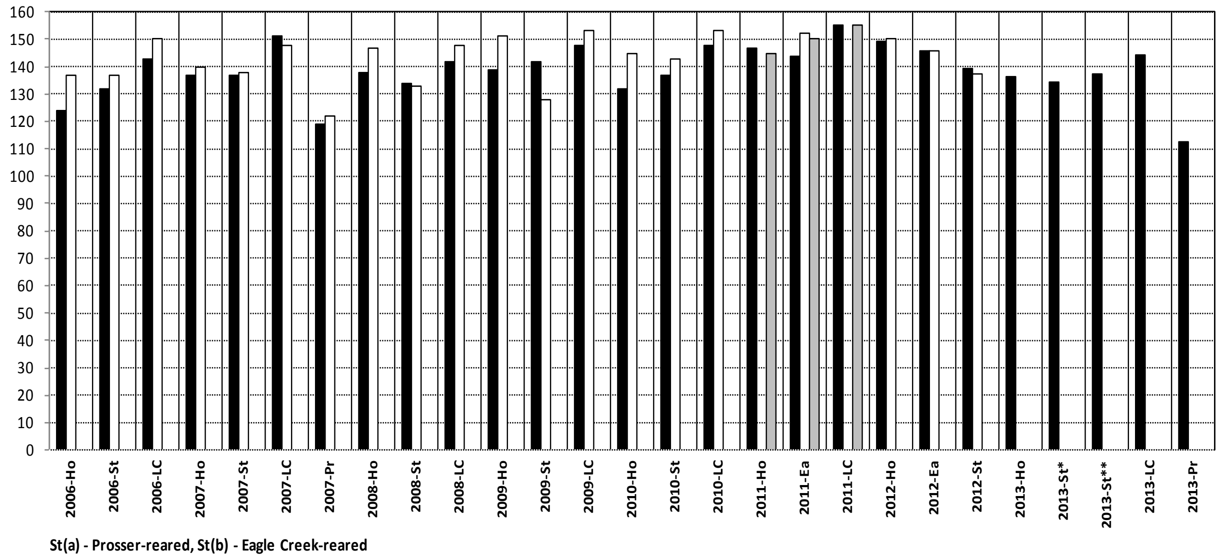
Estimates of Julian Date of McNary passage are presented in Table 5 for all releases and in Figure 4 for those sites having two or more of Yakima Stock, Eagle Creek Stock, or their cross.

**Table 5. Outmigration-Year 2006-2013 (2004-2011 Brood) Mean McNary Date of Passage of PIT-Tagged Coho Smolt**

| | | | Release-Site Subbasin and Pond within Subbasin | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Upper Yakima | | | | | | Naches | | Main Stem Yakima |
| Release Year | Stock | Measure | Holmes | Boone | Cle Elum | Taneum Creek | Easton Pond | Dam bypass | Stiles | Lost Creek | Prosser |
| 2006 | Yakima | Julian Passage Date | 124 | 133 | | | | | 132 | 143 | |
| | | Expanded McNary Passage | 313 | 92 | | | | | 871 | 865 | |
| | Eagle Creek | Julian Passage Date | 137 | 144 | | | | | 137 | 150 | 122 |
| | | Expanded McNary Passage | 297 | 64 | | | | | 878 | 110 | 744 |
| 2007 | Yakima | Julian Passage Date | 137 | | | | | | 137 | 151 | 119 |
| | | Expanded McNary Passage | 265 | | | | | | 628 | 598 | 1495 |
| | Eagle Creek | Julian Passage Date | 140 | | | | | | 138 | 148 | 122 |
| | | Expanded McNary Passage | 177 | | | | | | 805 | 436 | 552 |
| 2008 | Yakima | Julian Passage Date | 138 | | | | | | 134 | 142 | |
| | | Expanded McNary Passage | 278 | | | | | | 116 | 714 | |
| | Eagle Creek | Julian Passage Date | 147 | | | | 135 | | 133 | 148 | 142 |
| | | Expanded McNary Passage | 348 | | | | 1036 | | 105 | 675 | 171 |
| 2009 | Yakima | Julian Passage Date | 139 | | 164 | 160 | | | 142 | 148 | 133 |
| | | Expanded McNary Passage | 230 | | 25 | 204 | | | 1188 | 845 | 1422 |
| | Eagle Creek | Julian Passage Date | 151 | | | | 147 | | 128 | 153 | |
| | | Expanded McNary Passage | 171 | | | | 413 | | 1532 | 647 | |
| 2010 | Yakima | Julian Passage Date | 132 | | | 168 | | | 137 | 148 | 118 |
| | | Expanded McNary Passage | 57 | | | 185 | | | 454 | 462 | 980 |
| | Eagle Creek | Julian Passage Date | 145 | 155 | | | 144 | | 143 | 153 | |
| | | Expanded McNary Passage | 108 | 43 | | | 143 | | 372 | 447 | |
| 2011 | Yakima | Julian Passage Date | 147 | | | 162 | 144 | | | 155 | 124 |
| | | Expanded McNary Passage | 2516 | | | 4515 | 1272 | | | 2500 | 5036 |
| | Eagle Creek | Julian Passage Date | | | | | 152 | | | | |
| | | Expanded McNary Passage | | | | | 2561 | | | | |
| | Yakima x | Julian Passage Date | 145 | | | | 150 | | 143 | 155 | |
| | Eagle Creek | Expanded McNary Passage | 2506 | | | | 2522 | | 2524 | 2514 | |
| 2012 | Yakima | Julian Passage Date | 149 | | | | 146 | | 139 | 123 | 124 |
| | | Expanded McNary Passage | 58 | | | | 538 | | 939 | 792 | 484 |
| | Yakima* | Julian Passage Date | | | | | 148 | | | | |
| | | Expanded McNary Passage | | | | | 377 | | | | |
| | Eagle Creek | Julian Passage Date | 150 | | | | 146 | | 137 | | |
| | | Expanded McNary Passage | 65 | | | | 496 | | 1001 | | |
| 2013 | Yakima | Julian Passage Date | | | | | | 124 | 134 | 144 | 113 |
| | | Expanded McNary Passage (reared at Prosser) | | | | | | 621 | 1197 | 596 | 1873 |
| | Yakima | Julian Passage Date | 137 | | | | 140 | | 138 | | |
| | | Expanded McNary Passage (reared at Eagle Creek) | 485 | | | | 820 | | 919 | | |

* Reared at Eagle Creek

**Figure 4. 2006-2013 Outmigration-Year (2004-2011 Brood-Year) Mean Julian Date of McNary Passage for Release Sites having two or more of Yakima Stock (black), Eagle Creek Stock (white), or their Cross (gray)*.**




*Acclimation Sites within Release Year in Order (left to right): Holmes (Ho), Boone's Pond ((b0) Stiles (St), and Lost Creek (LC), and Prosser (Pr)

## In-Stream and Mobile-Raceway Releases

Scatter-plants of parr directly into streams and rivers and volitional releases of smolt from mobile acclimation raceways began with outmigration year 2010. (In-stream parr releases from 2009 through 2012 belong to the same outmigration years as smolt releases from 2010 through 2013.) There was no detection at release for any of these groups; survival rates were computed for all tagged fish using the same procedures used for the estimates given in Table 3.

Tagging-to-McNary survival estimates are given in Table 6, and mean McNary passage dates are given in Table 7.

## Table 6. Outmigration-Year 2010-2013 In-Stream and Mobile-Raceway 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 | |
| | | Tagging to McNary Survival | 8.18% | 12.06% | 69.42% | 13.79% | 23.29% | 17.25% | |
| | | Number Tagged | 1144 | 3053 | 16 | 3055 | 1248 | 3004 | |
| | | Pooled Survival | 11.00% | | 14.08% | | 19.02% | | |
| | | Pooled Number Tagged | 4197 | | 3071 | | 4252 | | |
| 2011 | Yakima | File Extender | | PLR-Parr | WNL-Parr * | PNL-Parr | MCW-Smolt | PCW-Parr | WCW-Parr* |
| | | Tagging to McNary Survival | | 7.97% | 69.45% | 7.46% | 31.50% | 19.54% | 81.99% |
| | | Number Tagged | | 3000 | 16 | 3110 | 1272 | 3021 | 28 |
| | | Pooled Survival | | | 7.78% | | 23.08% | | |
| | | Pooled Number Tagged | | | 3126 | | 4293 | | |
| 2012 | Yakima | | Rattlesnake | | | | | | |
| | | File Extender | MRS-Smolt | PLR-Parr | | PNL-Parr | MCW-Smolt | PCS-Parr | |
| | | Tagging to McNary Survival | 16.22% | 8.39% | | 8.28% | 41.05% | 11.86% | |
| | | Number Tagged | 1274 | 3006 | | 3017 | 1277 | 3024 | |
| | | Pooled Survival | 10.72% | | | | 20.52% | | |
| | | Pooled Number Tagged | 4280 | | | | 4301 | | |
| 2013 | Yakima | File Extender | MRA | PRS | | PNL | MCW | | PCW |
| | | Tagging to McNary Survival | 11.34% | 3.82% | | 4.72% | 19.87% | | 9.84% |
| | | Number Tagged | 2506 | 3002 | | 3033 | 3464 | | 3003 |
| | | Pooled Survival | 7.24% | | | | | | |
| | | Pooled Number Tagged | 5508 | | | | | | |

* High percent survival based on very small sample sizes

## Table 6 (cont) Outmigration-Year 2010-2013 In-Stream and Mobile-Raceway Tagging Release-to-McNary Survival

| Release Year | Stock | Measure | Ahtanum | | Big Creek | Reecer | Lost Creek | Umtanum Creek | Wilson | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | Yakima | File Extender | PAH-Parr | | PBG-Parr | PRC-Parr | | UMT | PWL-Parr | |
| | | Tagging to McNary Survival | 20.18% | | 10.49% | 21.47% | | 44.32% | 11.32% | |
| | | Number Tagged | 3050 | | 3006 | 3015 | | 150 | 3050 | |
| 2011 | Yakima | File Extender | PAH-Parr | | PBG-Parr | PRC-Parr | WLC-Parr * | UMT-Parr * | PWL-Parr | |
| | | Tagging to McNary Survival | 18.87% | | 15.81% | 29.61% | 57.39% | 34.95% | 16.93% | |
| | | Number Tagged | 3003 | | 3003 | 3004 | 10 | 42 | 2522 | |
| 2012 | Yakima | File Extender | PAL-Parr | | PBG-Parr | PRE-Parr | | | PWI-Parr | |
| | | Tagging to McNary Survival | 5.42% | | 11.59% | 19.43% | | | 11.02% | |
| | | Number Tagged | 4003 | | 3013 | 3026 | | | 3020 | |
| | | | | | | | | | Burried Section-Parr | |
| | | | | | | | | | Above | Below |
| 2013 | Yakima | File Extender | PAL-Parr | PAM-Parr | PBG-Parr | PRE-Parr | | | PWA | PWB |
| | | Tagging to McNary Survival | 10.66% | 6.81% | 7.45% | 13.75% | | | 4.55% | 10.71% |
| | | Number Tagged | 600 | 1213 | 3028 | 3032 | | | 1518 | 1502 |

*** 2011 WLC and UMT high percent based on very small sample size**

## Table 6 (cont) Outmigration-Year 2010-2013 In- Stream and Mobile-Raceway Tagging Release-to-McNary Survival

| Release Year | Stock | Measure | Rock Creek | Buckskin | Quartz Creek | @ Thorp Bridge | Taneum Creek | Little Naches | NF Little Naches | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | | | | | | | TAN | | | | |
| | | | | | | | 15.67% | | | | |
| | | | | | | | 1300 | | | | |
| 2010 | Yakima | File Extender | WRK-Wild | | | | TAN-Parr | PLN-Parr | PNF-Parr | | |
| | | Tagging to McNary Survival | 0.00% | | | | 9.89% | 17.87% | 19.72% | | |
| | | Number Tagged | 78 | | | | 1867 | 3072 | 3014 | | |
| 2011 | Yakima | File Extender | | WBK-Parr | | | TAN | PLN-Parr | PNF-Parr | | |
| | | Tagging to McNary Survival | | 37.95% | | | 13.64% | 9.54% | 17.59% | | |
| | | Number Tagged | | 216 | | | 4515 | 3022 | 3058 | | |
| 2012 | Yakima | File Extender | | | PQU-Parr | PYA-Parr | COT | PLN-Parr | PNF-Parr | Mercer Creek | |
| | | Tagging to McNary Survival | | | 12.09% | 10.68% | 26.48% | 21.91% | 19.12% | Burried Section-Parr | |
| | | Number Tagged | | | 3008 | 2499 | 1054 | 3014 | 3028 | Above | Below |
| 2013 | Yakima | File Extender | | | PQU | | RTA | PLN | PNF | PMA | PMB |
| | | Tagging to McNary Survival | | | 4.60% | | 12.40% | 7.48% | 10.90% | 15.61% | 16.46% |
| | | Number Tagged | | | 3007 | | 743 | 3019 | 3012 | 1502 | 1502 |

*** 2010 and 2011 WNL high percent based on very small sample size**

## Table 7. Outmigration-Year 2010-2013 In-Stream and Mobile-Raceway Mean Juvenile Detection Date

| Release Year | Stock | Measure | Little Rattlesnake | | Nile | | SF Cowiche | | Cowiche |
|---|---|---|---|---|---|---|---|---|---|
| 2010 | Yakima | File Extender | Smolt | PRS-Parr | WNL-Parr | PNL-Parr | Smolt | PCW-Parr | |
| | | Mean Detection Date | 166 | 155 | 171 | 159 | 149 | 166 | |
| | | Expanded McNary Passage | 94 | 368 | 11 | 421 | 1248 | 3004 | |
| | | Pooled Date | 157 | | 159 | | 161 | | |
| | | Pooled Passage | 462 | | 432 | | 4252 | | |
| 2011 | Yakima | File Extender | | PLR-Parr | WNL-Parr | PNL-Parr | Smolt | PCW-Parr | Parr |
| | | Mean Detection Date | | 154 | 165 | 163 | 156 | 162 | 144 |
| | | Expanded McNary Passage | | 239 | 11 | 232 | 401 | 590 | 23 |
| | | Pooled Date | | | 163 | | 160 | | |
| | | Pooled Passage | | | 243 | | 991 | | |
| | | | Rattlesnake | | | | | | |
| 2012 | Yakima | File Extender | MRS-Smolt | PLR-Parr | | PNL-Parr | MCW-Smolt | PCS-Smolt | |
| | | Mean Detection Date | 147 | 155 | | 157 | 147 | 155 | |
| | | Expanded McNary Passage | 207 | 252 | | 250 | 524 | 359 | |
| | | Pooled Date | | | | | 150 | | |
| | | Pooled Passage | | | | | 883 | | |
| 2013 | Yakima | File Extender | MRA | PRS | | PNL | Smolt | | PCW |
| | | Mean Detection Date | 138 | 143 | | 156 | 143 | | 153 |
| | | Expanded McNary Passage | 2506 | 3002 | | 3033 | 3464 | | 3003 |
| | | Pooled Survival | 140 | | | | | | |
| | | Pooled Number Tagged | 5508 | | | | | | |

## Table 7 (cont) Outmigration-Year 2010-2013 In-Stream and Mobile-Raceway Mean Juvenile Detection Date

| Release Year | Stock | Measure | Ahtanum | | Big Creek | Reecer | Lost Creek | Umtanum Creek | Wilson | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | Yakima | File Extender | PAH-Parr | | PBG-Parr | PRC-Parr | | UMT | PWL-Parr | |
| | | Mean Detection Date | 163 | | 160 | 145 | | 143 | 141 | |
| | | Expanded McNary Passage | 616 | | 315 | 647 | | 66 | 345 | |
| 2011 | Yakima | File Extender | PAH-Parr | | PBG-Parr | PRC-Parr | WLC-Parr | UMT-Parr | PWL-Parr | |
| | | Mean Detection Date | 156 | | 156 | 124 | 136 | 137 | 122 | |
| | | Expanded McNary Passage | 567 | | 475 | 890 | 6 | 15 | 427 | |
| 2012 | Yakima | File Extender | PAL-Parr | | PBG-Parr | PRE*-Parr | | | PWI-Parr | |
| | | Mean Detection Date | 151 | | 152 | 145 | | | 144 | |
| | | Expanded McNary Passage | 217 | | 349 | 588 | | | 333 | |
| | | | | | | | | | Burried Section | |
| | | | | | | | | | Above | Below |
| 2013 | Yakima | File Extender | PAL-Parr | PAM | PBG | PRE | | | PWA | PWB |
| | | Mean Detection Date | 121 | 146 | 147 | 140 | | | 152 | 147 |
| | | Expanded McNary Passage | 64 | 83 | 225 | 417 | | | 69 | 161 |

## Table 7 (cont)Outmigration-Year 2010-2013 In-Stream and Mobile-Raceway Mean Juvenile Detection Date

| Release Year | Stock | Measure | Rock Creek | Buckskin | Quarts | Taneum Creek | Yakima @ Thorp Bridge | Little Naches | NF Little Naches | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | | File Extender | | | | TAN | | | | | |
| | | Mean Detection Date | | | | 160 | | | | | |
| | | Expanded McNary Passage | | | | 204 | | | | | |
| 2010 | Yakima | File Extender | WRK-Wild | | | TAN-Parr | | PLN-Parr | PNF-Parr | | |
| | | Mean Detection Date | n.a. | | | 168 | | 163 | 160 | | |
| | | Expanded McNary Passage | 0 | | | 185 | | 549 | 594 | | |
| 2011 | Yakima | File Extender | | WBK-Parr | | TAN | | PLN-Parr | PNF-Parr | | |
| | | Mean Detection Date | | 135 | | 163 | | 163 | 166 | | |
| | | Expanded McNary Passage | | 82 | | 616 | | 288 | 538 | | |
| 2012 | Yakima | File Extender | | | PQU-Parr | COT | PYA-Parr | PLN-Parr | PNF-Parr | Mercer Creek | |
| | | Mean Detection Date | | | 154 | 146 | 148 | 152 | 146 | Burried Section-Parr | |
| | | Expanded McNary Passage | | | 364 | 279 | 267 | 660 | 579 | Above | Below |
| 2013 | Yakima | File Extender | | | | | | PLN | PNF | PMA | PMB |
| | | Mean Detection Date | | | | | | 153 | 156 | 150 | 140 |
| | | Expanded McNary Passage | | | | | | 3019 | 3012 | 234 | 247 |