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YAKIMA/KLICKITAT FISHERIES PROJECT MONITORING AND EVALUATION

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THE CONFEDERATED TRIBES AND BANDS OF THE YAKAMA NATION

FINAL REPORT
For the Performance Period
May 1, 2010 through April 30, 2011

Submitted: August 12, 2011

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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. Using principles of adaptive management, 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 dire situation of many salmon and steelhead stocks, and the heavy reliance on artificial propagation as a recovery tool, YKFP monitoring results will 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 + naturally-producing component) to a level that compensates for the high mortalities imposed by human development activities and fully seeds the natural environment.

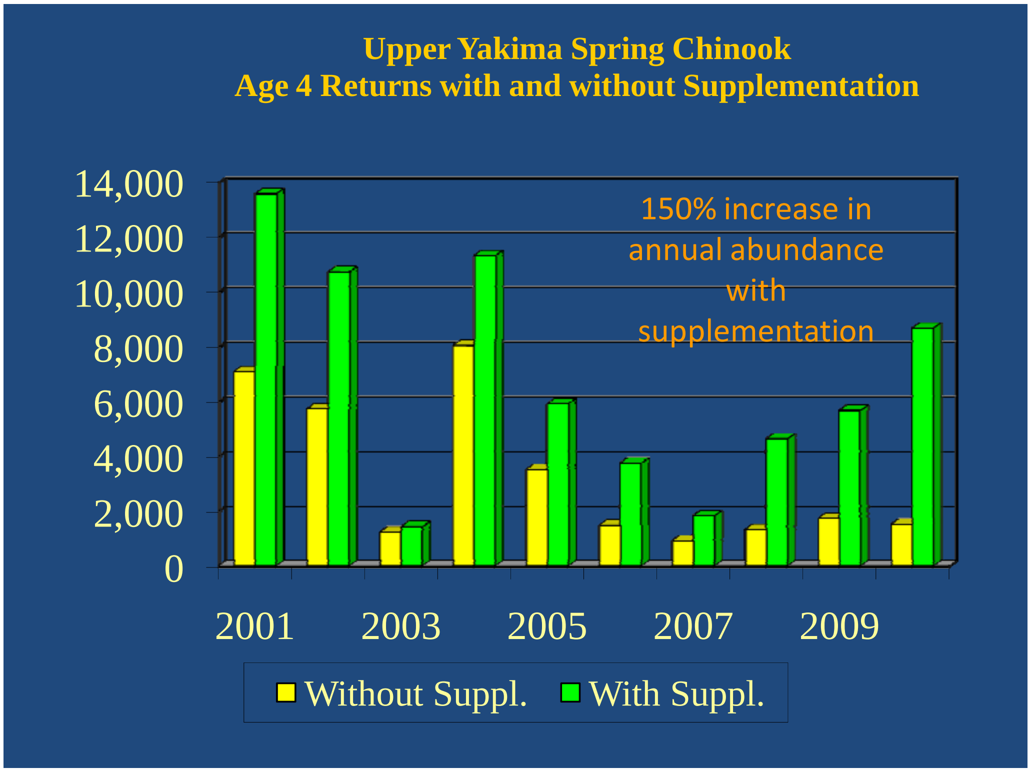
The objectives of the YKFP are to: use Ecosystem Diagnosis and Treatment (EDT) and other modeling tools to facilitate planning for project activities, enhance existing stocks, re-introduce extirpated stocks, protect and restore habitat in the Yakima Subbasin, and operate using a scientifically rigorous process that will foster application of the knowledge gained about hatchery supplementation and habitat restoration throughout the Columbia River Basin. The YKFP is still in the early stages of evaluation, and as such the data and findings presented in this report should be considered preliminary until results are published in the peer-reviewed literature. The following is a brief summary of current YKFP activities by species.

Spring Chinook

The Cle Elum Supplementation and Research Facility (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, with the first F2 generation (offspring of CESRF and wild fish spawning in the wild) returning as adults in 2005. In these initial years of CESRF operation, recruitment of hatchery origin fish has exceeded that of fish spawning in the natural environment (BPA annual reports). Preliminary results indicate that significant differences have been detected among hatchery and natural origin fish in about half of the traits measured in our monitoring plan and that these differences can be attributed to both environmental and genetic causes. For example, we have detected differences in hatchery and natural origin fish after only one generation of hatchery exposure for the following variables measured on adults: age composition, size-at-age, sex ratio, spawning timing, fecundity, egg weight, and adult morphology at spawning (Busack et al. 2007; Knudsen et al. 2006, 2008). With respect to spawning success, 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). Significant differences in juvenile traits have also been detected: emergence timing and size of progeny, food conversion efficiency, length-weight relationships, agonistic competitive behavior, predator avoidance, and incidence of precocious maturation (Beckman et al. 2008; BPA annual reports; Larsen et al. 2004, 2006). Most of the differences have been 10% or less.

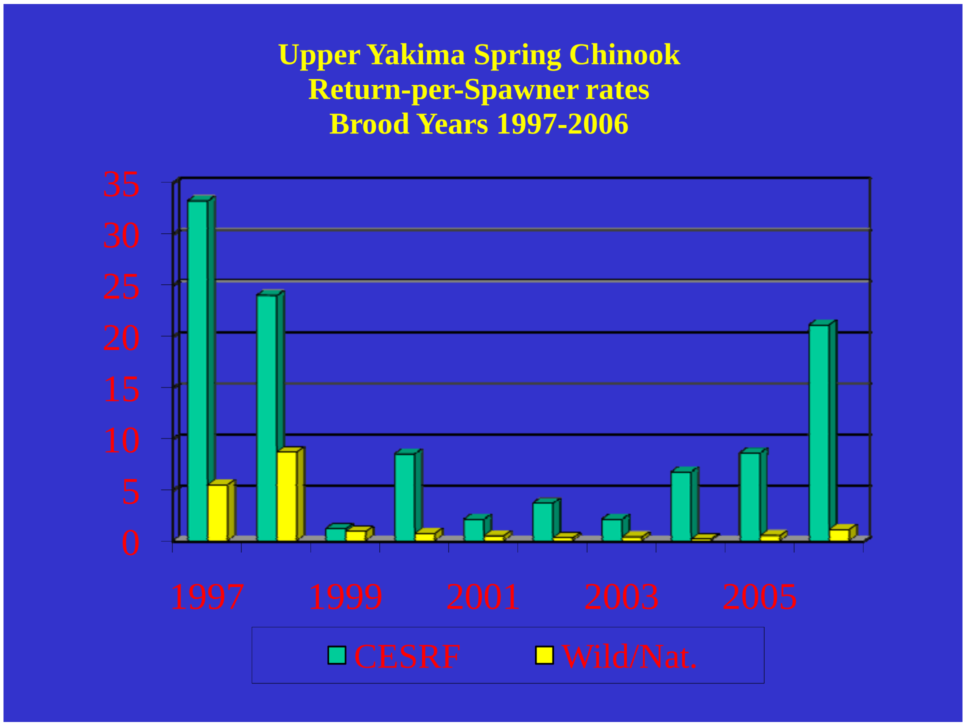
Redd counts in the 2001-2010 period have increased significantly in both the supplemented Upper Yakima and Naches control systems relative to the pre-supplementation period (1981-2000), but the average increase in redd counts in the upper Yakima (245%) was substantially greater than that observed in the Naches system (160%; BPA annual reports). Spatial distribution of spawners has also increased as a result of acclimation site location, salmon homing fidelity and more fully seeding preferred spawning habitats (Dittman et al. 2010). Semi-natural rearing and predator avoidance training have not resulted in significant increases in survival of hatchery fish (Fast et al. 2008; BPA annual reports). Growth manipulations in the hatchery appear to be reducing the number of precocious males produced by the YKFP and consequently increasing the number of migrants, however post-release survival of treated fish appears to be significantly lower than conventionally reared fish (Larsen et al. 2006; Pearsons et al. 2009; BPA annual reports). Genetic impacts to non-target populations appear to be low because of the low stray rates of YKFP fish (BPA annual reports). Ecological impacts to valued non-target taxa were generally within containment objectives, or impacts that were outside of containment objectives were not caused by supplementation activities (Pearsons and Temple 2007; BPA annual reports). Changes to rainbow trout abundance and biomass were observed in a tributary watershed where hatchery-origin fish were released, but the trout may have been simply displaced to other areas (Pearsons and Temple 2010). Fish and bird piscivores consume large numbers of salmonids in the Yakima Basin (Fritts and Pearsons 2006; BPA annual reports). Natural production of Chinook salmon in the upper Yakima Basin appears to be density dependent under current conditions and may constrain the benefits of supplementation (BPA annual reports). However, such constraints could be countered by YKFP habitat actions (see summary below). Additional habitat improvements implemented by other entities, including the Conservation Districts, counties and private interests are also continuing in the basin. Harvest opportunities for tribal and non-tribal fishers have also been enhanced, but are variable among years (BPA annual reports).

Figure 1. Actual returns (green bar) of age-4 Upper Yakima spring Chinook to the Yakima River mouth compared to estimated returns (yellow bar) if the Cle Elum Supplementation and Research Facility (CESRF) had not been constructed. Data are for age-4 return years 2001-2010.



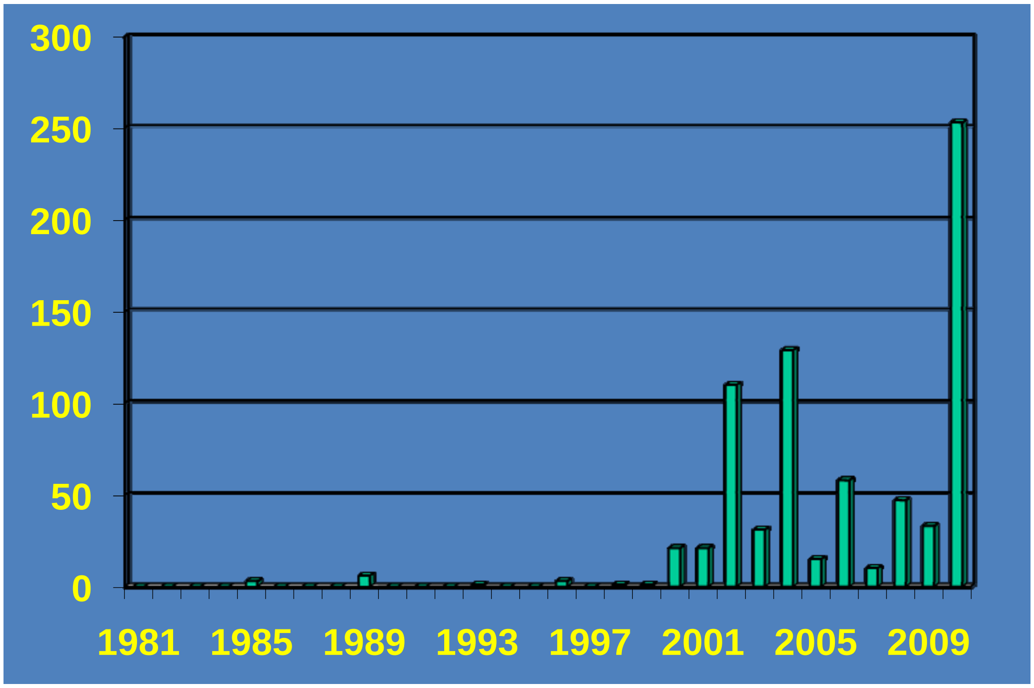
Methods and Discussion: For all years, actual returns with supplementation (green bars) are derived from actual counts of marked (CESRF) and unmarked (wild/natural) fish at Roza Dam backed through harvest to the Yakima River mouth. For F1 returns (returns from wild fish spawned in the hatchery) in 2001-2004, the yellow bars (estimated returns without supplementation) are calculated as the actual returns of unmarked (wild) fish at Roza backed to the river mouth plus estimated returns from fish taken for CESRF broodstock had these fish been allowed to spawn in the wild and returned at observed wild/natural return per spawner rates. For F2 and later generation returns from 2005 forward (where wild/natural returns are comprised of crosses of wild/natural and CESRF fish spawning together in the wild), estimated returns without supplementation are calculated as if the estimated "without supplementation" return four years earlier had been the total escapement, spawned in the wild, and their progeny returned at observed wild/natural return per spawner rates. Using this method the estimated benefit (increase in abundance of natural spawners) from supplementation ranged from 15% in return year 2003 to 470% in return year 2010 and averaged 150% from 2001-2010.

Figure 2. Yakima River mouth return per spawner (adult-to-adult productivity) rates of Cle Elum Supplementation and Research Facility (CESRF) and wild/natural upper Yakima spring Chinook for brood years 1997-2006. Note: Age-5 returns are not yet included for brood year 2006.



Methods and Discussion: Return per spawner rates for both CESRF and wild/natural upper Yakima spring Chinook are calculated using standard run reconstruction and brood/cohort methods from counts of marked (CESRF) and unmarked (wild/natural) fish at Roza Dam, age data from scale samples taken at Roza Dam, and in-basin harvest data. The CESRF is resulting in increased abundance of spring Chinook on the natural spawning grounds even in years when wild/natural productivity rates are less than 1.

Figure 3. Teanaway River Spring Chinook Redd Counts, 1981 – 2010.



Methods and Discussion: Redd surveys in the Teanaway River have been conducted annually by Yakama Nation staff since 1981. 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 76 redds per year. In addition, the number of natural origin spawners has increased in the targeted Teanaway River indicating this approach may be successful for reintroduction of salmonids into underutilized habitat.

For detailed data and supporting information, see Appendix A of this report and the references to WDFW reports shown under tasks 1.b, 1.k, 1.l, 3.a-3.b, and 4.c-4.d of this report.

Fall Chinook

The YKFP is presently studying the release of over 2.0 million Upriver Bright fall Chinook smolts annually from the Prosser Hatchery. These fish are a combination of in-basin production from brood stock collected in the vicinity of Prosser Dam plus out-of-basin Priest Rapids stock fish reared at Little White National Fish Hatchery and moved to Prosser Hatchery for final rearing and release. These fish contributed to the improved returns of fall Chinook to the Columbia River in recent years. The YKFP is investigating ways to improve the productivity of fish released from Prosser

Hatchery and to improve in-basin natural production of fall Chinook. For example, rearing conditions designed to accelerate smoltification of Yakima Basin fall Chinook have resulted in smolt-to-smolt survival indices that exceeded those of conventionally reared fall Chinook in five of the six years for which results are available.

A Master Plan is being developed that proposes to: 1) transition out-of-basin brood source releases from the Little White Salmon National Fish Hatchery to Priest Rapids Hatchery and release these fish from acclimation sites in the lower Yakima River below Horn Rapids Dam, 2) continue development of an integrated production program above Prosser Dam using locally collected brood stock, 3) re-establish a summer-run component using an appropriate founder stock, and 4) upgrade existing brood collection, production and acclimation facilities to accommodate changes in production strategies. The total number of fish released would remain similar to existing levels.

Coho

The YKFP is presently studying the release of over 1.0 million coho smolts annually from acclimation sites in the Naches and Upper Yakima subbasins. These fish are a combination of in-basin production from brood stock collected in the vicinity of Prosser Dam plus out-of-basin stock generally reared at Willard or Eagle Creek National Fish Hatcheries and moved to the Yakima Subbasin for final rearing and release. YKFP monitoring of these efforts to re-introduce a sustainable, naturally spawning coho population in the Yakima Basin have indicated that adult coho returns averaged about 3,700 fish from 1997-2010 (an order of magnitude greater than the average for years prior to the project) including estimated returns of wild/natural coho averaging over 1,400 fish since 2001. 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 broodstock and to establish specific release sites and strategies that optimize natural reproduction and survival.

Habitat

The project objectives include habitat protection and restoration in the most productive reaches of the Yakima Subbasin. Major accomplishments to date include protection of 1,812 acres of floodplain habitat, reconnection and screening of over 50 miles of tributary habitat, substantial water savings through irrigation improvements, and restoration of over 80 acres of mainstem Yakima River floodplain and side channels. Substantial restoration has been completed in the Taneum watershed, where over 1200 pieces of large woody material have been placed at 50 sites and artificial floodplain berms have been removed. A defunct bridge and all approach fill has also been removed. Restoration designs in middle Swauk Creek are complete, with implementation scheduled for this summer. Designs for lower Swauk are 60% complete, and will be completed once the contract amendment has been approved. The project continues to promote relocating a portion of a USFS road in the little Naches watershed. In the future, the project will work within available funding and personnel capacity to design and implement the highest priority restoration and protection projects for the benefit of anadromous salmonids.

Research

One of the YKFP's primary objectives is to provide knowledge about hatchery supplementation to resource managers and scientists throughout the Columbia River Basin, to determine if it may be used to mitigate effects of hydroelectric operations on anadromous fisheries. To facilitate this objective, the Project created a Data and Information Center (Center) in 1999. The Center's purpose is to gather, synthesize, catalogue, and disseminate data and information related to project research and production activities. Dissemination of accumulated project information occurs through the Project Annual Review (PAR) conference, the project web site (ykfp.org), other regional websites (e.g., DART, RMPC, PTAGIS, and Streamnet), numerous technical reports (such as BPA annual reports), publications, and other means (e.g., electronic mail). Data and results are published in the peer-reviewed literature as they become ripe. Since its inception, the YKFP has generated a number of technical manuscripts that are either in final internal review, in peer review, are in press, or are published. Please refer to the project web site for a complete list of project technical reports and publications. Project publications for this performance period relevant to this specific contract include:

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.

Pearsons, T.N. and G.M. Temple. 2010. Changes to Rainbow Trout Abundance and Salmonid Biomass in a Washington Watershed as Related to Hatchery Salmon Supplementation. Transactions of the American Fisheries Society 139:502-520.

Schroder, S. L., C. M. Knudsen, T. N. Pearsons, T. W. Kassler, S. F. Young, E.P. Beall, and D. E. Fast. 2010. Behavior and Breeding Success of Wild and First-Generation Hatchery Male Spring Chinook Salmon Spawning in an Artificial Stream. Transactions of the American Fisheries Society, 139:989-1003.

Introduction

While the statement of work for this contract period was provided in work element format, we believe that annual progress is best organized and communicated by task as presented in our FY2007-2009 proposal. The monitoring and evaluation program for the YKFP was organized into four categories- Natural Production (tasks 1.a - 1.p), Harvest (tasks 2.a and 2.b), Genetics (tasks 3.a and 3.b) and Ecological Interactions (tasks 4.a – 4.d). This annual report specifically discusses tasks directly conducted by the Yakama Nation during fiscal year 2010. Those tasks that are conducted directly by the Washington State Department of Fish and Wildlife cite the written report where a complete discussion of that task can be found. International Statistical Training and Technical Services (IntStats) provides the biometrical support for the YKFP and IntStats' written reports for tasks 1.c, 1.d, 1.f, and 1.g are included in full as appendices to this report. Some tasks have been completed or have been discontinued; information regarding these tasks was published in prior annual reports.

Contributing authors from the Yakama Nation YKFP in alphabetical order are: Bill Bosch, Melinda Davis, Chris Frederiksen, David Lind, Jim Matthews, Todd Newsome, Michael Porter and Sara Sohappy. Doug Neeley of Intstats Consulting also provided material used in this report, some or all of which are included as appendices.

Special acknowledgement and recognition is owed to all of the dedicated YKFP personnel who are working on various tasks. The referenced accomplishments and achievements are a direct result of their dedication and desire to seek positive results for the betterment of the resource. The readers of this report are requested to pay special attention to the Personnel Acknowledgements. Also, these achievements are attainable because of the efficient and essential administrative support received from all of the office and administrative support personnel for the YKFP.

We also wish to thank the Bonneville Power Administration for their continued support of these projects which we consider vital to salmon restoration efforts in the Yakima River Basin.

NATURAL PRODUCTION

Overall Objective: Determine if supplementation and habitat actions increase natural production. Evaluate changes in natural production with specified statistical power.

Task 1.a Modeling

Rationale: To design complementary supplementation/habitat enhancement programs for targeted stocks with computer models incorporating empirical estimates of life-stage-specific survival and habitat quality and quantity.

Methods: To diagnose the fundamental environmental factors limiting natural production, and to estimate the relative improvements in production that would result from a combination of habitat enhancement and supplementation using models such as "Ecosystem Diagnosis and Treatment" (EDT) and All-H analyzer (AHA).

Progress: During the 2010 contract year, YN Biologists collaborated with the Bureau of Reclamation, Yakima Basin Salmon Recovery Board, and other entities for the purpose of estimating the anadromous salmon and steelhead, and bull trout benefits for numerous scenarios including the future without the Integrated Plan (FWIP), the future with the Integrated Plan and habitat restoration actions, and the future with the Integrated Plan with both Restoration and Fish Passage.

Background

The Bureau of Reclamation (Reclamation) and the Washington State Department of Ecology (Ecology) convened the Yakima River Basin Water Enhancement Project (YRBWEP) Workgroup in 2009 to develop a preliminary Integrated Water Resource Management Plan (IWRMP) to address fisheries and water supply needs, which was released in January 2010. The Basin Study was initiated by Reclamation and Ecology in 2010 to further develop the technical basis and decision support for the IWRMP. Task 7 of the Basin Study was to analyze the total ecosystem benefits of implementing the proposed suite of actions (i.e. tributary and mainstem habitat restoration; fish passage; and flow improvements) in the IWRMP.

The Yakima Basin Fish & Wildlife Recovery Board (YBFWRB), Yakama Nation, Reclamation and HDR Consultants collaborated in scoping an approach to estimating the anadromous fish benefits for habitat, fish passage and flow improvements proposed in the preliminary IWRMP. It was proposed to use either a habitat capacity type model which would need to be developed for the Yakima Basin, or use of the Yakima Basin Ecosystem Diagnosis & Treatment (EDT) model that had been used for the Storage Study. After some debate it was decided to use the EDT model for the benefits analysis. The primary reason was because the EDT model was readily available and resolved many of the technical issues dealing with population abundance, productivity and capacity that needed to be addressed for a habitat capacity type model. Methods, results, and discussion on the modeling approach is available through the U.S. Bureau of Reclamation in the Yakima River Basin Study Fish Benefits Analysis Technical Memorandum, Plan of Study Task 7 (May 2011).

Task 1.b Percent habitat saturation and limiting factors

The WDFW annual report for this task can be located on the BPA website: http://www.efw.bpa.gov/searchpublications/. This year's report is expected to be available soon. The most recent report is:

C. L. Johnson and G. M.Temple. 2010. Spring Chinook Salmon Competition / Capacity and Residual/Precocious Male Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report 2009.

Task 1.c Yakima River Juvenile Spring Chinook Marking

Rationale: Estimate hatchery spring Chinook smolt-to-smolt survival at CJMF and Columbia River projects, and smolt-to-adult survival at Bonneville (PIT tags) and Roza (PIT and CWT) dams.

Method: Brood year 2001 marked the last brood year of the OCT/SNT treatment cycle. The last five-year old adults from this experiment returned in 2006 (see Fast et al 2008 for results). For brood years 2002-2004, the YKFP tested two different feeding regimes to determine whether a slowed-growth regime can reduce the incidence of precocialism (Larsen et al 2004 and 2006) without a reduction in post-release survival. The two growth regimes tested were a normal (HI) growth regime resulting in fish which were about 30/pound at release and a slowed growth regime (LO) resulting in fish which were about 45/pound at release. For brood years 2005 and 2007-08, the YKFP is testing a saltwater transition feed during the acclimation rearing phase to see if it improves survival to returning adult relative to standard nutritional feeds. For brood year 2006, we are testing a moist feed (EWOS, Canada) against a standard feed (BioVita, BioOregon, Inc., Oregon). However, because of high mortality rates associated with the EWOS feed, all fish were put on the same BioVita diet on May 3, 2007 after approximately two months of experimental and control diets. In addition to these treatments, the YKFP initiated a hatchery-control line in 2002 to test differences in fish that have only one generation of exposure to the hatchery environment (supplementation line whose parents are always natural-origin fish) to fish that have multiple generations of hatchery exposure (hatchery control line whose parents are always hatchery-origin fish).

To estimate smolt-to-smolt survival by rearing treatment, acclimation location and raceway, we PIT tagged and adipose clipped the minimum number to determine statistically meaningful differences detected at CJMF and lower Columbia River projects. The remaining fish are adipose fin clipped and tagged with visual implant elastomer (VIE) tags in the adipose eyelid tissue and also with coded wire tags in either the snout or the posterior dorsal area. This allows unique marking for rearing treatment, acclimation location, and raceway. Returning adults that are adipose clipped at Roza Dam Broodstock Collection Facility (RDBCF) are interrogated using a hand-held CWT detector to determine the presence/absence of body tags. We recover coded-wire tags during spawning ground surveys. We will use ANOVA to determine significant differences between treatment groups for both smolt-to-smolt and smolt-to-adult survival and report on these data annually.

Progress: Tagging of brood year 2009 fish began at the Cle Elum hatchery on October 18, 2010 and was completed on December 8, 2010. Marking results are summarized in Table 1. Appendix A contains mark summary data for brood years since 2002 (see previous annual reports for earlier brood years). As in prior years, all fish were adipose fin-clipped. Between 2,000 and 4,000 fish (4.0% to 9.1% of the fish) in each of 18 raceways were CWT tagged in either the snout or the posterior dorsal area and then PIT tagged. The remaining progeny of natural brood parents (~715,900 fish) had a CWT placed in their snout, while the remaining progeny of hatchery brood parents (hatchery control line; ~81,100 fish) had a CWT placed near their posterior dorsal fin. Previously CWTs were placed in one of six body locations to designate acclimation site raceways at release. However, beginning with brood year 2004, it was determined that placing CWTs in the snout would provide more information about harvest of CESRF fish in out-of-basin fisheries. All fish which were not PIT-tagged had a colored elastomer dye placed into the adipose eyelid. The three colors of elastomer dye in the adipose eyelid corresponded to the three acclimation sites (red = Clark Flat, orange = Jack Creek, and green = Easton). A final quality control check by YN staff took place on January 3, 2011 (ponds 1-11) and

January 4, 2011 (ponds 12-18). Estimated tag retention was generally good, ranging from 87-100% for CWT and 83-98% for elastomer tags.

Smolt-to-smolt and smolt-to-adult survival data and analyses for brood years 1997-2001 OCT/SNT treatments were published (see Fast et al 2008).

Appendix B contains an analysis of various smolt measures including smolt-to-smolt survival for supplementation (natural-by-natural crosses) and hatchery-control (hatchery-by-hatchery crosses) fish for release years 2004-2009 (brood years 2002-2007). Additional survival data across years are given in Appendix A. Appendix C contains an analysis of various smolt measures including smolt-to-smolt survival for saltwater transfer feed and control feed (standard BioVita diet) for release years 2007, 2009, and 2010 (brood years 2005, 2007, and 2008).

Table 1. Summary of 2009 brood year marking activities at the Cle Elum Supplementation and Research Facility.

CE RW ID	Treat-ment	Accl ID	Cross Type	Elastomer Eye Site	Elastomer Eye Color	CWT Body site	Number Tagged CWT	Number Tagged PIT	Number Tagged Total	Start Date	Finish Date
CLE01	STF	CFJ05	HH	Right	Red	Posterior Dorsal	40109	4000	44109	18-Oct-10	20-Oct-10
CLE02	BIO	CFJ06	HH	Left	Red	Posterior Dorsal	41012	4000	45012	20-Oct-10	25-Oct-10
CLE03	STF	JCJ01	WW	Right	Orange	Snout	37245	2000	39245	25-Oct-10	28-Oct-10
CLE04	BIO	JCJ02	WW	Left	Orange	Snout	42212	2000	44212	28-Oct-10	01-Nov-10
CLE05	STF	CFJ01	WW	Right	Red	Snout	47016	2000	49016	02-Nov-10	05-Nov-10
CLE06	BIO	CFJ02	WW	Left	Red	Snout	46733	2000	48733	05-Nov-10	09-Nov-10
CLE07	STF	ESJ05	WW	Right	Green	Snout	46302	2000	48302	10-Nov-10	16-Nov-10
CLE08	BIO	ESJ06	WW	Left	Green	Snout	46969	2000	48969	16-Nov-10	19-Nov-10
CLE09	STF	ESJ01	WW	Right	Green	Snout	43612	2000	45612	19-Nov-10	30-Nov-10
CLE10	BIO	ESJ02	WW	Left	Green	Snout	43173	2000	45173	30-Nov-10	03-Dec-10
CLE11	STF	JCJ05	WW	Right	Orange	Snout	47585	2000	49585	03-Dec-10	08-Dec-10
CLE12	BIO	JCJ06	WW	Left	Orange	Snout	47644	2000	49644	03-Dec-10	08-Dec-10
CLE13	STF	ESJ03	WW	Right	Green	Snout	45277	2000	47277	24-Nov-10	02-Dec-10
CLE14	BIO	ESJ04	WW	Left	Green	Snout	45529	2000	47529	17-Nov-10	24-Nov-10
CLE15	STF	JCJ03	WW	Right	Orange	Snout	43825	2000	45825	11-Nov-10	17-Nov-10
CLE16	BIO	JCJ04	WW	Left	Orange	Snout	43209	2000	45209	08-Nov-10	11-Nov-10
CLE17	STF	CFJ03	WW	Right	Red	Snout	45587	2000	47587	03-Nov-10	08-Nov-10
CLE18	BIO	CFJ04	WW	Left	Red	Snout	43952	2000	45952	29-Oct-10	03-Nov-10

Task 1.d Roza Juvenile Wild/Hatchery Spring Chinook Smolt PIT Tagging

Rationale: To capture and PIT tag wild and hatchery spring Chinook to estimate: 1) wild and hatchery smolt-to-smolt survival to CJMF and the lower Columbia River projects, and 2) to estimate differential smolt-to-adult survival between winter and spring migrant fish.

Methods: The Roza Dam juvenile fish bypass trap was used to capture wild and hatchery spring Chinook pre-smolts. The trap was operated from March 19 through April 30, 2010. The trap was fished five days per week, 24 hours per day. Fish were removed from the trap each morning, PIT tagged on site, and released the following day after recovery. Fish tagged on Friday mornings were released on Friday afternoons.

Progress: A total of 1,176 (105 wild and 1,071 hatchery) juvenile spring Chinook were PIT tagged from fish collected at the Roza juvenile fish bypass trap. The new "tucking" procedure at the Dam may have limited the ability or effectiveness to trap wild/natural smolts. Both wild and hatchery fish were tagged from March 19 through April 30, 2010.

Appendix D contains a detailed analysis of wild/natural and CESRF (hatchery) smolt-to-smolt survival for Roza-tagged releases for brood year 2008 (migration year 2010) and summarizes these data for prior brood years 1997-2007 (migration years 1999-2009). Additional data on this task are provided in Appendix A.

Task 1.e Yakima River Wild/Hatchery Salmonid Survival and Enumeration (CJMF)

Rationale: As referenced in the YKFP Monitoring Plan (Busack et al. 1997), CJMF is a vital aspect of the overall M&E for YKFP. The baseline data collected at CJMF includes: stock composition of smolts, outmigration timing, egg-to-smolt and/or smolt-to-smolt survival rates, hatchery versus wild (mark) enumeration, and differences in fish survival rates between rearing treatments for CESRF spring Chinook. Monitoring of these parameters is essential to determine whether post-supplementation changes are consistent with increased natural production. This data can be gathered for all anadromous salmonids within the basin.

In addition, the ongoing fish entrainment study is used to refine smolt count estimates, both present and historic, as adjustments are made to the CJMF fish entrainment to river discharge logistical relationship.

The facility also collects steelhead kelts for the kelt reconditioning project, and conducts trap and haul operations when conditions in the lower Yakima are not favorable to smolt survival.

Methods: The CJMF is operated on an annual basis, with smolt enumeration efforts conducted from late winter through early summer corresponding with salmonid smolt out-migrations. A sub-sample of salmonid outmigrants is bio-sampled on a daily basis and all PIT tagged fish are interrogated.

Replicate releases of PIT tagged smolts were made in order to estimate the fish entrainment and canal survival rates in relation to river conditions. The entrainment rate estimates were used in concert with a suite of independent environmental variables to generate a multi-variate smolt passage relationship and subsequently to derive passage estimates with confidence intervals (see Appendix D in 2009 annual report for details).

PIT tag detections were expanded to calculate passage of hatchery fish, although hand-held CWT detectors were also used to scan for body-tags on hatchery spring Chinook smolts. This monitoring and evaluation protocol is built in as a backup in the event that the corresponding PIT tagged fish from each CESRF treatment group failed to be accurately detected by the PIT detectors stationed at the CJMF. Fortunately there was good correspondence between the detection rates between the two mark groups.

Progress: The 2010 smolt passage estimates were as follows: natural-origin spring (yearling) Chinook – 166,663; hatchery-origin spring Chinook– 393,195; unmarked fall (sub-yearling) Chinook– 785,540; natural-origin (unmarked) coho– 134,786; hatchery-origin coho– 152,326; and wild steelhead– 57,948. These estimates are provisional and subject to change as better entrainment estimates are developed. Appendix D in our 2009 annual report contains an updated analysis of data obtained from these studies. These data are being reviewed and may be updated in the future. Additional data on this task are also provided in Appendix A.

Personnel Acknowledgements: Biologist Mark Johnston and Fisheries Technician Leroy Senator are, respectively, the project supervisors and on-site supervisor of CJMF operations. Other Technicians that assisted are Sy Billy, Wayne Smartlowit, Morales Ganuelas, Pharamond Johnson, Steve Salinas, Shiela Decoteau, Jimmy Joe Olney and Tammy Swan. Biologist David Lind uploads and queries PIT tag information, and performs daily passage calculations based on entrainment and canal survival estimates developed by consultant Doug Neeley.

Task 1.f.1 Yakima River Fall Run Chinook Survival Monitoring & Evaluation

Rationale: To determine optimal rearing treatments and acclimation site location(s) to increase overall smolt passage and smolt-to-adult survival.

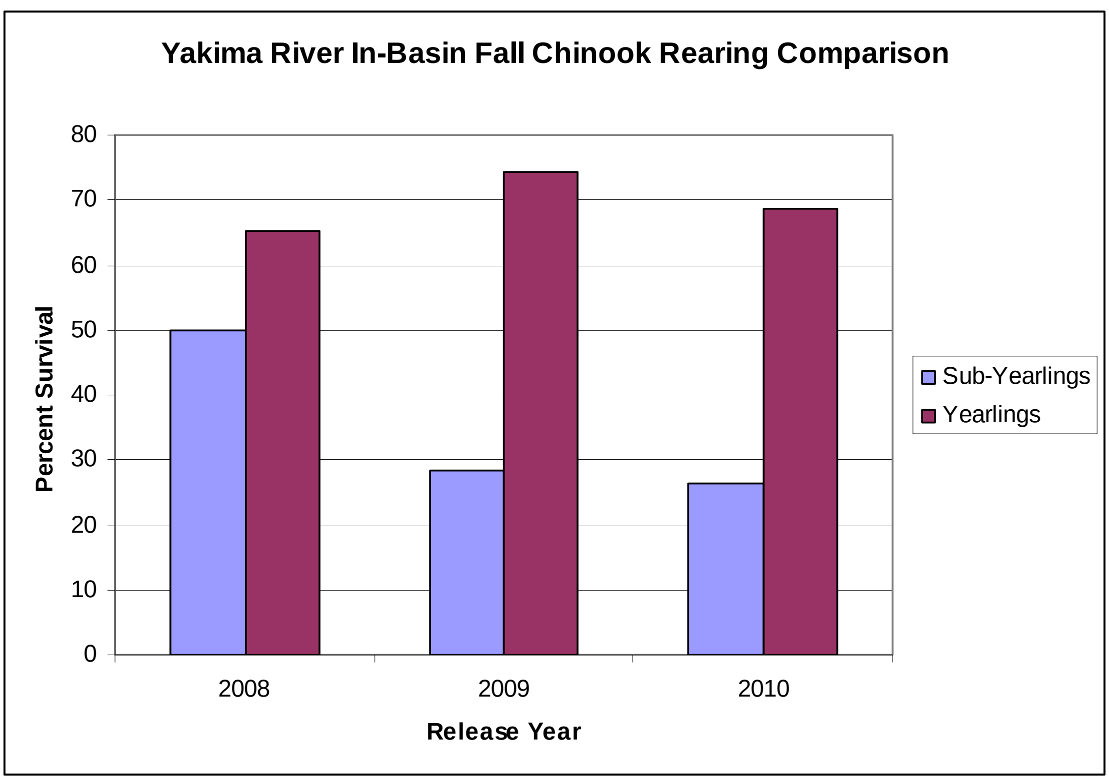
Method: In BY2007, we implemented two new experiments: 1) Using our in-basin stock, we compared a group of the accelerated subyearlings versus a group of yearling releases (BY2006). This experiment is on-going. Initially both groups were 100% adipose clipped and a portion PIT tagged for monitoring. For BY2008, 2009 and 2010, we moved to 100% PIT tag with no adipose clip. 2) Using our out-basin Little

White Salmon (LWS) stock, we compared a group of 500,000 brought in as eyed eggs and reared under accelerated conditions to the remainder of the group, 1.2 million, transferred as pre-smolts and reared conventionally with final acclimation at Prosser Hatchery. These LWS fish were 100% adipose clipped only and not PIT tagged for the 2010 release. BY2009 is the last year we intend to transfer 500,000 eyed eggs from LWS. For BY2010, we transferred 500,000 eyed eggs from WDFW Priest Rapids Hatchery (PRH). PRH fish were not marked. The YN plans to transition from the LWS stock to the PRH stock entirely in the future.

Progress: Using the BY2009 in-basin stock (subyearlings), we entered into the third year release comparison of the subyearling vs. yearling rearing treatments. The subyearlings were reared using an accelerated strategy already determined to have better survival than the traditional conventional method. Smolt-to-smolt survival to McNary was monitored using PIT tags. For the initial releases in 2008 (BY2006), we 100% marked the fish with either a PIT tag or an adipose fin-clip. For the following release years, we moved to 100% PIT tag and no adipose clip.

For BY2007-2009 releases, the Yearlings have out-performed the Subyearlings for every release (Figure 4).

Figure 4. Yakima River Fall Chinook Yearling vs. Subyearling Releases



For the 2011 (BY2009/2010) releases, we PIT tagged 22,752 yearlings and 22,791 subyearlings. These final numbers are pending. Based on preliminary detections at McNary (as of July 10th, 2011), yearling detections have out-numbered subyearling detections 2,176 to 625 respectively.

For the LWS 2010 (BY2009) release, we had 480,079 fish, 100% adipose fin-clipped that were transferred as eyed eggs and reared under accelerated conditions. The remaining 1,199,966 fish were transferred as pre-smolts with 10% coded-wire tagged (CWT) and 100% adipose fin-clipped.

The Yakama Nation is in a transition period of moving from the LWS broodstock to Priest Rapids Hatchery (PRH) broodstock. We believe the PRH brood will reduce risks from ecological interactions between hatchery-origin and natural-origin fall Chinook because Priest Rapids Hatchery is the integrated brood source for the aggregate Hanford Reach population which is geographically and genetically very close to the Yakima River population.

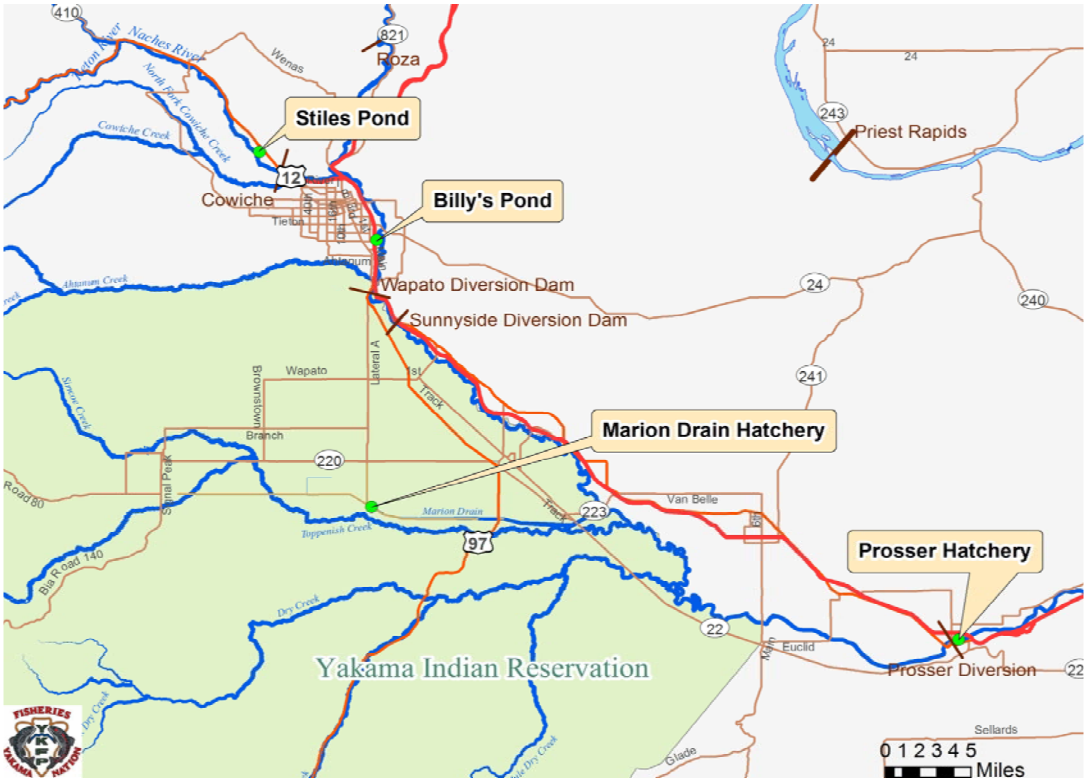
For BY2010, we transferred 503,772 eyed eggs from Priest Rapids Hatchery. These fish received the accelerated treatment and were released on May 4, 2011. We will continue to transfer pre-smolts from LWS as we gradually transition over to PRH stock entirely, as recommended by both the USFWS hatchery review and the HSRG. Eventually, we will no long seek eggs from LWS.

In previous years, we have released fall Chinook from Prosser Hatchery, Marion Drain, Stiles pond (lower Naches River), Billy's pond (Union Gap) (Figure 5) and a one-time release from Skov pond (Selah, WA). 2010 is the last year we will release any Fall Chinook above Prosser Hatchery. Approximately, 22,945 were collected, reared and released directly into the Marion Drain on April 15, 2010. All fall run Chinook will be reared and released from Prosser Hatchery with additional sites being sought between Prosser and the Tri-Cities areas. The Yakama Nation plans to use the release sites previously used for fall run Chinook above Prosser for incubation, rearing and release of summer-run Chinook (see task 1.f.2).

BY2009 was the last brood year that adults were taken using the adult fish wheel trap in the Marion Drain. Adults will be sampled in Marion Drain in 2014 to collect DNA for the purpose of monitoring the population.

Detailed statistical results and discussion of these ongoing fall Chinook evaluations are given in Appendix E.

Figure 5. Yakima River Fall/Summer Chinook Acclimation Sites.



Task 1.f.2 Yakima River Summer Run Chinook Monitoring & Evaluation

Rationale: Investigate the feasibility of re-establishing a summer run Chinook population in the Yakima River.

Method: In brood year 2008, the Yakama Nation imported approximately 200,000 green eggs and milt from an equal number of individual females and males from the Washington State Department of Fisheries Wells Hatchery in Pateros, WA. This egg take was repeated in BY2009 and 2010, and will continue until a more suitable broodstock is available, or until sufficient numbers of summer Chinook adults return to the Yakima River for collection in the Yakima basin. The YN in cooperation with Wells Hatchery staff spawned the fish at Wells Hatchery and transferred the eggs and milt to the Yakama Nation Prosser Hatchery in Prosser, WA (BY2008) and Marion Drain Hatchery in Toppenish, WA (BY2009 and 2010). All of the individual females were tested for virus and BKD at Wells Hatchery. Pathology was conducted by the US Fish and Wildlife Service. Eggs from the individual females were fertilized at

Marion Drain Hatchery using the imported milt from Wells Hatchery males. The individual lots of eggs were quarantined until fish health sampling results were confirmed negative. Incubation and rearing to the sub-yearling stage for BY2009 remained entirely at the Marion Drain Hatchery. Final acclimation of all fish was located at Stiles Pond, ~RM 3.4 of the Naches River. A total of 200,747 summer run Chinook (29,997 PIT tag and 170,750 CWT only) were released on May 14, 2010.

Progress: Pathology results allowed for 100% of the females cleared for release in 2010. For release year 2009, incubation temperatures were kept below 49ºF for the initial BY2008 egg take. The cool temperature was to limit mortality resulting from coagulated yolk, a problem associated with this stock of fish at Wells Hatchery. These cooler temperatures resulted in low mortality; however growth was slow which delayed our ability to mark these fish in an acceptable time that would allow for the minimum acclimation time at Stiles pond and a non-lethal release period. For the BY2009, incubation temperatures were increased to ~57ºF to accelerate growth. As a result, the fish put on adequate size and we were able to PIT tag this release earlier, as well as get the fish to Stiles pond sooner for a longer acclimation period.

Survival from release to McNary for the 2010 release year was 30.6%. This was up from 2009 where survival was a minimal 1.8%. The higher survival may be attributed to longer acclimation time, an earlier release date and the clearing of a blockage discovered at the Wapato Dam fish bypass.

For the BY2010 collection, eggs were incubated at an accelerated temperature of ~53-54ºF using well water. The accelerated temperature allows us to PIT tag and CWT sooner to get these fish to the acclimation site earlier. Unfortunately, an incubation water line froze during winter in February causing a break, resulting in a loss of the majority of Wells fish on hand. The decision was made to seek out "back-up" summer Chinook to supplement the loss.

Fortunately, we had a group of 76,356 surplus yearlings from Eastbank Hatchery that we secured the summer of 2010. Final acclimation was at Stiles pond. These fish were 100% marked, 20k PIT tagged and 56,356 AD clip only. An additional group of 101,000 yearlings (Wenatchee Stock) were transferred for a direct release to Stiles pond between April 20th and 21st, 2011. This group was 100% marked both CWT/AD clipped. These combined fish were released as one group on May 16, 2011. The surviving 39,406 subyearlings from Wells Hatchery were directly released into Buckskin Slough, Naches River (RM 3.3) between April 29th and May 5th, 2011. These fish were 100% marked with 30,000 fish PIT-tagged and the remainder CWT tagged only. Survival data for the 2011 releases is pending.

Detailed statistical results and discussion of these ongoing summer-run Chinook evaluations are given in Appendix E.

Task 1.g Yakima River Coho Optimal Stock, Temporal, and Geographic Study

Objective: The ultimate goal of the Yakima coho reintroduction project is to determine whether adaptation and recolonization success is feasible and to reestablish sustainable populations in the wild.

Rationale: Determine the optimal locations, life stage, release timing, and brood source that will maximize opportunities to achieve the long-term objective. Monitor trends in returning adults (e.g., abundance of natural- and hatchery-origin returns, spawning distribution, return timing, age and size at return, etc.) to evaluate progress towards achieving objectives. Continue to investigate the coho life history in the Yakima Basin. Assess ecological interactions (see tasks under Objective 4). Develop and test use of additional culturing, acclimation, and monitoring sites.

By the middle 1980s, coho were extirpated from the Yakima Basin and large portions of the middle and upper Columbia River Basins. This project is attempting to restore some of this loss pursuant to mitigation and treaty trust obligations embodied in the NPCC FWP and *U.S. v Oregon* agreements. Questions regarding rates of naturalization for hatchery-origin fish allowed to spawn in the wild and integration of hatchery and natural populations have been identified as high priority research needs by the NPCC. Restoration of coho salmon to the Yakima Basin and other middle and upper Columbia River Basins is also consistent with stated ecosystem restoration goals in the FWP and subbasin plans. Monitoring and evaluation results will facilitate decision making regarding long-term facility needs for coho.

Method: ***Phase I (1999-2003)*** Phase I of the coho study was designed to collect some preliminary information relative to the project's long-term objective and to test for survival differences between: out-of-basin and local (Prosser Hatchery) brood sources; release location (acclimation sites in the upper Yakima and Naches sub basins); and early versus late release date (May 7 and May 31). Phase I has been completed and results are published:

Bosch, W. J., T. H. Newsome, J. L. Dunnigan, J. D. Hubble, D. Neeley, D. T. Lind, D. E. Fast, L. L. Lamebull, and J. W. Blodgett. 2007. Evaluating the Feasibility of Reestablishing a Coho Salmon Population in the Yakima River, Washington. North American Journal of Fisheries Management 27:198-214.

Phase II (2004-2011) Implementation plans and guidance for phase II of the coho feasibility study are documented in the current coho master plan (Hubble et al. 2004). We are continuing to test survival from specific acclimation sites: Holmes and Boone ponds in the Upper Yakima and Lost Creek and Stiles ponds in the Naches subbasins. Each acclimation site releases fish from both local and out-of-basin brood sources and approximately 2,500 PIT tags represent each group at each acclimation site during the normal acclimation period of February through May. Acclimation sites have PIT tag detectors to evaluate fish movement during the late winter and early spring. Fish are released volitionally, beginning the first Monday of April. However, in an extreme drought emergency, project guidelines allow coho to be moved to acclimation sites earlier and forced out of acclimation sites in March. Up to 3,000 PIT-tagged coho (parr stage) are also planted into select tributaries during late summer to assess and monitor over winter survival and adults are also planted in select tributaries to assess spawning and rearing success.

Progress:

The program completed an interim phase (2004-2006) including necessary planning and environmental assessment work and moved to Phase II implementation activities in 2007. The 4 progressive goals of Phase I continue to be monitored in Phase II:

1. Increase juvenile survival out of the Yakima sub-basin (metric: smolt passage estimates at Chandler and estimated smolt survival from tagging and release to McNary Dam using PIT-tagged fish)
2. Increase natural production (metrics: dam counts and sampling, redd counts)
3. Continue to develop a local (Yakima Basin) coho brood stock
4. Increase smolt to adult return rates for both natural- and hatchery-origin coho (metric: Chandler juvenile and Prosser adult counts and sampling).

Estimated hatchery-origin coho smolt passage to McNary Dam in 2010 was average, approximately 227,800 fish. Redd counts dropped from 2009 but were the second highest the program has recorded. Development of the local coho brood source continues and smolt-to-adult return rates are encouraging, especially for natural-origin coho. Redd surveys are showing nearly all the targeted spawning areas above Wapato Dam are being utilized. Radio telemetry has provided evidence of more adults using tributaries and venturing into new, unseeded areas, and some adult coho are returning to the furthest upriver acclimation sites (e.g., Lost Creek and Easton Acclimation Sites). Additionally, radio tagged adults returning from the summer parr releases showed excellent fidelity.

Phase II Goals

1. Monitor and evaluate juvenile coho survival in tributaries.
2. Monitor and assess overall spawning success in select tributaries.
3. Test and monitor possible new acclimation techniques.
4. Continue to advance to a 100% in basin (local brood source) coho program.

2010 Methods

The 2010 juvenile coho releases again tested in-basin vs. out-of-basin stocks within acclimation sites. Approximately, 2,500 PIT tags (two 1,250 replicates) for each stock were put in each acclimation site, totaling 5,000 PIT tags per site (except Easton). Each acclimation site was fitted with multiple outlet PIT tag detectors. The fish were released volitionally on the first Monday in April. Smolts reared in the Mobile Acclimation unit were also PIT-tagged to assess migration success. Adult returns were monitored at the Prosser Right Bank Alaskan Steep Pass Denil, Roza Dam and by radio tracking. Redd surveys were conducted from October through December in the maintsem Yakima and Naches Rivers as well as select tributaries.

2010 Results

Juvenile Survival

In 2010, two PIT tag detectors each were used at Prosser, Lost Creek and Stiles to evaluate survival of PIT tagged coho from acclimation sites to McNary Dam. Using two detectors enabled significant gains in detection efficiency. Lost Creek and Stiles continue to have detection efficiencies between 95% and 100%. The Holmes acclimation site had only one detector and very few detections because of flooding and mechanical trouble. The Prosser Hatchery outfall ditch has very good detection efficiency ranging between 70% - 85%.

Survival estimates were calculated for the number of juvenile smolts that were PIT-tagged and released from the acclimation sites to passage at McNary Dam. The pre-release survival (tagging to volitional exit from the acclimation sites) of the Eagle Creek brood-stock (83.2%) was significantly greater than that of the local Yakima (71.8%) brood-stock ($P < 0.005$; D. Neeley, Appendix F). However, the mean estimated survival from volitional release (detection leaving acclimation site) to McNary Dam passage over all 3 upriver release sites was approximately 25.7% for the Yakima (local) brood source compared to about 19.6% for Eagle Creek brood source smolts. The mean Yakima-stock release-to-McNary survival over sites and years was significantly greater than that of the Eagle Creek stock ($P < 0.005$; D. Neeley,

Appendix F). See Appendix F for a detailed report and analysis of coho juvenile survival indices for 2010 and prior year releases.

Parr Releases

Summer Parr were released into tributaries throughout both the Upper Yakima and Naches basins. Up to 3,000 PIT-tagged parr were released in North Fork Little Naches, Little Naches, Cowiche Creek, Nile Creek, Wilson Creek, Ahtanum Creek, Reecer Creek, Little Rattlesnake Creek and Big Creek. The summer coho parr were approximately 70-85mm in length and were in excellent shape. The fish were scatter planted throughout each system. The coho were distributed using buckets with aerators.

Coho parr survival (tagging-to-McNary) has generally been good, with survival estimates close to or exceeding smolt survival estimates for some sites in some years. The highest tagging-to-McNary survival estimate at any site in any year was 32% in 2009 for parr released in July of 2008 into the lowest elevation tributary, Reecer Creek. In 2010, survival in Reecer creek dropped to 21%. South Fork Cowiche Creek also had good survival (17%) though somewhat reduced from previous years. Most other tributaries also had good survival (1.9-20 percent tagging-to-McNary smolt survival). Surprisingly, the higher elevation tributaries, North Fork Little Naches, Little Naches and Big Creek, had increases in overall survivals from previous years. This is in contrast to a preliminary trend in the data that was showing that higher elevation tributaries are subject to lower survival. Even tributaries with excellent habitat (North Fork Little Naches) have had depressed survival compared to the lowest elevation tributaries. There are some anomalies. Ahtanum Creek is the third lowest in elevation and has only average survival, however, in 2010 survival increased to 20%. Some further investigations will need to be done to understand these differences. We intend to use these data over the next 3 years to better target our tributary recovery efforts.

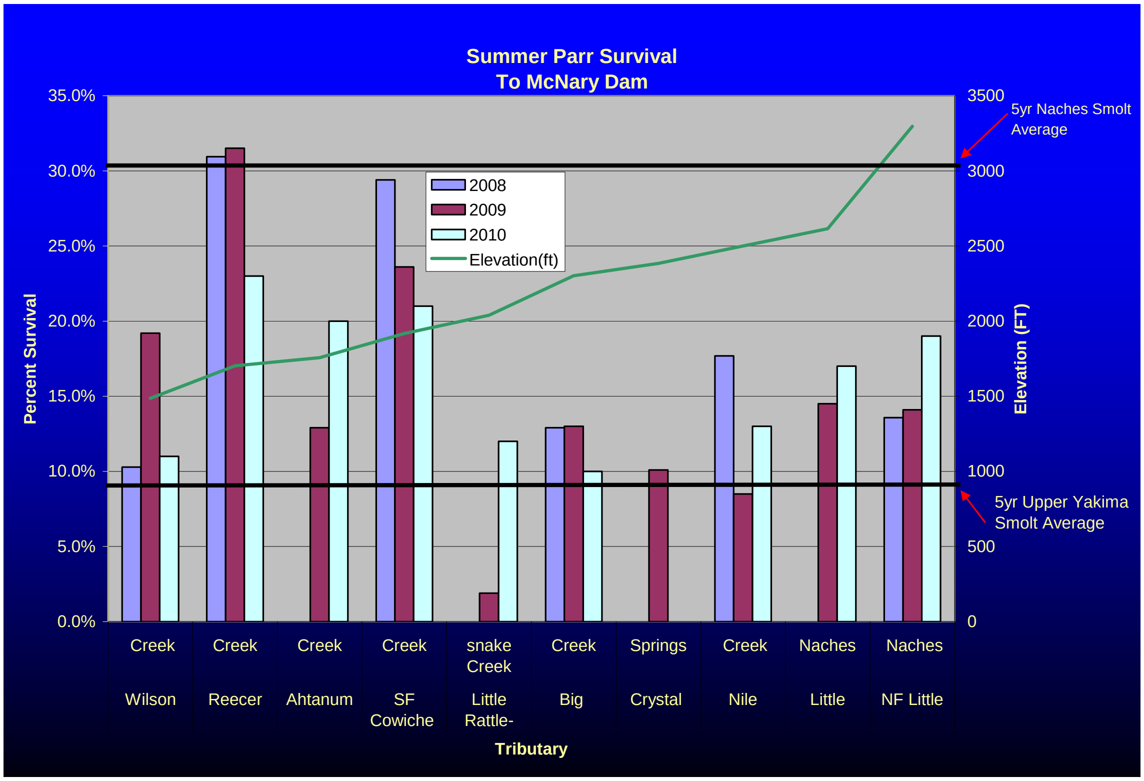


Figure 6. Summer parr survival from tagging to smolt passage at McNary Dam for coho plants by tributary for outmigration years 2008 through 2010. Tributaries are shown from lowest elevation on left of chart to highest elevation on right.

Mobile acclimation

Mobile acclimation sites are currently located on South Fork Cowiche Creek and Rattlesnake Creek. The Cowiche Creek site has had two years of operation whereas Rattlesnake Creek began operation in 2010. Survival of smolts released from the Cowiche Creek site to McNary Dam was estimated to be 46% in 2009 and 24% in 2010 while survival of smolts released from Rattlesnake Creek was estimated at 8%. Low survival of Rattlesnake Creek smolts was mainly attributed to a disease outbreak soon after acclimation began. Both sites began acclimation in late February and are released in early to mid April depending on start time. The goal is for a minimum of 4 weeks of acclimation time.

Adult Outplants

During 2010, adult Coho were planted only in Taneum Creek as part of the coho interactions study. The Taneum Creek study is a priority over the rest of the 5 out plant areas; therefore when there is insufficient brood available Taneum will receive the fish. Approximately 300 adults were planted into 3 separate sections of Taneum

Creek. Each section contained 50 males and 50 females. All adults were of unknown hatchery origin and collected off the right bank Steep Pass Denil at Prosser Dam. The fish for Taneum Creek were held until 300 adults were captured. Large 2,000 gallon fish hauling trucks were used to haul up to 50 adults per trip for release into Taneum Creek. Spawning coho were observed within days of release, but spawning lasted nearly a month in all three tributaries. Redd characteristics were measured in December.

The adults experienced very low mortality in transportation and movement into the stream, however, adults did experience some limited mortality from animals such as bear, bobcat and otter. Water conditions in 2010 were excellent with decent flows and there was no flooding. A total of 134 redds were located in Taneum Creek. The data for 2010 was the highest redd count for Taneum Creek that we have observed, surpassing 2009 by 4 redds. Only 16 fish were unaccounted for.

The progeny of the 2009 Taneum Creek adult outplants were monitored in conjunction with the WDFW Ecological Interactions Team. Beginning in mid-summer (2010), sections of the Taneum system were electrofished to PIT-tag the natural-origin juvenile progeny of adult coho outplanted in 2009. Approximately 4,000 wild juvenile coho salmon were PIT-tagged. Condition of these juvenile coho fry was excellent.

Juvenile out migration survival estimates (to McNary) were found to be approximately 16% in 2009 and fell to 10% in 2010. A new PIT tag array was installed at the mouth of Taneum Creek. This array showed approximately 620 one year old coho smolt left the system, putting overwinter survival at nearly 60%. An additional 9 two year old smolts and 1 three year old smolt left the system as well.

The first adults from the 2007 adult outplants returned in the fall of 2010. One PIT tagged adult was detected crossing Roza Dam in mid November and then into Taneum Creek 10 days later. A redd survey conducted by WDFW found 8 redds from the mouth upstream 4 miles.

Aggregate smolt passage and smolt-to-adult survival rates (SAR)

Overall smolt passage at Prosser in 2010 was estimated at about 227,800 hatchery coho (adjusted from Chandler counts using PIT tag survival to McNary Dam). This compared to a range of 14,000 to 300,000 coho smolts for the 2002-2009 migration years. In 2010, the estimated smolt-to-adult survival rate for 50,000 wild/natural origin coho smolts (counted at CJMF in 2009) was 5.2%. The estimated smolt-to-adult survival rate for 306,491 hatchery coho smolts (counted at CJMF in 2009) from releases in the Upper Yakima and Naches Rivers was 0.9%. The hatchery SAR for 2010 had returned to the normal average of approximately 1% after the dramatic increase in 2009 of 3.7%.

The upward trends in overall smolt passage have ultimately increased the returns of hatchery-origin adults since 2006. Beginning in 2007, the adults that were PIT-tagged and unmarked escaped back to the upper Columbia River at much higher Smolt to Adult (SAR) return rates than the remaining marked fish. This difference was observed again in 2008, 2009 and 2010. Beginning in 2011, adult hatchery coho escaping to the Yakima River will have CWT tags to differentiate themselves from wild fish.

The 2010 adult coho return to Prosser Dam was comprised of 2525 natural-origin or unmarked coho (40%) and 3750 (60%) hatchery-origin coho. An additional 1300 coho (adults and jacks combined) were counted at the Prosser Hatchery swim-in trap. While the entire hatchery release group (except for PIT tagged smolts) was 100% adipose fin clipped, a large fry release into Lake Cle Elum in the spring of 2008 obviously contributed to both the natural-origin (non clipped) out migration in 2009 and the adult returns in 2010, therefore the hatchery/natural breakdown is not fully valid. In the future, natural-origin broodstock will have to be taken off the Prosser Right Bank Denil and determined from the absence of a CWT.

Results of 2010 Radio Telemetry Studies and adult PIT tag returns for Yakima Basin

During the 2010 adult migration we again only radio tagged adult coho that had a PIT tag present during capture. Unfortunately, the company that manufactures the radio tags we use were redesigning a line of radio tags specially suited to coho salmon. Therefore the only tags available were larger than normal and we believe this created additional mortality. Of the 23 coho that were radio tagged at Prosser, only 16 were detected upstream. Of those only 2 of the Easton coho homed back to their release area.

Snorkel Surveys

Snorkel surveys to look for residualized juvenile coho were also conducted again in 2010. Surveys were conducted on the Upper Yakima River (Cle Elum Reach) from the Cle Elum Hatchery (Rkm 299) to the confluence of the Teanaway River (Rkm 283). In the Naches River (Lost Creek reach), surveys were done from the Lost Creek acclimation site (Rkm 61.8) to the confluence with Rock Creek (Rkm 53.9). A total of 1,500 meters of river was snorkeled in these surveys in 2005 and we found no incidence of age-0 precocials. There were significant numbers of sub yearling coho observed in the lower Naches River in 2010 surveys, indicating good natural production is occurring.

Personnel Acknowledgements: Special thanks to all the people involved in the coho monitoring and evaluation activities which also include redd surveys. These people include but are not limited to Joe Jay Pinkham III, Conan Northwind, Quincy Wallahee, Andrew Lewis, Nate Pinkham, Gene Sutterlick and Germaine Hart. Also, thanks to Joe Blodgett and the staff at the Prosser Fish Hatchery for their excellent fish culturing skills and year round cooperation. Gabriel Temple and crews from WDFW have been very helpful with adult plants, snorkel surveys, and interactions studies. Ida Sohappy is the YKFP book keeper, Rachel Rounds is the NEPA representative for BPA, and Patricia Smith is the contracting officer and technical representative for BPA for this project.

Task 1.h Adult Salmonid Enumeration at Prosser Dam

Rationale: To estimate the total number of adult salmonids returning to the Yakima Basin by species (spring and fall chinook, coho and steelhead), including the estimated return of externally marked fish (i.e., adipose clipped fish). In addition, biotic and abiotic data are recorded for each fish run.

Methods: In the past, monitoring was accomplished through use of time-lapse video recorders (VHS) and a video camera located at each of the three fishways. The use of digital video recorders (DVR) and progressive scan cameras (to replace the VHS systems) was tested at each of the three Prosser fishways in 2007 and became fully functional in February of 2008. The new system functions very similarly to the VHS system but allows video data to be downloaded directly from the equipment at Prosser to the viewing stations in Toppenish. This new system also allows technicians in Toppenish to scan directly to images of fish giving a quicker and more accurate fish count. The technicians review the images and record various types of data for each fish that migrates upstream via the ladders. These images and information are entered into a Microsoft Access database, and daily dam count reports are regularly posted to the ykfp.org web site. 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 Data Access in Real-Time (DART) web sites.

Progress:

Spring Chinook (2010)

Using video data, an estimated 12,675 spring Chinook passed upstream of Prosser Dam in 2010. The total adult count was 10,844 (86%) fish, while the jack count was 1,831 (14%) fish. Of the adult count, 6,517 were identified as hatchery origin. Returning hatchery adults this year comprised 4 and 5 year olds (brood years 2005 and 2006). The ratios of wild to hatchery fish were 40:60 and 31:69, for adults and jacks respectively. The 25%, 50% and 75% dates of cumulative passage were May 9, May 17 and May 26, respectively.

Post-season evaluation using Roza dam count and Yakima Basin harvest data resulted in adjusted final Prosser counts of 6,601 hatchery-origin adults, 4,327 natural-origin adults, 1,491 hatchery-origin jacks, and 567 natural-origin jacks.

Fall Run (coho and fall chinook)

Coho (2010)

Using video data, the estimated coho return upstream of Prosser Dam was 4,994 fish. Adults comprised 96% and jacks 4% of the run. Of the estimated run, 34.3% were processed at the Denil and mark sampling there indicated the run was comprised of approximately 45.9% wild/natural and 54.1% hatchery-origin coho. The 25%, 50% and 75% dates of cumulative passage were September 24, October 12, and October 23, respectively.

Note that some coho return to the Yakima River but are not reflected in the Prosser counts. Some fish may have been harvested or spawned below Prosser Dam while others may have been falsely attracted into tributaries such as Spring Creek.

Fall Chinook (2010)

Estimated fall chinook passage at Prosser Dam was 2,889 fish. Adults comprised 95.7% of the run, and jacks 4.3%. Of the total number of fish, 754 were adipose clipped or otherwise identified as of definite hatchery-origin (690 adults and 64 jacks). The median passage date was October 2, while the 25% and 75% dates of cumulative passage were September 18 and October 22, respectively. Of the total fish estimate, 405 (14.0%) were counted at the Denil.

Steelhead (2009-10 run)

The estimated steelhead run was 6,793 fish. Of the total, 194 (2.9%) were adipose clipped fish, which were all out-of-basin strays (hatchery-origin steelhead have not been released in the Yakima River since the early 1990s). The median passage date was November 3rd, 2009, while the 25% and 75% cumulative dates of passage were October 19th, 2009 and January 24th, 2010 respectively.

Personnel Acknowledgements: Biologist Jeff Trammel, Data Manager Bill Bosch, and Fisheries Technicians Winna Switzler, Florence Wallahee and Sara Sohappy.

Task 1.i Adult Salmonid Enumeration and Broodstock Collection at Roza and Cowiche Dams.

Rationale: The purpose is to estimate the total number of adult salmonids returning to the upper Yakima Basin for spring and fall Chinook, coho and steelhead at Roza Dam, and for coho only into the Naches Basin at Cowiche Dam. This includes the count of externally marked fish (i.e., adipose clipped). In addition, biotic and abiotic data are recorded for each fish run.

Methods: Monitoring was accomplished through use of time-lapse video recorders (VHS) and a video camera located at each fishway. The videotapes are played back and various types of data are recorded for each fish that passes. Spring Chinook passing Roza Dam are virtually entirely enumerated through the Cle Elum Supplementation and Research Facility trap operation activity. Roza Dam in-season counts and historical final counts are posted to the ykfp.org and Data Access in Real-Time (DART) web sites.

Progress:

Roza Dam

Steelhead

A total of 326 steelhead were counted past Roza Dam for the 2009-10 run year (July 1 – June 30). As shown in Figure 7, most steelhead migrated past Roza Dam from late February through early May of 2010.

Spring Chinook

At Roza Dam 9,904 (83% adults and 17% jacks) spring Chinook were counted at the adult facility between April 28 and September 30, 2010. The adult return was comprised of natural- (33%) and CESRF-origin (67%) fish. The jack return was comprised of natural- (26%) and CESRF-origin (74%) fish. Figure 8 shows spring Chinook passage timing at Roza in 2010.

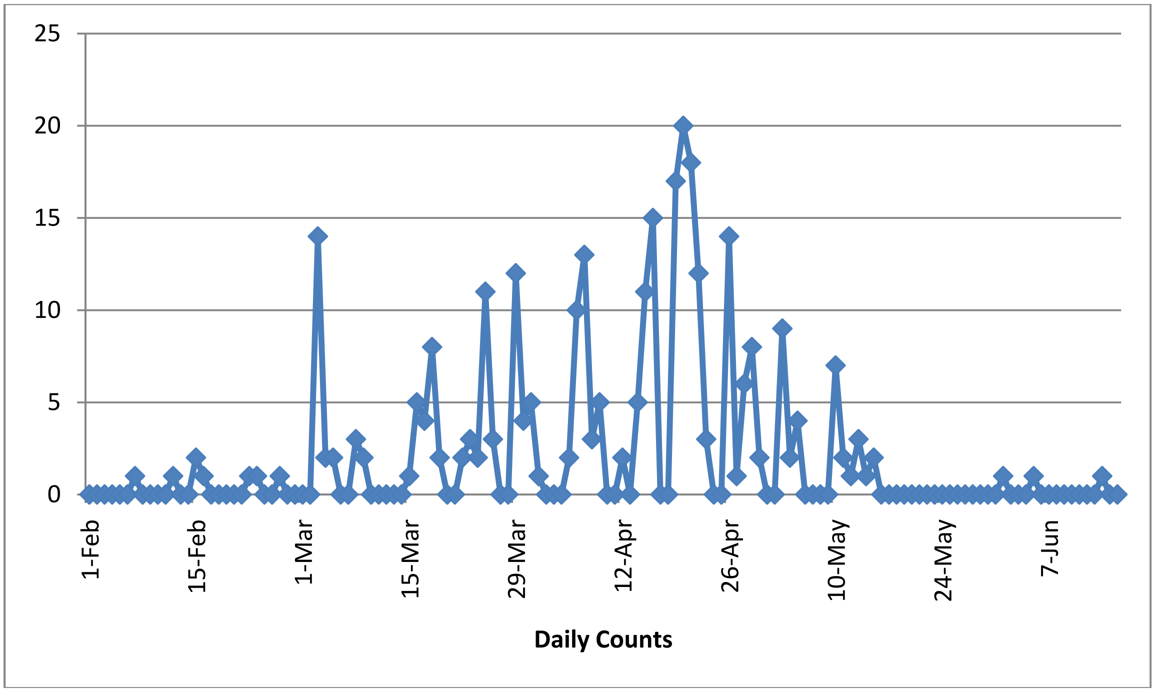


Figure 7. Daily steelhead passage at Roza Dam, 2009-10.

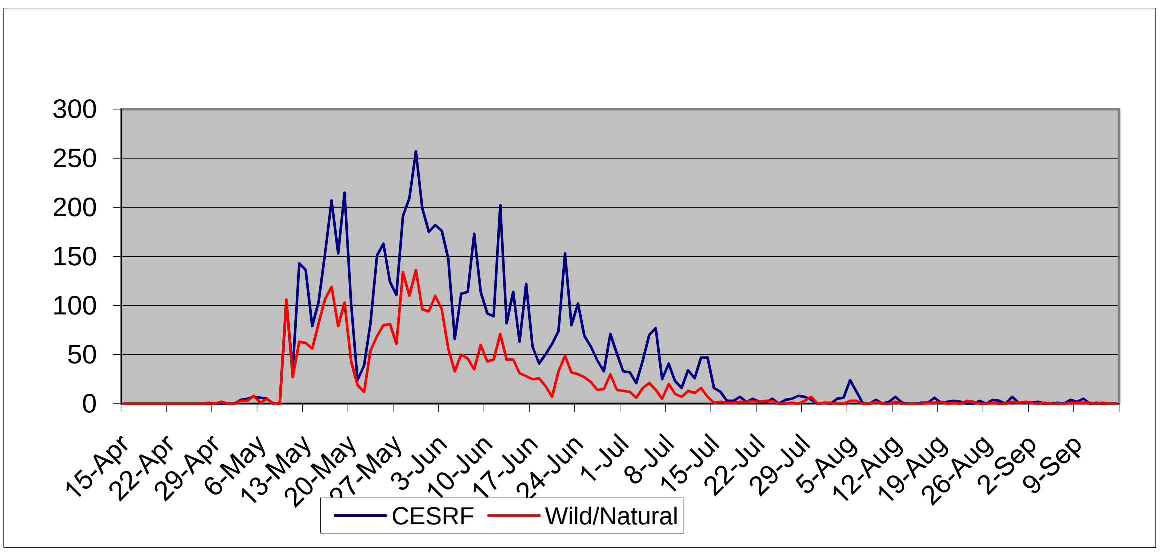


Figure 8. Daily passage counts for natural- and CESRF-origin spring Chinook at Roza Dam, 2010.

Coho

Video observations and trap sampling (20Sep – 27Dec) were conducted at Roza Dam during the fall and winter months of 2010. A total of 136 adult and 16 jack coho were counted and/or sampled.

<u>Cowiche Dam</u>

Coho

Video observations were not conducted at Cowiche Dam in 2010.

Task 1.j Spawning Ground Surveys (Redd Counts)

Rationale: Spawning ground surveys (redd counts): Monitor spatial and temporal redd distribution in the Yakima Subbasin (spring chinook, Marion Drain fall chinook, coho, Satus/Toppenish steelhead), and collect carcass data.

Methods: Regular foot and/or boat surveys 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, body length and to check for possible experimental marks.

Progress: A summary of the spawning ground surveys by species are as follows.

Steelhead: The Yakama Nation conducted steelhead spawner surveys in Satus and Toppenish basins and Ahtanum Creek in the spring of 2011. Redd counts in reservation creeks and tributaries were as follows.

Satus Creek : 293 redds were found during 3 complete passes. Conditions were fair to good.

Toppenish Creek: 103 redds were identified during 3 complete passes. Conditions were fair to good during surveys; however, there was evidence that many redds (marked on previous passes) were obliterated during high water events, particularly one in mid May.

Lower Toppenish Creek : No redds were found in lower Toppenish Creek during an aerial helicopter survey conducted on May 13. Water was high but clear. There isn't much spawning habitat below Shaker Church Rd. (lower end of wading reaches).

Ahtanum Creek: 28 redds were identified on one complete pass on April 26; conditions were fair. Water was too high to conduct any more passes and like Toppenish, significant scouring probably occurred after the survey.

Marion Drain: 5 redds were identified on a survey in early March. A second survey was attempted in April but was aborted due to poor visibility caused by agricultural runoff.

Data for steelhead redd surveys in the Naches River system (courtesy of G. Torretta USFS and Y. Reiss YBSRB) in the spring of 2011 were: Oak Creek – 27 redds; Nile Creek – 23 redds; and Cowiche Creek – about 25 redds. However these data should be considered incomplete. Most of the Naches drainage was unsurveyed as the main portion of the annual runoff occurred before spawning was complete. Historical steelhead redd count and Prosser and Roza escapement data can be obtained at http://www.ykfp.org/.

Spring Chinook: Redd counts began in late July 2010 in the American River and ended in early October 2010 in the upper Yakima River. Total counts for the American, Bumping, Little Naches, and Naches rivers were respectively: 167, 168, 39, and 167 redds. Redd counts in the upper Yakima, Teanaway and the Cle Elum rivers were: 2197, 253, and 219, respectively. The entire Yakima basin had a total of 3,210 redds (Naches- 541 redds, upper Yakima- 2,669). Historical spring Chinook redd count data are provided in Appendix A.

Fall Chinook: Redd counts in the Yakima River Basin above Prosser Dam began in mid-September and ended in late November. The river was divided into sections and surveyed every 7-10 days via raft or foot. Redd distribution for the Yakima, Naches, and Marion Drain was as follows:

Yakima R.: 269 redds. All redds were located between RM 70 and RM 117. The majority of redds (60%) were observed between RM 83 and 91, with only one redd observed above RM 107. However, as in 2010, visibility was poor between RM 70 and 83 where redd counts between 2003 and 2009 were almost equal to those found between RM 83 and 91. For 2010, only 88 redds were observed within this reach. Given the past data, we suspect this is probably only half of what was present, the rest were not visible.

Naches R.: 0 redds. Surveys were conducted from Wapatox Dam to the mouth of the river.

Marion Drain: 59 redds. 35.6% of the redds were located above Hwy 97 up to Old Goldendale Road. The remaining 64.6% were located below Hwy 97 down to the Hwy 22 bridge.

Historical fall Chinook redd count data can be obtained at http://www.ykfp.org/.

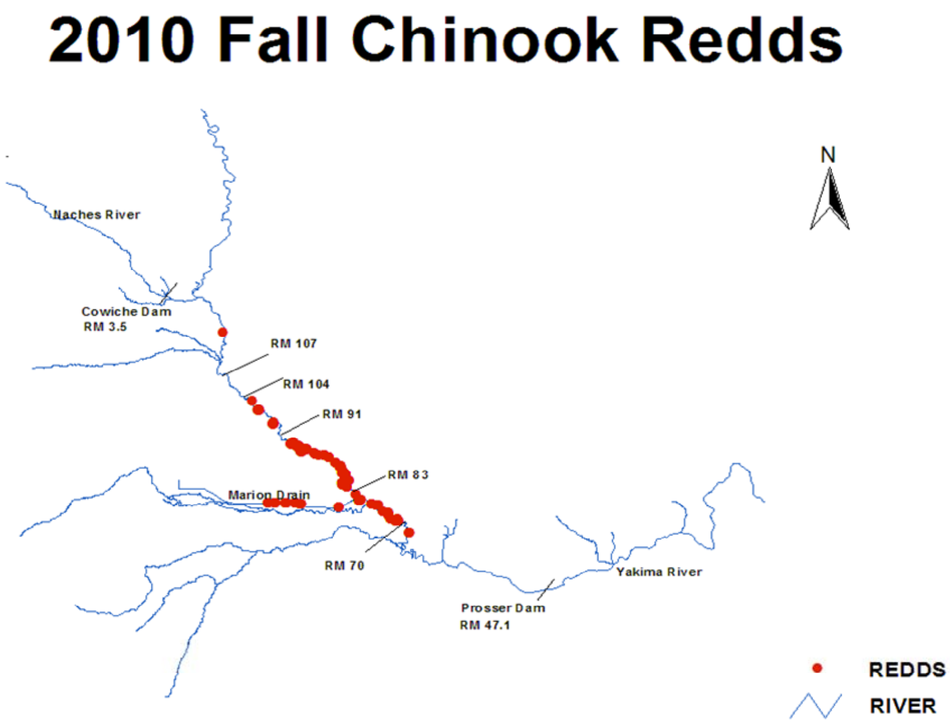


Figure 9. Distribution of fall Chinook redds in the Yakima River Basin in 2010.

Coho: Surveys began the third week of October and ended in late December. Redd surveys were conducted daily in conjunction with fall Chinook surveys. The Yakima and Naches Rivers are broken into sections that are checked by boat or ground surveys. Conditions were excellent for surveys throughout the spawning season. There was one late bump in flows that hindered our last surveys on tributaries. Tributaries were checked methodically by foot in conjunction with the Washington Dept of Fish and Wildlife. Main river sections of the Yakima and Naches were floated by raft once a week.

The 2010 redd count was approximately 678 redds. This ranks as second only to 2009. Approximately, 75 redds were found in the Upper Yakima River, this was down from the 160 redds that were found in 2009. The Naches River had 276 redds located mainly in the lower 5 miles, however redds were scattered all the way up to the Lost Creek acclimation site. Taneum Creek had 134 redds from the 150 females that were planted. Redds were found in high densities around the Stiles Acclimation site and the Holmes Acclimation site. Approximately, 327 redds were found in tributaries throughout the Yakima Basin (Table 2).

In the Naches River, Cowiche Creek had 6 adult coho detected over Bonneville Dam from the mobile acclimation site and 5 from the parr plants and none of these PIT tags were detected crossing Prosser Dam. The PIT tag detector that was used in Cowiche Creek in 2009 was not deployed in 2010. The river flows were too high just before and just after the coho would have been entering Cowiche Creek. This is unfortunate because there were 23 coho redds located in Cowiche Creek in 2010.

Table 2. Yakima Basin Coho Redd Counts, 1998-2010.

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

One of the overall goals of Phase II is to evaluate the transition of redds from the mainstem river into historic tributaries. With the beginning of Phase II of the Coho Program we have observed large increases in tributary spawning. Tributary spawning has averaged over 200 redds annually since 2004, a marked increase over the prior five years (Table 2). Coho are volunteering into many tributaries, and the fidelity of adults from the summer parr plants is showing good results. Overall redd counts and distribution has increased substantially. 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. Figure 10 shows the distribution of coho redds throughout the Yakima Basin from 2006 through 2009. These data encompass the range of redd distribution observed in 2010 as well.

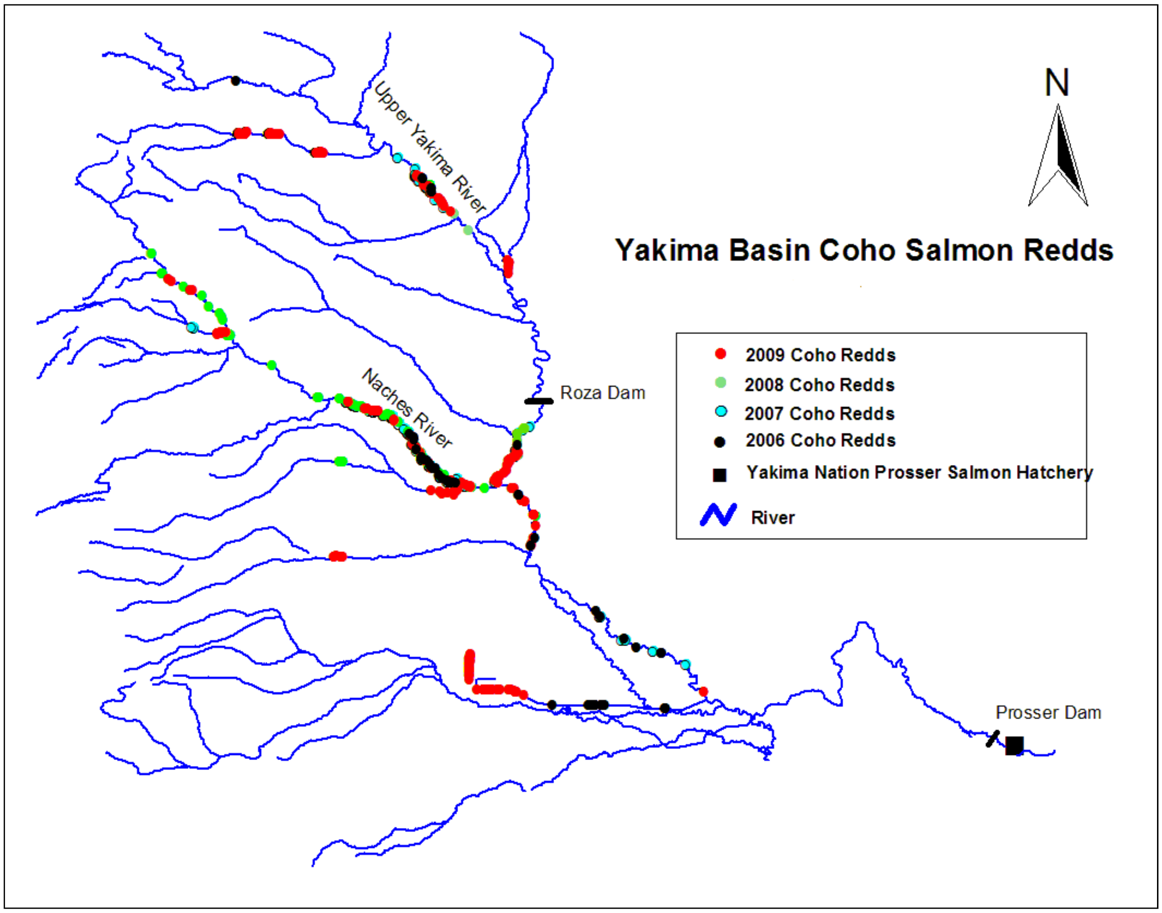


Figure 10. Distribution of coho redds in the Yakima River Basin, 2006-2009.

Task 1.k Yakima Spring Chinook Residual/Precocial Studies

The WDFW annual report for this task can be located on the BPA website: http://www.efw.bpa.gov/searchpublications/ . This year's report is expected to be available soon. The most recent report is:

C. L. Johnson and G. M.Temple. 2010. Spring Chinook Salmon Competition / Capacity and Residual/Precocious Male Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report 2009.

Task 1.l Yakima River Relative Hatchery/Wild Spring Chinook Reproductive Success

The latest information on these studies are available on the BPA website: http://www.efw.bpa.gov/searchpublications/ and in:

Schroder, S. L., C.M. Knudsen, T. N. Pearsons, T. W. Kassler, S. F. Young, E. P. Beall, and D. E. Fast. 2010. Breeding success of four male life history types in spring Chinook salmon spawning under quasi-natural conditions. Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report, June 2010.

Knudsen, C.M., editor. 2010. Reproductive Ecology of Yakima River Hatchery and Wild Spring Chinook. Yakima/Klickitat Fisheries Project Monitoring and Evaluation, Annual Report 2009.

Knudsen, C.M., S.L. Schroder, C. Busack, M.V. Johnston, T.N. Pearsons, and C.R. Strom. 2008. Comparison of Female Reproductive Traits and Progeny of First-Generation Hatchery and Wild Upper Yakima River Spring Chinook Salmon. Transactions of the American Fisheries Society 137:1433-1445.

Schroder, S. L., C. M. Knudsen, T. N. Pearsons, T. W. Kassler, S. F. Young, C. A. Busack, and D. E. Fast. 2008. Breeding Success of Wild and First-Generation Hatchery Female Spring Chinook Salmon Spawning in an Artificial Stream. Transactions of the American Fisheries Society, 137:1475-1489.

Schroder, S. L., C. M. Knudsen, T. N. Pearsons, T. W. Kassler, S. F. Young, E.P. Beall, and D. E. Fast. 2010. Behavior and Breeding Success of Wild and First-Generation Hatchery Male Spring Chinook Salmon Spawning in an Artificial Stream. Transactions of the American Fisheries Society, 139:989-1003.

Task 1.m Scale Analysis

Rationale: Determine age and stock composition of juvenile and adult salmonid stocks in the Yakima basin.

Methods: Random scale samples are collected at broodstock collection sites (Prosser and Roza dams and Chandler Canal) and from spawner surveys. Acetate impressions are made from scale samples and then are read for age and stock type using a microfiche reader. Data are entered into the YKFP database maintained by the Data Management staff.

Progress: Juvenile scale sample results for 2010 were not available at the time this report was produced. Available adult scale sample results for 2010 are summarized in Table 3 by species and sampling method. Historical data from age and length sampling activities of adult spring Chinook in the Yakima Basin are presented in Appendix A.

Table 3. Age composition of salmonid adults sampled in the Yakima Basin in 2010.

	Age 2		Age 3		Age 4		Age 5	
	Count	Length	Count	Length	Count	Length	Count	Length
Yakima R. Spring Chinook								
Roza Dam Samples								
Upper Yakima Supplementation	22	15.9	107	42.7	557	61.5	3	67.0
Upper Yakima Wild/Natural			40	43.9	427	62.7	2	72.0
Spawner Survey Samples								
Upper Yakima Supplementation			2	44.0	16	57.5		
Upper Yakima Wild/Natural			13	47.7	105	59.8		
American River Wild/Natural			no carcasses were sampled in 2010					
Naches River Wild/Natural			1	41.0	28	61.7	4	72.0
Yakima R. Fall Chinook	No data were available at the time this report was produced.							
Hatchery								
Wild/Natural								
Yakima R. Coho								
Hatchery								
Wild/Natural								

Note: Yak. SpCh Lengths are average post-eye to hypural plate length.
Yak. FaCh/Coho lengths are average mid-eye to hypural plate lengths from denil trap sampling.

Task 1.n Habitat inventory, aerial videos and ground truthing

Rationale: Measure critical environmental variables by analyzing data extracted from aerial videos and verified by ground observations. These data are critical to validating EDT and AHA model outputs which are used to guide Project decisions.

Methods: Aerial videos of the Yakima Subbasin will be conducted and analyzed. The habitat conditions (e.g. area of "watered" side channels, LWD, pool/riffle ratio, etc.) from the videos will be checked by dispatching technicians to specific areas to verify that conditions are in fact as they appear on video.

Progress: Although no aerial or ground surveys were conducted in project year 2010, YN biologists did collaborate with technical staff from the U.S. Bureau of Reclamation, the Yakima Subbasin Fish and Wildlife Recovery Board, and the Columbia River Inter-Tribal Fish Commission to:

- refine EDT parameters relative to present habitat conditions, and to
- investigate the feasibility of integrating EDT models with limiting factor data from the Subbasin and Recovery Plans as well as habitat project implementation data to form an integrated habitat effectiveness database for the Yakima Subbasin.

Task 1.0 Sediment Impacts on Habitat

Rationale: To monitor stream sediment loads associated with the operation of dams and other anthropogenic factors (e.g. logging, agriculture and road building) which can affect survival of salmonids in the Yakima Basin.

Methods: Representative gravel samples were collected from various reaches in the Little Naches, South Fork Tieton, and Upper Yakima Rivers in the fall of 2010. Each sample was analyzed to estimate the percentage of fine or small particles present (<0.85 mm). The Washington State TFW program guidelines on sediments were used to specify the impacts that estimated sedimentation levels have had on salmonid egg-to-smolt survival. These impacts will be incorporated in analyses of impacts of "extrinsic" factors on natural production.

Progress:

Little Naches

A total of 101 samples were collected and processed from the Little Naches drainage this past year (9 reaches). The reach on Pyramid Creek was not sampled this past year due to road access difficulties (end of road decommissioned and culvert crossing removed). Other methods will be explored to access and sample this site next year. In addition, one riffle on Bear Creek Reach 2 and a partial riffle on Bear Creek Reach 1 were missed by the new field crew. With this year's monitoring work, the data set for the Little Naches drainage now covers a time period of 26 years for the two historical reaches, and 19 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 11.1% for 2010 compared to 9.3 % for 2009). This compares to recent years when overall fine sediment conditions in the Little Naches drainage ranged from about 10.5% to 12% fines (Figure 11). The overall average fine sediment found in spawning substrate is still relatively low and should lessen mortality on incubating eggs and alevins. It is not surprising that fine sediment conditions have been fairly low and stable as little anthropogenic disturbance has been taking place in the drainage other than recreational activities. Fine sediment levels at the lower end of the range observed in recent years in the Little Naches are similar to those observed in the American River, a relatively undisturbed and reference watershed.

At the reach scale, several of the sampling reaches had somewhat higher fine sediment rates than those found in 2009. Three of the sampling reaches had greater than a 2.0% point increase in average fines compared to the previous year (Little Naches Reach 1, Little Naches Reach 2, and South Fork Reach 1). Active bank erosion was observable adjacent to Little Naches Reach 2 on the right bank above the bridge and also in upper portions of Little Naches Reach 1. An ATV trail also runs next to the eroding right bank on Reach 2. Some beaver activity is also taking place above Reach 2. The South Fork Reach has been experiencing channel shifting and splitting in the last couple years that could be influencing sediment levels. Four other sampling reaches had slightly higher average sediment rates (Bear Creek Reaches 1 and 2, Little Naches Reach 4 and North Fork Reach 2). These reaches have also had channel shifting, as well as some log jam formation. The remaining two reaches were nearly the same as the previous year (Little Naches Reach 3 and North Fork Reach 1). Variability within sampling reaches was generally greater in 2010 compared to 2009. Six of the reaches had a higher standard deviation, two reaches had a similar standard deviation, and one reach had a lower standard deviation, than in 2009. In some reaches, channel conditions have changed substantially over the last couple years that could be causing more variability (e.g. Little Naches Reach 4, Little Naches Reach 3, Little Naches Reach 1-Riffle 3). In addition, the new field crew may need more training to ensure that samples are more consistently taken.

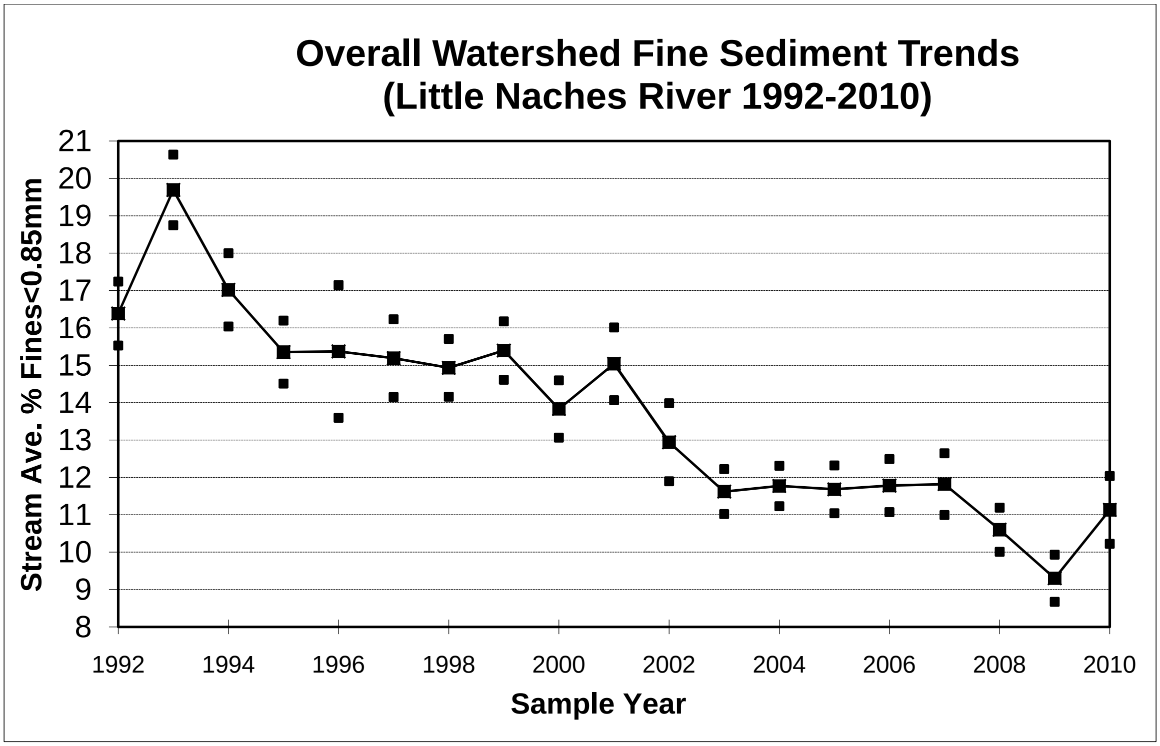


Figure 11. Overall Fine Sediment (<0.85mm) Trends with 95% confidence bounds in the Little Naches River Drainage, 1992-2010.

<u>South Fork Tieton</u>

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 12 years that the USFS has been sampling this area. This stream reach typically receives considerable bull trout spawning activity and the sampling provides additional information on their spawning conditions. Average fine sediment levels in this reach increased to 13.6% in 2010 (Figure 12). If fine sediment conditions continue to trend upward, further investigation may be needed to identify sediment sources and abate them.

<u>Upper Yakima</u>

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 14 years. Although average fine sediment levels in reaches 1, 3, and 4 increased from 2009, overall average percent fine sediment less than 0.85mm by reach and for the combined Upper Yakima drainage was lower than the average observed over the fourteen years of sampling (Figure 13).

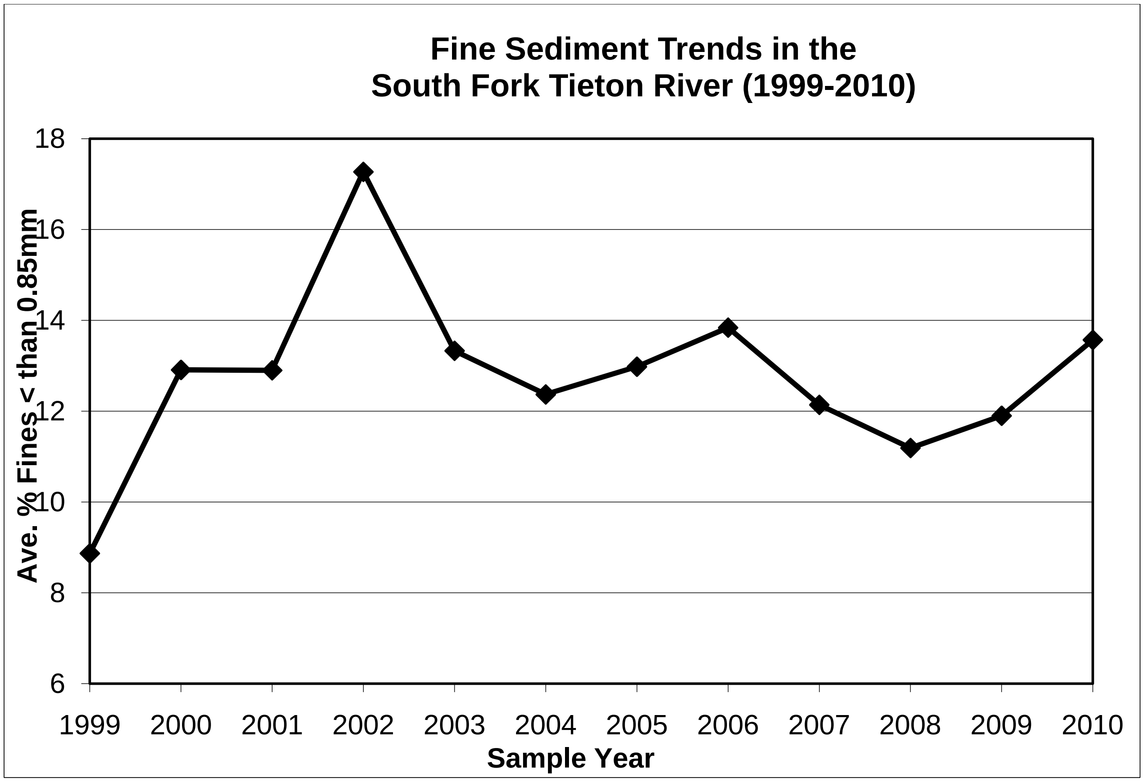


Figure 12. Fine Sediment Trends in the South Fork Tieton River, 1999-2010. Note: Data for 2007 were collected from only 1 Riffle.

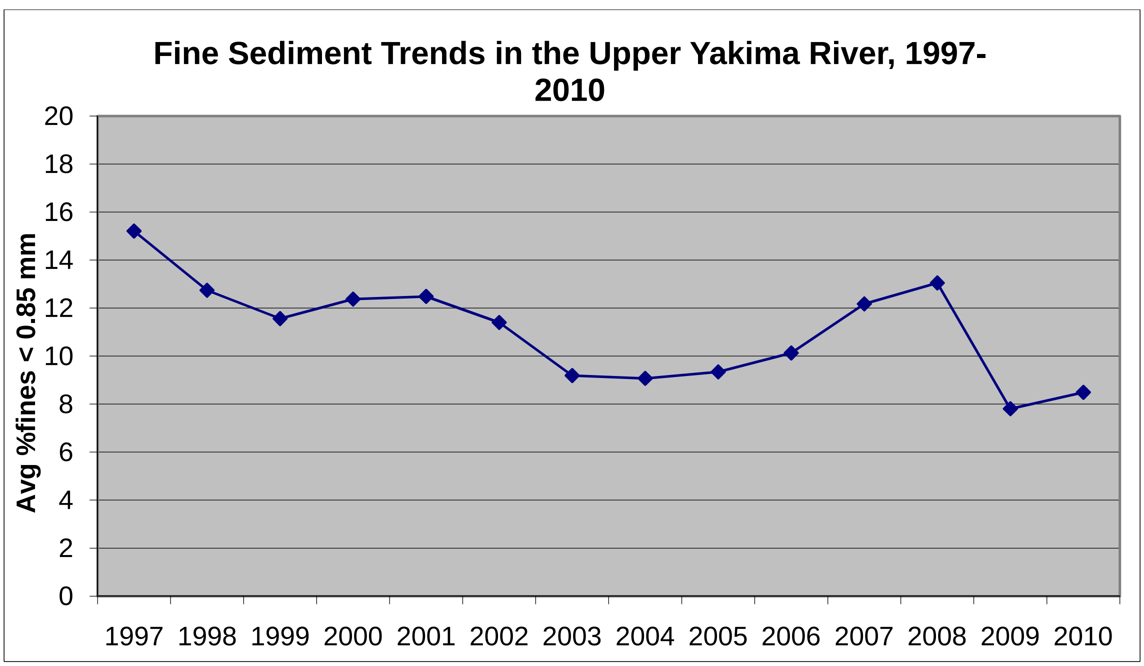


Figure 13. Overall average percent fine sediment (< 0.85 mm) in spawning gravels of the Upper Yakima River, 1997-2010.

Summary

The overall average fine sediment level in the Little Naches this past season was somewhat higher than last year. Overall average fine sediment in 2010 for all the samples in the Little Naches was 11.1%. While the sediment rate is elevated, it still represents favorable conditions for egg and alevin survival. Data were similar for the Upper Yakima system, where overall average fine sediment in 2010 was 8.5%, the second lowest in this watershed since sampling began in 1997. These conditions should favor salmonid spawning success.

The results of the USFS sampling in the South Fork Tieton River were also higher than the previous year. Reach average fines in the South Fork increased to 13.6% in 2010. If conditions continue rising, more effort may be needed to curb sediment delivery.

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 (jmatthews@yakama.com).

Personnel Acknowledgements: Again, major credit goes to the fisheries technicians from the Yakama Nation who cored the many samples from the Little Naches, and processing all of the samples this winter. Without their dedicated work, this project would not be possible. In addition, credit also goes to the U.S. Forest Service Naches Ranger District staff for their continued collection of samples from the upper South Fork Tieton River and other tributaries to the Naches drainage.

Task 1.p Biometrical Support

Doug Neeley of International Statistical Training and Technical Services (IntSTATS) was contracted by the YKFP to conduct the following statistical analyses:

- Annual Report: Comparisons between Smolt Measures of Hatchery x Hatchery- and Natural x Natural-Brood Stock from Upper Yakima Spring Chinook for Brood-Years 2002-2008 (Appendix B)
- Annual Report: Comparison of Transfer-Supplemented- and Unsupplemented-Feed Treatments evaluated on Hatchery-Reared Upper-Yakima Spring Chinook Smolt released in 2007, 2009, and 2010 (Appendix C)
- Annual Report: Smolt Survival to McNary Dam of 1999-2010 Spring Chinook Releases PIT-tagged and/or released at Roza Dam (Appendix D)
- 2010 Annual Report: Smolt-to-smolt Survival to McNary Dam of Yakima Fall and Summer Chinook (Appendix E)

- Annual Report: 2006-2010 Coho Smolt-to-smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin (Appendix F)

All of these reports are attached to this YKFP M&E annual report as appendices as noted above, and summaries of results have been incorporated within the appropriate M&E task.

HARVEST

Task 2.a Out-of-basin Harvest Monitoring

Rationale: Estimate harvest of hatchery- and natural-origin anadromous salmonids outside of the Yakima Subbasin.

Method: Monitor recoveries of CWTs and PIT tags in out-of-basin fisheries using queries of regional RMIS and PTAGIS databases. Coordinate with agencies responsible for harvest management (WDFW, ODFW, USFWS, CRITFC, etc.) to estimate the harvest of target stocks.

Progress: Additional detail about methods used to evaluate harvest of Yakima Basin spring Chinook in Columbia Basin and marine fisheries is given in Appendix A. Historical results of this evaluation including results for the present year are given in Tables 46 and 47 of Appendix A.

Task 2.b Yakima Subbasin Harvest Monitoring

Rationale: Estimate harvest of hatchery- and natural-origin anadromous salmonids within the Yakima Subbasin. Harvest monitoring is a critical element of project evaluation. Harvest data are also important for deriving overall smolt-to-adult survival estimates of hatchery- and natural-origin fish.

Method: 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. This information is used along with other adult contribution data (i.e. broodstock, dam counts, spawner ground surveys) to determine overall project success.

Progress: Yakima River in-basin Tribal harvest for salmon and steelhead are presented in Table 4. For additional data see Table 45 in Appendix A.

Personnel Acknowledgements: Data Manager Bill Bosch, biologists Mark Johnston and Roger Dick Jr., and Fisheries Technicians Steve Blodgett and Arnold Barney.

Table 4. A summary of Yakama Nation tributary estimated harvest in the Yakima Subbasin, 2010.

River	Dates	Weekly Schedule	Notes	Chinook	Jacks	Steelhead	Coho
Yakima River	4/13-6/26	Noon Tues to 6 PM Saturday		374	165	0	0
Yakima River	9/14-11/27	Noon Tues to 6 PM Saturday		0	0	0	0

GENETICS

Overall Objective: Monitor and evaluate genetic change due to domestication and potential genetic change due to in-basin and out-of-basin stray rates.

Progress: All Tasks within this Section are assigned to WDFW and are reported in written progress reports submitted to BPA. These tasks are the following:

- Task 3.a Yakima spring Chinook domestication.
- Task 3.b Stray recovery on Naches and American river spawning grounds.

The WDFW annual report for this task can be located on the BPA website: http://www.efw.bpa.gov/searchpublications/. This year's report is expected to be available soon. The most recent report is:

Blankenship, S., C. Bowman, C. Busack, A. Fritts, G. Temple, T. Kassler, S. Schroder, J. Von Bargen, K. Warheit, C. Knudsen, W. Bosch, D. Fast, M. Johnston, and D. Lind. 2010. Yakima/Klickitat Fisheries Project Genetic Studies, Yakima/Klickitat Fisheries Project Monitoring and Evaluation, Annual Report 2009.

ECOLOGICAL INTERACTIONS

Overall Objective: Monitor and evaluate ecological impacts of supplementation on non-target taxa, and impacts of strong interactor taxa on productivity of targeted stocks.

Task 4.a Avian Predation Index

Rationale: Monitor, evaluate, and index the impact of avian predation on annual salmon and steelhead smolt production in the Yakima Subbasin. Avian predators are capable of significantly depressing smolt production and accurate methods of indexing avian predation across years have been developed. 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. The index consists of two main components: 1) an index of bird abundance along sample reaches of the Yakima River and 2) an index of consumption along both sample reaches and at key dam and bypass locations (called hotspots). Due to a major shift in the major avian predator, first observed in 2003, from Ring-Billed and California Gulls (*Larus delawarensis* and *L. californicus*) to American White Pelican (*Pelecanus erythrorhynchos*) in the lower Yakima River, changes in piscivorous predation have occurred and warrant further study to quantify consumption rates of salmonids and other preferred prey species.

Methods: The methods used to monitor avian predation on the Yakima River in 2010 were consistent with the techniques used in 2001-2009. Consumption by gulls at hotspots was based on direct observations of gull foraging success and modeled abundance. Consumption by pelicans and all other piscivorous birds on river reaches and hotspots were estimated using published dietary requirements and modeled abundance. Seasonal patterns of avian piscivore abundance were identified, diurnal patterns of gull and pelican abundance at hotspots were identified, and predation indices were calculated for hotspots and river reaches for the spring and summer. In addition two aerial surveys for pelicans were conducted on the lower Yakima River from Union Gap to the mouth of the Columbia River.

A new method was also instituted in 2006 and continued in 2007-10: Pelican, Double-crested Cormorant, Great Blue Heron and Common Merganser roosting and nesting sites were examined for the presence of salmon PIT tags in August and September. Sites surveyed included the Roza recreation site gravel bar, cormorant and heron rookeries along the Yakima River near Selah, areas near the Selah gravel ponds (both pond islands and a gravel bar in the Yakima River itself), and the

Chandler pipe outfall. In 2006 and 2008-09, cormorant and heron rookeries at Satus Wildlife Management Area on the Yakama Reservation were also surveyed.

Details of survey, analytical methods and results can be found in Appendix G of this annual report.

Progress (Executive Summary, see Appendix G for additional detail, tables and figures):

Gull numbers remain low in the Yakima River Basin and the focus of future studies has shifted towards: Pelican numbers and diet, management of extreme numbers of piscivorous birds in given areas, and surveys of PIT tags where mortality can be linked to predation.

Mergansers on their breeding grounds in the upper and middle Yakima River have not shown a numeric response to hatchery supplementation of spring Chinook and Coho salmon smolts yet remain a concern as they are known to congregate in large numbers below Roza Dam.

Pelican numbers remain a concern as in previous years. Aerial surveys in 2008 showed that pelican numbers peaked at near 280 birds in the Yakima Basin. Pelican numbers at Chandler were only consistently high after smolt passage was largely complete and flows returned to levels conducive to foraging. High numbers of pelicans in Yakima Canyon in spring appeared to correlate with sucker runs, smolt emigration, and smallmouth bass spawning. New data of Pelican diet is presented (Appendix G) and Pelican impact on salmon runs will be proposed for a diet and site use study at Chandler.

The Chandler Bypass outfall pipe makes fish of all species vulnerable to predation at low water, as the fish are disoriented and upwelling at right angles to the current. The presence of large dead and disabled fish exiting from the bypass pipe may attract avian predators to the site. PIT tag detection at Chandler outlet pipe did show high mortality for both juvenile and adult salmonids.

PIT tag surveys in 2010 proved very productive as over 21,455 tags have been discovered in the Yakima Basin. PIT tag recoveries for 2010 are significantly greater than the previous high of 14,352 from 2009 surveys. Tags detected were linked to sources of release and 20,610 of these tags were from Yakima River juvenile salmonids. Predation by Herons showed correlation with river flow. High flow eliminates opportunity for wading bird foraging in many parts of the river. Conversely low flow creates foraging opportunities for Herons.

PIT tag survey of Toppenish Creek Great Blue Heron rookery showed predation increases when juvenile salmonids have late migration timing.

PIT tag analysis was developed by determining detection efficiencies in 2 diverse rookeries to assess a number of undetected PIT tags.

Plans for the 2011 field season include continued monitoring of river reaches and at Heron Rookeries with a focus on Pelican foraging. Heron rookeries and cormorant nesting colonies will continue to be surveyed. PIT tags found at pelican, heron nesting and roosting sites will be used to assign smolt predation estimates to specific bird species.

Personnel Acknowledgements: Michael Porter served as the project biologist for this task. Sara Sohappy and Jamie Bill collected the majority of the field data for this project. Dave Lind, Bill Bosch and Chris Fredrickson contributed to the analysis. Some photographs were taken by Ann Stephenson. Paul Huffman helped with the maps. Bird surveys at smolt acclimation ponds were conducted by Farrell Aleck, Marlin Colfax, Nate Pinkham, William Manuel, Terrance Compo and Levi Piel.

Task 4.b Fish Predation Index

Rationale: Monitor, evaluate, and index impact of piscivorous fish on annual smolt production of Yakima Subbasin salmon and steelhead. Fish predators are capable of significantly depressing smolt production. 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 fluctuations in hatchery and wild smolt-to-adult survival rate can be deduced.

Piscivorous Fish Populations and Management:
Based on YKFP and WDFW studies of piscivorous fish in the Yakima River Basin it was determined that management of the piscivorous fish populations in the area is necessary for survival of juvenile salmonids. 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.

Methods: During this project year, monthly multi-pass removal efforts 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). 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 (Figure 14). 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.

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

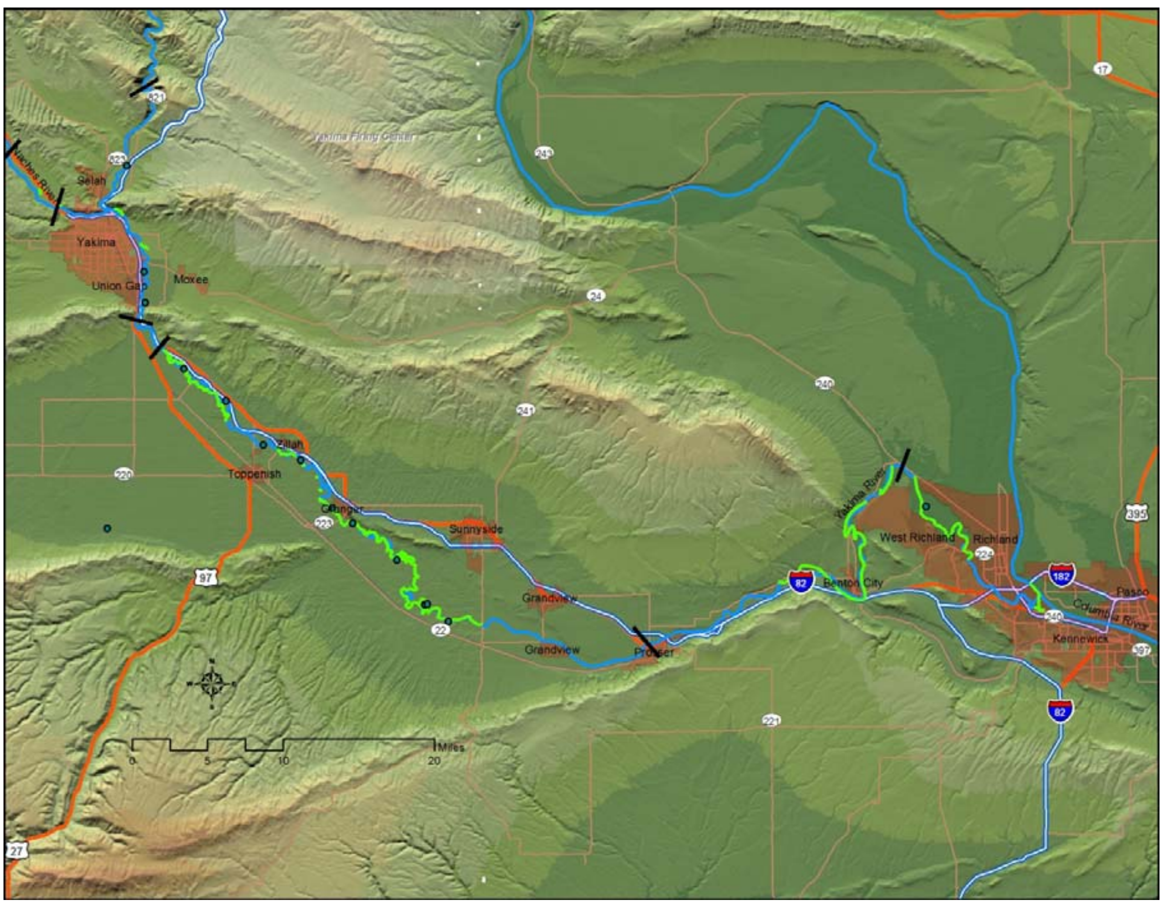


Figure 14. Yakima River Piscivorous Fish Populations Study Areas.

Progress:

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. Samples of possible river locations for the multi-pass population study were conducted (Table 5). Sites with high levels of piscivorous fish have been identified and will be the focus of future efforts.

SPECIES	*NUMBERS*	*LOCATION*	*ELECTRODE START TIME*	*ELECTRODE END TIME*
NORTHERN PIKE MINNOW	1	BUENA BOAT LAUNCH	12486	15186
NORTHERN PIKE MINNOW	2	DELTA FRONT OF CAUSEWAY	22284	25348
NORTHERN PIKE MINNOW	1	DELTA FRONT OF CAUSEWAY	29152	32953
NORTHERN PIKE MINNOW	4	DELTA FRONT OF CAUSEWAY	53344	56436
NORTHERN PIKE MINNOW	1	FRONT OF CAUSEWAY	9759	11418
NORTHERN PIKE MINNOW	12	GAP TO GAP		
NORTHERN PIKE MINNOW	2	GRANGER		
NORTHERN PIKE MINNOW	6	GRANGER below put-in		
NORTHERN PIKE MINNOW	96	GRANGER SC		
NORTHERN PIKE MINNOW	1	LOWER YAKIMA, HORN, AND DELTA		
NORTHERN PIKE MINNOW	25	MARION DRAIN		
NORTHERN PIKE MINNOW	85	MENINICK SLOUGH		
NORTHERN PIKE MINNOW	1	MENINICK-WILDLIFE AREA-GPS 82		
NORTHERN PIKE MINNOW	113	PARKER SC	27278	31590
NORTHERN PIKE MINNOW	1	PHILLIP JOHN WINNAWAY ROAD SIDE CHANNEL		
NORTHERN PIKE MINNOW	4	REST HAVEN RD SC		
NORTHERN PIKE MINNOW	5	SNIPES SIDE CHANNEL	15186	20462
NORTHERN PIKE MINNOW	267	SUB-BASIN DRAIN 35		
NORTHERN PIKE MINNOW	2	TOPP WILDLIFE AREA BLOC HARLAN/CURLEW RD		
NORTHERN PIKE MINNOW	16	WAPATO REACH		
NORTHERN PIKE MINNOW	2	WAYPOINT 216 Side Channel	28526	29278
NORTHERN PIKE MINNOW	2	YAKIMA DELTA ALONG RIVER	56436	58131
NORTHERN PIKE MINNOW	29	YAKIMA RIVER-GRANGER	46698	51887
NORTHERN PIKE MINNOW	1	ZILLAH/TOPP BRIDGE		
NORTHERN PIKE MINNOW	108	ZILLAH-GRANGER		
SMALLMOUTH BASS	1	DELTA BEHIND CAUSEWAY	51887	53344
SMALLMOUTH BASS	1	DELTA FRONT OF CAUSEWAY	22284	25348
SMALLMOUTH BASS	6	DELTA FRONT OF CAUSEWAY	53344	56436
SMALLMOUTH BASS	1	FRONT OF BATEMAN IS.	11418	12022
SMALLMOUTH BASS	1	GRANGER		
SMALLMOUTH BASS	2	HORN RAPIDS		
SMALLMOUTH BASS	181	LOWER RIVER-KENNEWICK		
SMALLMOUTH BASS	4	MARION DRAIN		
SMALLMOUTH BASS	1	MENINICK-WILDLIFE AREA-GPS 82		
SMALLMOUTH BASS	3	Sub-basin Drain 35		
SMALLMOUTH BASS	53	TOPP WILDLIFE AREA BLOC HARLAN/CURLEW RD		
SMALLMOUTH BASS	3	WAYPOINT 216 Side Channel	28526	29278
SMALLMOUTH BASS	1	YAKIMA DELTA ALONG RIVER	56436	58131

Table 5. Piscivorous fish preliminary sample numbers by location.

PIT Tag Surveys
Methods:
Predation within irrigation diversion fish screening facilities may cause significant mortality to juvenile salmonids. WDFW permits for scientific investigation of the removal of piscivorous Northern pikeminnow and Smallmouth bass were obtained by YKFP for Sunnyside dam, Wapato Dam, Roza Dam, and Prosser Dam to determine concentration of presence during smolt outmigration. In 2009 with these concerns and study questions in mind, the YKFP began PIT tag surveys at four Bureau of Reclamation and one City of Yakima-operated fish screening facilities. These studies were continued in 2010.

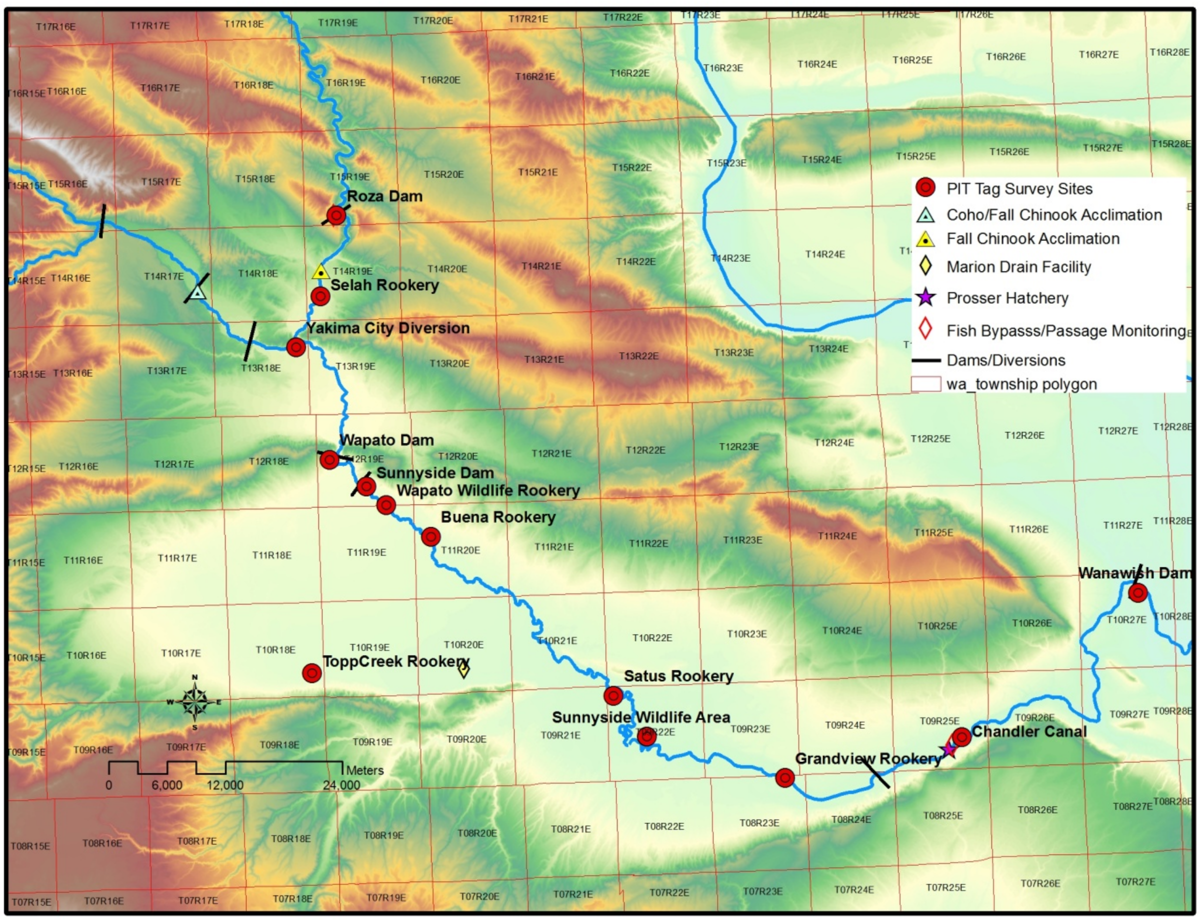


Figure 15. PIT tag survey sites (Includes Great Blue Heron Rookeries).

Survey times of irrigation diversion fish screening facilities coincide with Bureau of Reclamation annual services of the facilities at each site. Annual servicing occurs in the late fall and winter while irrigation diversion from the Yakima River is halted.

Irrigation Diversion PIT tags were related to fish predation given these key elements:

- Surveys conducted in front of fish screens and behind screens
- Numerous tags behind trash screens
- Underwater cameras behind trash screens have shown fish predation
- PIT tags at diversions are linked to fish predation due to saturation of salmonids at sites

Progress:

The combined number of PIT tags discovered at all irrigation diversions surveyed was 9,894 total PIT tags. The total number of PIT tags scanned was 10,173, which leaves nearly 300 PIT tags surveyed in the diversions without a tagging detail record in PTAGIS. These PIT tags with lack of tagging detail may be explained by either human error at tagging or possible tags inserted into adults for purposes of tracking their upstream locations after spawning (leaving them in an enclosed system of the Yakima River Basin). A large number of Summer Chinook PIT tags, in relation to other species and total years and numbers of PIT tags released were discovered at these irrigation sites.

YKFP Predation Study: Diversions PIT tag Numbers For 2010 - All Diversions

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Chinook	*Fall*	2446		**7**	**8**	**1**	**19**	**100**	**175**	**486**	**706**	**712**	**69**	**163**	
Chinook	Spring	3792	1	78	138	69	134	156	477	319	552	968	563	337	
Chinook	Summer	2095											1740	355	
Coho	Fall	124		24	20	22	58								
Coho	Unknown	1414						25	144	132	307	351	269	183	3
Steelhead	Resident	1									1				
Steelhead	Summer	19				2	1		3	1	2	7	3		
Steelhead	Unknown	3												3	
Totals		9894	1	109	166	94	212	281	799	938	1568	2038	2644	1041	3

Table 6. PIT tags surveyed at Yakima Basin Irrigation Fish Screening Facilities shown by migration year and species.

Task 4.c Upper Yakima Spring Chinook NTTOC Monitoring

The WDFW annual report for this task can be located on the BPA website: http://www.efw.bpa.gov/searchpublications. This year's report is expected to be available soon. The most recent report is:

Temple, G.M., A.L. Fritts, C.L. Johnson, T.D. Webster, Z. Mays, and G. Stotz. 2010. Ecological Interactions between Non-target Taxa of Concern and Hatchery Supplemented Salmon. Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report. Annual Report 2009.

Task 4.d   Pathogen Sampling

This project was discontinued. The latest WDFW annual report for this task can be located on the BPA website: http://www.efw.bpa.gov/searchpublications

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Hubble J., T. Newsome, and J. Woodward. 2004. Yakima Coho Master Plan. Prepared by Yakama Nation in cooperation with Washington State Department of Fish and Wildlife. September 2004. Yakima Klickitat Fisheries Project, Toppenish, WA. See www.ykfp.org Technical Reports and Publications to obtain an electronic copy of this report.

Knudsen, C. M., S. L. Schroder, C. A. Busack, M. V. Johnston, T. N. Pearsons, W. J. Bosch, and D. E. Fast. 2006. Comparison of Life History Traits between First-Generation Hatchery and Wild Upper Yakima River Spring Chinook Salmon. Transactions of the American Fisheries Society 135:1130–1144.

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APPENDICES A through G

	Task	
A.		Yakima River / CESRF Spring Chinook Salmon – Yakama Nation Data Summary
B.	1.c.	IntStats, Inc. Annual Report: Comparisons between Smolt Measures of Hatchery x Hatchery and Natural x Natural Brood Stock from Upper Yakima Spring Chinook for Brood-Years 2002-2008
C.	1.c.	IntStats, Inc. Annual Report: Comparison of Transfer-Supplemented- and Unsupplemented-Feed Treatments evaluated on Hatchery-Reared Upper-Yakima Spring Chinook Smolt released in 2007, 2009, and 2010
D.	1.d.	IntStats, Inc. Smolt Survival to McNary Dam of 1999-2010 Spring Chinook Releases PIT-tagged and/or released at Roza Dam
E.	1.f.	IntStats, Inc. Smolt-to-Smolt Survival to McNary Dam of Yakima Fall and Summer Chinook
F.	1.g.	Intstats, Inc. 2006-2010 Coho Smolt-to-Smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin
G.	4.a.	Avian Predation Annual Report

Appendix A

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

2010 Annual Report

August 12, 2011

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Project Numbers: 1995-063-25
Contract Numbers: 00042445

Acknowledgments

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

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

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

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

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

Abstract

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

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

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

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

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

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Introduction

Program Objectives

The CESRF was authorized in 1996 under the NPCC's Fish and Wildlife Program with the stated purpose being "to test the assumption that new artificial production can be used to increase harvest and natural production while maintaining the long-term genetic fitness of the fish population being supplemented and keeping adverse genetic and ecological interactions with non-target species or stocks within acceptable limits". The CESRF became operational in 1997. The experimental design calls for a total release of 810,000 smolts annually from each of three acclimation sites associated with the facility (see facility descriptions). 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 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).

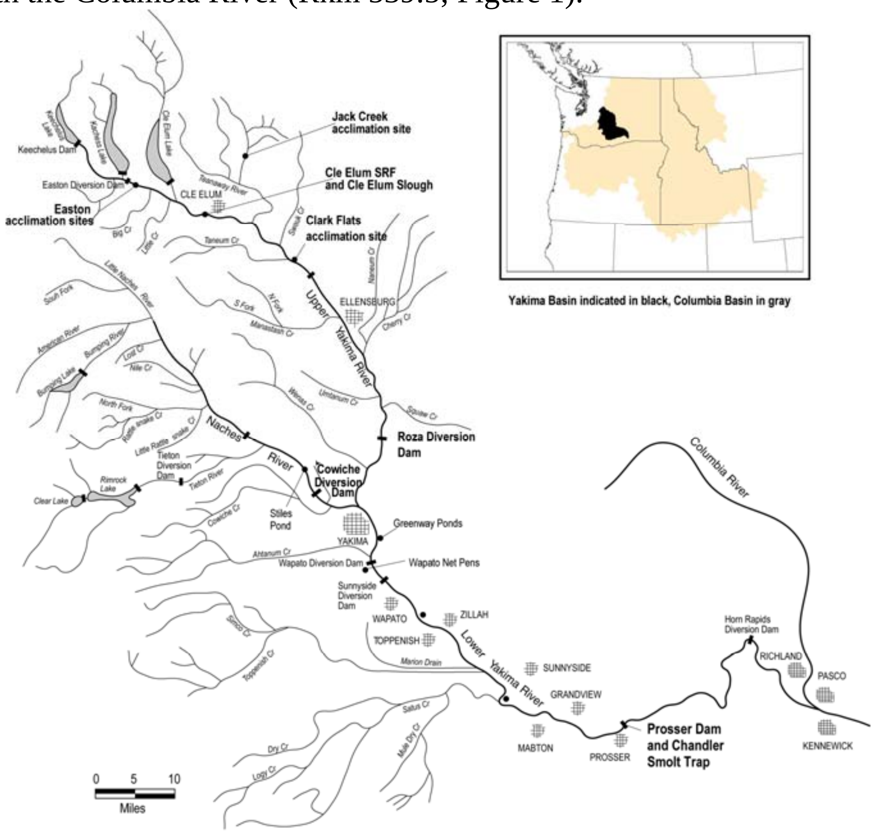

Figure 1. Yakima River Basin.

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).

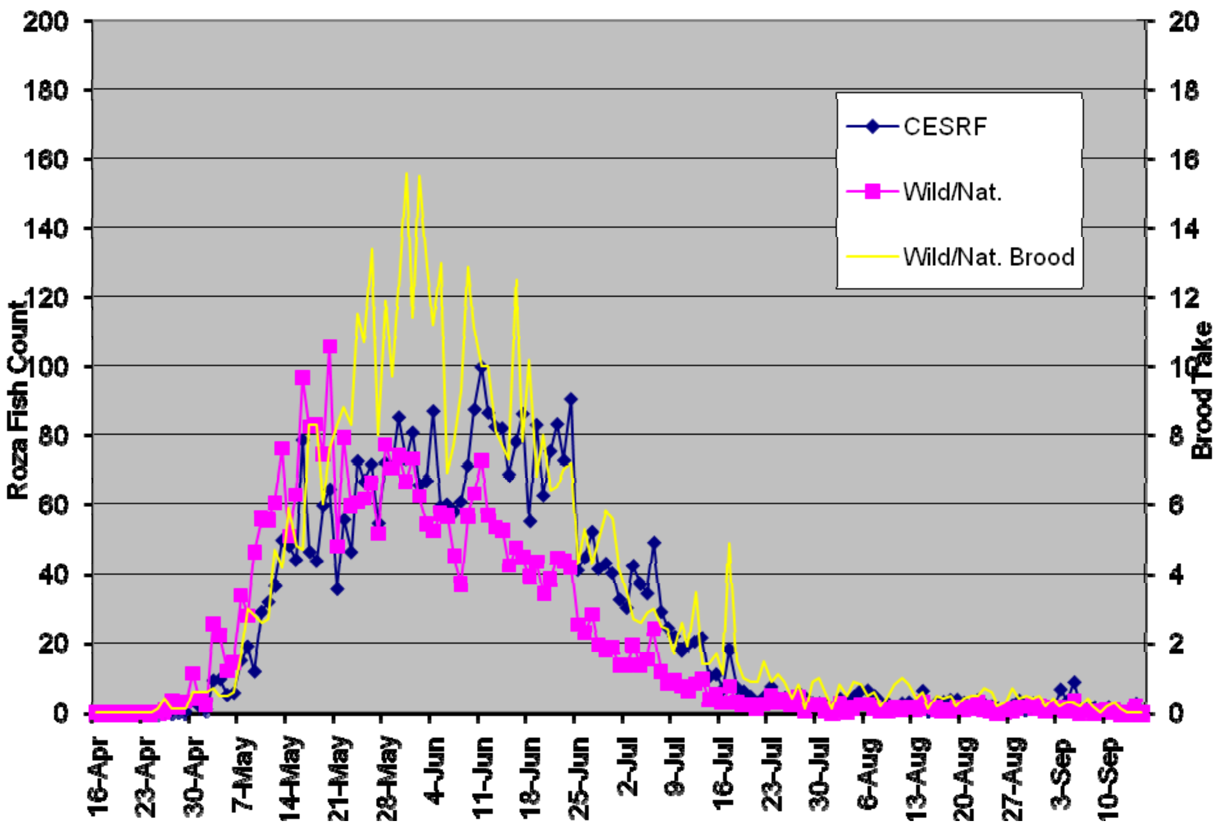

Figure 2. Mean spring Chinook run timing and broodstock collection at Roza Dam, 2001-2010.

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

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

Year	Trap Count	Brood Take	Brood %	Portion of run collected:[1] Early[3]	Middle[3]	Late[3]	Portion of collection from:[2] 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%

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%
Mean[3]	2,683	328	3,011	2,794	790	3,584	5,300	1,149	6,449	56.8%	64.7%

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, 1984-present.

	River Mouth Run Size[1]			Harvest Below Prosser	Prosser Count	Harvest Above Prosser	Spawners Below Roza[2]	Roza Count	Roza Removals[3]	Est. Escapement		Redd Counts	
Year	Adults	Jacks	Total							Upper Y.R.[4]	Naches[5]	Upper Y.R.	Naches
1984	2,251	407	2,658	119	2,539	170	180	1,619	84	1,535	570	634	220
1985	4,109	451	4,560	321	4,239	544	247	2,428	97	2,331	1,020	860	427
1986	8,841	598	9,439	530	8,909	810	709	3,267	16	3,251	4,123	1,472	1,313
1987	4,187	256	4,443	359	4,084	158	269	1,928	194	1,734	1,729	903	677
1988	3,919	327	4,246	333	3,913	111	60	1,575	235	1,340	2,167	424	490
1989	4,640	274	4,914	560	4,354	187	135	2,515	184	2,331	1,517	915	541
1990	4,280	92	4,372	131	*2,255*	532	282	2,047	31	2,016	*1,380*	678	464
1991	2,802	104	2,906	27	2,879	5	131		40	*1,583*	*1,121*	582	460
1992	4,492	107	4,599	184	4,415	161	39	3,027	18	3,009	1,188	1,230	425
1993	3,800	119	3,919	44	3,875	85	56	1,869	0	1,869	1,865	637	554
1994	1,282	20	1,302	0	1,302	25	10	563	0	563	704	285	272
1995	526	140	666	0	666	79	9	355	0	355	223	114	104
1996	3,060	119	3,179	100	3,079	375	26	1,631	0	1,631	1,047	801	184
1997	3,092	81	3,173	0	3,173	575	20	1,445	261	1,184	1,133	413	339
1998	1,771	132	1,903	0	1,903	188	3	795	408	387	917	147	330
1999	1,513	1,268	2,781	8	2,773	596	55	1,704	738	966	418	212	186
2000	17,519	1,582	19,101	90	19,011	2,368	204	12,327	667	11,660	4,112	3,770	887
2001	21,225	2,040	23,265	1,793	21,472	2,838	286	12,516	718	11,798	5,832	3,260	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	576
2006	5,951	363	6,314	0	6,314	600	14	4,028	664	3,364	1,672	1,245	444
2007	2,968	1,335	4,303	10	4,293	269	13	3,025	716	2,309	986	722	314
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	1,116	1,527	478
2010	11,027	2,114	13,142	156	12,986	1,585	9	9,900	1,526	8,374	1,491	2,666	541
Mean[6]	9,674	1,710	11,384	457	10,927	1,226	58	7,370	921	6,449	2,273	1,990	664

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 is estimated as the Prosser count less harvest above Prosser and the Roza counts, except in 1982, 1983 and 1990 when it is estimated as the upper Yakima fish/redd times the Naches redd count.
6. Recent 10-year average (2001-2010).

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 for upper Yakima wild/natural stock.

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns Age-3	Age-4	Age-5	Total	Returns/ Spawner
1982[1]	1,280	324	4,016	411	4,751	3.71
1983[1]	1,125	408	1,882	204	2,494	2.22
1984	1,715	92	1,348	139	1,578	0.92
1985	2,578	114	2,746	105	2,965	1.15
1986	3,960	171	2,574	149	2,893	0.73
1987	2,003	53	1,571	109	1,733	0.87
1988	1,400	53	3,138	132	3,323	2.37
1989	2,466	68	1,779	9	1,856	0.75
1990	2,298	79	566	0	645	0.28
1991	1,713	9	326	22	358	0.21
1992	3,048	87	1,861	95	2,043	0.67
1993	1,925	66	1,606	57	1,729	0.90
1994	573	60	737	92	890	1.55
1995	364	59	1,036	129	1,224	3.36
1996	1,657	1,059	12,882	630	14,571	8.79
1997	1,204	621	5,837	155	6,613	5.49
1998	390	434	2,803	145	3,381	8.68
1999	1,021[2]	164	722	45	930	0.91
2000	11,864	856	7,689	127	8,672	0.73
2001	12,084	775	5,074	222	6,071	0.50
2002	8,073	224	1,875	148	2,247	0.28
2003	3,341[2]	158	1,036	63	1,257	0.38
2004	10,377	207	1,547	75	1,828	0.18
2005	5,713	293	2,631	14	2,937	0.51
2006	3,378	868	2,887		3,755	1.11
2007	2,322	456				
2008	4,343[2]					
2009	7,056[2]					
2010	8,383					
Mean	3,836	330	2,949	120	3,386	0.88

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. Jack proportions for 1999, 2003, 2008 and 2009 respectively were: 0.48, 0.56, 0.27, and 0.43.

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 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	
1982[1]	86	85	1,275	324	0	1,683	19.57
1983[1]	131	123	928	757	10	1,818	13.83
1984	383	110	706	564	0	1,381	3.60
1985	683	132	574	396	0	1,102	1.61
1986	2,666	68	712	499	15	1,294	0.49
1987	1,162	27	183	197	0	407	0.35
1988	1,340	32	682	828	0	1,542	1.15
1989	992	28	331	306	0	665	0.67
1990	954	24	170	74	0	269	0.28
1991	706	7	37	121	57	222	0.31
1992	852	29	877	285	0	1,191	1.40
1993	1,145	45	593	372	0	1,010	0.88
1994	474	14	164	164	0	343	0.72
1995	124	40	164	251	0	455	3.66
1996	887	179	3,983	1,620	0	5,782	6.52
1997	762	207	3,081	708	0	3,996	5.24
1998	503	245	1,460	1,128	0	2,833	5.63
1999	358[2]	113	322	190	0	626	1.75
2000	3,862	71	2,060	215	0	2,345	0.61
2001	3,914	126	1,250	474	0	1,849	0.47
2002	1,861	59	758	153	0	970	0.52
2003	1,400	52	238	175	0	465	0.33
2004	2,197	107	875	218	0	1,200	0.55
2005	1,434	167	653	120		941	0.66
2006	1,171	192	840			1,032	0.88
2007	465	126					
2008	1,074						
2009	904						
2010	1,208						
Mean	1,313	93	976	411	3	1,460	1.11

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. Approximately 48% of these fish were jacks.

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

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns Age-3	Age-4	Age-5	Age-6	Total	Returns/ Spawner
1982[1]	22	42	223	248	0	513	23.32
1983[1]	101	67	359	602	0	1,028	10.21
1984	187	54	301	458	0	813	4.36
1985	337	81	149	360	0	590	1.75
1986	1,457	36	134	329	11	509	0.35
1987	567	12	71	134	0	216	0.38
1988	827	19	208	661	5	892	1.08
1989	524	11	69	113	0	193	0.37
1990	425	15	113	84	0	213	0.50
1991	414	3	5	22	0	30	0.07
1992	335	23	157	237	0	417	1.24
1993	721	8	218	405	8	639	0.89
1994	230	7	36	16	0	59	0.26
1995	98	33	32	98	0	163	1.65
1996	159	30	176	760	0	967	6.07
1997	371	13	1,544	610	0	2,167	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	111	0	335	1.34
2001	1,918	18	368	253	0	638	0.33
2002	1,180	19	274	256	0	550	0.47
2003	1,192	22	182	440	0	644	0.54
2004	318	120	52	33	0	205	0.64
2005	469	79	172	69[2]		319	0.68
2006	501	45	360[2]			405	0.81
2007	521	56[2]					
2008	504						
2009	212						
2010	284						
Mean	548	39	263	304	1	589	1.08

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. No survey samples in 2010 return year; data approximated using 2009 survey samples.

Table 7. Adult-to-adult productivity 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
1982[1]	108	127	1,274	601	0	2,002	18.54
1983[1]	232	190	1,257	1,257	8	2,713	11.68
1984	570	164	1,109	1,080	0	2,354	4.13
1985	1,020	213	667	931	0	1,811	1.77
1986	4,123	103	670	852	31	1,657	0.40
1987	1,729	39	231	400	0	669	0.39
1988	2,167	51	815	1,557	11	2,434	1.12
1989	1,517	39	332	371	0	741	0.49
1990	1,380	40	326	168	0	533	0.39
1991	1,121	10	32	144	127	314	0.28
1992	1,188	52	1,034	661	0	1,747	1.47
1993	1,865	53	603	817	17	1,489	0.80
1994	704	21	160	167	0	348	0.49
1995	223	73	201	498	0	771	3.46
1996	1,047	209	4,010	2,360	0	6,580	6.29
1997	1,133	220	4,645	1,377	0	6,242	5.51
1998	917	364	2,167	2,316	12	4,859	5.30
1999	418[2]	185	369	279	0	833	1.99
2000	4,112	131	2,286	346	0	2,762	0.67
2001	5,832	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	844	174[3]		1,264	0.66
2006	1,672	237	1,215[3]			1,452	0.87
2007	986	182[3]					
2008	1,578						
2009	1,194						
2010	1,491						
Mean	1,860	132	1,185	762	10	2,045	1.10

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. Approximately 48% of these fish were jacks.
3. 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	31	4,388	8.60
2006	419	3,038	5,802		8,840	21.10
2007	449	1,277				
2008	457					
2009	486					
2010	336					
Mean	492	955	3,554	122	4,587	6.60[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 2010, age composition of American River spring Chinook has averaged 1, 40, 57, and 2 percent age-3, -4, –5, and -6, respectively (Table 9). Naches system spring Chinook averaged 2, 59, 39 and 1 percent age-3, -4, –5 and -6, respectively (Table 10). The upper Yakima River natural origin fish averaged 8, 87, and 5 percent age-3, -4, and –5, respectively (Table 11). While these ages are biased toward the older age classes, we believe the bias is approximately equal across populations and is a good relative indicator of differences in age composition between populations. The data show distinct differences with the American River population having the oldest age of maturation, followed closely by the Naches system and then the upper Yakima River which has significantly more age-3's, fewer age-5's and no age-6 fish.

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

Return	Males					Females					Total			
Year	3	4	5	6	n	3	4	5	6	n	3	4	5	6
1986		23.8	76.2		21		8.9	86.7	4.4	45		13.6	83.3	3.0
1987		70.8	25.0	4.2	24		42.9	57.1		21		57.8	40.0	2.2
1988			100.0		1		100.0			1		33.3	66.7	
1989		39.6	60.4		48		10.0	90.0		50		24.5	75.5	
1990	2.5	25.0	72.5		40		28.3	71.7		46	1.2	26.7	72.1	
1991		23.8	76.2		42		13.3	86.7		60		17.6	82.4	
1992		71.2	23.1	5.8	52		45.8	54.2		48		59.0	38.0	3.0
1993	4.8	14.3	81.0		21		8.0	92.0		75	1.0	9.4	89.6	
1994		44.4	55.6		18		50.0	46.7	3.3	30		49.0	49.0	2.0
1995	14.3	14.3	71.4		7			100.0		13	5.0	5.0	90.0	
1996		100.0			2		83.3	16.7		6		87.5	12.5	
1997		40.0	60.0		5		22.2	64.4	13.3	45		24.0	64.0	12.0
1998		12.1	87.9		33		6.6	93.4		76		8.3	91.7	
1999		100.0			2		40.0	40.0	20.0	5		57.1	28.6	14.3
2000		66.7	33.3		15		61.5	38.5		13		64.3	35.7	
2001		65.6	34.4		90		67.9	32.1		106		67.0	33.0	
2002	1.7	53.4	44.8		58		56.4	43.6		110	0.6	55.4	44.0	
2003		8.1	91.9		74		7.9	92.1		151		8.0	92.0	
2004		100.0			3		20.0	80.0		5		50.0	50.0	
2005		64.7	35.3		17		84.0	16.0		25		76.7	23.3	
2006		61.5	38.5		13		48.6	51.4		35		52.1	47.9	
2007	10.5	31.6	57.9		19		43.8	56.3		48	3.0	40.3	56.7	
2008		8.7	91.3		23		11.9	88.1		42		10.6	89.4	
2009	30.8	69.2			13		75.0	25.0		16	13.8	72.4	13.8	
2010							No carcasses were sampled							
Mean	2.7	46.2	50.7	0.4			39.0	59.3	1.7		1.0	40.4	57.0	1.5

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	
Mean	4.5	64.9	29.9	0.8		0.7	54.5	44.4	0.4		2.1	58.7	38.6	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	
Mean	14.9	81.2	3.8		1.4	92.9	5.7		8.0	87.0	4.9

Carcasses from upper Yakima River CESRF origin fish allowed to spawn naturally have also been sampled since age-4 adults began returning in 2001. These fish averaged 19, 80, and 2 percent age-3, -4, and –5, respectively (Table 12) from 2001-2010 compared to 12, 83, and 5 percent respectively for their wild/natural counterparts in the upper Yakima for the same years (Table 11). The observed difference in age distribution between wild/natural and CESRF sampled on the spawning grounds may be due in part to the carcass recovery bias described above. A better comparison of age distribution between upper Yakima wild/natural and CESRF fish is from samples collected at Roza Dam which are displayed in Tables 13 and 14. However, it must be noted that jacks (age-3 males) were collected at Roza in proportion to run size from 1997 to 1999, but from 2000-present we have attempted to collect them at their mean brood representation rate (approximately 7% of the spawning population). Age-3 females do occur rarely in the Upper Yakima population, but it is likely that the data in Table 13 slightly over-represent the proportion of age-3 females due to human error associated with scale collection, handling, processing, and management and entry of these data.

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

Return	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					60.0	40.0	
2010	28.6	71.4		7					11.1	88.9	
Mean	40.6	58.2	1.2		0.1	97.1	2.2		18.7	79.9	1.5

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
Mean	20.3	74.7	5.0		0.2	93.6	6.2		10.1	84.4	5.5

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
Mean	25.6	69.6	4.8			93.2	6.7		11.3	82.9	5.8

Sex Composition

In the American River, the mean proportion of males to females in wild/natural carcasses sampled on the spawning grounds from 1986-2010 was 45:55 for age-4 and 32:68 for age-5 spring Chinook (Table 15). In the Naches River, the mean proportion of males to females was 42:58 for age-4 and 25:75 for age-5 fish (Table 16). In the upper Yakima River, the mean proportion of males to females was 35:65 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 1997-2010, 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 37:63 and 34:66 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					
mean			44.7	55.3	31.6	68.4		

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		
mean			41.8	58.2	25.5	74.5		

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		
mean	85.2	14.8	34.6	65.4	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		
mean	97.7	2.3	28.5	71.5		

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
mean	97.9	2.1	37.8	62.2	37.1	62.9

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

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
2001	100.0	0.0	31.8	68.2		
2002	100.0	0.0	33.5	66.5	33.3	66.7
2003	100.0	0.0	37.9	62.1	44.7	55.3
2004	100.0	0.0	38.1	61.9		
2005	100.0	0.0	39.5	60.5	30.0	70.0
2006	100.0	0.0	42.5	57.5	100.0	
2007	100.0	0.0	38.8	61.3	30.0	70.0
2008	100.0	0.0	26.3	73.7		
2009	93.8	6.3	33.9	66.1	66.7	33.3
2010	100.0	0.0	30.8	69.2		100.0
mean	99.4	0.6	35.3	64.7	34.5	65.9

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, 61, and 77 cm for age-3, -4, and -5 males, and averaged 62 and 73 cm for age-4 and -5 females, respectively, from carcasses sampled on the spawning grounds in the American River from 1996-2010 (Table 21). In the Naches River, mean POHP lengths averaged 41, 61, and 76 cm for age-3, -4, and -5 males, and averaged 61 and 73 cm for age-4 and -5 females, respectively (Table 22). For wild/natural spring Chinook sampled on the spawning grounds in the upper Yakima River, mean POHP lengths averaged 44, 60, and 72 cm for age-3, -4, and -5 males, and averaged 60 and 69 cm for age-4 and -5 females, respectively (Table 23). From 2001-2010, 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				
Mean[2]		40.3		60.9		77.5				62.5		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 1996-2009 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		
Mean[2]		41.3		60.5		75.9		78.0		41.0		61.3		72.9		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 1996-2009 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		
Mean[1]		44.0		59.9		71.9		45.5		59.6		69.1

[1] Mean of mean values for 1996-2010 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		
Mean		44.7		59.3		69.2				59.6		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		
Mean		42.8		59.5		70.5				59.9		68.3

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		
Mean		41.2		59.0		71.4				59.2		67.9

[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
Mean				42.8		60.8		70.7

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
Mean		15.4		41.1		59.9		69.1

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).

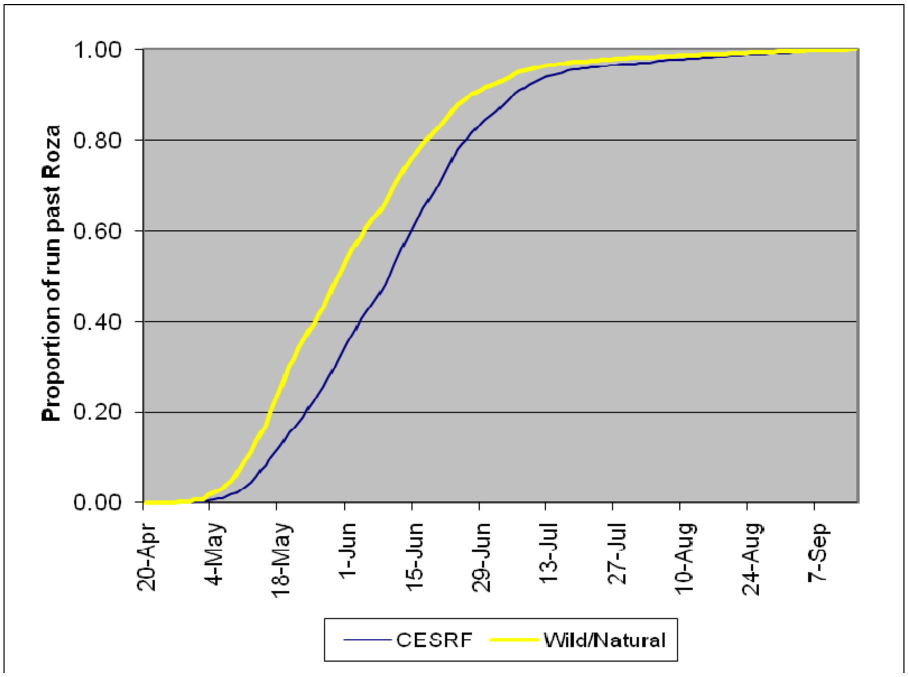

Figure 3. Proportionate passage timing at Roza Dam of wild/natural and CESRF adult spring Chinook (including jacks), 2001-2010.

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

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
Mean	13-Aug	11-Sep	25-Sep	21-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	53	483	278	73	887
2001	2,932	386	21	3,339	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	142	203	163	68	576
2006	1,077	100	58	1,235	133	163	115	33	444
2007	665	51	10	726	166	60	60	28	314
2008	1,191	137	47	1,375	158	165	102	70	495
2009	1,301	197	33	1,531	91	159	163	65	478
2010	2,197	219	253	2,669	167	167	168	39	541
Mean	1,061	130	25	1,216	156	179	111	48	494

[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 including preliminary results is available from NOAA fisheries.

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 February 2011 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	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	1	0.02%	3,101		
2005[1]	142	0	0.00%	4,400			3,052		
2006[2]	448	3	0.67%	8,837			5,799		
2007[3]	53	1	1.89%	1,494	1	0.07%			

[1] Age 5 data are preliminary.
[2] Through age 4 only and data are preliminary.
[3] 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%	761,526	98.2%	744,170	97.7%	95.8%
2010	483	20	95.9%	102	193	0.5%	787,953	753,464	4.4%	718,394	98.9%			
Mean	515	59	88.5%	139	223	6.1%	785,691	730,005	7.1%	701,991	98.2%	663,990	95.1%	93.3%

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 less all documented rearing mortality from ponding to release, except for BY2010 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%	90,395	98.3%	88,771	98.2%	96.5%
2010	162	9	94.4%	29	55	1.8%	215,814	94,925	8.4%	92,856	97.8%			
Mean	149	15	89.5%	30	50	1.1%	187,104	92,243	6.6%	93,630	98.4%	88,811	96.2%	94.7%

See footnotes for Table 33 above.

Female BKD Profiles

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

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

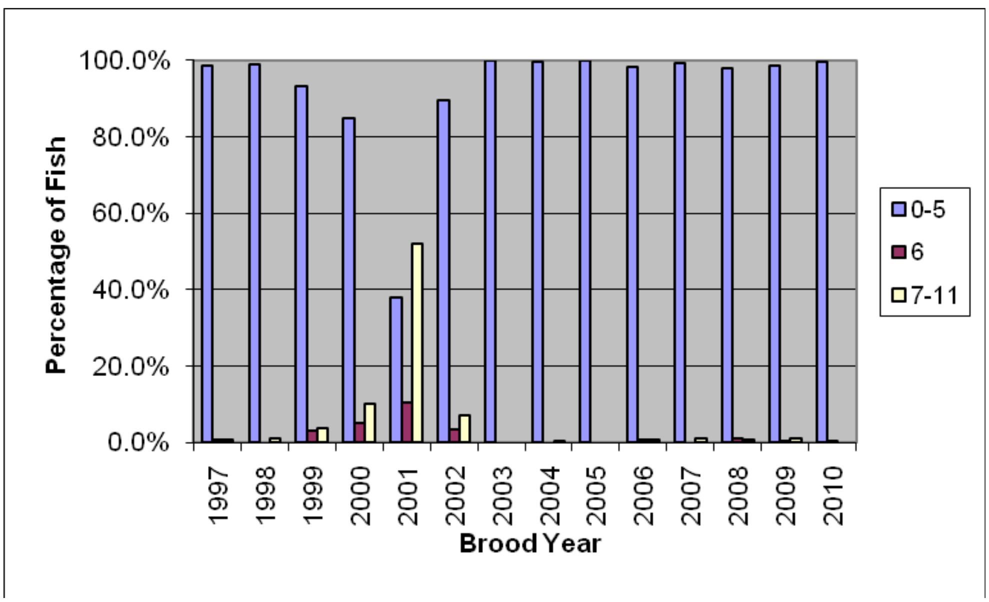

Figure 4. Proportion of wild/natural females spawned at CESRF by BKD rank, 1997 – present.

Fecundity

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

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

	Wild/Natural (SN)						CESRF (HC)					
Brood	Age-3		Age-4		Age-5		Age-3		Age-4		Age-5	
Year	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity
1997			105	3,842.0	4	4,069.9						
1998			161	3,730.3	15	4,322.5						
1999			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		
Mean				3,845.7		4,611.9				3,757.0		4,576.4

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	
Mean	0.9	0.9	1.1	1.1	1.2	1.1	1.9	1.2	1.6	0.2	1.2	1.1	0.6

Length and Weight Growth Profiles

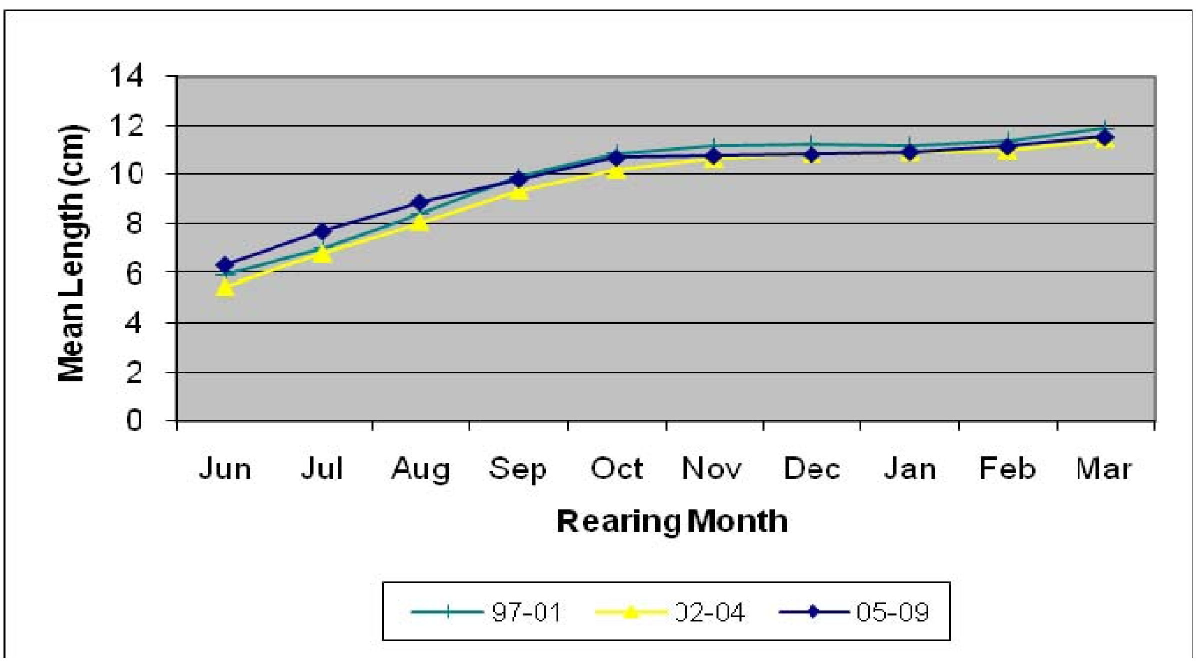

Figure 5. Mean length (cm) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.

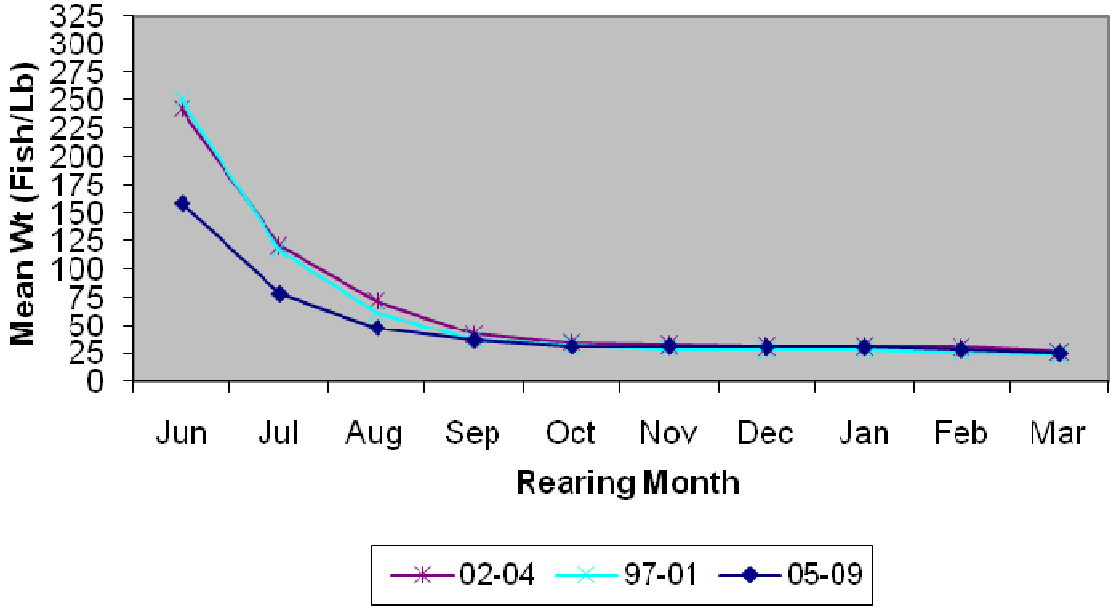

Figure 6. Mean Weight (fish/lb) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.

Juvenile Fish Health Profile

Approximately 30-60 fish from each acclimation site pond are sacrificed for juvenile fish health samples in the spring (usually in March) of their release year. Tissue samples from these fish are processed at USFWS laboratories in Olympia, Washington for presence of bacterial kidney disease (BKD) using enzyme-linked immunosorbent assay (ELISA) tests (see Female BKD Profiles for additional discussion). Fish are ranked from 0 to 13 based on the relative amounts of BKD in the tissue samples of the tested fish. Based on empirical evidence, fish with BKD ranks of 0-5 are considered to be low risk for incidence of BKD in the presence of a good fish culture and rearing environment (i.e., water temperature and flows, nutrition, densities, etc. all must be conducive to good fish health).

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

	Brood Year[1]									
Raceway	1997	1998	2000	2001[2]	2002	2003	2006	2007	2008	Mean
CFJ01	0.80	0.53	2.17	1.90	0.28	0.28	2.10	1.57	1.93	1.28
CFJ02	1.08	1.88	1.33	1.10	0.18	0.25	1.87	1.50	1.73	1.21
CFJ03	2.38	0.82	1.50		0.22	0.28	1.79	1.70	1.97	1.33
CFJ04	1.15	0.58	1.18		0.16	0.14	1.96	1.87	2.57	1.20
CFJ05	0.85	0.78	1.20		0.06	0.75	2.34	1.50	2.10	1.20
CFJ06	1.05	0.70	1.02		0.21	0.02	1.71	1.73	1.97	1.05
ESJ01	2.03	0.50	1.97	1.19	0.10	0.55	1.73	1.10	1.47	1.18
ESJ02	1.68	0.53	1.17	1.50	0.05	0.43	1.63	0.97	0.97	0.99
ESJ03	2.23	1.37	2.47	0.86	0.07	0.33	1.97	1.13	1.57	1.33
ESJ04	1.33	0.55	1.35	0.79	0.15	0.60	1.41	1.87	1.47	1.06
ESJ05		1.15	3.12	0.73	0.04	0.68	2.07	1.30	1.63	1.34
ESJ06		0.67	1.30	0.80	0.05	0.23	2.05	1.40	1.93	1.06
JCJ01		0.67	1.93	1.47	0.04	0.10	1.43	2.03	1.90	1.20
JCJ02		0.48	1.30	1.52	0.19	0.08	2.00	1.73	2.37	1.21
JCJ03		0.33	1.45	1.62	0.06	0.20	1.66	1.87	2.03	1.15
JCJ04		0.62	1.50	1.56	0.05	0.13	1.40	1.67	2.10	1.13
JCJ05			1.55	1.67	0.00	1.35	1.83	1.77	2.17	1.48
JCJ06			1.25	1.46	0.03	0.10	1.31	1.97	1.93	1.15
Clark Flat	1.22	0.88	1.40	1.50	0.18	0.29	1.96	1.64	2.04	1.24
Easton	1.81	0.80	1.89	0.98	0.08	0.47	1.81	1.29	1.51	1.18
Jack Creek		0.53	1.50	1.55	0.06	0.33	1.61	1.84	2.08	1.19
All Ponds	1.46	0.76	1.60	1.30	0.11	0.36	1.79	1.59	1.88	1.20

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.

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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
Mean	362,164	356,482	245,582	239,528	252,996	718,646

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

Brood Year	Treatment Control[1]	Treatment[2]	Acclimation Site CFJ	ESJ	JCJ
1997	41,487	35,722	38,215	39,190	
1998[3]	35,584	38,126	36,910	38,477	34,341
1999	42,729	41,581	38,761	44,917	42,787
2000	47,173	45,526	47,659	43,844	47,545
2001[4]	41,116	41,667	40,391	6,518	41,725
2002	46,752	46,238	44,427	48,425	46,632
2003	46,019	45,613	45,563	44,619	47,267
2004[5]	42,082	45,190	46,766	45,573	38,568
2005	47,948	47,607	47,855	46,858	48,621
2006	39,007	32,415	34,929	36,322	35,881
2007	43,006	42,690	44,318	42,423	41,803
2008	46,810	47,557	46,709	47,976	46,866
2009	46,479	46,070	46,521	46,899	45,404
Mean	43,553	42,769	43,002	43,794	43,120

1. Brood years 1997-2001: Optimum Conventional Treatment (OCT). Brood Years 2002-2004: Normal (High) growth. Brood Years 2005-2008: Normal feed at Cle Elum or accl. sites.
2. Brood years 1997-2001: Semi-natural Treatment (SNT). Brood Years 2002-2004: Slowed (Low) growth. Brood Year 2005, 2007-2008: saltwater transition feed at accl. sites. Brood Year 2006: EWS diet at CESRF through May 3, 2007.
3. At the Jack Creek acclimation site only 4 of 6 raceways were stocked, and raceway 4 suffered mechanical failures resulting in the loss of about 20,000 OCT (control) fish.
4. High BKD incidence in adult broodstock reduced production to just 9 ponds (Clark Flat 1-2, Jack Creek, and Easton). Easton ponds were used for predator avoidance trained (PAT) fish and a single Cle Elum pond was spread between 6 ponds at Easton with crowders used to simulate pond densities for fish at other acclimation sites. These releases were excluded from mean pond density calculations by treatment.
5. At the Jack Creek acclimation site raceway 3 suffered mechanical failures resulting in the loss of about 45,000 high-growth (control) fish.

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

Smolt Outmigration Timing

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

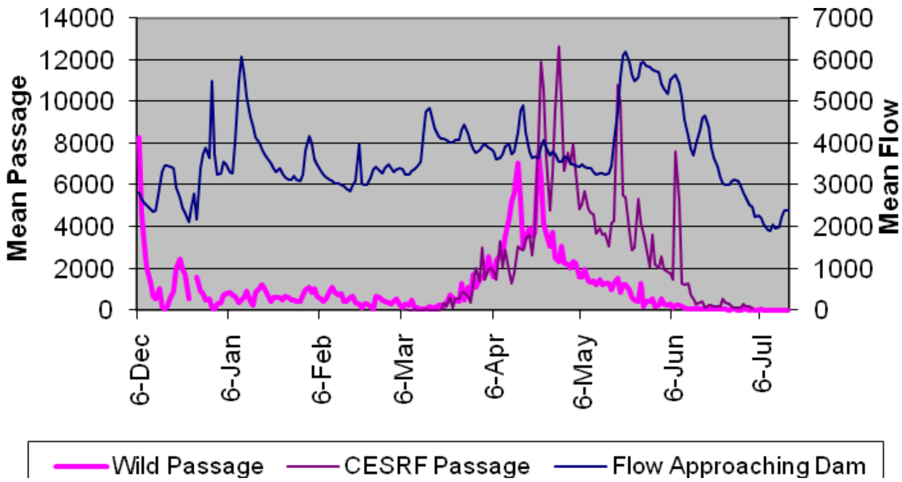

Figure 7. Mean flow approaching Prosser Dam versus mean estimated smolt passage at Prosser of aggregate wild/natural and CESRF spring Chinook for outmigration years 1999-2010.

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, and 2008; Migration Years 2007, 2009, and 2010)

Prior to releases in 2007, 2009, and 2010, 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 over the three release years indicated a significant pre-release weight loss associated with the Transfer supplement and a Year x Acclimation-Site x Treatment interaction. A detailed analysis indicated a significant increase in survival associated with the Transfer supplement in release year 2010, an increase in 2009 that appeared to be associated with two sites, and no significant difference between the supplemented and non-supplemented feed in release year 2007. See Appendix C 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 43-44). 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 43 and only as an adult return in Table 44. 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 43 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 43 and 44.

9) Due to issues relating to water permitting and size required for tagging, CESRF juveniles are not allowed to migrate until at least March 15 of their smolt year. However, juvenile sampling observations at Roza and Chandler indicate that a substantial number of wild/natural juveniles migrate downstream during the summer, fall, and winter months prior to their smolt year. Analysis of adult returns of wild/natural spring chinook that were PIT-tagged as juveniles at either Roza or Chandler indicate that 35-40% (or more-cumulative across several brood years) of adult return PIT detections at Bonneville for these fish were from fish that migrated 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 40-44 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 factors noted above prior to any use of these data.

Table 40. Estimated smolt passage at Chandler and smolt-to-adult survival rates (Chandler smolt to Yakima R. mouth adult).

			Estimated Smolt Passage at Chandler				CESRF smolt-to-smolt	Yakima R. Mouth Adult Returns[6]		Smolt-to-Adult Survival[6]	
Brood Year	Migr. Year	Mean Flow[1]	Wild/ Natural[2]	Control[3]	Treatment[4]	CESRF Total	survival[5]	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	42,668	55,176	97,844	25.3%	12,855	8,670	4.0%	8.9%
1998	2000	4946	38,885	109,087	116,020	225,107	38.2%	8,228	9,782	21.2%	4.3%
1999	2001	1321	171,290	233,921	216,649	450,570	59.4%	1,765	864	1.0%	0.2%
2000	2002	5015	441,880	193,515	132,228	325,743	39.0%	11,445	4,819	2.6%	1.5%
2001	2003	3504	332,586	49,845	62,232	112,077	30.3%	8,597	1,251	2.6%	1.1%
2002	2004	2439	150,706	155,031	145,056	300,087	35.9%	3,743	2,300	2.5%	0.8%
2003	2005	1285	155,258	124,412	106,253	230,665	28.0%	2,746	932	1.8%	0.4%
2004	2006	5652	199,391	86,308	73,044	159,352	20.3%	2,817	4,021	1.4%	2.5%
2005	2007	4551	220,329	163,151	162,197	325,348	37.8%	4,063[7]	4,324[7]	1.9%	1.3%[7]
2006	2008	4298	235,569	92,914	71,623	164,537	25.6%			2.2%[7]	
2007	2009	5784	297,197			176,489	22.9%				
2008	2010	3592	180,913			680,191	80.1%				

1. Mean flow (cfs) approaching Prosser Dam March 29-July 4. 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.
2. Aggregate of Upper Yakima, Naches, and American wild/natural populations.
3. Brood years 1997-2001: Optimum Conventional Treatment (OCT). Brood Years 2002-2006 : Normal (High) growth.
4. Brood years 1997-2001: Semi-natural Treatment (SNT). Brood Years 2002-2004 : Slowed (Low) growth. BY05: transfer diet at accl. Sites. BY06: EWS diet at CESRF through May 3. BY07 to present: no treatment.
5. Estimated smolt-to-smolt (release from upper Yakima River acclimation sites to Chandler) survival for CESRF juveniles.
6. 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.
7. Preliminary; data do not include age-5 adult returns.

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

		Wild/Natural smolts tagged at Roza				
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		45	2.69%
2007	3,795	6				
2008	106					

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		63	1.53%
2007	3,736	10				
2008	2,566					

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. 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		575	1.49%	186	262		448	1.16%
2007	38,618	73					53				

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

Brood	Number	Adult Detections at Roza Dam				
Year	Tagged[1]	Age3	Age4	Age5	Total	SAR
1997[2]	346,156	623	5,663	120	6,406	1.85%
1998	552,295	936	5,834	534	7,304	1.32%
1999	719,996	103	652	13	768	0.11%
2000	796,703	1,005	2,764	69	3,837	0.48%
2001	333,713	290	791	9	1,091	0.33%
2002[3]	797,901	332	1,771	135	2,238	0.28%
2003	785,776	115	1,568	14	1,696	0.22%
2004	749,022	683	3,688	202	4,574	0.61%
2005	820,883	1,012	5,302	47	6,362	0.77%
2006	604,200	2,384	6,404		8,787	1.45%
2007	732,647	972				

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 45. Spring Chinook harvest in the Yakima River Basin, 1982-present.

	Tribal		Non-Tribal		River Totals			Harvest
Year	CESRF	Wild	CESRF	Wild	CESRF	Wild	Total	Rate[1]
1982	0	434	0	0	0	434	434	23.8%
1983	0	84	0	0	0	84	84	5.8%
1984	0	289	0	0	0	289	289	10.9%
1985	0	865	0	0	0	865	865	19.0%
1986	0	1,340	0	0	0	1,340	1,340	14.2%
1987	0	517	0	0	0	517	517	11.6%
1988	0	444	0	0	0	444	444	10.5%
1989	0	747	0	0	0	747	747	15.2%
1990	0	663	0	0	0	663	663	15.2%
1991	0	32	0	0	0	32	32	1.1%
1992	0	345	0	0	0	345	345	7.5%
1993	0	129	0	0	0	129	129	3.3%
1994	0	25	0	0	0	25	25	1.9%
1995	0	79	0	0	0	79	79	11.9%
1996	0	475	0	0	0	475	475	14.9%
1997	0	575	0	0	0	575	575	18.1%
1998	0	188	0	0	0	188	188	9.9%
1999	0	604	0	0	0	604	604	21.7%
2000	53	2,305	0	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%
Mean	474	574	459	98	933	612	935	12.4%

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 46. Estimated run size, harvest, and harvest rates of Yakima Basin spring Chinook in Columbia River mainstem and terminal area fisheries, 1982-present.

						Columbia Basin Harvest Summary			Col. Basin Harvest Rate	
Year	Columbia R. Mouth Run Size	Col. R. Mouth to BON Harvest	BON to McNary Harvest	Yakima R. Mouth Run Size	Yakima River Harvest	Total	Wild	CESRF	Total	Wild
1982	3,916	69	269	1,822	434	772	772	0	19.7%	
1983	2,493	120	100	1,441	84	304	304	0	12.2%	
1984	3,955	137	262	2,658	289	688	688	0	17.4%	
1985	5,326	193	182	4,560	865	1,240	1,240	0	23.3%	
1986	13,730	284	796	9,439	1,340	2,420	2,420	0	17.6%	
1987	6,341	99	383	4,443	517	999	999	0	15.8%	
1988	5,763	369	381	4,246	444	1,194	1,194	0	20.7%	
1989	9,119	217	685	4,914	747	1,650	1,650	0	18.1%	
1990	7,046	357	464	4,372	663	1,483	1,483	0	21.1%	
1991	4,710	187	284	2,906	32	503	503	0	10.7%	
1992	6,361	105	383	4,599	345	833	833	0	13.1%	
1993	5,265	45	320	3,919	129	494	494	0	9.4%	
1994	2,417	94	116	1,302	25	235	235	0	9.7%	
1995	1,393	1	69	666	79	149	149	0	10.7%	
1996	5,761	6	302	3,179	475	783	783	0	13.6%	
1997	5,209	3	350	3,173	575	928	928	0	17.8%	
1998	2,836	3	142	1,903	188	333	333	0	11.7%	
1999	4,117	4	190	2,781	604	798	798	0	19.4%	
2000	28,861	58	1,755	19,100	2,458	4,271	4,147	123	14.8%	
2001	30,961	985	3,851	23,265	4,630	9,467	5,440	4,027	30.6%	29.2%
2002	24,175	1,384	2,413	15,099	3,108	6,906	2,577	4,328	28.6%	24.5%
2003	9,910	346	747	6,957	440	1,533	920	613	15.5%	14.5%
2004	22,235	1,083	1,754	15,289	1,679	4,515	2,473	2,042	20.3%	15.6%
2005	12,011	353	693	8,758	474	1,520	1,190	330	12.7%	11.8%
2006	11,688	358	741	6,314	600	1,699	946	753	14.5%	12.7%
2007	5,190	229	339	4,303	279	846	394	452	16.3%	13.8%
2008	11,337	1,201	1,358	8,598	1,532	4,091	1,119	2,972	36.1%	25.4%
2009	13,311	1,074	1,030	12,120	2,353	4,456	1,224	3,232	33.5%	24.5%
2010[1]	17,737	1,469	2,416	13,142	1,741	5,626	1,284	4,342	31.7%	20.8%
Mean	9,764	373	785	6,733	935	2,094	1,294	2,309	18.5%	16.9%

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 47 gives the results of a query of the RMIS database run on Feb. 10, 2011 for CESRF spring Chinook CWTs released in brood years 1997-2006. 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.

Table 47. Marine and freshwater recoveries of CWTs from brood year 1997-2006 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) 10 Feb, 2011.

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	483	3.0%
2005	2	96	2.0%	2	80	2.4%
2006[1]	14	311	4.3%	12	1130	1.1%

1. Reporting of CWT recoveries to the RMIS database typically lags actual fisheries by one to two years. Therefore, CWT recovery data for brood year 2006 are considered preliminary or incomplete.

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Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2002-2009.

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 2002-2009.

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 2002-2009.

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 2002-2009.

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 2002-2009.

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 2002-2009.

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.

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2008	CLE01	ESJ01	STF	WW	3.3	Right	Orange	Snout	3/15/2010	5/11/2010	190191	2,000	44,917	46,704
2008	CLE02	ESJ02	BIO	WW	3.3	Left	Orange	Snout	3/15/2010	5/11/2010	190192	2,000	45,576	47,414
2008	CLE03	CFJ03	STF	WW	3.2	Right	Red	Snout	3/15/2010	5/11/2010	190193	2,000	44,099	45,931
2008	CLE04	CFJ04	BIO	WW	3.2	Left	Red	Snout	3/15/2010	5/11/2010	190194	2,000	42,464	44,271
2008	CLE05	JCJ05	STF	WW	3.0	Right	Green	Snout	3/15/2010	5/11/2010	190195	2,000	46,118	47,936
2008	CLE06	JCJ06	BIO	WW	3.0	Left	Green	Snout	3/15/2010	5/11/2010	190196	2,000	43,708	45,466
2008	CLE07	ESJ05	STF	WW	3.2	Right	Orange	Snout	3/15/2010	5/11/2010	190197	2,000	48,468	50,299
2008	CLE08	ESJ06	BIO	WW	3.2	Left	Orange	Snout	3/15/2010	5/11/2010	190198	2,000	47,611	49,419
2008	CLE09	CFJ05	STF	HH	2.9	Right	Red	Posterior Dorsal	3/15/2010	5/11/2010	190199	4,000	45,169	48,942
2008	CLE10	CFJ06	BIO	HH	2.9	Left	Red	Posterior Dorsal	3/15/2010	5/11/2010	190201	4,000	44,493	48,254
2008	CLE11	JCJ01	STF	WW	3.3	Right	Green	Snout	3/15/2010	5/11/2010	190202	2,000	44,583	46,413
2008	CLE12	JCJ02	BIO	WW	3.3	Left	Green	Snout	3/15/2010	5/11/2010	190203	2,000	45,086	46,856
2008	CLE13	ESJ03	STF	WW	3.1	Right	Orange	Snout	3/15/2010	5/11/2010	190204	2,000	45,518	47,317
2008	CLE14	ESJ04	BIO	WW	3.1	Left	Orange	Snout	3/15/2010	5/11/2010	190205	2,000	44,879	46,704
2008	CLE15	CFJ01	STF	WW	3.2	Right	Red	Snout	3/15/2010	5/11/2010	190206	2,000	45,169	46,893
2008	CLE16	CFJ02	BIO	WW	3.2	Left	Red	Snout	3/15/2010	5/11/2010	190207	2,000	44,149	45,962
2008	CLE17	JCJ03	STF	WW	3.2	Right	Green	Snout	3/15/2010	5/11/2010	190208	2,000	45,807	47,580
2008	CLE18	JCJ04	BIO	WW	3.2	Left	Green	Snout	3/15/2010	5/11/2010	190209	2,000	45,157	46,944

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

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

Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2002-2009.

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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Appendix B
Annual Report: Comparisons between Smolt Measures of Hatchery x Hatchery- and Natural x Natural-Brood Stock from Upper Yakima Spring Chinook for Brood-Years 2002-2008

Doug Neeley, Consultant to the Yakama Nation

Summary

Hatchery x Hatchery (HxH) and Natural x Natural (NxN) Stock[1] were allocated to Clark Flat acclimation-site raceway pairs, within which different pairs of nutrition treatments had been assigned. This report focuses on the Stock comparisons, not main-effect nutrition-treatment comparisons. Nutritional treatment comparisons are discussed in a different report.

The juvenile traits for which comparisons are made between the HxH and NxN stock are given below:

Pre-Release Weights did not significantly differ between stocks.

Pre-Release Survival Index is lower for the HxH Stock than for the NxN stock within all but broods but the most recent brood, brood year (BY) 2008, for which year the difference was not significant.

Pre-Release Male Proportion did not significantly differ between stock and did not differ significantly from 0.5.

Pre-Release Mini-Jack Proportion of Males stocks' differences significantly interacted with brood year, and, within those years for which the stocks significantly differed, the NxN stock's mean mini-jack proportion exceeded the HxH stock's.

[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.

Release-to-McNary-Dam Survival stocks' differences significantly interacted with brood year. The nature of the interaction suggested that the brood-year NxN-HxH differences in mini-jack proportion of males were negatively correlated with brood-year NxN - HxH differences in survival. When release numbers were adjusted for mini-jack proportion and survivals were computed using the adjusted release numbers, the adjusted NxN-HxH survival difference did not significantly interact with brood year.

Volitional Release Date did not significantly differ between the two stocks, and there was no significant stock-difference interaction with years.

McNary-Dam Passage Date, like Volitional Release Date, did not significantly differ between the two stocks, and there was no significant stock-difference interaction with years.

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 the feed treatments[3] allocated to the different raceways within each pair[4]. The HxH Stock was allocated to one of the three pairs of raceways and the NxN Stock to the other two pairs[5]. 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 Spilt-Plot design at Clark Flat with the Stock assigned to the raceway pairs (main plot), and the feed levels assigned to raceways within raceway pairs (subplot).

A portion of the fish in each raceway was PIT-tagged for the primary purpose of estimating pre-release survival and smolt survival from release to McNary Dam (McNary). Beginning with the 2006 brood, there were twice as many HxH fish PIT-

[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 set of diallele crosses, there being different male and female parental sources in the different diallele sets. 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, the High level being the standard feed or control. The Low Nutrition was tested to determine whether it would reduce the proportion of male smolts that were sexually mature (mini-jacks). In BY 2005, 2007, and 2008, the standard feed 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 to determine whether there their smoltification rates differed.

[4] The feed treatments were allocated to the raceways within the one HxH raceway pair and within the two NxN raceway pairs in BY 2002-2004.

[5] 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).

tagged per raceway than there were NxN fish to give approximately an equal total number of PIT-tagged fish for both Stocks at Clark Flat. In previous brood years, there were approximately half as many HxH fish tagged as NxN fish at that acclimation site. For the purpose of assessing Mini-Jack Proportions, approximately twice as many fish were sampled from HxH raceways in all but Brood Year 2002.

Analysis of Individual Traits

Six variable sets were analyzed:

1. Mean Pre-Release Weights,
2. Mean Proportion of PIT-Tagged fish Leaving the Acclimation Site,
3. Mean Pre-Release Male Proportion,
4. Mean Pre-Release Mini-Jack Proportion of Males,
5. Mean Release-to-McNary Smolt-to-Smolt Survival,
6. Mean Dates of Juvenile Release, and Mean McNary-Dam Juvenile Passage

Of these variables, Pre-Release Mini-Jack Proportion and Release-to-McNary Survival NxN–HxH comparisons significantly interacted with years[6] at the 5% level, and the NxN-HxH interaction with years was significant at the 10% level for Mini-Jack Proportion. The analyses of variation on which the statistical significance of the comparison were made are presented in Appendix A.

1. Mean Pre-Release Smolt Weight

Table 1 and Figure 1 present the individual release year HxH and NxN stock mean pre-release fish-weight estimates. There was no significant main effect difference between stock (P = 0.23), nor did the NxN-HxN comparisons significantly interact with years (P= 0.17).

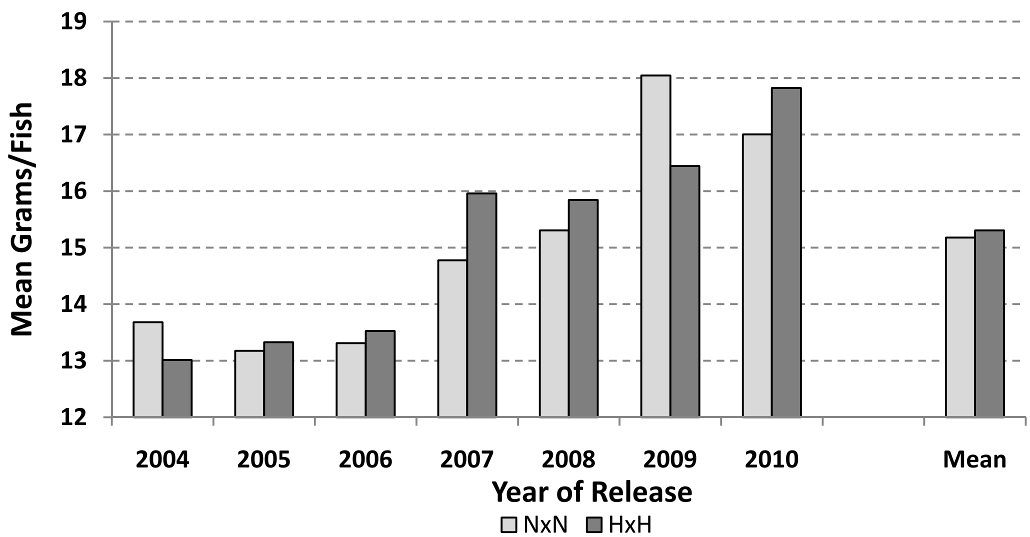
[6] Significant at 5% significance level. Stock x Year interaction for pre-release weight and for McNary detection date was significant at the 10% level.

Table 1. Mean Pre-Release Weight (grams/fish) of Natural x Natural and Hatchery x Hatchery Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2008)[7]

Source	Brood Year / Release Year	2002 / 2004	2003 / 2005	2004 / 2006	2005 / 2007	2006 / 2008	2007 / 2009	2008 / 2010	Adjusted* Mean
NxN	**Weight**	**13.7**	**13.2**	**13.3**	**14.8**	**15.3**	**18.0**	**17.0**	**15.2**
	Number Weighed	240	240	240	240	240	240	240	1680
HxH	**Weight**	**13.0**	**13.3**	**13.5**	**16.0**	**15.8**	**16.4**	**17.8**	**15.3**
	Number Weighed	120	120	239	240	240	240	240	1439
NxN - HxH Difference		**0.7**	**-0.2**	**-0.2**	**-1.2**	**-0.5**	**1.6**	**-0.8**	**-0.1**
Type 1 Error P - Difference		**0.7757**	**0.9486**	**0.9098**	**0.5373**	**0.7778**	**0.4042**	**0.6676**	**0.8686**

* Adjusted for year Effects

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 2008)



2. Mean Proportion of PIT-Tagged fish leaving the Acclimation Site

This measure is simply the ratio between the number of fish detected leaving the raceway and the total number of tagged fish in the raceway and is an index of pre-release survival.

Table 2 and Figure 2 present the individual year and mean pre-release survival-index estimates. While the NxN-HxH main effect comparison is not quite significant at the 5% level ($P = 0.056$), the comparison's interaction with years is significant at the 0.01% level ($P < 0.0001$). The nature of the interaction is evident from the Table and Figure. In all release years except 2010 (brood year 2008), the NxN pre-release survival index is

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

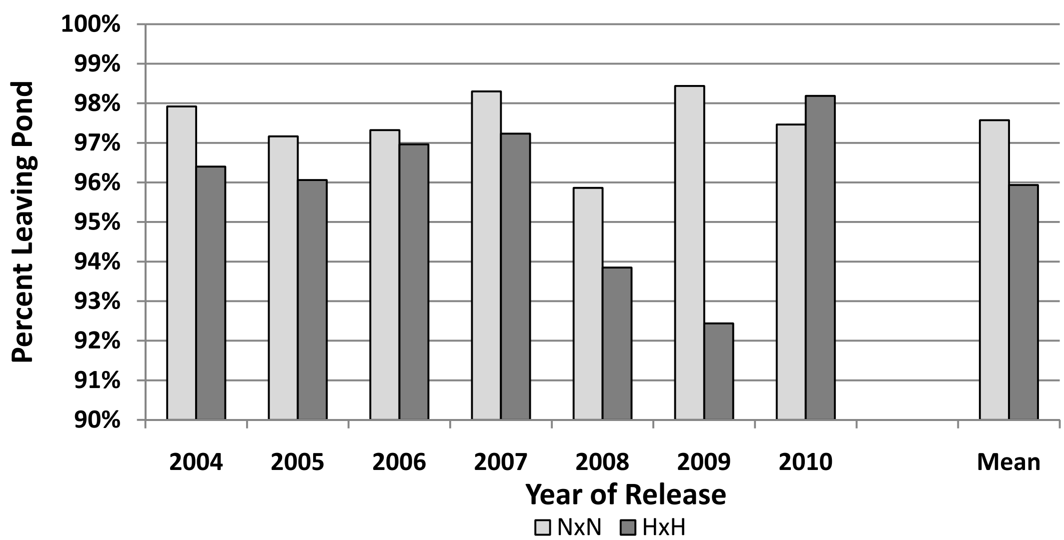
greater than that of the HxH stock. It is 2008 brood-year's difference (which is small in magnitude) that resulted in the main-effect's significance level being slightly greater than 5%.

Table 2. Percent of PIT-Tagged Natural x Natural and Hatchery x Hatchery Upper Yakima Spring Chinook Detected Leaving Acclimation Sites (brood years 2002 through 2008)[8]

Source	Brood Year / Release Year	2002 / 2004	2003 / 2005	2004 / 2006	2005 / 2007	2006 / 2008	2007 / 2009	2008 / 2010	Adjusted* Mean
NxN	Released %	97.9%	97.2%	97.3%	98.3%	95.9%	98.4%	97.5%	97.6%
	Number Tagged	8892	8889	8889	8894	8000	8000	8000	59564
HxH	Released %	96.4%	96.1%	97.0%	97.2%	93.9%	92.4%	98.2%	95.9%
	Number Tagged	4446	4444	4446	4445	8000	8000	8000	41781
NxN - HxH Difference		1.5%	1.1%	0.4%	1.1%	2.0%	6.0%	-0.7%	1.6%
Type 1 Error P - Difference		0.0242	0.1299	0.5919	0.0708	0.0135	0.0000	0.1614	0.0564

* Adjusted for year Effects

Figure 2. Percent of PIT-Tagged Natural x Natural and Hatchery x Hatchery Upper Yakima Spring Chinook Detected Leaving Acclimation Sites (brood years 2002 through 2008)



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

3. Pre-Release Male Proportion

There were no significant differences involving HxH and NxN stock (neither main-effect nor interaction differences). And the mean percentage of males over all years, stock, and treatments was near 50%.[9]

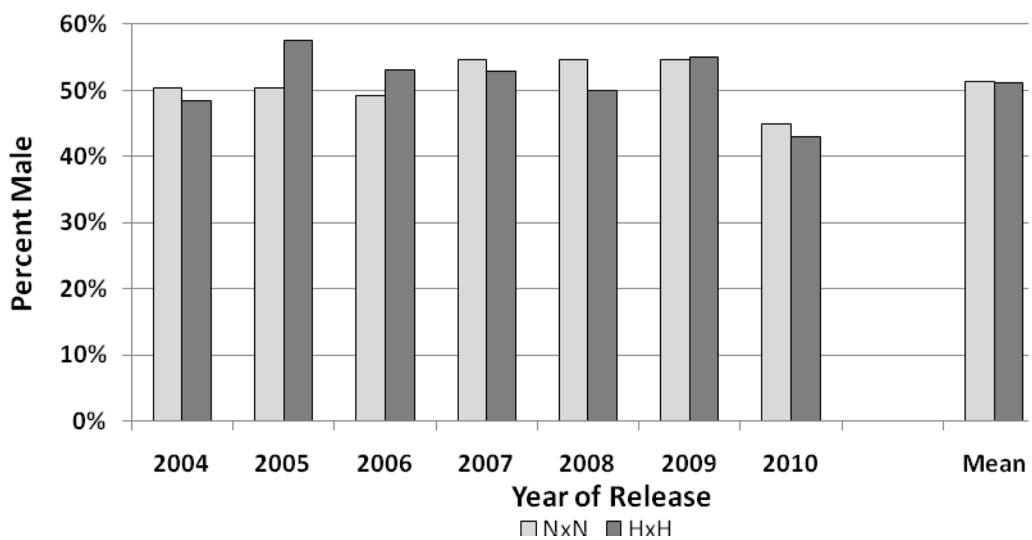
The primary reason for statistically evaluating the male percentage is that, as will be seen later, there is a significant difference between the stocks' proportions of precocial males (mini-jacks), and later adjustments for mini-jack proportion are made to release numbers in order to evaluate smolt-to-smolt survival of smolt that do not include mini-jacks.

Table 3. <u>Male Percent</u> of Pre-Release Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002-2008)

Source	Brood Year / Release Year	2002 / 2004	2003 / 2005	2004 / 2006	2005 / 2007	2006 / 2008	2007 / 2009	2008 / 2010	Adjusted* Mean
NxN	Percent Male	50.4%	50.4%	49.2%	54.6%	54.6%	54.6%	45.0%	51.2%
	Number Sexed	240	240	240	240	240	240	240	1680
HxH	Percent Male	48.3%	57.5%	53.1%	52.9%	50.0%	55.0%	42.9%	51.1%
	Number Sexed	120	120	239	240	240	240	240	1439
NxN - HxH Difference		2.1%	-7.1%	-4.0%	1.7%	4.6%	-0.4%	2.1%	0.1%
Type 1 Error P - Difference		0.7287	0.2587	0.4275	0.7333	0.3626	0.9317	0.6695	1.0000

* Adjusted for year Effects

Figure 3. <u>Male Percent</u> of Pre-Release Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002-2008)



[9] 51.2% males did not significantly differ from 50% (P = 0.18) based on a logistic fit of the mean. (Mean Deviance = 1.03).

4. Pre-Release Mini-Jack Proportion of Males

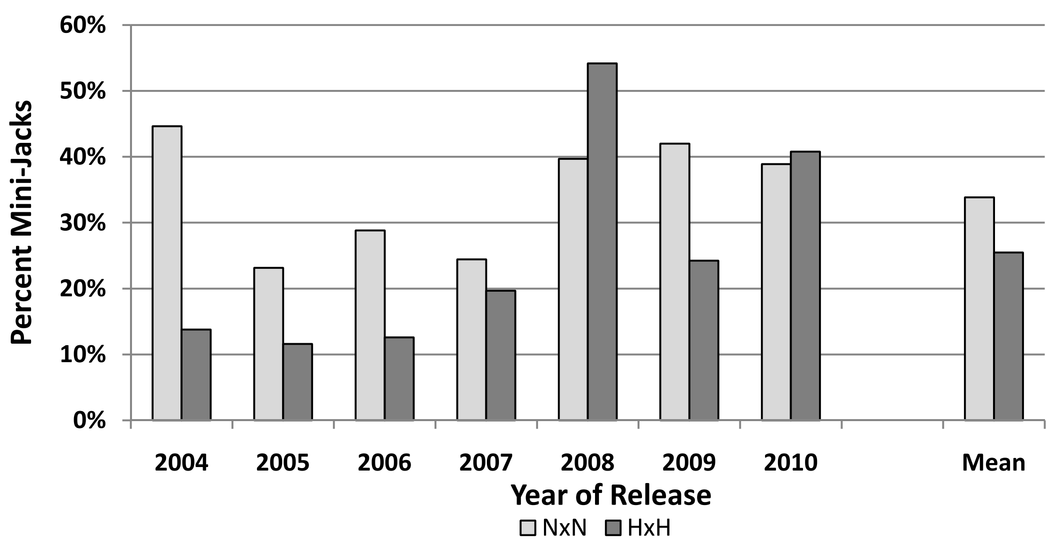
Table 4 and Figure 4 present the individual year and HxH and NxN mean Mini-Jack Percentages. The NxN- HxH Mini-Jack Percentage main-effect mean difference was not significant at the 5% level (P = 0.19), but the NxN-HxH differences interaction with years was (P = 0.017). As will be seen, the NxN-HxH differences in mini-jack proportion were correlated with NxN-HxH differences in survival, and these differences helped in the interpretation of the survival estimates. Note in Table 4, that in 5 of the 7 years, the HxH mini-jack proportions were smaller than those of the NxN stock.

Table 4. <u>Mini-Jack Percent</u> of Pre-Release Male Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt(brood years 2002 through 2008)[10]

Source	Brood Year Release Year	2002 2004	2003 2005	2004 2006	2005 2007	2006 2008	2007 2009	2008 2010	Adjusted* Mean
NxN	Mini-Jack %	44.6%	23.1%	28.8%	24.4%	39.7%	42.0%	38.9%	33.8%
	Number Males	121	121	118	131	131	131	108	861
HxH	Mini-Jack %	13.8%	11.6%	12.6%	19.7%	54.2%	24.2%	40.8%	25.5%
	Number Males	58	69	127	127	120	132	103	736
NxN - HxH Difference		30.83%	11.55%	16.22%	4.74%	-14.47%	17.74%	-1.89%	8.38%
Type 1 Error P - Difference		0.0167	0.1761	0.0458	0.5022	0.1202	0.0506	0.8353	0.1900

* Adjusted for year Effects

Figure 4. <u>Mini-Jack Percent</u> of Pre-Release Male Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt(brood years 2002 through 2008)



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

5. Release-to-McNary Smolt Survival

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

Eq.1. $$\text{Release - to - McNary Survival} = \frac{\text{Expanded Released Fish Detected at McNary}}{\text{Release Number (detected at release)}}$$

Table 5.a and Figure 5.a present the individual year and HxH and NxN mean Release-to-McNary Survivals. While the main-effect NxN-HxH survival difference was not significant (P = 0.74), the differences interaction with years was significant at the 10% level (P=0.067).

Brood years having the higher HxH survivals to McNary tended to be the years having lower HxH mini-jack percentages. The associated lower NxN survivals may be artificial. If the mini-jacks do not out-migrate past McNary but remain in the upper-Yakima and contribute to reproduction, then these fish would not be counted as surviving smolt. The decision was made to perform an analysis that assumed that no mini-jacks survived to McNary. The numbers of released fish were then adjusted using equation Eq.2:

Eq.2. $$\text{Adjusted Release Number} = [\text{Release Number}]*[(\text{Proportion Females}) + (\text{Proportion Males})*(1-\text{Q})]$$

$$\text{wherein } \text{Q} = \text{Propotion of Mini - Jacks,} \quad \text{Proportion(Females)} = \text{Propotion(Males)} = 0.5$$ [11]

This adjusted release number was then substituted into equation Eq.1 to estimate the adjusted survivals. Table 5.b. and Figure 5.b. presented the resulting survivals. As can be seen, the main effect-mean differences over years between HxH- and NxN-stock have been reversed; the unadjusted NxN survival being -0.49% less than the HxH, but the adjusted being 1.16% greater than the HxH. Although both the adjusted and unadjusted Main-Effect differences were not significant (unadjusted P = 0.74 and adjusted P = 0.30). The adjusted NxN-HxH interaction with years was no longer significant at the 10% level (P =0. 88, recall that, for the unadjusted, P = 0.067).

[11] Recall from earlier that the estimated male proportion was 0.512, the estimated female proportion was 0.475. Use of these proportions instead of 0.5's in Equation Eq.2 would have had a larger effect on the adjusted survivals.

Table 5. Volitional-Release-to-McNary-Dam Percent Survival of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2008)

a. Unadjusted for Mini-Jack Proportion[12]

Source	Brood Year / Release Year	2002 / 2004	2003 / 2005	2004 / 2006	2005 / 2007	2006 / 2008	2007 / 2009	2008 / 2010	Adjusted* Mean
NxN	**Survival %**	**22.0%**	**15.4%**	**30.4%**	**34.4%**	**35.9%**	**42.7%**	**33.2%**	**30.2%**
	Number Released	8707	8637	8651	8743	7669	7875	7789	58071
HxH	**Survival %**	**22.1%**	**17.1%**	**36.4%**	**32.7%**	**30.7%**	**47.0%**	**32.4%**	**30.7%**
	Number Released	4286	4269	4311	4322	7508	7395	7855	39946
NxN - HxH Difference		**-0.19%**	**-1.66%**	**-5.96%**	**1.71%**	**5.25%**	**-4.34%**	**0.75%**	**-0.49%**
Type 1 Error P - Difference		**0.9092**	**0.2903**	**0.0145**	**0.3880**	**0.0143**	**0.0383**	**0.6492**	**0.7412**

* Adjusted for year Effects

b. Adjusted for Mini-Jack Proportion[13]

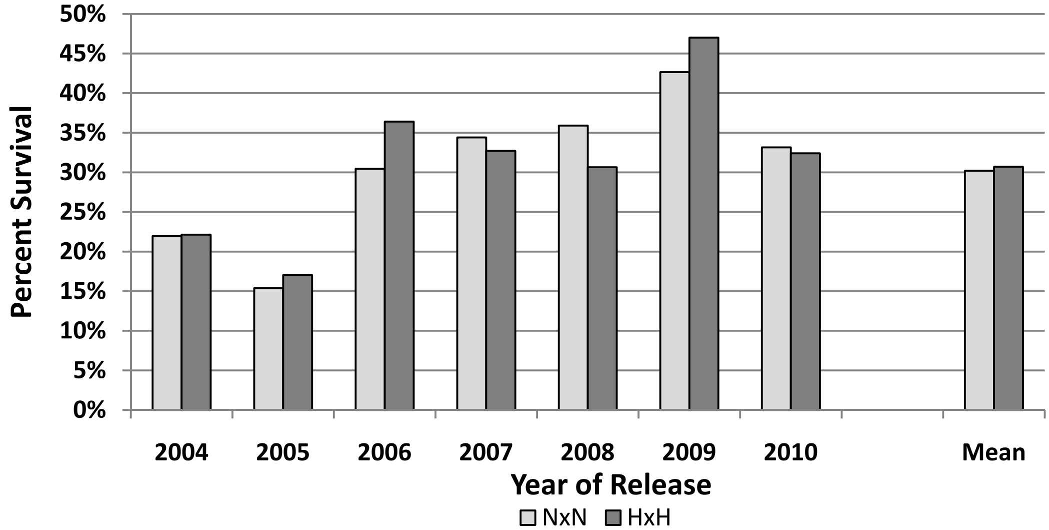
Source	Brood Year / Release Year	2002 / 2004	2003 / 2005	2004 / 2006	2005 / 2007	2006 / 2008	2007 / 2009	2008 / 2010	Adjusted* Mean
NxN	**Survival %**	**28.6%**	**17.4%**	**35.7%**	**39.2%**	**44.9%**	**54.0%**	**41.4%**	**36.8%**
	Number Released*	6688	7650	7385	7685	6136	6224	6232	48000
HxH	**Survival %**	**23.8%**	**18.0%**	**38.8%**	**36.2%**	**42.0%**	**53.4%**	**40.7%**	**35.6%**
	Number Released*	3990	4037	4040	3900	5474	6510	6249	34200
NxN - HxH Difference		**4.79%**	**-0.65%**	**-3.18%**	**2.91%**	**2.82%**	**0.59%**	**0.71%**	**1.16%**
Type 1 Error P - Difference		**0.0879**	**0.7559**	**0.2567**	**0.3005**	**0.2991**	**0.8138**	**0.7760**	**0.2994**

* Adjusted for year Effects

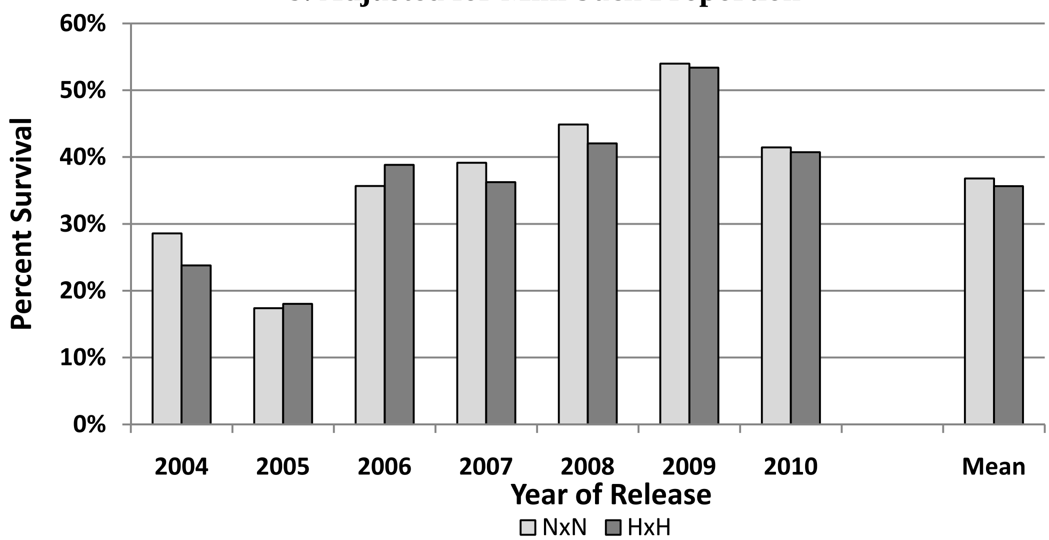
[12] Appendix A.5.a presents the associated analysis of variance with the significance levels.
[13] Appendix A.5.b presents the associated analysis of variance with the significance levels.

Figure 5. Volitional-Release-to-McNary-Dam Percent Survival of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2008)

a. Unadjusted for Mini-Jack Proportion



b. Adjusted for Mini-Jack Proportion



6. Mean Dates of Juvenile Release and Mean McNary-Dam Juvenile Passage

The mean juvenile-release and mean McNary-passage dates are presented respectively in Tables 6.a and 6.b. and respectively in Figures 6.a and 6.b. The trends are nearly the same for both measures. The signs of the two measures' NxN-HxH differences are the same from year to year except for Brood-Year 2004. The Main Effect effects were not significantly different in either measure (P = 0.47 and 0.23 respectively for release and detection dates); the interaction with years was significant at the 10% level for Release Date (P = 0.067) but not for McNary-Detection Date (P 0.17).

Table 6.a. Mean <u>Release Julian Release Date</u> of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection (brood years 2002 through 2008)[14]

Source	Brood Year / Release Year	2002 / 2004	2003 / 2005	2004 / 2006	2005 / 2007	2006 / 2008	2007 / 2009	2008 / 2010	Adjusted* Mean
NxN	Release Date	97.3	77.0	102.2	88.8	116.7	110.1	101.1	99.7
	Number Released	8707	8637	8651	8743	7669	7875	7789	58071
HxH	Release Date	99.5	75.8	103.2	84.9	112.3	105.1	105.2	98.6
	Number Released	4286	4269	4311	4322	7508	7395	7855	39946
NxN - HxH Difference		-2.2	1.1	-1.0	3.9	4.4	5.0	-4.2	1.1
Type 1 Error P - Difference		0.4096	0.1440	0.1954	0.0008	0.0002	0.0001	0.0002	0.0030

* Adjusted for year Effects

Table 6.b. Mean <u>McNary-Dam Julian Passage Date</u> of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection (brood years 2002 through 2008)[15]

Source	Brood Year / Release Year	2002 / 2004	2003 / 2005	2004 / 2006	2005 / 2007	2006 / 2008	2007 / 2009	2008 / 2010	Adjusted* Mean
NxN	Detection Date	121.9	123.5	126.0	126.2	136.3	131.3	127.2	128.6
	Expanded Detections	1911	1330	2634	3009	2753	3360	2583	17579
HxH	Detection Date	123.3	123.2	125.8	122.9	133.4	131.0	127.6	127.7
	Expanded Detections	949	728	1569	1413	2302	3476	2545	12982
NxN - HxH Difference		-1.4	0.3	0.2	3.3	2.9	0.2	-0.4	0.8
Type 1 Error P - Difference		0.3763	0.8685	0.8621	0.0284	0.0282	0.7985	0.7011	0.2307

* Adjusted for year Effects

[14] Appendix A.6.a presents the associated analysis of variance with the significance levels.
[15] Appendix A.6.b presents the associated analysis of variance with the significance levels.

Figure 6.a. Mean <u>Release Julian Release Date</u> of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection (brood years 2002 through 2008)[16]

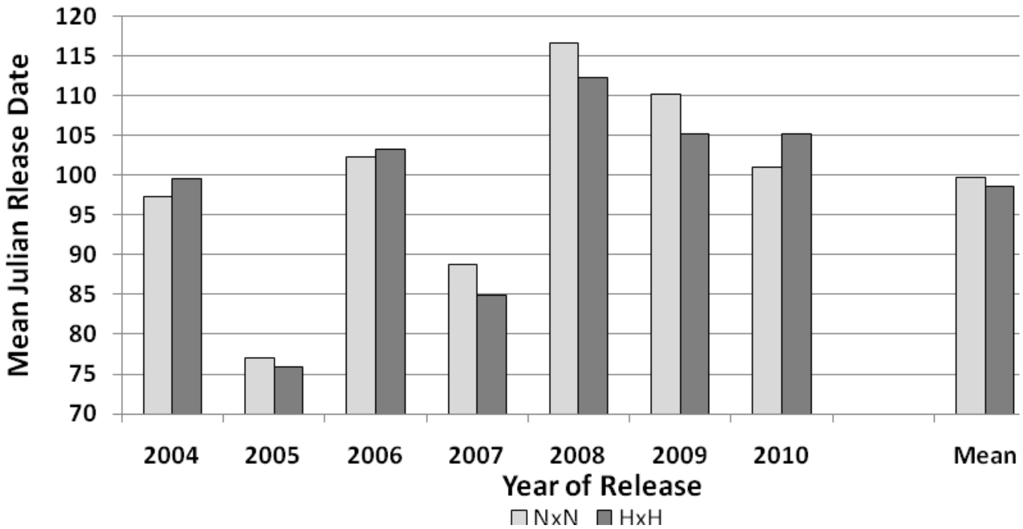
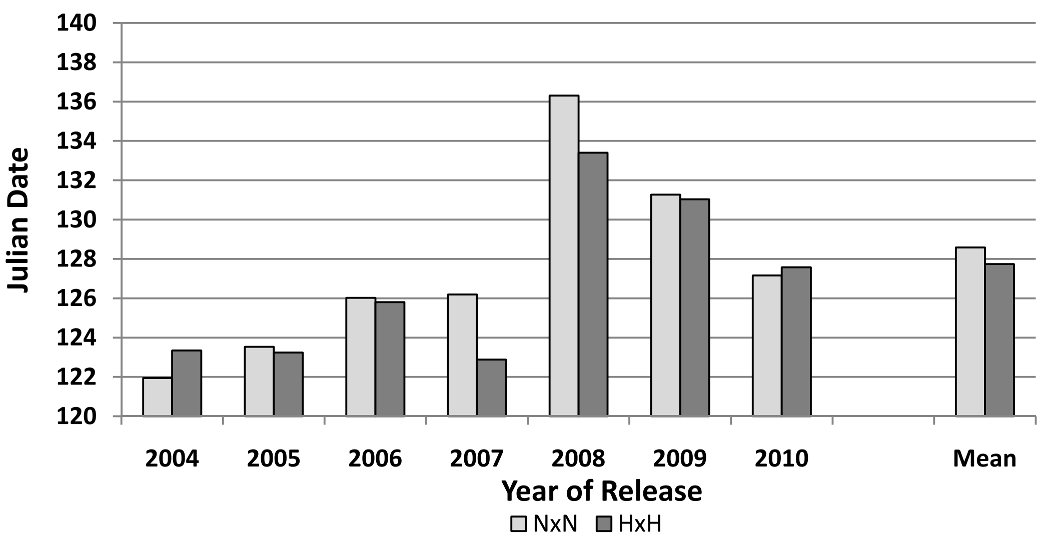


Figure 6.b. Mean <u>McNary-Dam Julian Passage Date</u> of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection (brood years 2002 through 2008)[17]



[16] Appendix A.6.a presents the associated analysis of variance with the significance levels.
[17] Appendix A.6.b presents the associated analysis of variance with the significance levels.

Appendix A. Analyses of Variation for the Analyzed Measures

In previous years' annual reports, analyses were base on grouping of years assuming that any differences between the NxN and HxH stock would increase as time progressed; however, there is no current evidence of a time-trend. The analyses here are thus simplified wherein the sources of variation of interest, NxN verses HxH main effect, are tested against Year x (NxN versus HxH) interaction assuming Year is a random effect. That interaction is tested against a pooling of Main Plot Error (differences in NxN raceway pairs) and subplot error, because for no measure was the Main Plot variation significantly greater than the Subplot variation (smallest P = 0.26 for F-ratio = 1.38).

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 2008).

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Year	501158.50	6	83526.42	**47.28**	**0.0000**
HxH vs NxN	5191.20	1	5191.20	1.78	0.2307
Year x (HxH vs NxN)	17511.80	6	2918.63	1.65	0.1700
Error	49462	28	1766.5		

Weight is number of fish weighed/raceway

Table A.2. Weighted Logistic Analysis of Variation of Per-Release Survival of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2008)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Year	398.79	6	66.47	**13.92**	**0.0000**
HxH vs NxN	219.61	1	219.61	**5.56**	**0.0564**
Year x (HxH vs NxN)	236.95	6	39.49	**8.27**	**0.0000**
Error	133.70	28	4.78		

Weight is number of fish tagged/raceway

Table A.3. Weighted Logistic Analysis of Variation of Male Percent of Pre-Release Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002-2008)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Year	14.73	6	2.46	**3.03**	**0.0176**
HxH vs NxN	0.00	1	0.00	0.00	1.0000
Year x (HxH vs NxN)	3.87	6	0.65	0.80	0.5803
Error	27.58	34	0.81		

Weight is number of fish gender-tested/raceway

Table A.4. Weighted Logistic Analysis of Variation of Mini-Jack Percent of Pre-Release Male Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2008)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Year	73.84	6	12.31	**7.31**	**0.0096**
HxH vs NxN	12.76	1	12.76	2.18	0.1900
Year x (HxH vs NxN)	35.07	6	5.85	**3.16**	**0.0169**
Error	51.71	28	1.85		

Weight is number males from gender-tested/raceway

Table A.5. Weighted Logistic Analysis of Variation of Volitional-Release-to-McNary-Dam Percent Survival of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2008)

a. Unadjusted for Mini-Jack Proportion

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Year	3,458.30	6	576.38	59.87	**0.0000**
HxH vs NxN	2.60	1	2.60	0.12	0.7412
Year x (HxH vs NxN)	130.33	6	21.72	2.26	**0.0669**
Error	269.56	28	9.63		

Weight is number number-of-smolt/raceway detected leaving acclimation site

b. Adjusted for Mini-Jack Proportion

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Year	4374.8	6	729.14	43.61	**0.0000**
HxH vs NxN	10.9	1	10.88	1.29	0.2994
Year x (HxH vs NxN)	50.6	6	8.43	0.50	0.8006
Error	568.4	34	16.72		

Weight is number number-of-smolt/raceway detected leaving acclimation site *** [1 –** proportion(mini-jack/raceway)]

Table A.6.a. Weighted Analysis of Variance of Acclimation-Release Julian Detection Date of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2008)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Year	13440116	6	2240019.3	**94.61**	**0.0000**
HxH vs NxN	26625	1	26625.0	0.58	0.4746
Year x (HxH vs NxN)	274658	6	45776.3	**2.22**	**0.0712**
Error	578601	28	20664.3		

Weight is number number-of-smolt/raceway detected leaving acclimation site

Table A.6.b. Weighted Analysis of Variance of McNary-Dam Julian Detection Date of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2008)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Year	501159	6	83526.4	**47.28**	**0.0000**
HxH vs NxN	5191	1	5191.2	1.78	0.2307
Year x (HxH vs NxN)	17512	6	2918.6	1.65	0.1700
Error	49462	28	1766.5		

Weight is expanded number of fish passing McNary dam which is the total over strata of fish detected passing McNary with strata/(stratum's detection rate at McNary dam based on detections at dams downstream of McNary)

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Appendix C
Annual Report: Comparison of Transfer-Supplemented- and Unsupplemented-Feed Treatments evaluated on Hatchery-Reared Upper-Yakima Spring Chinook Smolt released in 2007, 2009, and 2010

Doug Neeley, Consultant to Yakama Nation

Introduction

Prior to releases in 2007, 2009, and 2010, two feed treatments were allocated to raceways within adjacent raceway pairs. Fish from each raceway within the pairs were fed Vita prior to smoltification, then the Vita feed for one of the raceway pairs was supplemented with Transfer 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. Five evaluated measures are discussed herein: 1) mean pre-release fish size (assessed from individual fish samples taken by NOAA Fisheries), 2) mean volitional release date, 3) mean McNary Dam (McNary) passage date, 4) mean proportion of PIT tagged fish detected volitionally leaving the acclimation ponds, 5) mean survival from volitional release to McNary.

Summary

Analyses over the three release years indicated a significant pre-release weight loss associated with the Transfer supplement and a Year x Acclimation-Site x Treatment interaction. A detailed analysis indicated a significant increase in survival associated with the Transfer supplement in release year 2010, an increase in 2009 that appeared to be associated with two sites, and no significant difference between the supplemented and non-supplemented feed in release year 2007. Tables of means are presented in the following text, and the analyses used to judge the significance of the treatment differences are presented in the Appendix.

Mean Pre-Release Size

The pre-release-size means (grams/fish) for the treatments are given in Table 1. Appendix Table A.1 indicates Year x Site x Treatment interaction (significant at the 10% level, P = 0.065, Appendix A, Table A.1). This interaction was used as a basis of mean treatment differences over years. The treatment difference was significant at the 10% level (P = 0.085). While differences were not consistent over all combinations of sites and years, the yearly mean weights of fish receiving the Transfer-supplement were less than those not receiving the supplement.

Table 1. Mean pre-release Size (weight in grams/fish) of Spring Chinook Smolt receiving and not-receiving STF Supplement

		Release Year 2007 (2005 Brood)			Release Year 2009 (2007 Brood)			Release Year 2010 (2008 Brood)		
		Mean Fish Size		Difference as % of Control	Mean Fish Size		Difference as % of Control	Mean Fish Size		Difference as % of Control
Site	Measure	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control
Clark Flat	Fish Size	14.4	15.1	-4.67%	18.5	17.6	4.78%	16.6	17.4	-5.07%
	Number Sampled	120	120		120	120		120	120	
Easton	Fish Size	14.7	14.9	-1.29%	16.0	16.4	-2.17%	16.4	16.2	0.95%
	Number Sampled	180	180		180	179		180	176	
Jack Creek	Fish Size	14.1	15.0	-5.39%	15.3	15.6	-1.68%	17.0	17.2	-0.97%
	Number Sampled	180	180		240	120		180	180	
	Weighted* Mean Size	14.4	15.0	-3.68%	16.3	16.5	-1.55%	16.7	16.9	-1.37%
	Number Sampled	480	480		540	419		480	476	
	Weighted* Over-Year Mean Fish Size				15.8	16.1	-1.91%			
	Number Sampled				1500	1375				

* Weighted by number of sampled fish weighed prior to Release

Mean Volitional Release Date

The mean Julian volitional-release dates for the treatments are given in Table 2. Appendix Table A.2 indicates no significant difference in the means (P = 0.51, Appendix A, Table A.2.), and there is no difference in the mean Julian release date receiving the Transfer supplement relative to the Control treatment when averaged over all sites and years.

Table 2. Mean Julian Volitional-Release Date based on Detections of Fish leaving Acclimation Site

		Release Year 2007 (2005 Brood)			Release Year 2009 (2007 Brood)			Release Year 2010 (2008 Brood)		
		Mean Julian Release Date		Difference	Mean Julian Release Date		Difference	Mean Julian Release Date		Difference
Site	Measure	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control
Clark Flat	Release Date	88	89	-1	111	108	3	101	100	1
	Number Tagged	4379	1545		3936	1606		3895	1252	
Easton	Release Date	86	81	5	110	110	0	99	101	-2
	Number Tagged	6473	1850		5859	2494		5856	1690	
Jack Creek	Release Date	92	93	-1	113	114	-1	102	98	4
	Number Tagged	6574	2070		5794	2118		5828	1746	
Weighted*	Mean Release Date	88	87	1	111	110	1	100	99	1
	Number Tagged	17426	5465		15589	6218		15579	4688	
	Weighted* Over-Year Mean Passage date				99	99	0			
	Total Expanded Passage				48594	16370				

* Weight = Number of fish detected leaving Acclimation Site

Mean McNary Smolt-Passage Date

The mean McNary passage-date means for the treatments are given in Table 3. Appendix Table A.3 indicates no significant difference in the means over sites (Type Error 1 P = 0.73, Appendix A, Table A.3). There is an indication of a Site x Treatment interaction (P = 0.065); At the Jack Creek Site, there is a three-day average delay in passage of the supplemented-treated fish in two of the three years; however, yearly mean differences in passage dates do not exceed 1 day.

Table 3. Expanded Mean Julian McNary-Dam Passage Date (daily number of PIT-tagged number detected at McNary expanded by proportion of PIT-tagged fish detected at McNary)

		Release Year 2007 (2005 Brood)			Release Year 2009 (2007 Brood)			Release Year 2010 (2008 Brood)		
		Mean Julian Passage Date		Difference	Mean Julian Passage Date		Difference	Mean Julian Passage Date		Difference
Site	Measure	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control
Clark Flat	Passage Date	125	126	-1	131	131	0	126	128	-2
	Expanded Passage	1464	1545		1753	1606		1331	1252	
Easton	Passage Date	124	123	1	134	136	-2	132	132	0
	Expanded Passage	1957	1850		2287	2494		1894	1690	
Jack Creek	Passage Date	128	128	0	138	135	3	134	131	3
	Expanded Passage	2053	2070		2250	2118		1853	1746	
Weighted*	Mean Passage Date	125	125	0	134	134	0	131	130	1
	Expanded Passage	5474	5465		6290	6218		5078	4688	
Weighted* Over-Year Mean Passage Date					130	129	1			
Total Expanded Passage					16843	16370				

* Weight = Expanded Passage Number of Fish

Mean Proportion of PIT-Tagged Fish Volitionally Leaving Acclimation Ponds

The mean Julian volitional-release proportions of all fish tagged for the treatments are given in Table 4. Appendix Table A.4 indicates no significant difference between the treatment proportions pooled over sites (Type Error 1 P = 0.65, Appendix A, Table A.4). While there is, again, an indication of a Site x treatment interaction (P = 0.096), none of the sites within years had more than a 1.5% difference as a proportion of the control. There is less than a 1% difference in the released proportion of the Transfer supplement relative to the Control treatment when averaged over years and sites.

Table 4. Proportion of PIT-Tagged Fish that were detected leaving Acclimation Ponds

		Release Year 2007 (2005 Brood)			Release Year 2009 (2007 Brood)			Release Year 2010 (2008 Brood)		
		Proportion Released		Difference as % of Control	Proportion Released		Difference as % of Control	Proportion Released		Difference as % of Control
Site	Measure	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control
Clark Flat	Mean Proportion	0.985	0.981	0.48%	0.984	0.985	-0.08%	0.974	0.973	0.03%
	Number PIT-Tagged	4444	4450		4000	4000		4000	4000	
Easton	Mean Proportion	0.971	0.969	0.22%	0.976	0.969	0.74%	0.976	0.972	0.45%
	Number PIT-Tagged	6666	6669		6001	6009		6000	6000	
Jack Creek	Mean Proportion	0.986	0.982	0.46%	0.966	0.978	-1.28%	0.971	0.976	-0.43%
	Number PIT-Tagged	6666	6666		6000	6001		6000	6000	
Weighted*	Mean Proportion	0.980	0.977	0.37%	0.974	0.976	-0.23%	0.974	0.974	0.01%
	Total Number PIT-Tagged	17776	17785		16001	16010		16000	16000	

Measure	STF	Control	STF - Control
Weighted* Mean Over-Year Release Proportion	0.9762	0.9756	0.06%
Total Number PIT-Tagged	49777	49795	

* Weight = Number of PIT-Tagged Fish

Mean Volitional-Release-to-McNary-Dam Survival

In the case of survival of the released fish to McNary, the Year x Site x Treatment interaction was significant (P = 0.029). A detailed assessment in Appendix A. indicates a real increase in relative transfer-supplement survival for the 2010 release (P = 0.016, Table A, Table A.5). Such increases are not indicated in release years 2007 and 2009, although there was a significant Site x Treatment interaction associated with release year 2009 (P = 0.012) with two sites having a substantial relative transfer-supplement increase in survival but the other having a substantial decrease.

Table 5. Proportion of those PIT-Tagged Fish detected leaving Ponds that Survived to McNary Dam

		Release Year 2007 (2005 Brood)			Release Year 2009 (2007 Brood)			Release Year 2010 (2008 Brood)		
		Proportion Survived		Difference as % of Control	Proportion Survived		Difference as % of Control	Proportion Survived		Difference as % of Control
Site	Measure	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control
Clark Flat	McNary Survival	0.334	0.354	-5.51%	0.445	0.408	9.24%	0.342	0.321	6.32%
	Number Released	4379	4364		3936	3939		3895	3894	
Easton	McNary Survival	0.302	0.286	5.59%	0.390	0.428	-8.84%	0.323	0.290	11.58%
	Number Released	6473	6462		5859	5824		5856	5830	
Jack Creek	McNary Survival	0.312	0.316	-1.31%	0.388	0.361	7.65%	0.318	0.298	6.59%
	Number Released	6574	6544		5794	5870		5828	5853	
	Weighted* Mean Survival	0.314	0.315	-0.16%	0.404	0.398	1.46%	0.326	0.301	8.32%
	Total Number Released	17426	17370		15589	15633		15579	15577	
	Weighted* Over-Year Mean Survival				0.347	0.337	2.86%			
	Total Number Released				48594	48580				

*** Weight = Number of Fish that were PIT-tagged**

Appendix. Statistical Analyses for the Measures presented in the Text

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

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-ratio	Type 1 Error P
Year x Site	3517	8	440	8.58	**0.0002**
Among Raceway Pairs	769	15	51	5.30	**0.0013**
Treatment	50	1	50	5.17	**0.0853**
Treatment x Year	34	2	17	1.76	0.2060
Treatment x Site	10	2	5	0.52	0.6064
Treatment x Year x Site	108	4	27	2.79	**0.0646**
Error	145	15	10		

*** Weight = number of sampled fish weighed prior to Release**

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

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-ratio	Type 1 Error P
Year x Site	9476191	8	1184524	23.36	**0.0000**
Among Raceway Pairs	760686	15	50712	1.38	0.2718
Treatment	16738	1	16738	0.45	0.5105
Treatment x Year	600	2	300	0.01	0.9919
Treatment x Site	10181	2	5091	0.14	0.8720
Treatment x Year x Site	143018	4	35755	0.97	0.4523
Error	552600	15	36840		

*** Weight = Number of fish detected leaving Acclimation Site**

Appendix. (continued)

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

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-ratio	Type 1 Error P
Year x Site	390353	8	48794	3.38	**0.0203**
Among Raceway Pairs	216775	15	14452	9.80	**0.0000**
Treatment	177	1	177	0.12	0.7338
Treatment x Year	179	2	90	0.06	0.9413
Treatment x Site	9691	2	4846	3.29	**0.0655**
Treatment x Year x Site	12882	4	3221	2.18	0.1203
Error	22113	15	1474		

*** Weight = Expanded Passage Number of Fish**

Table 4. Weighted* Logistic Analysis of Variation of Proportion of PIT-Tagged Fish detected leaving Acclimation Ponds for Spring Chinook Smolt receiving and not receiving STF Supplement

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-ratio	Type 1 Error P
Year x Site	128.43	8	16.054	8.14	**0.0099**
Among Raceway Pairs	93.93	15	6.262	3.17	**0.0160**
Treatment	0.43	1	0.430	0.22	0.6473
Treatment x Year	4.79	2	2.395	1.21	0.3246
Treatment x Site	10.86	2	5.430	2.75	**0.0959**
Treatment x Year x Site	17.09	2	8.545	4.33	0.0327
Error	29.59	15	1.973		

*** Weight = Number of PIT-Tagged Fish**

Table 5. Weighted* Logistic Analysis of Variation of Proportion of those PIT-Tagged Fish detected leaving Ponds that survived to McNary Dam for Spring Chinook smolt receiving and not receiving STF supplement

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-ratio	Type 1 Error P
Year x Site	**833.92**	**8**	**104.24**	**33.61**	**0.0001**
Among Raceway Pairs	**108.39**	**15**	**7.226**	**2.33**	**0.0561**
Treatment	10.16	1	10.16	3.28	0.0904
Treatment x Year	13.69	2	6.845	2.21	0.1445
2007 Treatment	0.01	1	0.01	0.00	0.9555
2009 Treatment	1.01	1	1.01	0.33	0.5767
2010 Treatment	22.83	1	22.83	7.36	**0.0160**
Treatment x Site	1.94	2	0.97	0.31	0.7361
Treatment x Year x Site	44.94	4	11.235	3.62	**0.0294**
2007 Treatment x Site	7.93	2	3.965	1.28	0.3071
2009 Treatment x Site	37.26	2	18.63	6.01	**0.0121**
2010 Treatment x Site	1.69	2	0.845	0.27	0.7652
Error	46.52	15	3.101		

*** Weight = Number of Fish that were PIT-tagged**

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Appendix D
Annual Report: Smolt Survival to McNary Dam of 1999-2010 Spring Chinook Releases PIT-tagged and/or released at Roza Dam

Doug Neeley, Consultant to the Yakama Nation

Introduction

As in previous years, survivals to McNary Dam (McNary) of hatchery-brood (hatchery) released into the Roza bypass are compared to survivals of natural-brood (natural) smolt released contemporaneously with hatchery smolt. These contemporaneously Roza-passing natural smolts are referred to as "late" natural smolt. The survival of the late natural smolt is also compared to the survival of "early" natural smolt being those passing Roza prior to the hatchery smolt.

All smolt releases in this study were originally collected in the Roza bypass system, PIT-tagged, and released.

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

As was the case in the majority of the previous Roza-release years, late naturally spawned smolt released at Roza in 2010 had a significantly higher survival to McNary Dam than hatchery smolt. Figure 1 presents the natural- and hatchery-smolt survivals to McNary for late natural and hatchery smolt from 1999 through 2010 Roza releases. Table 1 presents the associated survival estimates. Weekly[1] release estimates of natural- and hatchery-smolt survival within each year are presented in Appendix A in the form of figures.

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

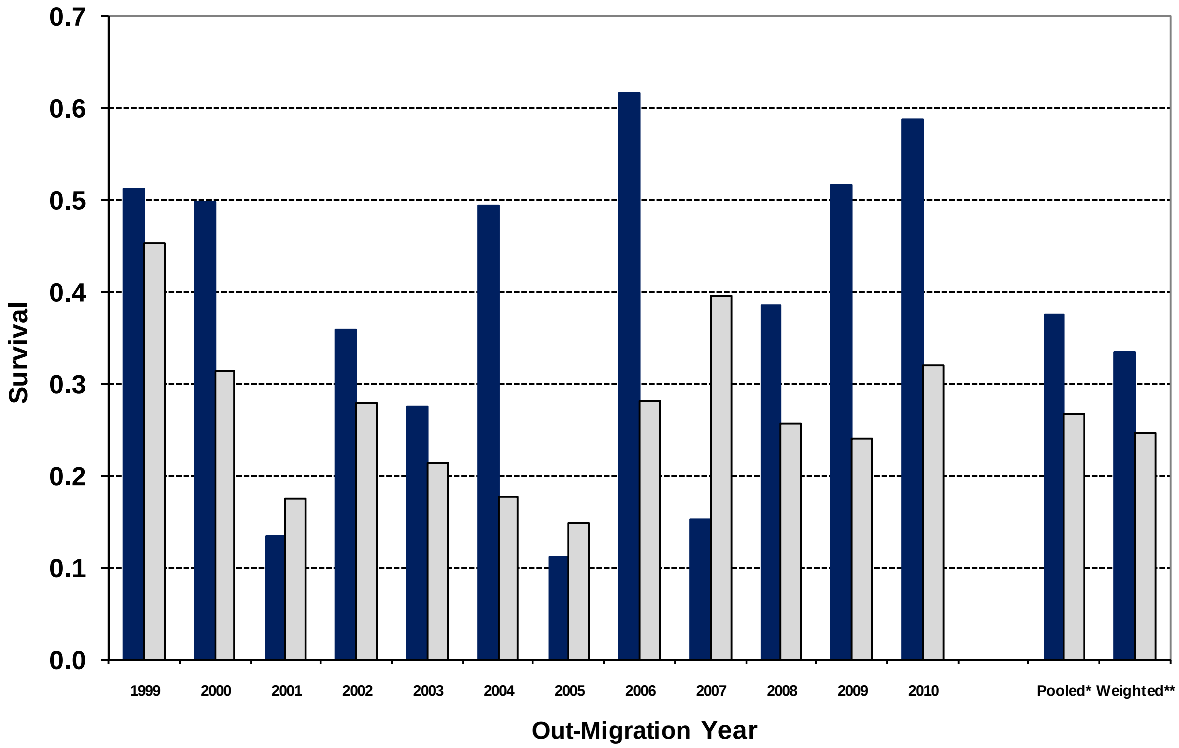
$$\text{natural survival} - \text{hatchery survival} > 0$$

[1] A week is defined as ending on a Julian date that is a multiple of 7; weeks were sometimes combined to guarantee that the period included a sufficient number of both naturally spawned and hatchery-spawned smolt for analysis purposes.

are performed as well as two-sided tests for the natural – hatchery differences in means. Table 1 presents the means, mean differences, and statistical-test summaries.

As can be seen from Figure 1 and Table 1, the late natural smolt survival exceeded that of the hatchery smolt in nine of the twelve years. Of those nine, the differences were significant[2] in six (bold-faced probabilities in the Table 1); for the additional three, the differences were significant at the 10% level. Only in 2007 was there a significant indication that the naturally-spawned spawned smolt had a lower survival. Note that the pooled survival and weighted estimates over years were significantly higher for the naturally spawned smolt.

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



[2] Significance is the estimated Type 1 Error probability is less than 0.05 (5% significance level).

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

		Outmigration Year												Mean	
Stock	Measure	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Pooled*	Weighted**
Natural	Survival	0.5122	0.4987	0.1339	0.3584	0.2750	0.4935	0.1122	0.6160	0.1529	0.3857	0.5161	0.5874	0.3760	0.3352
(Nat)	Released	133	3196	1424	2114	1190	74	45	500	336	421	172	105	9710	
Hatchery	Survival	0.4540	0.3155	0.1759	0.2803	0.2137	0.1768	0.1494	0.2810	0.3955	0.2573	0.2405	0.3196	0.2665	0.2466
(Hat)	Released	675	2999	1744	1503	2146	2201	1344	3802	2477	4406	2334	1130	26761	
Difference: Nat-Hat		0.0582	0.1832	-0.0420	0.0781	0.0613	0.3167	-0.0371	0.3350	-0.2426	0.1284	0.2756	0.2678	0.1095	0.0886
		Type 1 Error P													
(2-sided)	(Nat ≠ Hat)	0.1511	0.0000	0.5246	0.1732	0.1498	0.0487	0.9410	0.0012	0.0352	0.0192	0.0726	0.0431	0.0085	0.0178
(1-sided)	(Nat > Hat)	0.0755	0.0000	0.7377	0.0866	0.0749	0.0243	0.5295	0.0006	0.9824	0.0096	0.0363	0.0216	0.0043	0.0089

***Pooled Survival = [total over years (Released*Survival)]/[total over years (Released)]**
****Weight = [(number released)/(mean deviance)[, refer tto Appendix B**

The analyses on which individual year significance levels in Table 1 were based are presented in Appendix B as are the two analyses of years leading to the significance levels indicated in the two mean summaries in Table 1 which are explained in the appendix.

Comparison of Early- and Late-Passage Natural-Origin Smolt Survival from Roza Release to McNary Passage

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 fish were tagged at Roza prior to Prosser passage of hatchery-spawned fish. Figure 2 presents the survivals to McNary for 2000 through 2009 of Roza-released early and late naturally spawned smolt. Table 2 presents the associated survival estimates. Again, weekly release estimates of natural- and hatchery-smolt survival within each year are presented in Appendix A. Statistical analyses procedures are presented in Appendix C.

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

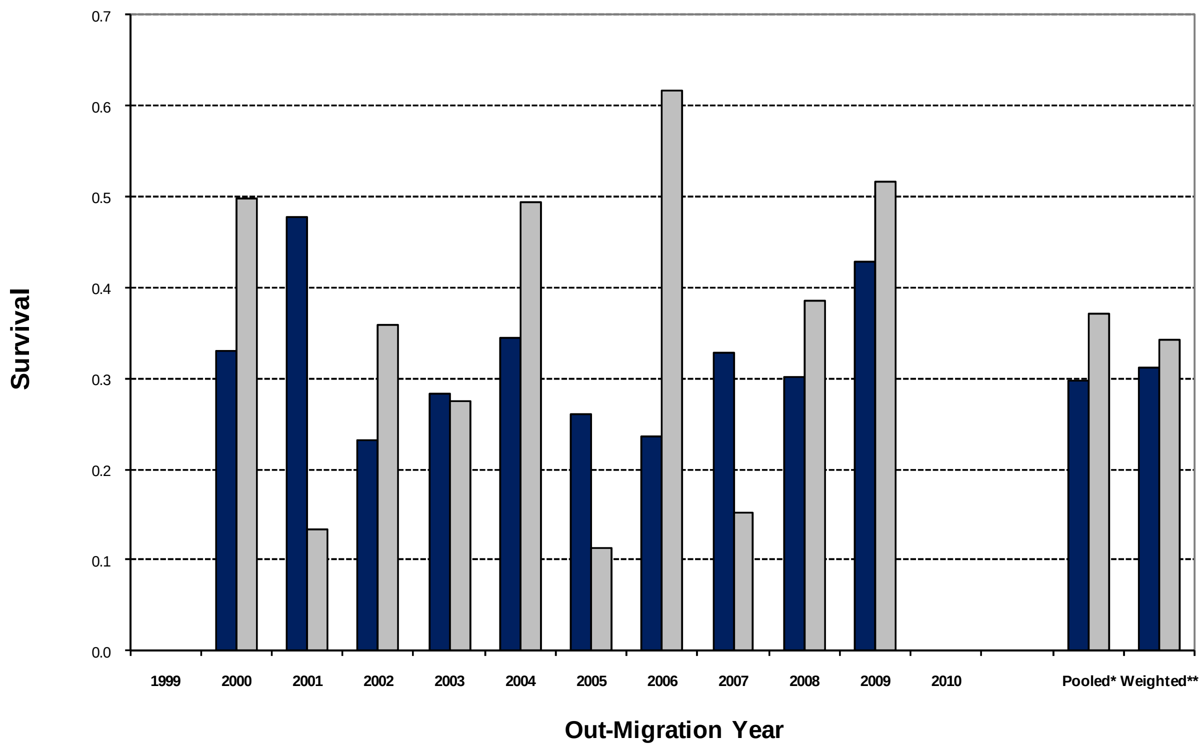
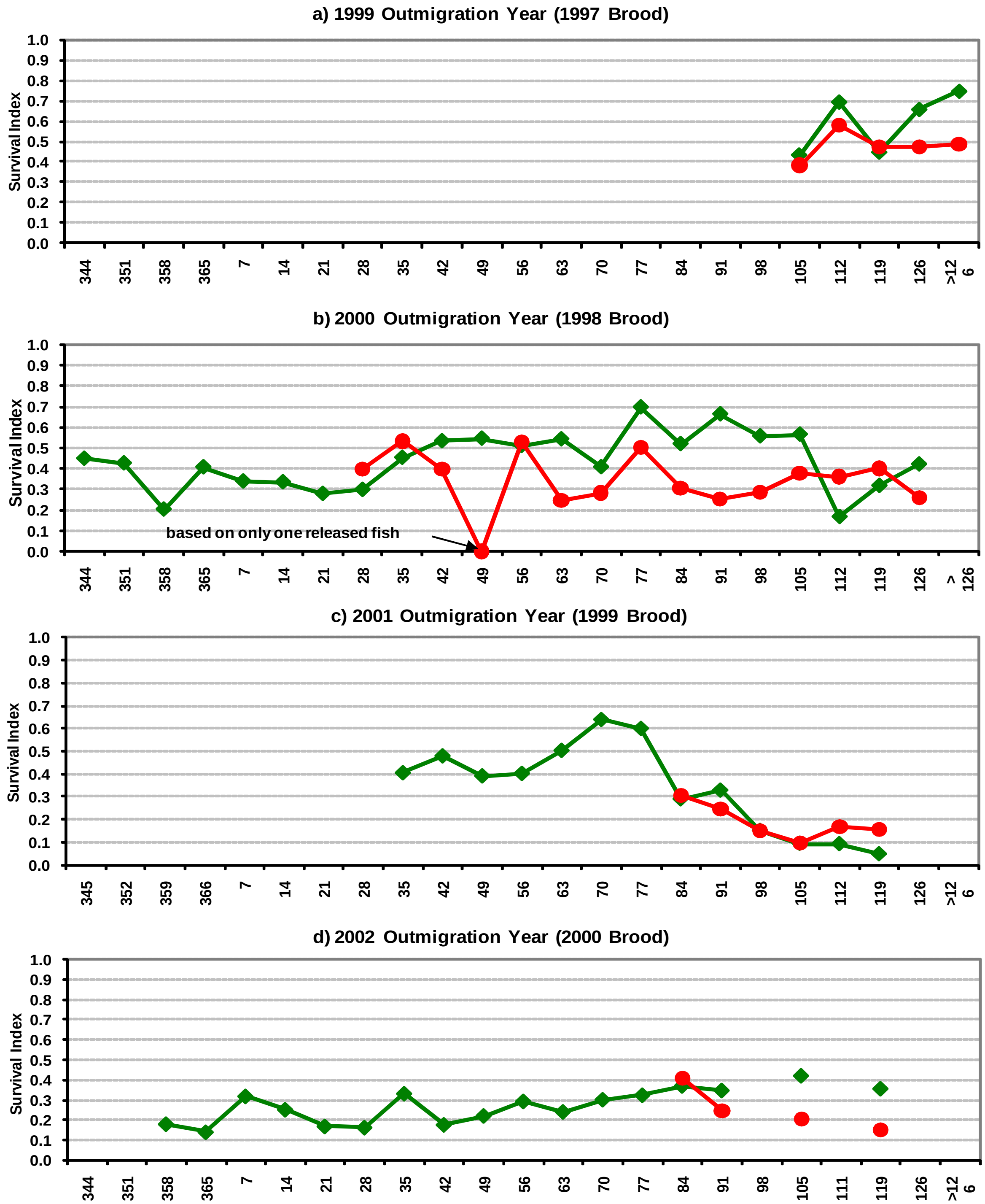


Table 2. Upper-Yakima Spring-Chinook Roza-to-McNary Smolt Survival Indices for Early and Late Natural Smolt

Natural Stock	Measure	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean Pooled*	Mean Weighted**
Early	Survival	**0.3307**	**0.4771**	**0.2314**	**0.2837**	**0.3442**	**0.2608**	**0.2361**	**0.3273**	**0.3020**	**0.4286**	**0.2971**	**0.3109**
	Released	3013	755	6604	6614	3857	1688	1833	1072	1254	1804	28494	
Late	Survival	**0.4987**	**0.1339**	**0.3584**	**0.2750**	**0.4935**	**0.1122**	**0.6160**	**0.1529**	**0.3857**	**0.5161**	**0.3718**	**0.3428**
	Released	3196	1424	2114	1190	74	45	500	336	421	172	9472	
Difference: Early-Late		**-0.1679**	**0.3432**	**-0.1270**	0.0087	-0.1493	0.1485	**-0.3799**	0.1744	**-0.0837**	-0.0875	**-0.0747**	**-0.0318**
Type 1 Error P		**0.0000**	**0.0001**	**0.0004**	0.8230	0.4903	0.4035	**0.0010**	0.0889	**0.0000**	0.1001	**0.6171**	**0.7904**

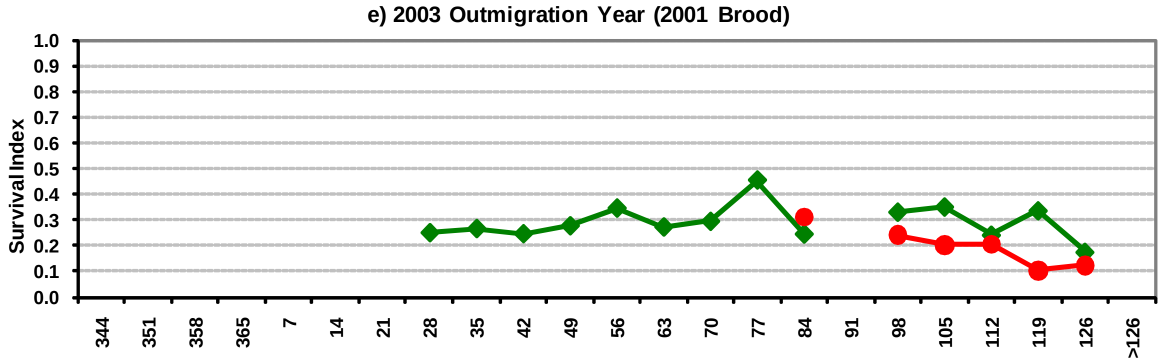
As stated in the 2009 Annual Report, there is no consistency over the release years as to whether the early or late natural-smolt passage had the highest survival to McNary. In five of the ten years, there were significant differences between the early- and late-run natural smolt, with four of those having late-run with the highest survival; however, the pooled survival and weighted estimates over all years gave similar late- and early-run estimates which were not significantly different. The analyses on which individual year significance levels in Table 2 were based are presented in Appendix C as are the two analyses of years leading to the significance levels indicated in the two mean summaries in Table 2.

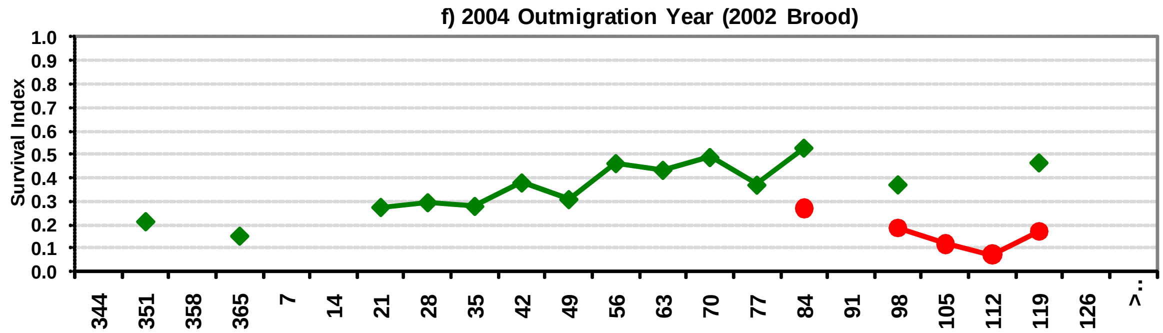
Appendix A.1. Plotted McNary Smolt Survival of Roza-Released Upper-Yakima Natural- (diamonds) and Hatchery-Brood (circles) Spring Chinook

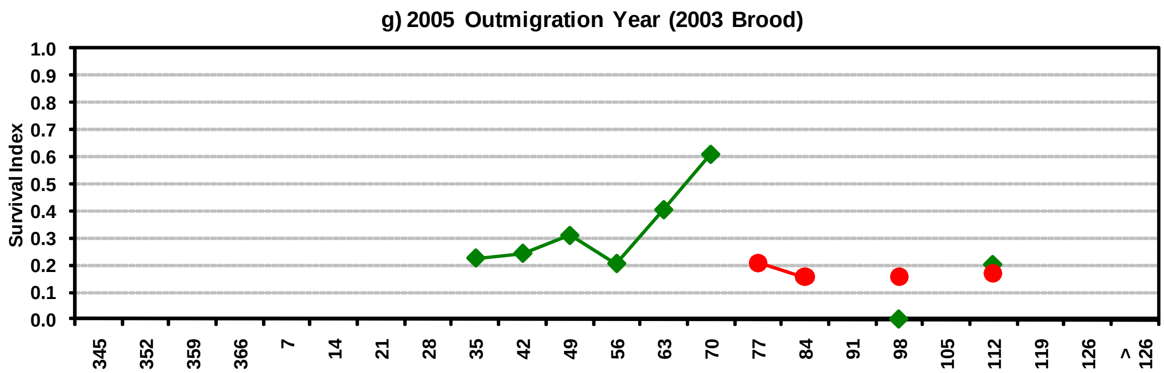


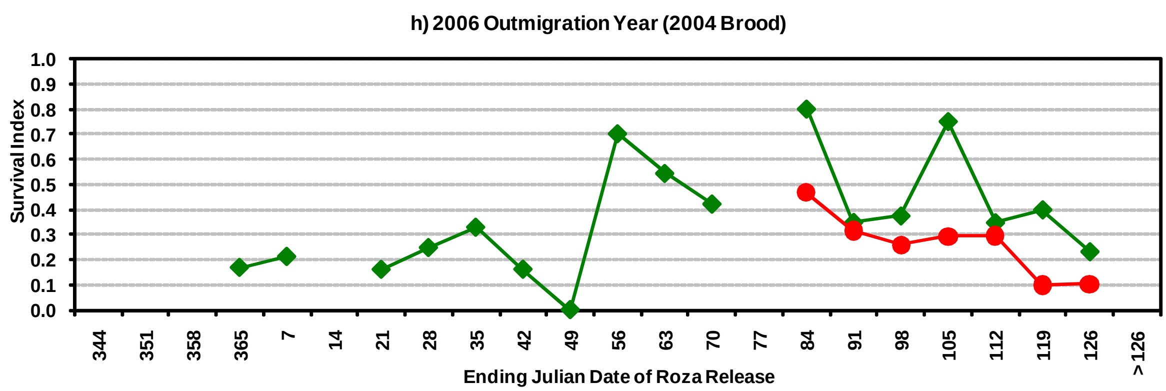
Note: The screens at the acclimation sites are generally pulled on March 15. In 2000 there was leakage that resulted in many of the hatchery fish leaving earlier.

Appendix A.1. (continued)

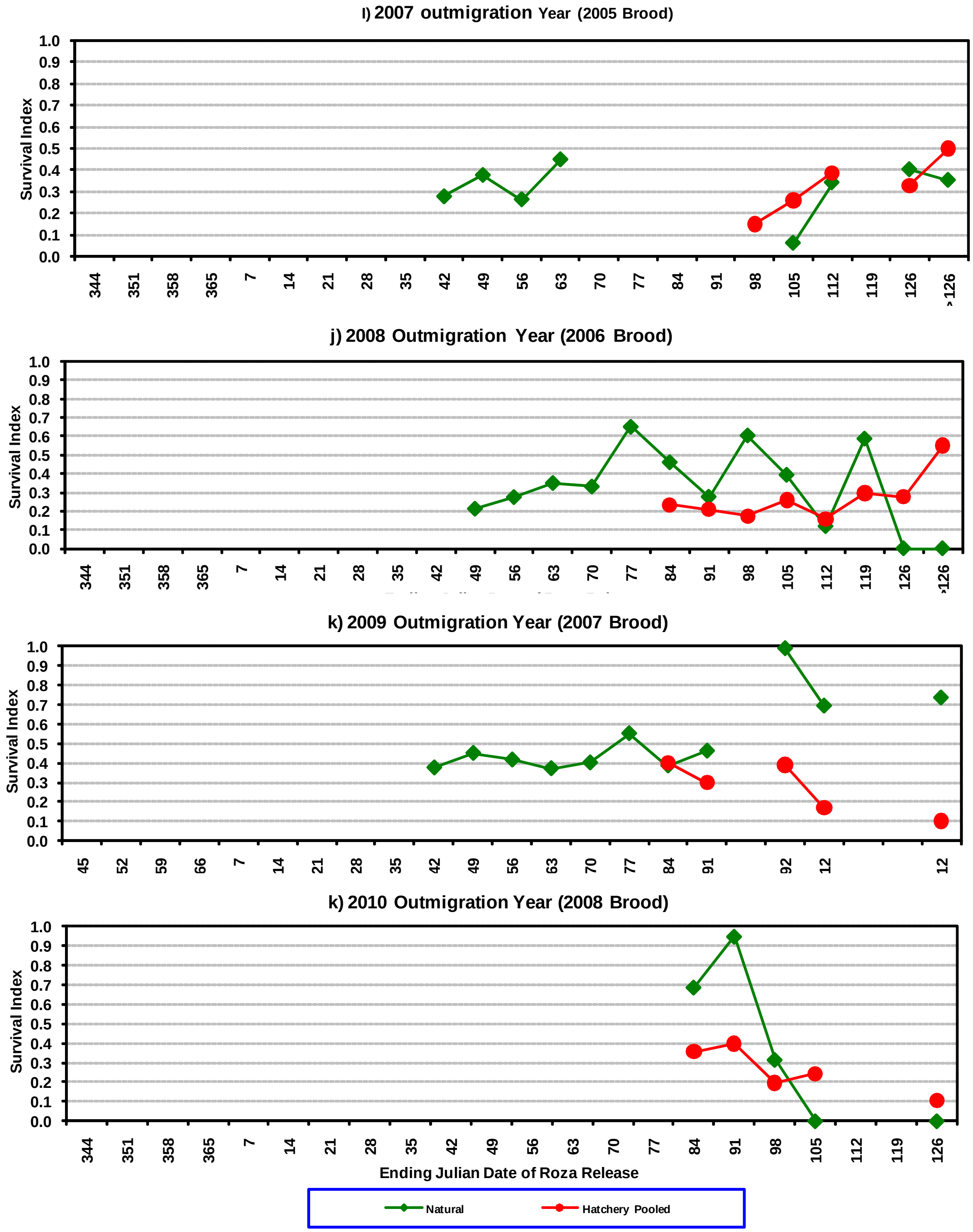








Appendix A.1. (continued)



For 2009, >92 is pooling of ending dates 98 and 105, > 112 is pooling of ending dates 119 and higher because non-pooling resulted in survival estimates of greater than 1

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

a. 1999 Outmigration Year (Brood 1997)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)			04/15/99
Ending Week (ending date of week)			05/13/99
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	05/11/00
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	05/05/01
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	05/05/02
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	05/06/03
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	04/28/04
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 A.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	04/22/05
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	05/06/06
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	05/13/07
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	05/12/08
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	05/13/09
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**

k. 2010 Outmigration Year (Brood 2007)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)			03/25/10
Ending Week (ending date of week)			05/06/10
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.1. Weighted* Logistic Analyses of Variance for Roza-to-McNary Survival of Hatchery Spawned Smolt Passing Roza contemporaneously with Naturally Spawned Smolt (Late Passage) (non-shaded-analysis 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 B.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	5.065			
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	3.5416667			
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 B.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	5.9758333	0.00		
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	4.7942857			
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 B.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 (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]	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	0.00	0.0000	
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	0.00	0.0000	

* 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 B.2. Weighted* Logistic Analyses of Variance over Years for Pooled Roza-to-McNary Survival of Hatchery Spawned (Hat) Smolt Passing Roza contemporaneously with Naturally Spawned Smolt (Nat)

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)	299.16	1	299.16	7.88	0.0170	0.0085
Among Years (adjusted for stock)	1202.86	11	109.35	2.88	0.0466	
Stock x Year Interaction	417.52	11	37.96			

* 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)	299.16	1	299.16	7.88	0.0170	0.0085
Among Years (adjusted for stock)	1202.86	11	109.35	2.88	0.0466	
Stock x Year Interaction	417.52	11	37.96			

* Weight = (number of given stock released in given year)/(Error Mean Deviance in Tables in Appendix B.1) to account for differences in Mean Deviances over years..

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

a) 1999 Outmigration (1997 Brood Year)
[No Roza Tagging prior to Hatchery-Release Passage at Roza]

b) 2000 Outmigration (1998 Brood Year)

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

c) 2001 Outmigration (1999 Brood Year)

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

d) 2002 Outmigration (2000 Brood Year)

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

e) 2003 Outmigration (2001 Brood Year)

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

f) 2004 Outmigration (2002 Brood Year)

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

* Weight is Number Released

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

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

Appendix C.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			

g) 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	72.51	11	6.59	0.00	0.0000	Late
Error	0.00	0	0.00			

h) 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			

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

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Early vs Late Natually Spaw ned Brood (adjusted for Years)	148.55	1	148.55	1.7269	0.22
Among Years (adjusted for Brood)	631.15	9	70.13	0.8152	0.62
Brood x Year Interaction	774.2	9	86.02		

* 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)	5.55	1	5.55	0.19	0.6763
Among Years (adjusted for Brood)	153.76	9	17.08	0.57	0.7904
Brood x Year Interaction	268.38	9	29.82		

* Weight = (number of given stock released in given year)/(Error Mean Deviance in Tables in Appendix B.1) to account for differences in Mean Deviances over years..

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Appendix E
2010 Annual Report: Smolt-to-Smolt Survival to McNary Dam of Yakima Fall and Summer Chinook

Doug Neeley, Consultant to Yakama Nation

Introduction

In out-migration year 2008 through 2010 subyearling and yearling Yakima-stock Fall Chinook were released fish from Prosser. In outmigration-years 2009 and 2010, Summer Chinook subyearlings were released from Stiles pond.

The analyses presented in this report are for:

1. Outmigration-year 2008 through 2010 smolt survival and dates-of-release/McNary-Dam detection comparisons for Fall Chinook subyearling and yearling releases.

2. Outmigration-year 2009 and 2010 smolt survival and dates-of-release/McNary-Dam detection comparisons of Summer Chinook subyearling releases.

Levels of significance (p values) 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 ($p < 0.05$[1]). Estimation procedures and individual release and combined estimates are presented in Appendix B.

[1] The 5% significance level represents a 0.05 probability of erroneously concluding that there is a true population difference based on sample estimates when there actually is no true population difference.

Subyearling[2] and Yearling Fall Chinook Releases

For the 2008 through 2010 brood-years, the release-to-McNary survival has been consistently and significantly higher for Yakima-stock yearling than subyearling releases (Figure and Table 1[3], p[4] < 0.045 from Appendix A, Table A.1.). The estimated yearling-subyearling (treatment) difference, while greater than zero, was substantially less in 2008 than in 2009 and 2010, and this is reflected in a large but not quite significant interaction between the years and the treatment effect (F-Ratio = 4.28 and p[5] = 0.061.)

There was no significant or notable difference between subyearling and yearling mean pre-release survivals (Figure and Table 2, p[6] = 0.828 from Appendix A, Table A.2.), nor was there any significant interaction between the comparisons with years (p =0.684).

Mean Yearling–Subyearling volitional release dates did not significantly differ (Figure and Tables 3, p = 0.40 when tested against interaction with year and P = 0.10 when tested against error from Appendix A, Table A.3.); interaction between the comparisons with years was nearly marginally significant at 10% level (p = 0.1003). However, the sub-yearling Fall Chinook McNary passage dates were significantly later than the yearling. (Figure and Table 4, p[4] = 0.020 from Appendix A, Table A.4); even though there was a significant stock interaction with years p = 0.003).

2009 Summer Chinook Estimates

The Summer Chinook, released as subyearlings in 2009, had an abysmal release-to-McNary survival rate, 1.8%; whereas the releases in 2010 had a much better survival, 30.6%, comparable to Fall Chinook subyearlings (Figure and Table 1). The low survivals in 2009 may be attributed to a couple of factors:

- late volitional Summer Chinook release date (June 22 in 2009 versus May 15 in 2010 given as Julian dates in Table 3) and associated later McNary passage in 2009 (Table 4), and

---

[2] This report presents estimates for Yakima stock. From 2007 through 2009 there were also releases of Little White stock subyearlings; however, no yearling releases were made for this stock and they are not presented in the main text of this report. Their estimates were presented in the 2009 annual report, and their survival estimates can also be extracted from Appendix B of this report.

[3] For all variables, Fall Sub-Yearling Chinook estimates for 2007 releases are also presented to provide a time-series reference.

[4] F-ratio is a test against Year interaction with stock comparison since interaction is significant at the 10% level or less.

[5] For all variables, Year x Treatment interaction tested against Error. (Within each Treatment and Year, there were replicated releases, the second release made a few days after the first release; the squared differences between the two releases' measures when combined over release pairs comprised the error measure.)

[6] Tested against error because F-ratio for interaction is small and not significant.

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

Table 2 presents pre-release survivals which happened to be higher in 2009 (88.7%) than in 2010 (65.2%).

Figures and Tables

Figure 1. Mean Volitional-Release-to-McNary-Dam Survival

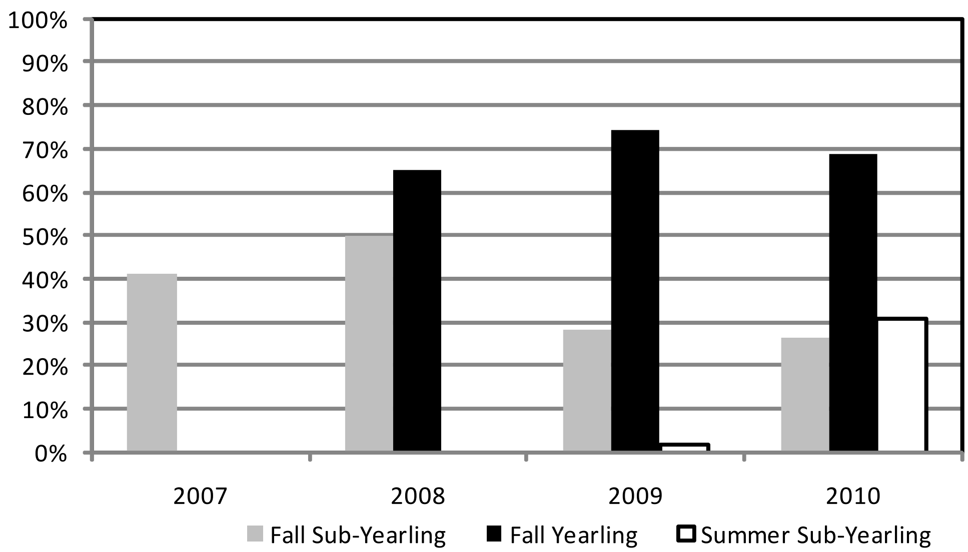


Table 1. Mean Volitional-Release-to-McNary Survival

Year	Measure	Fall Chinook (Prosser) Sub-Yearling	Fall Chinook (Prosser) Yearling	Summer Chinook Sub-Yearling
2007	**Survival**	**41.15%**		
	Number Released	4209		
2008	**Survival**	**49.90%**	**65.15%**	
	Number Released	6187	1706	
2009	**Survival**	**28.37%**	**74.27%**	**1.78%**
	Number Released	5777	4659	17054
2010	**Survival**	**26.47%**	**68.56%**	**30.61%**
	Number Released	4324	5327	5669

Figures and Tables (continued)

Figure 2. Mean Pre-Release Survival

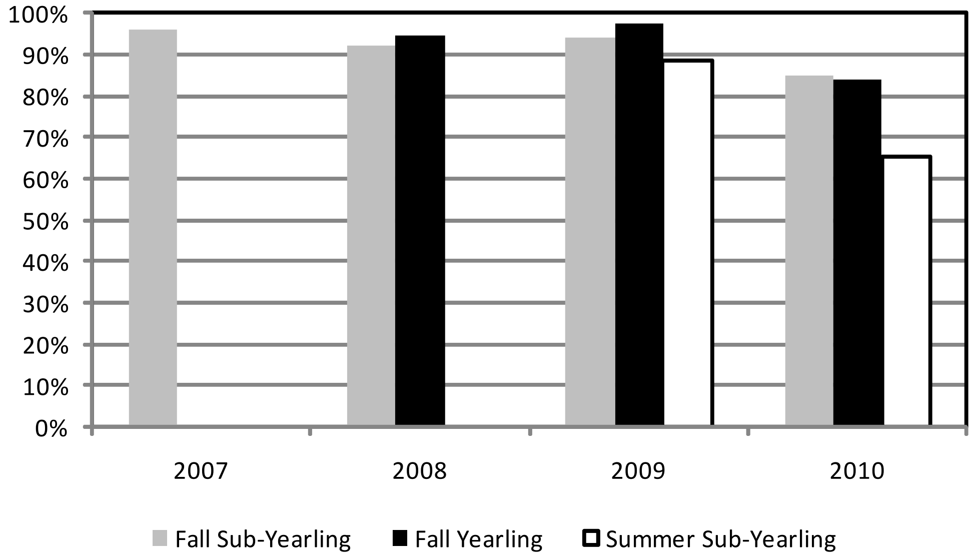


Table 2. Mean Pre-Release Survival*

Year	Measure	Fall Chinook (Prosser) Sub-Yearling	Fall Chinook (Prosser) Yearling	Summer Chinook Sub-Yearling
2007	**Pre-Release Survival**	**96.18%**		
	Number Tagged	5002		
2008	**Pre-Release Survival**	**92.26%**	**94.59%**	
	Number Tagged	10005	1831	
2009	**Pre-Release Survival**	**94.32%**	**97.58%**	**88.73%**
	Number Tagged	7565	7516	30037
2010	**Pre-Release Survival**	**84.89%**	**83.82%**	**65.22%**
	Number Tagged	13685	12167	29865

*** Proportion Detected at Release/[(# volitional-release detected at McN)/(#tagged detected at McN)}**

Figures and Tables (continued)

Figure 3.Mean Volitional Julian release Date

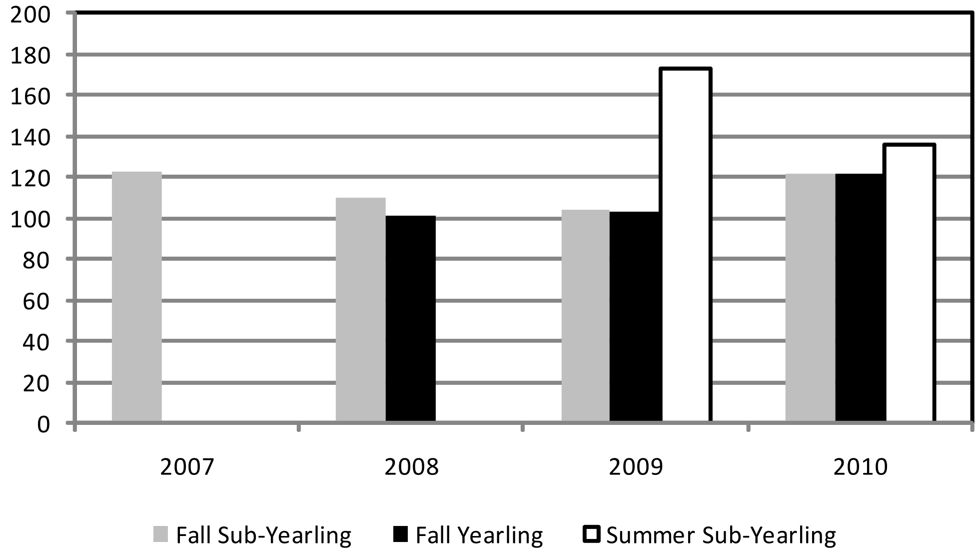
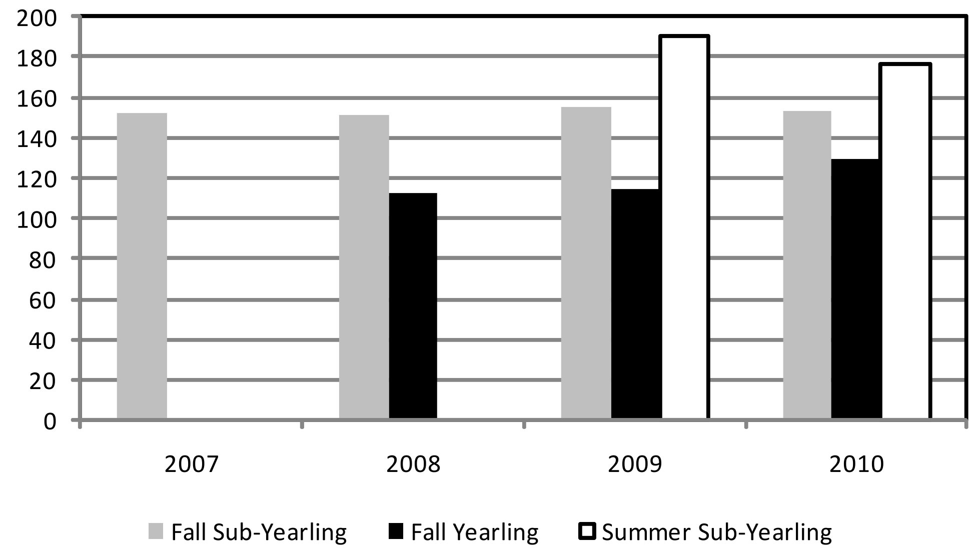


Table 3. Mean Volitional Julian-Release Date

Year	Measure	Fall Chinook (Prosser) Sub-Yearling	Fall Chinook (Prosser) Yearling	Summer Chinook Sub-Yearling
2007	**Mean Release Date**	**123.0**		
	Number Released	4209		
2008	**Mean Release Date**	**109.9**	**101.0**	
	Number Released	6187	1706	
2009	**Mean Release Date**	**104.1**	**102.7**	**173.4**
	Number Released	5777	4659	17054
2010	**Mean Release Date**	**122.2**	**122.0**	**135.9**
	Number Released	4324	5327	5669

Figures and Tables (continued)

Figure 4. Mean McNary Passage Date



		Fall Chinook (Prosser)		Summer Chinook
Year	**Measure**	**Sub-Yearling**	**Yearling**	**Sub-Yearling**
2007	**Mean Passage Date**	**152.6**		
	Expanded Detections*	1731.8		
2008	**Mean Passage Date**	**151.4**	**112.8**	
	Expanded Detections*	3087.3	1111.5	
2009	**Mean Passage Date**	**154.8**	**115.0**	**190.3**
	Expanded Detections*	1639.2	3460.3	266.5
2010	**Mean Passage Date**	**153.3**	**129.6**	**176.4**
	Expanded Detections*	1144.5	3652.4	1735.0

*** Based on fish originally detected at release**

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[7]

Table A.1. Logistic Analysis of Variance of Yakima-stock fall Chinook Release-to-McNary Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio*	Type 1 Error p*	F-Ratio**	Type 1 Error p**
Year	161.78	3	53.93	1.263	0.3582		
S vs Y***	3767.57	1	3767.57	88.236	0.0000	20.61	0.0452
Year x (S vs Y) Interaction	365.53	2	182.77	4.280	0.0611		
Error	298.89	7	42.70				

Table A.2. Logistic Analysis of Variance of Yakima-stock Fall Chinook Pre-Release Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio*	Type 1 Error p*	F-Ratio**	Type 1 Error p**
Year	1902.19	3	634.06	4.336	0.0503		
S vs Y***	7.42	1	7.42	0.051	0.8282	0.13	0.7559
Year x (S vs Y) Interaction	117.14	2	58.57	0.401	0.6844		
Error	1023.54	7	146.22				

Table A.3. Analysis of Variance of Yakima-stock Fall Chinook Date Leaving Pond

Source	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-Ratio*	Type 1 Error p*	F-Ratio**	Type 1 Error p**
Year	2359352	3	786450.67	72.108	0.0000		
S vs Y***	39056	1	39056.00	3.581	0.1003	1.10	0.4041
Year x (S vs Y) Interaction	70927.6	2	35463.80	3.252	0.1003		
Error	76346.4	7	10906.63				

Table A.4. Analysis of Variance of McNary Detection Date

Source	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-Ratio*	Type 1 Error p*	F-Ratio**	Type 1 Error p**
Year	931815	3	310605.00	64.454	0.0000		
S vs Y***	3327243	1	3327243.00	690.436	0.0000	45.67	0.0212
Year x (S vs Y) Interaction	145693.7	2	72846.85	15.116	0.0029		
Error	33733.3	7	4819.04				

* Tested against Error

** Tested against Interaction

*** Subyearling versus Yearling

[7] Note: Year main-effect comparisons includes outmigration year 2007 Yakima-stock subyearlings; however, subyearling versus yearling main-effect comparison and interaction comparisons involve only outmigration years 2008-2010.

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[8] 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[9]

4. Totaling the release's expanded numbers over strata

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

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

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

[9] Adjustments 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.

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

Equation 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.

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

$$=$$

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

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

Equation B.3.

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

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

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

The denominator with [ ] in the above equation is a measure of the detection efficiency at the acclimation site for the release in question. In earlier years estimates for this detection efficiency was based on expanded detection numbers using the detection rate in Equation A.1 as the expansion factor rather than the unexpanded detections; however, there were occasional detection efficiencies estimates based on the expanded detection numbers that resulted in survival estimates slightly exceeding 100%. While this also happened using the unexpanded numbers[11], the occurrence was even less; therefore the unexpanded numbers were used.

[11] This happened for Fall Chinook. When this occurred, the pre-release survival was equated to 1 (100%).

McNary Detection Rate Estimates

Estimates for 2006 through 2010 are given Table B.1; Tagging-to-McNary Survival given in Table B.2; Volitional-Release-to McNary Survival and other estimates are given in table B.3.

Table B.1. McNary Dam Detection Rates for 2007 and 2009 Fall Releases.

	Julian Date Strata		Bonneville (Bonn.) Based			John Day (J.D. based)			**Pooled over Bonn.and J.D. (applied detection rates)**		
Year	Beginning	Ending	Total Bonn. Det.	Joint Bonn. McN. Det.	McN. Det. Rate	Total J.D. Det.	Joint J.D. McN. Det.	McN. Det. Rate	**Pooled Total Det.**	**Pooled J.D. Det**	**Pooled McN. Det. Rate**
2007		139	41.2	9.0	0.2185	114.8	28.0	0.2439	**156.0**	**37.0**	**0.2372**
	140	143	17.2	7.0	0.4060	62.5	22.0	0.3521	**79.7**	**29.0**	**0.3637**
	144	155	100.0	31.0	0.3101	371.2	107.0	0.2882	**471.2**	**138.0**	**0.2929**
	156		505.6	187.0	0.3698	1177.5	420.0	0.3567	**1683.1**	**607.0**	**0.3606**
	Total		664.0	234.0	0.3524	1726.0	577.0	0.3343	**2390.0**	**811.0**	**0.3393**
2008		142	160.1	25.0	0.1562	384.3	71.0	0.1847	**544.4**	**96.0**	**0.1763**
	143	163	402.4	101.0	0.2510	1427.0	339.0	0.2376	**1829.4**	**440.0**	**0.2405**
	164	175	287.7	90.0	0.3128	313.1	84.0	0.2683	**600.8**	**174.0**	**0.2896**
	176		555.8	114.0	0.2051	502.6	112.0	0.2228	**1058.4**	**226.0**	**0.2135**
	Total		1406.0	330.0	0.2347	2627.0	606.0	0.2307	**4033.0**	**936.0**	**0.2321**
2009-Fall		113	278.9	73.0	0.2617	800.0	239.0	0.2987	**1079.0**	**312.0**	**0.2892**
	114	120	119.7	43.0	0.3593	350.9	121.0	0.3448	**470.6**	**164.0**	**0.3485**
	121	138	115.3	50.0	0.4336	125.4	55.0	0.4387	**240.7**	**105.0**	**0.4363**
	139	146	29.0	9.0	0.3101	35.9	10.0	0.2784	**64.9**	**19.0**	**0.2926**
	147	154	89.0	18.0	0.2022	183.4	35.0	0.1908	**272.4**	**53.0**	**0.1946**
	155	164	125.2	30.0	0.2396	248.4	61.0	0.2455	**373.6**	**91.0**	**0.2436**
	165		64.8	25.0	0.3856	96.9	31.0	0.3199	**161.7**	**56.0**	**0.3463**
	Total		822.0	248.0	0.3017	1841.0	552.0	0.2998	**2663.0**	**800.0**	**0.3004**
2009-Summer*	Total		43	10	0.2326	39	10	0.2564	**82**	**20**	**0.2439**
*insufficient numbers for stratification											
2010-Fall		127	650.0	101.0	0.1554	446.5	52.0	0.1165	**1096.5**	**153.0**	**0.1395**
	128	129	180.5	37.0	0.2050	129.5	19.0	0.1467	**310.0**	**56.0**	**0.1806**
	130	138	404.6	96.0	0.2373	242.7	50.0	0.2060	**647.3**	**146.0**	**0.2255**
	139	160	352.0	102.0	0.2898	545.3	156.0	0.2861	**897.3**	**258.0**	**0.2875**
	161	273	287.0	60.0	0.2091	398.0	99.0	0.2488	**684.9**	**159.0**	**0.2321**
	Total		1874.0	396.0	0.2113	1762.0	376.0	0.2134	**3636.0**	**772.0**	**0.2123**
2010-Summer	#REF!	173	78	15	0.1919	105	13	0.1238	**183**	**28**	**0.1529**
	174	183	388	71	0.1831	197	53	0.2691	**585**	**124**	**0.2120**
	184	273	124	16	0.1290	86	14	0.1627	**210**	**30**	**0.1428**
	Total		590.0	102.0	0.1729	388.0	80.0	0.2062	**978.0**	**182.0**	**0.1861**

Table B.2. Tagging-to-McNary Survival Indices Estimates

a. Tagging-to-McNary 2007 Survival

	Rearing Pond >	Prosser: Little White, Subyearling		Prosser: Yakima, Subyearling		Prosser: Yakima, Yearling	Stiles: Summer, Subyearling
	Tagging Group (File Extender) >	LW1	LW3	PR1	PR3		
Stratum 1	Total	11	13	57	26		
	Removed	0	0	0	0		
	Subtotal	11	13	57	26		
	Expanded Total	46.4	54.8	240.3	109.6		
Stratum 2	Total	14	8	28	15		
	Removed	0	0	0	0		
	Subtotal	14	8	28	15		
	Expanded Total	38.5	22.0	77.0	41.2		
Stratum 3	Total	24	35	95	67		
	Removed	0	0	0	0		
	Subtotal	24	35	95	67		
	Expanded Total	81.9	119.5	324.4	228.8		
Stratum 4	Total	222	182	170	170		
	Removed	0	0	0	0		
	Subtotal	222	182	170	170		
	Expanded Total	615.6	504.6	471.4	471.4		
	Total over Strata	271	238	350	278		
	Expanded Total over Strata	782.4	701.0	1113.0	851.0		
	Number Tagged	2505	2504	2501	2501		
	Tagging-to-McNary Survival	0.3123	0.2799	0.4450	0.3403		
	Pooled Number Tagged		5009		5002		
	Pooled Tagging-to-McNary Survival		0.2961		0.3926		

Table B.2. (continued)

b. Tagging-to-McNary 2008 Survival

	Rearing Pond >	Prosser: Little White, Subyearling		Prosser: Yakima, Subyearling		Prosser: Yakima, Yearling		Stiles: Summer, Subyearling
	Tagging Group (File Extender) >	LW1	LW3	PS1	PS3	PY1	PY2	
Stratum 1	Total	31	19	35	20	125	74	
	Removed	0	0	0	0	0	0	
	Subtotal	31	19	35	20	125	74	
	Expanded Total	175.8	107.7	198.5	113.4	708.9	419.6	
Stratum 2	Total	259	266	336	356	0	0	
	Removed	0	0	0	0	0	0	
	Subtotal	259	266	336	356	0	0	
	Expanded Total	1076.8	1105.9	1397.0	1480.1	0.0	0.0	
Stratum 3	Total	106	112	62	81	0	0	
	Removed	0	0	0	0	0	0	
	Subtotal	106	112	62	81	0	0	
	Expanded Total	366.0	386.7	214.1	279.7	0.0	0.0	
Stratum 4	Total	16	26	8	5	0	0	
	Removed	0	0	0	0	0	0	
	Subtotal	16	26	8	5	0	0	
	Expanded Total	74.9	121.8	37.5	23.4	0.0	0.0	
	Total over Strata	412	423	441	462	125	74	
	Expanded Total over Strata	1693.6	1722.2	1847.0	1896.6	708.9	419.6	
	Number Tagged	5000	5001	5001	5004	1089	742	
	Tagging-to-McNary Survival	0.3387	0.3444	0.3693	0.3790	0.6509	0.5656	
	Pooled Number Tagged		10001		10005		1831	
	Pooled Tagging-to-McNary Survival		0.3415		0.3742		0.6163	

Table B.2. (continued)

c. Tagging-to-McNary 2009 Survival

	Rearing Pond >	Prosser: Little White, Subyearling		Prosser: Yakima, Subyearling		Prosser: Yakima, Yearling		Stiles: Summer, Subyearling
	Tagging Group (File Extender) >	LW1	LW3	PS1	PS3	PY1	PY3	WS1-WS6
Stratum 1	Total	0	0	4	4	526	313	112
	Removed	0	0	0	0	0	0	0
	Subtotal	0	0	4	4	526	313	112
	Expanded Total	0.0	0.0	13.8	13.8	1819.0	1082.4	459.2
Stratum 2	Total	0	0	3	26	190	337	
	Removed	0	0	0	0	0	0	
	Subtotal	0	0	3	26	190	337	
	Expanded Total	0.0	0.0	8.6	74.6	545.2	967.1	
Stratum 3	Total	1	0	3	7	148	249	
	Removed	0	0	0	0	0	0	
	Subtotal	1	0	3	7	148	249	
	Expanded Total	2.3	0.0	6.9	16.0	339.2	570.7	
Stratum 4	Total	9	4	27	9	10	19	
	Removed	0	0	0	0	0	0	
	Subtotal	9	4	27	9	10	19	
	Expanded Total	30.8	13.7	92.3	30.8	34.2	64.9	
Stratum 5	Total	21	21	64	46	1	2	
	Removed	0	0	0	0	0	0	
	Subtotal	21	21	64	46	1	2	
	Expanded Total	107.9	107.9	329.0	236.4	5.1	10.3	
Stratum 6	Total	71	60	105	111	1	0	
	Removed	0	0	0	0	0	0	
	Subtotal	71	60	105	111	1	0	
	Expanded Total	291.5	246.4	431.1	455.8	4.1	0.0	
Stratum 7	Total	39	57	46	65	0	0	
	Removed	0	0	0	0	0	0	
	Subtotal	39	57	46	65	0	0	
	Expanded Total	112.6	164.6	132.8	187.7	0.0	0.0	
	Total over Strata	141.0	142.0	252.0	268.0	876.0	920.0	112.0
	Expanded Total over Strata	545.1	532.6	1014.5	1015.2	2746.9	2695.5	459.2
	Number Tagged	2025	2035	3550	4015	3529	3987	30037
	Tagging-to-McNary Survival	0.2692	0.2617	0.2858	0.2528	0.7784	0.6761	0.0153
	Pooled Number Tagged		4060		7565		7516	30037
	Pooled Tagging-to-McNary Survival		0.2655		0.2683		0.7241	0.0153

Table B.2. (continued)

d. Tagging-to-McNary 2010 Survival

	Rearing Pond >	Prosser: Yakima, Subyearling		Prosser: Yakima, Yearling		Stiles: Summer, Subyearling		
	Tagging Group (File Extender) >	PR1	PR3	PY1	PY3	WS1	WS2	WS3
Stratum 1	Total	0	2	382	115	49	50	51
	Removed	0	0	0	0	0	0	0
	Subtotal	0	2	382	115	49	50	51
	Expanded Total	0.0	14.3	2737.7	824.2	320.5	327.1	333.6
Stratum 2	Total	0	3	85	154	228	199	219
	Removed	0	0	0	0	0	0	0
	Subtotal	0	3	85	154	228	199	219
	Expanded Total	0.0	16.6	470.5	852.5	1075.2	938.5	1032.8
Stratum 3	Total	4	10	188	302	85	120	93
	Removed	0	0	0	0	0	0	0
	Subtotal	4	10	188	302	85	120	93
	Expanded Total	17.7	44.3	833.5	1339.0	595.2	840.3	651.2
Stratum 4	Total	305	391	43	47			
	Removed	0	0	0	0			
	Subtotal	305	391	43	47			
	Expanded Total	1060.7	1359.8	149.5	163.5			
Stratum 5	Total	54	86	1	1			
	Removed	0	0	0	0			
	Subtotal	54	86	1	1			
	Expanded Total	232.6	370.5	4.3	4.3			
	Total over Strata	363.0	492.0	699.0	619.0	362.0	369.0	363.0
	Expanded Total over Strata	1311.0	1805.5	4195.6	3183.4	1990.9	2105.8	2017.6
	Tagged	6462	7223	6436	5731	9954	9933	9978
	Tagging-to-McN Survival	0.2029	0.2500	0.6519	0.5555	0.2000	0.2120	0.2022
	Pooled Number Tagged		13685		12167			29865
	Pooled Tagging-to-McNary Survival		0.2277		0.6065			0.2047

Table B.3. Detection Numbers, Release-to-McNary Survival, and other Estimates

a. Release-to-McNary 2007 Survival and other estimates

	Rearing Pond >	Prosser: Little White, Subyearling		Prosser: Yakima, Subyearling		Prosser: Yakima, Yearling	Stiles: Summer, Subyearling
	Tagging Group (File Extender) >	LW1	LW3	PR1	PR3		
Stratum 1	Total	11	11	55	19		
	Removed	0	0	0	0		
	Subtotal	11	11	55	19		
	Expanded Total	46.4	46.4	231.9	80.1		
Stratum 2	Total	13	7	26	13		
	Removed	0	0	0	0		
	Subtotal	13	7	26	13		
	Expanded Total	35.7	19.2	71.5	35.7		
Stratum 3	Total	22	34	90	50		
	Removed	0	0	0	0		
	Subtotal	22	34	90	50		
	Expanded Total	75.1	116.1	307.3	170.7		
Stratum 4	Total	210	173	159	142		
	Removed	0	0	0	0		
	Subtotal	210	173	159	142		
	Expanded Total	582.3	479.7	440.9	393.7		
	Total over Strata	256	225	330	224		
	Expanded Total over Strata	739.5	661.4	1051.5	680.3		
	Number Released	2097	2045	2288	1921		
	Released-to-McNary Survival	0.3527	0.3234	0.4596	0.3541		
	Pooled Number Released		4142		4209		
	Pooled Release-to-McNary Survival		0.3382		0.4115		
	Total Tagged Det MCJ	271	238	350	278		
	Total Tagged	2505	2504	2501	2501		
	Accl Det Rate	0.9446494	0.9453782	0.9428571	0.8057554		
	Num Rel/Num Tag	0.8371257	0.8166933	0.9148341	0.7680928		
	Pre-Rel Survival*	0.8861761	0.86388	0.9702786	0.953258		
	Pre-Rel Survival**		0.8750		0.9618		
	Total Tagged		5009		5002		

* [(Volitional Releases)/(Number Tagged)]/
[(Total Released detected at McNary)/(Total Tagged detected at McNary)]

** Weighted by Number Tagged fish Released over Tagging Groups with Site

Table B.3. (continued)

b. Release-to-McNary 2008 Survival and other estimates

	Rearing Pond >	Prosser: Little White, Subyearling		Prosser: Yakima, Subyearling		Prosser: Yakima, Yearling		Stiles: Summer, Subyearling
	Tagging Group (File Extender) >	LW1	LW3	PS1	PS3	PY1	PY2	
Stratum 1	Total	179	217	230	194	123	73	
	Removed	0	0	0	0	0	0	
	Subtotal	179	217	230	194	123	73	
	Expanded Total	1015.1	1230.6	1304.3	1100.1	697.5	414.0	
Stratum 2	Total	31	22	24	26	0	0	
	Removed	0	0	0	0	0	0	
	Subtotal	31	22	24	26	0	0	
	Expanded Total	128.9	91.5	99.8	108.1	0.0	0.0	
Stratum 3	Total	86	91	52	53	0	0	
	Removed	0	0	0	0	0	0	
	Subtotal	86	91	52	53	0	0	
	Expanded Total	296.9	314.2	179.5	183.0	0.0	0.0	
Stratum 4	Total	26	43	11	13	0	0	
	Removed	0	0	0	0	0	0	
	Subtotal	26	43	11	13	0	0	
	Expanded Total	121.8	201.4	51.5	60.9	0.0	0.0	
	Total over Strata	322	373	317	286	123	73	
	Expanded Total over Strata	1562.7	1837.6	1635.1	1452.1	697.5	414.0	
	Number Released	3450	3781	3405	2782	1022	684	
	Released-to-McNary Survival	0.4529	0.4860	0.4802	0.5220	0.6825	0.6052	
	Pooled Number Released		7231		6187		1706	
	Pooled Tagging-to-McNary Survival		0.4702		0.4990		0.6515	
	Total Tagged Det MCJ	412.0	423.0	441.0	462.0	125.0	74.0	
	Total Tagged	5000.0	5001.0	5001.0	5004.0	1089.0	742.0	
	Accl Det Rate	0.7816	0.8818	0.7188	0.6190	0.9840	0.9865	
	Num Rel/Num Tag	0.6900	0.7560	0.6809	0.5560	0.9385	0.9218	
	Pre-Rel Survival*	0.8829	0.8574	0.9472	0.8981	0.9537	0.9345	
	Pre-Rel Survival**		0.8701		0.9226		0.9459	
	Total Tagged		10001		10005		1831	

* [(Volitional Releases)/(Number Tagged)]/[(Total Released detected at McNary)/(Total Tagged detected at McNary)]

** Weighted by Number Tagged fish Released over Tagging Groups w ith Site

Table B.3. (continued)

c. Release-to-McNary 2009 Survival and other estimates

	Rearing Pond >	Prosser: Little White, Subyearling		Prosser: Yakima, Subyearling		Prosser: Yakima, Yearling		Stiles: Summer, Subyearling
	Tagging Group (File Extender) >	LW1	LW3	PS1	PS3	PY1	PY3	WS1-WS6
Stratum 1	Total	0	0	2	4	347	183	74
	Removed	0	0	0	0	0	0	0
	Subtotal	0	0	2	4	347	183	74
	Expanded Total	0.0	0.0	6.9	13.8	1200.0	632.9	303.4
Stratum 2	Total	0	0	2	20	131	208	
	Removed	0	0	0	0	0	0	
	Subtotal	0	0	2	20	131	208	
	Expanded Total	0.0	0.0	5.7	57.4	375.9	596.9	
Stratum 3	Total	1	0	3	6	97	154	
	Removed	0	0	0	0	0	0	
	Subtotal	1	0	3	6	97	154	
	Expanded Total	2.3	0.0	6.9	13.8	222.3	353.0	
Stratum 4	Total	7	4	21	8	5	14	
	Removed	0	0	0	0	0	0	
	Subtotal	7	4	21	8	5	14	
	Expanded Total	23.9	13.7	71.8	27.3	17.1	47.9	
Stratum 5	Total	21	19	52	35	1	1	
	Removed	0	0	0	0	0	0	
	Subtotal	21	19	52	35	1	1	
	Expanded Total	107.9	97.7	267.3	179.9	5.1	5.1	
Stratum 6	Total	65	53	86	90	1	0	
	Removed	0	0	0	0	0	0	
	Subtotal	65	53	86	90	1	0	
	Expanded Total	266.9	217.6	353.1	369.5	4.1	0.0	
Stratum 7	Total	36	52	38	54	0	0	
	Removed	0	0	0	0	0	0	
	Subtotal	36	52	38	54	0	0	
	Expanded Total	104.0	150.2	109.7	156.0	0.0	0.0	
	Total over Strata	130.0	128.0	204.0	217.0	582.0	560.0	74.0
	Expanded Total over Strata	505.0	479.1	821.4	817.7	1824.6	1635.7	303.4
	Number Released	1703	1701	2674	3103	2324	2335	17054
	Released-to-McNary Survival	0.2965	0.2817	0.3072	0.2635	0.7851	0.7005	0.0178
	Pooled Number Released		3404.0		5777		4659	30037
	Pooled Release-to-McNary Survival		0.2891		0.2837		0.7427	0.0178
	Total Tagged Det MCJ	141.0	142.0	252.0	268.0	876.0	920.0	112.0
	Total Tagged	2025.0	2035.0	3550.0	4015.0	3529.0	3987.0	30037.0
	Accl Det Rate	0.9220	0.9014	0.8095	0.8097	0.6644	0.6087	0.6607
	Num Rel/Num Tag	0.8410	0.8359	0.7532	0.7729	0.6585	0.5857	0.5678
	Pre-Rel Survival*	0.9121	0.9273	0.9305	0.9545	0.9912	0.9621	0.8593
	Pre-Rel Survival**		0.9197		0.9432		0.9758	0.8593
	Total Tagged		4060.0		7565		7516	30037.0

* [(Volitional Releases)/(Number Tagged)]/[(Total Released detected at McNary)/(Total Tagged detected at McNary)]

** Weighted by Number Tagged fish Released over Tagging Groups within Site

Table B.3. (continued)

d. Release-to-McNary 2010 Survival and other estimates

	Rearing Pond >	Prosser: Yakima, Subyearling		Prosser: Yakima, Yearling		Stiles: Summer, Subyearling		
	Tagging Group (File Extender) >	PR1	PR3	PY1	PY3	WS1	WS2	WS3
Stratum 1	Total	0	0	127	77	28	29	27
	Removed	0	0	0	0	0	0	0
	Subtotal	0	0	127	77	28	29	27
	Expanded Total	0.0	0.0	910.2	551.8	183.2	189.7	176.6
Stratum 2	Total	0	0	28	100	52	64	76
	Removed	0	0	0	0	0	0	0
	Subtotal	0	0	28	100	52	64	76
	Expanded Total	0.0	0.0	155.0	553.6	245.2	301.8	358.4
Stratum 3	Total	2	1	72	223	7	14	19
	Removed	0	0	0	0	0	0	0
	Subtotal	2	1	72	223	7	14	19
	Expanded Total	8.9	4.4	319.2	988.7	49.0	98.0	133.0
Stratum 4	Total	160	112	20	30			
	Removed	0	0	0	0			
	Subtotal	160	112	20	30			
	Expanded Total	556.4	389.5	69.6	104.3			
Stratum 5	Total	22	21	0	0			
	Removed	0	0	0	0			
	Subtotal	22	21	0	0			
	Expanded Total	94.8	90.5	0.0	0.0			
	Total over Strata	184.0	134.0	247.0	430.0	87.0	107.0	122.0
	Expanded Total over Strata	660.1	484.4	1454.0	2198.5	477.4	589.6	668.1
	Volitional Releases	2507	1817	1820	3507	1477	1818	2374
	Release-to-McN Survival	0.2633	0.2666	0.7989	0.6269	0.3232	0.3243	0.2814
	Pooled Number Released		4324		5327			5669
	Pooled Release-to-McNary Survival		0.2647		0.6856			0.3061
	Total Tagged Det MCJ	363.0	492.0	699.0	619.0	362.0	369.0	363.0
	Total Tagged	6462.0	7223.0	6436.0	5731.0	9954.0	9933.0	9978.0
	Accl Det Rate	0.5069	0.2724	0.3534	0.6947	0.2403	0.2900	0.3361
	Num Rel/Num Tag	0.3880	0.2516	0.2828	0.6119	0.1484	0.1830	0.2379
	Pre-Rel Survival*	0.7654	0.9236	0.8003	0.8809	0.6174	0.6312	0.7079
	Pre-Rel Survival**		0.8489		0.8382			0.6522
	Total Tagged		13685		12167			29865.0

* [(Volitional Releases)/(Number Tagged)]/[(Total Released detected at McNary)/(Total Tagged detected at McNary)]

** Weighted by Number Tagged fish Released over Tagging Groups within Site

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Appendix F
Annual Report: 2006-2010 Coho Smolt-to-Smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin

Doug Neeley, Consultant to Yakama Nation

Introduction and Summary

This annual report focuses on smolt-estimate comparisons between Eagle Creek and Yakima-origin stock. As such, only sites and years from which both stock were released as smolt are discussed in the body of this report[1]. Detailed survival-estimation procedures were presented in the 2008 annual report along with individual release survival estimates for releases made through release-year 2008; similar detailed information for releases made in 2009 were presented in 2009 annual report. The detailed information for 2010 releases are presented in Appendix B Tables B.2 for sites presented in the main body of this report and in Appendix B Table.B.3 for sites not[2] reported in the main body of this report.

Smolt Survival and Time of McNary Passage

Volitional Release-to-McNary Survival for Yakima stock was higher than that of Eagle Creek stock for all fourteen paired-release sites at which there were PIT-tag detectors[3]. The survival estimates are graphically presented in Figure 1 with the estimated values given in Table 1. The mean Yakima-stock release-to-McNary

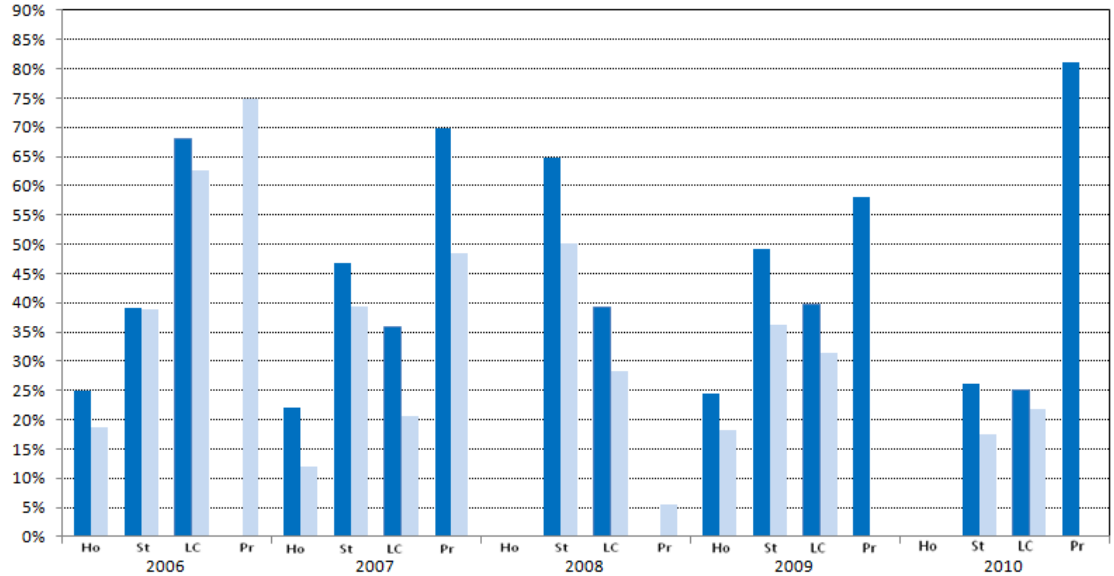
[1] Figures and tables will include the single stock estimates when only one stock was released at a site for which both stock were released in other sites in that year and for which both stocks were released at that site in other years.

[2] These are sites at which the releases within years have included only one stock/year overall years.

[3] There were sites at which there were there no PIT-tag detectors and from which Release-to-McNary survival were not possible since that survival is based on an expanded number of those fish detected leaving the site that later detected at McNary Dam.

survival over sites and years was significantly[4] greater than that of the Eagle Creek stock.

Figure 1. Outmigration-Year 2006-2010 Release-to-McNary Smolt-to-Smolt Survival for Yakima Stock (dark) and Eagle Creek Stock (light) (2004-2008 Brood)



Note: Acclimation Sites within Release Year in Order (left to right): Holmes (Ho), Stiles (St), Lost Creek (LC), Prosser (Pr); Lack of bar indicates no data, not zero survival

[4] p = 0.0001 when tested against error, p = 0.0044 when tested against Year x Stock interaction, Appendix A. Table A.1.

Table 1. Outmigration-Year 2006-2010 Volitional-Release-to-McNary Smolt Survival (2004-2008 Brood)

Release Year	Stock	Measure	Upper Yakima: Holmes	Naches: Stiles	Naches: Lost Creek	Naches: Pooled*	Main Stem Yakima: Prosser
			Release-Site Subbasin and Pond within Subbasin				
2006	Yakima	Survival from Release to McNary	25.01%	39.15%	68.02%	50.64%	
		Number Volitionally Released	781	1598	1057	2655	
	Eagle Creek	Survival from Release to McNary	18.62%	38.81%	62.66%	49.72%	74.78%
		Number Volitionally Released	636	1974	1663	3637	912
2007	Yakima	Survival from Release to McNary	22.01%	46.76%	35.83%	40.41%	69.75%
		Number Volitionally Released	920	1204	1671	2875	2112
	Eagle Creek	Survival from Release to McNary	12.02%	39.39%	20.68%	29.53%	48.35%
		Number Volitionally Released	1293	1881	2092	3973	1136
2008	Yakima	Survival from Release to McNary		64.75%	39.25%	52.37%	
		Number Volitionally Released	**	1731	1633	3364	
	Eagle Creek	Survival from Release to McNary		50.09%	28.37%	39.64%	5.53%
		Number Volitionally Released	**	2110	1956	4066	507
2009	Yakima	Survival from Release to McNary	24.38%	49.24%	39.61%	42.05%	58.14%
		Number Volitionally Released	48	696	2053	2749	2299
	Eagle Creek	Survival from Release to McNary	18.29%	36.23%	31.32%	32.88%	
		Number Volitionally Released	130	908	1946	2854	
2010	Yakima	Survival from Release to McNary		26.24%	25.10%	25.68%	81.15%
		Number Volitionally Released	**	1580	1519	3099	1210
	Eagle Creek	Survival from Release to McNary		17.41%	21.88%	19.62%	
		Number Volitionally Released	**	1836	1801	3637	

*** Pooled over only those Sites having both Yakima and Eagle Creek Releases (unshaded)**

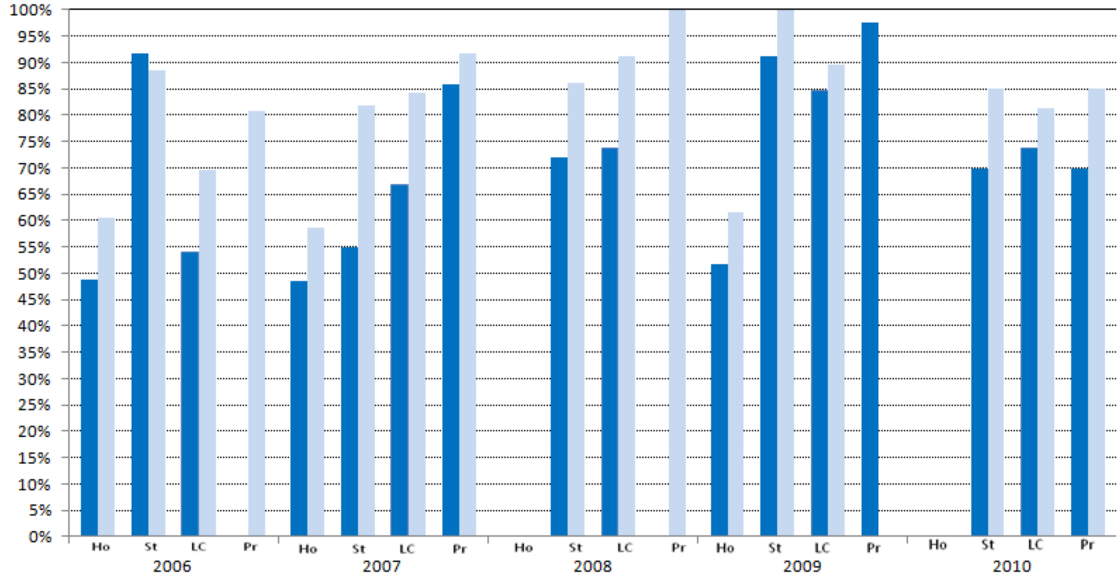
**** No PIT-tag detections at acclimation site**

<u>Pre-Release Survival</u> for Yakima stock, unlike the case for Volitional Release-to-McNary survival, was significantly[5] lower than that of Eagle Creek stock. This lower Yakima-stock survival[6] was true for all but one of the fourteen paired-releases. Pre-Release survival estimates are graphically presented in Figure 2 with the estimated values given in Table 2.

[5] p = 0.0046 when tested against error, p = 0.0013 when tested against Year x Stock interaction, Appendix A. Table A.2.

[6] Pre-release survival is 100*proportion of tagged fish estimated to have left acclimation pond. The estimate = (proportion of total tagged fish detected leaving the pond)/(detection efficiency); detection efficiency = (number of McNary-detected fish previously detected leaving pond)/ (number of pond's tagged fish detected at McNary)

Figure 2. Outmigration-Year 2006-2010 Pre-Release Survival for Yakima Stock (dark) and Eagle Creek Stock (light) (2004-2008 Brood)



Note: Acclimation Sites within Release Year in Order (left to right): Holmes (Ho), Stiles (St), Lost Creek (LC), Prosser (Pr); Lack of bar indicates no data, not zero survival

Table 2. Outmigration-Year 2006-2010 Pre-release Survival (2004-2008 Brood)

			Release-Site Subbasin and Pond within Subbasin				
			Upper Yakima	Naches			Main Stem Yakima
Release Year	Stock	Measure	Holmes	Stiles	Lost Creek	Pooled*	Prosser
2006	**Yakima**	**Pre-Release Survival**	**48.69%**	**91.75%**	**53.84%**	**72.79%**	
		Number Tagged	2512	2490	2491	4981	
	Eagle Creek	**Pre-Release Survival**	**60.50%**	**88.55%**	**69.56%**	**79.04%**	**80.82%**
		Number Tagged	2514	2506	2515	5021	1231
2007	**Yakima**	**Pre-Release Survival**	**48.40%**	**54.99%**	**66.81%**	**60.96%**	**85.88%**
		Number Tagged	2460	2449	2501	4950	2499
	Eagle Creek	**Pre-Release Survival**	**58.62%**	**81.81%**	**84.26%**	**83.04%**	**91.67%**
		Number Tagged	2504	2513	2511	5024	1246
2008	**Yakima**	**Pre-Release Survival**	**	**71.98%**	**73.82%**	**72.90%**	
		Number Tagged	2493	2492	2499	4991	
	Eagle Creek	**Pre-Release Survival**	**	**86.02%**	**91.13%**	**88.61%**	**100.00%**
		Number Tagged	2508	2453	2524	4977	854
2009	**Yakima**	**Pre-Release Survival**	**51.59%**	**91.12%**	**84.60%**	**87.87%**	**97.56%**
		Number Tagged	2512	2515	2508	5023	2506
	Eagle Creek	**Pre-Release Survival**	**61.49%**	**100.00%**	**89.56%**	**96.00%**	
		Number Tagged	1427	3755	2331	6086	
2010	**Yakima**	**Pre-Release Survival**		**69.82%**	**73.78%**	**71.80%**	**88.26%**
		Number Tagged		2501	2505	**5006**	**1371**
	Eagle Creek	**Pre-Release Survival**	**	**85.03%**	**81.33%**	**83.20%**	
		Number Tagged	**2504**	2581	2520	**5101**	

*** Pooled over only those Sites having both Yakima and Eagle Creek Releases (unshaded)**

**** No PIT-tag detections at acclimation site**

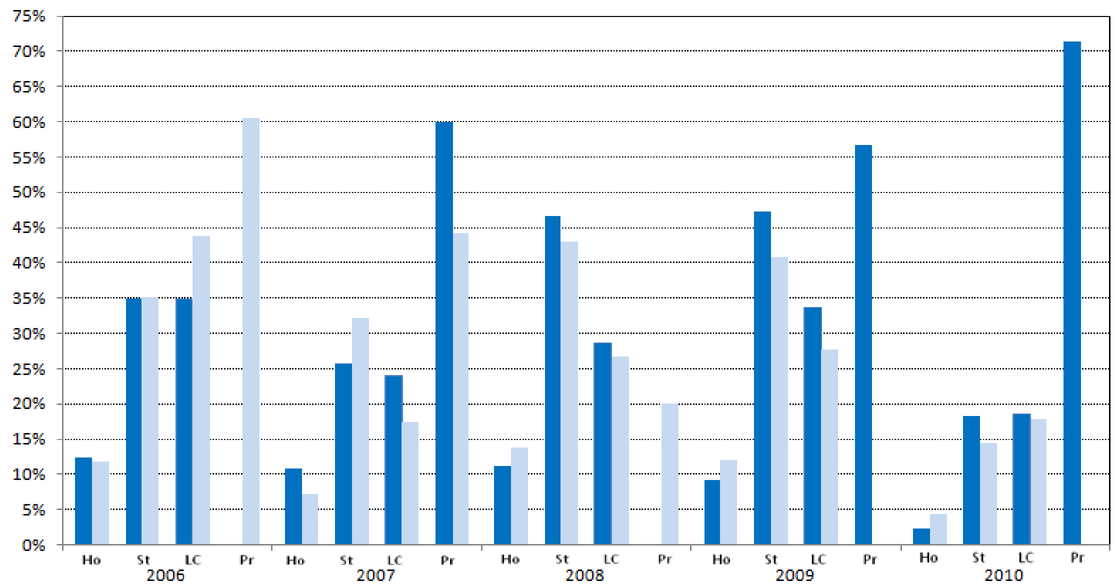
Percent of Tagged Fish Detected at McNary[7] was affected by the inconsistency in the Yakima-stock's relatively higher Volitional-Release-to-McNary survivals and its lower Pre-Release survivals. The result was that ten out of the sixteen[8] comparable paired releases had higher Yakima-stock percentages compared to all fourteen for the Volitional-Release-to-McNary survival percentages. Figure 3 presents the relative survivals for all sixteen paired-release sites for which percentages of tagged fish detected at McNary were available for both stock.

[7] Note: In past reports this has been has been referred to as Time-of-Tagging-to-McNary Survival. This is not correct because this estimate has not been adjusted for acclimation-pond detection efficiency. This is because there are ponds with no Pit-tag detectors at the acclimation sites.

[8] Two of the paired releases had no PIT-tag detector at the rearing site outfall, therefore there were no estimates of volitional-release to-McNary survivals for this site. This was one of the five sites for which the time-of-tagging-to-McNary survival was lower for the Yakima stock than for the Eagle Creek Stock.

It is probably because of the inconsistency in pre-release and post-release survivals that there was no significant[9] difference between the Yakima- and Eagle-Creek-stock percentages of tagged fish detected at McNary (p = 0.30 from Table 3). It should be noted that in past reports percentages of tagged fish detected at McNary has been referred to as Time-of-Tagging-to-McNary Survival. This was not a correct definition because this estimate has not been adjusted for the acclimation-ponds' detection efficiencies. The adjustment was not made because there are ponds with no PIT-tag detectors. For those sites with PIT-tag detectors, if Time-of-Tagging-to-McNary Survival were estimated by multiplying Volitional Release-to-McNary Survival by Pre-Release Survival, then twelve of the fourteen paired estimates had a greater Yakima-stock Time-of-Tagging-to-McNary survival estimate.

Figure 3. Outmigration-Year 2006-2010 Time-of-Tagging-to-McNary Smolt Survival (2004-2008 Brood)



Note: Acclimation Sites within Release Year in Order (left to right): Holmes (Ho), Stiles (St), Lost Creek (LC), Prosser (Pr); Lack of bar indicates no data, not zero survival

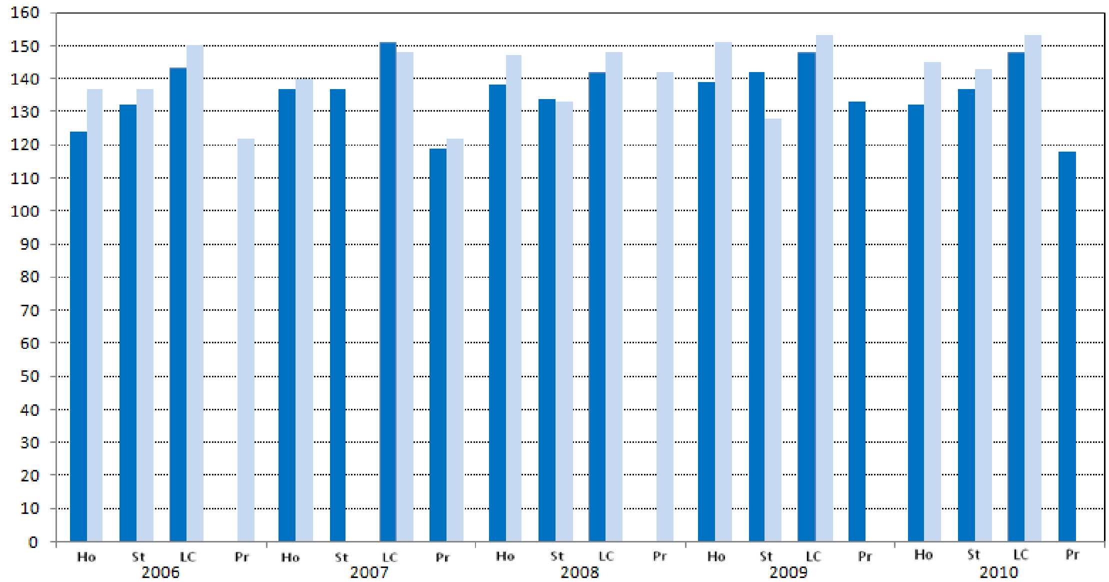
[9] p = 0.32 when tested against error, p = 0.22 when tested against Year x Stock interaction, Appendix A. Table A.3.

Table 3. Outmigration-Year 2006-2010 Time-of-Tagging-to-McNary Smolt Survival (2004-2008 Brood)

			Release-Site Subbasin and Pond within Subbasin				
			Upper Yakima	Naches			Main Stem Yakima
Release Year	Stock	Measure	Holmes	Stiles	Lost Creek	Pooled*	Prosser
2006	**Yakima**	**Survival from Tagging to McNary**	**12.48%**	**34.99%**	**34.76%**	**34.87%**	
		NumberTagged	2512	2490	2491	4981	
	Eagle Creek	**Survival from Tagging to McNary**	**11.82%**	**35.05%**	**43.81%**	**39.44%**	**60.52%**
		NumberTagged	2514	2506	2515	5021	1231
2007	**Yakima**	**Survival from Tagging to McNary**	**10.77%**	**25.65%**	**23.94%**	**24.79%**	**59.84%**
		NumberTagged	2460	2449	2501	4950	2499
	Eagle Creek	**Survival from Tagging to McNary**	**7.08%**	**32.07%**	**17.39%**	**24.73%**	**44.30%**
		NumberTagged	2504	2513	2511	5024	1246
2008	**Yakima**	**Survival from Tagging to McNary**	**11.17%**	**46.59%**	**28.58%**	**37.57%**	
		NumberTagged	2493	2492	2499	4991	
	Eagle Creek	**Survival from Tagging to McNary**	**13.89%**	**43.08%**	**26.76%**	**34.81%**	**20.13%**
		NumberTagged	2508	2453	2524	4977	854
2009	**Yakima**	**Survival from Tagging to McNary**	**9.19%**	**47.27%**	**33.70%**	**40.49%**	**56.76%**
		NumberTagged	2512	2515	2508	5023	2506
	Eagle Creek	**Survival from Tagging to McNary**	**12.01%**	**40.80%**	**27.76%**	**35.81%**	
		NumberTagged	1427	3755	2331	6086	
2010	**Yakima**	**Survival from Tagging to McNary**	**2.26%**	**18.17%**	**18.45%**	**12.21%**	**71.49%**
		NumberTagged	2516	2501	2505	7507	1371
	Eagle Creek	**Survival from Tagging to McNary**	**4.29%**	**14.43%**	**17.76%**	**16.07%**	
		NumberTagged	2504	2581	2520	5101	

McNary Detection Dates were estimated using the detections for the fourteen paired release sites. These are presented in Figure 4. The mean of the paired differences in detections between the stock was not significant[10].

Figure 4. Outmigration-Year 2006-2010 Mean Julian Date of expanded Passage at McNary Dam - Yakima Stock (dark) and Eagle Creek Stock (light) (2004-2008 Brood)



Note: Acclimation Sites within Release Year in Order (left to right): Holmes (Ho), Stiles (St), Lost Creek (LC), Prosser (Pr); Lack of bar indicates no data, not zero survival

[10] p = 0.37 when tested against error, p = 0.55 when tested against Year x Stock interaction, Appendix A. Table A.3.

Table 4. Outmigration-Year 2006-2010 Time-of-Tagging-to-McNary Smolt Survival (2004-2008 Brood)

Table 4. Outmigration-Year 2006-2009 Mean Julian Pasage Date of Tagged Smolt (2004-2007 Brood)

			Release-Site Subbasin/Pond within Subbasin			
			Upper Yakima	Naches		Main Stem Yakima
Release Year			Holmes	Stiles	Lost Creek	Prosser
2006	Yakima	Pasage Date	124.0	132	143	
		Expanded McNary Passage	313	871	865	
	Eagle Creek	Pasage Date	137.0	137	150	122
		Expanded McNary Passage	297	878	110	744
2007	Yakima	Pasage Date	137.0	137	151	119
		Expanded McNary Passage	265	628	598	1495
	Eagle Creek	Pasage Date	140.0	138	148	122
		Expanded McNary Passage	177	805	436	552
2008	Yakima	Pasage Date	138.0	134	142	
		Expanded McNary Passage	278	116	714	
	Eagle Creek	Pasage Date	147.0	133	148	142
		Expanded McNary Passage	348	105	675	171
2009	Yakima	Pasage Date	139.0	142	148	133
		Expanded McNary Passage	230	1188	845	1422
	Eagle Creek	Pasage Date	151.0	128	153	
		Expanded McNary Passage	171	1532	647	
2010	Yakima	Pasage Date	132	137	148	118
		NumberTagged	57	454	462	980
	Eagle Creek	Pasage Date	145	143	153	
		NumberTagged	108	372	447	

Appendix A. Tables of Smolt Means

Note: In the following analyses, the sources of variation year, site, and year x site interaction involve sites within years that had only one of the two stocks (Yakima and Eagle Creek) assessed as well as sites that had both stock so long as both stock were assessed in some years. All sources of variation involving stock involved only those sites within years that had both stocks assessed.

Table A.1. Logistic Analysis of Variation for 2006-2010 Expanded Release-to-McNary Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio *	Type 1 Error P*	F-Ratio	Type 1 Error P
Year	881.2	4	220.30	37.11	0.0002		
Site	2850.5	3	950.17	160.05	0.0000	3.89	0.0445 **
Year x Site	2445.52	10	244.55	41.19	0.0001		
Stock	425.29	1	425.29	71.64	0.0001	33.43	0.0044 ***
Stock x Year	50.89	4	12.72	2.14	0.1930		
Stock x Site	19.73	3	6.58	1.11	0.4165		
Error	35.62	6	5.94				

* Tested against Error which is confounded with Year x Site x Stock

** Year Tested against Year x Site

*** Stock tested against Stock x Year

Table A.2. Logistic Analysis of Variation for 2006-2010 Pre-Release Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio *	Type 1 Error P	F-Ratio	Type 1 Error P
Year	1295.09	4	323.77	4.43	0.0524		
Site	4771.8	3	1590.60	21.78	0.0013	6.89	0.0085 **
Year x Site	2308.11	10	230.81	3.16	0.0860		
Stock	1406.98	1	1406.98	19.26	0.0046	65.09	0.0013 ***
Stock x Year	86.47	4	21.62	0.30	0.8706		
Stock x Site	86.79	3	28.93	0.40	0.7608		
Error	438.22	6	73.04				

* Tested against Error which is confounded with Year x Site x Stock

** Year Tested against Year x Site

*** Stock tested against Stock x Year

Table A.3. Logistic Analysis of Variation for 2006-2010 Expanded Percent PIT-tagged-Smolt detected at McNary

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio *	Type 1 Error P	F-Ratio	Type 1 Error P	
Year	1423.59	4	355.90	17.24	0.0005			
Site	8681.49	3	2893.83	140.19	0.0000	20.96	0.0000	**
Year x Site	1656.65	12	138.05	6.69	0.0059			
Stock	22.95	1	22.95	1.11	0.3225	2.13	0.2178	***
Stock x Year	43.01	4	10.75	0.52	0.7236			
Stock x Site	49.11	3	16.37	0.79	0.5312			
Error	165.14	8	20.64					

* Tested against Error which is confounded with Year x Site x Stock

** Year Tested against Year x Site

*** Stock tested against Stock x Year

Table A.4. Least Squares Analysis of Variance for 2006-2010 Julian Date of McNary Expanded Passage

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio *	Type 1 Error P	F-Ratio	Type 1 Error P	
Year	77494	4	19373.50	2.16	0.1647			
Site	1468125	3	489375.00	54.51	0.0000	18.44	0.0001	**
Year x Site	318411	12	26534.25	2.96	0.0660			
Stock	8244	1	8244.00	0.92	0.3660	0.42	0.5527	***
Stock x Year	78676.9	4	19669.23	2.19	0.1603			
Stock x Site	67112.9	3	22370.97	2.49	0.1343			
Error	71820.1	8	8977.51					

* Tested against Error which is confounded with Year x Site x Stock

** Year Tested against Year x Site

*** Stock tested against Stock x Year

Appendix B. Estimated Survival Index

The 2008 Annual report describes estimation procedures and also presents the estimated detection rates at McNary Dam and the individual-acclimation-pond survival-rate and other estimates for release-years 2006 through 2008. The 2009 Annual report presents the individual-acclimation-pond survival-rate and other estimates for release-year 2009. For release year 2010, Table D.1 provides the McNary detection rates, Table D.2 provides the individual-acclimation-pond survival-rates for releases discussed in the main text of this report, and Table D.3 provides the individual-acclimation-pond survival-rates for releases not discussed in the main text of this report.

Table B.1. 2010 Estimated McNary (McN) Detection (Det.) Rates based on Bonneville (Bonn.) and John Day (J.D.) Detections and Pooled

		Bonneville (Bonn.) Based			John Day (J.D. based)			Pooled over Bonn.and J.D. (applied detection rates)		
Julian Date Strata		Total	Joint Bonn.	McN. Det.	Total	Joint J.D.	McN. Det.		Joint J.D.	Pooled
Beginning	Ending	Bonn. Det.	McN. Det.	Rate	J.D. Det.	McN. Det.	Rate	Total Det.	McN. Det.	Det. Rate
	128	227.8	23	0.1010	47.0	3	0.0638	**274.8**	**26**	**0.0946**
129	135	115.2	17	0.1476	38.5	3	0.0779	**153.7**	**20**	**0.1301**
136	147	820.4	114	0.1390	67.8	13	0.1917	**888.2**	**127**	**0.1430**
148		588.6	79	0.1342	477.7	113	0.2366	**1066.3**	**192**	**0.1801**
Total		1752.0	233	0.1330	631.0	132	0.2092	**2383.0**	**365**	**0.1532**

Note: Det. Are detections at the site(s) indicated

Table B.2.a. 2010 Estimated Proportion of all PIT-Tagged fish detected at McNary Dam for Sites discussed in Main text (within strata expanded total passage equals total detected passage divided by pooled detection rate in Table B.1)

		2010 Releases on Volitionally Released Fish								
		HOLMES POND NULL	HOLMES POND NULL	LOST CREEK PONDS Eagle Creek	LOST CREEK PONDS Eagle Creek	LOST CREEK PONDS Yakima	PROSSER HATCHERY Yakima	STILES POND Eagle Creek	STILES POND Eagle Creek	STILES POND Yakima
Stratum 1	Total			0	0	0	84	0	0	2
	Removed			0	0	0	0	0	0	0
	Subtotal			0	0	0	84	0	0	2
	Expanded Total			0.0	0.0	0.0	887.9	0.0	0.0	21.1
Stratum 2	Total			0	0	1	12	2	1	17
	Removed			0	0	0	0	0	0	0
	Subtotal			0	0	1	12	2	1	17
	Expanded Total			0.0	0.0	7.7	92.2	15.4	7.7	130.6
Stratum 3	Total			9	9	31	0	21	18	35
	Removed			0	0	0	0	0	0	0
	Subtotal			9	9	31	0	21	18	35
	Expanded Total			62.9	62.9	216.8	0.0	146.9	125.9	244.8
Stratum 4	Total			26	22	28	0	2	2	3
	Removed			0	0	0	0	0	0	0
	Subtotal			26	22	28	0	2	2	3
	Expanded Total			144.4	122.2	155.5	0.0	11.1	11.1	16.7
Stratum 5	Total			0	0	0	0	0	0	0
	Removed			0	0	0	0	0	0	0
	Subtotal			0	0	0	0	0	0	0
	Expanded Total			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stratum 6	Total			0	0	0	0	0	0	0
	Removed			0	0	0	0	0	0	0
	Subtotal			0	0	0	0	0	0	0
	Expanded Total			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stratum 7	Total			0	0	0	0	0	0	0
	Removed			0	0	0	0	0	0	0
	Subtotal			0	0	0	0	0	0	0
	Expanded Total			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Release Summary	Total over Strata			35	31	60	96	25	21	57
	Expanded Total over Strata			208.9	185.1	381.3	981.9	174.9	144.7	414.6
	Volitional Releases			893	908	1519	1210	929	907	1580
	Release-to-McN Survival			0.2339	0.2039	0.2510	0.8115	0.1883	0.1595	0.2624
Source Summary	Pooled Number Released				1801	1519	1210		1836	1580
	Pooled Tagging-to-McNary Survival				0.2188	0.2510	0.8115		0.1741	0.2624
Pre- Release Summary	Num Rel/Num Tag			0.7065	0.7229	0.6064	0.882567469	0.7124	0.7103	0.6317
	Number Tagged			1264	1256	2505	1371	1304	1277	2501
	Pond Detection Rate			0.8974	0.8611	0.8219	1.0000	0.8333	0.8400	0.9048
	Pond Survival			0.7872	0.8395	0.7378	0.8826	0.8549	0.8455	0.6982
	Pooled Pond Survival				0.8133	0.7378	0.8826		0.8503	0.6982

Note; McN - McNary Dam; Rel - Release

Table B.2.b. 2010 Volitional-to-McNary Survival-Index and Pre-Release Survival Estimates for Sites discussed in Main Text (within strata expanded total equals total divided by pooled detection rate in Table B.1)

		2010 Releases on Volitionally Released Fish								
		HOLMES POND NULL	HOLMES POND NULL	LOST CREEK PONDS Eagle Creek	LOST CREEK PONDS Eagle Creek	LOST CREEK PONDS Yakima	PROSSER HATCHERY Yakima	STILES POND Eagle Creek	STILES POND Eagle Creek	STILES POND Yakima
Stratum 1	Total			0	0	0	84	0	0	2
	Removed			0	0	0	0	0	0	0
	Subtotal			0	0	0	84	0	0	2
	Expanded Total			0.0	0.0	0.0	887.9	0.0	0.0	21.1
Stratum 2	Total			0	0	1	12	2	1	17
	Removed			0	0	0	0	0	0	0
	Subtotal			0	0	1	12	2	1	17
	Expanded Total			0.0	0.0	7.7	92.2	15.4	7.7	130.6
Stratum 3	Total			9	9	31	0	21	18	35
	Removed			0	0	0	0	0	0	0
	Subtotal			9	9	31	0	21	18	35
	Expanded Total			62.9	62.9	216.8	0.0	146.9	125.9	244.8
Stratum 4	Total			26	22	28	0	2	2	3
	Removed			0	0	0	0	0	0	0
	Subtotal			26	22	28	0	2	2	3
	Expanded Total			144.4	122.2	155.5	0.0	11.1	11.1	16.7
Stratum 5	Total			0	0	0	0	0	0	0
	Removed			0	0	0	0	0	0	0
	Subtotal			0	0	0	0	0	0	0
	Expanded Total			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stratum 6	Total			0	0	0	0	0	0	0
	Removed			0	0	0	0	0	0	0
	Subtotal			0	0	0	0	0	0	0
	Expanded Total			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stratum 7	Total			0	0	0	0	0	0	0
	Removed			0	0	0	0	0	0	0
	Subtotal			0	0	0	0	0	0	0
	Expanded Total			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Release Summary	Total over Strata			35	31	60	96	25	21	57
	Expanded Total over Strata			208.9	185.1	381.3	981.9	174.9	144.7	414.6
	Volitional Releases			893	908	1519	1210	929	907	1580
	Release-to-McN Survival			0.2339	0.2039	0.2510	0.8115	0.1883	0.1595	0.2624
Source Summary	Pooled Number Released				1801	1519	1210		1836	1580
	Pooled Tagging-to-McNary Survival				0.2188	0.2510	0.8115		0.1741	0.2624
Pre- Release Summary	Num Rel/Num Tag			0.7065	0.7229	0.6064	0.882567469	0.7124	0.7103	0.6317
	Number Tagged			1264	1256	2505	1371	1304	1277	2501
	Pond Detection Rate			0.8974	0.8611	0.8219	1.0000	0.8333	0.8400	0.9048
	Pond Survival			0.7872	0.8395	0.7378	0.8826	0.8549	0.8455	0.6982
	Pooled Pond Survival				0.8133	0.7378	0.8826		0.8503	0.6982

Table B.3.a. 2010 Tagging-to-McNary Survival-Index Estimates for Sites not discussed in Main text (within strata expanded total passage equals total detected passage divided by pooled detection rate in Table B.1)

	Site	BOONE POND	EASTON POND	EASTON POND	SOUTH FORK COWICHE CREEK	SOUTH FORK COWICHE CREEK	RATTLE SNAKE CREEK	AHTANUM CREEK	BIG CREEK	LITTLE NACHES RIVER
	Stock	Eagle Creek Smolt	Eagle Creek Smolt	Eagle Creek SmoltS	Yakima Smolt	Yakima Parr	Yakima Smolt	Yakima Smolt	Yakima Smolt	Yakima Smolt
Stratum 1	Total	0	0	0	0	0	0	0	0	0
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	0	0	0	0	0	0	0	0	0
	Expanded Total	0	0	0	0	0	0	0	0	0
Stratum 2	Total	0	0	0	1	0	2	0	0	0
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	0	0	0	1	0	2	0	0	0
	Expanded Total	0	0	0	7.685	0	15.37	0	0	0
Stratum 3	Total	3	7	18	23	5	8	11	3	11
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	3	7	18	23	5	8	11	3	11
	Expanded Total	20.980839	48.95529	125.88503	160.8531	34.968065	55.94890331	76.929742	20.980839	76.929742
Sratum 4	Total	4	7	3	22	87	4	97	53	85
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	4	7	3	22	87	4	97	53	85
	Expanded Total	22.214121	38.874712	16.660591	122.17767	483.15714	22.21412139	538.69244	294.33711	472.05008
	Total over Strata	7	14	21	46	92	14	108	56	96
	Expanded McNary Passage	43.19496	87.830003	142.54562	290.71576	518.1252	93.5330247	615.62219	315.31795	548.97982
	Number Tagged	1265	1281	1251	1248	3004	1144	3050	3006	3072
	Tagging-to-McN Survival	0.0341	0.0686	0.1139	0.2329	0.1725	0.0818	0.2018	0.1049	0.1787

	Site	NORTH FORK LITTLE NACHES RIVER	NILE CREEK	REECER CREEK	RATTLE SNAKE CREEK	WILSON CREEK	TANEUM CREEK	UMTANUM CREEK	NILE CREEK	ROCK CREEK
	Stock	Yakima In-basin	Yakima In-basin	Yakima In-basin	Yakima In-basin	Yakima In-basin	Yakima Wild	Yakima Wild	Yakima In-basin	Yakima In-basin
Stratum 1	Total	0	0	0	0	1	0	0	0	0
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	0	0	0	0	1	0	0	0	0
	Expanded Total	0	0	0	0	10.570513	0	0	0	0
Stratum 2	Total	0	0	1	1	1	0	1	0	0
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	0	0	1	1	1	0	1	0	0
	Expanded Total	0	0	7.685	7.685	7.685	0	7.685	0	0
Stratum 3	Total	4	11	70	19	42	1	1	0	0
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	4	11	70	19	42	1	1	0	0
	Expanded Total	27.974452	76.929742	489.5529	132.87865	293.73174	6.9936129	6.9936129	0	0
Sratum 4	Total	102	62	27	41	6	32	0	2	0
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	102	62	27	41	6	32	0	2	0
	Expanded Total	566.4601	344.31888	149.94532	227.69474	33.321182	177.71297	0	11.107061	0
	Total over Strata	106	73	98	61	50	33	2	2	0
	Expanded McNary Passage	594.43455	421.24862	647.18322	368.25839	345.30844	184.70658	14.678613	11.107061	0
	Number Tagged	3014	3055	3015	3053	3050	1867	42	16	78
	Tagging-to-McN Survival	0.1972	0.1379	0.2147	0.1206	0.1132	0.0989	0.3495	0.6942	0.0000

Appendix G

Monitoring and Evaluation of Avian Predation on Juvenile Salmonids on the Yakima River, Washington

Annual Report 2010

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EXECUTIVE SUMMARY

Gull numbers remain low in the Yakima River Basin and the focus of future studies has shifted towards: Pelican numbers and diet, management of extreme numbers of piscivorous birds in given areas, and surveys of PIT tags where mortality can be linked to predation.

Mergansers on their breeding grounds in the upper and middle Yakima River have not shown a numeric response to hatchery supplementation of spring Chinook and Coho salmon smolts yet remain a concern as they are known to congregate in large numbers below Roza Dam.

Pelican numbers remain a concern as in previous years. Aerial surveys in 2008 showed that pelican numbers peaked at near 280 birds in the Yakima Basin. Pelican numbers at Chandler were only consistently high after smolt passage was largely complete and flows returned to a forgeable level. High numbers of pelicans in Yakima Canyon in spring appeared to correlate with sucker runs, smolt emigration, and smallmouth bass spawning. New data of Pelican diet is presented and Pelican impact on salmon runs will be proposed for a diet and site use study at Chandler.

The Chandler Bypass outfall pipe makes fish of all species vulnerable to predation at low water, as the fish are disoriented and upwelling at right angles to the current. The presence of large dead and disabled fish exiting from the bypass pipe may attract avian predators to the site. PIT tag detection at Chandler outlet pipe did show high mortality for both juvenile and adult salmonids.

PIT tag surveys in 2010 proved very productive as over 21,455 tags have been discovered in the Yakima Basin. PIT tag numbers for 2010 are significantly larger than the previous 14,352 from 2009 surveys. Tags detected were linked to sources of release and 20,610 of these tags were from Yakima River juvenile salmonids. Predation by Herons showed correlation with river flow. High flow eliminates opportunity for wading bird foraging in many parts of the river. Conversely low flow creates foraging opportunities for Herons.

PIT tag survey of Toppenish Creek Great Blue Heron rookery showed predation increases when juvenile salmonids have late migration timing.

PIT tag analysis was developed by determining detection efficiencies in 2 diverse rookeries to assess a number of undetected PIT tags.

Plans for the 2011 field season include continued monitoring of river reaches and at Heron Rookeries with a focus on Pelican foraging. Heron rookeries and cormorant nesting colonies will continue to be surveyed. PIT tags found at pelican, heron nesting and roosting sites will be used to assign smolt predation estimates to specific bird species.

INTRODUCTION

Note:
For the purposes of this document the phrase "juvenile salmonids" refers to immature fish of the following stocks: Spring Chinook and Fall Chinook (*Oncorhynchus tshawytscha*), Coho (*O. kisutch*), and summer steelhead (*O. mykiss*). Please review the 2005 report for the goals and history of the avian predation project. For a more detailed description of previous years' results and the statistical

methods involved in this monitoring effort please refer to this project's previous annual reports located on the Yakima Klickitat Fisheries Project's website, www.ykfp.org or the Bonneville Power Administration's fish and wildlife technical publications and draft reports website, http://www.efw.bpa.gov/IntegratedFWP/reportcenter.aspx.

Avian Predation of Juvenile Salmon

Bird predation of juvenile salmonids is common throughout the Columbia River Basin, which supports some of the highest populations of piscivorous birds in North America and Europe (Ruggerone 1986; Roby et al. 1998). Many piscivorous birds within this basin are colonial nesters, including Ring-billed and California Gulls, Caspian and Forster's Terns, Double-crested Cormorants, Great Blue Herons, Black-crowned Night-herons, Great Egrets and American White Pelicans (See table 1 for Latin names). Colonial nesters are particularly suited to the exploitation of prey fish with fluctuating densities (Alcock 1968; Ward and Zahavi 1996). Prey fish density fluctuations can result from large migratory accumulations, releases from hatcheries, physical obstructions that concentrate or disorient fish, and other features and events which occur in complex river systems. Table 1 includes surveys piscivorous birds and acronyms they are referred to in this document.

Common Merganser (*Mergus merganser*) COME
American White Pelican (*Pelecanus erythrorhynchos*) AWPE
California Gull (*Larus californicus*) GULL
Ring-billed Gull (*Larus delawarensis*) GULL
Belted Kingfisher (*Ceryle alcyon*) BEKI
Great Blue Heron (*Ardea herodias*) GBHE
Double-crested Cormorant (*Phalacrocorax auritus*) DCCO
Black-crowned Night-Heron (*Nycticorax nycticorax*) BCHE
Forster's Tern (*Sterna forsteri*) FOTE
Great Egret (*Ardea alba*) GREG
Hooded Merganser (*Lophodytes cucullatus*) HOME
Bald Eagle (*Haliaeetus leucocephalus*)
Osprey (*Pandion haliaetus*) OSPR
Caspian Tern (*Sterna caspia*) CATE

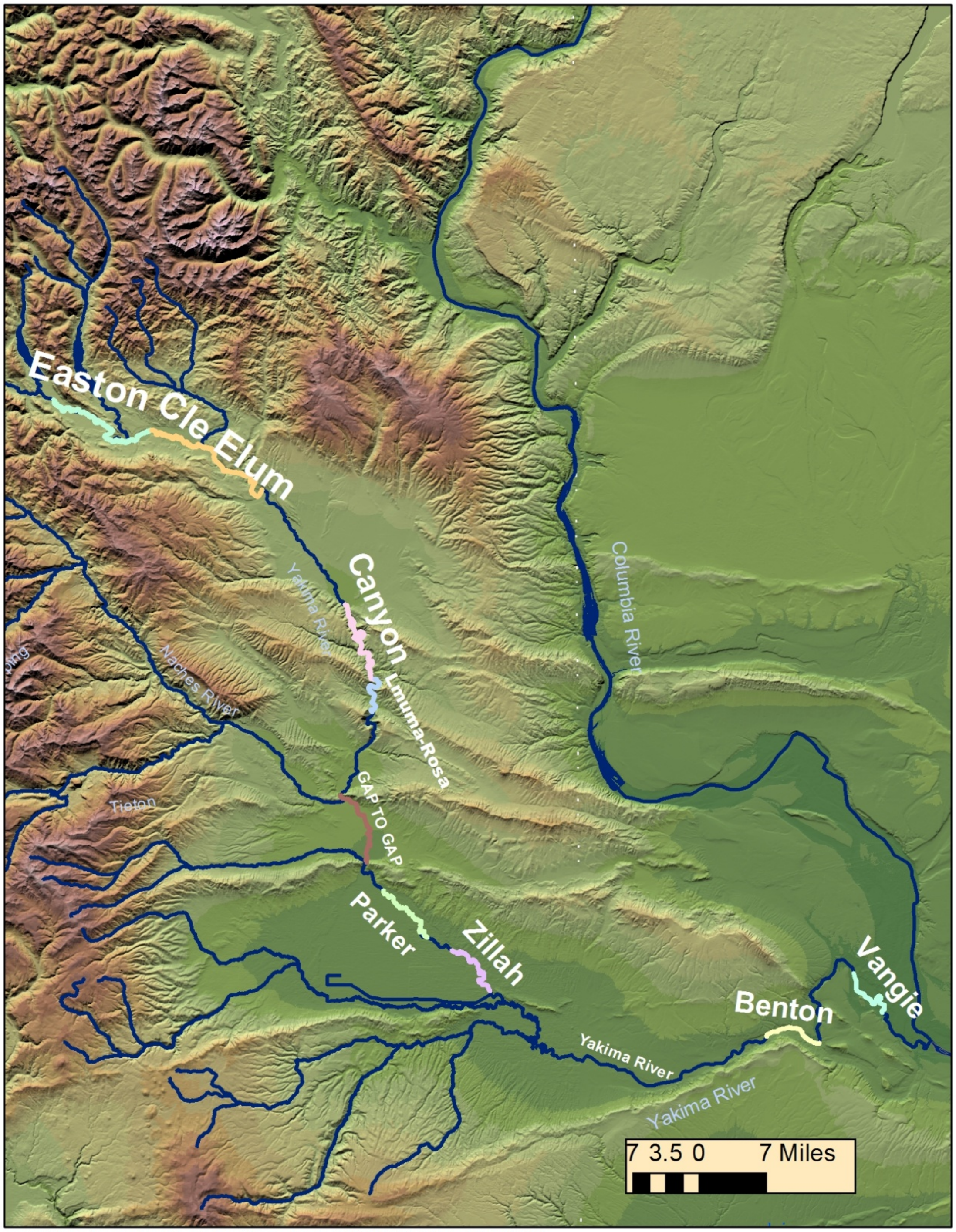
Table 1. Piscivorous birds observed along the Yakama River (note codes for graphs)

Study Area

The Yakima River Basin encompasses a total of 15,900 square kilometers in south-central Washington State. The Yakima River runs along the eastern slopes of the Cascade mountain range for a total length of approximately 330 kilometers (Figures 2). The terrain and habitat varies greatly along its length, which begins at 2,440 meters in elevation at the headwaters and ends at 104 meters elevation at its mouth on the Columbia River near the City of Richland, WA.

The upper reaches of the Yakima River, above the town of Cle Elum, are high gradient areas dominated by mixed conifer forests in association with a high degree of river braiding, log jams and woody debris. Middle reaches from Cle Elum to Selah are areas of intermediate gradient with less braiding and more varied terrain, including mixed hardwoods and conifers proximate to the river channel, frequent canyon type geography, and increasingly frequent arid shrub-steppe and irrigated agricultural lands. The lower reaches of the river, from Selah to the Columbia River, exhibit a low gradient, an infrequently braided river channel, and are dominated by hardwoods proximate to the river channel with some arid steppe and irrigated agricultural lands abutting the shoreline.

In 2010 river surveys included sections of the Yakima River near the towns of Parker (18.31) and Yakima near the Greenway (15.85). These sections include areas where piscivorous birds are commonly seen and a section of the river thought to be a high source of mortality of juvenile salmonids. These river sections are included in the river drift map (Figure 1).



c:\avdata\birdpred\reaches3.mxd Paul Huffman Yakama fisheries 4/10/2007. Edited: Michael Porter 7/21/10

Figure 1. Yakima River Basin with locations of surveyed river reaches

Survey of PIT tags in the Yakima Basin: Water Flow effect on Predation Rate

Within the Yakima Basin YKFP is implementing a study to assess the impacts of the Great Blue Heron on anadromous salmonids. Goals of the study are to identify, map, and survey heron rookeries for salmonid PIT Tags. Heron Rookeries have been discovered to contain PIT tags under nested trees (Sampson and Fast 2000). In 2007 testing with a portable Pit Tag reader was conducted to determine whether surveys of Bird Colonies/Rookeries and gravel bars was possible. Testing found that it was possible for the portable Pit Tag reader to detect defecated pit tags. In 2008 YKFP began development of survey methods for Pit Tags within Great Blue Heron rookeries**.** In 2009 PIT tag surveys produced significantly great results of 7,609 PIT tags discovered (total includes all survey years). For the 2010 survey time period a total of 3,147 new tags bringing the total number up to 10,756 PIT tags.

For over a decade, research and supplementation of the various salmon run has been conducted within the Yakima Basin. Research to assess the survivability and return rates of supplemented salmon using information gathered from Passive Integrated Transponder (PIT Tags) is a designated work task for YKFP. PIT tags are implanted within a low percentage of Hatchery and wild salmon stocks, and were initially uses as a method to determine the returning number of adult salmon. Pit tag readers are strategically placed along salmon migration routes for interrogating outgoing and incoming PIT tagged salmon. Portable Pit Tag readers have been developed to assist in research and hatchery operation. The use of PIT tags for discovering the mortality rate of salmonid smolts will be the focus of this study. Pit tag data for the region is currently managed by the Pacific Marine Fisheries Commissions.

PIT tags contain a variety of information about the fish it is associated with. The type of information included is determined by the biologist and organization the tag was issued to. This information has helped fisheries biologists find the success of PIT tag fish returns as adult spawners and show the overall success of fisheries programs. Examples of some types of information available within PIT tags are; species, run, rear type, length, acclimation site, release, fish groups (tag file id) along with messages and organization info. The Pacific Marine States Fisheries Commission under the data program maintains PTAGIS, "PIT Tag Information System (PTAGIS) is a data collection, distribution, and coordination project. The fundamental purpose of PTAGIS is to monitor the migratory habits of fish in migrating through the federal Columbia River power system dams (FCRPS) by collecting and distributing data via electronic PIT Tags" (PSMFC 2006).

Selah Rookery along interstate 82 remains the focus of the study. The rookery consists of over 30 nests and comprises an area of 12.25 acres (GPS data). PIT tag numbers gained by survey of this rookery are currently being used in a comparison with flow below Roza Dam. Data gathered from the Bureau of Reclamation (BOR) records of water flow, corresponding to the years of the sampled PIT tags, will be used. 2000-2010 years of flow, between the time period beginning in March and ending in June, will examine water flow in the reach between Roza Dam and ending at the confluence of the Yakima and Naches Rivers. This reach is unique due to its low flow from the Roza Power Plant and irrigation system diversion at Roza Dam.

All rookeries in the Yakima Basin will be surveyed and a nest count along with bird counts will be conducted. If feasible all rookeries will be scanned for PIT tags. Selah rookery and the Wapato Wildlife rookery were chosen as sites for detection efficiency estimates.

Along with rookery survey of PIT tags a survey of Dams/Diversions was conducted in 2008. The initial focus was to identify PIT tags below the Chandler outlet pipe and Prosser hatchery release outlet. As a result of a high number of PIT tags survey in this area a follow survey of the Chandler canal area of fish screens to trash racks was conducted. A high number of PIT tags were observed in this area. Subsequently surveys were expanded to include a number of other dams/diversions along the Yakima River for the 2009 season. PIT tags numbers discovered within the irrigation diversions total 6743 (information on Diversion PIT tags can be found in the 2010 YKFP annual report fish predation section). Combined numbers for total numbers of PIT tags found over all survey years and sites is 14,352.

American White Pelican in the Mid-Columbia Region

The American White Pelicans (pelican) appeared as a Washington breeder in 1994, when 50 birds nested on Crescent Island in the Columbia River, near Burbank, WA. They are currently listed as a Washington State endangered species. At present, the only breeding site in Washington is on Badger Island on the Columbia River, downstream from the mouth of the Yakima River. The Badger Island colony consists of about 500 breeding pairs. These colonial nesters are known to travel 50-80 km in search of food, so some of the birds observed on the Yakima River could be coming from this colony (Motschenbacher 1984). However, the behavior of the birds at Chandler and other Yakima River sites suggests most of these individuals are non-breeders. Leg bands that were recovered from three pelicans found dead on the lower Yakima Basin in recent years indicated the birds came from British Columbia, eastern Montana, and the Klamath National Wildlife Refuge in Oregon border (Tracy Hames, YNWRP, personal communication). Those findings suggest that Yakima River pelicans are birds dispersing from much of the western breeding range of the species.

In the YKFP study, pelicans were first populations numbers were recorded during hotspot surveys at the Chandler fish bypass facility (Figure 2) in 2000 and during river reach surveys along the lower Yakima River in 2001. Based on the river reach model, pelicans in the lower Yakima River, below the Yakima Canyon to its mouth on the Columbia River, accounted for about half of the total fish biomass depredated by piscivorous birds in the entire Yakima River in spring 2001-2002 (Sampson and Fast 2003) .

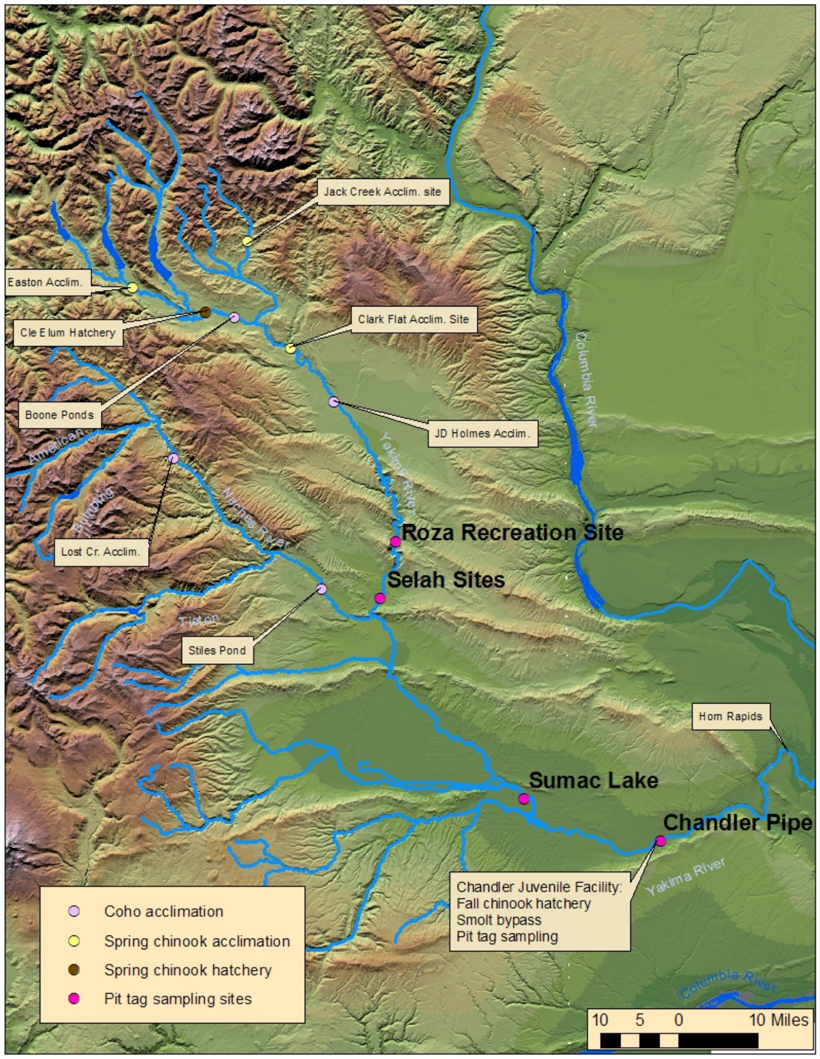


Figure 2 Yakima River Basin with locations of hotspots (Chandler & Horn Rapids), Spring Chinook acclimation sites, and areas of concern of high concentrations of piscivorous birds.

Data collected from the previous year's studies have influenced a decision by YKFP biologists to look more closely at Pelican impacts on salmon runs. Study proposal plans will likely focus on Pelican use of Chandler Pipe Outlet with hopes of gaining Pelican diet preference, and their impacts on juvenile salmonids.

PIT tag surveys of the only known breeding colony of American White Pelican colony on Badger Island (Columbia River) produced data linking Yakama Nation fish to predation by pelicans. Coupled with YKFP PIT tag survey of a known Pelican foraging area it is becoming evident Pelicans are targeting salmonid smolts as they emigrate from the Yakima River on their way to the ocean.

Hazing of Pelicans at Chandler Juvenile fish bypass and Horn Rapids will be implemented subsequent years if Pelicans remain in large numbers at these Hotspots.

Common Mergansers

One of the original concerns of YKFP managers focused on whether mergansers and other avian predators are becoming more abundant in response to increases in Yakama Nation hatchery releases of Chinook and Coho salmon in the Yakima River over time. Data from 2004-2009 appears to indicate that mergansers are not showing a numeric response to increases in the numbers of salmon smolts in the Yakima River over time.

The diet analysis of 20 Common Mergansers collected along the middle and lower Yakima River by Phinney et al. (1998) challenges the assumptions of the worst case scenario above. During that study, only in fall/winter did salmonids make up a significant proportion of the prey, 42.2% (comprised of 15.8% Chinook salmon, 21.1% rainbow trout and 5.3% unidentified salmonids). In spring, middle Yakima River mergansers readily consumed sculpin (alone making up 71.9%), while lower river mergansers readily consumed chiselmouth (alone making up 50%). Yakima River mergansers consumed a wide variety of fish species based on their availability.

Based on the river reach model, Common Mergansers consumed an estimated 21.2% of the fish biomass consumed by birds in the entire Yakima River during the spring 2007 period. This is higher than the 11.3 -12.0% estimated consumption by mergansers during spring 2005-2006. Based on past WDFW data, small fish suitable as prey for small avian predators (5-75 g) make up an estimated average of 21.0% of the fish biomass in the entire Yakima River in spring (2.3% salmonids and 18.7% other taxa), although salmon smolt numbers may be under-estimated (WDFW 1997-2001). These three statistics suggest that mergansers consume salmonids and other fish taxa of the appropriate prey size at a proportion that is less than or equal to their availability in the Yakima River.

A conclusion that could be drawn from these varied data sources is that mergansers breeding along the Yakima River eat small fish and a diversity of species based on their local and seasonal availability. It should not be assumed that mergansers eat only juvenile salmonids. Nor can it be assumed that mergansers select salmonids in a greater proportion than their availability out of the entire fish community assemblage.

Previous data along with large numbers of mergansers located below Roza Dam in 2007 prompted a study of diet and management to be proposed to and permitted by the United States Forest and Wildlife Service. The proposed study was not implemented as drop in the numbers of mergansers was seen in 2008 and 2009. The study permit carried into 2009 and will be up for renewal if numbers of over 150 appear at Roza. The study proposal is attached as appendix A.

METHODS

Survey Seasonality

River reach are organized into two specific time frames within which the impacts of bird predation on juvenile salmon were assessed. The first time frame, from April 1 to June 30, “spring”, addressed the impacts of avian predators on juvenile salmon during the spring migration of smolts out of the Yakima River. The second time frame, from July 1 to August 31, “summer”, addressed impacts to Coho and Spring Chinook parr and/or residual Coho and Spring Chinook in the upper reaches of the Yakima River. Dividing the survey dates into these time periods allowed for all future sampling efforts to be accomplished on even numbers of 2-week blocks which best fits the consumption model. These two time frames followed the methodological design set forward in the 1999 annual report (Grassley and Grue 2001) and are referred to within this document as “spring” and “summer”. This report and subsequent analysis is organized into these two generalized time frames in an effort to focus on impacts to particular salmonid life histories. Pit tag surveys in Rookeries occur in the fall and winter at a period after all PIT tag deposition has occurred and juvenile Great Blue Heron Fledging is completed. PIT tag surveys in Irrigation fish screening facilities occurs during the fall and winter months after dewatering of the diversions as the irrigation season ends.

Data Collection Methods

River Reach Surveys

The spring river surveys includ nine river reaches (Figure 1, Table 2). All reaches surveyed in both the spring and summers were identical in length and location to those conducted in previous years, with the exception of the middle reach, Canyon, and new lower reaches Gap to Gap, and Selah Section, added in 2008 (the Selah Section was not surveyed in 2010). The entire Canyon from Ellensburg to Roza was surveyed this year in spring before fishermen and boaters disturbed pelicans and other birds in the Lmuma to Roza stretch. Afterward the lower stretch above Roza Recreation Site was avoided. The survey accounts for coverage of approximately 40% of the total length of the Yakima River.

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

Table 2. River reach survey starting and end locations, and total length of reach.

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, & Easton) and one Coho site (Holmes) were surveyed for piscivorous birds in 2008 (Figure 2). 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.

Pelican Aerial Surveys

Two aerial surveys were conducted to identity the abundance and distribution of pelicans. Surveys area focused along the Yakima River from its confluence with the Columbia River to the city of Ellensburg during the Spring and Summer. Based on aerial surveys conducted on the Yakima River in the past, surveys of the Yakima River were divided into 8 geographic reaches extending from the mouth of the Yakima to the northern part of the Canyon south of Ellensburg. Surveys were conducted in the morning between 0600 – 0730. Surveys lasted approximately three hours.

Salmon PIT Tag Surveys at Great Blue Heron Rookeries and Dams and Diversions

A Passive Integrated Transponder (PIT) tag reader was used to survey for PIT tags deposited in various Yakima River Great Blue Rookeries and Fish Bypass Dams/Diversions in late summer and early fall.

Areas surveyed included: Chandler Fish Bypass/Canal, Wapato Diversion Canal in front and behind Screens, and Wanawish Dam canal right, Roza Dam Fish Screen, Naches River Fish Screens; 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 is assignment is 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. Dams and Diversion canals sources of mortality may vary by source, possibly piscivorous fish, structure, avian, and flow.

Pit Tags surveys will be 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 will be used to navigate and map rookeries along with survey plots or points. Additional equipment will include 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 are surveyed in the spring and summer for population numbers using binoculars, rookeries are not entered for fear of causing bird abandonment. Once birds have fledged rookeries are cleared of debris under nests to scan for defecated/regurgitated PIT tags.

Dams/Diversions are scanned for PIT tags during the BOR annual maintenance in November and December.

Selah Rookery was chosen as an area of focus due to high concentrations of PIT tags surveyed in 2008. Methods for a study were developed and fall under these general criteria;

- Identify all Rookeries in the Yakima Basin
- Population surveys during nesting
- Detection efficiencies by seeding PIT Tags
- Clearing PIT Tag deposit areas after fledging
- PIT Tag reading post fledge and after flooding
- PIT Tag removal (Tag collision causes interference)
- Aerial flights and river surveys monitor populations

RESULTS & DISCUSSION

River Reach Surveys

In 2010, 14 different piscivorous bird species were observed on the Yakima River (see Table 1 for English and Latin names and alphabetic codes used in figures). These were the typical species observed in previous years.

The middle river reach, Canyon, exhibited the lowest diversity of bird species and the Zillah and Parker drift in the lower river had the highest. The Great Blue Heron and Common Merganser were the only species found on all seven reaches in the spring. The Parker reach appears to have the highest density of avian predators supporting higher numbers of pelicans, Common Mergansers and Great Blue Herons than any other reach.

Common Mergansers were most abundant in the upper reaches of the river as has been the case in all 10 previous years surveyed, followed by Belted Kingfishers (Figure 3 & 4). In the middle reach, Common Mergansers were the most common species in spring and summer as well (Figure 3 & 4). The species distribution along the lower reaches was more variable: pelicans were the most abundant bird at Parker, mergansers were the most abundant bird at Zillah; and gulls were the most abundant bird at Benton and Vangie (Figure 3 & 4)). The number of pelicans counted during the river reach surveys was significantly reduced from the counts in 2006 and similar to 2007. Caspian Terns, another major fish predator on the Lower Columbia River, were occasionally seen in the lower and middle Yakima, Chandler, Horn Rapids, and the Selah Ponds.

Common Mergansers are of particular importance because of their known utilization of salmon smolts in Europe and North America (White 1957; Wood and Hand 1985) and because as in the previous 9 years, they remain the primary avian predator of the upper Yakima River in both the spring and summer periods. Pelicans are important because of their high populations in the lower river and their high daily dietary requirements.

Double-crested Cormorants, a major fish predator on the Lower Columbia River, were found in increasingly high numbers in the lower river and occasionally in the middle river and seen up in the Easton river reach. Cormorants although only common in the river below the Yakima Canyon are the fourth most significant bird predator of small fish in the entire river and appear to have increased in numbers in the middle river and upper stretches of the lower river the last few years. Cormorants also invaded a Great Blue Heron rookery in the spring of 2009, taking over nests and roosting. Figure 5 shows a map of the rookery and nesting cormorants located within the WDFW Sunnyside wildlife area.

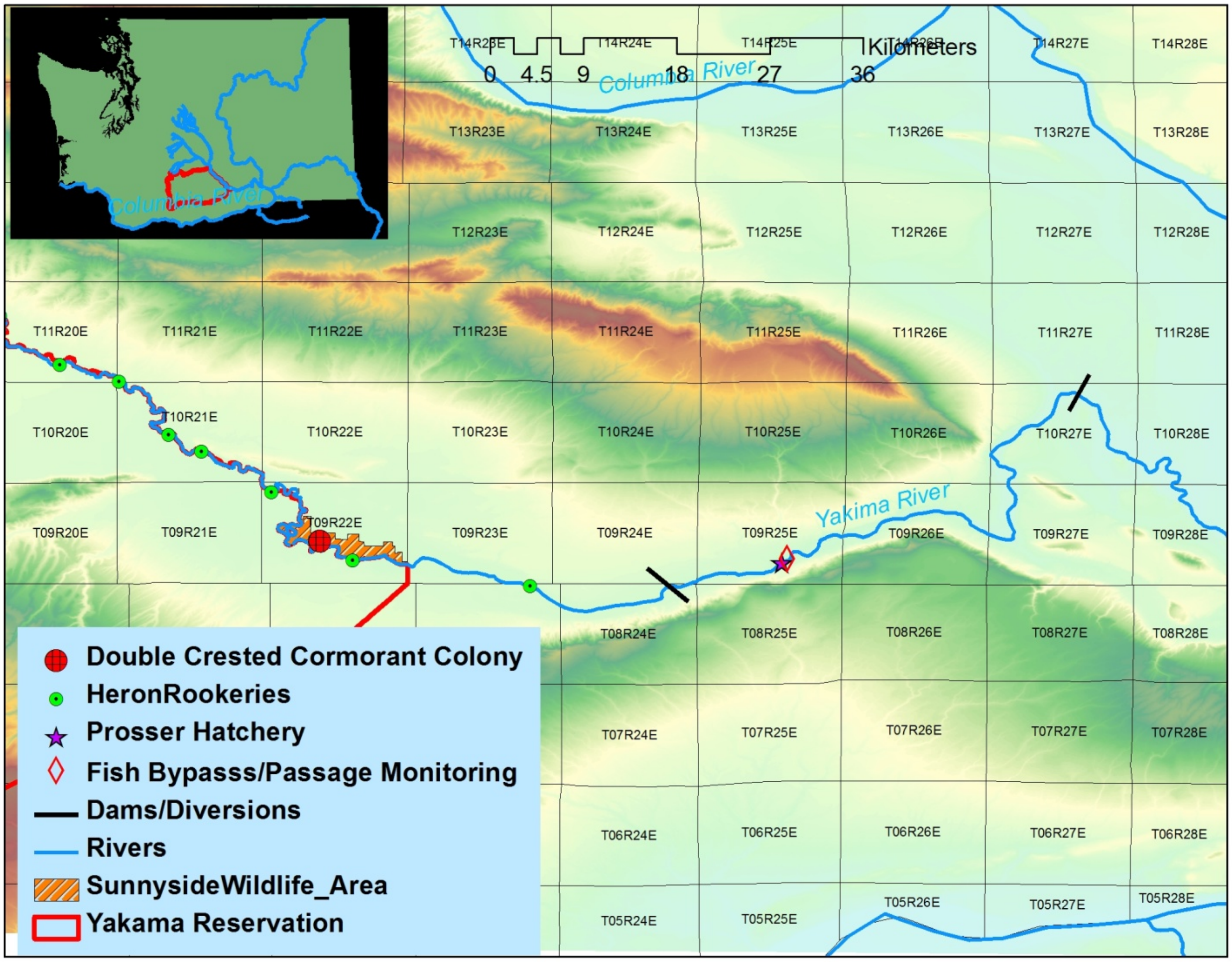


Figure 3. Double Crested Cormorant Colony

Lastly, the Great Blue Heron was the third most common piscivorous bird in the Yakima Basin, previously considered a less significant consumer of smolts because they are known to prey on a wide variety of aquatic and terrestrial species including frogs, crayfish and rodents. New PIT tag studies have shown the Great Blue heron may have a more significant impact to juvenile salmonids than previously believed.

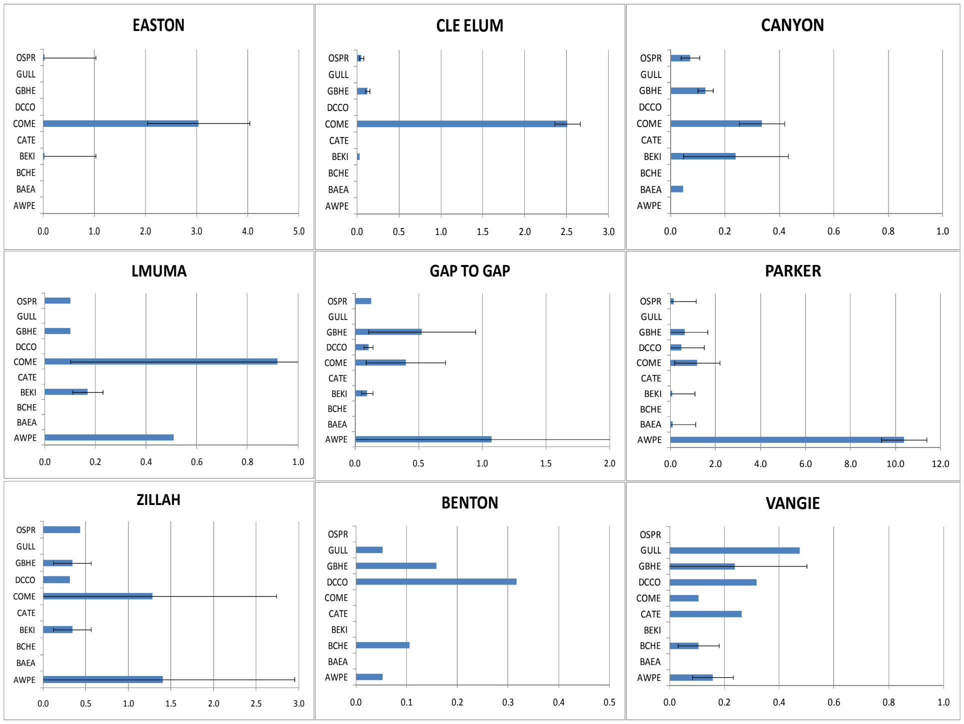


Figure 4. Spring bird abundance per kilometer shown with standard deviation error bars

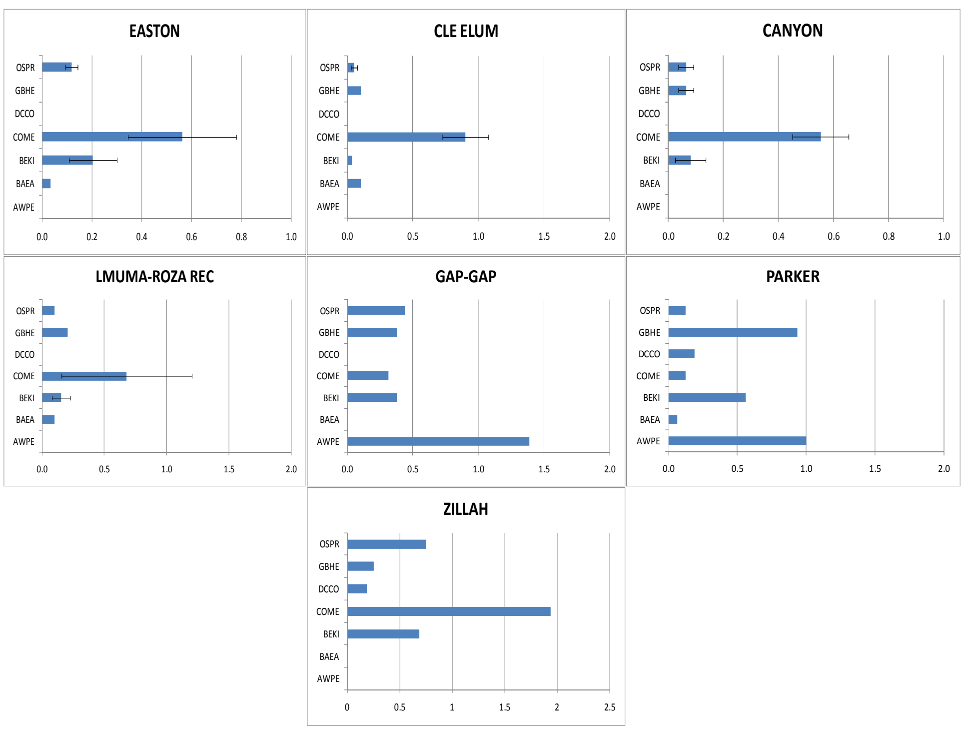


Figure 5. Summer bird abundance per kilometer shown with standard deviation error bars

Abundance for all bird species along with standard deviations is given for the spring (Figure 4) and the summer (Figure 5). These bird abundance show pelicans are found in high numbers in the spring in the Yakima from Selah to the lower reaches of the Yakima river. Pelican numbers a were not reduced in the summer in this the Wapato Reach as it was in 2009 as shown in Figure 5 numbers of the Parker and Gap to Gap reaches. Normally during the summer months Pelicans nesting at Badger Island, due greater foraging success at Chandler Fish Bypass and Wanawish Dam, are seen in the in the Lower Yakima River.

Total numbers of birds per reach are given by tables 3 & 4. Along the Yakima River and the Yakama reservation boundary it is notable that reaches of Parker and Zillah show the largest amount of piscivorous birds and the number in the reaches significantly increases between April and May.

REACH	REACH LENGTH (KM)	Date	SumOfTOTAL NUMBER	TotalNumberBirdsPerKm
BENTON	18.9	6/23/2010	13	0.69
CANYON	20.8	4/28/2010	12	0.58
CANYON	20.8	5/11/2010	19	0.91
CANYON	20.8	6/22/2010	18	0.87
CLE ELUM	28.3	5/12/2010	78	2.76
CLE ELUM	28.3	6/15/2010	75	2.65
EASTON	29.3	6/16/2010	91	3.11
GAP	15.85	4/19/2010	11	0.69
GAP	15.85	5/10/2010	13	0.82
GAP	15.85	6/24/2010	66	4.16
LMUMA	9.8	4/20/2010	25	2.55
LMUMA	9.8	5/11/2010	12	1.22
LMUMA	9.8	6/22/2010	2	0.2
PARKER	20.3	4/21/2010	234	11.53
PARKER	20.3	5/5/2010	223	10.99
PARKER	20.3	5/19/2010	332	16.35
VANGIE	18.9	4/22/2010	23	1.22
VANGIE	18.9	6/23/2010	24	1.27
ZILLAH	16	4/27/2010	20	1.25
ZILLAH	16	5/6/2010	100	6.25

Table 3. Spring total of piscivorous birds per km (shown by survey date)

REACH	REACH LENGTH (KM)	Date	SumOfTOTAL NUMBER	TotalNumberBirdsPerKm
CANYON	20.8	7/13/2010	3	0.144230769
CANYON	20.8	8/3/2010	19	0.913461538
CANYON	20.8	8/16/2010	14	0.673076923
CLE ELUM	28.3	7/19/2010	36	1.272084806
CLE ELUM	28.3	8/11/2010	25	0.883392226
EASTON	29.3	8/2/2010	19	0.648464164
EASTON	29.3	8/11/2010	34	1.160409556
GAP	15.85	8/9/2010	46	2.902208202
LMUMA	9.8	7/13/2010	10	1.020408163
LMUMA	9.8	8/3/2010	16	1.632653061
LMUMA	9.8	8/16/2010	1	0.102040816
ZILLAH	16	7/6/2010	48	3

Table 4. Summer total of piscivorous birds per km (shown by survey date)

Common Mergansers along River Reaches

Abundance of Common Merganser in 2010 showed the continuing trend of mergansers as the primary piscivorous bird in the upper Yakima River. Figure 6 reflects this pattern and depicts total merganser numbers by reaches in river order. This has been the common trend for Common Mergansers during the duration of YKFP's avian predation monitoring and evaluation (M&E) work.

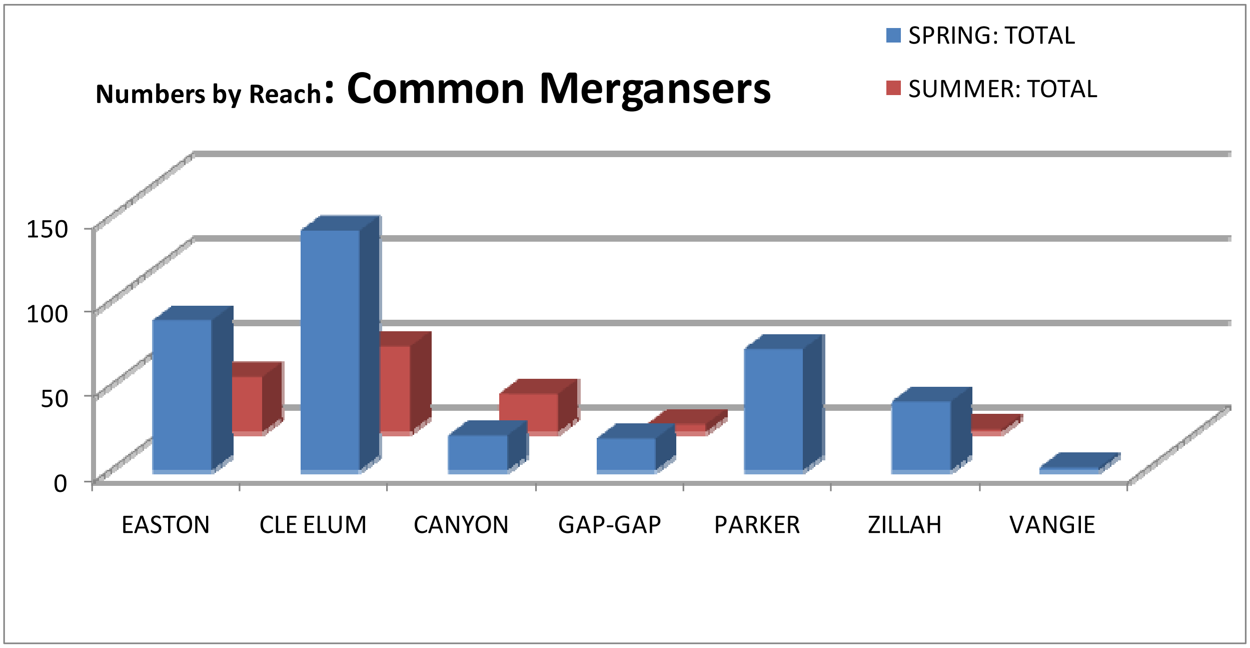


Figure 6. River reaches total number of surveyed COME for spring and summer of 2010.

A breeding pair of Common Mergansers

American White Pelicans along River Reaches

Pelicans were the most abundant avian piscivorous in the lower river in spring 2010, as in 2003-2006. Pelicans were common in the lower and middle river in spring.

Pelicans averaged over 10 birds per km at Parker in the spring. In 2006, pelicans averaged 2.6 birds per km at Parker, 1.5 birds per km in Zillah, 0.8 birds per km in Vangie, and 0.02 birds per km in Benton. Differences in Pelican numbers may between varying years points toward river CFS levels affecting Pelican numbers (shown in Aerial Surveys Data). The birds per km number may be misleading as Pelicans could total anywhere between 250 to 300 birds on a given day in Parker and Zillah in the Spring during 2009 yet river surveys during 2010 show high numbers only in the Parker reach for 2010 (Figure 7).

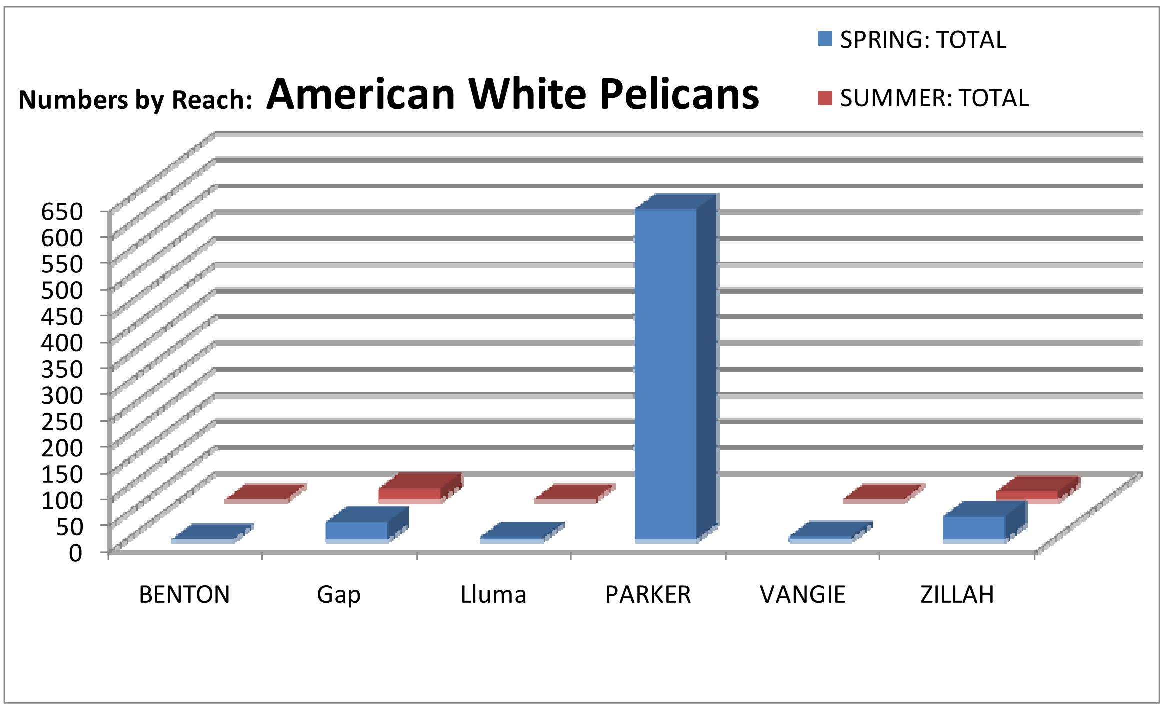


Figure 7. River reaches total number of surveyed American White Pelicans for spring and summer of 2010.

Great Blue Heron along River Reaches

On average, the number of Great Blue Herons in the lower river remained low and maintained similar numbers of 2008, when they averaged 0.5 birds/km, similar to the average of 0.8 birds/km in 2006. Heron numbers are more prevalent in along the Parker and Zillah reaches and it is possible to see up to 40 birds on a float in the Parker reach and 15 in the Zillah reach (Figure 8). This is to be expected as most Heron rookeries of the Yakima Basin are located along this reach.

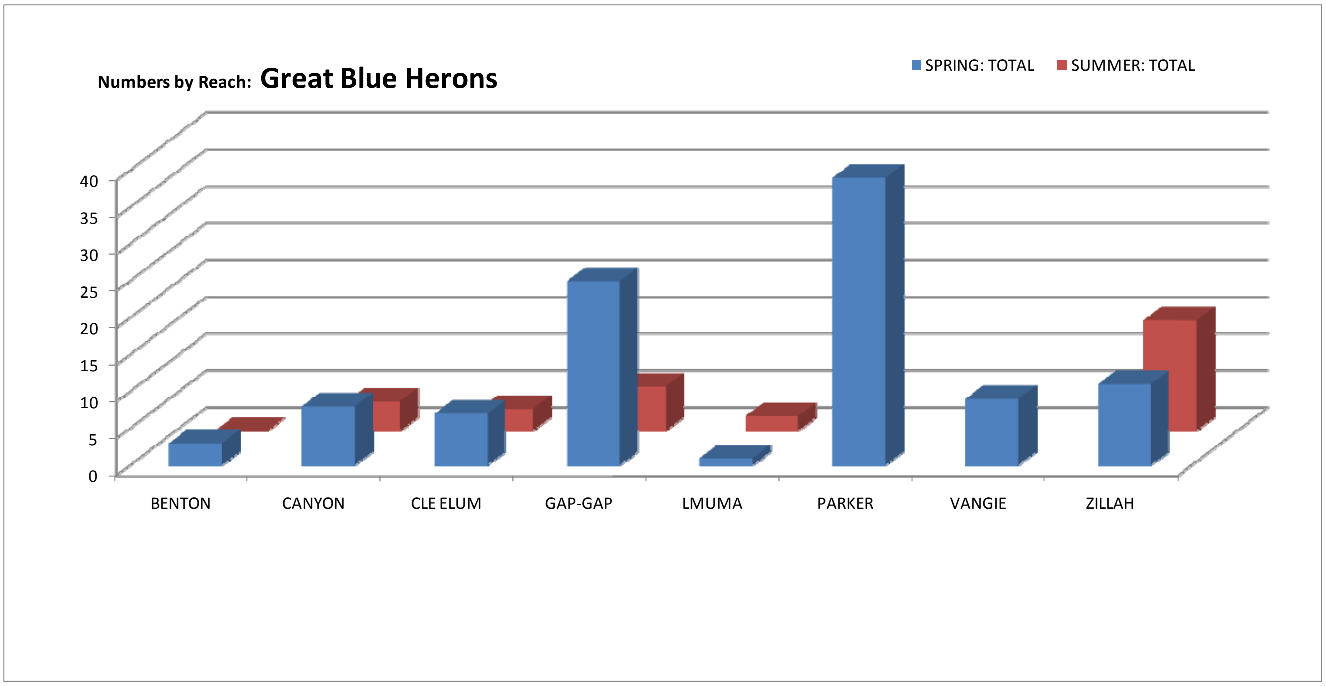


Figure 8. River reaches total number of surveyed Great Blue Herons for spring and summer of 2010.

Smolts Consumed at Acclimation Sites

At the three Spring Chinook, one Summer Chinook and five Coho salmon acclimation sites in the upper Yakima River and its tributaries piscivorous bird surveys were conducted over a 3-5 month period in the winter and spring of 2010. The most common birds preying on smolts were the Common Merganser, Great Blue Heron, Belted Kingfisher, Bald Eagle and Osprey. If it is assumed that birds feeding in acclimation ponds are consuming only smolts on bird days on site, an average of consumption can be calculated using the; average number of birds at each site, daily energy requirements of the birds, and the average size of smolts. Smolt weights were averaged combination of in-basin and out-basin stocks for Coho acclimation sites.

For the Spring Chinook sites (Clark Flat, Easton and Jack Creek), it was estimated that these bird species together consumed 519 smolts at Clark Flat, 1,704 smolts at Easton and 55 smolts at Jack Creek. In 2009, Bald Eagle, Belted Kingfishers, Common Merganser and Great Blue Herons consumed 732 smolts at Clark Flat, 1708 smolts at Easton and 320 smolts and Jack Creek.
Bald Eagle, Belted Kingfishers, Common Merganser and Great Blue Herons were the most common birds preying on smolts at the Summer Chinook site (Stiles). It is estimated that these bird species together consumed 9,039 smolts.

At the Coho acclimation sites (Boone, Easton Pond, Holmes, Lost Creek and Stiles), the most common birds preying on smolts were Bald Eagle, Belted Kingfishers, Common Merganser and Great Blue Herons. It is estimated that these bird species together consumed 44,836 smolts at Boone, 5,251 smolts at Holmes, 29,113 smolts at Easton Pond, 737 smolts at Lost Creek and 6,777 smolts at Stiles. In 2009, Belted Kingfishers, Common Merganser, Great Blue Heron, Bald Eagle, Hooded Merganser and Ospreys consumed 28,470 smolts at Boone, 2,131 smolts at Holmes, 10,922 smolts at Easton Pond, 1,017 smolts at Lost Creek and 2,485 smolts at Stiles.

Aerial Surveys

Aerial Surveys in 2010 were conducted on April 26 for the spring survey and August 5 for the summer survey. American White Pelicans were the dominant species for aerial surveys. Bias in counting piscivorous birds in aerial surveys will be towards Pelicans as they are large and white making them easier to count from the air. Pelicans congregate in large numbers (evidenced from river drift surveys) and are the dominant avian fish consumers of the Yakima River Basin. Based on current data Pelicans are found in higher numbers on the Yakima River during years of low water flow as demonstrated by 2005 numbers during extremely low water levels (Figure 9). This may be due to numbers of perching locations of exposed rock, when flows are high lower numbers of rocks are exposed resulting in lower numbers of perches and loafing sites. Numbers may also relate to foraging success as higher water may allow smolts to migrate at a depth which reduces Pelicans foraging success.

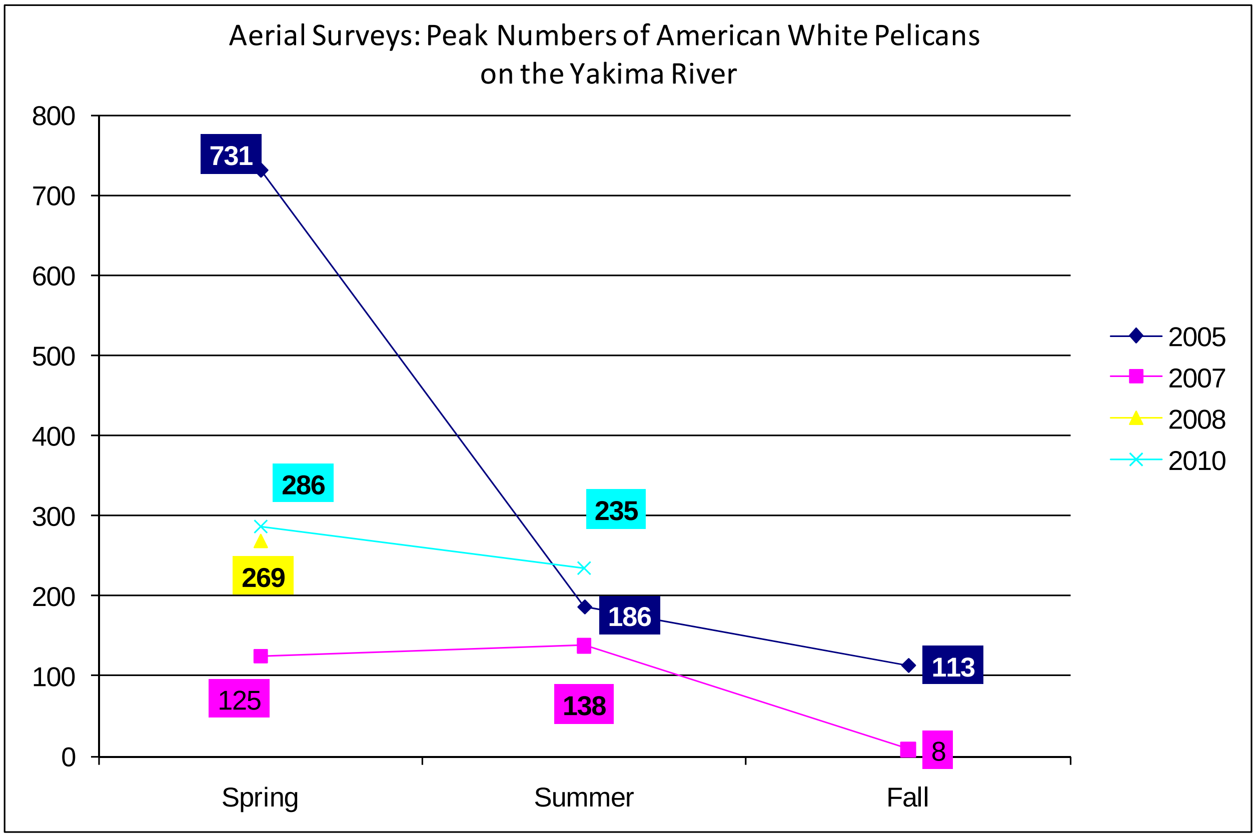


Figure 9. Aerial Surveys: American White Pelican numbers for the Yakima River

PIT Tag Surveys

In 2010 PIT tag surveys yielded a total of 21,455 distinct tags over all survey years this is up from 2009 number of 14,350. These were discovered within the 14 survey sites (Figure16). Of this total number, 20,610 of the PIT tags were from Yakama Nation juvenile salmonid tagged fish. Species of fish tagged and surveyed as mortalities for 2010 are represented by Table 5 (includes fish tagged by other organizations which were found during surveys).

YKFP Predation Study: Total PIT tag Numbers For 2010

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	<>	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Orphan tag		20	20														
Chinook	Fall	4295				9	10	13	32	153	341	1244	1008	1136	128	221	
Chinook	Spring	8641			2	195	421	244	368	498	1056	893	1359	1608	1403	594	
Chinook	Summer	2487									1			1	1905	580	
Chinook	Unknown	3							1	1					1		
Coho	Fall	697		1	2	142	183	126	243								
Coho	Unknown	4279								210	738	449	702	1131	641	405	3
Sockeye	Summer	1													1		
Steelhead	N/A	1														1	
Steelhead	Resident	9											2	3	4		
Steelhead	Summer	288						9	23	67	54	8	17	31	47	32	
Steelhead	Unknown	5								1						4	
Totals		20726	20	1	4	346	614	392	667	930	2190	2594	3088	3910	4130	1837	3

Table 5. PIT tags surveyed at all YKFP survey sites shown by Species and Migration Year.

All PIT tags possess a specific file in which their entire released group is placed. Files will possess information about species, release location, etc. By accessing a PIT tags file you can determine the total of all PIT tagged fish released for that specific file. For the 2010 PIT tags surveyed there are 1293 YINN juvenile salmonid files associated. These associated files contained 1,237,133 fish released since 1999 (overall there is close to 1.5 million of these tagged fish). The total number of PIT tags surveyed is 1.67% of these associated files. The percentage jumps to near 2% if you include Badger Island PIT tags of YINN origin.

Avian Rookeries PIT tags

Avian Rookeries have produced large numbers of PIT tags over the survey years. Great Blue Herons are the primary species inhabiting these rookeries with one inhabited by Double Crested Cormorant.

YKFP Predation Study: Rookeries PIT tag Numbers For 2010 - All Rookeries

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	<>	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
		7	7													
Chinook	Fall	1843				2	2	12	13	52	163	757	301	424	59	58
Chinook	Spring	4813			1	116	283	170	234	340	572	563	797	640	840	257
Chinook	Summer	392									1			1	165	225
Chinook	Unknown	2								1					1	
Coho	Fall	571		1	2	117	162	104	185							
Coho	Unknown	2857								185	592	313	394	779	372	222
Sockeye	Summer	1													1	
Steelhead	0	1														1
Steelhead	Resident	8											1	3	4	
Steelhead	Summer	259						7	22	66	45	7	13	23	44	32
Steelhead	Unknown	2								1						1
Totals		10756	7	1	3	235	447	293	454	645	1373	1640	1506	1870	1486	796

Table 6. Avian Rookeries PIT tags shown by Species and Migration Year (YINN tags).

Irrigation Diversion Fish Screening PIT tags

Irrigation Diversions and analogous fish screening facilities were produced 10,173 surveyed PIT tags. Yakama Nation Juvenile PIT tags which produced a tagging detail are shown in Table 7 and numbered 9894. A large number of Summer Chinook PIT tags, in relation to other species and total years and numbers of PIT tags released, were discovered at these irrigation sites.

YKFP Predation Study: Diversions PIT tag Numbers For 2010 - All Diversions

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Chinook	***Fall***	2446		**7**	**8**	**1**	**19**	**100**	**175**	**486**	**706**	**712**	**69**	**163**	
Chinook	**Spring**	3792	1	78	138	69	134	156	477	319	552	968	563	337	
Chinook	**Summer**	2095											1740	355	
Coho	**Fall**	124		24	20	22	58								
Coho	**Unknown**	1414						25	144	132	307	351	269	183	3
Steelhead	**Resident**	1									1				
Steelhead	**Summer**	19				2	1		3	1	2	7	3		
Steelhead	**Unknown**	3												3	
Totals		9894	1	109	166	94	212	281	799	938	1568	2038	2644	1041	3

Table 7. PIT tags: Irrigation Fish Screening Facilities PIT tags shown by Species and Migration Year (YINN tags).

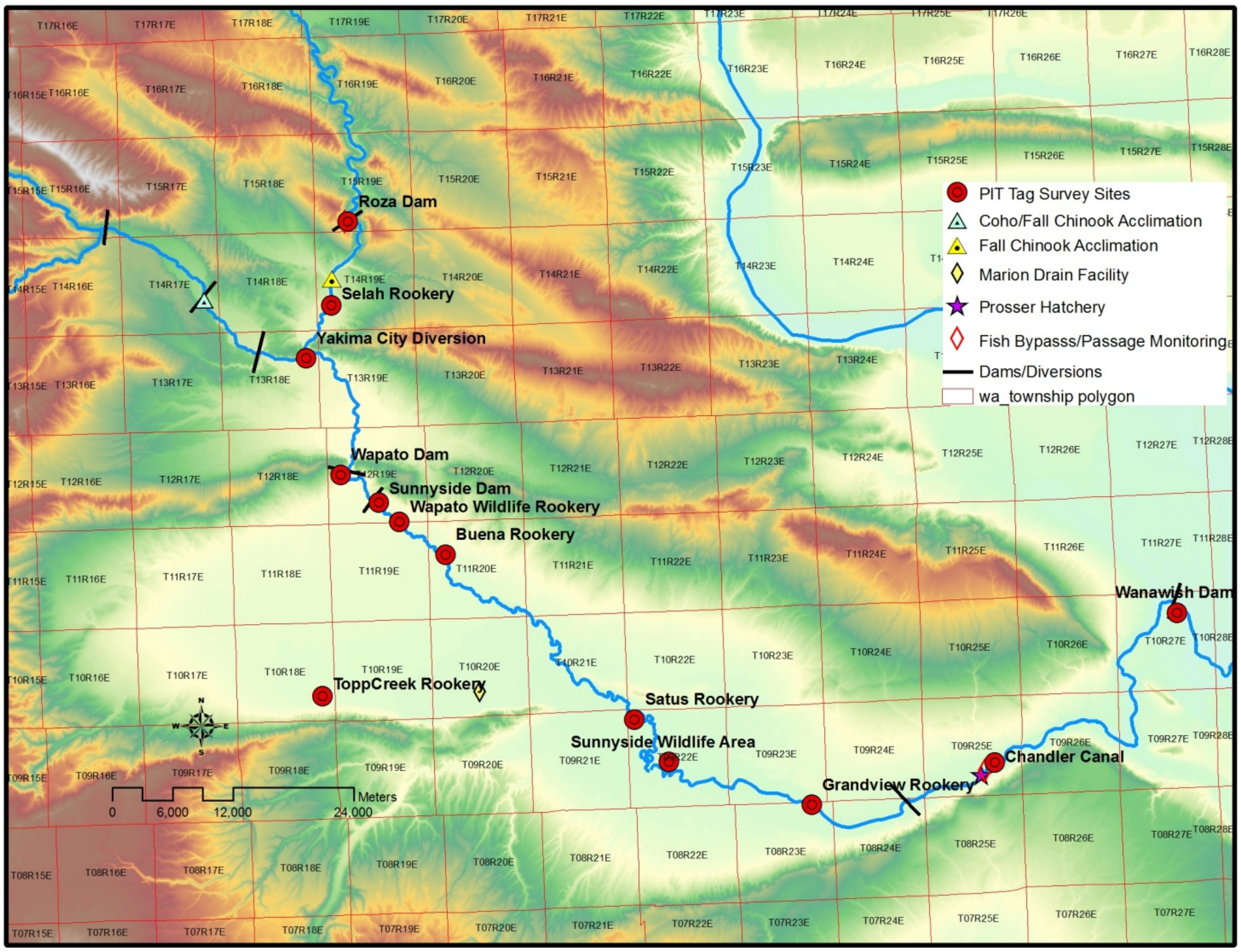


Figure 10. YKFP PIT Tag Survey Sites

Selah Heron Rookery

A total of 2436 PIT tags returned a tagging detail from the Selah rookery (Table 5). PIT tags are sorted by release year and species and showed significant correlation to flows varying by year. The foraging source of these tags is believed to be primarily gathered from the Yakima River at section between Roza Dam to the confluence of the Naches River (Figure 17).

YKFP Predation Study: Total PIT tag Numbers For 2010 - Selah Rookery														
PIT Tags Sorted by Migration Year														
species	***run***	***Total PIT Tag Numbers***	**<>**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
		3	3											
Chinook	**Fall**	258							6	151	16	85		
Chinook	**Spring**	1252		41	33	71	44	151	223	168	66	208	185	62
Chinook	**Summer**	43											14	29
Coho	**Fall**	89		27	23	21	18							
Coho	**Unknown**	784						62	240	87	66	176	95	58
Steelhead		4										1	3	
Steelhead	**0**	1												1
Steelhead	**Summer**	2						1				1		
Totals		2436		68	56	92	62	214	469	406	148	471	297	150

Table 8. Selah Rookery PIT tag totals by species and year released.

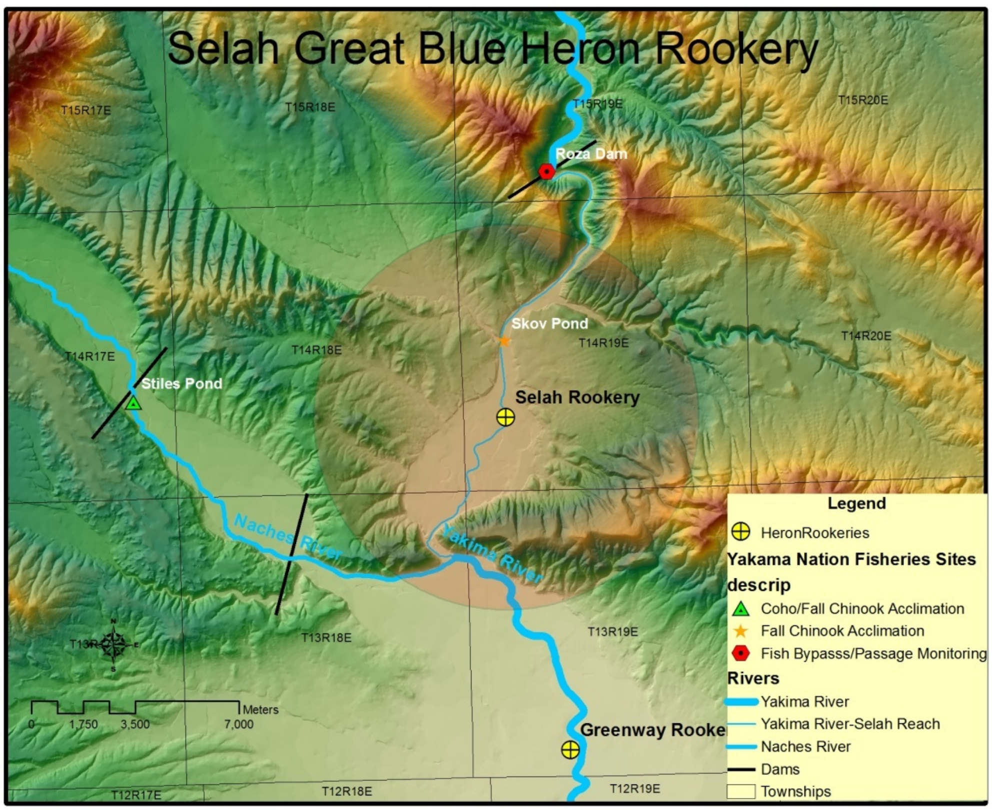


Figure 11. Selah Great Blue Heron Rookery

Analysis of the data for this research project will attempt to answer the primary question; what effects do water flows have on the rate of Great Blue Heron predation on anadromous salmonids for the Selah Heron Rookery. For this analysis, variables of river flow (CFS) by date, PIT tag fish release timing, and species of fish will be analyzed by a comparing variable value across data source years. Data from the rookery varied with PIT tag sources over a time period of 2000 to present. Water flow recorded by the Bureau of Reclamation below Roza dam, provided baseline data to be used for comparison with PIT tags (BOR 2009).

Significant factors based on the life history and migration patterns of anadromous salmonid show a direct link to flow. Freshets (spikes in CFS) may be a main determining factor for migration and the number of freshets within migration period may directly affect predation. PIT tag numbers may be associated with Smolt Flushing Flows, which have been determined to be 1000 CFS for a period of three days. Flushing flow requirements for out-migrating smolts were agreed upon by biologists of the Yakama Nation, BOR, and WDFW under the SOAC group. Table 6 shows number of flushing flows within the Roza Reach by year and month. Red text within table 6 highlights 2005 low numbers of flushing flows and large numbers of Spring Chinook PIT tags (Table 5) and 2007 high numbers of flushing flows and low numbers of Spring Chinook PIT tags (Table 5).

Number of Flushing Flows									
	2009		2008		2007		2006		2005
March	0	March	0	March	0	March		March	2
April	12	April	4	April	3	April	10	April	3
May	10	May	10	May	10	May	5	May	1
June	6	June	3	June	3	June	5	June	8
Total	**16**	Total	**15**	Total	**16**	Total	**20**	Total	**14**
Average QD	1590		1188		1988		1240		861

Table 9. Number of Flushing Flows for the Roza Reach

Yakima River water flow (CFS) below Roza dam for years of 2005 and 2008, combined with PIT tags found for the corresponding years is shown in figure 18. In an extreme low flow year of 2005, and extreme low flow into late April, a high amount of PIT tags with release year 2005 were found within the Selah Rookery. With high flows in 2008, consistently above 1000 CFS by the third week of March, only 80 tags of release year 2008 were found at the Selah rookery.

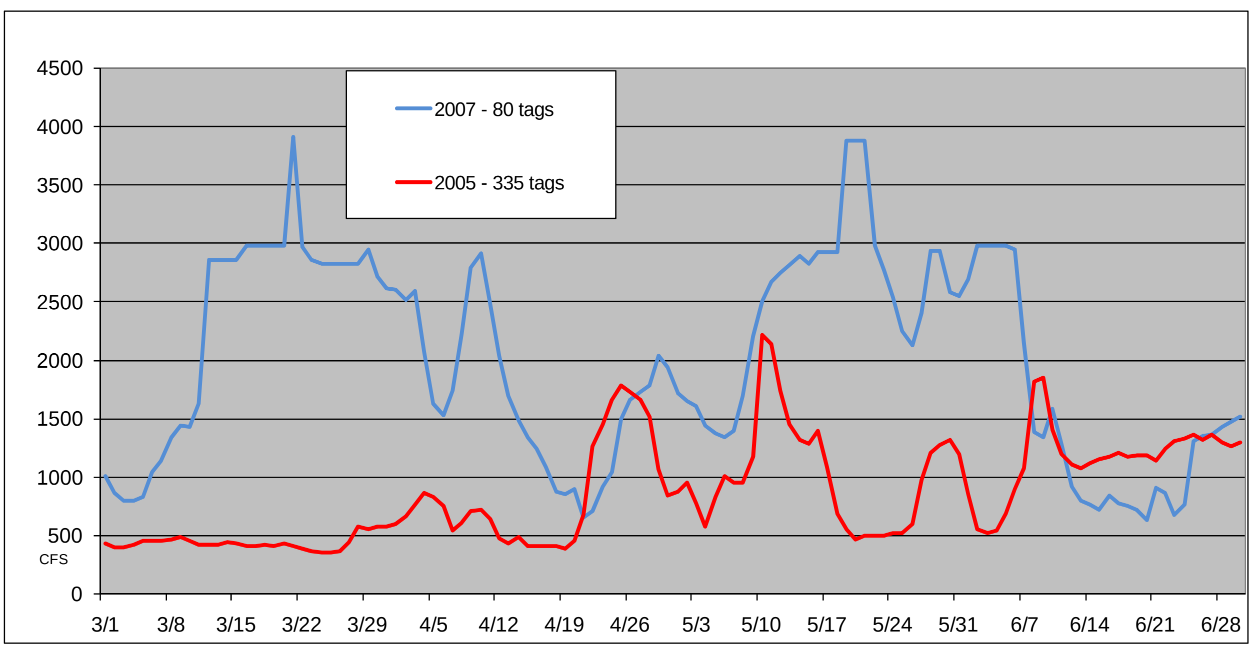


Figure 12. Yakima River water flow (CFS) below Roza dam for years of 2005 and 2008. Shown with number of tags found at the Selah Rookery for corresponding years.

Analysis of Species Composition within the Selah rookery found that near 50 percent of the tags belonged to Spring Chinook salmon smolts (Figure 19). This along value of the species has focused the Selah Rookery Study on Spring Chinook Salmon. Analysis of Spring Chinook tag data is added by the fact that; Hatchery smolts of Spring Chinook are released in a consistent ratio of PIT tagged fish release and total hatchery smolts released. These Spring Chinook from Cle Elum hatchery have been released in this fashion since 2001.

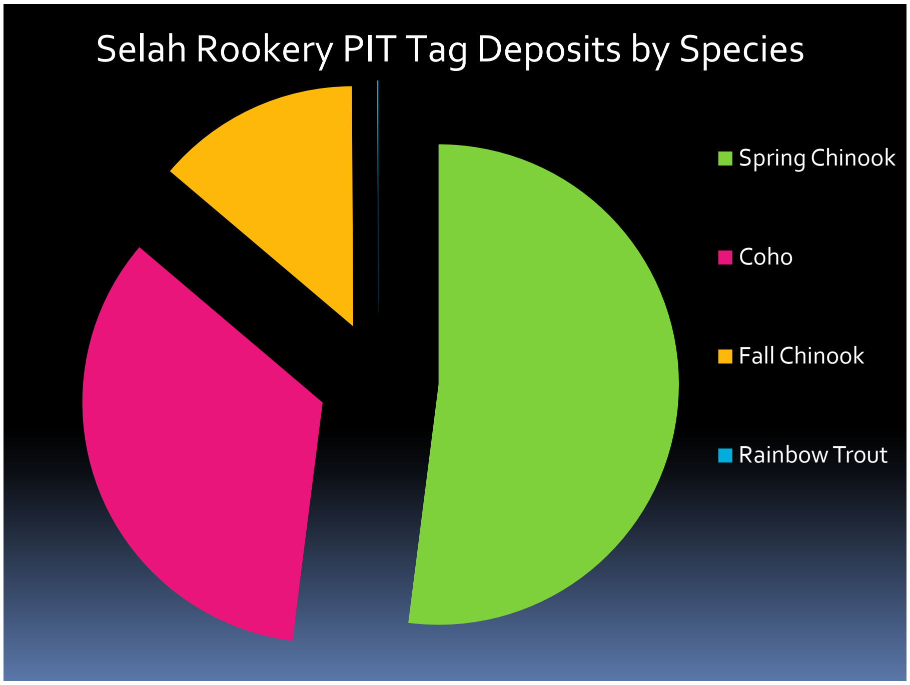


Figure 13. Selah Heron Rookery PIT tags pie chart of species composition.

Overall Spring Chinook Releases by Yakama Nation were high and PIT tag files which correspond to PIT tags surveyed contained an overall 38,527 of released tags from 2000 to 2010. Of these overall releases 1,262 were found in Selah Rookery. Percentages of total fish PIT tagged and the PIT tags found during surveys is given in Table 10.

Selah Rookery PIT tags by Total of PIT tags Released (Corresponding Files)			
	PIT tags Surveyed	*Total PIT tags Released*	*% of File*
Total	1262	426708	0.30%
2000	42	35028	0.12%
2001	33	33247	0.10%
2002	73	39773	0.18%
2003	45	31755	0.14%
2004	151	42258	0.36%
2005	224	41580	0.54%
2006	169	39794	0.42%
2007	66	38481	0.17%
2008	211	43903	0.48%
2009	186	42362	0.44%
2010	62	38527	0.16%

Table 10. Spring Chinook PIT tags by Release Year and their corresponding total released PIT tags by File for the Selah Rookery surveys

PIT Survey Sites Data

Pit tag surveys in 2008 were carried out in 5 rookeries other than Selah rookery. Rookery surveys were done in a limited basis to test whether they would yield PIT tags. Surveys were also carried out in depth at 3 Dams/Diversion sites. Tables 7-11 show rookeries surveyed PIT tags by release year and species. Tables 12-17 show Dams/Diversions by site and area surveyed and PIT tags by release year and species. Figure 21 shows PIT tag survey site locations

Rookeries PIT tags By Sites

Barker Ranch Rookery

The Barker Ranch Great Blue Heron Rookery was added in 2009 and 2010 to the PIT tag surveys. The Rookery does not appear to be currently active (personal communication Barker Ranch Staff).

YKFP Predation Study: Total PIT tag Numbers For 2010 - Barker Ranch Rookery

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	<>	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2009	2010	2011
		2	2														
Chinook	**Fall**	177		2		10	5	15	36	58	2	19	12	18	181	221	
Chinook	**Spring**	150		4	21	10	17	15	39	15	15	7	5	2	1570	594	
Chinook	**Summer**	1							1						2106	580	
Coho	**Fall**	23		2	14	2	5								1		
Coho	**Unknown**	104						9	59	6	7	11	11	1			
Steelhead	**Summer**	58					16	29	10		1	2			722	405	3
Totals		515		8	35	22	43	68	145	79	25	39	28	21	4580	1800	

Table 11. Pit tag numbers by species surveyed in Barker Ranch Rookery

Grandview Rookery

YKFP Predation Study: Total PIT tag Numbers For 2010 - Grandview Rookery

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chinook	**Fall**	98		1	1	4	7	8	1	34	26	8	8
Chinook	**Spring**	298	3	15	9	33	18	15	29	54	48	49	25
Chinook	**Summer**	32										26	6
Coho	**Fall**	29		10	6	13							
Coho	**Unknown**	163					9	7	8	63	31	25	20
Steelhead	**Summer**	6						4			1	1	
Steelhead	**Unknown**	1											1
Totals		627		26	16	50	34	34	38	151	106	109	60

Table 12. Pit tag numbers by species surveyed in Grandview Rookery

Niemeyer Rookery

YKFP Predation Study: Total PIT tag Numbers For 2010 - Niemeyer Rookery

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	<>	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
		1	1											
Chinook	**Fall**	142			1		4	15	49	4	43	16	5	5
Chinook	**Spring**	171		4	8	5	15	10	26	15	23	22	34	9
Chinook	**Summer**	1												1
Coho	**Fall**	15		4	6	1	4							
Coho	**Unknown**	146						12	30	13	10	52	12	17
Steelhead	**Resident**	1											1	
Steelhead	**Summer**	53				5	3	20	8	2	2	1	11	1
Totals		530		8	15	11	26	57	113	34	78	91	63	33

Table 13. Pit tag numbers by species surveyed in Niemeyer Rookery

Sunnyside Rookery

YKFP Predation Study: Total PIT tag Numbers For 2010 - Sunnyside Rookery

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chinook	Fall	352			1		12	12	31	71	173	31	21
Chinook	Spring	1607	1	2	1	8	52	58	232	454	237	466	96
Chinook	Summer	6									1	2	3
Chinook	Unknown	1										1	
Coho	Fall	5	2	1		2							
Coho	Unknown	436					10	46	68	47	110	131	24
Sockeye	Summer	1										1	
Steelhead		1									1		
Steelhead	Summer	23					4	2	1	1	5	8	2
Totals		2432		3	2	10	78	118	332	573	527	640	146

Table 14. tag numbers by year/species surveyed in Toppenish Creek Rookery

Toppenish Creek Rookery

YKFP Predation Study: Total PIT tag Numbers For 2010 - Toppenish Creek Rookery

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chinook	Spring	2			2						
Coho	Unknown	261							261		
Steelhead	Summer	89	1	2	4	8	3	8	13	22	28
Totals		352		2	6	8	3	8	274	22	28

Table 15. Pit tag numbers by year/species surveyed in Toppenish Creek Rookery

Out of these 260 PIT tags which returned a tagging detail 215 belonged to one tag file (Appendix F). These 215 were Coho released from a net pen in Cle Elum Lake in 2008 and it is thought that these Coho were late migrators (Tags were not detected at Cle Elum passage detector).

Wapato Wildlife Rookery

YKFP Predation Study: Total PIT tag Numbers For 2010 - Wapato Rookery

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	<>	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
species	run	Total PIT Tag Numbers	<>	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
		1	1														
Chinook	Fall	612								2	51	331	129	93		6	
Chinook	Spring	1120			1	49	192	72	112	83	156	82	146	92	72	63	
Chinook	Summer	309													123	186	
Coho	Fall	384		1	2	75	100	72	134								
Coho	Unknown	848								74	152	112	190	127	91	102	3
Steelhead		2											1	1			
Steelhead	Summer	13						1	1	4	6					1	
Totals		3289		1999	2002	2124	2293	2147	2250	2167	2370	2531	2473	2321	2295	2368	3

Table 16. Pit tag numbers by year/species surveyed in Wapato Wildlife Rookery

Irrigation Diversions PIT Tags by Site

Chandler

YKFP Predation Study: Total PIT tag Numbers For 2010 - Chandler														
PIT Tags Sorted by Migration Year														
species	*run*	*Total PIT tag Numbers*	<>	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Orphan Tags		4	4											
Chinook	Fall	1029		2	5		8	44	49	156	313	280	58	114
Chinook	Spring	1456		16	9	5	28	33	44	128	286	518	237	152
Chinook	Summer	818											664	154
Chinook	Unknown	1					1							
Coho	Fall	6			3		3							
Coho	Unknown	368						1	14	19	113	112	88	21
Steelhead	Summer	5				1				1		3		
Steelhead	Unknown	3												3
Totals		3690		18	17	6	40	78	107	304	712	913	1047	444

Table 17. Pit tag numbers by year/species surveyed Chandler Irrigation Diversion Fish Screening Facility

[redacted]

Table 18. Pit tag numbers by year/species surveyed Chandler Canal Outlet Pipe

Sunnyside Diversion

YKFP Predation Study: Total PIT tag Numbers For 2010 - Sunnyside Diversion																	
PIT Tags Sorted by Migration Year																	
species	*run*	*Total PIT Tag Numbers*	<>	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2011
		1	1														
Chinook	Fall	536							2	40	182	120	143		49		
Chinook	Spring	1393		1	51	81	52	83	90	226	142	167	186	189	125		
Chinook	Summer	751												588	163		
Coho	Fall	84			21	9	19	35									
Coho	Unknown	566							17	57	79	109	133	87	83	1	
Steelhead		1										1					3
Steelhead	Summer	3								2		1					
Totals		3335		1	72	90	71	118	109	325	403	398	462	864	420	1	

Table 19. Pit tag numbers by year/species surveyed Sunnyside Diversion

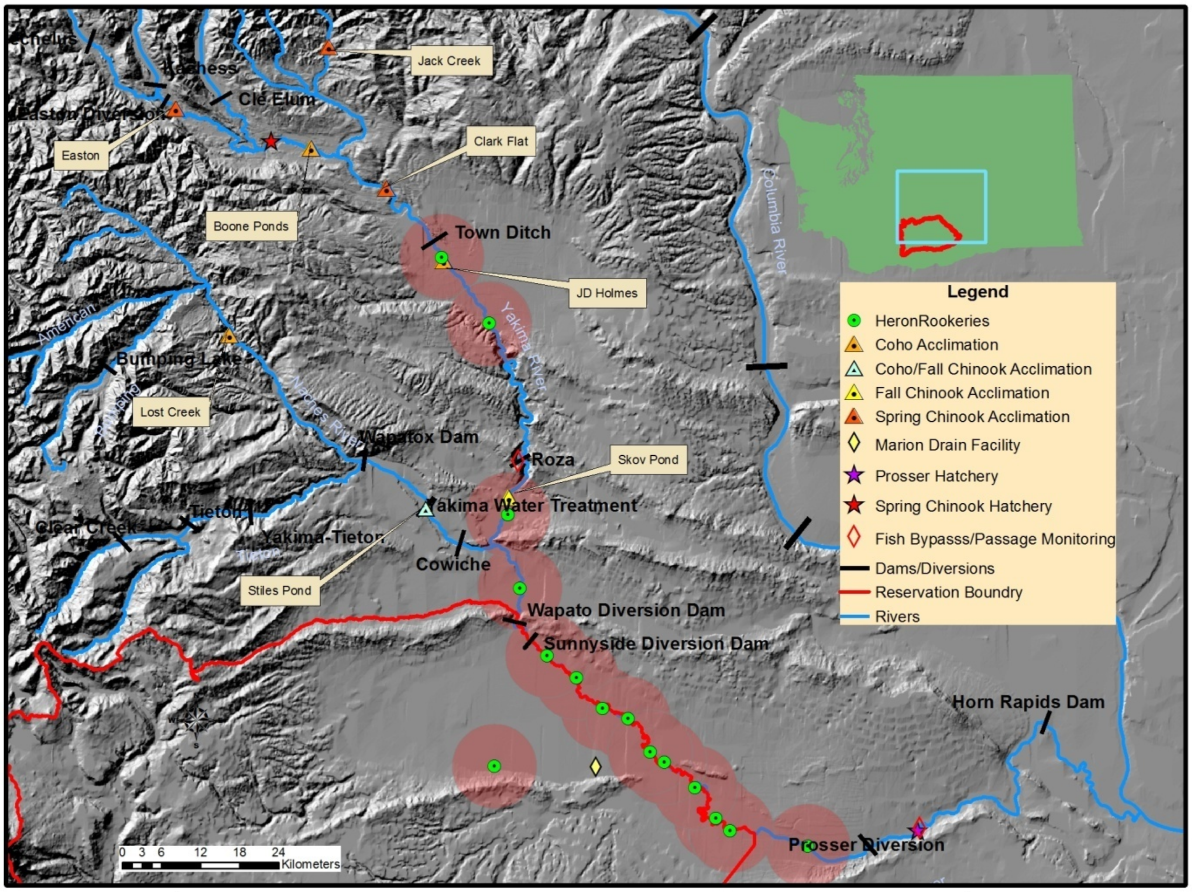
Wapato Diversion

YKFP Predation Study: Total PIT tag Numbers For 2010 - Wapato Diversion														
PIT Tags Sorted by Migration Year														
species	*run*	*Total PIT Tag Numbers*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Chinook	Fall	362						47	117	82	116			
Chinook	Spring	649	6	43	7	11	20	176	25	34	177	90	60	
Chinook	Summer	483										445	38	
Coho	Fall	26	2	5	1	18								
Coho	Unknown	384					6	65	31	42	78	81	79	2
Steelhead	Summer	3						1			2			
Totals		1907	2	48	8	29	26	289	173	158	373	616	177	2

Table 20. Pit tag numbers by year/species surveyed at Wapato Irrigation Diversion

Yakima Basin Rookeries Surveyed

In Between 2008 and 2010 Great Blue Herons Rookeries in the Yakima Basin were surveyed to determine populations and yearly trends. Figure 20 gives the locations of these 16 rookeries. Out of the total number of rookeries surveyed and mapped 13 were active with nesting Great Blue Herons. A nest count found that within these 16 rookeries there are approximately 395 Nests.



Heron Rookeries are outlined with a 6.5 km transparent buffer representing an upper mean foraging area.

Figure 20. Map of Yakima Basin Great Blue Heron Rookeries.

The Wapato Wildlife Rookery and the Holmes rookery were selected for tag detection efficiencies as each displays habitat characteristics of Rookeries within their give Stratum. Many of these rookeries have been scanned for PIT tags, and found to contain many of these tags.

Badger Island PIT tags

The American White Pelican Colony on Badger Island in the Columbia River is located below the Confluence of the Yakima River. It is also within foraging distance to two prime Pelican foraging locations on the Yakima River; Wanawish Dam and the Chandler Fish Bypass outlet pipe.
PIT tags surveyed on the bottom of the Yakima River below the outlet pipe are most likely deposited by the areas primary predator the American White Pelican. These tags are shown in Table 18.

PIT tags surveyed on Badger Island are readily available through PTAGIS courtesy of Pacific States Marine Fisheries Commission. The Island is primarily inhabited by the American White Pelican and PIT tags are linked to the birds. A total of 7,299 PIT tags have been surveyed, and loaded onto

PTAGIS, from the Badger Island location. Of these tags approximately 55% are from Yakama Nation juvenile salmonids, a number of 3,261 PIT tags (Table 20).

PSMFC: Total PIT tag Numbers For 2010 - Badger Island YINN Fish

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chinook	***Fall***	1216			**7**	**5**	**4**	**40**	**54**	**636**	**57**	**413**
Chinook	**Spring**	831	1		3	3	11	20	24	306	178	285
Chinook	**Summer**	630									217	413
Coho	**Fall**	2		1	1							
Coho	**Unknown**	564				3	5	16	30	200	104	206
Steelhead	**Resident**	2									2	
Steelhead	**Summer**	15			1			1	3	5		5
Steelhead	**Unknown**	1										1
Totals		3261	1	1	12	11	20	77	111	1147	558	1323

Table 21. Badger Island PIT tags YINN fish by species and migration year

CONCLUSIONS

Gull numbers remain low in the Yakima River Basin and the focus of future studies have shifted towards; Pelican numbers and diet, management of extreme numbers of piscivorous birds in given areas, and surveys of PIT tags where mortality can be linked to predation.

Pelican numbers remain a concern as in previous years. Aerial surveys in 2010 showed that pelican numbers peaked at near 286 birds in the Yakima Basin this year down from highs of 731 birds in 2005 and higher than 2007 peak at 138. Gulls were only common in one reach in the lower river. Mergansers on their breeding grounds in the upper and middle Yakima River have not shown a numeric response to hatchery supplementation of Spring Chinook and Coho salmon smolts yet remain a concern as they are known to congregate in large numbers below Roza Dam.

Pelican numbers at Chandler were only consistently high after smolt passage was largely complete and flows returned to a forgeable level. When observed feeding at Chandler, pelicans have frequently consumed non-salmonid species, including chiselmouth, sucker and pikeminnow exiting the pipe. Most of these non-salmonid fish taken were significantly larger than the average size of salmon smolts. High numbers of pelicans in Yakima Canyon in spring appeared to correlate with sucker runs. PIT tags at discovered at the Pelican Colony at Badger Island show Pelicans are taking a high number of salmonids. Badger Island PIT tags were made up of 55% Yakama Nation Juvenile Salmonids with a high number being the very small Fall and Summer Chinook fish.

The greater the amount of water that passes over Prosser and Horn Rapids Dams during peak smolt out-migration periods, the lesser the impact of bird predation on smolt survival. The Chandler Bypass outfall pipe makes fish of all species vulnerable to predation at low water, as the fish are disoriented and upwelling at right angles to the current. A simple reconfiguring of the outfall could largely eliminate smolt vulnerability at Chandler. The presence of large dead and disabled fish exiting from the bypass pipe may attract avian predators to the site. PIT tag detection at the Chandler outlet pipein 2008 did show high mortality for both juvenile and adult salmonids

PIT tag surveys in 2010 proved very productive as over 21,455 tags were discovered in the Yakima Basin. Tags detected show a source of mortality for Yakima River juvenile salmonids as 20,610 of these tags were from Yakama Nation juvenile salmonids. Predation by Herons shows correlation with flow, not surprising as high flow eliminates opportunity for wading bird foraging in many parts of the river. Conversely low flow creates foraging opportunities for Herons.

Plans for the 2011 field season include continued monitoring of river reaches and at hotspots with a focus on Pelican foraging. Heron rookeries and cormorant nesting colonies will continue to be surveyed. PIT tags found at pelican, heron nesting and roosting sites will be used to assign smolt predation estimates to specific bird species.

PIT tag analysis will continue to develop and new sites will be added to surveys. Detection efficiencies will be conducted in 3 diverse rookeries to assess a number of undetected tags.
PIT tags will be assessed by extrapolating a wild component utilizing salmon red data and juvenile fish passage facilities. Temporal trends of predation will be tested by attempting to simulate smolt river travel through river flows and acclimation site detection. Work towards developing a PIT tag array will begin in an attempt to gain real time PIT tag deposition.

Management Options will be assessed by looking at: flow bumps during smolt migration, improving fish passage, earlier smolt releases, acclimation site placement/attributes, developing Pelican diet studies, testing Merganser hazing/lethal control effectiveness, expanded PIT tag surveys, expanded studies of flow vs. smolt rate of travel, and Dam/Diversion fish bypass mortality studies.

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Appendix A. Common Merganser Study 2008

Yakima Klickitat Fisheries Project: Monitoring and Evaluating Avian Predation on Juvenile Salmonids on the Yakima River, Washington.

Common Merganser Smolt Consumption near Roza Dam, WA.

Anadromous fish of the Yakima Basin have experienced severe declines in populations as a result of anthropogenic actions. In response to these declines, millions of dollars are spent annually in efforts to restore anadromous fish runs (Yakima Basin Fish and Wildlife Planning Board 2004). The Yakima Klickitat Fisheries Project (YKFP), co-managed by the Yakama Nation and Washington Department of Fish and Wildlife (WDFW), with funding from the Bonneville Power Administration, is leading the effort to restore salmon runs in the Yakima River. YKFP seeks to "test the hypothesis that new supplementation techniques can be used in the Yakima River Basin to increase natural production and to improve harvest opportunities, while maintaining the long-term genetic fitness of the wild and native salmonid populations and keeping adverse ecological interactions within acceptable limits" (Sampson and Fast 2000).

Predator and prey relationships have demonstrated considerable change as the result of developments within the Yakima River Basin. Some changes have resulted in “hotspots,” areas experiencing high predation of anadromous salmonids (Sampson, Fast, and Bosch 2008). Common Mergansers (Mergus Merganser) were found to be the major predator on the upper reaches of the Yakima River (Phinney, et al.1998.) Surveys conducted from 1999 through 2002, by the Washington Cooperative Fish and Wildlife Research Unit, found that this trend is continuing thru time (Grassley and Grue 2001;Grassley, et al 2002; Major, et al 2002). The Common Merganser has altered its predator prey relation with anadromous salmonids as a result of the development of Roza Dam, located in the upper Yakima River. Roza Dam has seen increased population numbers of Common Mergansers and has now become a “hotspot” for predation salmonids (Sampson, Fast, and Bosch 2008).

Under YKFP’s avian predation monitor and evaluation study, stomach content analysis and management studies of the Common Merganser will be implemented at Roza Dam. Roza Dam is fitted with passage via fish ladders for returning adults and bypass structures for migrating smolts. Structures of passage along with dam effects concentrate many fish in small areas during species migration timing (Sampson, Fast, and Bosch 2008). As a result of structure, Roza Dam becomes an area of high concentrations of smolts during this migration. Piscivorous species such as the Common Merganser is then attracted to Roza Dam and consumes large numbers of migrating smolts. YKFP is hoping to obtain a permit for the lethal taking of the Common Merganser to complete a stomach content analysis and assess anadromous salmonid consumption and management techniques. With study results YKFP will assess the impact these Mergansers are having on migrating smolts and possible management strategies.

Location

The area of study collection is located below Roza Dam on the Yakima River of Washington. Migrating Smolts pool above and below the dam from March to June between this time period it is expected that over 1 million smolts pass the dam. Mergansers have congregated in numbers reaching 150+ during days of smolt migration at the dam and are thought to have a severe impact on smolts through consumption (personnel communication, Mark Johnston Biologist YKFP).

Methods

The Common Merganser at Roza Dam they will be taken by shotgun. Dogs and boats will be used to recover the birds from the river below Horn Rapids Dam. 50 Mergansers will be taken over a period of 5 weeks, twice a week, 5 per day, during a timing of peak smolt migration of the second week of March to the third week of April. Smolt consumption thru diet analysis would entail species of fish identification using bone diagnostics. The study would involve using personnel from YKFP, Yakama Nation and WDFW, who have in the past taken Mergansers and completed bone diagnostics (Fritts and Pearsons 2006). Stomach contents of avian predators taken during lethal control efforts will be processed for whole and partial fish, diagnostic cranial bones, and otoliths.

Fish will be individually bagged and tagged with the date and place of collection, and kept frozen at -20oC at the Prosser Fish Hatchery until processed. Stomach contents will be collected, analyzed, and preserved according to techniques described in the Field Manual of Wildlife Diseases, General Field Procedure and Diseases of Birds (USGS 1999).

Conditioned Response for Management

Management of the Common Merganser for the smolt consumption near Roza Dam may be deemed necessary. A study concurrent with the lethal take for stomach content analysis would attempt to assess lethal control and conditioned response as a management tool. YKFP would study the effectiveness of lethal control combined with frightening techniques, which when combined have shown to be an effective management tool (Littauer 1990). After a count of Common Mergansers at the collection site a handheld horn would be blown during each lethal take as a frightening technique. Frightening techniques would extend for a period 5 weeks after lethal collection is completed. Numbers of Common Mergansers would be recorded over the 5 week period of lethal collection and a period extending 5 weeks after lethal collection.

Results

Results for the scientific collection study will be incorporated into the annual report, “The Monitoring and Evaluation of Avian Predation of Juvenile Salmonids on the Yakima River, Washington”, for the Yakima Klickitat Fisheries Project, submitted to the U.S. Department of Energy, Bonneville Power Administration. Results may also be submitted to relevant scientific journals for publication. For a more detailed description of previous years’ results of the monitoring effort and statistical methods involved please refer to the annual reports located at YKFP’s website, www.ykfp.org or the Bonneville Power Administration website,
www.efw.bpa.gov/Environment/EW/EWP/DOCS/REPORTS/YAKIMA

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