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
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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 depressed status 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.

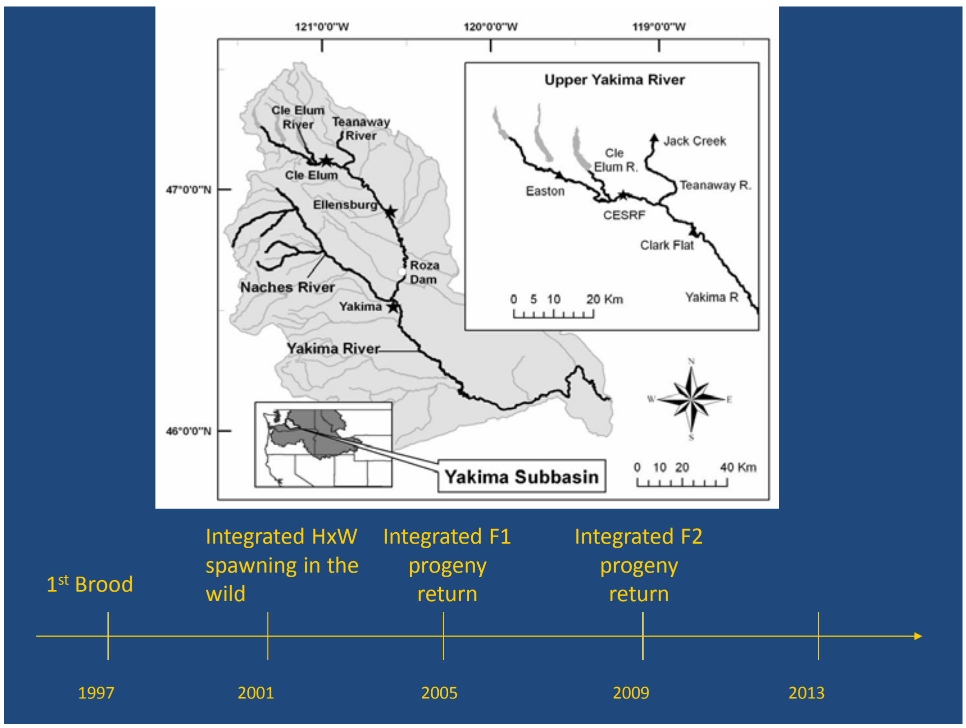
Supplementation is envisioned as a means to enhance and sustain the abundance of wild and naturally-spawning populations at levels exceeding the cumulative mortality burden imposed on those populations by habitat degradation and by natural cycles in environmental conditions. A supplementation hatchery 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. However, it is important to recognize that "rebuilding natural populations will ultimately depend on improving habitat quality and quantity" (ISRP 2011) of which habitat connectivity is an essential component (Milbrink et al. 2011). Hatchery programs, even "state of the art" integrated supplementation programs designed to follow all of the best management practices recommended by regional scientific review groups, do not directly affect any of these habitat parameters which are vital to improving natural productivity. Therefore, the YKFP is working with Subbasin partners through the Subbasin Planning and Recovery process to implement habitat restoration projects designed to address factors limiting productivity in the Yakima Subbasin.

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. 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 findings to date by species including a description of how these findings link to critical hatchery-program related uncertainties identified in the Columbia River Basin Research Plan. Additional detail including methods, statistical analyses, links to additional information, etc. can be found in the main body or appendices of this report.

Spring Chinook

The YKFP began a spring Chinook (*O. tshawytscha*) salmon hatchery program at the Cle Elum Supplementation and Research Facility (CESRF) near Cle Elum on the upper Yakima River (river kilometer 297, measuring from the confluence with the Columbia River; Figure 1) in 1997. This program is a supplementation effort targeting the upper Yakima River population and is designed to test whether artificial propagation can be used to increase natural production and harvest opportunities while limiting ecological and genetic impacts (RASP 1992). It is an integrated hatchery program (Mobrand et al. 2005) because only natural-origin broodstock are used and returning hatchery-origin adults are allowed to spawn in the wild. The program employs "best practice" hatchery management principles (see Cuenco et al. 1993, Mobrand et al. 2005) including reduced pond densities, strict disease management protocols, random broodstock selection, and factorial mating (Busack and Knudsen 2007) to maximize effective population size. Fish are reared at the central facility, but released from three acclimation sites located near the central facility at: Easton approximately 25km upstream of the central facility, Clark Flat about 25km downstream of the central facility, and Jack Creek about 12km upstream from the Teanaway River's confluence with the Yakima River. The CESRF collected its first spring Chinook brood stock in 1997, released its first fish in 1999, and age-4 adults have been returning since 2001. The first generation of offspring of CESRF and wild fish spawning in the wild returned as adults in 2005. The program uses the adjacent, unsupplemented Naches River population as an environmental and wild control system.

Figure 1. Map of the Yakima River Basin, Cle Elum Supplementation and Research Facility (CESRF) locations, and timeline of the spring Chinook supplementation program.



Hatchery Critical Uncertainty 1. What is the cost to natural populations caused by interactions (e.g., competition and predation) with hatchery-origin fish?

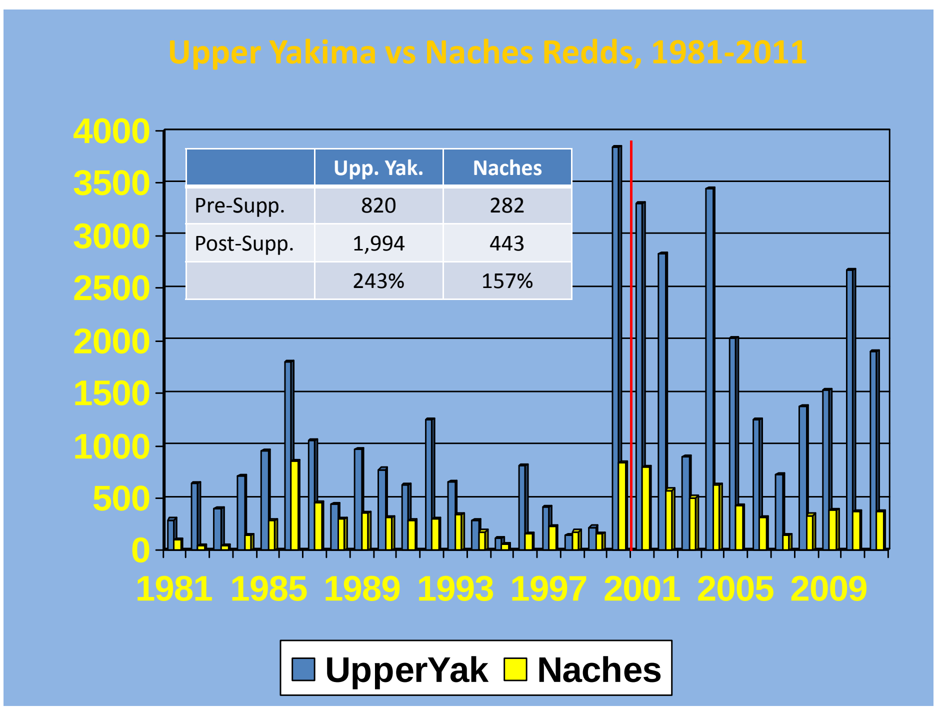
Hatchery Critical Uncertainty 7. What effect do hatchery fish have on other species in the freshwater environment?

YKFP Findings: We have detected generally small, but significant differences in juvenile traits between hatchery- and natural-origin fish including: size of progeny (Knudsen et al. 2008), agonistic competitive behavior (Pearsons et al. 2007), predator avoidance (Fritts et al. 2007), and incidence of precocious maturation (Beckman et al. 2008; Larsen et al. 2004, 2006; Pearsons et al. 2009). 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). 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).

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

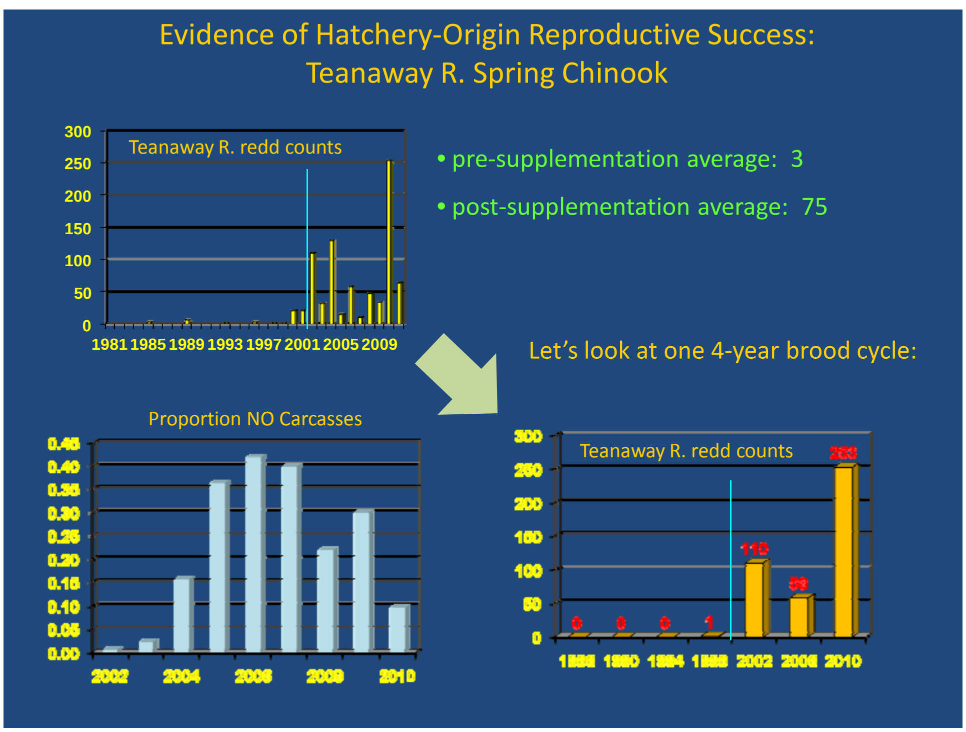
YKFP Findings: Supplementation has increased redd abundance in the Upper Yakima relative to the control system. Figure 2 presents Before-After Control-Impact (BACI) redd count data for the Upper Yakima and Naches rivers. Redd counts in the post-supplementation period (2001-2011) have increased significantly 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 (243%; P=0.001) was about 85% greater than that observed in the Naches system (157%; P=0.048).

Figure 2. Spring Chinook redd counts in the supplemented Upper Yakima (blue bar) relative to the unsupplemented Naches (control; yellow bar) for the pre- (1981-2000) and post-supplementation (2001-2011) periods.



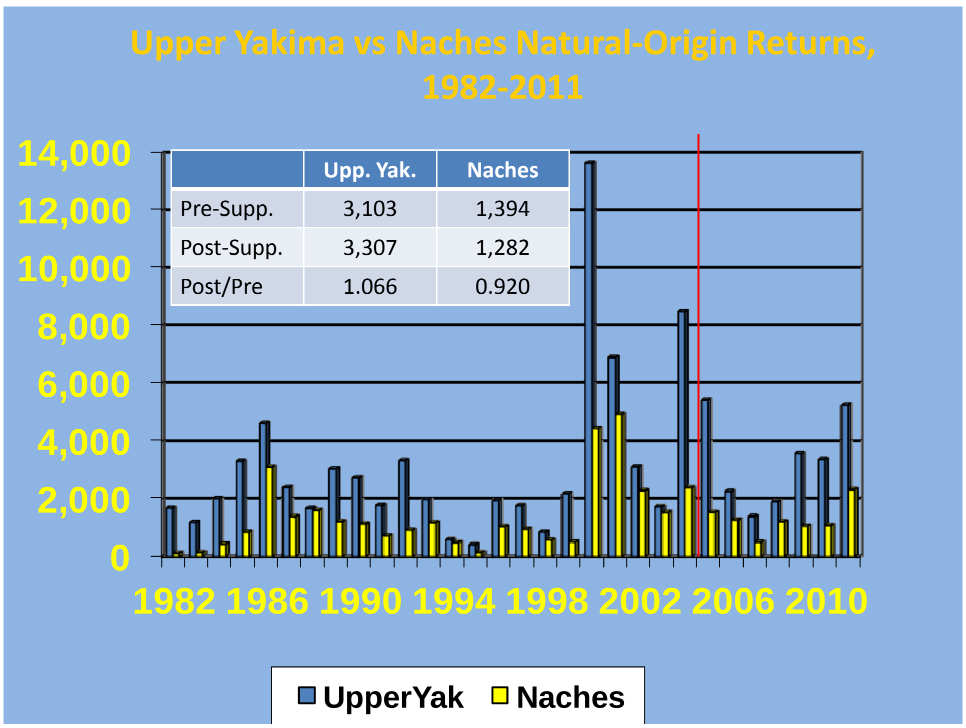
Spatial distribution of spawners has also increased as a result of acclimation site location, salmon homing fidelity and more fully seeding preferred spawning habitats (Dittman et al. 2010). Redd surveys in the Teanaway River conducted annually by Yakama Nation staff since 1981 demonstrate the benefits of reintroducing salmonids into underutilized habitat (Figure 3). The Jack Creek acclimation site began releasing CESRF spring chinook in 2000, with the first age-4 females returning from these releases in 2002. Redd counts in this tributary have increased from a pre-supplementation average of 3 redds per year to a post supplementation average of 75 redds per year. The proportion of natural-origin carcasses increased from less than one percent in 2002 (when CESRF fish first returned to the natural spawning grounds) to 42% in 2006 when the progeny of the 110 redds produced in 2002 (virtually 100% of which were produced by CESRF-origin fish) returned. These data clearly indicate that naturally-spawning CESRF spring Chinook were successful in returning natural-origin adults back to the Teanaway River.

Figure 3. Teanaway River Spring Chinook redd counts, 1981-2011 (blue lines denote pre- and post-supplementation periods) and the proportion of natural-origin (NO) carcasses observed in intensive spawning ground surveys, 2002-2010.



Supplementation has not increased natural-origin returns in the Upper Yakima relative to the control system. Figure 4 presents Before-After Control-Impact (BACI) natural-origin return data for the Upper Yakima and Naches rivers. Natural-origin returns in the post-supplementation period (2005-2011) have not changed significantly in either the supplemented Upper Yakima or Naches control systems relative to the pre-supplementation period (1982-2004). However, the mean natural-origin return in the post-supplementation period increased in the upper Yakima (1.07; P=0.86) and decreased in the Naches system (0.92; P=0.83) relative to the pre-supplementation period. It may be that the post-supplementation time period is not yet long enough to detect a significant change in this natural production parameter.

Figure 4. Natural-Origin returns of Spring Chinook in the supplemented Upper Yakima (blue bar) relative to the unsupplemented Naches (control; yellow bar) for the pre- (1982-2004) and post-supplementation (2005-2011) periods.



Regarding other demographic parameters, we have detected significant 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). Most of the differences have been 10% or less. Semi-natural rearing did not result in significant increases in survival of hatchery fish (Fast et al. 2008). Growth manipulations in the hatchery demonstrated the ability to reduce the number of precocious male progeny, however post-release survival of treated fish may be lower than conventionally reared fish due to reduced size-at-release (Larsen et al. 2006; Pearsons et al. 2009). Smolt-to-adult recruit survival (SARS) on observed fish tagged with passive integrated transponder (PIT) tags was significantly lower than that of non-PIT-tagged fish because of PIT tag loss and taginduced mortality, resulting in an average underestimate of SARS of 25.0% (Knudsen et al. 2009).

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

YKFP Findings: 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).

For additional data and supporting information, see Appendix B 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.

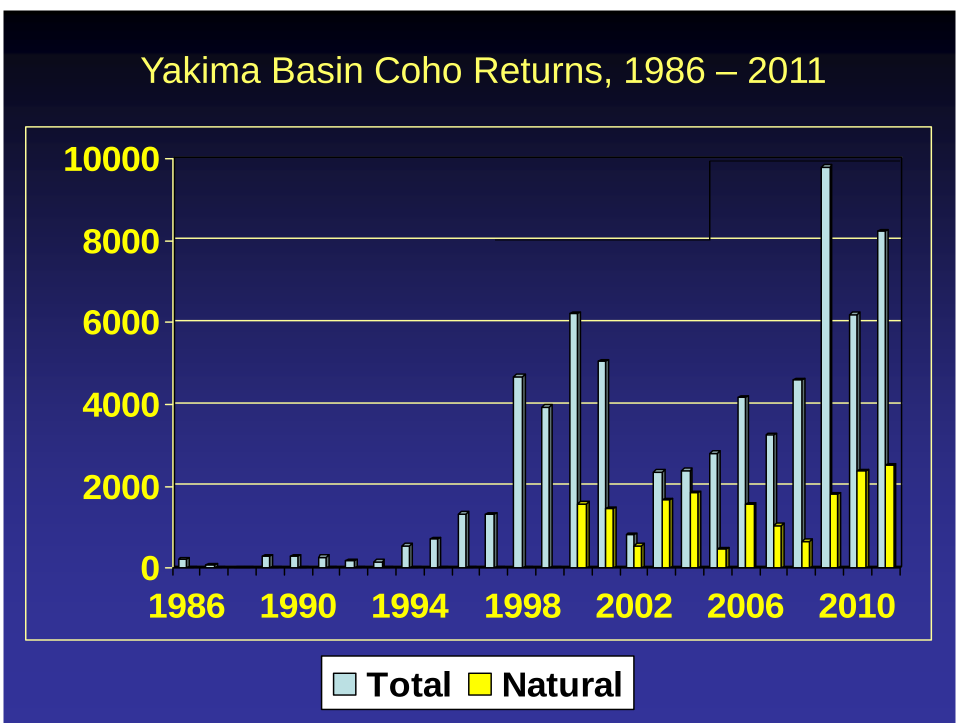
A Master Plan has been completed that proposes to: 1) transition out-of-basin brood source releases from the Little White Salmon National Fish Hatchery to Priest Rapids or local brood source and release these fish from acclimation sites in the lower Yakima River below Horn Rapids Dam, 2) continue development 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

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

YKFP Findings: The YKFP is presently studying the release of over 1.0 million coho smolts annually from acclimation sites in the Naches and Upper Yakima subbasins. These fish are a combination of in-basin production from brood stock collected in the vicinity of Prosser Dam plus out-of-basin stock generally reared at Willard or Eagle Creek National Fish Hatcheries and moved to the Yakima Subbasin for final rearing and release. YKFP monitoring of these efforts to re-introduce a sustainable, naturally spawning coho population in the Yakima Basin have indicated that adult coho returns averaged about 3,900 fish from 1997-2011 (an order of magnitude greater than the average for years prior to the project) including estimated returns of wild/natural coho averaging over 1,400 fish since 2001 (Figure 5). 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.

Figure 5. Total (blue bar) and natural-origin (yellow bar) returns of Coho to the Yakima River Basin, 1986-2011.



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 instream and floodplain restoration on the mainstem Yakima River and tributaries. Substantial restoration has been completed in the Taneum and Swauk watersheds with more planned for the coming year. Large woody material has been placed, step pools and engineered jams have been constructed in middle Swauk. 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.

In addition to these YKFP habitat protection and restoration activities, the Yakama Nation is also working to restore habitats in the Satus, Toppenish, and Ahtanum watersheds (see Yakama Reservation Watershed Project and http://host119.yakama.com/Habitat/SWP/swp.html), and working with subbasin partners to implement numerous Salmon Recovery Funding Board projects (see Yakima Basin Fish and Wildlife Recovery Board summary).

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, Streamnet, and cbfish.org), 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 (see References).

To view recent technical reports or publications for the project, please visit ykfp.org or http://www.cbfish.org/Project.mvc/Publications/1995-063-25.

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 FY2010 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 2011. 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.e, 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: The EDT model was used to evaluate the bypass mortality effects of four major diversion dams in the Yakima Basin (Roza, Wapato, Sunnyside, and Prosser Dams). Mortality effects from the bypass systems were evaluated for three populations of spring Chinook, and the recently reintroduced population of summer Chinook. Temporal bypass mortality was estimated for 3 of the 4 facilities by analyzing 42 paired releases of PIT-Tagged Chinook salmon smolts. The fourth diversion facility (Wapato Dam), which lacked paired releases and empirically-based estimates of bypass mortality, relied on mortality estimates from the Sunnyside diversion facility located one mile downstream.

Mortality effects incurred at diversion facilities are captured in the EDT model by estimating the monthly proportion of smolts surviving emigration past the Dam and diversion facility. Emigrants include fish that are spilled directly over the dam, and fish entrained into the headworks of the diversion canal, which in turn, are subjected to the bypass system before being routed back to the River. Mean monthly survival was estimated for the outmigration months including April, May and June for all four facilities, and for yearling and sub-yearling Chinook.

The mortality effects of the diversion dams were evaluated at the population level by estimating changes in a population's equilibrium adult abundance and intrinsic productivity. Several scenarios were modeled that included the current conditions (used mortality estimates from paired releases), doubling of mortality at each of the four diversion dams, and 100% elimination of mortality at each of the diversion dams. The complete Bypass Mortality report is included in this report as Appendix A.

Task 1.b Percent habitat saturation and limiting factors

The WDFW annual report for this task can be located on the website: http://www.cbfish.org/Project.mvc/Publications/1995-063-25. This year's report is expected to be available soon. The most recent report is:

C. L. Johnson and G. M.Temple. 2011. Spring Chinook Salmon Competition / Capacity and Residual/Precocious Male Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report 2010.

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 2007-09, 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 tested 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 2010 fish began at the Cle Elum hatchery on October 17, 2011 and was completed on December 2, 2011. Marking results are summarized in Table 1. Appendix B 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 (4.4% to 8.9% 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 (~674,900 fish) had a CWT placed in their snout, while the remaining progeny of hatchery brood parents (hatchery control line; ~84,700 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 4, 2012. Estimated tag retention was very good, ranging from 94-100% for CWT and 84-100% 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). For brood-year-2006 smolts, which were released from the acclimation sites in 2008, there was no significant difference in the measured trait effects between the EWOS and BioVita feeds. The release-to-McNary smolt-survival percentages of the EWOS and BioVita treatments were nearly identical, 30.0% and 29.8% respectively (P = 0.85; D. Neeley, Appendix B in project year 2008 annual report).

Appendix C 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 2004-2011 (brood years 2002-

2009). Additional survival data across years are given in Appendix B. Appendix D 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 and 2009 through 2011 (brood years 2005 and 2007-2009).

Table 1. Summary of 2010 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	WW	Right	Red	Snout	40221	2000	42221	17-Oct-11	19-Oct-11
CLE02	BIO	CFJ06	WW	Left	Red	Snout	40845	2000	42845	20-Oct-11	24-Oct-11
CLE03	STF	CFJ03	HH	Right	Red	Posterior Dorsal	43725	4000	47725	25-Oct-11	27-Oct-11
CLE04	BIO	CFJ04	HH	Left	Red	Posterior Dorsal	40976	4000	44976	28-Oct-11	02-Nov-11
CLE05	STF	ESJ01	WW	Right	Green	Snout	40710	2000	42710	02-Nov-11	07-Nov-11
CLE06	BIO	ESJ02	WW	Left	Green	Snout	40419	2000	42419	07-Nov-11	09-Nov-11
CLE07	STF	JCJ01	WW	Right	Orange	Snout	43833	2000	45833	11-Nov-11	15-Nov-11
CLE08	BIO	JCJ02	WW	Left	Orange	Snout	43815	2000	45815	15-Nov-11	18-Nov-11
CLE09	STF	ESJ03	WW	Right	Green	Snout	42528	2000	44528	18-Nov-11	28-Nov-11
CLE10	BIO	ESJ04	WW	Left	Green	Snout	42649	2000	44649	29-Nov-11	01-Dec-11
CLE11	STF	ESJ05	WW	Right	Green	Snout	43878	2000	45878	01-Dec-11	02-Dec-11
CLE12	BIO	ESJ06	WW	Left	Green	Snout	43750	2000	45750	22-Nov-11	30-Nov-11
CLE13	STF	JCJ03	WW	Right	Orange	Snout	41816	2000	43816	17-Nov-11	22-Nov-11
CLE14	BIO	JCJ04	WW	Left	Orange	Snout	41052	2000	43052	15-Nov-11	17-Nov-11
CLE15	STF	JCJ05	WW	Right	Orange	Snout	42894	2000	44894	09-Nov-11	14-Nov-11
CLE16	BIO	JCJ06	WW	Left	Orange	Snout	42371	2000	44371	07-Nov-11	09-Nov-11
CLE17	STF	CFJ01	WW	Right	Red	Snout	42329	2000	44329	02-Nov-11	04-Nov-11
CLE18	BIO	CFJ02	WW	Left	Red	Snout	41829	2000	43829	28-Oct-11	02-Nov-11

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 February 18 through May 13, 2011. 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 6,599 juvenile migrants were PIT tagged from fish collected at the Roza juvenile fish bypass trap. Tagged fish included 5,656 spring Chinook (3,641 hatchery-origin and 2,015 natural-origin), 22 coho (19 wild/natural), 351 steelhead, and 570 sockeye.

Appendix E contains a detailed analysis of wild/natural and CESRF (hatchery) smolt-to-smolt survival for Roza-tagged releases for brood year 2009 (migration year 2011) and summarizes these data for prior brood years 1997-2008 (migration years 1999-2010). Additional data on this task are provided in Appendix B.

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 F for current status and additional 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 number of smolts sampled at the CJMF by species in 2011 were as follows: natural-origin spring (yearling) Chinook – 23,861; hatchery-origin spring Chinook– 40,505; unmarked fall (sub-yearling) Chinook– 6,573; natural-origin (unmarked) coho– 6,818; hatchery-origin (marked) coho– 464; and wild steelhead– 5,743. We are still evaluating flow and entrainment relationships and issues (see Appendix F for an update). Therefore estimates of total smolt passage at Prosser for 2011 are unavailable at this time. These data continue to be reviewed and will be updated in the future. Additional data on this task are also provided in Appendix B.

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, and Jimmy Joe Olney. 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: Beginning with BY2006, we held back a portion of our subyearling program to be reared to the yearling stage. This experiment grew out of the previous experimental comparisons of an accelerated treatment strategy versus the conventional rearing method. The accelerated method out-performed the conventional method in 6 of 7 years. The first experimental release was in 2008. Using our in-basin stock, we compared a group of the accelerated subyearlings (BY2007) versus the first group of yearling releases (BY2006). Initially both groups were 100% adipose clipped and a portion PIT tagged for monitoring. For BY2008-11, we moved to 100% PIT tag with no adipose clip. This experiment is on-going.

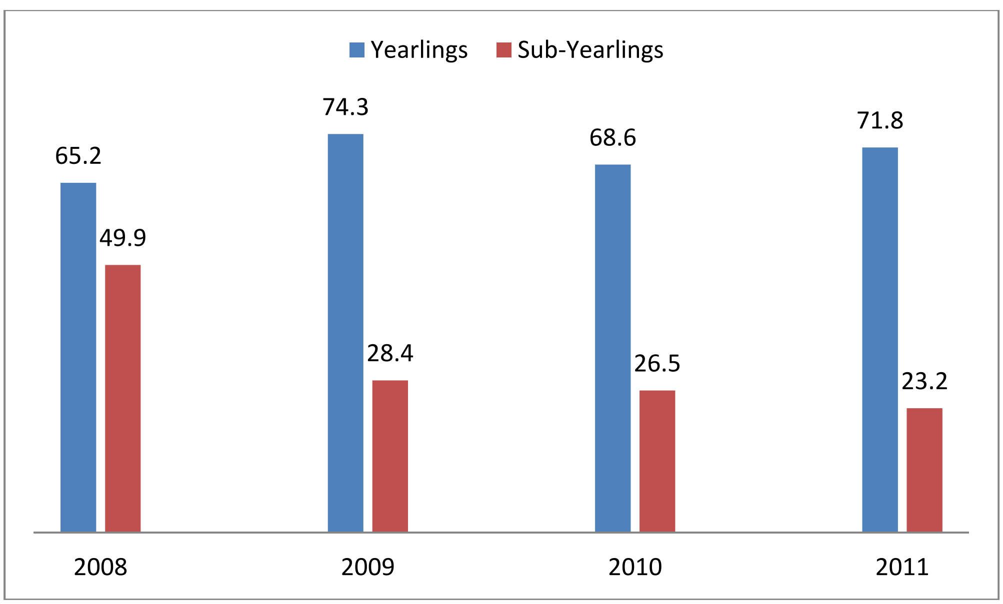
In 2010, we brought in 500,000 eyed eggs from Priest Rapids Hatchery (PRH). We brought in the same amount from Little White Salmon Hatchery (LWS) for back up in the event the transfer from Priest did not go well, neither group was marked. However, a portion of additional LWS fish that came in later were 10% CWT and 100% adipose clipped. There were no problems with transfer, incubation or rearing. The goal is to transition from out-of-basin brood transferred from LWS Hatchery to a more local brood source collected either from Priest Rapids Hatchery or the off-ladder adult collection facility at the Dam.

For BY2011 we brought in 500,000 "green" eggs/milt from PRH versus eyed eggs which were brought in the previous year. Due to limited space at PRH, this was the feasible approach. These eggs were transferred directly to Prosser Hatchery for incubation and rearing. All females were sampled for pathology and eggs were kept in isolation until results cleared them for use. These fish will no longer be marked for experimental purposes, but will be adipose clipped for adult identification at Prosser.

Progress: As their cohorts did in previous years, BY2009 yearlings out-performed the subyearling releases 71.8% vs. 23.2% to McNary Dam in 2011 (Figure 6). Using the BY2009 in-basin stock (subyearlings), we entered into the fourth year release comparison of the subyearling vs. yearling rearing treatments. The subyearlings continue to be reared using an accelerated strategy already determined to have better survival than the traditional conventional method. The yearlings are reared using conventional methods as there is no need to accelerate growth for release. Smolt-smolt survival to McNary is monitored via PIT tags. For the initial releases in 2008 (BY2006), we marked the fish 100% using a PIT tag or an AD clip. For the following release years, we moved to 100% PIT tag and no adipose clip.

For BY2007-2009 (subs) and BY2006-2008 (year) releases, the Yearlings have out-performed the Subyearlings for every release (Figure 6).

Figure 6. Percent survival from release to McNary Dam passage of Yakima River Fall Chinook yearling vs. subyearling smolts for juvenile migration years 2008-2011.



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 15th, 2012), yearling detections have out-numbered subyearling detections 2,619 to 1,064 respectively.

For the LWS 2011 (BY2010) release, we had 561,621 fish, 100% adipose fin-clipped that were transferred as eyed eggs and reared under accelerated conditions. The remaining 1,138,323 fish were transferred as pre-smolts with 10% coded-wire tagged (CWT) and 100% adipose fin-clipped. The PRH 2011 (BY2010) release was 503,772 fish with no marks or tags.

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.

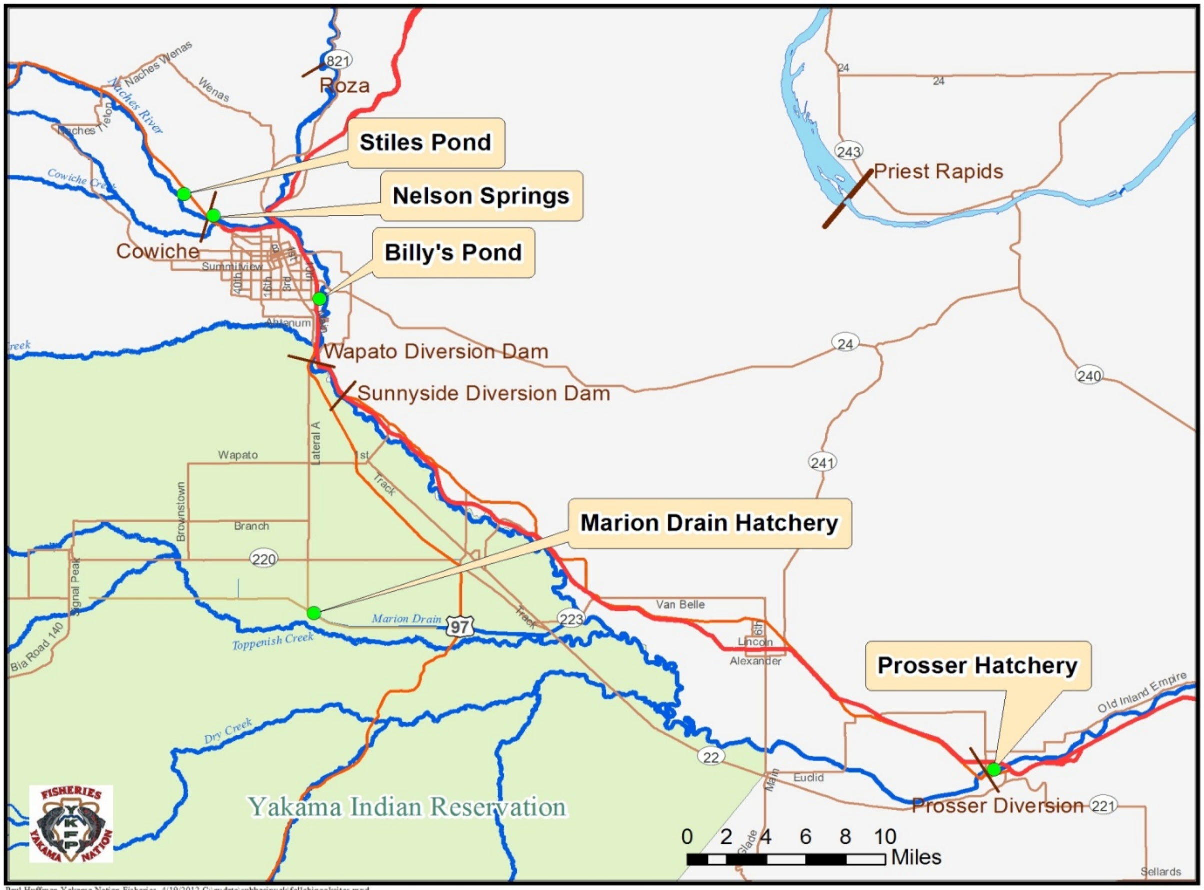
For BY2011, we transferred green eggs and milt from Priest Rapids Hatchery (instead of eyed eggs as in prior years). These fish received the accelerated treatment. Approximately 405,000 fish were released for 2012. These fish were 100% adipose clipped only. We will continue to transfer pre-smolts from 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.

2010 marked the last year fall Chinook were released above Prosser Hatchery. Fall Chinook will continue to be reared at Prosser Hatchery and released there or from to be determined acclimation sites in the lower Yakima River Basin.

The "Yakima Subbasin Summer- and Fall-run Chinook and Coho Salmon Hatchery Master Plan" was completed. The Master Plan documents long-term program goals and strategies as well as the facilities required to implement them. The Master Plan is being submitted to the NPCC for step-review in the summer of 2012.

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

Figure 7. Present 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 BY2009-11, 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 BY2011 eggs and milt from individual males and females to the Yakama Nation Prosser Hatchery in Prosser, WA. Water use upgrades prevented using Marion Drain Hatchery for incubation and rearing for 2011-12. 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 Prosser 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 BY2010 remained entirely at the Marion Drain Hatchery. A pipe burst due to below freezing temps resulting in a significant loss of fish still in incubation trays. We were able to save 39,406 fish. These fish were planted in Buckskin Slough, Naches River (RM3.3) on 4/29/11. In addition, 177,356 yearlings (a combination of two groups) received as surplus fish were reared at Prosser Hatchery with final acclimation located at Stiles Pond, ~RM 3.4 of the Naches River. These fish were released on 5/16/11. Fish were 100% marked with a PIT tag or Ad-clip and/or CWT and Adipose clip.

For BY2011 all summer Chinook were incubated and reared at Marion Drain Hatchery. Final acclimation was spread out between Prosser Hatchery, Marion Drain Hatchery and the new Nelson Springs acclimation site, lower Naches River (Figure 7). Approximately 10,000 fish from each site were PIT tagged and all remaining were CWT only. Survival data to McNary Dam is pending. No fish were acclimated at either Stiles or Billy's ponds in 2012.

Progress: Pathology results allowed for 100% of the females cleared for release in 2011. For release year 2009, incubation temperatures were kept below 49^{o}F 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 BY2009-2011, incubation temperatures were increased to ~57^{o}F to accelerate growth. As a result, the fish put on adequate size enabling us to PIT tag fish prior to release. This also made it possible to move fish to the final release site for a longer acclimation period. For BY2011 final acclimation sites were spread between Prosser Hatchery, Marion Drain Hatchery and Nelson Springs. We were able to mark the fish at the final release site allowing for an even longer acclimation period than previously possible. Fish were marked and released directly from each site.

For the BY2010 collection, eggs were incubated at an accelerated temperature of ~53-54^{o}F 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 5/16/11. 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 30k PITs with the remainder CWT tagged only. Survival from release to McNary for the 2011 release year was 43.5% compared to 30.6% in 2010.

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

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 were documented in an interim 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 2011 was average, approximately 302,389 fish. Redd counts in 2011 were the third highest the program has observed. 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 spawning in 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.

All of the program goals and the infrastructure required to achieve them are further described in the "Yakima Subbasin Summer- and Fall-run Chinook and Coho Salmon Hatchery Master Plan" which is being submitted to the NPCC for step-review in the summer of 2012.

2011 Methods

The 2011 juvenile coho releases again tested in-basin vs. out-of-basin stocks within acclimation sites. However, due to a massive disease outbreak just before release, the tests were only evaluated at the Holmes, Easton and Lost Creek Acclimation Sites. In all three cases the out of basin stock had higher survival than the Yakima in basin stock. This was most likely due to the disease carried by transported fish. Evaluations were also done on Yakima/ Eagle Creek genetic crosses. 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 mainstem Yakima and Naches Rivers as well as select tributaries.

2011 Results

Juvenile Survival

In 2011, 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 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. Tagging to McNary survival indices were greater for Naches subbasin releases than for upper Yakima River releases (Appendix H). This was true for both out-of-basin (Eagle Creek NFH) and local brood source fish. Within the Naches sub basin, Lost Creek Ponds had Yakima Coho and Yakima x Eagle Creek Coho. In 2011, Yakima smolt to smolt survival from Lost Creek was only 23% whereas the Yakima x Eagle Creek hybrids had 40% survival (Appendix H). The Stiles acclimation site had only the Yakima hybrids and they had 28% survival. The mobile acclimation smolts from Cowiche had 32% survival which is nearly 10% higher than 2010. In the Upper Yakima River, the Holmes acclimation site had low survival for Yakima and Eagle Creek smolts, 3.4% and 7.4% respectively. The Easton acclimation ponds fared better. Easton was set up to evaluate Yakima vs. Eagle Creek and Yakima/Eagle Creek hybrids. Smolt survival from Easton was nearly average relative to prior years. The Yakima smolts had only 6.8% survival whereas the Eagle Creek and hybrids had 22.4% and 25% respectively (Appendix H). The overall reduction in Yakima in basin coho survival was most likely due to illness that set in on the population 2 weeks before transport.

The pre-release survival (tagging to release) of the Eagle Creek brood-stock was higher but post-release survival to McNary Dam was lower than that of the Yakima (local) brood-stock (D. Neeley, Appendix H). The combination of the two components resulted in a reduced relative over-all survival from tagging for the Yakima stock. These data may indicate differential tagging-induced mortality effects between the two brood sources. We are investigating the causes of this and have begun PIT-tagging both stock within the same month.

See Appendix H for a detailed report and analysis of coho juvenile survival indices for 2011 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. This compares to 21% and 30% survival for Reecer Creek parr plants in 2010 and 2011, respectively. South Fork Cowiche Creek also had good survival in 2011 (19%) though somewhat lower than previous years. Most other tributaries also had good survival (9-20 percent tagging-to-McNary smolt survival). Surprisingly, the higher elevation tributaries, North Fork Little Naches, Little Naches and Big Creek, continue to show 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) show somewhat lower 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% and remained about the same in 2011 (19.4%). Some further investigations will need to be done to understand these differences. We intend to use these data to better target our tributary recovery efforts.

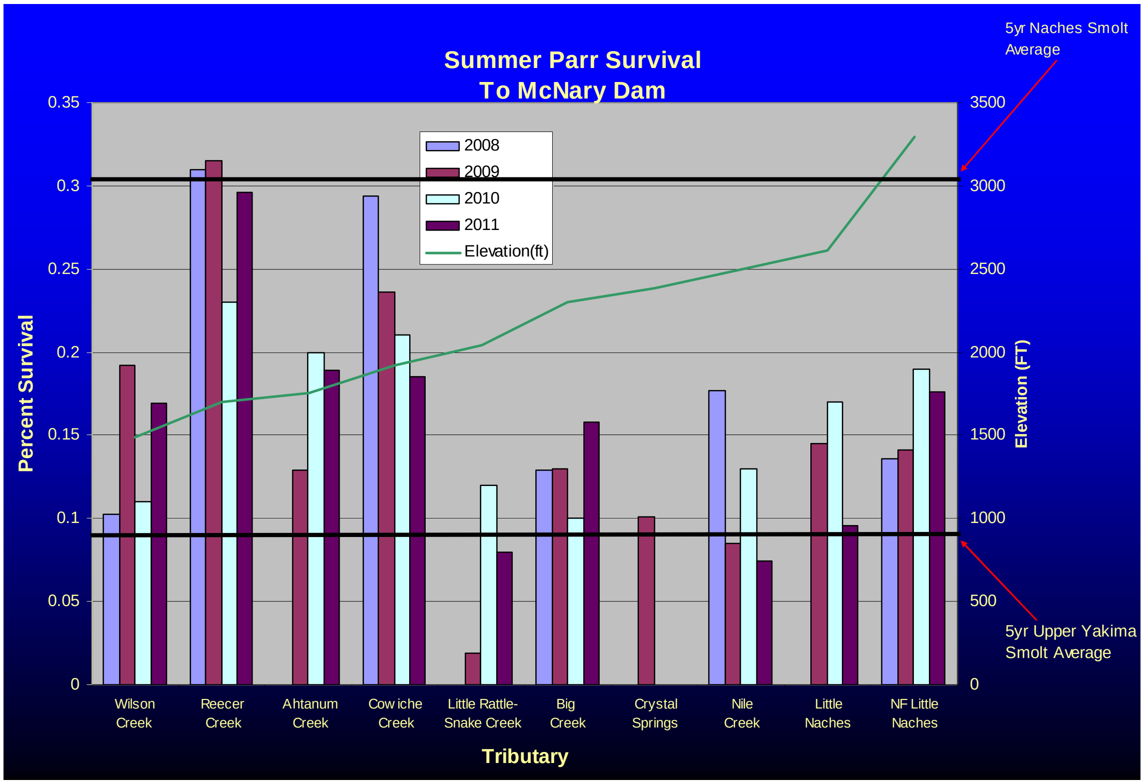


Figure 8. Summer parr survival from tagging to smolt passage at McNary Dam for coho plants by tributary for outmigration years 2008 through 2011. Tributaries are shown from lowest elevation on left of chart to highest elevation on right.

Mobile acclimation

Mobile acclimation sites are currently located on South Fork Cowiche Creek and Rattlesnake Creek. Each vessel is 20ft long, 4ft deep, and 5ft wide with water typically cycled at 60-90 gallons per minute. The Cowiche site is operated off electricity with a backup generator. The Rattlesnake site is operated off a 17Kw generator and 1,000 gallon propane tank. Both sites begin 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.

The Cowiche Creek site has had three 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, 24% in 2010, and 31% in 2011. In 2010, survival of smolts released from Rattlesnake Creek was estimated at 8%. This was due in large part to a disease outbreak soon after acclimation began. During 2011, an overnight freshet covered the pump with 10 inches of mud and 90% of the coho died. We hope to fix this situation with some backup measures that will be implemented in 2012.

Adult Out-plants

The 2011 adult out-plants went very well. 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 at Prosser Hatchery 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. All 300 adults were planted in designated sections of the Creek. Each section contained 50 males and 50 females. Spawning coho were observed within days of release, but spawning lasted nearly a month. 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 advanced disease caused by holding the fish in warm water. Water conditions in 2011 were excellent with decent flows and there was no flooding. A total of 100 redds were located in Taneum Creek in 2011.

After a successful adult out-plant in 2010 a large 100 year freshet wiped out a large portion of the 134 redds. Summer sampling indicated few if any juvenile coho in the upper two sections. However, the lowest section had a few zero age coho surviving. Therefore, the total number the progeny of the 2010 out-plants will be extremely limited. Sampling crews were able to PIT-tag approximately 200 sub-yearling coho and nearly 1500 one year plus aged coho. The Taneum system is producing one, two and three year class coho smolts.

Juvenile out migration survival estimates in 2011 were estimated to be approximately 13% in 20011. A new pit tag array was installed at the mouth of Taneum Creek.

The first progeny from the 2007 adult out-plants 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. The SAR produced by Taneum Creek remains consistent with other Yakima wild SAR's. A total of 1867 juvenile coho were PIT-tagged from the 2008 brood class of which approximately 10% survived to McNary Dam. In 2011, a total of 14 PIT-tagged adult coho from the 2008 brood were detected passing upstream at McNary Dam. The associated SAR from McNary juvenile to McNary adult is 7.65%. This is somewhat higher than the prior seven year average of 5.2%. Additionally, it is much higher than the average hatchery coho SAR of 1.5%.

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

Overall smolt passage at Prosser in 2011 was estimated at about 302,389 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 2002-2010 migration years. The estimated smolt-to-adult survival rate for 63,961 wild/natural origin coho smolts (counted at CJMF in 2010) was 2.3%. The estimated smolt-to-adult survival rate for 307,530 hatchery coho smolts (estimated Prosser Dam passage for 2010) from releases in the Upper Yakima and Naches Rivers was 1.3%. The hatchery SAR for 2010 and 2011 has returned to the normal average of approximately 1% compared to an estimated 3.7% in 2009.

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. The entire in basin Yakima hatchery release group and Eagle Creek/Yakima Crosses (except for PIT-tagged smolts) were coded wire tagged. The only adipose clipped coho released were acclimated in Boone pond (~37,000 fish).

The 2011 adult coho return to Prosser Dam was comprised of 2,403 natural-origin or unmarked coho (37%) and 4,021 (63%) hatchery-origin coho. An additional 1,594 coho (adults and jacks combined) were counted at the Prosser Hatchery swim-in trap. The total escapement into the Yakima River was estimated at 8,217. This is the second highest escapement in recent memory.

Results of 2011 Radio Telemetry Studies and adult PIT tag returns for Yakima Basin

During the 2011 adult migration we again only radio tagged adult coho that had a PIT tag present during capture. A total of 28 adult coho were radio tagged at Prosser Right Bank Denil Ladder and another 10 were tagged at Roza Dam. The results indicated very limited homing to rearing streams in 2011. Radio tagged coho were found straying into systems from the same watershed but a good distance from their rearing streams and acclimation sites. For example, one Cowiche Creek Coho was found spawning in Ahtanum Creek. They share a watershed but are a good distance from each other.

Snorkel Surveys

Snorkel surveys to look for residualized juvenile coho were also conducted again in 2011. 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 2011 and we found no incidence of age-0 precocials. Significant numbers of sub yearling coho have been observed in the lower Naches River in surveys since 2009, indicating good natural production is occurring. There were also large numbers of sub yearling coho observed in the Upper Yakima River from Thorp to Ellensburg.

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 (2011)
Using video data, an estimated 15,374 spring Chinook passed upstream of Prosser Dam in 2011. The total adult count was 11,875 (77%) fish, while the jack count was 3,499 (23%) fish. Of the adult count, 6,830 (44%) were identified as hatchery origin. Returning hatchery adults this year comprised 4 and 5 year olds (brood years 2006 and 2007). The ratios of wild to hatchery fish were 59:41 and 44:56, for adults and jacks respectively. The 25%, 50% and 75% dates of cumulative passage were May 24, May 29 and June 15, respectively.

Post-season evaluation using Roza dam count and Yakima Basin harvest data resulted in adjusted final Prosser counts of 5,705 hatchery-origin adults, 7,043 natural-origin adults, 2,770 hatchery-origin jacks, and 1,533 natural-origin jacks.

Fall Run (coho and fall chinook)

Coho (2011)
Using video data, the estimated coho return upstream of Prosser Dam was 6,545 fish. Adults comprised 98% and jacks 2% of the run. Of the estimated run, 25.9% were processed at the Denil and mark sampling there indicated the run was comprised of approximately 30% wild/natural and 70% hatchery-origin coho. The 25%, 50% and 75% dates of cumulative passage were October 2, October 15, and October 20, 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 (2011)
Estimated fall chinook passage at Prosser Dam was 2,718 fish. Adults comprised 85% of the run, and jacks 15%. Of the total number of fish, 811 were adipose clipped or otherwise identified as of definite hatchery-origin (673 adults and 138 jacks). The median passage date was September 26, while the 25% and 75% dates of

cumulative passage were September 17 and October 14, respectively. Of the total fish estimate, 110 (4.1%) were counted at the Denil.

<u>**Steelhead (2010-11 run)**</u>

The estimated steelhead run was 6,196 fish. Of the total, 132 (2.1%) 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 9th, 2010, while the 25% and 75% cumulative dates of passage were October 16th, 2010 and January 30th, 2011 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:

<u>Roza Dam</u>

Steelhead

A total of 346 steelhead were counted past Roza Dam for the 2010-11 run year (July 1 – June 30). Most steelhead migrated past Roza Dam from early March through mid May of 2011 (Figure 9).

Spring Chinook

At Roza Dam 10,501 (73% adults and 27% jacks) spring Chinook were counted at the adult facility between May 16 and September 30, 2011. The adult return was comprised of natural- (45%) and CESRF-origin (55%) fish. The jack return was comprised of natural- (34%) and CESRF-origin (66%) fish. Figure 10 shows spring Chinook passage timing at Roza in 2011.

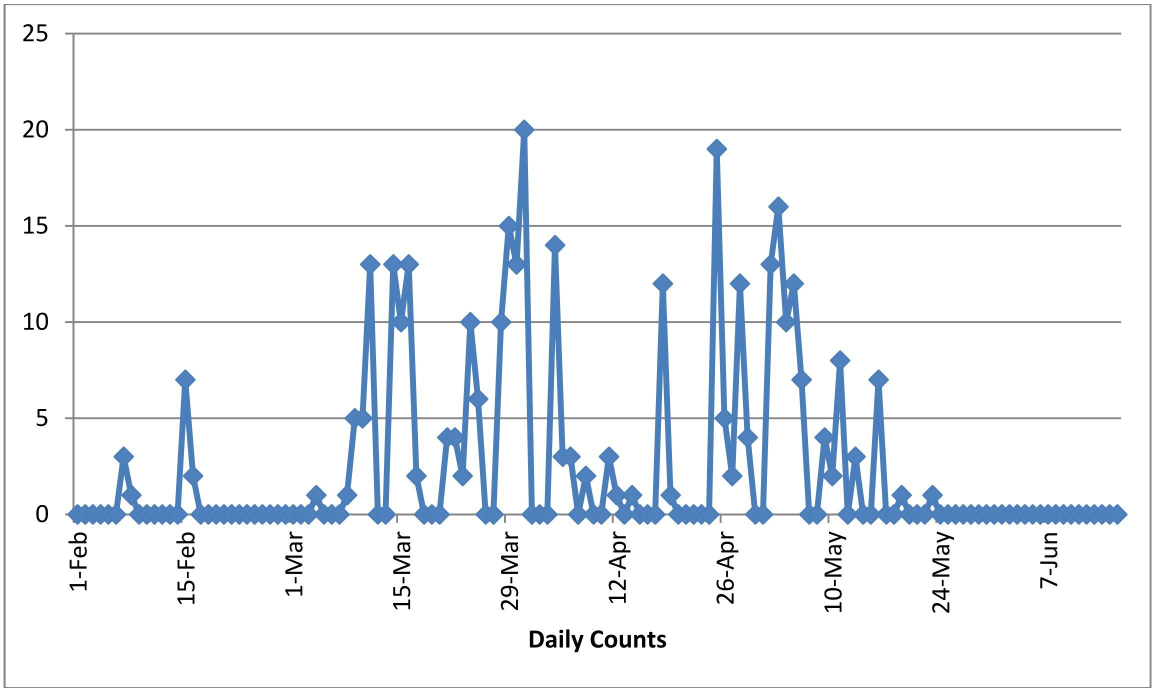


Figure 9. Daily steelhead passage at Roza Dam, 2010-11.

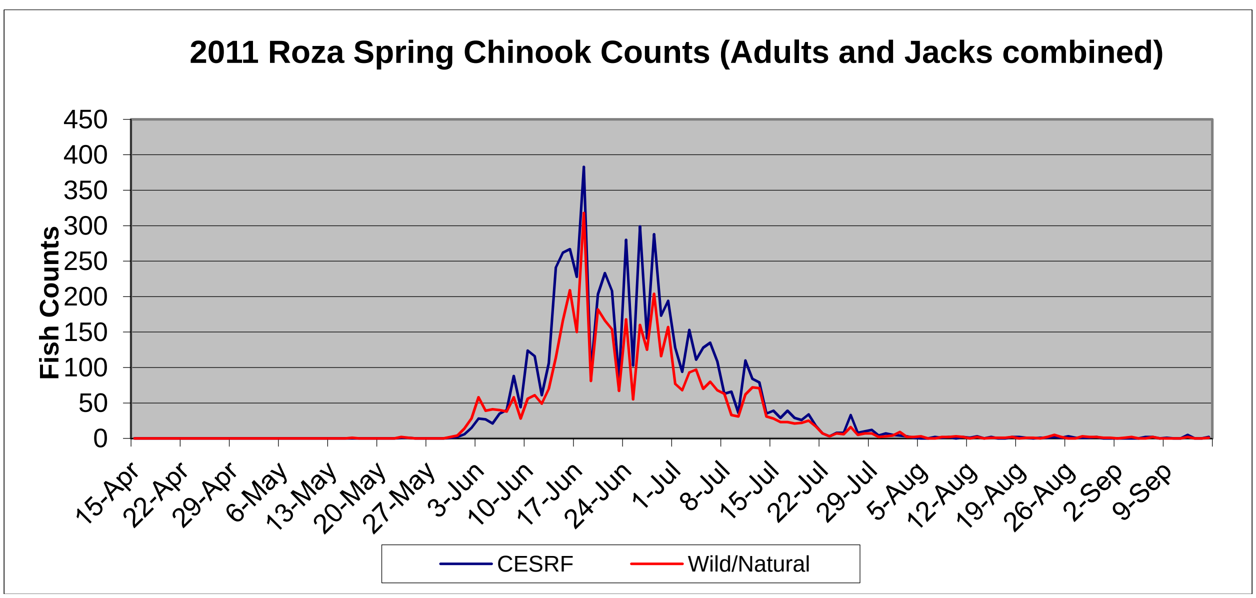


Figure 10. Daily passage counts for natural- and CESRF-origin spring Chinook at Roza Dam, 2011.

Coho

Video observations and trap sampling (22Sep2011 – 10Feb2012) were conducted at Roza Dam during the fall and winter months of 2011-12. A total of 367 adult and 16 jack coho were counted and/or sampled.

Cowiche Dam

Coho

Video observations were not conducted at Cowiche Dam in 2011.

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 2012. Redd counts in reservation creeks and tributaries were as follows.

Satus Creek : 152 redds

Toppenish Creek: 46 redds

Ahtanum Creek: No survey

Marion Drain: 7 redds

Conditions were very poor for surveys this year.

Data for steelhead redd surveys in the Naches River system (courtesy of G. Torretta USFS and Y. Reiss YBSRB) in the spring of 2012 were: Oak Creek – 35 redds; and Nile Creek – 25 redds. There were no redd surveys in Cowiche Creek this year.

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 2011 in the American River and ended in early October 2011 in the upper Yakima River. Total counts for the American, Bumping, Little Naches, and Naches rivers were respectively: 212, 175, 48, and 145 redds. Redd counts in the upper Yakima, Teanaway and the Cle Elum rivers were: 1663, 64, and 171, respectively. The entire Yakima basin had a total of 2,478 redds (Naches- 580 redds, upper Yakima- 1,898). Historical spring Chinook redd count data are provided in Appendix B.

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.: 331 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.: 1 redd. Surveys were conducted from Wapatox Dam to the mouth of the river.

Marion Drain: 59 redds. 55.9% of the redds were located above Hwy 97 up to Old Goldendale Road. The remaining 44.1% 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/.

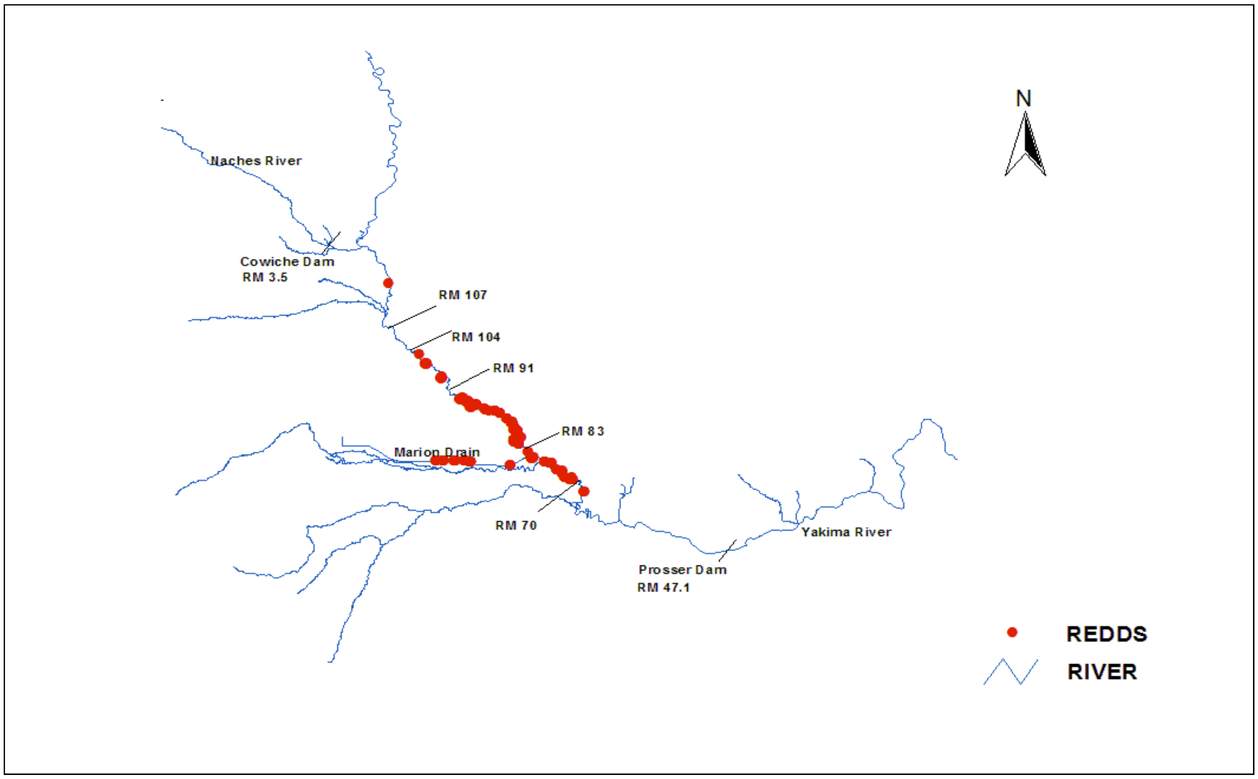


Figure 11. Distribution of fall Chinook redds in the Yakima River Basin in 2011.

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. 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. In 2011 conditions remained consistent from prior years, however spawning seemed to peak three separate times from October through December. Spawning began in mid October and continued into January. There were even live fish seen on redds the first week of February. This run elasticity may prove to be an adaptation that may be developing as in basin returns increase.

The 2009 coho redd count was the highest the YN has recorded. The 2010 redd count was approximately 678 redds (second only to 2009). The 2011 redd count was down from the previous two years to 521. The largest decrease seems to be in tributary spawning which correlated to the fall low flow conditions. Also, fish migration was delayed about 3 weeks at Nelson Dam on the Naches River due to complications with fish passage. Approximately 82 redds were found in the Upper Yakima River, an increase from 2010. The Naches River had 243 redds located mainly in the lower 5 miles, be we also observed redds scattered all the way up to the Lost Creek acclimation site. Taneum Creek had 100 redds from the 150 females that were planted. Redds were found in high densities around the Stiles Acclimation site and the Holmes Acclimation site. Only 196 redds were found in tributaries throughout the Yakima Basin (Table 2).

In the Naches River, Cowiche Creek had 14 redds located from the mouth up to the bottom of the canyon. This is a drop from 2010 when 23 redds were found in the same stretch of creek. A stream spanning PIT tag detector was installed in the winter of 2011/2012. The new PIT tag antenna was installed too late for adult coho returns but it will be used for adult returns in 2012.

Table 2. Yakima Basin Coho Redd Counts, 1998-2011.

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

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. We also observed our first natural returns from the Taneum Creek adult out-plant study. 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 12 shows the distribution of coho redds throughout the Yakima Basin based on observations from 2006 through 2009. These data continue to encompass the range of coho redd distribution.

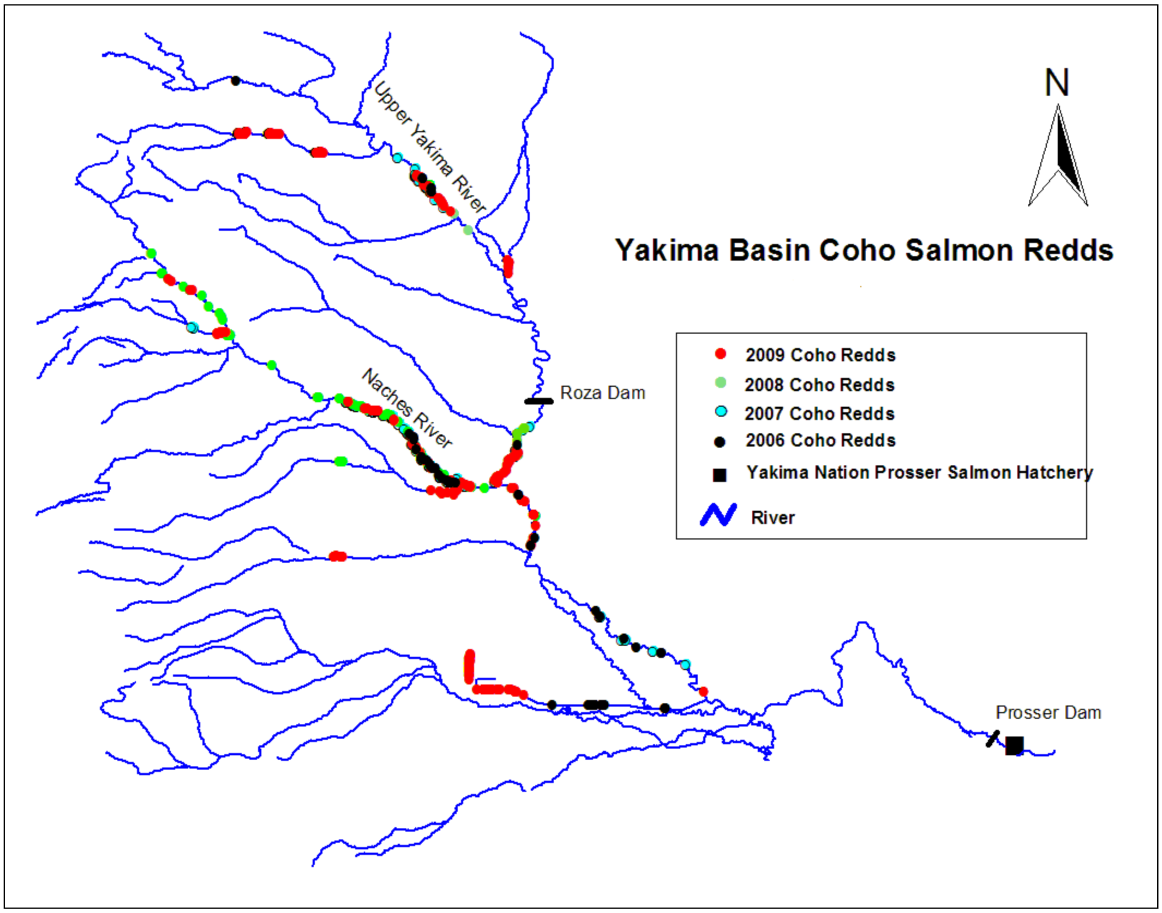


Figure 12. Distribution of coho redds in the Yakima River Basin.

Task 1.k Yakima Spring Chinook Residual/Precocial Studies

The WDFW annual report for this task can be located on the website: http://www.cbfish.org/Project.mvc/Publications/1995-063-25. This year's report is expected to be available soon. The most recent report is:

C. L. Johnson and G. M.Temple. 2011. Spring Chinook Salmon Competition / Capacity and Residual/Precocious Male Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report 2010.

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

The latest information on these studies are available on the website: http://www.cbfish.org/Project.mvc/Publications/1995-063-25 and in:

Schroder, S. L., C.M. Knudsen, T. W. Kassler, and C.A. Stockton. 2011. The breeding success of first- and second-generation hatchery spring Chinook salmon spawning in an artificial stream. Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report, May 2011 .

Knudsen, C.M., editor. 2011. Reproductive Ecology of Yakima River Hatchery and Wild Spring Chinook. Yakima/Klickitat Fisheries Project Monitoring and Evaluation, Annual Report 2010.

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., 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 2011 were not available at the time this report was produced. Available adult scale sample results for 2011 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 B.

Table 3. Age composition of salmonid adults sampled in the Yakima Basin in 2011.

	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	2	15.0	157	43.0	411	61.3	21	73.4
Upper Yakima Wild/Natural			44	47.0	389	61.6	13	75.8
Spawner Survey Samples								
Upper Yakima Supplementation			7	41.4	31	59.0		
Upper Yakima Wild/Natural			6	47.0	37	59.2		
American River Wild/Natural					16	65.7	13	79.1
Naches River Wild/Natural			3	44.3	36	61.3	6	77.2
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: No aerial or ground surveys were conducted in project year 2011. YN biologists continued to 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.

Additional work was done this project year to ground truth survival estimates used in EDT models through bypass systems at Wapato, Sunnyside, Prosser, and Horn Rapids Dams. This work is presented under Task 1.a and in Appendix A.

Task 1.o 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 2011. 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:

<u>Little Naches</u>

A total of 99 McNiel core samples were collected and processed from 9 spawning reaches in the Little Naches drainage this past year. The reach on Pyramid Creek was not sampled this past year due to road being decommissioned. Other means for accessing the Pyramid Creek reach need to be found. With this year's monitoring work, the data set for the Little Naches drainage now covers a time period of 27 years for the two historical reaches, and 20 years for the expanded sampling area that includes several tributary streams.

The average percent fine sediment less than 0.85mm for the entire Little Naches drainage has gone down from the previous year (cumulative average of 9.0% for 2011 compared to 11.1% for 2010). This compares to recent years when overall fine sediment conditions in the Little Naches drainage ranged from about 10.5% to 12% fines (Figure 13). The overall average fine sediment found in spawning substrate remains relatively low and should lessen mortality on incubating eggs and alevins. It is not surprising that fine sediment conditions have been fairly low and stable as little anthropogenic disturbance has been taking place in the drainage other than recreational activities. Timber harvest activity and road building has been minimal for several years. Landowners have also improved roads and trails to reduce sediment delivery. Further, enhanced stream protection measures have been instituted through the Northwest Forest Plan and the Central Cascades Habitat Conservation Plan for roughly the past 15 years. These factors have likely helped reduce fine sediment inputs to the stream system. However recreational activity, such as dispersed camping sites and off-road vehicle use near streams, continues to be a concern. Localized sediment delivery and loss of riparian vegetation from recreational use has been observed.

Stream flows may be having an effect on observed fme sediment levels. The Little Naches River has experienced some larger flood events in recent years. The U.S. Bureau of Reclamation maintains a stream gauge on the Little Naches River near its confluence. Annual maximum daily flows from 1992 to 2011 were evaluated along with fine sediment conditions observed later in the year. Generally observed fine sediment levels have been decreasing as peak flows have been elevating. Regression analysis was performed to further evaluate this relationship. Regression output indicated that peak flows explain some of the variability found in fine sediment levels ($R2 = 0.3397$; $p = 0.007$). A downward trend in fine sediment was apparent as peak flows increase. Higher flows can flush fine sediment out of spawning gravels, especially if incoming sediment delivery sources are stable or decreasing. Conversely, larger peak flows can also have major consequences if incubating eggs and fry are scoured from the substrate. Peak flow conditions warrant further attention and monitoring to determine what effect they may be having on salmonid production in the watershed.

At the reach scale, most of the sampling reaches had lower fine sediment rates than those found in 2010. Only the South Fork Little Naches Reach had appreciably higher fine sediment this year (increase from 11.0% to 13.4%). Most of this increase occurred on one riffle that has had substantial in-channel wood recruitment and channel shifting the past couple years. Some off-road vehicle and dispersed camping activity has also been observed upstream of this sampling riffle. All the remaining sampling reaches had lower or similar fine sediment rates compared to 2010. Five reaches decreased by more than two percentage points in average fine sediment (Little

Naches Reach 1, Little Naches Reach 2, Bear Creek Reach 2, Little Naches Reach 4, and North Fork Little Naches Reach 2). Two reaches had smaller reductions in fine sediment of approximately one percentage point (Little Naches Reach 3 and Bear Creek Reach 1), and one reach was nearly the same as last year (North Fork Little Naches Reach 1). Similar trends can be seen when looking at individual reach conditions over the longer term monitoring period since 1992. Most reaches, with the exception of the South Fork Little Naches, have had a declining level of fine sediment in recent years.

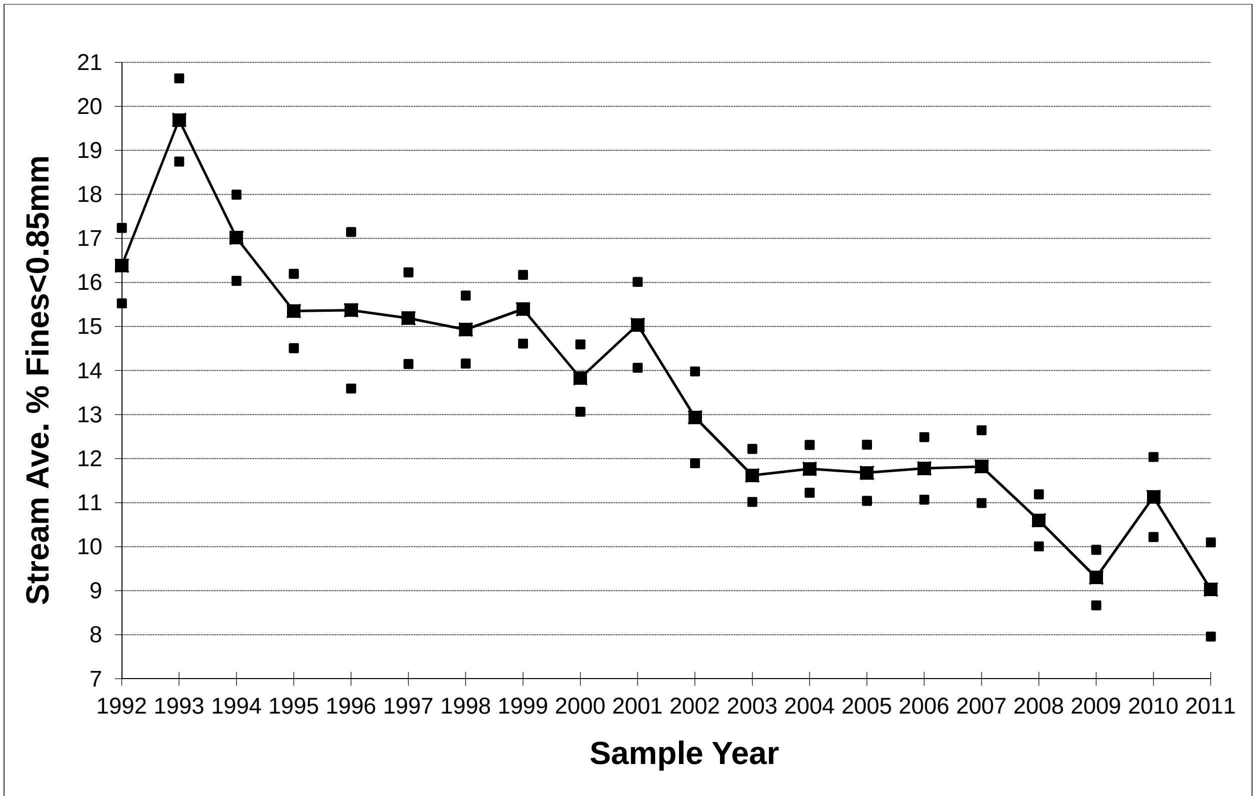


Figure 13. Overall Fine Sediment (<0.85mm) Trends with 95% confidence bounds in the Little Naches River Drainage, 1992-2011.

South Fork Tieton

One reach on the South Fork Tieton River (in the vicinity of Minnie Meadows) was sampled again this past season by the U.S. Forest Service. This marks 13 years that the USFS has been sampling this area. This stream reach typically receives significant bull trout spawning activity and the monitoring efforts provide valuable information on their spawning conditions. Average fine sediment levels in this reach decreased markedly from 13.6% in 2010 to 9.3% in 2011 (Figure 14). The 2011 sediment rates are comparable to the first year of sampling in 1999, which had the lowest level of fine sediment found in spawning gravels.

Upper Yakima

A total of 60 samples were collected and processed from the Upper Yakima River drainage this past year (5 reaches, 12 samples from each reach). The same reaches (Stampede Pass, Easton, Camelot to Ensign Ranch, Elk Meadows, and Cle Elum) have been sampled annually for the past 15 years. Although average fine sediment levels in the Easton and Cle Elum reaches increased from 2010, overall average percent fine sediment less than 0.85mm for the combined Upper Yakima drainage was the lowest observed over the fifteen years of sampling (Figure 15).

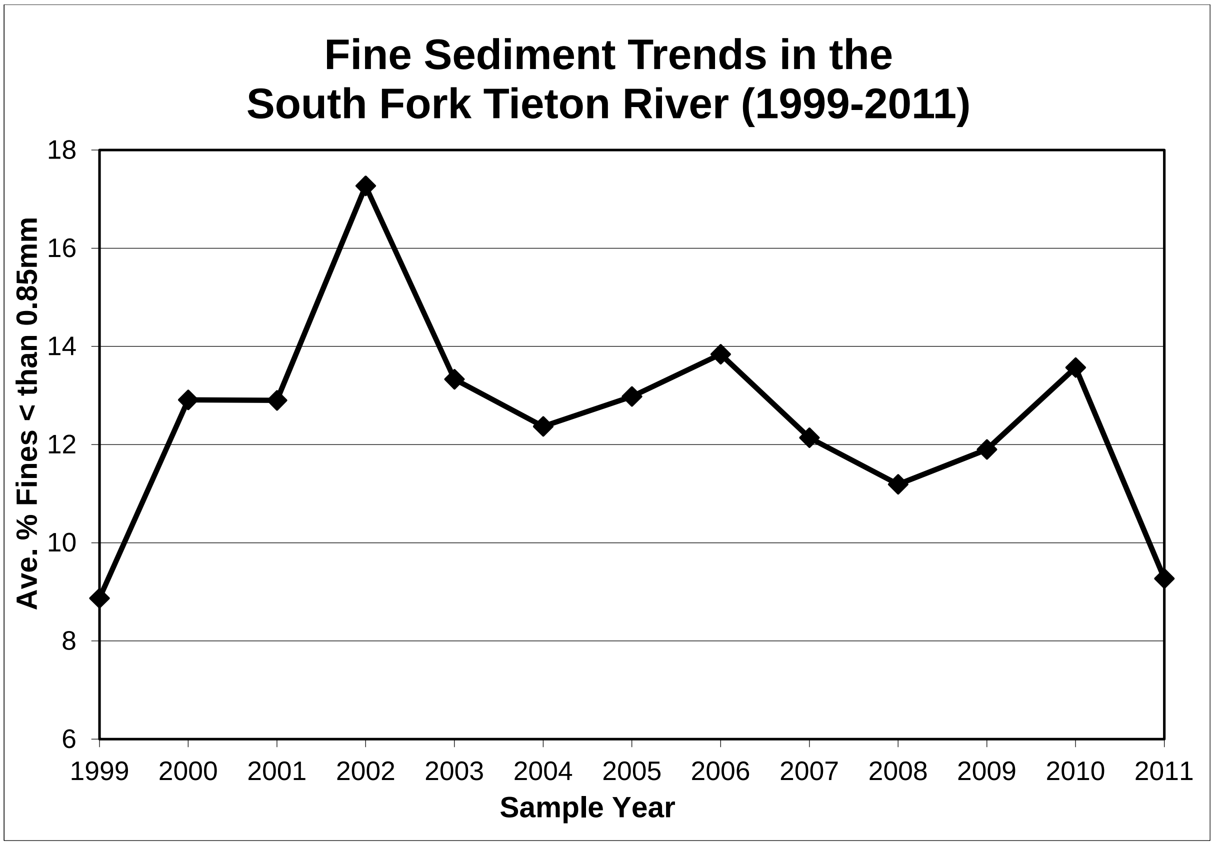


Figure 14. Fine Sediment Trends in the South Fork Tieton River, 1999-2011. Note: Data for 2007 were collected from only 1 Riffle.

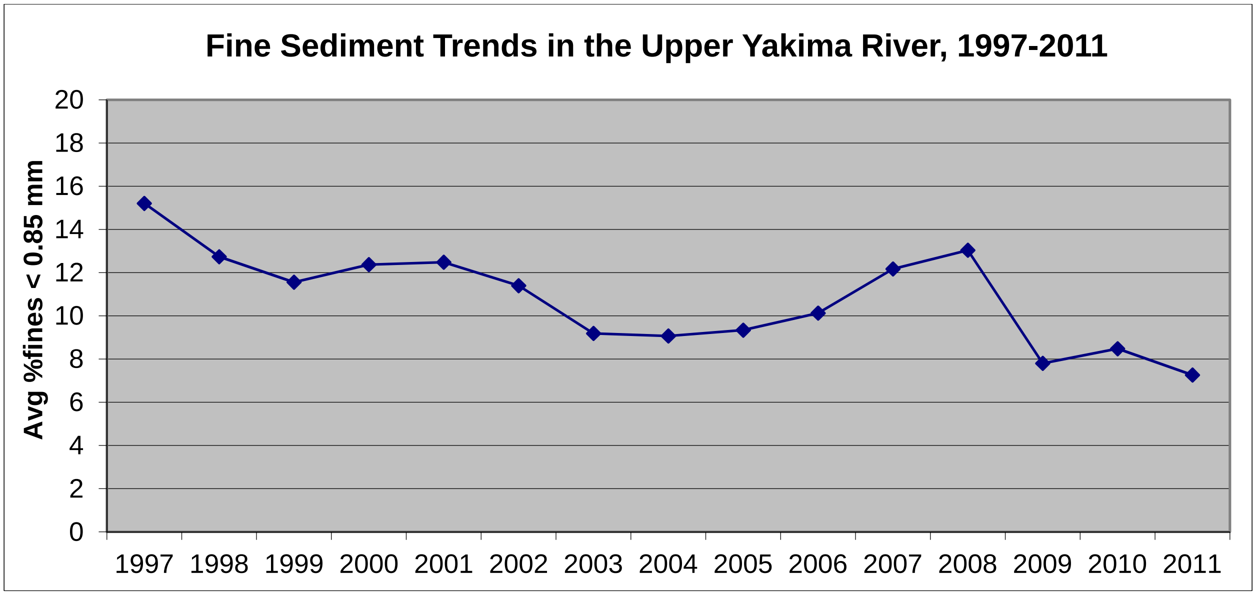


Figure 15. Overall average percent fine sediment (< 0.85 mm) in spawning gravels of the Upper Yakima River, 1997-2011.

<u>Summary</u>

The overall average fine sediment level in the Little Naches this past season was lower than last year. Overall average fine sediment in 2011 for all the samples in the Little Naches was 9.0%. This is the lowest level of average fine sediment found in Little Naches spawning gravels since sampling was expanded in 1992. This low rate of fine sediment should be conducive for egg and alevin survival. Data were similar for the Upper Yakima system, where overall average fine sediment in 2011 was 7.3%, the 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 noticeably lower than the previous year. Reach average fines in the South Fork decreased to 9.3% in 2011. These conditions are similar to the lowest levels observed in 1999 and should be favorable for early life history survival of bull trout.

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

Personnel Acknowledgements: Again, major credit goes to the fisheries technicians from the Yakama Nation who cored the many samples from the Little Naches, and processed 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 2002-2009 (Appendix C)
- Annual Report: Comparison of Transfer-Supplemented- and Unsupplemented-Feed Treatments evaluated on Hatchery-Reared Upper-Yakima Spring Chinook Smolt released in 2007, and 2009 through 2011 (Appendix D)
- Annual Report: Smolt Survival to McNary Dam of 1999-2011 Spring Chinook Releases PIT-tagged and/or released at Roza Dam (Appendix E)
- Prosser passage estimation issues (Appendix F)
- 2011 Annual Report: Smolt-to-smolt Survival to McNary Dam of Yakima Fall and Summer Chinook (Appendix G)
- Annual Report: 2011 Coho Smolt-to-smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin (Appendix H)

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 B. Historical results of this evaluation including results for the present year are given in Tables 46 and 47 of Appendix B.

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 B.

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, 2011.

River	Dates	Weekly Schedule	Notes	Chinook	Jacks	Steelhead	Coho
Yakima River	4/12-6/25	Noon Tues to 6 PM Saturday		1,665	956	1	0
Yakima River	9/13-11/26	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 website: http://www.cbfish.org/Project.mvc/Publications/1995-063-25. This year's report is expected to be available soon. The most recent report is:

Kassler, T.W., C. Bowman, C. Dean, A. Fritts, S. Peterson, and J. Von Bargen. 2011. Yakima/Klickitat Fisheries Project Genetic Studies, Yakima/Klickitat Fisheries Project Monitoring and Evaluation, Annual Report 2010.

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 2011 were consistent with the techniques used in 2001-2010. 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.

A new method was also instituted in 2006 and continued in 2007-11: 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 I of this annual report.

Progress (Executive Summary, see Appendix I 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.

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 2011 produced 28,072 tags tied to smolt mortality in the Yakima Basin. PIT tag numbers for 2011 are significantly larger than the previous 21,455 from 2010 surveys. Tags detected were linked to sources of release and 28,477of these tags were from Yakima River juvenile salmonids. Predation by Herons, shown by PIT tags discovered below heronries showed correlation with river flows. High flow correlated with less PIT tag numbers which may be a function of lower opportunity for wading bird as fish move faster through the basin. Conversely low flow correlated with higher PIT tag numbers, as low flow creates higher foraging opportunities for Herons.

PIT tag analysis was developed by determining detection efficiencies in 2 diverse rookeries to assess a number of undetected PIT tags. Results showed surveys of PIT tags may have a greater than 65% detection rate.

Plans for the 2012 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 these 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 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. Initial steps were taken in 2009 in identifying locations which would be suitable for the multi-pass removal population study. In early 2010, the YKFP began initial study checks to determine management and study goals for piscivorous fish. Presence and absence of piscivorous fish was determined through electro-fishing various sections of the Yakima River to determine temporal and spatial trends of each species of piscivorous fish.

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 16). 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.

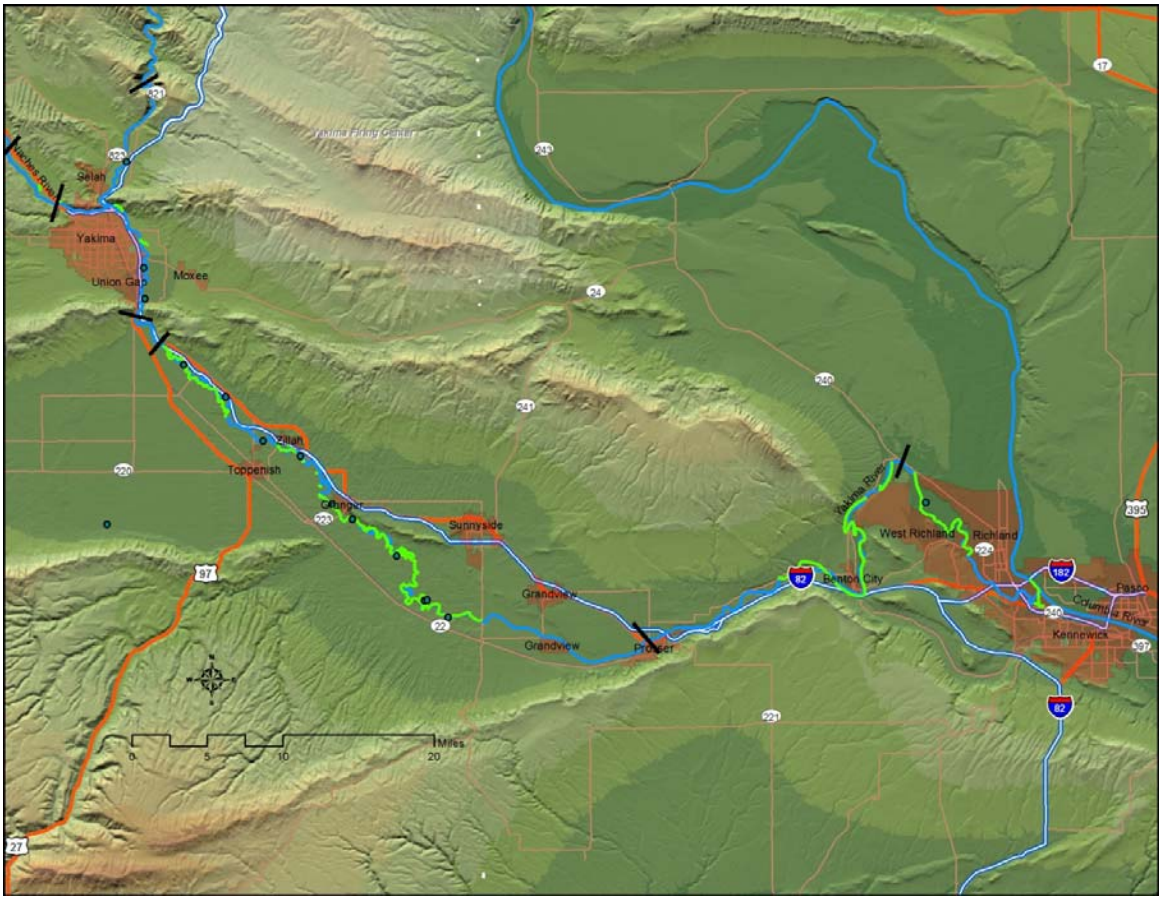


Figure 16. Yakima River Piscivorous Fish Populations Study Areas.

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.

Smallmouth Bass, the primary focus of the two pass removal population study, were once again found in higher numbers in the lower river. River conditions for the 2010 and the 2011 survey years were ideal for smolt passage as high a CFS was recorded during the smolt migration. High CFS also confounds electro-fishing surveys for piscivorous fish creating limited survey dates and catch numbers. Table 6 shows catch numbers by location for the study.

DATE	LOCATION	SPECIES	NUMBERS
2/7/2011	GRANGER	SMALLMOUTH BASS	1
3/9/2011	LOWER RIVER-KENNEWICK	SMALLMOUTH BASS	1
3/25/2011	Sub-basin Drain 35	SMALLMOUTH BASS	2
3/25/2011	WAYPOINT 216 SIDE CHANNEL	SMALLMOUTH BASS	1
4/19/2011	FRONT OF BATEMAN IS.	SMALLMOUTH BASS	1
5/4/2011	DELTA FRONT OF CAUSEWAY	SMALLMOUTH BASS	1
7/6/2011	BENTON	SMALLMOUTH BASS	26
7/11/2011	DELTA BEHIND CAUSEWAY	SMALLMOUTH BASS	1
7/11/2011	DELTA FRONT OF CAUSEWAY	SMALLMOUTH BASS	4
7/11/2011	DELTA YAKIMA RIVER	SMALLMOUTH BASS	1
7/11/2011	LOWER RIVER/BELOW HORN	SMALLMOUTH BASS	3
7/13/2011	BENTON	SMALLMOUTH BASS	28
9/8/2011	DELTA FRONT OF CAUSEWAY	SMALLMOUTH BASS	2
9/8/2011	DELTA YAKIMA RIVER	SMALLMOUTH BASS	1
9/8/2011	FRONT OF CAUSEWAY	SMALLMOUTH BASS	1
9/29/2011	MENINICK SPRING POND	SMALLMOUTH BASS	3
11/9/2011	DELTA BEHIND CAUSEWAY	SMALLMOUTH BASS	2
11/9/2011	DELTA FRONT OF CAUSEWAY	SMALLMOUTH BASS	1
11/17/2011	DELTA BEHIND CAUSEWAY	SMALLMOUTH BASS	1
11/17/2011	DELTA FRONT OF CAUSEWAY	SMALLMOUTH BASS	2
11/30/2011	DELTA BEHIND CAUSEWAY	SMALLMOUTH BASS	1

Table 6: Smallmouth Bass Catch Numbers for 2011.

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 and 2011.

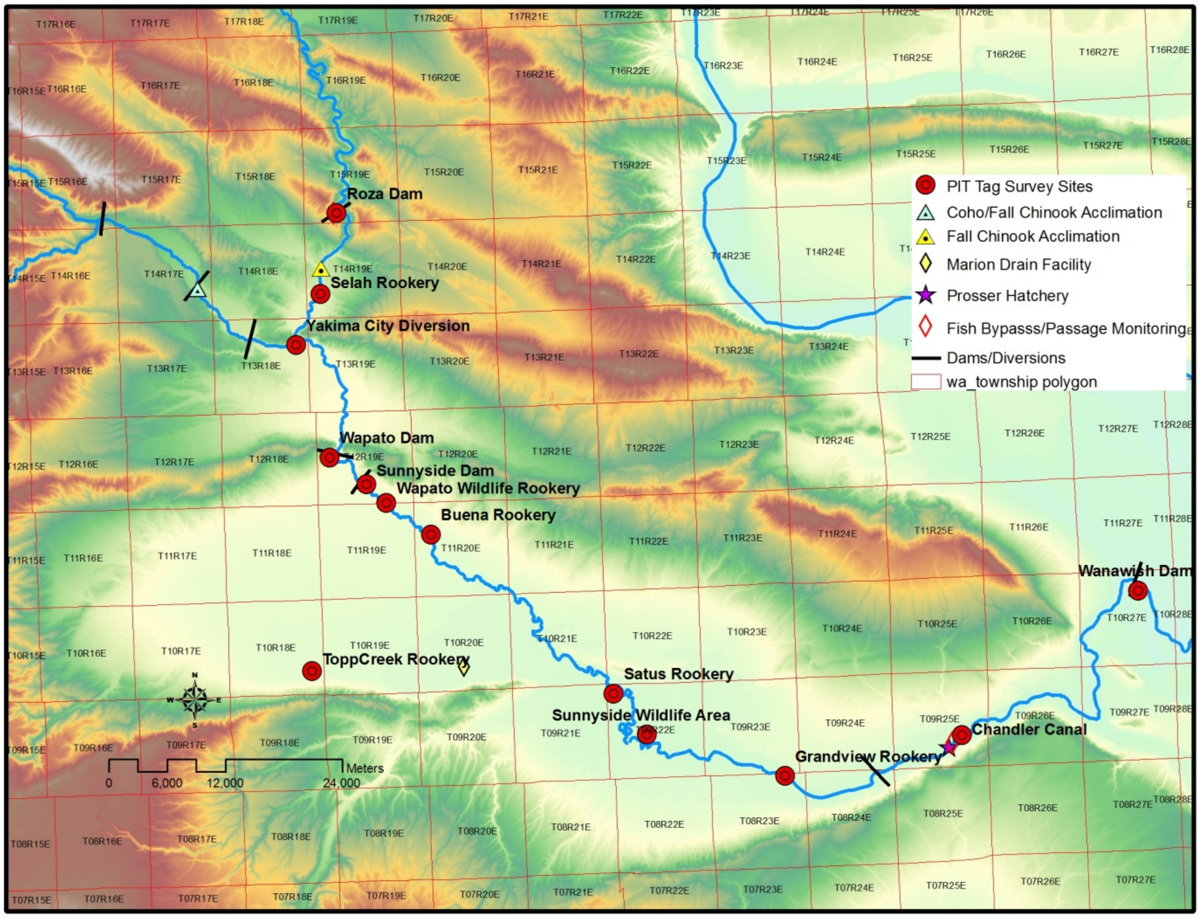


Figure 17. PIT tag survey sites (Includes Great Blue Heron Rookeries).

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 11,893 total PIT tags. Yakama Nation Juvenile PIT tags which produced a PTagis tagging detail record are shown in Table 7 and numbered 11,877. 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: Total PIT tag Numbers For 2011 - Irrigation 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	2012
Chinook	*Fall*	2977		7	8	1	27	124	379	515	893	747	76	200		
Chinook	Spring	4336	1	91	151	84	162	202	498	402	593	1017	605	382	148	
Chinook	Summer	2444											1824	434	186	
Chinook	Unknown	2				1	1									
Coho	Fall	136		27	24	23	62									
Coho	Unknown	1922						29	154	148	338	370	285	198	57	343
Sockeye	Summer	7													7	
Steelhead	Resident	2									1					1
Steelhead	Summer	48				2	1	1	9	1	5	13	5	3	8	
Steelhead	Unknown	3												3		

Table 7. PIT tags surveyed at Yakima Basin Irrigation Fish Screening Facilities shown by migration year and species (YINN tags).

Surveys were also carried out in depth at 3 Dams/Diversion sites. Results from surveys at these sites are described below.

The Chandler Fish Screening Facility located on the Chandler irrigation canal in Prosser, WA lies just below the Prosser Dam. The canal pulls an average of 1000 cfs of water during the irrigation season for irrigation and power production. The Yakama Nation operates a juvenile fish bypass facility which directs fish from the canal through the facility and returns them to the Yakima River. The YN is studying entrainment of fish in the canal and uses data from the juvenile sampling facility to provide estimates on juvenile smolt production for the Yakima Basin. The entrainment study releases PIT tagged fish directly into the canal and into the river above the canal to improve entrainment estimates.

YKFP Predation Study: Total PIT tag Numbers For 2011 - Chandler

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sockeye	*Summer*	1												**1**	
Chinook	Fall	1124	2	5		10	49	57	169	330	293	63	146		
Chinook	Spring	1678	20	10	5	31	34	49	147	303	543	261	178	97	
Chinook	Summer	961										716	195	50	
Chinook	Unknown	1				1									
Coho	Fall	8	1	4		3									
Coho	Unknown	491					1	15	27	125	116	98	26	6	77
Steelhead	Resident	1													1
Steelhead	Summer	8			1				1		3			3	
Steelhead	Unknown	3											3		

Table 8: Number of PIT tags sampled by year and species at Chandler Irrigation Diversion.

The Wapato irrigation diversion and fish screening facility is located on the Yakima River just Below Union Gap. It diverts an average of 1000 cfs of Yakima River water for irrigators within the Wapato Irrigation Project. The facility utilizes 3 diversion points and fish screens to collect fish, which were diverted into the irrigation canal, and return them to the Yakima River. The fish screening facility has been surveyed for PIT tags annually since 2008. In 2010, based on high numbers of PIT tags found within the facility, it was discovered that the fish return bypass pipes were virtually not operational. The problem was addressed the following season by the Bureau of Reclamation which operates the facility.

YKFP Predation Study: Total PIT tag Numbers For 2011 - 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	2012
Chinook	**Fall**	732						94	238	166	234				
Chinook	**Spring**	1331	13	89	14	22	41	354	51	70	358	181	123	15	
Chinook	**Summer**	1071										899	79	93	
Coho	**Fall**	55	5	10	2	38									
Coho	**Unknown**	845					12	131	63	85	157	163	162	33	39
Sockeye	**Summer**	4												4	
Steelhead	**Summer**	7						2			4			1	

Table 9: Number of PIT tags sampled by year and species at Wapato Irrigation Diversion.

The Sunnyside irrigation diversion is located below the Wapato Dam near the town of Parker, WA. The Sunnyside Canal diverts an average of 1000 cfs.

YKFP Predation Study: Total PIT tag Numbers For 2011 - 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	2012
Chinook	***Fall***	565						**2**	**41**	**193**	**124**	**151**		**54**		
Chinook	**Spring**	1492	1	55	88	54	88	98	236	152	174	191	195	132	28	
Chinook	**Summer**	850											611	196	43	
Chinook	**Unknown**	1				1										
Coho	**Fall**	89		22	12	20	35									
Coho	**Unknown**	851						18	63	83	121	141	91	88	19	227
Sockeye	**Summer**	2													2	
Steelhead	**Resident**	1									1					
Steelhead	**Summer**	3							2		1					
Steelhead	**N/A**	1													1	
Steelhead	**Resident**	12										3	3	5		
Steelhead	**Summer**	381					9	24	69	73	13	30	35	58	46	24

Table 10: Number of PIT tags sampled by year and species at Sunnyside Diversion.

Surveys were also conducted within various other irrigation diversion fish screening facilities in the Yakima Basin. Roza, Satus, Wanawish, Townditch, and Toppenish Creek Diversions were all surveyed in 2011. These diversions produced PIT tags of YINN smolt mortalities in low numbers.

New monitoring of diversions is currently being implemented to assess the smolt passage through irrigation diversion fish screening facilities. YKFP is currently testing PIT tag antennas placed within the Sunnyside Fish Screening facility to ascertain smolt passage. Preliminary results have shown the PIT antennas function well within the facility. Fish releases directly into canals where PIT antennas have been placed within the fish screening facility is planned for the future.

Task 4.c Upper Yakima Spring Chinook NTTOC Monitoring

The WDFW annual report for this task can be located on the website: http://www.cbfish.org/Project.mvc/Publications/1995-063-25. This year's report is expected to be available soon. The most recent report is:

Temple, G.M., T.D. Webster, Z.J. Mays, T.D. DeBoer and N.D. Mankus. 2011. Ecological Interactions between Non-target Taxa of Concern and Hatchery Supplemented Salmon. Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report. Annual Report 2010.

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APPENDICES A through I

	Task	
A.	1.a.	Yakima River Bypass Survival Study
B.		Yakima River / CESRF Spring Chinook Salmon – Yakama Nation Data Summary
C.	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 2002-2009
D.	1.c.	IntStats, Inc. Annual Report: Comparison of Salt-Water-Transfer-Supplemented-Feed and Unsupplemented-Feed Treatments evaluated on Natural-Origin Hatchery-Reared Upper-Yakima Spring Chinook Smolt released in 2007 and 2009 through 2011
E.	1.d.	IntStats, Inc. Annual Report: Smolt Survival to McNary Dam of 1999-2011 PIT-tagged Spring Chinook released or detected at Roza Dam
F.	1.e.	IntStats, Inc. Prosser-Passage Estimation Issues
G.	1.f.	IntStats, Inc. Annual Report: Smolt-to-Smolt Survival to McNary Dam of Yakima Fall and Summer Chinook
H.	1.g.	Intstats, Inc. Annual Report: 2011 Coho Smolt-to-Smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin
I.	4.a.	Avian Predation Annual Report

Appendix A

Yakima River Bypass Survival Study

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for

The Yakima/Klickitat Fisheries Project

April 30, 2011

Abstract

In an effort to estimate survival through the bypass system, a total of 42 paired releases (fish released just inside headgates and just below the outfall mixing zone) of PIT-tagged Chinook and coho salmon smolts were made at three Yakima River diversion dams (Roza, Sunnyside and Prosser) during the outmigration seasons of 2003 – 2010. Survival was estimated for “yearlings” (yearling Chinook and coho salmon) and “subyearlings” (subyearling Chinook). Bypass survival was estimated as the regression of the detection proportion of headgates fish on the detection proportion of below-outfall fish (yearlings and subyearlings over all months), and as the ratio of the detection proportion of headgates fish to the detection proportion of below-outfall fish. By the regression technique, bypass survival over the outmigration season for yearlings and subyearlings combined was 76, 78 and 80% at Prosser, Sunnyside and Roza Dam, respectively. By the ratio method, survival of yearlings at Prosser Dam was 82.8 and 72.1% in April and May, respectively, while subyearling survival in June was 64.0%. At Sunnyside Dam, yearling survival in May was 84.4%, while subyearling survival in May and June was 92.6 and 97.2%, respectively. Bypass survival for yearlings at Roza Dam was 89.1 and 84.1% in April and May, respectively. The empirical estimates for yearlings were generally consistent with existing estimates in the EDT model and elsewhere, but the survival estimates for subyearlings ranged from 12 to 30% (mean 21%) higher than existing estimates.

The upper bound of the 95% confidence interval of survival estimates included 100% 83.3, 71.4 and 48.3% of the time for Roza, Sunnyside and Prosser Dam, respectively. The frequency with which survival confidence intervals included 100% (no bypass mortality) was attributed to small release numbers and/or low detection proportions and large resulting standard errors.

Across all dams, bypass survival was negatively correlated with release day and water temperature on and surrounding the day of release, and positively correlated with migration time to McNary Dam. The seasonal and temperature effects were attributed to increased metabolic rates of piscivorous fish under higher temperatures, while the increase in survival with mean travel time to McNary was assumed to reflect the increased probability of surviving to McNary for slower moving fish when conditions are good for survival. There were no correlations between yearling bypass survival and river flow, canal flow, percent discharge diverted or mean size of fish released. There was no significant regression between subyearling survival and candidate predictor variables, although the relationship between mean length and survival was significant at the 0.1 level.

Migration speed, as reflected by travel time to McNary Dam, was greater for yearling smolts than subyearlings, for fish migrating later in the season and for fish migrating greater distances. McNary travel time for yearlings ranged from about three weeks in late March or early April to a week or less in mid to late May. McNary travel time for

subyearlings ranged from five weeks in mid May to 10 days in mid June. Over 90% of releases that could be tested with the 2-sample KS test were well mixed in time as they passed McNary Dam.

When revised bypass survival estimates were incorporated into the EDT model, equilibrium abundance for all stocks of Yakima spring Chinook increased from the pre-revision estimate of 4,285 to 5,202 (a 21.4% increase), while summer Chinook abundance increased from 3,219 to 7,805 (a 142.5% increase). The difference between spring and summer Chinook was attributed to the fact 49% of Yakima summer Chinook were assumed to smolt as subyearlings while spring Chinook were assumed smolt exclusively as yearlings. Relative to current estimates, revised bypass survival increased much more for subyearlings than yearlings. This difference is reflected in the productivity estimates under the revised bypass scenarios, which increased from 3.0 to 3.2 for all stocks of spring Chinook, a 6.2% increase, while summer Chinook productivity increased from 1.4 to 2.0, a 50.3% increase. Under the revised bypass scenario the EDT model projected abundance increases of 13, 37 and 41% for Upper Yakima, Naches and American River spring Chinook, respectively. The smaller impact on the upper Yakima stock was due to the fact only upper Yakima outmigrants passed Roza Dam and the revised bypass survival at Roza Dam decreased relative to current estimates for the months of March and April.

In an attempt to gauge the importance of bypass mortality at the four dams targeted by this study, EDT scenarios were run in which revised bypass morality was doubled or set to zero. A scenario was also run under which bypass mortality at all dams in the Yakima Subbasin was set to zero. Relative to current estimates, the abundance of summer Chinook and all stocks of spring Chinook except the upper Yakima stock still increased when revised bypass mortality was doubled, and the decrease in upper Yakima spring Chinook abundance was marginal. When bypass mortality was totally eliminated, the abundance of summer Chinook and all stocks of spring Chinook increased by 164 and 39%, respectively. The importance of the particular dams targeted by this study to spring and summer Chinook was highlighted by the fact that 87% of the abundance increase associated with the elimination of bypass mortality throughout the basin could be achieved by the eliminating mortality at just the four targeted dams.

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INTRODUCTION

This study attempts to quantify the effect of smolt losses incurred in juvenile bypass systems of irrigation diversions in the Yakima Basin. The Yakima Valley is well known for intensively irrigated agriculture, and hundreds of structures divert water from the Yakima River and its tributaries. In aggregate, these diversions undoubtedly caused major losses of outmigrating smolts during historical times, and may well have been responsible for much of the initial decline in production of Yakima salmon and steelhead (Tuck 1995). The Bonneville Power Administration undertook a series of retrofitting projects on Yakima Basin diversions in the 1980s and 1990s that greatly reduced juvenile mortality attributable to entrainment and physical trauma at bypass systems throughout the basin (Neitzel et al. 1990). However, some concern remains about the efficacy of the retrofitted bypass systems, especially as they may affect losses to birds and fish that prey on smolts. Smallmouth bass (*Micropterus dolomieu*) and/or northern pikeminnow (*Pteichocheilus oregonensus*) have been observed congregating in the outfall areas of the diversions at Roza, Wapato, Sunnyside and, especially, Prosser Dams (Fast et al. 1991), and several species of gulls and American white pelicans have been documented feeding on smolts in the outfall zones of Chandler Canal and immediately below Horn Rapids Dam (Stephenson et al. 2006). Although it has been speculated that substantial numbers of smolts are lost to predators congregating inside bypass systems and within the outfall area, such a mechanism has not been conclusively demonstrated. More importantly, the precise magnitude of bypass mortality, of whatever mechanism, has not been determined. This study attempts to estimate bypass survival at three of the major diversion dams in the lower Yakima River, to assess the degree of correlation between bypass survival and plausible predictor variables, and to estimate production of Yakima spring and summer Chinook under specified scenarios of bypass survival.

The three diversion dams and bypass systems that were studied directly were located on the Yakima River. Upstream to downstream, the diversion dams were Roza Dam (RM 129), Sunnyside Dam (RM 104) and Prosser Dam (RM 47). A fourth facility, Wapato Dam (RM 103) was included in production estimates based on study findings because it is only a mile upstream of Sunnyside Dam and might, absent aberrant conditions, reasonably be supposed to subject outmigrants to the same survival conditions as Sunnyside Dam.

The four facilities analyzed include the largest points of diversion in the basin. At the peak of the irrigation season (July - September), each facility diverts from 1,000 to 1,600 cfs, or from 50 to 70 percent of the flow approaching the dam. Smolt entrainment rates at Prosser Dam sometimes exceed the percent discharge diverted (PDD), occasionally reaching 75 or 80 percent (Neeley 2002). Assuming entrainment rates at other large diversion dams are similar to those observed at Prosser Dam, cumulative smolt losses over multiple diversions can be quite serious if bypass mortality is not negligible. For example, if mean smolt entrainment into the four canal/bypass systems targeted by this study is 30% over the course of the outmigration, and if bypass mortality is 20% in each bypass, over 22% of brood year smolt production would be lost due to these bypass systems alone. Considerations such as this were the motivation behind this study.

In addition to estimating bypass mortality at major diversion dams, this study will shed some light on the factors affecting the magnitude of bypass mortality, and will estimate the impact of a range of plausible bypass mortality rates on equilibrium production of Yakima spring and summer Chinook.

METHODS

Bypass survival at the targeted diversions was estimated by analyzing paired releases of Chinook salmon smolts implanted with Passive Integrated Transponder (PIT) tags. The paired releases at Roza and Sunnyside occurred in the spring of 2009 and 2010, and were explicitly intended to estimate bypass survival. The releases at Prosser Dam were originally intended to estimate smolt entrainment rate and related factors, and were made over the years 2003 through 2008 (see Table 1 for a summary of all releases analyzed). The generic layout of all paired releases is schematically summarized in Figure 1.

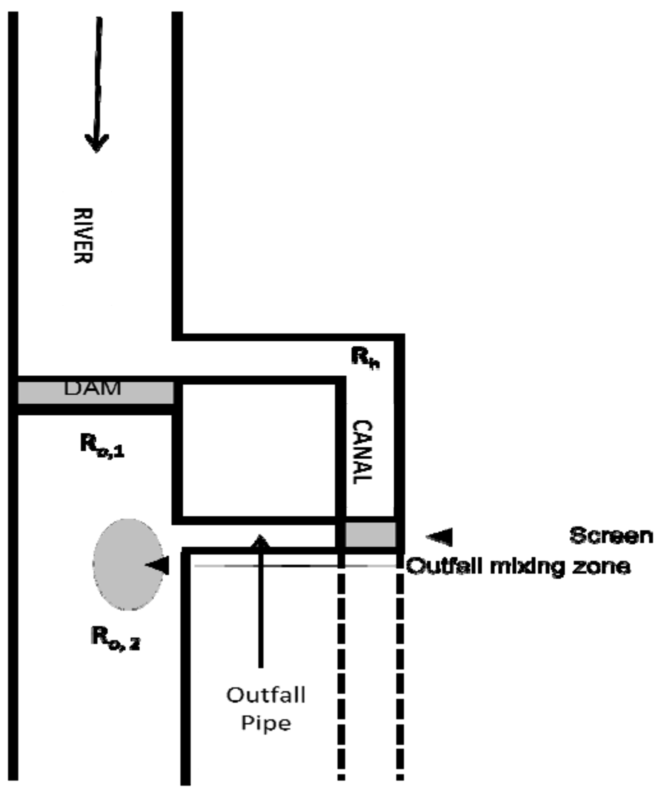

Figure 1. Layout of paired releases of PIT-tagged smolts used to estimate bypass survival.

Table 1. Releases of yearling (primarily spring Chinook) and subyearling (fall Chinook) smolts analyzed for bypass corridor survival. Blue text denotes subyearling fall Chinook.

Dam	Release Point	Date/Time Released	Experimental Subjects	Mean Fork Length (mm)	Number Released	File Name
Prosser	Just below Prosser Dam	4/2/03 18:25	Wild actively migrating spring Chinook yearling smolts captured on site	138.0	197	BDW03091.BEL
Prosser	Just inside Headgates	4/2/03 18:20	Wild actively migrating spring Chinook yearling smolts captured on site	131.3	200	BDW03091.CAN
Prosser	Just below Prosser Dam	4/9/03 18:31	Wild actively migrating spring Chinook yearling smolts captured on site	130.3	154	BDW03098.BEL
Prosser	Just inside Headgates	4/9/03 18:20	Wild actively migrating spring Chinook yearling smolts captured on site	130.6	144	BDW03098.CAN
Prosser	Just below Prosser Dam	4/16/03 19:15	Actively migrating wild & hatchery spring Chinook smolts captured on site	138.1	386	BDW03105.BEL
Prosser	Just inside Headgates	4/16/03 18:32	Actively migrating wild & hatchery spring Chinook smolts captured on site	136.5	379	BDW03105.CAN
Prosser	Just below Prosser Dam	4/23/03 19:49	Actively migrating wild & hatchery spring Chinook smolts captured on site	134.5	375	BDW03112.BEL
Prosser	Just inside Headgates	4/23/03 19:41	Actively migrating wild & hatchery spring Chinook smolts captured on site	134.1	347	BDW03112.CAN
Prosser	Just below Prosser Dam	4/30/03 18:11	Wild actively migrating spring Chinook yearling smolts captured on site	133.5	100	BDW03119.BEL
Prosser	Just inside Headgates	4/30/03 18:16	Actively migrating wild & hatchery spring Chinook smolts captured on site	135.6	192	BDW03119.CAN
Prosser	Just below Prosser Dam	5/7/03 18:40	Actively migrating wild & hatchery spring Chinook smolts captured on site	129.0	198	BDW03126.BEL
Prosser	Just inside Headgates	5/7/03 18:46	Wild actively migrating spring Chinook yearling smolts captured on site	131.3	249	BDW03126.CAN
Prosser	Just below Prosser Dam	5/28/03 19:43	Actively migrating hatchery and wild Chinook smolts, primarily yearlings, captured on site	116.5	200	BDW03147.BEL
Prosser	Just inside Headgates	5/28/03 19:47	Actively migrating hatchery and wild yearling Chinook and coho smolts captured on site	124.2	329	BDW03147.CAN
Prosser	Just below Prosser Dam	6/20/03 19:00	Actively migrating unmarked subyearling fall Chinook captured on site	92.1	236	BDW03170.BEL
Prosser	Just inside Headgates	6/20/03 19:07	Actively migrating unmarked subyearling fall Chinook captured on site	92.9	199	BDW03170.CAN
Prosser	Just below Prosser Dam	4/8/04 19:10	Wild actively migrating spring Chinook yearling smolts captured on site	147.4	99	DTL04098.BEL
Prosser	Just inside Headgates	4/8/04 19:06	Wild actively migrating spring Chinook yearling smolts captured on site	147.1	118	DTL04098.CA1
Prosser	Just below Prosser Dam	4/14/04 19:41	Wild actively migrating spring Chinook yearling smolts captured on site	143.8	96	DTL04104.BEL

Dam	Release Point	Date/Time Released	Experimental Subjects	Mean Fork Length (mm)	Number Released	File Name
Prosser	Just inside Headgates	4/14/04 19:36	Wild actively migrating spring Chinook yearling smolts captured on site	136.7	101	DTL04104.CA1
Prosser	Just below Prosser Dam	4/21/04 19:07	Wild actively migrating spring Chinook yearling smolts captured on site	135.4	103	DTL04111.BEL
Prosser	Just inside Headgates	4/21/04 19:03	Wild actively migrating spring Chinook yearling smolts captured on site	131.0	101	DTL04111.CA1
Prosser	Just below Prosser Dam	2/9/05 17:49	Wild actively migrating spring Chinook yearling pre-smolts captured on site	110.2	149	DTL05039.BEL
Prosser	Just inside Headgates	2/9/05 17:40	Wild actively migrating spring Chinook yearling pre-smolts captured on site	109.5	86	DTL05039.CA1
Prosser	Just below Prosser Dam	2/23/05 17:57	Wild actively migrating spring Chinook yearling pre-smolts captured on site	109.8	119	DTL05053.BEL
Prosser	Just inside Headgates	2/23/05 18:02	Wild actively migrating spring Chinook yearling pre-smolts captured on site	110.2	70	DTL05053.CA1
Prosser	Just below Prosser Dam	4/8/05 18:59	Wild actively migrating spring Chinook yearling smolts captured on site	135.6	101	DTL05097.BEL
Prosser	Just inside Headgates	4/8/05 19:08	Wild actively migrating spring Chinook yearling smolts captured on site	137.8	51	DTL05097.CA1
Prosser	Just below Prosser Dam	4/13/05 19:03	Wild actively migrating spring Chinook yearling smolts captured on site	122.3	88	DTL05102.BEL
Prosser	Just inside Headgates	4/13/05 18:57	Wild actively migrating spring Chinook yearling smolts captured on site	129.9	34	DTL05102.CA1
Prosser	Just below Prosser Dam	4/27/05 19:02	Actively migrating wild & hatchery spring Chinook yearling smolts	132.8	401	DTL05116.BEL
Prosser	Just inside Headgates	4/27/05 19:25	Actively migrating wild & hatchery spring Chinook yearling smolts captured on site	132.4	200	DTL05116.CA1
Prosser	Just below Prosser Dam	5/11/05 20:00	Actively migrating hatchery & wild yearling Chinook and coho smolts captured on site	128.9	168	DTL05130.BEL
Prosser	Just inside Headgates	5/11/05 19:50	Actively migrating hatchery & wild yearling Chinook and coho smolts captured on site	129.5	111	DTL05130.CA1
Prosser	Just below Prosser Dam	6/8/05 20:08	Actively migrating unmarked subyearling fall Chinook captured on site	92.0	74	DTL05158.BEL
Prosser	Just inside Headgates	6/8/05 20:00	Actively migrating unmarked subyearling fall Chinook captured on site	96.2	34	DTL05158.CA1
Prosser	Just below Prosser Dam	4/12/06 19:10	Wild actively migrating spring Chinook yearling smolts captured on site	130.4	108	DTL06101.BEL
Prosser	Just inside Headgates	4/12/06 19:24	Wild actively migrating spring Chinook yearling smolts captured on site	134.2	51	DTL06101.CA1
Prosser	Just below Prosser Dam	4/26/06 19:00	Actively migrating wild & hatchery yearling spring Chinook captured on site	115.6	354	DTL06115.BEL
Prosser	Just inside Headgates	4/26/06 18:54	Actively migrating wild & hatchery yearling spring Chinook captured on site	119.5	201	DTL06115.CA1

Dam	Release Point	Date/Time Released	Experimental Subjects	Mean Fork Length (mm)	Number Released	File Name
Prosser	Just below Prosser Dam	5/10/06 18:40	Actively migrating wild & hatchery yearling spring Chinook captured on site	117.8	238	DTL06129.BEL
Prosser	Just inside Headgates	5/10/06 18:35	Actively migrating wild & hatchery yearling spring Chinook captured on site	117.9	130	DTL06129.CA1
Prosser	Just below Prosser Dam	6/28/06 20:37	Actively migrating unmarked subyearling fall Chinook captured on site	90.8	171	DTL06178.BEL
Prosser	Just inside Headgates	6/28/06 20:25	Actively migrating unmarked subyearling fall Chinook captured on site	93.1	88	DTL06178.CA1
Prosser	Just below Prosser Dam	4/11/07 6:58	Actively migrating wild & hatchery yearling spring Chinook captured on site	122.8	135	DTL07100.BEL
Prosser	Just inside Headgates	4/11/07 6:51	Actively migrating wild & hatchery yearling spring Chinook captured on site	123.3	68	DTL07100.CA1
Prosser	Just below Prosser Dam	4/25/07 20:15	Actively migrating wild & hatchery yearling spring Chinook captured on site	134.0	292	DTL07114.BEL
Prosser	Just inside Headgates	4/25/07 20:15	Actively migrating wild & hatchery yearling spring Chinook captured on site	131.2	195	DTL07114.CA1
Prosser	Just below Prosser Dam	5/9/07 19:14	Actively migrating wild & hatchery yearling spring Chinook captured on site	129.3	89	DTL07128.BEL
Prosser	Just inside Headgates	5/9/07 19:09	Actively migrating hatchery & wild Chinook and coho yearling smolts captured on site	138.7	81	DTL07128.CA1
Prosser	Just below Prosser Dam	5/16/07 19:27	Actively migrating unmarked yearling coho smolts captured on site	144.6	90	DTL07135.BEL
Prosser	Just inside Headgates	5/16/07 19:09	Actively migrating unmarked yearling coho smolts captured on site	144.4	45	DTL07135.CA1
Prosser	Just below Prosser Dam	5/30/07 20:10	Unknown fall Chinook and Coho	135.4	240	DTL07149.BEL
Prosser	Just inside Headgates	5/30/07 20:00	Unknown fall Chinook and Coho	132.8	120	DTL07149.CA1
Prosser	Just below Prosser Dam	6/13/07 19:42	Actively migrating unmarked Chinook subyearling smolts & some unmarked coho smolts	116.9	98	DTL07163.BEL
Prosser	Just inside Headgates	6/13/07 19:37	Actively migrating unmarked Chinook subyearling smolts & some unmarked coho smolts	110.4	50	DTL07163.CA1
Prosser	Just below Prosser Dam	4/18/08 19:00	Actively migrating wild spring Chinook yearling smolts captured on site	129.9	300	DTL08108.BEL
Prosser	Just inside Headgates	4/18/08 19:00	Actively migrating wild spring Chinook yearling smolts captured on site	132.4	300	DTL08108.CA1
Roza	Just inside headgates	4/10/09 14:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	119.1	250	DTL09100.R13
Roza	Below outfall	4/10/09 14:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	118.2	250	DTL09100.R14
Roza	Just inside headgates	4/16/09 14:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	118.8	250	DTL09105.R15

Dam	Release Point	Date/Time Released	Experimental Subjects	Mean Fork Length (mm)	Number Released	File Name
Roza	Below outfall	4/16/09 14:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	117.3	250	DTL09105.R16
Roza	Just inside headgates	4/22/09 14:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	120.3	250	DTL09111.R17
Roza	Below outfall	4/22/09 14:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	120.7	250	DTL09111.R18
Roza	Just inside headgates	4/29/2009 9:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	124.7	250	DTL09119.R19
Roza	Below outfall	4/29/2009 9:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	124.2	250	DTL09119.R20
Roza	Just inside headgates	5/5/2009 9:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	125.5	250	DTL09125.R21
Roza	Below outfall	5/5/2009 9:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	124.9	250	DTL09125.R22
Roza	Just inside headgates	5/14/2009 9:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	127.0	250	DTL09133.R23
Roza	Below outfall	5/14/2009 9:00	Actively migrating hatchery spring Chinook yearling smolts captured on site	125.2	250	DTL09133.R24
Sunnyside	Just inside headgates	5/8/2009 19:10	Actively migrating hatchery spring Chinook yearling smolts captured at Roza Dam & released at Sunnyside Dam	131.9	250	DTL09127.SCA
Sunnyside	Below outfall	5/8/2009 19:00	Actively migrating hatchery spring Chinook yearling smolts captured at Roza Dam & released at Sunnyside Dam	132.7	250	DTL09127.SBL
Sunnyside	Just inside headgates	5/15/2009 19:10	Actively migrating hatchery spring Chinook yearling smolts captured at Roza Dam & released at Sunnyside Dam	132.7	240	DTL09134.SCA
Sunnyside	Below outfall	5/15/2009 19:00	Actively migrating hatchery spring Chinook yearling smolts captured at Roza Dam & released at Sunnyside Dam	131.6	240	DTL09134.SBL
Sunnyside	Just inside headgates	5/22/2009 19:10	Actively migrating hatchery spring Chinook yearling smolts captured at Roza Dam & released at Sunnyside Dam	129.7	240	DTL09141.SCA
Sunnyside	Below outfall	5/22/2009 19:00	Actively migrating hatchery spring Chinook yearling smolts captured at Roza Dam & released at Sunnyside Dam	129.5	239	DTL09141.SBL
Sunnyside	Just inside headgates	5/20/2010 8:10	Subyearling hatchery fall Chinook transported directly from rearing facility to Sunnyside Dam	68.7	807	DTL10138.SCA
Sunnyside	Below outfall	5/20/2010 8:00	Subyearling hatchery fall Chinook transported directly from rearing facility to Sunnyside Dam	68.5	801	DTL10138.SBL
Sunnyside	Just inside headgates	5/28/2010 8:10	Subyearling hatchery fall Chinook transported directly from rearing facility to Sunnyside Dam	70.2	805	DTL10147.SCA
Sunnyside	Below outfall	5/28/2010 8:00	Subyearling hatchery fall Chinook transported directly from rearing facility to Sunnyside Dam	67.2	801	DTL10146.SBL

Dam	Release Point	Date/Time Released	Experimental Subjects	Mean Fork Length (mm)	Number Released	File Name
Sunnyside	Just inside headgates	6/4/2010 8:10	Subyearling hatchery fall Chinook transported directly from rearing facility to Sunnyside Dam	66.8	802	DTL10154.SCA
Sunnyside	Below outfall	6/4/2010 8:00	Subyearling hatchery fall Chinook transported directly from rearing facility to Sunnyside Dam	66.9	801	DTL10154.SBL
Sunnyside	Just inside headgates	6/11/2010 8:10	Subyearling hatchery fall Chinook transported directly from rearing facility to Sunnyside Dam	66.5	806	DTL10159.SBL
Sunnyside	Below outfall	6/11/2010 8:00	Subyearling hatchery fall Chinook transported directly from rearing facility to Sunnyside Dam	66.5	806	DTL10159.SBL

Release Protocol and Experimental Subjects

Procedures varied among releases. Release timing varied substantially over all of the releases analyzed. All of the older, Prosser releases were made in the late afternoon. It is well known that smolts move primarily at night, and afternoon/evening releases were made in an attempt to reduce the time the fish remained at the release point incurring mortality from predatory birds and fish. Most of the releases made in 2009 and 2010, however, were made in the morning, around 10-11 AM.

All test releases were paired, with a group of fish being released just inside the canal headgates ("headgates fish") and another group released just below Prosser Dam or just below the bypass outfall at Roza and Sunnyside Dams ("outfall fish"; see subsequent section for details). The order in which the marked fish were released differed over releases, with outfall fish being released first at Prosser Dam and Roza Dam. At Sunnyside Dam, the headgate group was always released first in both 2009 and 2010.

Over years of monitoring entrainment rate at Prosser Dam, it has been noticed that intra-canal survival in Chandler Canal (the canal fed by Prosser Dam) is often very similar for yearling spring Chinook and yearling coho smolts released simultaneously (B. Watson, former YN biologist, 2011). This relationship was used to justify increasing the sample size of releases for the Prosser Dam analysis by including releases made up of both yearling coho and yearling Chinook salmon smolts.

Calculation of Bypass Survival: Season-long Estimates by Dam and Fish Type

A preliminary estimate of season-long bypass survival estimate for yearlings and subyearlings at Roza, Sunnyside and Prosser Dams was calculated by means of regressions giving the detection proportion of headgates fish, p_h, as a function of the detection proportion of outfall fish, $\boldsymbol{p_{o,1}}$ or $\boldsymbol{p_{o,2}}$. The coefficient of such regressions approximates bypass survival over the period for which both detection proportions could be calculated.

Calculation of Bypass Survival: Month-specific and Life-stage-specific values

All of the bypass facilities investigated have the same general layout: a dam, an irrigation canal at one end of the dam, and a set of rotary drum screens diverting juvenile fish into a bypass pipe that returns them to the river in an outfall mixing zone. Figure 2 is a schematic of such a diversion dam showing these structures and three release points for PIT-tagged fish designated $R_{o,1}$, $R_{o,2}$, and R_h. These release point represent, respectively, the first and second outfall release points and the headgate release point. All Sunnyside and Roza release pairs occurred at points R_h and $R_{o,2}$, while all releases at Prosser Dam occurred at points R_h and $R_{o,1}$.

If the number of fish released at R_h and $R_{o,2}$ are equal, and if fish from both release points encounter the same survival conditions below the outfall, then the ratio of detections of headgate to outfall fish ($D_h/D_{o,2}$) at downstream detection facilities represents survival through the bypass corridor, and $1 - D_h/D_{o,2}$ estimates bypass mortality. This is so because the survival of headgate fish to a downstream detection point is the product of bypass survival and the survival from the outfall zone to the detection facility, while the survival of outfall-released fish is simply the outfall-to-detection-site survival. If, as is assumed, outfall-to-detection-site survival is equal for both release groups, the ratio of headgate detections to outfall detections is bypass survival.

The bypass corridor is defined as the path from the headgates to the downstream edge of the outfall mixing zone. If R_h and $R_{o,2}$ are not equal, then bypass survival is estimated by the ratio of the detection proportions of headgate to outfall fish:

$$\textit{Bypass survival} = p_h/p_{o,2} \qquad \text{eq. 1}$$

where p_h, the detection proportion of headgate fish, is equal to D_h/R_h, and $p_{o,2}$, the detection proportion of outfall fish, is equal to $D_{o,2}/R_{o,2}$.

The detection numbers, D_h, $D_{o,1}$, and $D_{o,2}$, designate the number of fish detected at at least one point downstream of the release point. In this study, three mainstem detection sites were used for Prosser releases, McNary Dam (MCJ), John Day Dam (JDA), and Bonneville Dam (B2J), while Roza and Sunnyside releases were monitored at Prosser Dam (PRJ) as well as the mainstem sites. Fish that survive the bypass corridor and the river below may be detected at any combination of downstream detection sites. The D statistic, however, is never greater than 1, thus indicating that one fish from a release survived the release area.

The procedure just described was not utilized in estimating bypass survival at Prosser Dam. Specifically, the release paired with R_h was not $R_{o,2}$ but $R_{o,1}$, and bypass mortality was therefore estimated by $p_h/p_{o,1}$. This deviation was necessitated by the fact that funds were not available to study bypass survival at Prosser Dam directly over the course of this study (2009 and 2010), and by the fact that a series of earlier PIT-tag releases were available that approximated the headgates/below-outfall release protocol best suited to estimating bypass survival. There were in fact 49 releases made between 2003 and 2008 that entailed PIT-tagged fish being released just inside the canal, just below the dam, and in the dam forebay. These three-point releases were made to estimate entrainment rate and to monitor forebay mortality (estimated roughly by the ratio of the detection proportion of forebay to below-dam detections). They are, however, capable of being used to estimate bypass mortality as well assuming that the survival of fish released immediately below the dam is equal to the survival of fish released below the outfall.

Statistical Analysis of Bypass Survival

The standard error for bypass survival, SE(S), as estimated by eq. 1, is:

$$SE(S) = \sqrt{S^2(\frac{1-p_o}{p_oR_o} + \frac{1-p_h}{p_hR_h})} \qquad \text{eq. 2}$$

where p_o and R_o represent below-dam or below-outfall releases for Prosser or Roza/Sunnyside releases, respectively. The expression for standard error of the bypass survival estimate was used to place confidence intervals around point estimates.

Causes of Bypass Mortality

Factors contributing to bypass mortality were assessed by regressing a series of physical factors on bypass survival (arcsine square root transform) whenever sufficient data was available. Such regressions were made separately for yearlings (spring Chinook and coho smolts) and for subyearlings (fall Chinook smolts).

For yearling smolts and subyearling smolts, transformed bypass survival was regressed against the following potential predictive variables:

- mean river flow day of release and over the three-day period centered on the day of release;
- mean percent discharge diverted day of release and for the three-day period centered on the day of release;
- peak daily water temperature the day of release and mean peak temperature over the three-day period centered on the day of release;
- day of year of release, where 1 = January 1;
- mean fork length of all fish released (headgates and outfall); and
- mean travel time of all fish in a release to McNary Dam.

Effect on the EDT Model

The EDT (Ecosystem Diagnosis and Treatment) model considers bypass mortality in estimating equilibrium abundance and survival. It does so by incorporating monthly bypass survival estimates by species and life stage for every "obstruction" modeled. The scarcity of empirical bypass survival data necessitated the assignment of mean monthly bypass survival estimates for subyearling Chinook to all species and to all life stages younger than age-1. Similarly, mean monthly bypass survival estimates for yearling spring Chinook and coho were incorporated into the model for all species and life stages age-1 or older.

The month- and life-stage-specific survival data were modified by assumed entrainment rates before being added to the EDT model. It was assumed that entrainment rate at all four diversion dams is equal to PDD. If bypass survival for month i is denoted $S_{b, i}$ and survival during month i from the downstream face of the dam to the downstream edge of the outfall zone is denoted $S_{not\ b, i}$, the survival of all fish – fish spilled over the dam as well as those entrained and subsequently bypassed – is given by the following expression:

Total survival past dam, month i = $PDD_i*(S_{b, i}) + (1 - PDD_i)*S_{not\ b, i}$ **eq. 3**

Because it is assumed $S_{not\ b, i}$ is 1.0, the equation simplifies to:

Total survival past dam, month i = $PDD_i*(S_{b, i}) + (1 - PDD_i)$ **eq. 4**

Bypass survival values estimated by this study were input into the EDT model by the use of eq. 4. A series of simulations were then made in which bypass survival at the four targeted diversion dams was set to zero or to twice the revised rate. For comparison sake, a scenario was also run in which bypass mortality at all dams in the Yakima Subbasin was set to zero. Although Wapato Dam was assigned mean monthly bypass survival estimates from Sunnyside Dam, eq. 4 and PDD values from Wapato Dam were used to parameterize Wapato Dam in the EDT model.

RESULTS

Survival

Survival as Estimated from the Relationship between Detection Proportion of Headgate Fish and the Detection Proportion of Outfall Fish

Linear regressions giving the detection proportion of headgate fish as a function of the detection proportion of outfall fish showed that about 80% as many headgate fish were detected as outfall fish (Figure 2). Specifically, the detection proportion of headgate fish was 76, 78 and 80% of the detection proportion of outfall fish at Prosser, Sunnyside and

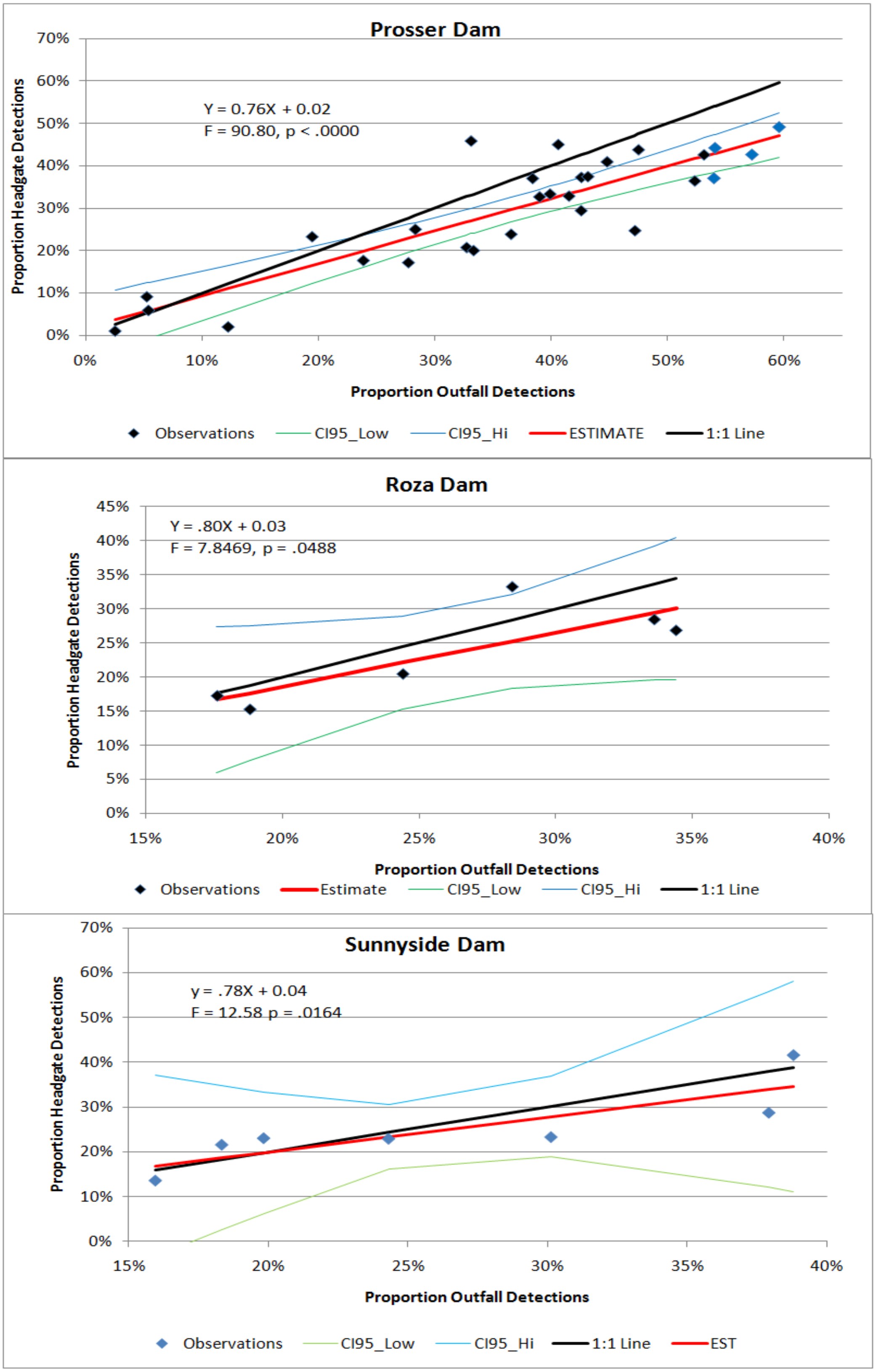

Figure 2. Detection proportion of headgates fish as a function of detection proportion of outfall fish, Prosser, Roza and Sunnyside Dams. 95% confidence intervals and one-to-one lines also depicted.

Roza Dams, respectively. The variability of these regressions was high as evidenced by the wide 95% confidence intervals (95%CI) for the regressions. A high variability is also reflected by the confidence intervals about the coefficients of these regressions. The 95%CI about the regression coefficient for the Roza regression was 0.7% to 158%. The 95%CIs around the coefficients of the regressions for Sunnyside and Prosser Dams were 21-134% and 60-93%, respectively. Therefore only Prosser Dam showed a bypass mortality greater than 0% (bypass survival < 100%) at the upper boundary of the 95% confidence interval. It should be borne in mind that the data used in all of these regressions was not truncated at 100% -- viz., bypass survival estimates greater than 100% were included -- and that data for yearlings and subyearlings were combined.

Month-specific and Life-stage-specific Bypass Survival

Of the 42 paired releases (29 Prosser, 7 Sunnyside, 6 Roza) for which bypass survival could be estimated, nine (21%) resulted in bypass survival point estimates in excess of 100%. The frequency with which the 95%CI of bypass survival estimates included 100% for Roza, Sunnyside and Prosser Dams was 83.3% (five of six), 71.4% (five of seven) and 48.3% (14 of 29), respectively.

Mean monthly bypass survival for yearling smolts at Roza, Sunnyside and Prosser Dams ranged from 72.1 to 89.1%, and declined from April to May (Table 2). Yearling survival at Prosser declined from 82.8% in April to 78.1% in May; comparable figures for April and May at Roza are 89.1 and 84.1%, respectively. Bypass survival for subyearling Chinook was 92.6 and 97.2% for May and June at Sunnyside, while survival for subyearling Chinook at Prosser in June, the only month for which estimates are available, was 64%.

It should be noted that the mean survival figures in Table 2 were truncated at 100%. That is to say, when the ratio of p_h to p_o was > 1.0, a survival value of 100% was assigned automatically.

Figure 3 shows the exact bypass survival estimates and their 95% confidence intervals for all releases. The variability in survival estimates is once again evident, especially for the estimates for subyearling Chinook smolts.

Table 2. Bypass survival estimates by month and fish type at Prosser, Sunnyside and Roza Dams.

Dam	Fish Type	April Bypass Survival	May Bypass Survival	June Bypass Survival	All Months Bypass Survival
Prosser	Subyearling Chinook	---	---	64.0%	64.0%
	Yearling Chinook & Coho	82.8%	72.1%	---	79.6%
Sunnyside	Subyearling Chinook	---	92.6%	97.2%	94.9%
	Yearling Chinook	---	84.4%	---	84.4%
Roza	Yearling Chinook	89.1%	84.1%	---	87.4%

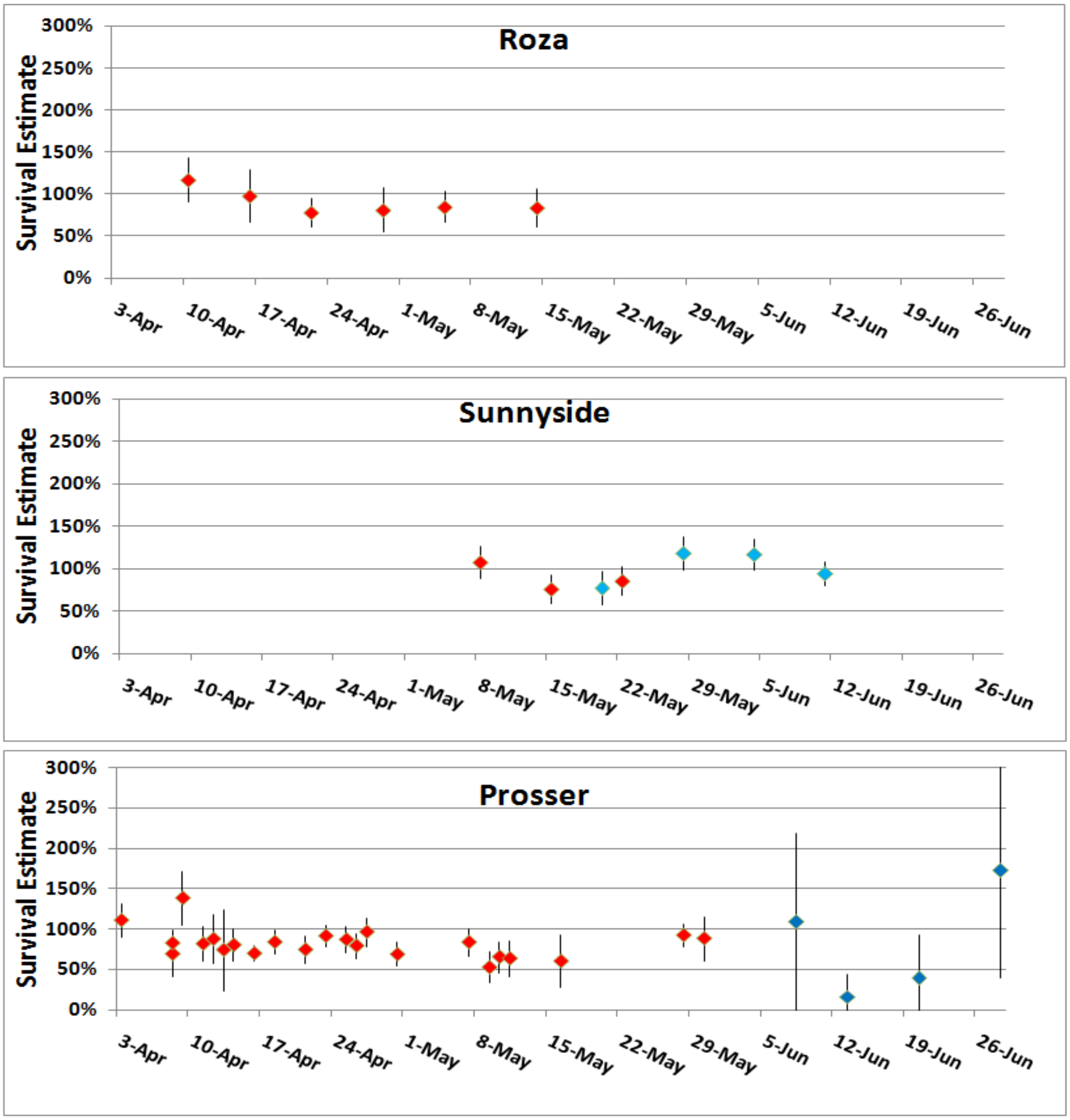

Figure 3. Bypass survival estimates with 95% confidence intervals for yearling smolts (red points) and subyearling smolts (blue points) at Roza, Sunnyside and Prosser Dams. Note that some lower CI bounds for subyearling Chinook are negative.

Correlations with Candidate Explanatory Variables

Across all dams, yearling bypass survival was significantly (p = .05) correlated with day of year, three-day mean maximum water temperature at release site and mean travel time to McNary Dam. The regression of bypass survival on maximum water temperature at release site the day of release was significant at the .06 level. Bypass survival varied inversely with day of year and both water temperature variables, and positively with mean travel time to McNary Dam. Table 3 summarizes the significant regressions for yearling Chinook and coho smolts, and Figure 4 plots the relationships between survival and correlated independent variables.

There were no significant regressions between yearling bypass survival and the following candidate explanatory variables:

- river flow at release site, either on release day or the mean over the 3-day period centered on release day;
- canal diversion, either on release day or the mean over the 3-day period centered on release day;
- percent discharge diverted, either on release day or the mean over the 3-day period centered on release day; and
- mean size (fork length) of fish released.

Across all dams, none of the regressions for the bypass survival of subyearling Chinook were significant at the .05 level. Bypass survival was, however, inversely correlated with the mean fork length of fish released, and the regression was significant at the .09 level:

Bypass $\text{survival}_{\text{subyearling}}$ = -0.0161(Length) + 2.572
n = 8, R square = 0.4017, p = .0915

Table 3. Significant regressions of transformed (arcsine square root) bypass survival of yearling smolts on candidate explanatory variables.

Variable	Intercept	Coefficient	R square	Standard Error	Observations	Significance
Day of Year[a]	1.7362	-0.0050	0.1286	0.1957	31	0.0475
Maximum water temperature day of release	1.8293	-0.0122	0.1065	0.2085	33	0.0638
Three-day mean maximum water temperature	1.8432	-0.0125	0.1204	0.2069	33	0.0479
Travel time to McNary Dam	1.0878	0.0056	0.1174	0.2072	33	0.0510

a Excluding two February releases

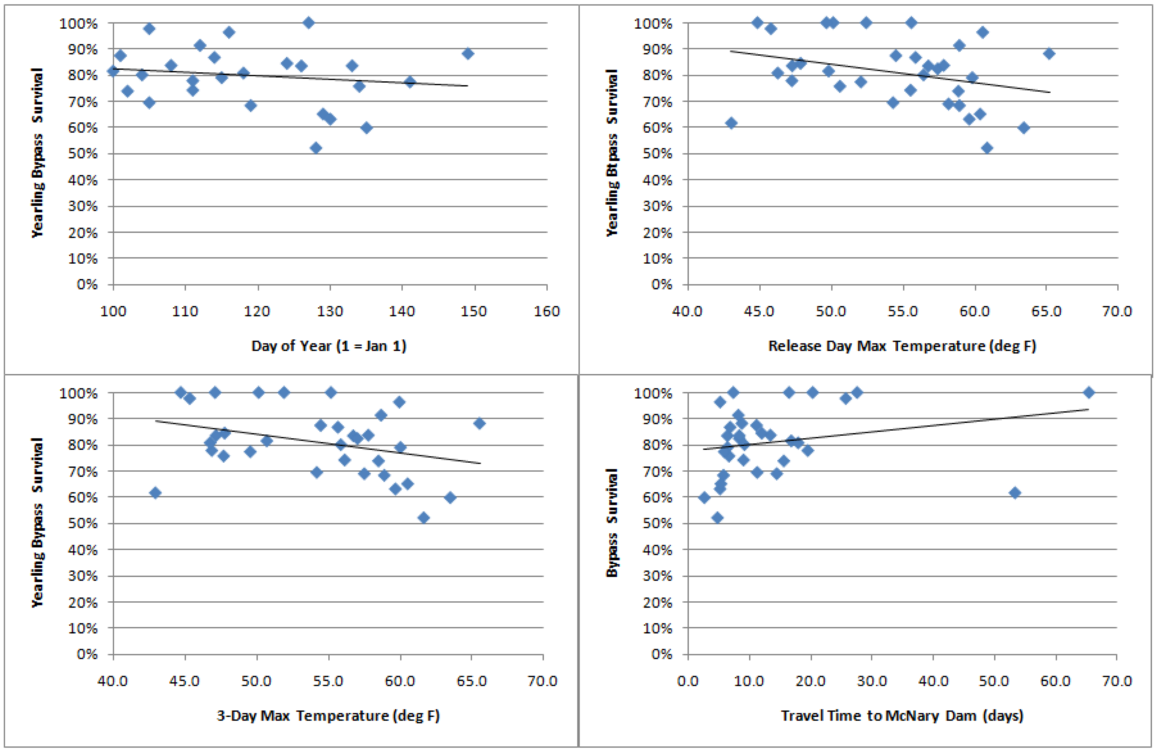

Figure 4. Bypass survival of yearling Chinook and coho smolts as a function of day of year, release day maximum water temperature at release site, 3-day mean maximum water temperature at release site and mean travel time to McNary Dam.

Travel Time

Figures 5 and 6 show that travel time to McNary Dam decreased with release date and proximity to McNary Dam, and that yearling Chinook and coho move much more rapidly than subyearling Chinook. McNary travel time for yearlings ranged from roughly three weeks in late March and early April to a week or less in mid to late May. By contrast, McNary travel times for subyearlings ranged from five weeks in mid May to roughly 10 days in mid June.

Thirty-eight of 42 total bypass survival estimates were based on a sufficient number of recoveries of both release groups to use the 2 sample Kolmagorov-Smirnov test to assess the degree to which headgate and outfall fish were well mixed. The temporal detection distribution of headgate and outfall fish was statistically indistinguishable in 34 of these 38 releases. The four releases that were not well-mixed in time at McNaryDam were yearling Chinook releases made 4/30/2003 (Prosser Dam), 5/16/2007 (Prosser Dam), 5/8/2009 (Sunnyside Dam) and 5/15/2009 (Sunnyside Dam). The survival estimate was truncated to 100% for the May 15, 2009 Sunnyside Dam release. The other three releases that were not well mixed generated survival estimates less than 100%.

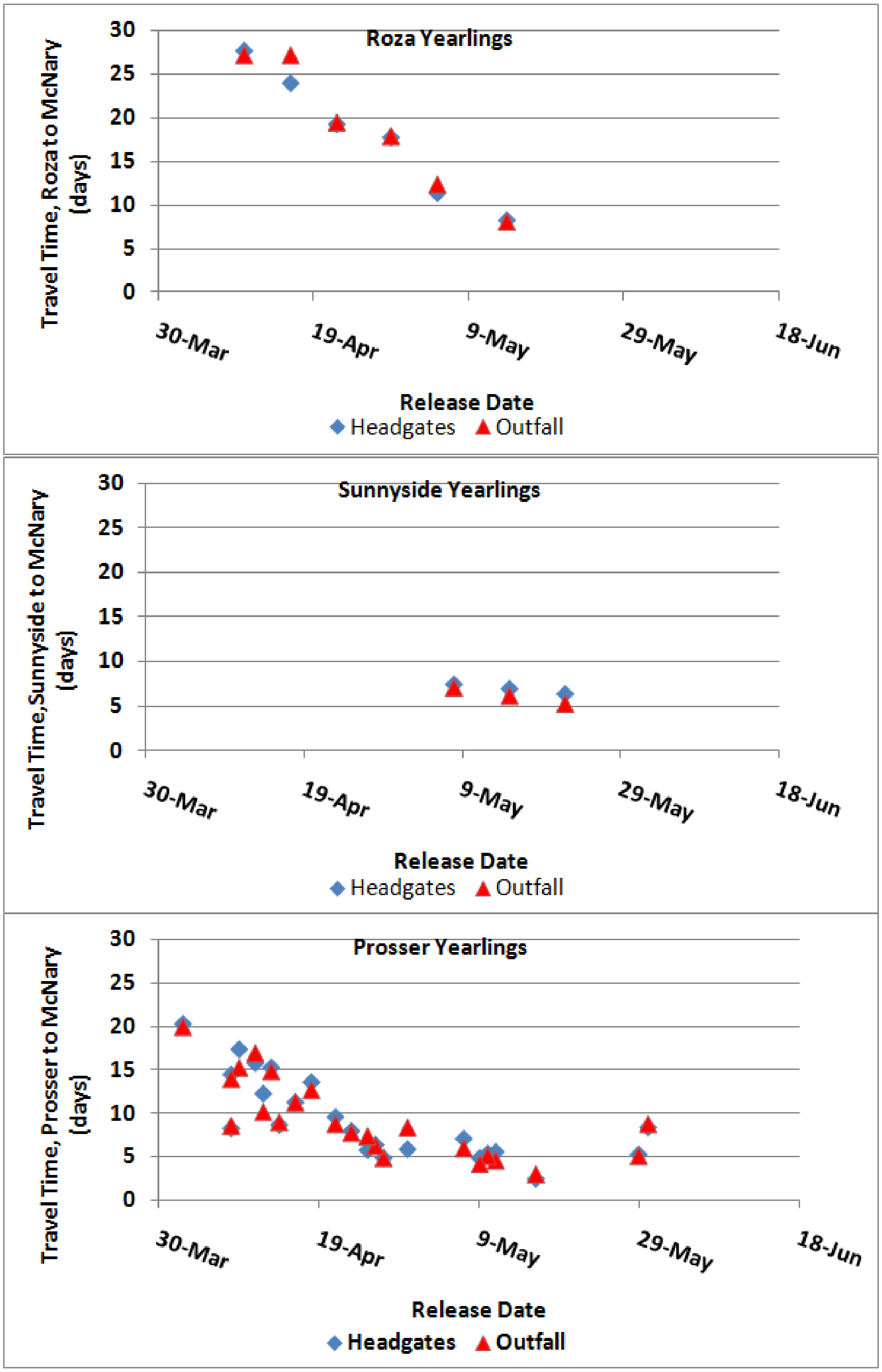

Figure 5. Travel time in days from release sites to McNary Dam, yearling Chinook and coho smolts.

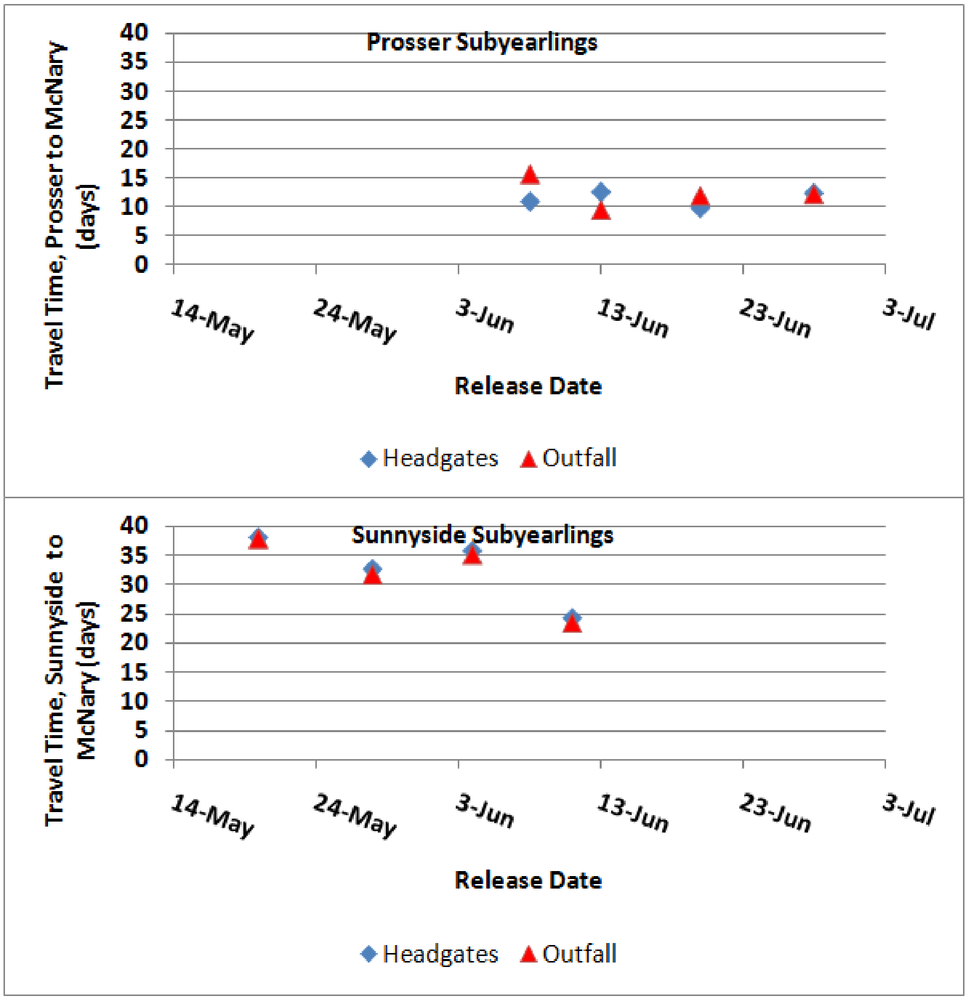

Figure 6. Travel time in days from release sites to McNary Dam, subyearling Chinook smolts.

Implications for the EDT Model

With the exception of yearlings at Roza in March and April, revised monthly survival rate is always greater than existing estimates, especially for subyearlings. Revised monthly bypass survival rates range from 12 to 30% higher than existing rates for subyearlings. Revised monthly bypass survival rates for yearlings range from -0.4% less than to 4% greater than existing estimates.

Table 4. Existing and revised bypass survival estimates used in the EDT model.

Bypass	Life Stage	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	All Month Mean
Roza	Current Subyearling	0.991	0.939	0.825	0.835	0.824	0.817	0.855	0.927	0.877
	Revised Subyearling	1.000	1.000	0.970	0.984	0.971	0.963	1.000	1.000	0.986
	Current Age-1	0.991	0.962	0.931	0.881	0.838	0.845	0.878	0.939	0.908
	Revised Age-1	0.976	0.947	0.935	0.885	0.842	0.849	0.882	0.944	0.908
Wapato	Current Subyearling	0.997	0.926	0.869	0.754	0.669	0.668	0.772	0.886	0.818
	Revised Subyearling	1.000	1.000	0.977	0.990	0.879	0.877	1.000	1.000	0.965
	Current Age-1	0.999	0.959	0.911	0.822	0.708	0.702	0.815	0.908	0.853
	Revised Age-1	1.000	1.000	0.952	0.859	0.740	0.733	0.852	0.949	0.886
Sunnyside	Current Subyearling	0.997	0.918	0.858	0.707	0.548	0.531	0.655	0.827	0.755
	Revised Subyearling	1.000	1.000	0.976	0.988	0.766	0.742	0.916	1.000	0.924
	Current Age-1	0.999	0.958	0.904	0.790	0.600	0.582	0.722	0.861	0.802
	Revised Age-1	1.000	1.000	0.949	0.830	0.630	0.611	0.758	0.904	0.835
Prosser	Current Subyearling	0.978	0.838	0.772	0.581	0.391	0.379	0.519	0.760	0.652
	Revised Subyearling	1.000	1.000	1.000	0.866	0.583	0.565	0.773	1.000	0.848
	Current Age-1	0.989	0.926	0.855	0.710	0.477	0.463	0.625	0.812	0.732
	Revised Age-1	1.000	0.941	0.903	0.750	0.504	0.489	0.660	0.858	0.763

When revised bypass survival estimates were incorporated into the EDT model, equilibrium abundance for all stocks of Yakima spring Chinook increased from the pre-revision estimate of 4,285 to 5,202, a 21.4% increase, while summer Chinook abundance increased from 3,219 to 7,805, a 142.5% increase (Figure 7 and Table 5). The difference between spring and summer Chinook reflects the fact that 49% of Yakima summer Chinook was assumed to smolt as subyearlings, while spring Chinook were assumed smolt exclusively as yearlings. Relative to current estimates, revised bypass survival increased much more for subyearlings than yearlings. This difference is reflected in the productivity estimates under the revised bypass scenarios (Figure 8 and Table 6), which increased from 3.0 to 3.2 for all stocks of spring Chinook, a 6.2% increase, while summer Chinook productivity increased from 1.4 to 2.0, a 50.3% increase. Under the revised bypass scenario the EDT model projected abundance increases of 13, 37 and 41% for Upper Yakima, Naches and American River spring Chinook, respectively. The smaller impact on the upper Yakima stock was due to the fact only upper Yakima outmigrants passed Roza Dam and the revised bypass survival at Roza Dam decreased relative to current estimates for the months of March and April.

In an attempt to gauge the importance of bypass mortality at the four dams targeted by this study, EDT scenarios were run in which revised bypass morality was doubled or set to zero. A scenario was also run under which bypass mortality at all dams in the Yakima Subbasin was set to zero. Relative to current estimates, the abundance of summer Chinook and all stocks of spring Chinook except the upper Yakima stock still increased when revised bypass mortality was doubled, and the decrease in upper Yakima spring Chinook abundance was marginal. When bypass mortality was totally eliminated at the four targeted dams, the abundance of summer Chinook and all stocks of spring Chinook increased by 164 and 39%, respectively. The importance of the particular dams targeted by this study to spring and summer Chinook was highlighted by the fact that, averaged over all four stocks, 87% of the abundance increase associated with the elimination of bypass mortality throughout the basin could be achieved by eliminating mortality at just the four targeted dams.

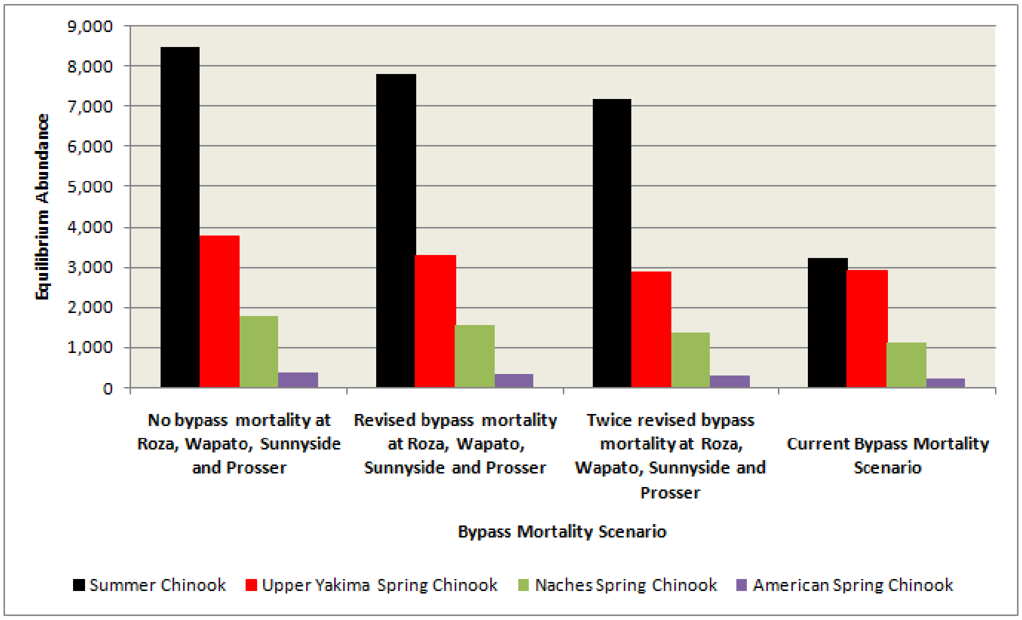

Figure 7. Equilibrium abundance for four Yakima River Chinook salmon populations as a function of bypass survival rate. Estimates are generated by the EDT model.

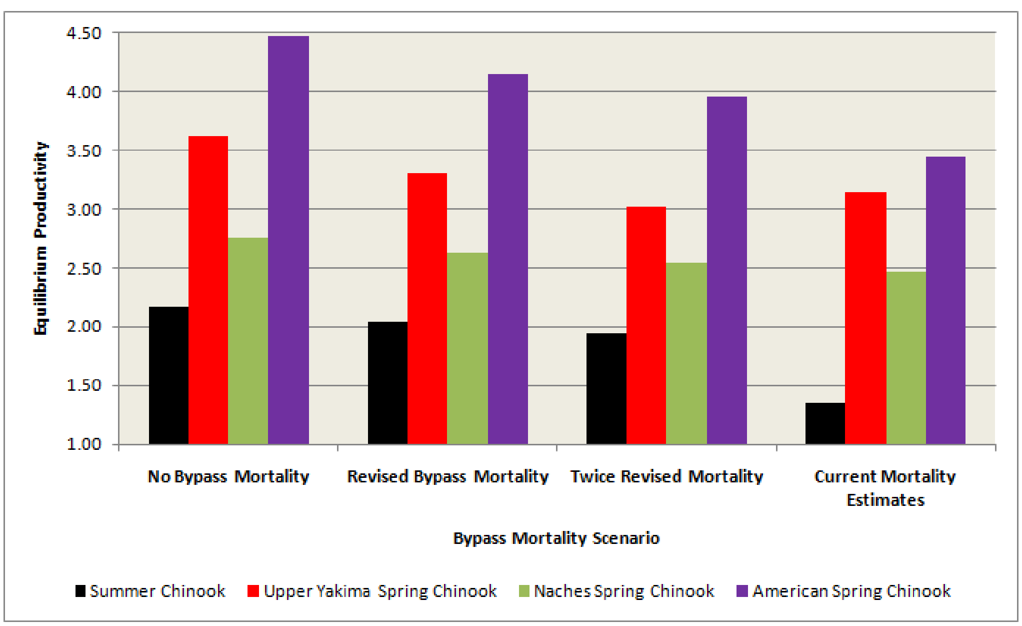

Figure 8. Equilibrium productivity for four Yakima River Chinook salmon populations as a function of bypass survival rate. Estimates are generated by the EDT model.

Table 5. Estimated equilibrium abundance of Yakima spring and summer Chinook as a function of multiples of the revised bypass survival rate for Roza, Wapato, Sunnyside and Prosser diversion dams. Percent change for each scenario relative to the current (unrevised) EDT estimate is also shown.

						Percent Change Relative to Current Estimate				
Bypass Mortality Scenario	Summer Chinook	Upper Yakima Spring Chinook	Naches Spring Chinook	American Spring Chinook	All Spring Chinook	Upper Yakima Spring Chinook	Naches Spring Chinook	American Spring Chinook	All Spring Chinook	Summer Chinook
No bypass mortality at any diversion dam in the Yakima Subbasin	9,636	4,183	2,075	486	6,744	44.2%	82.8%	94.7%	57.4%	199.4%
No bypass mortality at Roza, Wapato, Sunnyside and Prosser	8,483	3,772	1,803	399	5,974	30.1%	58.8%	59.7%	39.4%	163.6%
Revised bypass mortality at Roza, Wapato, Sunnyside and Prosser	7,805	3,292	1,558	353	5,202	13.5%	37.2%	41.3%	21.4%	142.5%
Twice revised bypass mortality at Roza, Wapato, Sunnyside and Prosser	7,194	2,859	1,370	320	4,549	-1.4%	20.7%	28.2%	6.2%	123.5%
Current Bypass Mortality Scenario	**3,219**	**2,900**	**1,135**	**250**	**4,285**					

Table 6. Estimated productivity of Yakima spring and summer Chinook as a function of bypass survival rate for Yakima Subbasin diversion dams. Percent change for each scenario relative to the current (unrevised) EDT estimate is also shown.

						Percent Change Relative to Current Estimate				
Bypass Mortality Scenario	Summer Chinook	Upper Yakima Spring Chinook	Naches Spring Chinook	American Spring Chinook	All Spring Chinook	Upper Yakima Spring Chinook	Naches Spring Chinook	American Spring Chinook	All Spring Chinook	Summer Chinook
No bypass mortality at any diversion dam in the Yakima Subbasin	2.3	3.8	3.0	5.4	3.7	22.4%	22.2%	55.9%	24.1%	72.9%
No bypass mortality at Roza, Wapato, Sunnyside and Prosser	2.2	3.6	2.8	4.5	3.4	15.4%	12.0%	30.0%	14.8%	59.3%
Revised bypass mortality at Roza, Wapato, Sunnyside and Prosser	2.0	3.3	2.6	4.1	3.2	5.3%	6.9%	20.5%	6.2%	50.3%
Twice revised bypass mortality at Roza, Wapato, Sunnyside and Prosser	1.9	3.0	2.5	4.0	2.9	-4.0%	2.9%	15.0%	-1.4%	42.9%
Current Bypass Mortality Scenario	**1.4**	**3.1**	**2.5**	**3.4**	**3.0**					

Discussion

The most important issue to discuss in relation to this work is whether bypass mortality at the targeted facilities is real and biologically significant. While the first issue cannot be answered with absolute certainty, it is clear that effects of the magnitude posited are biologically significant for subyearling outmigrants. The current, EDT-derived productivity estimate for Yakima summer Chinook, a race that includes a substantial proportion of subyearling smolts, is only 1.36, meaning that spawners just barely replace themselves even when spawning density is so low as to eliminate density dependent mortality. A productivity of 1.36 is so low that even a relatively short succession of sub-par water years could result in the extirpation of a naturally reproducing population. Under the revised bypass mortality scenario, productivity is 2.04, a value that approaches that of Naches spring Chinook which has been evaluated as stable ("listing not warranted") under the ESA. Just as significantly, equilibrium abundance of summer Chinook more than doubles under the revised bypass survival scenario, increasing from 3,219 to 7,805.

Of course the numbers for subyearlings have no reality outside the EDT model, and they are based on only eight releases with low detection proportions and high standard errors. But if the basic message of the subyearling releases is true – that bypass survival of subyearlings is substantially higher than had been thought – the prognosis for re-introducing summer Chinook to the Yakima Subbasin improves to the degree that cumulative bypass mortality is considered a significant limiting factor.

The significance of the increases in abundance and productivity under the revised bypass survival scenario for spring Chinook lies less in the magnitudes of effects, which are relatively modest, than in the fact that the revised estimates – of bypass survival, abundance and productivity – differ so little from current estimates. In turn, this finding reinforces the credibility of certain analyses of instream flow in the Yakima Subbasin (Bureau of Reclamation 2008), which showed that the fish production benefits of increased flow are attributable primarily to decreased entrainment and decreased bypass mortality at major Yakima diversion dams.

The basis for believing that a substantial fraction of fish actually die while passing through the bypass systems of the three dams studied rests primarily on the fact that headgates and outfall fish are commingled as they move downriver, and thus are likely to experience the same in-river survival conditions; and because outfall fish are usually detected at higher rates than headgates fish at mainstem Columbia River dams. All three regressions of the detection proportion of headgates fish on the detection proportion of outfall fish were significant at .05, and the correlation coefficients ranged from 0.76 to 0.80. It is also true that 90% (38 of 42 testable releases) of headgates and outfall fish were well-mixed in time as they passed McNary Dam. These two pieces of information suggest that the lower detection rates of headgates fish is more likely the result of bypass mortality on the order of ~20% than differences in in-river mortality associated with significantly different travel times.

Unfortunately, the 95% confidence interval of the regression coefficient includes 100% for the Roza and Sunnyside regressions. This fact implies that there is a 5% chance that there might actually be no difference in the detection proportions of headgates and outfall fish, and that therefore bypass mortality might be non-existent. The same possibility is evidenced by the month- and age-specific bypass mortality estimates for Roza Dam and Sunnyside Dam. The 95% confidence interval for five of six Roza estimates and five of seven Sunnyside estimates included 100%, implying that bypass survival could not be distinguished from 100% (no bypass mortality) at the .05 level.

A reasonable interpretation of the preceding data is that bypass survival is quite variable and sometimes does in fact equal 100%. The fact that 9 of 42 releases generated point estimates of bypass survival above 100% is consistent with such a hypothesis: when bypass survival actually equals 100%, the detection rate of headgates fish at a point far downstream might well exceed the detection rate of outfall fish.

It is also true that the release numbers and detection proportions of both headgates and outfall fish were lower than optimal. Recall that the standard error of the bypass survival estimate is as follows:

$$SE(S) = \sqrt{S^2\left(\frac{1-p_o}{p_oR_o} + \frac{1-p_h}{p_hR_h}\right)}$$

This expression implies that the standard error decreases as detection proportions and release numbers increase, and as estimated bypass survival decreases. For example, a bypass survival estimate of 0.8 based on equal releases of 250 fish and recovery proportions of 10 % and 8% has a standard error of 0.229. If the recovery proportions are tripled, to 30 and 24%, the survival estimate remains 0.8 but the standard error decreases to 0.119. If the release numbers are doubled to 500, the standard error of an 0.8 survival estimate based on detection proportions of 10 and 8% is 0.162, while the standard error of an 0.8 survival based on 30 and 24% is 0.084. The variability of the survival estimates generated over the course of this study is due both to relatively small release numbers and, especially, low detection proportions. Low detection proportions affected survival estimates for slow-moving fall Chinook smolts more than spring Chinook, resulting in larger standard errors for the subyearling estimates.

To this point the discussion of the reality of bypass mortality has excluded Prosser Dam and its bypass, tacitly suggesting that the bypass survival estimates for Prosser are more "believable" than the estimates for Roza and Sunnyside. Such an inference is correct to the degree that survival from Prosser Dam to the bypass outfall mixing zone is 100%. For Prosser Dam the regression that gives the detection rate of headgates fish as a function of the detection rate of outfall fish does not include the possibility of 100% bypass survival at the .05 level: the 95% confidence interval of regression coefficient does not include 100%. It is also true that the confidence intervals of only 14 of 29 month- and age-specific bypass survival estimates for Prosser include 100%, and that almost all Prosser releases were well mixed at McNary. However, Prosser bypass survival estimates might overestimate true bypass survival because the impact of survival from Prosser Dam to the outfall ($S_{dam\text{-}to\text{-}outfall}$) was not controlled. Explicitly, point estimates of Prosser bypass survival equal the product of the bypass survival estimate and the survival from Prosser Dam through the outfall:

Prosser survival estimator = detection proportion headgates/detection proportion outfall
$= (S_{bypass} * S_{outfall\text{-}to\text{-}detector}) / (S_{dam\text{-}to\text{-}outfall} * S_{outfall\text{-}to\text{-}detector})$
$= S_{bypass} / S_{dam\text{-}to\text{-}outfall}$

and therefore

true Prosser bypass survival = Estimated survival* $S_{dam\text{-}to\text{-}outfall}$

Although there is no evidence that mortality from Prosser Dam to the outfall zone half a mile downstream is substantial, it likely is less than 100% at least on some occasions.

If one accepts the reality and biological significance of bypass mortality at mainstem Yakima Dams, it is important to consider the mechanism of such losses. If fish entering diversion canals are lost because of entrainment behind the screens or physical trauma encountered somewhere along the migratory corridor, one would not expect to see a significant correlation between mortality and water temperature. Rather, one would expect that factors that increase the physical entrainment rate into the canals should be positively correlated with bypass mortality.

Such was not the case: neither mean river discharge, nor percent discharge diverted was correlated with bypass survival for either yearlings or subyearlings, but water temperature was inversely correlated with survival for yearlings. These facts suggest that bypass mortality is primarily due to predation by cold-blooded predator, possibly pikeminnow. Pikeminnow are indicated more than smallmouth bass because pikeminnow are positively size-selective for prey items (Poe et al. 1991), and therefore feed preferentially on yearling smolts. By contrast, Yakima River smallmouth bass consume juvenile salmonids only as yearlings or larger subyearlings, and these relatively small bass overwhelmingly consumed smaller subyearling fall Chinook (Fritts and Pearsons 2006).

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Dam	Release Site	File Name	Species/Run	Date Released	Headgate Release Number	Outfall Release Number	Proportion Detected Headgate	Proportion Detected Outfall	Survival Estimate[a]	Standard Error of Survival Estimate	95% Confidence Interval	
											Lower Bound	Upper Bound
Prosser	headworks	BDW03091.BEL	Wild spring Chinook	4/2/2003	200	197	0.445	0.406	110%	0.1281	89%	131%
Prosser	outfall	BDW03091.CAN	Wild spring Chinook									
Prosser	headworks	BDW03098.BEL	Wild spring Chinook	4/9/2003	144	154	0.333	0.266	125%	0.2232	88%	162%
Prosser	outfall	BDW03098.CAN	Wild spring Chinook									
Prosser	headworks	BDW03105.BEL	Mixed Wild/Hatchery spring Chinook	4/16/2003	379	386	0.359	0.417	86%	0.0785	73%	99%
Prosser	outfall	BDW03105.CAN	Mixed Wild/Hatchery spring Chinook									
Prosser	headworks	BDW03112.BEL	Mixed Wild/Hatchery spring Chinook	4/23/2003	347	375	0.409	0.443	92%	0.0802	79%	106%
Prosser	outfall	BDW03112.CAN	Mixed Wild/Hatchery spring Chinook									
Prosser	headworks	BDW03119.BEL	Wild spring Chinook	4/30/2003	192	100	0.370	0.540	68%	0.0903	54%	83%

											95% Confidence Interval	
Dam	Release Site	File Name	Species/Run	Date Released	Headgate Release Number	Outfall Release Number	Proportion Detected Headgate	Proportion Detected Outfall	Survival Estimate[a]	Standard Error of Survival Estimate	Lower Bound	Upper Bound
Prosser	outfall	BDW03119.CAN	Wild spring Chinook									
Prosser	headworks	BDW03126.BEL	Wild spring Chinook	5/7/2003	249	198	0.325	0.399	82%	0.1029	65%	98%
Prosser	outfall	BDW03126.CAN	Wild spring Chinook									
Prosser	headworks	BDW03170.BEL	Unknown fall Chinook	6/20/2003	199	236	0.010	0.025	39.5%	0.3205	-13%	92%
Prosser	outfall	BDW03170.CAN	Unknown fall Chinook									
Prosser	headworks	DTL04098.BEL	Wild spring Chinook	4/8/2004	118	99	0.492	0.596	82%	0.1031	66%	99%
Prosser	outfall	DTL04098.CA1	Wild spring Chinook									
Prosser	headworks	DTL04104.BEL	Wild spring Chinook	4/14/2004	101	96	0.426	0.531	80%	0.1203	60%	100%
Prosser	outfall	DTL04104.CA1	Wild spring Chinook									
Prosser	headworks	DTL04111.BEL	Wild spring Chinook	4/21/2004	101	103	0.436	0.573	76%	0.1077	58%	94%
Prosser	outfall	DTL04111.CA1	Wild spring Chinook									
Prosser	headworks	DTL05039.BEL	Wild spring Chinook	2/9/2005	86	149	0.233	0.195	119%	0.3073	69%	170%

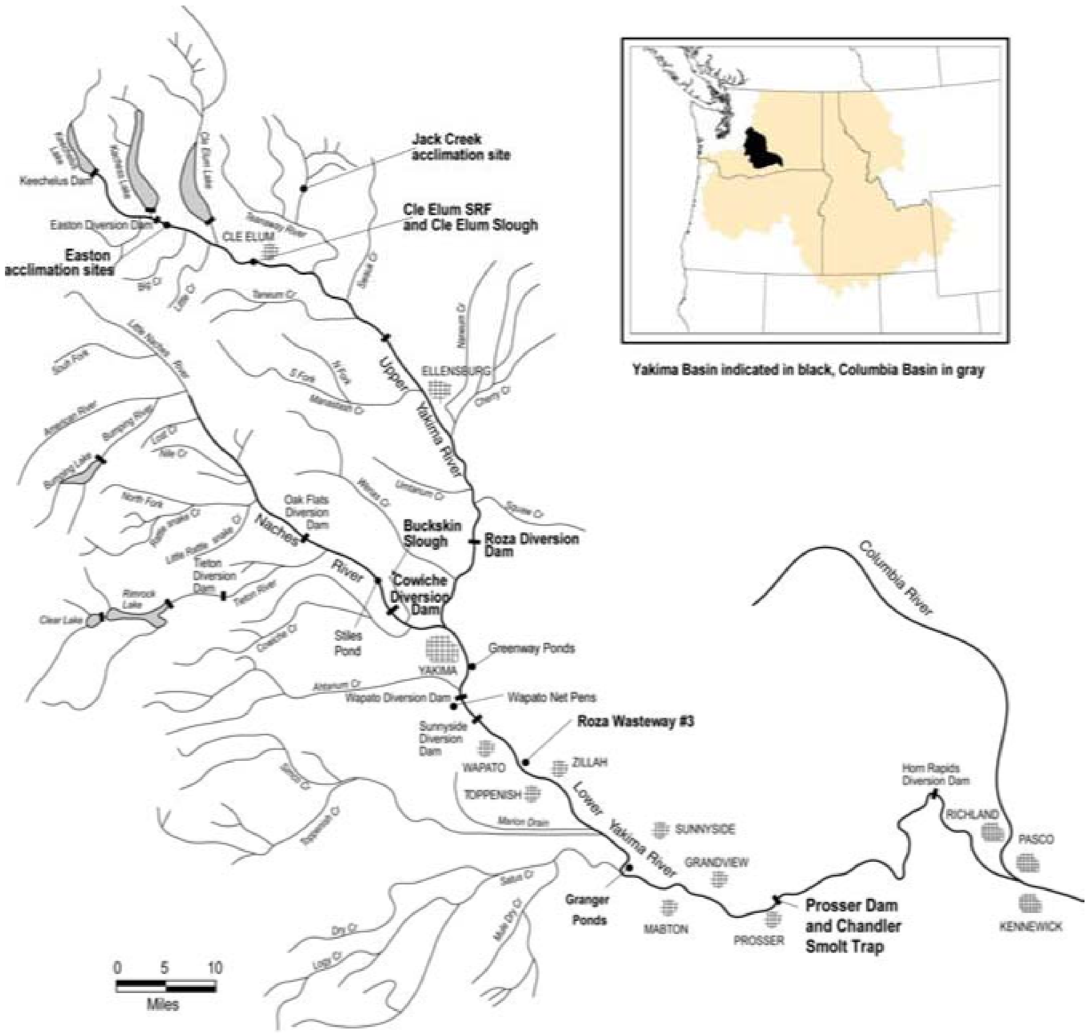
Dam	Release Site	File Name	Species/Run	Date Released	Headgate Release Number	Outfall Release Number	Proportion Detected Headgate	Proportion Detected Outfall	Survival Estimate[a]	Standard Error of Survival Estimate	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Prosser	outfall	DTL05039.CA1	Wild spring Chinook									
Prosser	headworks	DTL05053.BEL	Wild spring Chinook	2/23/2005	70	119	0.171	0.277	62%	0.1864	31%	92%
Prosser	outfall	DTL05053.CA1	Wild spring Chinook									
Prosser	headworks	DTL05097.BEL	Wild spring Chinook	4/8/2005	51	101	0.294	0.426	69%	0.1698	41%	97%
Prosser	outfall	DTL05097.CA1	Wild spring Chinook									
Prosser	headworks	DTL05102.BEL	Wild spring Chinook	4/13/2005	34	88	0.176	0.239	74%	0.3080	23%	125%
Prosser	outfall	DTL05102.CA1	Wild spring Chinook									
Prosser	headworks	DTL05116.BEL	Mixed Wild/Hatchery spring Chinook	4/27/2005	200	401	0.370	0.384	96%	0.1078	79%	114%
Prosser	outfall	DTL05116.CA1	Mixed Wild/Hatchery spring Chinook									
Prosser	headworks	DTL05130.BEL	Mixed Hatchery/Unknown spring/fall Chinook and unknown coho	5/11/2005	111	168	0.207	0.292	71%	0.1571	45%	97%

Dam	Release Site	File Name	Species/Run	Date Released	Headgate Release Number	Outfall Release Number	Proportion Detected Headgate	Proportion Detected Outfall	Survival Estimate[a]	Standard Error of Survival Estimate	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Prosser	outfall	DTL05130.CA1	Mixed Hatchery/Unknown spring/fall Chinook and unknown coho									
Prosser	headworks	DTL05158.CA1	Unknown fall Chinook	6/8/2005	34	74	0.059	0.054	108.8%	0.9151	-42%	259%
Prosser	outfall	DTL05158.BEL	Unknown fall Chinook									
Prosser	headworks	DTL06101.BEL	Wild spring Chinook	4/12/2006	51	108	0.373	0.426	87%	0.1866	57%	118%
Prosser	outfall	DTL06101.CA1	Wild spring Chinook									
Prosser	headworks	DTL06115.BEL	Mixed Wild/Hatchery spring Chinook	4/26/2006	201	354	0.328	0.415	79%	0.0941	64%	95%
Prosser	outfall	DTL06115.CA1	Mixed Wild/Hatchery spring Chinook									
Prosser	headworks	DTL06129.BEL	Mixed Wild/Hatchery spring Chinook	5/10/2006	130	238	0.231	0.357	65%	0.1177	45%	84%
Prosser	outfall	DTL06129.CA1	Mixed Wild/Hatchery spring Chinook									

Dam	Release Site	File Name	Species/Run	Date Released	Headgate Release Number	Outfall Release Number	Proportion Detected Headgate	Proportion Detected Outfall	Survival Estimate[a]	Standard Error of Survival Estimate	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Prosser	headworks	DTL06178.BEL	Unknown fall Chinook	6/28/2006	88	171	0.011	0.041	27.8%	0.2945	-21%	76%
Prosser	outfall	DTL06178.CA1	Unknown fall Chinook									
Prosser	headworks	DTL07100.BEL	Mixed Hatchery-Wild Spring Chinook	4/11/2007	68	135	0.441	0.511	86.3%	0.1384	64%	109%
Prosser	outfall	DTL07100.CA1	Mixed Hatchery-Wild Spring Chinook									
Prosser	headworks	DTL07114.BEL	Mixed Hatchery-Wild Spring Chinook	4/25/2007	195	292	0.369	0.425	87%	0.1007	70%	104%
Prosser	outfall	DTL07114.CA1	Mixed Hatchery-Wild Spring Chinook									
Prosser	headworks	DTL07128.BEL	Mixed Hatchery-Wild Spring Chinook	5/9/2007	81	89	0.210	0.461	46%	0.1113	27%	64%
Prosser	outfall	DTL07128.CA1	Mixed Hatchery-Wild Spring Chinook									
Prosser	headworks	DTL07135.BEL	Unknown Coho	5/16/2007	45	90	0.178	0.300	59%	0.2126	24%	94%
Prosser	outfall	DTL07135.CA1	Unknown Coho									

											95% Confidence Interval	
Dam	Release Site	File Name	Species/Run	Date Released	Headgate Release Number	Outfall Release Number	Proportion Detected Headgate	Proportion Detected Outfall	Survival Estimate[a]	Standard Error of Survival Estimate	Lower Bound	Upper Bound
Prosser	headworks	DTL07149.BEL	Unknown fall Chinook and Coho	5/30/2007	120	240	0.217	0.258	84%	0.1721	56%	112%
Prosser	outfall	DTL07149.CA1	Unknown fall Chinook and Coho									
Prosser	headworks	DTL07163.BEL	Unknown fall Chinook and Coho	6/13/2007	50	98	0.020	0.112	17.8%	0.1835	-12%	48%
Prosser	outfall	DTL07163.CA1	Unknown fall Chinook and Coho									
Prosser	headworks	DTL08108.BEL	Wild spring Chinook	4/18/2008	300	300	0.237	0.360	66%	0.0849	52%	79.7%
Prosser	outfall	DTL08108.CA1	Wild spring Chinook									
Roza	headworks	DTL09100.R13	Spring Chinook	4/10/2009	250	250	0.332	0.280	119%	0.1605	92%	145%
Roza	outfall	DTL09100.R14	Spring Chinook									
Roza	headworks	DTL09105.R15	Spring Chinook	4/16/2009	250	250	0.172	0.168	102%	0.2024	69%	136%
Roza	outfall	DTL09105.R16	Spring Chinook									
Roza	headworks	DTL09111.R17	Spring Chinook	4/22/2009	250	250	0.264	0.340	77.6%	0.1068	60%	95%
Roza	outfall	DTL09111.R18	Spring Chinook									
Roza	headworks	DTL09119.R19	Spring Chinook	4/29/2009	250	250	0.168	0.184	91.3%	0.1769	62%	120%
Roza	outfall	DTL09119.R20	Spring Chinook									
Roza	headworks	DTL09125.R21	Spring Chinook	5/5/2009	250	250	0.284	0.336	84.5%	0.1134	66%	103%
Roza	outfall	DTL09125.R22	Spring Chinook									

Dam	Release Site	File Name	Species/Run	Date Released	Headgate Release Number	Outfall Release Number	Proportion Detected Headgate	Proportion Detected Outfall	Survival Estimate[a]	Standard Error of Survival Estimate	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Roza	headworks	DTL09133.R23	Spring Chinook	5/14/2009	250	250	0.200	0.244	82.0%	0.1381	59%	105%
Roza	outfall	DTL09133.R24	Spring Chinook									
Sunnyside	headworks	DTL09127.SCA	Spring Chinook	5/8/2009	250	250	0.404	0.388	104%	0.1151	85%	123%
Sunnyside	outfall	DTL09127.SBL	Spring Chinook									
Sunnyside	headworks	DTL09134.SCA	Spring Chinook	5/15/2009	240	240	0.288	0.375	77%	0.1008	60%	93%
Sunnyside	outfall	DTL09134.SBL	Spring Chinook									
Sunnyside	headworks	DTL09141.SCA	Spring Chinook	5/22/2009	240	239	0.233	0.381	61%	0.0877	47%	76%
Sunnyside	outfall	DTL09141.SBL	Spring Chinook									
Sunnyside	headworks	DTL10138.SCA	Fall Chinook	5/20/2010	807	801	0.136	0.159	86%	0.1034	69%	103%
Sunnyside	outfall	DTL10138.SBL	Fall Chinook									
Sunnyside	headworks	DTL10147.SCA	Fall Chinook	5/28/2010	805	801	0.215	0.184	117%	0.1176	98%	136%
Sunnyside	outfall	DTL10146.SBL	Fall Chinook									
Sunnyside	headworks	DTL10154.SCA	Fall Chinook	6/4/2010	802	801	0.228	0.196	116%	0.1125	98%	135%
Sunnyside	outfall	DTL10154.SBL	Fall Chinook									
Sunnyside	headworks	DTL10159.SCA	Fall Chinook	6/11/2010	806	806	0.230	0.243	94%	0.0846	80%	108%
Sunnyside	outfall	DTL10159.SBL	Fall Chinook									


Jack Creek acclimation site
Keechelus Dam
Easton Diversion Dam
Easton acclimation sites
Cle Elum SRF and Cle Elum Slough
CLE ELUM
ELLENSBURG
Upper Yakima River
Oak Flats Diversion Dam
Naches River
Buckskin Slough
Roza Diversion Dam
Tieton Diversion Dam
Cowiche Diversion Dam
Stiles Pond
YAKIMA
Greenway Ponds
Wapato Diversion Dam
Wapato Net Pens
Roza Wasteway #3
Sunnyside Diversion Dam
WAPATO
ZILLAH
TOPPENISH
Lower Yakima River
SUNNYSIDE
GRANDVIEW
Granger Ponds
MABTON
PROSSER
Prosser Dam and Chandler Smolt Trap
Columbia River
Horn Rapids Diversion Dam
RICHLAND
PASCO
KENNEWICK
0 5 10
Miles
Yakima Basin indicated in black, Columbia Basin in gray

Appendix B

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

2011 Annual Report

August 10, 2012

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Acknowledgments

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

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

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

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

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

Abstract

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

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

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

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

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

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Introduction

Program Objectives

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

Facility Descriptions

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

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

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

Yakima River Basin Overview

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

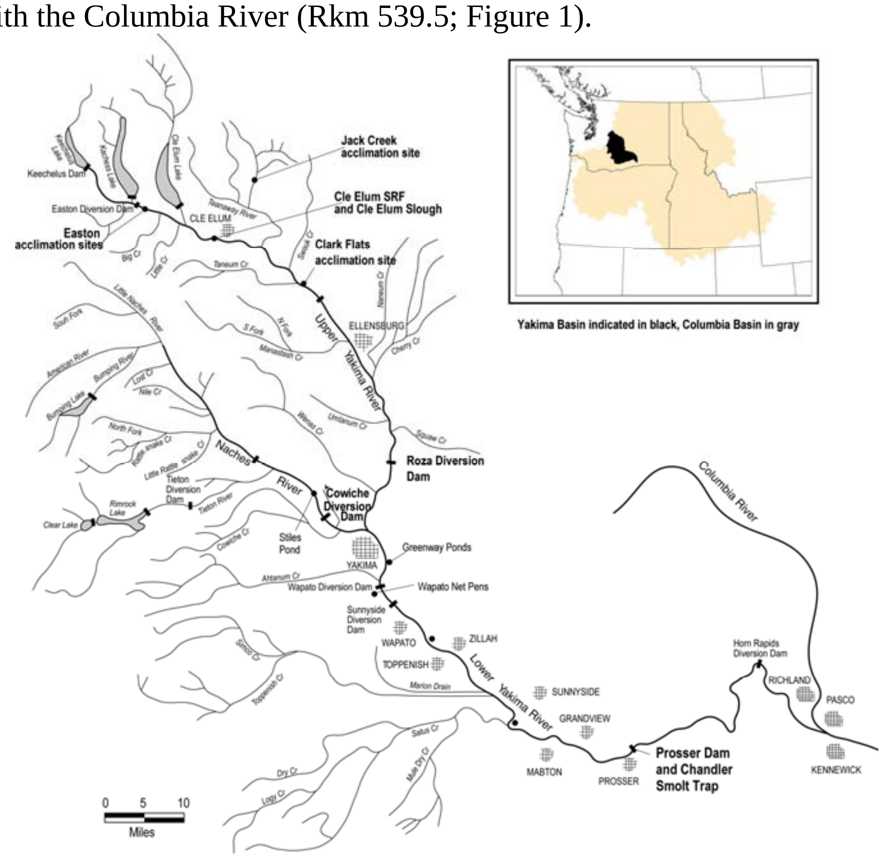

Figure 1. Yakima River Basin.

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).

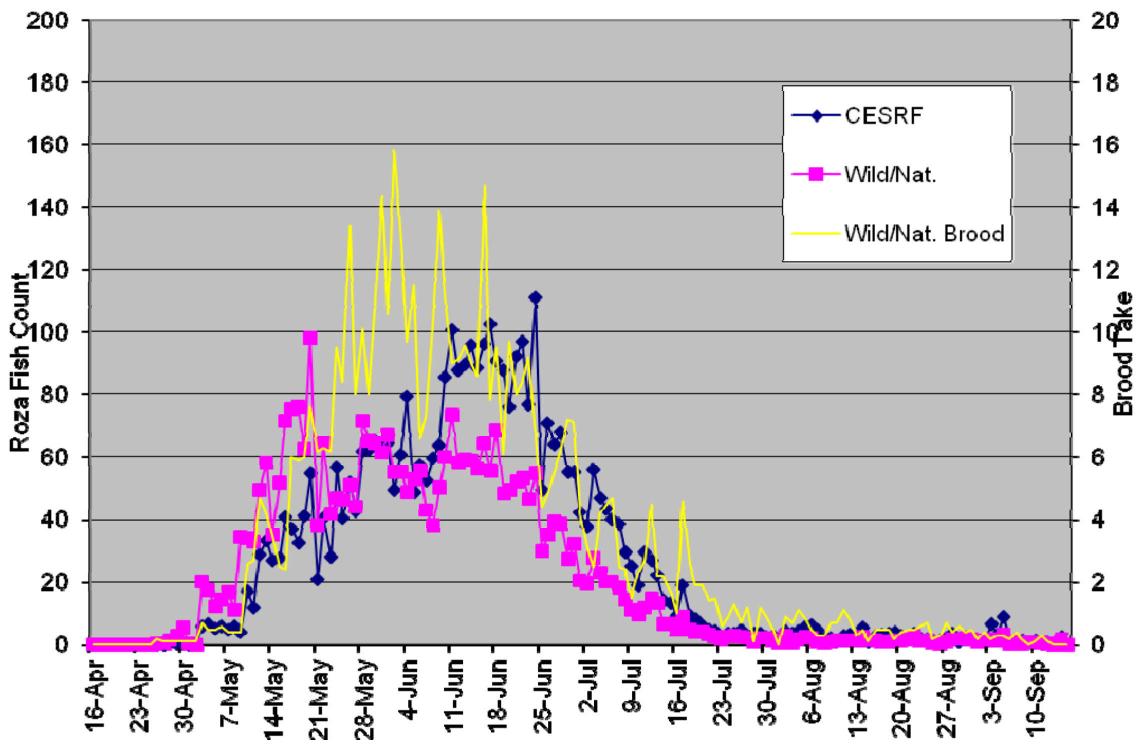

Figure 2. Mean spring Chinook run timing and broodstock collection at Roza Dam, 2002-2011.

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

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

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

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

Natural- and Hatchery-Origin Escapement

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

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

	Wild/Natural (NoR)			CESRF (HoR)			Total				
Year	Adults	Jacks	Total	Adults	Jacks	Total	Adults	Jacks	Total	PHOS[1]	PNI[1]
1982			1,146								
1983			1,007								
1984			1,535								
1985			2,331								
1986			3,251								
1987			1,734								
1988			1,340								
1989			2,331								
1990			2,016								
1991			*1,583*[2]								
1992			3,009								
1993			1,869								
1994			563								
1995			355								
1996			1,631								
1997	1,141	43	1,184								
1998	369	18	387								
1999	498	468	966								
2000	10,491	481	10,972		688	688	10,491	1,169	11,660	5.9%	
2001	4,454	297	4,751	6,065	982	7,047	10,519	1,279	11,798	59.7%	62.6%
2002	1,820	89	1,909	6,064	71	6,135	7,884	160	8,044	76.3%	56.7%
2003	394	723	1,117	1,036	1,105	2,141	1,430	1,828	3,258	65.7%	60.3%
2004	6,536	671	7,207	2,876	204	3,080	9,412	875	10,287	29.9%	77.0%
2005	4,401	175	4,576	627	482	1,109	5,028	657	5,685	19.5%	83.7%
2006	1,510	121	1,631	1,622	111	1,733	3,132	232	3,364	51.5%	66.0%
2007	683	161	844	734	731	1,465	1,417	892	2,309	63.4%	61.2%
2008	988	232	1,220	2,157	957	3,114	3,145	1,189	4,334	71.9%	58.2%
2009	1,843	701	2,544	2,234	2,260	4,494	4,077	2,961	7,038	63.9%	61.0%
2010	2,436	413	2,849	4,524	1,001	5,525	6,960	1,414	8,374	66.0%	60.2%
2011	3,092	926	4,018	3,162	1,404	4,566	6,254	2,330	8,584	53.2%	65.3%
Mean[3]	2,710	368	3,078	2,827	846	3,674	5,387	1,256	6,643	56.5%	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, 1985-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
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	888
2001	21,225	2,040	23,265	1,793	21,472	2,838	286	12,516	718	11,798	5,829	3,226	1,192
2002	14,616	483	15,099	328	14,771	2,780	29	8,922	878	8,044	3,041	2,816	943
2003	4,868	2,089	6,957	59	6,898	381	83	3,842	584	3,258	2,592	868	935
2004	13,974	1,315	15,289	135	15,154	1,544	90	11,005	718	10,287	2,515	3,414	719
2005	8,059	699	8,758	34	8,724	440	28	6,352	667	5,685	1,904	2,009	574
2006	5,951	363	6,314	0	6,314	600	14	4,028	664	3,364	1,672	1,245	447
2007	2,968	1,335	4,303	10	4,293	269	13	3,025	716	2,309	986	722	313
2008	6,615	1,983	8,598	539	8,059	993	9	5,478	1,144	4,334	1,578	1,372	495
2009	7,441	4,679	12,120	1,517	10,603	836	18	8,633	1,595	7,038	1,117	1,575	482
2010	11,027	2,114	13,142	156	12,986	1,585	9	9,900	1,526	8,374	1,491	2,668	552
2011	13,398	4,561	17,960	909	17,051	3,471	0	10,520	1,936	8,584	3,060	1,898	580
Mean[6]	8,892	1,962	10,854	369	10,485	1,290	29	7,171	1,043	6,128	1,996	1,859	604

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 (2002-2011).

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	Estimated	Estimated Yakima R. Mouth Returns				Returns/
Year	Spawners	Age-3	Age-4	Age-5	Total	Spawner
1982[1]	1,280	324	4,016	411	4,751	3.71
1983[1]	1,125	408	1,882	204	2,494	2.22
1984	1,715	92	1,348	139	1,578	0.92
1985	2,578	114	2,746	105	2,965	1.15
1986	3,960	171	2,574	149	2,893	0.73
1987	2,003	53	1,571	109	1,733	0.87
1988	1,400	53	3,138	132	3,323	2.37
1989	2,466	68	1,779	9	1,856	0.75
1990	2,298	79	566	0	645	0.28
1991	1,713	9	326	22	358	0.21
1992	3,048	87	1,861	95	2,043	0.67
1993	1,925	66	1,606	57	1,729	0.90
1994	573	60	737	92	890	1.55
1995	364	59	1,036	129	1,224	3.36
1996	1,657	1,059	12,882	630	14,571	8.79
1997	1,204	621	5,837	155	6,613	5.49
1998	390	434	2,803	145	3,381	8.68
1999	1,021[2]	164	722	45	930	0.91
2000	11,864	856	7,689	127	8,672	0.73
2001	12,084	775	5,074	222	6,071	0.50
2002	8,073	224	1,875	148	2,247	0.28
2003	3,341	158	1,036	63	1,257	0.38
2004	10,377	207	1,547	75	1,828	0.18
2005	5,713	293	2,630	14	2,936	0.51
2006	3,378	868	2,887	133	3,888	1.15
2007	2,322	456	3,976		4,433	
2008	4,343	1,135				
2009	7,056					
2010	8,383					
2011	8,584					
Mean[3]	4,066	326	2,844	122	3,253	1.80

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. The mean jack proportion of spawning escapement from 1999-2011 was 0.24 (geometric mean 0.17).
3. 1984-present.

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

Table 5. Adult-to-adult productivity 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	2,346	0.61
2001	3,912	126	1,254	471	0	1,850	0.47
2002	1,861	59	753	153	0	965	0.52
2003	1,400	52	237	175	0	464	0.33
2004	2,197	107	875	218	0	1,200	0.55
2005	1,439	167	653	119	0	940	0.65
2006	1,163	192	834	254		1,280	1.10
2007	463	125	1,649			1,774	
2008	1,074	414					
2009	903						
2010	1,207						
2011	2,476						
Mean[3]	1,284	104	932	405	3	1,414	1.67

1. Data not considered as reliable for these years as methods were still being developed and standardized.
2. The mean jack proportion of spawning escapement from 1999-2011 was 0.08 (geometric mean 0.09).
3. 1984-present.

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	1,543	610	0	2,166	5.84
1998	414	120	766	1,136	0	2,022	4.88
1999	61	72	99	163	0	334	5.50
2000	250	60	163	110	0	333	1.33
2001	1,917	18	364	256	0	638	0.33
2002	1,180	19	279	257	0	555	0.47
2003	1,192	23	183	440	0	646	0.54
2004	318	121	52	33	0	206	0.65
2005	464	79	173	263[2]	0	515	1.11
2006	509	45	172[2]	451		668	1.31
2007	523	57[2]	645			702	
2008	504	239					
2009	213						
2010	285						
2011	584						
Mean[3]	538	48	254	322	1	604	1.78

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

Table 7. Adult-to-adult productivity 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	2,359	0	6,579	6.29
1997	1,133	220	4,644	1,377	0	6,241	5.51
1998	917	364	2,167	2,316	12	4,859	5.30
1999	418[2]	185	369	279	0	833	1.99
2000	4,112	131	2,286	346	0	2,762	0.67
2001	5,829	144	1,598	785	0	2,526	0.43
2002	3,041	78	975	443	0	1,496	0.49
2003	2,592	75	387	1,028	0	1,489	0.57
2004	2,515	227	514	232	0	973	0.39
2005	1,904	246	845	174[3]	0	1,264	0.66
2006	1,672	237	1,215[3]	759		2,211	1.32
2007	986	182[3]	2,239			2,421	
2008	1,578	653					
2009	1,117						
2010	1,491						
2011	3,060						
Mean[4]	1,822	152	1,143	771	9	2,022	1.69

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

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

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

Brood	Estimated	Estimated Yakima R. Mouth Returns				Returns/
Year	Spawners	Age-3	Age-4	Age-5	Total	Spawner
1997	261	741	7,753	176	8,670	33.22
1998	408	1,242	7,939	602	9,782	23.98
1999	738[1]	134	714	16	864	1.17
2000	567	1,103	3,647	70	4,819	8.50
2001	595	396	845	9	1,251	2.10
2002	629	345	1,886	69	2,300	3.66
2003	441	121	800	12	932	2.11
2004	597	805	3,101	116	4,022	6.74
2005	510	1,305	3,052	31	4,388	8.60
2006	419	3,038	5,802	264	9,104	21.73
2007	449	1,277	5,174		6,450	
2008	457	2,344				
2009	486					
2010	336					
2011	377					
Mean	485	1,071	3,701	137	4,780	6.62[2]

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

Age Composition

Comparisons of the age composition in the Roza adult monitoring facility (RAMF) samples and spawning ground carcass recovery samples show that older, larger fish are recovered as carcasses on the spawning grounds at significantly higher rates than younger, smaller fish (Knudsen et al. 2003 and Knudsen et al. 2004). Based on historical scale-sampled carcass recoveries between 1986 and 2011, age composition of American River spring Chinook has averaged 1, 41, 56, and 2 percent age-3, -4, –5, and -6, respectively (Table 9). Naches system spring Chinook averaged 2, 60, 38 and 0.5 percent age-3, -4, –5 and -6, respectively (Table 10). The upper Yakima River natural origin fish averaged 8, 87, and 5 percent age-3, -4, and –5, respectively (Table 11). While these ages are biased toward the older age classes, we believe the bias is approximately equal across populations and is a good relative indicator of differences in age composition between populations. The data show distinct differences with the American River population having the oldest age of maturation, followed closely by the Naches system and then the upper Yakima River which has significantly more age-3's, fewer age-5's and no age-6 fish.

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

Return	Males					Females					Total			
Year	3	4	5	6	n	3	4	5	6	n	3	4	5	6
1986		23.8	76.2		21		8.9	86.7	4.4	45		13.6	83.3	3.0
1987		70.8	25.0	4.2	24		42.9	57.1		21		57.8	40.0	2.2
1988			100.0		1		100.0			1		33.3	66.7	
1989		39.6	60.4		48		10.0	90.0		50		24.5	75.5	
1990	2.5	25.0	72.5		40		28.3	71.7		46	1.2	26.7	72.1	
1991		23.8	76.2		42		13.3	86.7		60		17.6	82.4	
1992		71.2	23.1	5.8	52		45.8	54.2		48		59.0	38.0	3.0
1993	4.8	14.3	81.0		21		8.0	92.0		75	1.0	9.4	89.6	
1994		44.4	55.6		18		50.0	46.7	3.3	30		49.0	49.0	2.0
1995	14.3	14.3	71.4		7			100.0		13	5.0	5.0	90.0	
1996		100.0			2		83.3	16.7		6		87.5	12.5	
1997		40.0	60.0		5		22.2	64.4	13.3	45		24.0	64.0	12.0
1998		12.1	87.9		33		6.6	93.4		76		8.3	91.7	
1999		100.0			2		40.0	40.0	20.0	5		57.1	28.6	14.3
2000		66.7	33.3		15		61.5	38.5		13		64.3	35.7	
2001		65.6	34.4		90		67.9	32.1		106		67.0	33.0	
2002	1.7	53.4	44.8		58		56.4	43.6		110	0.6	55.4	44.0	
2003		8.1	91.9		74		7.9	92.1		151		8.0	92.0	
2004		100.0			3		20.0	80.0		5		50.0	50.0	
2005		64.7	35.3		17		84.0	16.0		25		76.7	23.3	
2006		61.5	38.5		13		48.6	51.4		35		52.1	47.9	
2007	10.5	31.6	57.9		19		43.8	56.3		48	3.0	40.3	56.7	
2008		8.7	91.3		23		11.9	88.1		42		10.6	89.4	
2009	30.8	69.2			13		75.0	25.0		16	13.8	72.4	13.8	
2010							No carcasses were sampled							
2011		40.0	60.0		10		63.2	36.8		19		58.8	41.2	
Mean	2.6	46.0	51.1	0.4			40.0	58.4	1.6		1.0	41.1	56.4	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	
2011	11.5	80.8	7.7		26		78.9	21.1		19	6.3	81.3	12.5	
Mean	4.6	65.6	29.0	0.8		0.7	55.5	43.5	0.4		2.3	59.6	37.6	0.5

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

Return	Males				Females				Total		
Year	3	4	5	n	3	4	5	n	3	4	5
1986		100.0		12		94.1	5.9	51		95.2	4.8
1987	10.8	81.5	7.7	65		77.8	22.2	126	3.7	79.1	17.3
1988	22.5	70.0	7.5	40	10.4	75.0	14.6	48	15.6	73.3	11.1
1989	0.8	93.1	6.2	130	0.4	95.5	4.1	246	0.5	94.7	4.8
1990	6.3	88.4	5.3	95	2.1	94.8	3.1	194	3.4	92.8	3.8
1991	9.1	87.3	3.6	55		89.2	10.8	111	3.0	88.6	8.4
1992	2.4	91.6	6.0	167		98.1	1.9	315	0.8	95.9	3.3
1993	4.0	90.0	6.0	50	0.9	92.0	7.1	112	1.9	91.4	6.8
1994		100.0		16		98.0	2.0	50		98.5	1.5
1995	20.0	80.0		5		100.0		12	5.6	94.4	
1996	9.1	89.6	1.3	154	0.7	98.2	1.1	282	3.7	95.2	1.1
1997		96.7	3.3	61		96.3	3.7	136		96.4	3.6
1998	14.3	85.7		21	5.3	86.8	7.9	38	8.5	86.4	5.1
1999	61.8	38.2		34		94.4	5.6	36	31.0	66.2	2.8
2000	2.8	97.2		72		100.0		219	1.0	99.0	
2001	2.7	89.2	8.1	37		83.6	16.4	122	0.6	85.0	14.4
2002	2.4	58.5	39.0	41	3.6	87.5	8.9	56	5.1	73.7	21.2
2003	60.5	39.5		38	4.3	82.6	13.0	23	39.3	55.7	4.9
2004	6.5	93.5		108	0.0	99.5	0.5	198	2.3	97.4	0.3
2005	9.2	90.0		120	1.4	97.2	1.4	214	4.2	94.7	1.2
2006	23.7	74.6		59	2.3	96.5	1.2	86	11.0	87.6	1.4
2007	17.1	82.9		76	0.9	93.8	5.4	112	7.4	89.4	3.2
2008	11.8	88.2		34	0.0	95.8	4.2	24	6.9	91.4	1.7
2009	47.7	52.3		111	2.2	95.6	2.2	45	34.6	64.7	0.6
2010	27.7	72.3		47		100.0		71	11.0	89.0	
2011	37.5	62.5		16		100.0		27	13.6	86.4	
Mean	15.8	80.5	3.6		1.3	93.2	5.5		8.3	87.0	4.7

Carcasses from upper Yakima River CESRF origin fish allowed to spawn naturally have also been sampled since age-4 adults began returning in 2001. These fish averaged 19, 80, and 1 percent age-3, -4, and –5, respectively (Table 12) from 2001-2011 compared to 12, 83, and 5 percent respectively for their wild/natural counterparts in the upper Yakima for the same years (Table 11). The observed difference in age distribution between wild/natural and CESRF sampled on the spawning grounds may be due in part to the carcass recovery bias described above. A better comparison of age distribution between upper Yakima wild/natural and CESRF fish is from samples collected at Roza Dam which are displayed in Tables 13 and 14. However, it must be noted that jacks (age-3 males) were collected at Roza in proportion to run size from 1997 to 1999, but from 2000-present we have attempted to collect them at their mean brood representation rate (approximately 7% of the spawning population). Age-3 females do occur rarely in the Upper Yakima population, but it is likely that the data in Table 13 slightly over-represent the proportion of age-3 females due to human error associated with scale collection, handling, processing, and management and entry of these data.

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

Return	Males				Females				Total		
Year	3	4	5	n	3	4	5	n	3	4	5
2001	23.5	76.5		34	0.9	99.1		108	6.3	93.7	
2002	8.0	81.3	10.7	75		88.6	11.4	140	2.8	86.2	11.1
2003	100.0			1		100.0		1	50.0	50.0	
2004	9.5	90.5		21		98.0	2.0	51	2.8	95.8	1.4
2005	42.9	57.1		21		90.9	4.5	22	23.3	74.4	2.3
2006	26.7	73.3		15		100.0		43	6.9	93.1	
2007	66.7	33.3		6		100.0		11	23.5	76.5	
2008				0		100.0		1		100.0	
2009	60.0	40.0		5				0	60.0	40.0	
2010	28.6	71.4		7		100.0		11	11.1	88.9	
2011	37.5	62.5		16	4.5	95.5		22	18.4	81.6	
Mean	40.3	58.6	1.1		0.5	97.2	1.8		18.6	80.0	1.3

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

Return	Males				Females				Total		
Year	3	4	5	n	3	4	5	n	3	4	5
1997	4.5	92.0	3.4	88		94.6	5.4	111	2.0	93.5	4.5
1998	22.4	73.1	4.5	134		91.6	8.4	179	9.6	83.7	6.7
1999	71.1	26.1	2.8	425		92.6	7.4	215	48.8	47.0	4.2
2000	17.8	81.7	0.4	230		98.7	1.3	313	7.5	91.5	0.9
2001	12.4	77.4	10.3	234	0.9	90.5	8.5	328	5.7	85.2	9.2
2002	16.4	78.3	5.3	226	0.6	94.8	4.7	343	6.9	88.2	4.9
2003	27.4	60.2	12.4	201		83.3	16.7	228	12.8	72.6	14.7
2004	15.1	84.5	0.4	239	0.3	99.0	0.7	305	6.8	92.6	0.6
2005	15.5	82.3	2.2	181	0.4	97.1	2.5	276	6.3	91.2	2.4
2006	11.1	77.4	11.5	226		89.4	10.6	255	5.2	83.8	11.0
2007	13.6	74.7	11.7	162		87.8	12.2	255	5.3	82.7	12.0
2008	20.0	77.4	2.6	190		95.6	4.4	252	8.6	87.8	3.6
2009	17.4	81.2	1.4	207	0.8	96.1	3.1	258	8.2	89.5	2.4
2010	20.0	79.4	0.6	155	0.4	99.3	0.4	285	7.3	92.3	0.5
2011	18.1	81.3	0.5	182	0.8	95.3	3.8	236	8.4	89.2	2.4
Mean	20.2	75.1	4.7		0.3	93.7	6.0		10.0	84.7	5.3

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

Return	Males				Females				Total		
Year	3	4	5	n	3	4	5	n	3	4	5
2001	12.5	87.5		40		100.0		75	5.1	94.9	
2002	14.7	83.8	1.5	68		98.3	1.7	115	5.5	92.9	1.6
2003	36.1	34.7	29.2	72		61.2	38.8	67	18.7	47.5	33.8
2004	19.6	80.4		46		100.0		60	8.5	91.5	
2005	17.8	75.6	6.7	45		88.1	11.9	59	7.7	82.7	9.6
2006	18.3	80.0	1.7	60		100.0		65	8.8	90.4	0.8
2007	33.3	60.8	5.9	51		87.5	12.5	56	15.9	74.8	9.3
2008	50.0	50.0		40		100.0		56	20.8	79.2	
2009	25.4	71.2	3.4	59	1.2	97.6	1.2	84	11.2	86.7	2.1
2010	27.9	72.1		61		99.0	1.0	100	10.6	88.8	0.6
2011	21.2	72.7	6.1	66	0.9	97.2	1.9	107	8.7	87.9	3.5
Mean	25.2	69.9	4.9			93.5	6.3		11.0	83.4	5.6

Sex Composition

In the American River, the mean proportion of males to females in wild/natural carcasses sampled on the spawning grounds from 1986-2011 was 44:56 for age-4 and 32:68 for age-5 spring Chinook (Table 15). In the Naches River, the mean proportion of males to females was 42:58 for age-4 and 26:74 for age-5 fish (Table 16). In the upper Yakima River, the mean proportion of males to females was 34:66 for age-4 and 23:77 for age-5 fish (Table 17).

For upper Yakima fish collected at Roza Dam for brood stock or research purposes from 1997-2011, the mean proportion of males to females was 38:62 and 35:65 for age-4 fish from the wild/natural and CESRF populations, respectively (Tables 19 and 20). For these same samples, the mean proportion of males to females was 35:65 and 45:55 for age-5 fish from the wild/natural and CESRF populations (excluding years with very small age-5 sample sizes), respectively (Tables 19 and 20). For adult fish, the mean proportion of males to females in spawning ground carcass recoveries was substantially lower than the ratio found at RAMF (Tables 17 and 19), indicating that sex ratios estimated from hatchery origin carcass recoveries were biased due to female carcasses being recovered at higher rates than male carcasses (Knudsen et al, 2003 and 2004). Again, despite these biases, we believe these data are good relative indicators of differences in sex composition between populations and between years.

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

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

Return	Age-3		Age-4		Age-5		Age-6	
Year	M	F	M	F	M	F	M	F
1986			55.6	44.4	29.1	70.9		100.0
1987			65.4	34.6	33.3	66.7	100.0	
1988			0.0	100.0	100.0	0.0		
1989			79.2	20.8	39.2	60.8		
1990	100.0		43.5	56.5	46.8	53.2		
1991			55.6	44.4	38.1	61.9		
1992			62.7	37.3	31.6	68.4	100.0	
1993	100.0		33.3	66.7	19.8	80.2		
1994			34.8	65.2	41.7	58.3		100.0
1995	100.0		100.0	0.0	27.8	72.2		
1996			28.6	71.4	0.0	100.0		
1997			16.7	83.3	9.4	90.6		100.0
1998			44.4	55.6	29.0	71.0		
1999			50.0	50.0	0.0	100.0		100.0
2000			55.6	44.4	50.0	50.0		
2001			45.0	55.0	47.7	52.3		
2002	100.0		33.3	66.7	35.1	64.9		
2003			33.3	66.7	32.9	67.1		
2004			75.0	25.0	0.0	100.0		
2005			34.4	65.6	60.0	40.0		
2006			32.0	68.0	21.7	78.3		
2007	100.0		22.2	77.8	28.9	71.1		
2008			28.6	71.4	36.2	63.8		
2009			42.9	57.1	0.0	100.0		
2010			No carcasses were sampled					
2011			25.0	75.0	46.2	53.8		
mean			43.9	56.1	32.2	67.8		

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

Return	Age-3		Age-4		Age-5		Age-6	
Year	M	F	M	F	M	F	M	F
1986	100.0		46.2	53.8	18.2	81.8	50.0	50.0
1987	100.0		31.0	69.0	13.3	86.7	100.0	
1988		100.0	36.4	63.6	28.6	71.4		
1989			60.0	40.0	25.9	74.1		100.0
1990	50.0	50.0	55.6	44.4	52.6	47.4		
1991	100.0		66.7	33.3	20.4	79.6		
1992	100.0		45.5	54.5	23.1	76.9	100.0	
1993			57.9	42.1	30.0	70.0		
1994			40.0	60.0	22.2	77.8		
1995			33.3	66.7	37.5	62.5		
1996			58.6	41.4		100.0		
1997	100.0		46.2	53.8	28.0	72.0	40.0	60.0
1998			29.4	70.6	27.9	72.1		
1999	100.0		62.5	37.5	25.0	75.0		
2000	100.0		44.1	55.9	25.0	75.0		
2001	100.0		37.4	62.6	24.6	75.4		
2002	100.0		37.4	62.6	20.0	80.0		
2003	83.3	16.7	47.1	52.9	36.1	63.9		
2004	100.0		29.4	70.6	20.0	80.0		
2005			22.5	77.5	25.0	75.0		
2006			50.0	50.0	50.0	50.0		
2007			21.4	78.6	11.1	88.9		
2008	100.0		20.0	80.0	40.0	60.0		
2009	100.0		33.3	66.7	33.3	66.7		
2010			33.3	66.7		100.0		
2011	100.0		58.3	41.7	33.3	66.7		
mean			42.4	57.6	25.8	74.2		

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

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
1986			20.0	80.0		100.0
1987	100.0		35.1	64.9	15.2	84.8
1988	64.3	35.7	43.8	56.3	30.0	70.0
1989	50.0	50.0	34.0	66.0	44.4	55.6
1990	60.0	40.0	31.3	68.7	45.5	54.5
1991	100.0		32.7	67.3	14.3	85.7
1992	100.0		33.1	66.9	62.5	37.5
1993	66.7	33.3	30.4	69.6	27.3	72.7
1994			24.6	75.4		100.0
1995	100.0		25.0	75.0		
1996	87.5	12.5	33.3	66.7	40.0	60.0
1997			31.1	68.9	28.6	71.4
1998	60.0	40.0	35.3	64.7		100.0
1999	100.0		27.7	72.3		100.0
2000	100.0		24.2	75.8		
2001	100.0		24.4	75.6	13.0	87.0
2002	33.3	66.7	32.9	67.1	76.2	23.8
2003	95.8	4.2	44.1	55.9		100.0
2004	100.0		33.9	66.1		100.0
2005	78.6	21.4	34.2	65.8	25.0	75.0
2006	87.5	12.5	34.6	65.4	50.0	50.0
2007	92.9	7.1	37.5	62.5		100.0
2008	100.0		56.6	43.4		100.0
2009	98.1	1.9	57.4	42.6		100.0
2010	100.0		32.4	67.6		
2011	100.0		27.0	73.0		
mean	85.9	14.1	34.3	65.7	22.5	77.5

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

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
2001	88.9	11.1	19.5	80.5		
2002	100.0		33.0	67.0	33.3	66.7
2003	100.0			100.0		
2004	100.0		27.5	72.5		100.0
2005	90.0	10.0	37.5	62.5		100.0
2006	100.0		20.4	79.6		
2007	100.0		15.4	84.6		
2008				100.0		
2009	100.0		100.0			
2010	100.0		31.3	68.8		
2011	85.7	14.3	32.3	67.7		
mean	96.5	3.5	28.8	71.2		

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

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
1997	100.0		43.5	56.5	33.3	66.7
1998	100.0		37.4	62.6	28.6	71.4
1999	100.0		35.8	64.2	42.9	57.1
2000	100.0		37.8	62.2	20.0	80.0
2001	90.6	9.4	37.9	62.1	46.2	53.8
2002	94.9	5.1	35.3	64.7	42.9	57.1
2003	100.0		38.9	61.1	39.7	60.3
2004	97.3	2.7	40.1	59.9	33.3	66.7
2005	96.6	3.4	35.7	64.3	36.4	63.6
2006	100.0		43.4	56.6	49.1	50.9
2007	100.0		35.1	64.9	38.0	62.0
2008	100.0		37.9	62.1	31.3	68.8
2009	94.7	5.3	40.4	59.6	27.3	72.7
2010	96.9	3.1	30.3	69.7	50.0	50.0
2011	94.3	5.7	39.7	60.3	10.0	90.0
mean	97.7	2.3	37.9	62.1	35.2	64.8

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

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
2001	100.0	0.0	31.8	68.2		
2002	100.0	0.0	33.5	66.5	33.3	66.7
2003	100.0	0.0	37.9	62.1	44.7	55.3
2004	100.0	0.0	38.1	61.9		
2005	100.0	0.0	39.5	60.5	30.0	70.0
2006	100.0	0.0	42.5	57.5	100.0	
2007	100.0	0.0	38.8	61.3	30.0	70.0
2008	100.0	0.0	26.3	73.7		
2009	93.8	6.3	33.9	66.1	66.7	33.3
2010	100.0	0.0	30.8	69.2		100.0
2011	93.3	6.7	31.6	68.4	66.7	33.3
mean	98.8	1.2	35.0	65.0	45.2	54.8

Size at Age

Prior to 1996, samplers were instructed to collect mid-eye to hypural plate (MEHP) lengths from carcasses surveyed on the spawning grounds. From 1996 to present the method was changed and post-eye to hypural plate (POHP) lengths have been recorded. Mean POHP lengths averaged 40, 61, and 78 cm for age-3, -4, and -5 males, and averaged 63 and 73 cm for age-4 and -5 females, respectively, from carcasses sampled on the spawning grounds in the American River from 1996-2011 (Table 21). In the Naches River, mean POHP lengths averaged 42, 61, and 76 cm for age-3, -4, and -5 males, and averaged 61 and 73 cm for age-4 and -5 females, respectively (Table 22). For wild/natural spring Chinook sampled on the spawning grounds in the upper Yakima River, mean POHP lengths averaged 44, 60, and 72 cm for age-3, -4, and -5 males, and averaged 60 and 69 cm for age-4 and -5 females, respectively (Table 23). From 2001-2011, 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.

Return	Males								Females					
	Age 3		Age 4		Age 5		Age 6		Age 4		Age 5		Age 6	
Year	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP
1986			5	57.1	16	80.9			4	65.8	39	75.2	2	74.0
1987			17	58.0	6	80.8	1.0	86.0	9	64.5	12	76.9		
1988					1	79.0			1	63.0				
1989			19	61.1	29	77.4			5	63.0	45	73.5		
1990	1	41.0	10	63.6	29	77.3			13	62.5	33	73.6		
1991			10	59.5	32	77.1			8	65.1	52	73.4		
1992			37	60.6	12	76.2	3.0	86.7	22	64.1	26	76.4		
1993	1	47.0	3	64.0	17	80.2			6	63.7	69	75.5		
1994			8	67.3	10	83.0			15	70.8	14	76.4	1	85.0
1995	1	44.4	1	70.0	4	83.5					12	76.4		
		POHP		POHP		POHP		POHP		POHP		POHP		POHP
1996			2	56.3					5	59.0	1	67.0		
1997[1]			2	62.0	1	63.0			4	62.8	14	64.4	5	71.0
1998			4	58.3	29	79.1			5	64.0	71	73.4		
1999			2	50.5					2	61.0	2	73.0	1	77.0
2000			10	57.9	5	83.2			8	63.9	5	76.2		
2001			59	65.9	31	77.6			72	63.6	34	73.0		
2002	1	40.0	31	63.0	26	77.3			62	64.4	48	74.7		
2003			6	63.0	68	79.4			12	64.3	139	76.7		
2004			3	56.0					1	58.0	4	77.5		
2005			11	60.6	6	80.2			21	62.6	4	74.8		
2006			8	60.8	5	75.4			17	61.8	18	71.7		
2007	2	37.0	6	62.8	11	76.5			21	60.0	27	73.3		
2008			2	67.5	21	83.1			5	67.4	37	78.9		
2009	4	44.0	9	68.3					12	62.6	4	69.8		
2010				No samples						No samples				
2011			4	65.5	6	82.8			12	65.8	7	75.9		
Mean[2]		40.3		61.2		78.0				62.7		73.4		74.0

[1] Carcasses sampled in 1997 had a mix of MEHP and POHP lengths taken. Only POHP samples are given here.
[2] Mean of mean values for 1996-2011 post-eye to hypural plate lengths.

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

	Males								Females							
Return	Age 3		Age 4		Age 5		Age 6		Age 3		Age 4		Age 5		Age 6	
Year	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP
1986	1	45.0	12	62.7	6	74.3	1.0	80.0			14	64.5	27	73.6	1	83.5
1987	1	37.0	12	64.2	2	80.5	1.0	94.0			29	67.9	13	75.7		
1988			4	62.0	4	74.6			1	45.0	7	69.1	10	73.6		
1989			33	58.4	14	77.5					22	61.7	40	73.2	1	75.0
1990	3	53.0	20	59.4	10	75.9			3	51.7	16	60.9	9	73.7		
1991	1	31.0	12	56.3	10	72.8					6	62.5	39	71.1		
1992	1	42.0	20	58.8	3	72.3	1.0	83.0			24	62.4	10	71.7		
1993			11	60.0	15	77.7					8	63.3	35	72.5		
1994			2	62.5	2	77.0					3	63.7	7	73.1		
1995			1	59.0	3	73.0					2	64.0	5	73.8		
		POHP		POHP		POHP		POHP		POHP		POHP		POHP		POHP
1996			17	58.1							12	60.3	4	69.6		
1997[1]	1	39.0	24	59.8	4	71.5	2.0	78.0			28	60.0	15	68.6	1	75.0
1998			5	57.8	12	75.0					12	61.1	31	71.6		
1999	1	40.0	5	61.2	2	73.0					3	58.7	6	75.0		
2000	1	35.0	56	58.2	2	84.0					71	59.5	6	72.8		
2001	1	45.0	43	61.4	15	73.4					72	62.2	46	74.5		
2002	1	40.0	37	63.6	9	77.3					62	62.4	36	71.8		
2003	5	41.4	16	62.2	43	79.4			1	41.0	18	62.8	76	75.6		
2004	3	46.0	35	59.8	2	74.5					84	61.5	8	75.8		
2005			9	60.1	2	78.0					31	61.7	6	71.7		
2006			8	56.9	5	76.0					8	63.8	5	71.2		
2007			3	61.3	1	67.0					11	56.9	8	72.1		
2008	4	42.0	5	59.6	2	81.5					20	62.0	3	78.7		
2009	1	43.0	10	67.9	3	76.3					20	63.9	6	73.2		
2010			9	60.3							18	62.6	4	72.0		
2011	3	44.3	21	61.9							15	60.4	4	76.8		
Mean[2]		41.6		60.6		75.9		78.0		41.0		61.2		73.2		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 1996-2011 post-eye to hypural plate lengths.

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

	Males						Females					
Return	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Year	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP
1986			12	60.8					48	58.7	3	70.3
1987	7	45.3	53	58.5	5	73.0			96	59.3	28	70.6
1988	9	40.0	28	59.0	3	79.0	5	52.6	36	59.2	7	70.3
1989	1	50.0	121	59.7	8	70.6	1	40.0	235	58.6	10	67.2
1990	6	47.0	84	58.0	5	77.0	4	51.5	184	59.3	6	72.5
1991	5	39.6	48	56.2	2	67.5			99	57.6	12	68.8
1992	4	43.0	153	58.4	10	71.2			309	58.2	6	69.5
1993	2	44.0	45	60.7	3	75.0	1	56.0	101	59.5	8	70.3
1994			15	62.9					49	61.3	1	72.0
1995	1	43.0	4	62.0					12	61.4	0	
		POHP		POHP		POHP		POHP		POHP		POHP
1996	14	40.9	138	59.1	2	66.5	2	41.0	277	58.6	3	68.0
1997			59	59.3	2	74.0			131	58.6	5	69.4
1998	3	38.7	18	56.4			2	47.0	33	57.5	3	66.7
1999	21	38.8	13	57.4					34	58.9	2	69.8
2000	2	41.0	70	60.3					219	58.3	0	
2001	1	43.0	33	60.7	3	74.7			102	60.6	20	69.8
2002	1	44.0	24	64.9	16	69.3	2	46.0	49	62.5	5	70.2
2003	23	44.4	15	59.8					19	62.4	3	67.8
2004	7	47.3	101	59.9					197	58.7	1	67.0
2005	11	49.2	108	60.6	1	75.0	3	48.7	207	59.5	3	67.3
2006	14	41.8	44	59.4	1	72.0	2	39.5	82	58.3	1	71.0
2007	13	44.2	61	61.7					101	60.6	6	66.0
2008	3	48.3	29	60.5					22	59.7	1	77.0
2009	53	46.8	58	57.6			1	51.0	43	60.2	1	68.0
2010	13	47.7	34	60.5					70	59.5		
2011	6	47.0	10	58.9					27	59.3		
Mean[1]		44.2		59.8		71.9		45.5		59.6		69.1

[1] Mean of mean values for 1996-2011 post-eye to hypural plate lengths.

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

	Males						Females					
Return	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2001	8	40.5	25	59.0	1	69.5	1	41.0	107	59.0		
2002	6	47.7	61	61.2	8	68.9			124	60.6	16	71.2
2003	1	42.0							1	69.0		
2004	2	52.0	19	60.8					50	57.9	1	68.0
2005	8	41.8	12	59.9			1	46.0	20	59.6	1	72.0
2006	4	42.3	11	54.0					43	57.0		
2007	4	44.3	2	58.5					11	60.1		
2008	0		0						1	58.0		
2009	3	47.7	2	---								
2010	2	44.0	5	61.8					11	55.5		
2011	6	40.7	10	59.1			1	46.0	21	59.0		
Mean		44.3		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		
2011	11	47.5	91	60.3	1	75.3	1	52.5	182	60.2	4	72.9
Mean		43.1		59.6		70.8				59.9		68.6

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

	Males						Females					
Return	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2001			4	61.3					33	60.4		
2002	2	40.2	25	59.6					63	59.4	2	66.1
2003	17	42.6	16	57.8	15	74.0			31	59.7	19	70.4
2004	6	39.4	9	57.1					42	59.3		
2005	6	37.9	21	58.4	2	68.7			38	58.6	5	68.0
2006[1]			3	57.2					3	56.3		
2007	8	40.4	18	59.3	1	71.4			35	58.2	5	67.6
2008	17	43.8	9	59.1					28	59.4		
2009	5	43.8	11	61.1					32	60.1	1	67.5
2010	11	41.8	18	59.2					40	61.0		
2011	4	43.4	10	62.7	1	79.2			32	60.4	2	71.7
Mean		41.5		59.3		73.3				59.3		68.6

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

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

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

Table 28. Counts and mean post-orbital to hypural plate (POHP) lengths (cm) of upper Yakima River CESRF spring Chinook from fish sampled at Roza Dam by age, 2000-present.

Return	Age 2		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2000	66	15.9	633	38.3				
2001	893	15.2	474	40.0	2343	59.3		
2002	475	15.2	26	38.7	1535	59.2	34	67.0
2003	137	15.7	394	41.8	255	60.6	215	71.4
2004	83	15.5	49	40.4	451	59.5	2	71.0
2005	137	15.6	98	40.4	218	59.3	18	70.1
2006	26	14.5	26	40.4	407	57.6	2	70.5
2007	54	15.5	175	41.4	231	59.4	19	70.4
2008	11	15.4	95	45.0	251	60.3	1	67.0
2009	12	15.1	255	43.6	290	62.1	11	67.5
2010	22	15.9	107	42.7	557	61.5	3	67.0
2011	2	15.0	157	43.0	411	61.3	21	73.4
Mean		15.4		41.3		60.0		69.5

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).

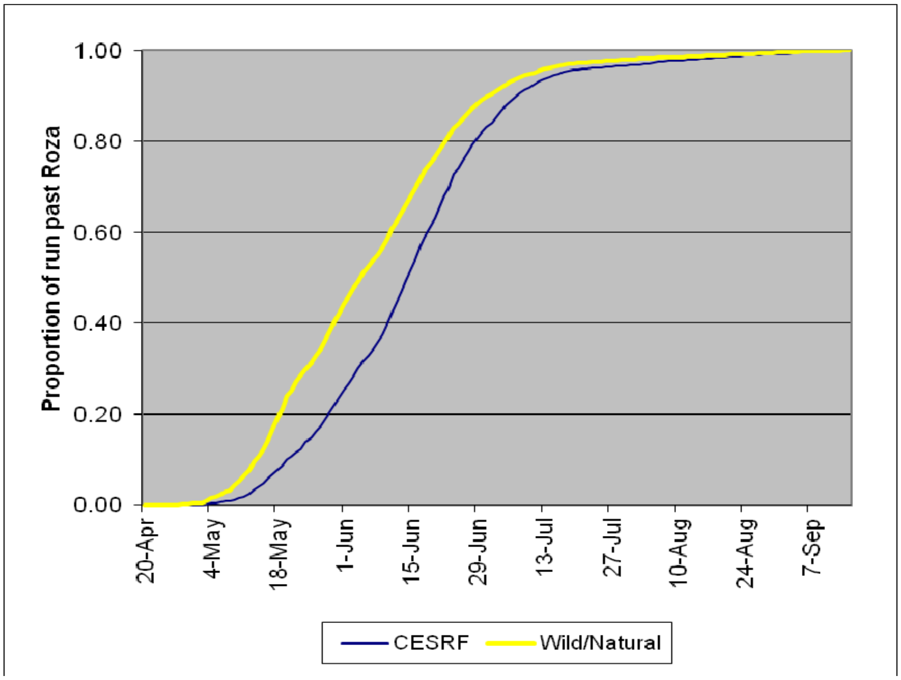

Figure 3. Proportionate passage timing at Roza Dam of wild/natural and CESRF adult spring Chinook (including jacks), 2002-2011.

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

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

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

Spawning Timing

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

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

Year	American	Naches	Upper Yakima	CESRF
1988	14-Aug	7-Sep	3-Oct	
1989	14-Aug	7-Sep	19-Sep	
1990	14-Aug	12-Sep	25-Sep	
1991	12-Aug	12-Sep	24-Sep	
1992	11-Aug	10-Sep	22-Sep	
1993	9-Aug	8-Sep	27-Sep	
1994	16-Aug	14-Sep	26-Sep	
1995	14-Aug	7-Sep	1-Oct	
1996	20-Aug	18-Sep	23-Sep	
1997	12-Aug	11-Sep	23-Sep	23-Sep
1998	11-Aug	15-Sep	30-Sep	22-Sep
1999	24-Aug	8-Sep	27-Sep	21-Sep
2000	7-Aug	20-Sep	19-Sep	19-Sep
2001	14-Aug	13-Sep	25-Sep	18-Sep
2002	12-Aug	11-Sep	23-Sep	24-Sep
2003	11-Aug	14-Sep	28-Sep	23-Sep
2004	17-Aug	12-Sep	27-Sep	21-Sep
2005	15-Aug	15-Sep	27-Sep	20-Sep
2006	15-Aug	14-Sep	26-Sep	19-Sep
2007	14-Aug	12-Sep	25-Sep	25-Sep
2008	11-Aug	12-Sep	23-Sep	23-Sep
2009	17-Aug	10-Sep	23-Sep	28-Sep
2010	17-Aug	12-Sep	21-Sep	21-Sep
2011	23-Aug	8-Sep	21-Sep	20-Sep
Mean	14-Aug	11-Sep	24-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	54	483	278	73	888
2001	2,910	374	21	3,305	392	436	257	107	1,192
2002	2,441	275	110	2,826	366	226	262	89	943
2003	772	87	31	890	430	228	216	61	935
2004	2,985	330	129	3,444	91	348	205	75	719
2005	1,717	287	15	2,019	140	203	163	68	574
2006	1,092	100	58	1,250	136	163	115	33	447
2007	665	51	10	726	166	60	60	27	313
2008	1,191	137	47	1,375	158	165	102	70	495
2009	1,349	197	33	1,579	92	159	163	68	482
2010	2,199	219	253	2,671	173	171	168	40	552
2011	1,663	171	64	1,898	212	145	175	48	580
Mean	1,081	131	26	1,238	158	178	113	48	497

[1] Including minor tributaries.

Homing

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

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

Straying

The regional PTAGIS (PIT tag) and RMIS (CWT) databases were queried in January 2012 to determine the number of CESRF releases not returning to the Yakima River Basin. For adult (age-3, -4, or -5) PIT tagged fish, a stray is defined as detection at an out-of-basin facility in the Snake (Ice Harbor or Lower Granite) or Upper Columbia (Priest Rapids, Rock Island, or Wells) without a subsequent detection at Prosser or Roza Dam. For coded-wire tagged fish, a stray is generally defined as a tag recovery in tributaries of the Columbia River upstream (and including the Snake River Basin) of its' confluence with the Yakima River. Marked (adipose fin clipped) fish are occasionally found during carcass surveys in the Naches River system. All marked fish observed in spawning ground carcass surveys in the Naches Basin are assumed to be CESRF fish and are used to estimate in-basin stray rates.

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

	CESRF PIT-Tagged Fish			All CESRF Fish			CESRF Age-4 Fish		
Brood Year	Roza Adult Returns	Adult Strays	Stray Rate	Yakima River Mth Return	CWT Strays	Stray Rate	Yak R. MthRtn	In-Basin Strays[1]	Stray Rate
1997	598	2	0.33%	8,670	1	0.01%	7,753		
1998	398	0	0.00%	9,782			7,939	1	0.01%
1999	23	0	0.00%	864			714		
2000	150	4	2.67%	4,819	2	0.04%	3,647	4	0.11%
2001	80	3	3.75%	1,251			845	2	0.24%
2002	97	5	5.15%	2,300			1,886	1	0.05%
2003	31	0	0.00%	932			800		
2004	125	1	0.80%	4,022	4	0.10%	3,101		
2005	142	0	0.00%	4,388			3,052		
2006[2]	459	3	0.65%	9,119			5,802		
2007[3]	235	1	0.43%	6,435	1	0.02%	5,159	1	0.02%
2008[4]	81			2,344					

[1] All marked fish observed in spawning ground carcass surveys in the Naches Basin are assumed to be CESRF fish.
[2] Age 5 data are preliminary.
[3] Through age 4 only and data are preliminary.
[4] Through age 3 only and data are preliminary.

CESRF Spawning and Survival

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

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

where

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

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

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

Brood Year	Total Collected	Total Morts.	PreSpawn Survival	No. Fish Spawned[1] Males[2]	Females	% BKD Loss	Total Egg Take	Live Eggs	% Egg Loss[3]	Fry Ponded[4]	Live-Egg-Fry Survival	Smolts Released	Fry-Smolt Survival	Live-Egg-Smolt Survival
1997	261	23	91.2%	106	132	2.6%	500,750	463,948	7.3%	413,211	98.5%	386,048	93.4%	91.9%
1998	408	70	82.8%	140	198	1.4%	739,802	664,125	10.2%	627,481	98.7%	589,648	94.0%	92.7%
1999	738[5]	24	96.7%	213	222	2.7%	818,816	777,984	5.0%	781,872	97.3%	758,789	97.0%	94.5%
2000	567	61	89.2%	170	278	9.2%	916,292	851,128	7.1%	870,328	97.3%	834,285	95.9%	93.4%
2001	595	171	71.3%	145	223	53.2%	341,648	316,254	7.4%	380,880	98.6%	370,236	97.2%	96.1%
2002	629	89	85.9%	125	261	10.0%	919,776	817,841	11.1%	783,343	98.0%	749,067	95.6%	93.6%
2003	441	54	87.8%	115	200	0.0%	856,574	787,933	8.0%	761,968	98.4%	735,959	96.6%	95.1%
2004	597	70	88.3%	125	245	0.4%	873,815	806,375	7.7%	776,941	97.8%	691,109[6]	89.0%	87.0%
2005	526	57	89.2%	136	241	0.0%	907,199	835,890	7.9%	796,559	98.1%	769,484	96.6%	94.7%
2006	519	45	91.3%	122	239	1.7%	772,357	703,657	8.9%	631,691	97.3%	574,361[7]	90.9%	88.3%
2007	473	49	89.6%	149	216	0.9%	798,729	760,189	4.8%	713,814	98.9%	676,602	94.8%	93.7%
2008	480	38	92.1%	151	253	2.0%	915,563	832,938	9.0%	809,862	99.0%	752,109[8]	97.3%	96.3%
2009	486	57	88.3%	142	219	1.4%	850,404	848,339	0.2%	770,706	98.2%	744,170	96.6%	94.6%
2010	483	20	95.9%	102	193	0.5%	787,953	753,464	4.4%	726,325	98.9%	702,751	96.8%	95.6%
2011	455	28	93.8%	103	197	0.0%	798,229	765,221	4.1%	698,207	98.1%			
Mean	511	57	88.9%	136	221	5.7%	786,527	732,352	6.9%	702,879	98.2%	666,758	95.0%	93.2%

1. Total collected minus total mortalities does not equal total spawned. This is because some fish are used in the spawning channel, some have been released back to the river, and some have not been used.
2. Includes jacks.
3. All documented egg loss at spawn time plus dead eggs counted at shock divided by the estimated total egg take.
4. Based on physical counts at mark time and all documented rearing mortality from ponding to release, except for BY2011 it is live eggs (est.) minus fry loss.
5. Approximately one-half of these were jacks, many of which were not used in spawning.
6. Approximately 45,000 smolts lost at Jack Creek due to frozen equipment in February, 2006.
7. EWOS feed treatment had high mortality and was discontinued in May 2007; resulted in lower survival to release.
8. Approximately 36,000 NoR (Table 33) and 12,000 HoR (Table 34) fish were culled in July 2009 to reduce pond densities; these fish were added back in to fry-smolt and live-egg-smolt survival calculations.
9. Table 34 -- From 2002 to present this is the estimated total egg take from all HxH crosses. Due to the large surplus of eggs over the approximately 100K needed for the HxH line, many surplus fry were planted in nearby land-locked lakes and some surplus eggs were destroyed.
10. Table 34 -- For only those HxH fish which were actually ponded.

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

Brood Year	Total Collected	Total Morts.	PreSpawn Survival	No. Fish Spawned[1] Males[2]	Females	% BKD Loss	Total Egg Take[9]	Live Eggs[10]	% Egg Loss[3]	Fry Ponded[4]	Live-Egg-Fry Survival	Smolts Released	Fry-Smolt Survival	Live-Egg-Smolt Survival
2002	201	22	89.1%	26	72	4.2%	258,226	100,011	7.8%	91,300	98.2%	87,837	96.2%	94.4%
2003	143	12	91.6%	30	51	0.0%	219,901	83,128	7.3%	91,203	98.8%	88,733	97.3%	96.1%
2004	126	19	84.9%	22	49	0.0%	187,406	94,659	5.9%	100,567	98.3%	94,339	93.8%	92.2%
2005	109	6	94.5%	26	45	0.0%	168,160	89,066	12.2%	92,903	98.1%	90,518	97.4%	95.6%
2006	136	21	84.6%	28	41	2.4%	112,576	80,121	8.6%	74,735	97.6%	68,434[7]	91.6%	89.4%
2007	110	15	86.4%	26	35	0.0%	125,755	90,162	3.2%	96,912	99.2%	94,663	97.7%	96.9%
2008	194	10	94.8%	51	67	1.5%	247,503	106,122	5.1%	111,797	98.9%	97,196[8]	97.4%	96.4%
2009	164	24	85.4%	30	38	0.0%	148,593	91,994	0.8%	91,221	98.3%	88,771	97.3%	95.6%
2010	162	9	94.4%	29	55	1.8%	215,814	94,925	8.4%	96,144	97.9%	92,030	95.7%	93.7%
2011	166	7	95.8%	28	49	0.0%	188,075	89,107	4.5%	87,686	98.4%			
Mean	151	15	90.1%	30	50	1.0%	187,201	91,930	6.4%	93,447	98.4%	89,169	96.1%	94.5%

See footnotes for Table 33 above.

Female BKD Profiles

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

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

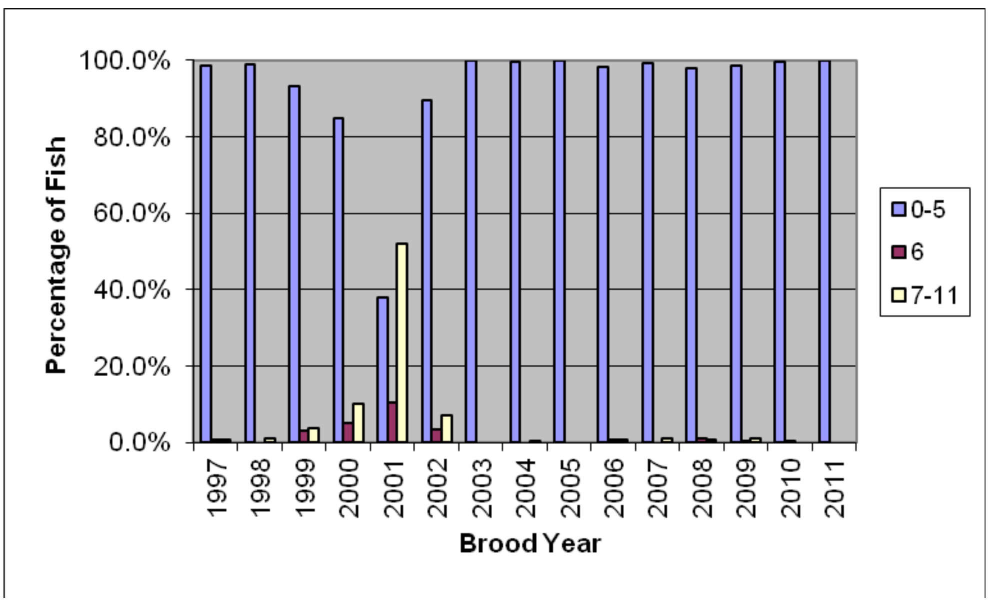

Figure 4. Proportion of wild/natural females spawned at CESRF by BKD rank, 1997 – present.

Fecundity

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

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

	Wild/Natural (SN)						CESRF (HC)					
Brood	Age-3		Age-4		Age-5		Age-3		Age-4		Age-5	
Year	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity
1997			105	3,842.0	4	4,069.9						
1998	2[1]	3,908.9	161	3,730.3	15	4,322.5						
1999	3[1]	4,470.4	183	3,968.1	14	4,448.6						
2000			224	3,876.5	2	5,737.9						
2001			72	3,966.9	9	4,991.2			18	4,178.9		
2002	1	1,038.0	205	3,934.7	7	4,329.4			60	3,820.0	1	4,449.0
2003			163	4,160.2	31	5,092.8			30	3,584.1	19	5,459.9
2004			224	3,555.4	2	4,508.3			42	3,827.2		
2005	1	1,769.0	218	3,815.5	5	4,675.1			38	3,723.9	5	4,014.7
2006			196	3,396.4	24	4,338.9			36	3,087.3		
2007			178	3,658.3	24	4,403.3			33	3,545.2	2	4,381.9
2008			207	3,814.0	10	4,139.9			58	3,898.0		
2009	1	2,498.2	195	4,018.9	6	4,897.1			34	3,920.3		
2010			185	4,103.0					54	3,996.6		
2011	1[1]	3,853.1	179	4,000.1	4	5,692.1			41	3,843.3	2	4,098.2
Mean				3,856.0		4,689.1				3,764.8		4,480.7

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

Juvenile Salmon Evaluation

Food Conversion Efficiency

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

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

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

Length and Weight Growth Profiles

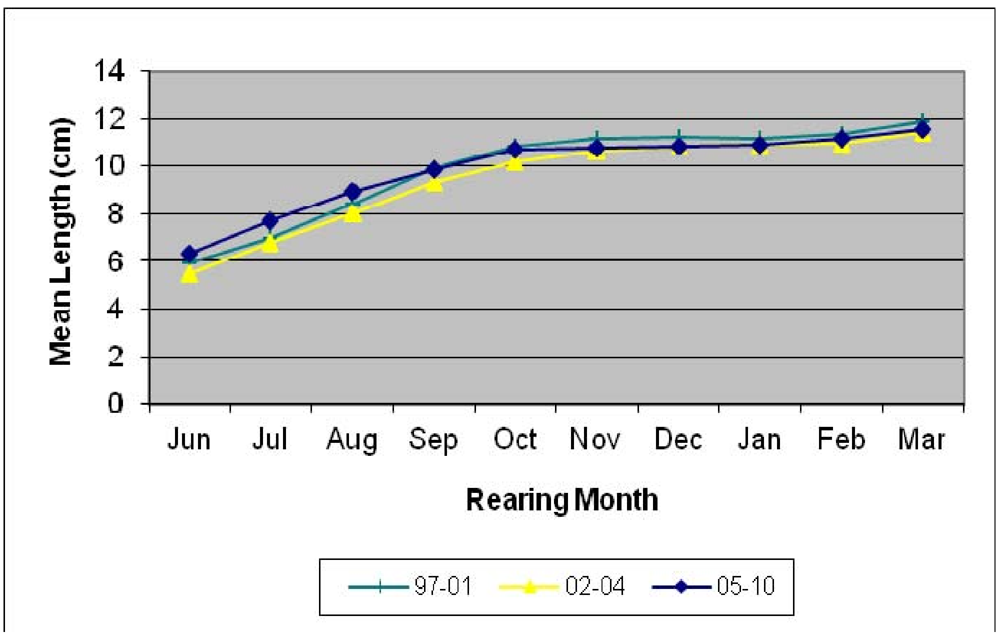

Figure 5. Mean length (cm) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.

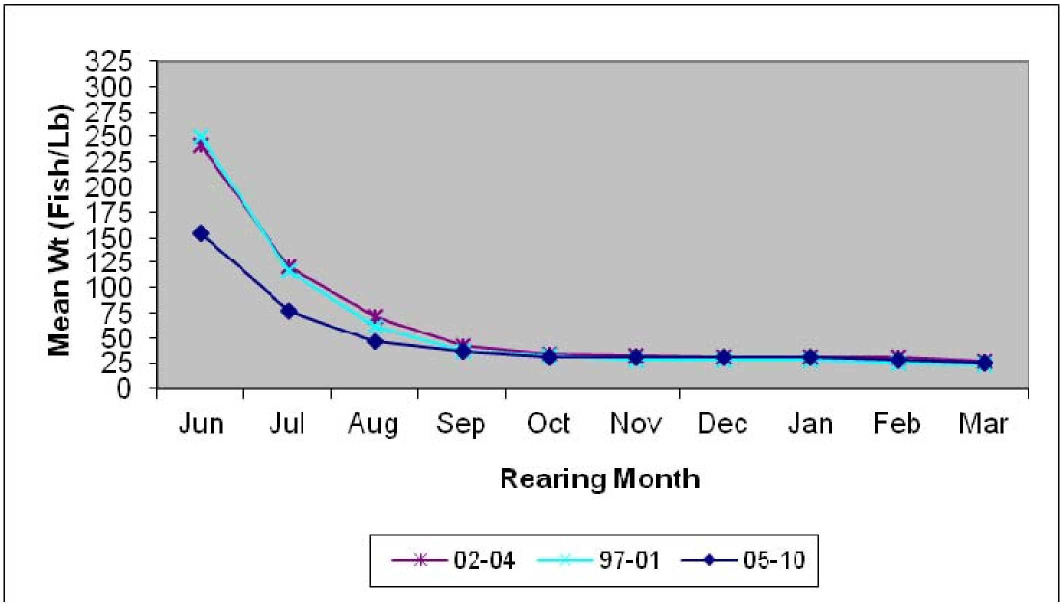

Figure 6. Mean Weight (fish/lb) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.

Juvenile Fish Health Profile

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

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

	Brood Year[1]											
Raceway	1997	1998	2000	2001[2]	2002	2003	2006	2007	2008	2009	2010	Mean
CFJ01	0.80	0.53	2.17	1.90	0.28	0.28	2.10	1.57	1.93	1.77	1.20	1.32
CFJ02	1.08	1.88	1.33	1.10	0.18	0.25	1.87	1.50	1.73	2.53	0.40	1.26
CFJ03	2.38	0.82	1.50		0.22	0.28	1.79	1.70	1.97	2.13	0.97	1.37
CFJ04	1.15	0.58	1.18		0.16	0.14	1.96	1.87	2.57	2.27	1.60	1.35
CFJ05	0.85	0.78	1.20		0.06	0.75	2.34	1.50	2.10	2.10	1.53	1.32
CFJ06	1.05	0.70	1.02		0.21	0.02	1.71	1.73	1.97	3.27	1.53	1.32
ESJ01	2.03	0.50	1.97	1.19	0.10	0.55	1.73	1.10	1.47	2.63	1.63	1.35
ESJ02	1.68	0.53	1.17	1.50	0.05	0.43	1.63	0.97	0.97	2.83	1.90	1.24
ESJ03	2.23	1.37	2.47	0.86	0.07	0.33	1.97	1.13	1.57	2.47	1.40	1.44
ESJ04	1.33	0.55	1.35	0.79	0.15	0.60	1.41	1.87	1.47	1.60	1.53	1.15
ESJ05		1.15	3.12	0.73	0.04	0.68	2.07	1.30	1.63	2.30	2.27	1.53
ESJ06		0.67	1.30	0.80	0.05	0.23	2.05	1.40	1.93	3.10	2.13	1.37
JCJ01		0.67	1.93	1.47	0.04	0.10	1.43	2.03	1.90	2.83	1.80	1.42
JCJ02		0.48	1.30	1.52	0.19	0.08	2.00	1.73	2.37	2.90	2.20	1.48
JCJ03		0.33	1.45	1.62	0.06	0.20	1.66	1.87	2.03	2.53	1.90	1.37
JCJ04		0.62	1.50	1.56	0.05	0.13	1.40	1.67	2.10	2.53	1.97	1.35
JCJ05			1.55	1.67	0.00	1.35	1.83	1.77	2.17	2.30	2.20	1.65
JCJ06			1.25	1.46	0.03	0.10	1.31	1.97	1.93	3.13	1.77	1.44
Clark Flat	1.22	0.88	1.40	1.50	0.18	0.29	1.96	1.64	2.04	2.34	1.21	1.33
Easton	1.81	0.80	1.89	0.98	0.08	0.47	1.81	1.29	1.51	2.49	1.81	1.36
Jack Creek		0.53	1.50	1.55	0.06	0.33	1.61	1.84	2.08	2.71	1.97	1.42
All Ponds	1.46	0.76	1.60	1.30	0.11	0.36	1.79	1.59	1.88	2.51	1.66	1.37

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

Incidence of Precocialism

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

Relevant Publications:

Larsen, D. A., B. R. Beckman, K. A. Cooper, D. Barrett, M. Johnston, P. Swanson, and W. W. Dickhoff. 2004. Assessment of High Rates of Precocious Male Maturation in a Spring Chinook Salmon Supplementation Hatchery Program. Transactions of the American Fisheries Society 133:98-120.

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

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

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

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

CESRF Smolt Releases

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

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

Brood Year	Control[1]	Treatment[2]	Acclimation Site CFJ	ESJ	JCJ	Total
1997	207,437	178,611	229,290	156,758		386,048
1998[3]	284,673	305,010	221,460	230,860	137,363	589,683
1999	384,563	374,226	232,563	269,502	256,724	758,789
2000	424,554	409,731	285,954	263,061	285,270	834,285
2001[4]	183,963	186,273	80,782	39,106	250,348	370,236
2002	420,764	416,140	266,563	290,552	279,789	836,904
2003	414,175	410,517	273,377	267,711	283,604	824,692
2004[5]	378,740	406,708	280,598	273,440	231,410	785,448
2005	431,536	428,466	287,127	281,150	291,725	860,002
2006	351,063	291,732	209,575	217,932	215,288	642,795
2007	387,055	384,210	265,907	254,540	250,818	771,265
2008	421,290	428,015	280,253	287,857	281,195	849,305
2009	418,314	414,627	279,123	281,395	272,423	832,941
2010	395,455	399,326	264,420	264,362	265,999	794,781
Mean	364,542	359,542	259,708	256,855	263,716	724,084

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

Brood Year	Treatment Control[1]	Treatment[2]	Acclimation Site CFJ	ESJ	JCJ
1997	41,487	35,722	38,215	39,190	
1998[3]	35,584	38,126	36,910	38,477	34,341
1999	42,729	41,581	38,761	44,917	42,787
2000	47,173	45,526	47,659	43,844	47,545
2001[4]	41,116	41,667	40,391	6,518	41,725
2002	46,752	46,238	44,427	48,425	46,632
2003	46,019	45,613	45,563	44,619	47,267
2004[5]	42,082	45,190	46,766	45,573	38,568
2005	47,948	47,607	47,855	46,858	48,621
2006	39,007	32,415	34,929	36,322	35,881
2007	43,006	42,690	44,318	42,423	41,803
2008	46,810	47,557	46,709	47,976	46,866
2009	46,479	46,070	46,521	46,899	45,404
2010	43,939	44,370	44,070	44,060	44,333
Mean	43,581	42,884	43,078	43,814	43,213

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.

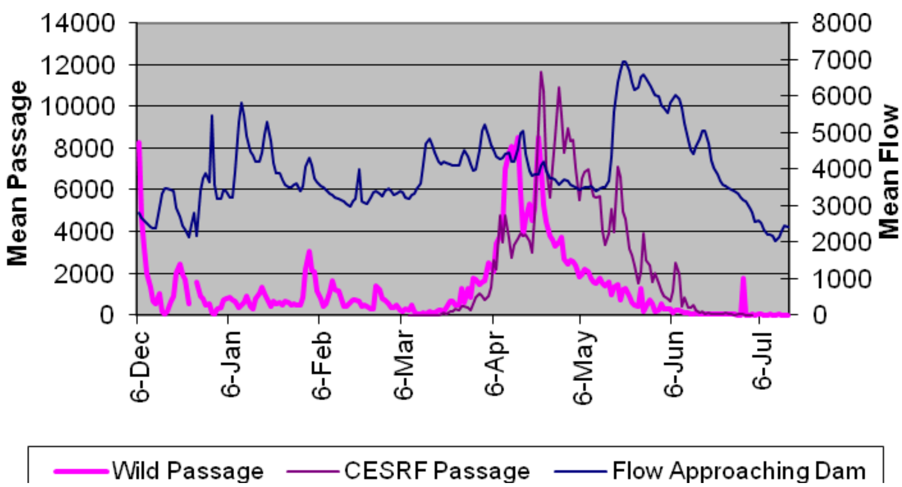

Figure 7. Mean flow approaching Prosser Dam versus mean estimated smolt passage at Prosser of aggregate wild/natural and CESRF spring Chinook for outmigration years 1999-2011.

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-	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	to-smolt 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[7]	4946		109,087	116,020	225,107	38.2%	8,240	9,782		4.3%
1999	2001	1321	171,290	233,921	216,649	450,570	59.4%	1,764	864	1.0%	0.2%
2000	2002	5015	441,880	193,515	132,228	325,743	39.0%	11,434	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%	2,802	4,022	1.4%	2.5%
2005	2007	4551	220,329	163,151	162,197	325,348	37.8%	4,201	4,388	1.9%	1.3%
2006	2008	4298	235,569	92,914	71,623	164,537	25.6%	5,951	9,119	2.5%	5.5%
2007	2009	5784	297,197			176,489	22.9%	7,002[8]	6,435[8]	2.4%[8]	3.6%[8]
2008	2010	3592	166,663			393,195	46.3%				
2009	2011	9414									

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. Available data were not sufficient to estimate juvenile flow-entrainment and passage of wild/natural fish.
8. 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.

Brood Year	Number Tagged	Wild/Natural smolts tagged at Roza Adult Returns at Age[1] Age 3	Age 4	Age 5	Total	SAR[1]
1997	310	0	1	0	1	0.32%[2]
1998	6,209	15	171	14	200	3.22%
1999	2,179	2	8	0	10	0.46%
2000	8,718	1	51	1	53	0.61%
2001	7,804	9	52	3	64	0.82%
2002	3,931	2	46	4	52	1.32%
2003	1,733	0	6	1	7	0.40%
2004	2,333	1	8	1	10	0.43%
2005	1,200	0	8	0	8	0.67%
2006	1,675	12	33	2	47	2.81%
2007	3,795[1]	6	47		53	1.40%
2008	105	0				
2009	2,087					

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

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

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

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 Year	Number Tagged[1]	Adult Detections at Bonn. Dam					Adult Detections at Roza Dam				
		Age3	Age4	Age5	Total	SAR	Age3	Age4	Age5	Total	SAR
1997[2]	39,892	18	182	4	204	0.51%	65	517	16	598	1.50%
1998	37,388	49	478	48	575	1.54%	54	310	34	398	1.06%
1999	38,793	1	25	1	27	0.07%	1	22	0	23	0.06%
2000	37,582	42	159	2	203	0.54%	37	112	1	150	0.40%
2001	36,523	32	71	0	103	0.28%	22	58	0	80	0.22%
2002[3]	39,003	25	119	4	148	0.38%	15	80	2	97	0.25%
2003	38,916	7	37	1	45	0.12%	3	27	1	31	0.08%
2004	36,426	37	123	4	164	0.45%	24	98	3	125	0.34%
2005	39,119	63	126	2	191	0.49%	44	96	2	142	0.36%
2006	38,595	221	354	15	590	1.53%	186	262	11	459	1.19%
2007	38,618	73	279		352	0.91%	53	182		235	0.61%
2008	39,013	135					81				

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 Year	Number Tagged[1]	Adult Detections at Roza Dam				
		Age3	Age4	Age5	Total	SAR
1997[2]	346,156	623	5,663	120	6,406	1.85%
1998	552,295	936	5,834	534	7,304	1.32%
1999	719,996	103	652	13	768	0.11%
2000	796,703	1,005	2,764	69	3,837	0.48%
2001	333,713	290	791	9	1,091	0.33%
2002[3]	797,901	332	1,771	135	2,238	0.28%
2003	785,776	115	1,568	14	1,696	0.22%
2004	749,022	683	3,688	202	4,574	0.61%
2005	820,883	1,012	5,302	34	6,362	0.77%
2006	604,200	2,384	6,417	304	9,104	1.51%
2007	732,647	1,024	5,628		6,653	0.91%
2008	810,292	1,171				

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%
2011	1,361	1,261	1,579	179[2]	2,940	1,440	4,380	24.4%
Mean	553	597	492	39	1,045	639	1,050	12.8%

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

Columbia Basin Fisheries

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

Table 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	3,820	67	263	1,822	434	764	764	0	20.0%	
1983	2,453	118	99	1,441	84	300	300	0	12.2%	
1984	3,870	134	257	2,658	289	680	680	0	17.6%	
1985	5,249	191	178	4,560	865	1,234	1,234	0	23.5%	
1986	13,522	280	784	9,439	1,340	2,403	2,403	0	17.8%	
1987	6,141	96	371	4,443	517	984	984	0	16.0%	
1988	5,631	360	372	4,246	444	1,177	1,177	0	20.9%	
1989	8,878	212	663	4,914	747	1,622	1,622	0	18.3%	
1990	6,913	350	453	4,372	663	1,466	1,466	0	21.2%	
1991	4,623	183	278	2,906	32	493	493	0	10.7%	
1992	6,202	102	373	4,599	345	821	821	0	13.2%	
1993	5,122	44	312	3,919	129	484	484	0	9.5%	
1994	2,225	86	107	1,302	25	219	219	0	9.8%	
1995	1,385	1	69	666	79	149	149	0	10.7%	
1996	5,773	6	303	3,179	475	783	783	0	13.6%	
1997	5,198	3	348	3,173	575	926	926	0	17.8%	
1998	2,843	3	143	1,903	188	333	333	0	11.7%	
1999	4,095	4	189	2,781	604	797	797	0	19.5%	
2000	28,729	58	1,747	19,100	2,458	4,262	4,139	123	14.8%	
2001	31,161	1,000	4,070	23,265	4,630	9,700	5,589	4,111	31.1%	29.8%
2002	24,186	1,282	2,577	15,099	3,108	6,967	2,619	4,348	28.8%	24.8%
2003	9,890	300	776	6,957	440	1,517	922	595	15.3%	14.5%
2004	22,242	1,020	1,923	15,289	1,679	4,622	2,585	2,037	20.8%	16.3%
2005	12,023	339	749	8,758	474	1,562	1,231	331	13.0%	12.2%
2006	11,616	304	763	6,314	600	1,668	949	719	14.4%	12.8%
2007	5,120	180	352	4,303	279	812	394	418	15.9%	13.9%
2008	11,524	1,152	1,574	8,598	1,532	4,259	1,201	3,058	37.0%	26.8%
2009	13,144	1,153	1,130	12,120	2,353	4,635	1,267	3,368	35.3%	25.9%
2010	17,738	1,521	2,628	13,142	1,741	5,889	1,349	4,540	33.2%	22.0%
2011[1]	23,174	1,009	1,703	17,960	4,380	7,092	2,434	4,658	30.6%	21.9%
Mean	10,150	385	852	7,108	1,050	2,287	1,344	2,562	19.1%	17.3%

1. Preliminary.

Marine Fisheries

Based on available CWT information, harvest managers have long assumed that Columbia River spring Chinook are not harvested in any abundance in marine fisheries as the timing of their ocean migration does not generally overlap either spatially or temporally with the occurrence of marine fisheries (TAC 1997). The Regional Mark Information System (RMIS) will be queried regularly for any CWT recoveries of CESRF releases in ocean or Columbia River mainstem fisheries. Table 47 gives the results of a query of the RMIS database run on Dec. 7, 2011 for CESRF spring Chinook CWTs released in brood years 1997-2007. Based on the information reported to RMIS to date, it is believed that marine harvest accounts for about 0-3% of the total harvest of Yakima Basin spring Chinook. CWT recovery data for brood year 2007 were considered too incomplete to report at this time.

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) 07 Dec, 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	526	2.8%
2005	2	96	2.0%	2	304	0.7%
2006[1]	14	316	4.2%	16	1154	1.4%

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

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Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2002-2010.

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 2002-2010.

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 2002-2010.

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 2002-2010.

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 2002-2010.

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 2002-2010.

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.

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

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

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

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

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Brood Year	C.E. Pond	Accl. Pond	Treatment[1] /Avg BKD			Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
2010	CLE01	CFJ05	STF	WW	4.2	Right	Red	Snout	3/15/2012	5/14/2012	190256	2,000	40,221	41,972
2010	CLE02	CFJ06	BIO	WW	4.2	Left	Red	Snout	3/15/2012	5/14/2012	190257	2,000	40,845	42,664
2010	CLE03	CFJ03	STF	HH	4.0	Right	Red	Posterior Dorsal	3/15/2012	5/14/2012	190258	4,000	43,725	47,415
2010	CLE04	CFJ04	BIO	HH	4.0	Left	Red	Posterior Dorsal	3/15/2012	5/14/2012	190259	4,000	40,976	44,615
2010	CLE05	ESJ01	STF	WW	4.2	Right	Green	Snout	3/15/2012	5/14/2012	190260	2,000	40,710	42,374
2010	CLE06	ESJ02	BIO	WW	4.2	Left	Green	Snout	3/15/2012	5/14/2012	190261	2,000	40,419	42,157
2010	CLE07	JCJ01	STF	WW	4.0	Right	Orange	Snout	3/15/2012	5/14/2012	190262	2,000	43,833	45,471
2010	CLE08	JCJ02	BIO	WW	4.0	Left	Orange	Snout	3/15/2012	5/14/2012	190263	2,000	43,815	45,573
2010	CLE09	ESJ03	STF	WW	4.1	Right	Green	Snout	3/15/2012	5/14/2012	190264	2,000	42,528	44,257
2010	CLE10	ESJ04	BIO	WW	4.1	Left	Green	Snout	3/15/2012	5/14/2012	190265	2,000	42,649	44,443
2010	CLE11	ESJ05	STF	WW	4.2	Right	Green	Snout	3/15/2012	5/14/2012	190266	2,000	43,878	45,633
2010	CLE12	ESJ06	BIO	WW	4.2	Left	Green	Snout	3/15/2012	5/14/2012	190267	2,000	43,750	45,498
2010	CLE13	JCJ03	STF	WW	4.2	Right	Orange	Snout	3/15/2012	5/14/2012	190268	2,000	41,816	43,473
2010	CLE14	JCJ04	BIO	WW	4.2	Left	Orange	Snout	3/15/2012	5/14/2012	190269	2,000	41,052	42,772
2010	CLE15	JCJ05	STF	WW	4.1	Right	Orange	Snout	3/15/2012	5/14/2012	190270	2,000	42,894	44,603
2010	CLE16	JCJ06	BIO	WW	4.1	Left	Orange	Snout	3/15/2012	5/14/2012	190271	2,000	42,371	44,107
2010	CLE17	CFJ01	STF	WW	4.2	Right	Red	Snout	3/15/2012	5/14/2012	190272	2,000	42,329	44,128
2010	CLE18	CFJ02	BIO	WW	4.2	Left	Red	Snout	3/15/2012	5/14/2012	190273	2,000	41,829	43,626

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

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

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Appendix C
Annual Report: Comparisons between Smolt Measures of Hatchery x Hatchery- and Natural x Natural-Brood Stock from Upper Yakima Spring Chinook for Brood-Years 2002-2009

Doug Neeley, Consultant to the Yakama Nation

Summary

Hatchery x Hatchery (HxH) and Natural x Natural (NxN) stocks[1] were allocated to Clark Flat acclimation-site raceway pairs, within each of which, the two raceways were assigned different nutritional treatments. This report focuses on the stock comparisons, not the nutrition-treatment comparisons which are presented in different annual reports.

The juvenile measure comparisons between HxH and NxN stock are given below:

Pre-Release Weights did not significantly differ between stocks.

Pre-Release Survival Index was lower for the HxH stock than for the NxN stock within the first six brood years (2002-2007) but not for the last two brood years (2008-2009).

Pre-Release Male Proportion did not significantly differ between the two stocks and did not differ significantly or substantially from 0.5.

Pre-Release Mini-Jack Proportion of Male 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; however, the difference between the two stock did not significantly differ when averaged over all eight brood years.

Release-to-McNary-Dam Survival differences significantly and substantially interacted with brood year; however, the difference between the two stock did not significantly differ when averaged over all eight brood years.

[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.

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; however, there was a significant stock-difference interaction with years. For those brood years where there was a significant difference, the NxN brood-stock passed McNary at a later date than did the HxH stock.

Design of Experiment

The HxH assignment was superimposed at only the Clark Flat Acclimation Site at which there were three pairs of raceways[2] with 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 Split-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).

Beginning with that 2002 brood, a portion of fish in each raceway was PIT-tagged for the primary purpose of estimating smolt-to-smolt survival from release to McNary Dam (McNary). Beginning with the 2006 brood, there were twice as many HxH fish PIT-tagged per raceway than there were NxN fish to give approximately an equal total number of PIT-tagged fish for both the HxH and NxN stocks at Clark Flat. (In previous brood years, there were approximately half as many HxH fish tagged as NxN fish at Cle Elum). For the purpose of assessing Male Proportions, Mini-Jack Proportions, and Pre-Release Fish Weights, approximately twice as many fish were sampled from HxH raceways than from NxN raceways to give an equal number of sampled HxH and NxN fish in all brood years except in Brood Year 2002 wherein there were approximately half as many HxH fish tagged as NxN fish.

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

[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 and 2007 through 2009, 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 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 2005 and 2007-2009.

[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).

Both main effect HxH–NxN differences and the interaction among these differences with years were tested at the 5% significance level using either a weighted logistic analyses of variation or least-squares analyses of variance[6]. Year was taken to be a random effect; therefore, the mean HxH-NxN main-effect difference averaged over years was tested against the interaction of stock differences with years, and the interaction was tested against the main plot error (differences among raceway-pair means).

Analysis of Individual Measures

Seven variable sets were analyzed:

1. Mean Pre-Release Weights (Weight),
2. Mean Proportions of PIT-Tagged fish Leaving the Acclimation Site (Release Proportion), which serves as an indicator of Pre-Release Survival
3. Mean Pre-Release Male Proportions (Male Proportion),
4. Mean Pre-Release Mini-Jack Proportions of Males (Mini-Jack or Precocial Proportion),
5. Mean Release-to-McNary Smolt-to-Smolt Survivals to McNary Dam (McNary Survival),
6. Mean Julian Dates of Juvenile Release (Release Date), and
7. Mean Julian Dates of McNary-Dam Juvenile Passage (McNary-Passage Date).

Of these variables, the interaction between HxH-NxN comparisons and years were significant at the 5% level for the following measures: Release Proportion, Release-to-McNary Survival unadjusted for Mini-Jack Proportion, and McNary-Passage Date; and the interactions significant at the 10% level were: Mini-Jack proportion of males and Release-to-McNary Survival adjusted for Mini-Jack Proportion. No variable's main effect HxH-NxN difference averaged over all years was significant at the 5% significance level (the Release Proportion mean difference over years was significant at the 10% level, not the 5% level).

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

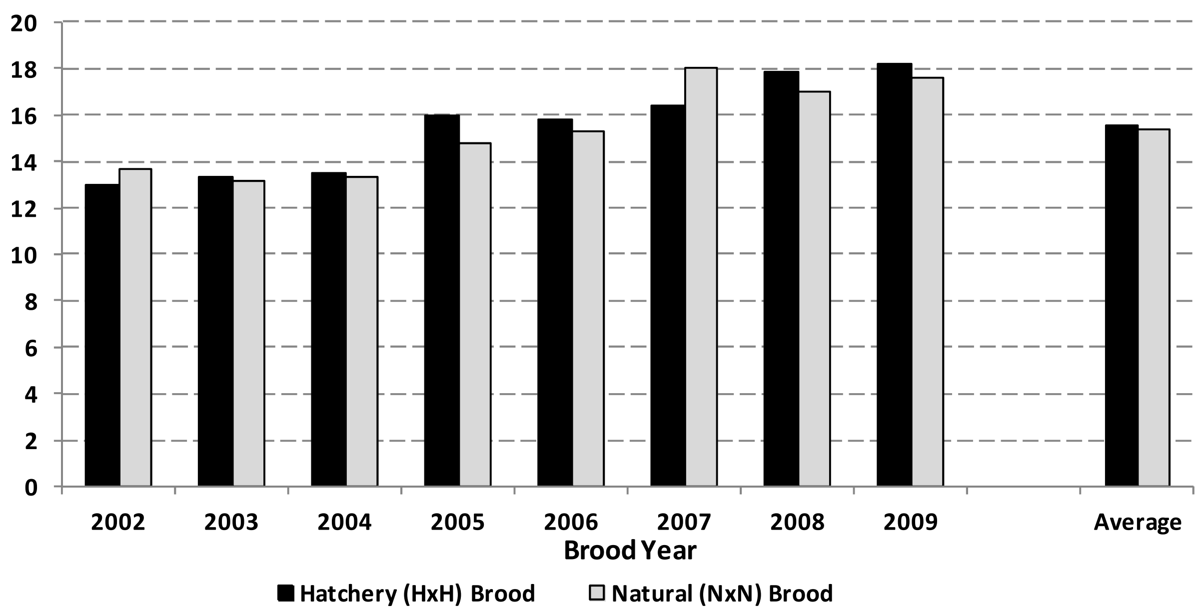
Mean Pre-Release Smolt Weight

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 = 0.57, Appendix Table A.1), nor did the NxN-HxH comparisons significantly interact with years (P= 0.29, Appendix Table A.1).

Table 1. Mean <u>Pre-Release Weight</u> (grams/fish) of Natural x Natural and Hatchery x Hatchery Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2009)[7]

Brood Year Release Year	2002 2004	2003 2005	2004 2006	2005 2007	2006 2008	2007 2009	2008 2010	2009 2011	Average
Hatchery (HxH) Brood	13.0	13.3	13.5	16.0	15.8	16.4	17.8	18.2	15.5
Natural (NxN) Brood	13.7	13.2	13.3	14.8	15.3	18.0	17.0	17.6	15.4
HxH - NxN Difference	-0.7	0.2	0.2	1.2	0.5	-1.6	0.8	0.6	0.2

Figure 1. Mean <u>Pre-Release Weight</u> (grams/fish) of Natural x Natural and Hatchery x Hatchery Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2009)



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

Mean Proportion of PIT-Tagged fish leaving the Acclimation Site

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

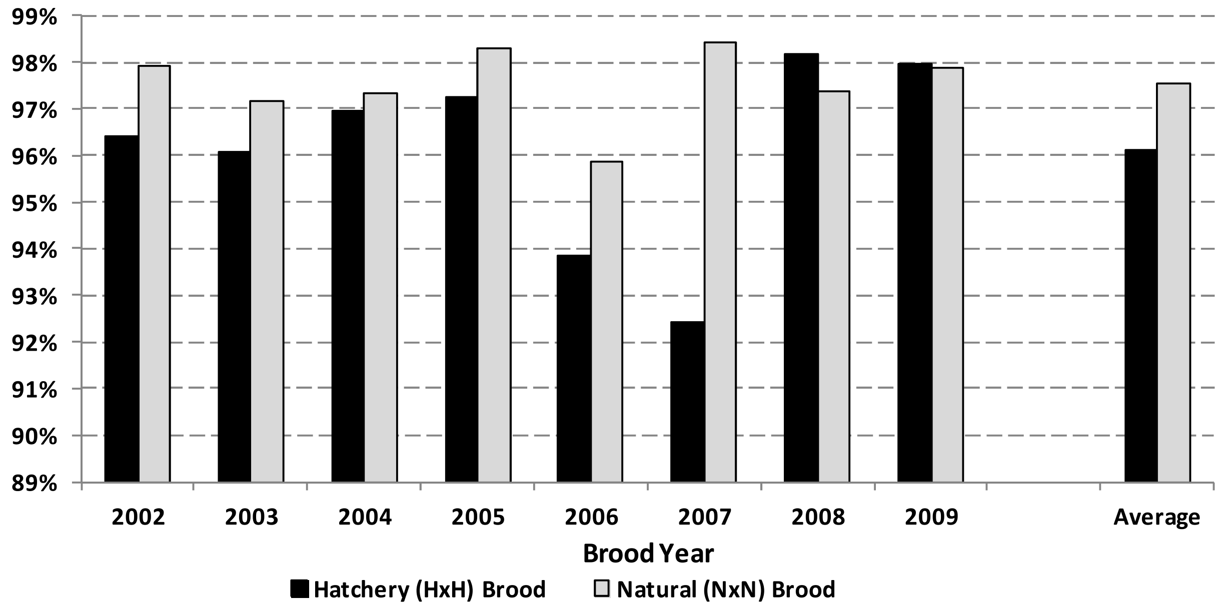
Table 2 and Figure 2 present the individual year and mean pre-release survival-index estimates. While the NxN-HxH main effect comparison is not quite significant at the 5% level (P = 0.060, Appendix Table A.2), the comparison's interaction with years is significant at the 0.01% level (P < 0.013, Appendix Table A.2). The nature of the interaction is evident from the table and figure. In all release years except 2010 and 2011 (brood years 2008 and 2009), the NxN pre-release survival index is greater than that of the HxH stock. Based on t-tests for within year differences, for each of the three release years for which the HxH-NxN difference is significant (release years 2004, 2008, 2009; i.e. brood years 2002, 2006, 2007), the NxN stock having a higher proportion released than did the HxH stock, suggesting a higher pre-release survival rate for those NxN stock.

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 2009)[8]

Brood Year	2002	2003	2004	2005	2006	2007	2008	2009	Average
Release Year	2004	2005	2006	2007	2008	2009	2010	2011	
Hatchery (HxH) Brood	96.40%	96.06%	96.96%	97.23%	93.85%	92.44%	98.19%	97.95%	**96.14%**
Natural (NxN) Brood	97.92%	97.17%	97.32%	98.30%	95.86%	98.44%	97.36%	97.89%	**97.53%**
HxH - NxN Difference	**-1.52%**	-1.10%	-0.36%	-1.07%	**-2.01%**	**-6.00%**	0.82%	0.06%	**-1.40%**
t-ratio of Difference	-1.988	-1.312	-0.458	-1.571	-2.213	-6.367	1.360	0.107	2.244
Type 1 Error P	**0.082**	0.226	0.659	0.155	**0.058**	**0.000**	0.211	0.917	**0.0597**

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

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 2009)



Pre-Release Male Proportion

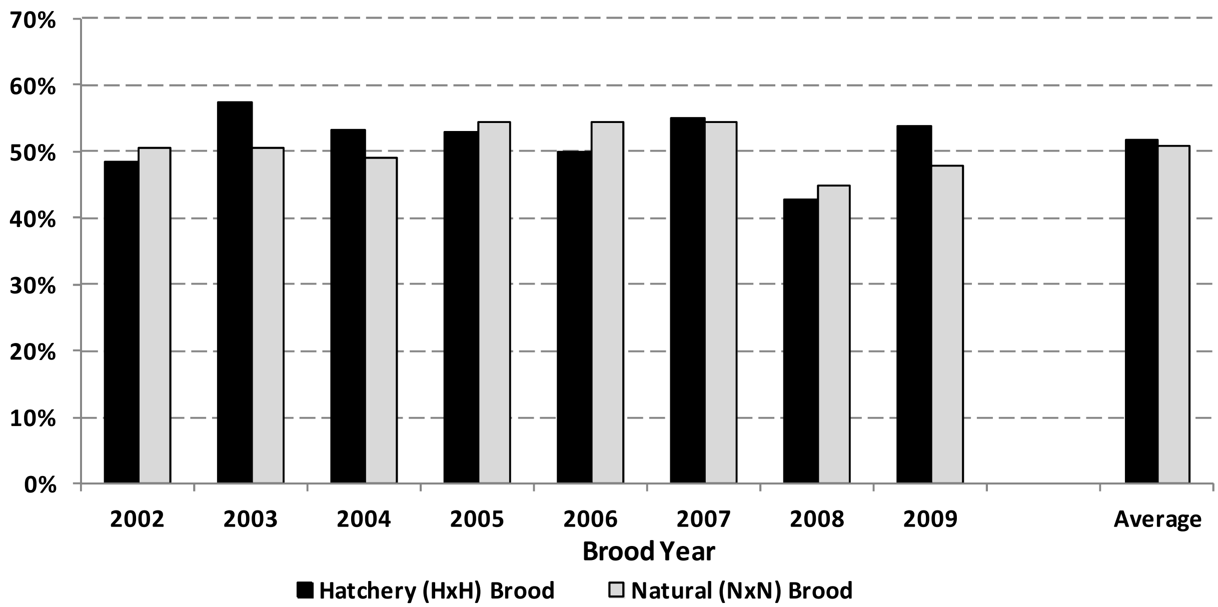
There were no significant differences involving HxH and NxN stock (neither main-effect nor interaction differences). And the mean percentage of males over all years, stock, and treatments was near 50%[9]. The primary reason for statistically evaluating the male percentage is that, as will be seen later, there is a significant interaction between the HxH-NxN differences with years. Later adjustments for mini-jack proportion are made to release numbers in order to evaluate smolt-to-smolt to McNary survival of smolt that do not include mini-jacks. These adjustments involve the mini-jack or precocial percentage of males (percentage of male smolt with mature gonads) and involve the proportion of smolt that are male which is assumed to 0.5 over years and stock, an assumption that is supported by analysis in Appendix Table A.3 and by the male proportions presented in Table and Figure 3 below.

Table 3. Male Percent of Pre-Release Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002-2009)

Brood Year Release Year	2002 2004	2003 2005	2004 2006	2005 2007	2006 2008	2007 2009	2008 2010	2009 2011	Average
Hatchery (HxH) Brood	48.33%	57.50%	53.14%	52.92%	50.00%	55.00%	42.92%	53.75%	**51.69%**
Natural (NxN) Brood	50.42%	50.42%	49.17%	54.58%	54.58%	54.58%	45.00%	47.92%	**50.83%**
HxH - NxN Difference	-2.08%	7.08%	3.97%	-1.67%	-4.58%	0.42%	-2.08%	5.83%	0.86%

[9] 51.2% males did not significantly differ from 50% (P = 0.17) based on a logistic fit of the mean. (Mean Deviance = 1.03).

Figure 3. Male Percent of Pre-Release Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002-2009)



Pre-Release Mini-Jack Proportion of Males

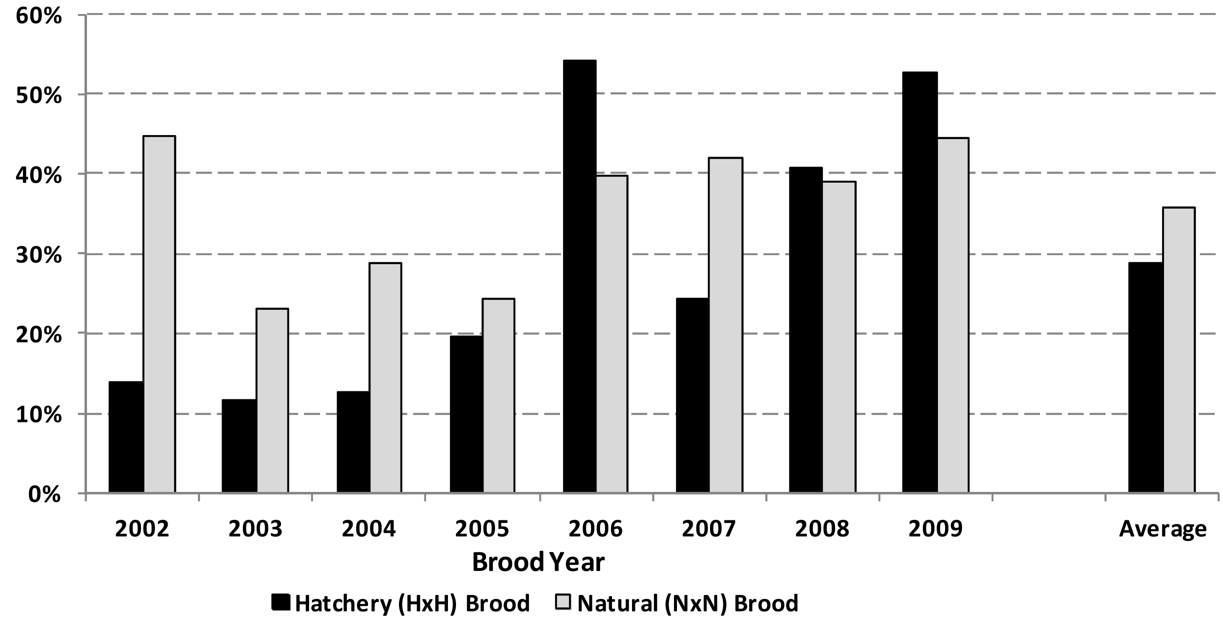
Table 4 and Figure 4 present the individual year and HxH and NxN mean Mini-Jack Percentages. While the NxN- HxH Mini-Jack Percentage main-effect mean difference over years was not significant at the 5% level (P = 0.30, Appendix Table A.4), the NxN-HxH differences interaction with years was significant at the 10% level (P = 0.052, Appendix Table A.4). Note that in Table 4 within the three years in which the HxH-NxN difference is significant (brood years 2002, 2004, and 2007), the HxH mini-jack proportions were smaller than those of the NxN stock.

Table 4. 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 2009)[10]

Brood Year Release Year	2002 2004	2003 2005	2004 2006	2005 2007	2006 2008	2007 2009	2008 2010	2009 2011	Average
Hatchery (HxH) Brood	13.79%	11.59%	12.60%	19.68%	54.17%	24.24%	40.78%	52.71%	28.70%
Natural (NxN) Brood	44.63%	23.14%	28.81%	24.43%	39.69%	41.98%	38.89%	44.35%	35.74%
HxH - NxN Difference	**-30.83%**	-11.55%	**-16.22%**	-4.74%	14.47%	**-17.74%**	1.89%	8.37%	-7.04%
t-ratio of Difference	-2.907	-1.456	-2.335	-0.696	1.737	-2.300	0.213	0.990	1.120
Type 1 Error P	**0.020**	0.183	**0.048**	0.506	0.121	**0.050**	0.837	0.351	0.2996

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

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 2009)**



Release-to-McNary Smolt Survival

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

Eq.1.

$$\text{Release - to - McNary Survival} = \frac{\text{Expanded Number of Released Fish Detected at McNary}}{\text{Release Number (detected at release)}} \quad [11]$$

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 = 0.39, Appendix Table A.5.a), the differences' interaction with years was significant at the 1% level (P=0.0098, Appendix Table A.5.a.). These interactions are not consistent. When comparing the HxH-NxN differences within the years, for the release years with the four lowest P, three of those years (2004, 2007, 2009) had the higher survival for the HxH stock and one year (2006) had the highest survival for the NxN stock (Table 5.a).

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

The survival differences may be artificial. If the precocials 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.

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

$$\text{wherein } Q = \text{Propotion of Mini-Jacks}, \quad \text{Proportion(Females)} = \text{Propotion(Males)} = 0.5$$ [12]

This adjusted release number was then substituted into equation Eq.1 to estimate the adjusted survivals. The relative results have not dramatically changed. The main-effect NxN-HxH survival difference P value increased (from P = 0.39 for the unadjusted to P = 0.79 for the adjusted, Appendix Table A.5.b) as did the HxH-NxN difference interaction with years (from P = 0.0098 for the unadjusted to 0. 053 for the adjusted, Appendix Table A.5.b). However, this may simply be because the individual releases adjustments created more variability in the data; the variable adjustment to the individual raceway survivals resulted in the denominator mean deviance in the F-test for testing interaction going from 3.87 to 8.17 (appendix Tables A.5.a. and A.5.b Raceway Pair Sources), an increase that decreased the F-ratio and increased the P value. The adjusted mean yearly HxH and NxN stock survivals are given in Table 5.b and Figure 5.b.

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 2009)

a. Unadjusted for Mini-Jack Proportion[13]

Brood Year / Release Year	2002 / 2004	2003 / 2005	2004 / 2006	2005 / 2007	2006 / 2008	2007 / 2009	2008 / 2010	2009 / 2011	Average
Hatchery (HxH) Brood	22.14%	17.05%	36.40%	32.70%	30.65%	47.00%	32.39%	40.29%	**32.33%**
Natural (NxN) Brood	21.95%	15.39%	30.44%	34.42%	35.90%	42.66%	33.11%	34.53%	**31.05%**
HxH - NxN Difference	0.19%	1.66%	**5.96%**	-1.71%	**-5.25%**	**4.34%**	-0.72%	**5.76%**	**1.28%**
t-ratio of Difference	0.127	1.230	3.468	-0.990	-3.483	2.739	-0.485	3.785	0.913
Type 1 Error P	0.902	0.254	**0.008**	0.351	**0.008**	**0.025**	0.641	**0.005**	0.3915

b. Adjusted for Mini-Jack Proportion[14]

[12] 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.

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

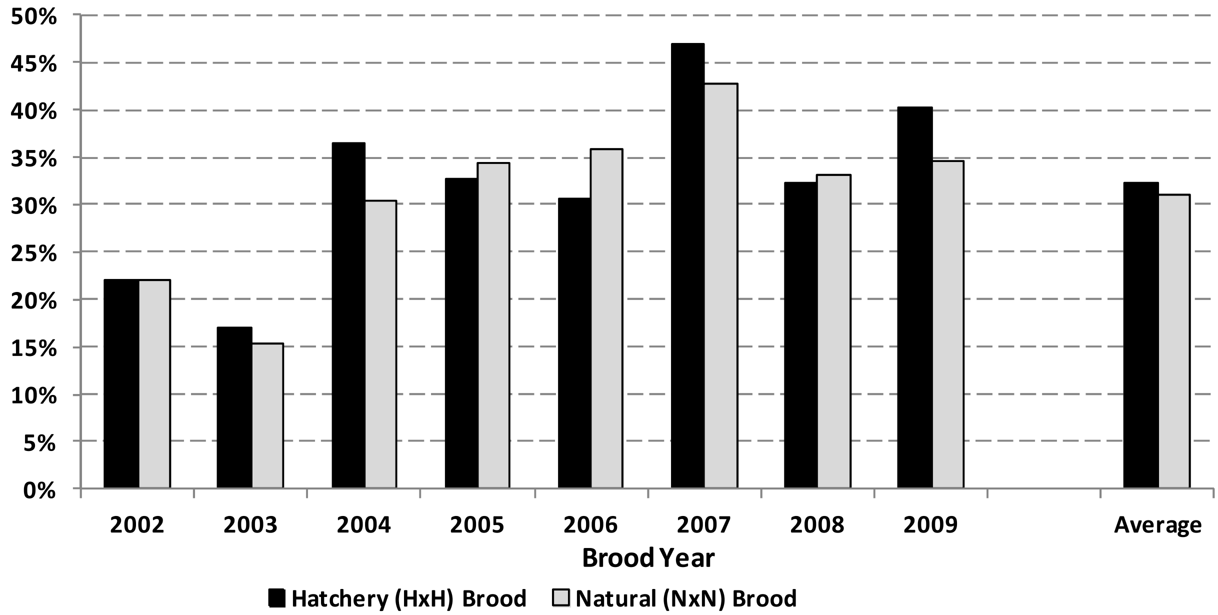
[14] Appendix A.5.b presents the associated analysis of variance with the significance levels.

Volitional-Release-to-McNary Smolt-to-Smolt Survival adjusted for Precocials

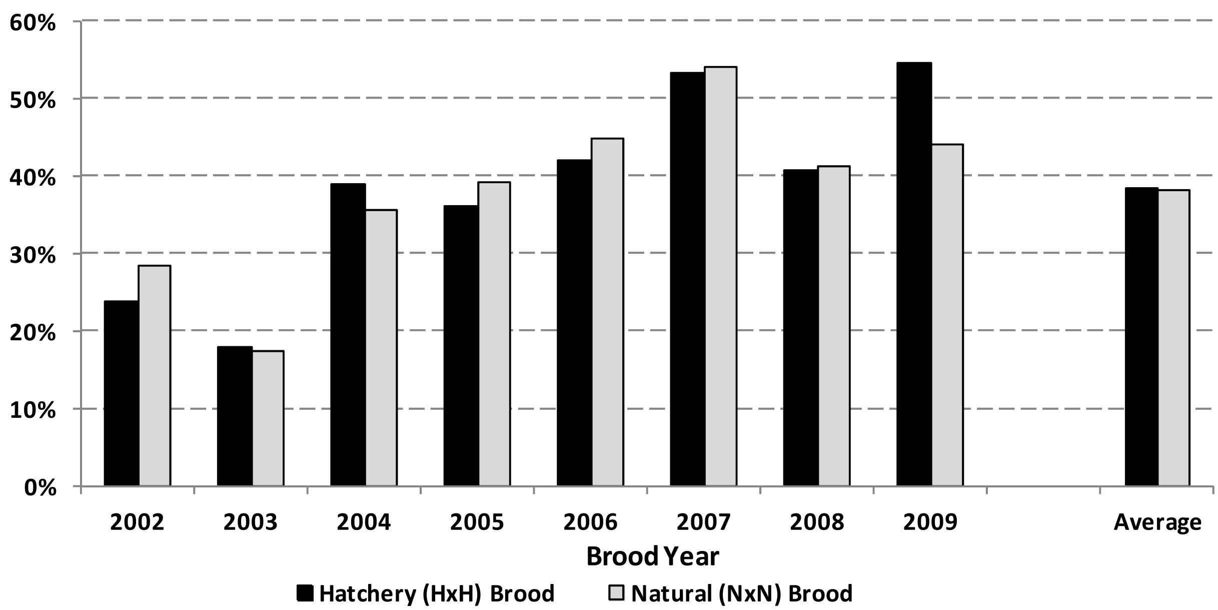
Brood Year Release Year	2002 2004	2003 2005	2004 2006	2005 2007	2006 2008	2007 2009	2008 2010	2009 2011	Average
Hatchery (HxH) Brood	23.79%	18.03%	38.84%	36.24%	42.04%	53.39%	40.72%	54.72%	38.47%
Natural (NxN) Brood	28.58%	17.38%	35.66%	39.15%	44.87%	53.98%	41.38%	44.04%	38.13%
HxH - NxN Difference	**-4.79%**	0.65%	3.18%	-2.91%	-2.82%	-0.59%	-0.66%	**10.68%**	0.34%
t-ratio of Difference	-1.890	0.309	1.179	-1.067	-1.071	-0.233	-0.263	4.069	0.270
Type 1 Error P	**0.095**	0.765	0.272	0.317	0.316	0.821	0.799	**0.004**	0.7947

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 2009)**

a. Unadjusted for Mini-Jack Proportion



b. Adjusted for Mini-Jack Proportion



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' HxH-NxN differences are the same from year to year except for release year 2006. The Main Effect effects were not significantly different in either measure (P = 0.22 for release date and 0.11 for McNary-passage date, Appendix Tables A.6.a and A.6.b, respectively). The interaction of the HxH-NxN differences with years was significant at the 5% level for McNary Passage Date (P = 0.042, Appendix A.6.b) but not significant for Release date (P = 0.27, Appendix A.6.a). For those years in which the difference was significant (brood-years 2005, 2006, 2009), the mean passage date was later for the NxN stock; however, the mean McNary-passage date of the NxN stock when averaged over years was only one day later than that of the HxH stock.

Table 6.a. Mean Julian Release Date of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection (brood years 2002 through 2009)[15]

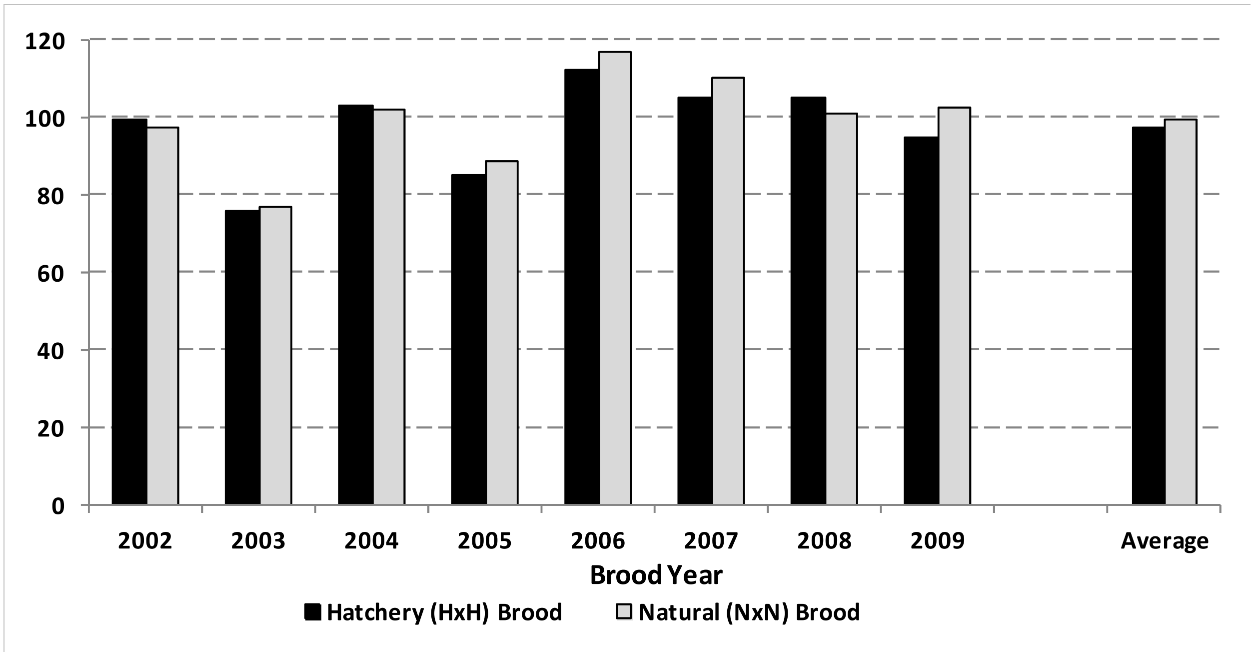
Brood Year Release Year	2002 2004	2003 2005	2004 2006	2005 2007	2006 2008	2007 2009	2008 2010	2009 2011	Average
Hatchery (HxH) Brood	99.5	75.8	103.2	84.9	112.3	105.1	105.2	95.0	97.6
Natural (NxN) Brood	97.3	77.0	102.2	88.8	116.7	110.1	101.1	102.4	99.4
HxH - NxN Difference	2.2	-1.1	1.0	-3.9	-4.4	**-5.0**	4.2	**-7.3**	-1.8
t-ratio of Difference	0.765	-0.390	0.339	-1.333	-1.728	-1.959	1.652	-2.911	1.693
Type 1 Error P	0.4661	0.7070	0.7433	0.2193	0.1223	**0.0857**	0.1371	**0.0195**	0.1290

Table 6.b. Mean McNary-Dam Julian Passage Date of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection (brood years 2002 through 2009)[16]

Brood Year Release Year	2002 2004	2003 2005	2004 2006	2005 2007	2006 2008	2007 2009	2008 2010	2009 2011	Average
Hatchery (HxH) Brood	123.3	123.2	125.8	122.9	133.4	131.0	128.5	113.7	125.2
Natural (NxN) Brood	121.9	123.5	126.0	126.2	136.3	131.3	128.1	120.2	126.7
HxH - NxN Difference	1.4	-0.3	-0.2	**-3.3**	**-2.9**	-0.2	0.5	**-6.5**	-1.5
t-ratio of Difference	0.792	-0.144	-0.151	-2.309	-2.311	-0.222	0.375	-5.598	1.848
Type 1 Error P	0.451	0.889	0.884	**0.050**	**0.050**	0.830	0.717	**0.001**	0.1070

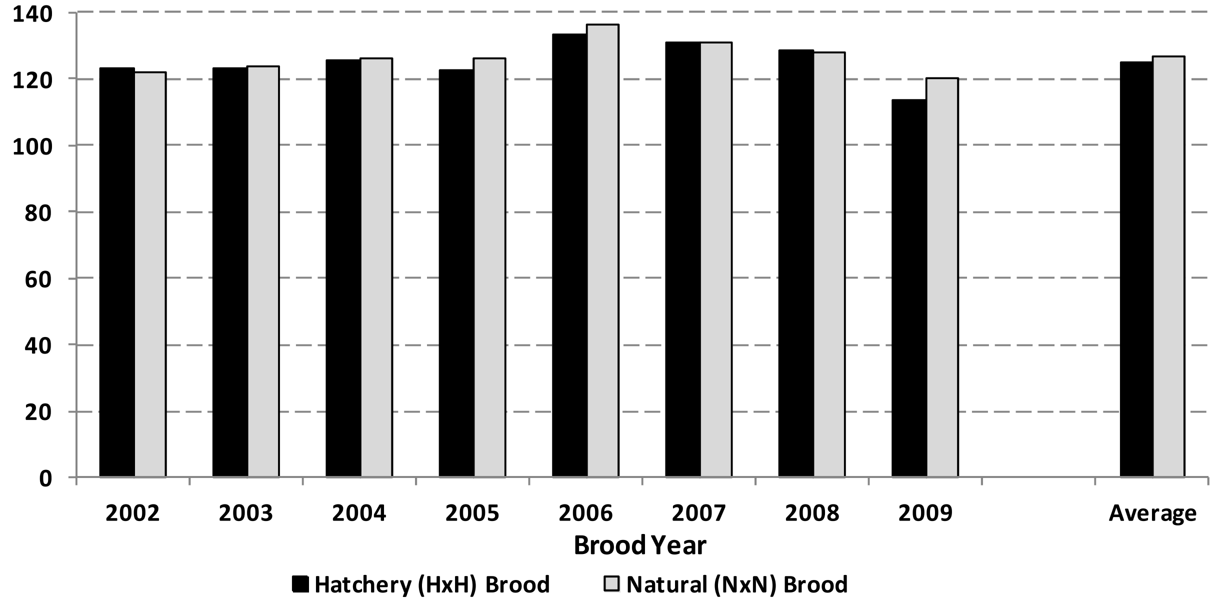
[15] Appendix A.6.a presents the associated analysis of variance with the significance levels.
[16] Appendix A.6.b presents the associated analysis of variance with the significance levels.

Figure 6.a. Mean Julian Release Date of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection (brood years 2002 through 2009)[17]



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

Figure 6.b. Mean McNary-Dam Julian Passage Date of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt Detection (brood years 2002 through 2009)[18]



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

Appendix. 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 HxH and NxN 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, the Main Plot HxH-NxN main effect, is against Year x (NxN versus HxH) interaction assuming Year is a random effect.

Both main-plot and sub-plot analyses are presented, but only main plot analyses are referred to in the text. The HxH and NxN means presented in the text represent means over the treatments that were assigned to the raceways within raceway pairs within the given brood-year. Raceways within each pair were similar in that they were physically adjacent to each other and in that they both received progeny from the same set of diallele crosses, 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.

Within each main-plot analysis, the HxH-NxN (stock) main-effect comparison source is always tested against Year x Stock interaction source (treated as a random effect), and the Year x Stock interaction is always tested against the among Raceway Pair source. Within the sub-plot analysis, give treatment sources (including Stock x treatment interactions) are tested against the source's respective lowest order interaction with year if that interaction is significant at the 10% level, otherwise it is tested against error because the degrees of freedom associated with the interactions are too small to provide a sufficiently powerful statistical test. Treatment comparisons are not discussed in other annual reports.

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 2009).**

*Weight is number of fish weighed/raceway.

1) Main Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year[1]	11202.0	7	1600.3	26.34	**0.0001** [a]
Stock (HH vs NN)	33.0	1	33.0	0.36	0.5684 [b]
Year x Stock	645.0	7	92.1	1.52	0.2851 [a]
Raceway Pair within Year[2]	486.0	8	60.8		

[1] Year treated as a random effect

[2] Differences among raceway pairs treated as random effect because each raceway within pair has same diallele cross, different raceways having different diallele crosses

[a] Tested against Raceway Pair

[b] Tested against the Year x Stock interaction

2) Sub-Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Raceway Pair (within Year)[2]	486.00	8	60.75	2.34	0.1249 [c]
Hi vs Lo (2004-2006)	5134.01	1	5134.01	198.02	**0.0000** [c]
Stock x (Hi vs Lo)	1.2682	1	1.2682	0.05	0.8305 [c]
Year x (Hi vs Lo)	39.8293	2	19.91465	0.77	0.4953 [c]
Year x Stock x (Hi vs Lo)	38.2666	2	19.1333	0.74	0.5080 [c]
STF vs Vita (2007, 2009-2011)	6.82	1	6.82	0.26	0.6220 [c]
Stock x (STF vs Vita)	42.48	1	42.48	1.64	0.2364 [c]
Year x (STF vs Vita)	93.77	3	31.26	1.21	0.3682 [c]
Year x Stock x (STF vs Vita)	159.37	3	53.12	2.05	0.1856 [c]
EWOS vs Vita (2008)	0.01	1	0.01	0.00	0.9854 [c]
Stock x (STF vs Vita)	14.67	1	14.67	0.57	0.4735 [c]
Error (pooled over treatments)	207.42	8	25.93		

[b] Tested against the source's lowest order interaction if source averaged over years and the interaction is significant at 10% level

[c] Tested against Error

Table A.2. Weighted* Logistic Analysis of Variation of Proportion Released (Pre-Release Survival) of Natural x Natural (NxN) and Hatchery x Hatchery (HxH) Upper-Yakima Spring Chinook Smolt (brood years 2002 through 2009)

***Weight is number of fish tagged/raceway.**

1) Main Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year[1]	431.59	7	61.66	9.21	**0.0028** [a]
Stock (HH vs NN)	192.20	1	192.20	5.04	0.0597 [b]
Year x Stock	267.09	7	38.16	5.70	**0.0128** [a]
Raceway Pair within Year[2]	53.55	8	6.69		

[1] Year treated as a random effect

[2] Differences among raceway pairs treated as random effect because each raceway within pair has same diallele cross, different raceways having different diallele crosses

[a] Tested against Raceway Pair

[b] Tested against the Year x Stock interaction

2) Sub-Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Raceway Pair (within Year)[2]	53.55	8	6.69	4.60	0.0224 [c]
Hi vs Lo (2004-2006)	10.69	1	10.69	1.46	0.3505 [b]
Stock x (Hi vs Lo)	1.70	1	1.70	0.23	0.6775 [b]
Year x (Hi vs Lo)	0.85	2	0.43	0.29	0.7542 [c]
Year x Stock x (Hi vs Lo)	14.65	2	7.33	5.04	**0.0384** [c]
STF vs Vita (2007, 2009-2011)	17.22	1	17.22	2.26	0.2296 [b]
Stock x (STF vs Vita)	4.94	1	4.94	0.65	0.4794 [b]
Year x (STF vs Vita)	6.03	3	2.01	1.38	0.3165 [c]
Year x Stock x (STF vs Vita)	22.83	3	7.61	5.23	**0.0273** [c]
EWOS vs Vita (2008)	20.13	1	20.13	13.85	0.0059 [c]
Stock x (STF vs Vita)	4.23	1	4.23	2.91	0.1264 [c]
Error (pooled over treatments)	11.63	8	1.45		

[b] Tested against the source's lowest order interaction if source averaged over years and the interaction is significant at 10% level

[c] Tested against Error

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 2002-2009).

***Weight is number of fish gender-tested/raceway**

1) Main Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year[1]	14.75	7	2.11	2.22	**0.1438** [a]
Stock (HH vs NN)	0.17	1	0.17	0.22	0.6509 [b]
Year x Stock	5.33	7	0.76	0.80	0.6090 [a]
Raceway Pair within Year[2]	7.61	8	0.95		

[1] Year treated as a random effect

[2] Differences among raceway pairs treated as random effect because each raceway within pair has same diallele cross, different raceways having different diallele crosses

[a] Tested against Raceway Pair

[b] Tested against the Year x Stock interaction

2) Sub-Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Raceway Pair (within Year)[2]	7.61	8	0.95	1.17	0.4137 [c]
Hi vs Lo (2004-2006)	0.07	1	0.07	0.02	0.8947 [b]
Stock x (Hi vs Lo)	1.73	1	1.73	2.13	0.1823 [c]
Year x (Hi vs Lo)	6.24	2	3.12	3.85	**0.0676** [c]
Year x Stock x (Hi vs Lo)	1.36	2	0.68	0.84	0.4672 [c]
STF vs Vita (2007, 2009-2011)	0.21	1	0.21	0.26	0.6246 [c]
Stock x (STF vs Vita)	3.37	1	3.37	4.15	**0.0759** [c]
Year x (STF vs Vita)	1.11	3	0.37	0.46	0.7203 [c]
Year x Stock x (STF vs Vita)	0.45	3	0.15	0.18	0.9037 [c]
EWOS vs Vita (2008)	0.21	1	0.21	0.26	0.6246 [c]
Stock x (STF vs Vita)	0.41	1	0.41	0.51	0.4973 [c]
Error (pooled over treatments)	6.49	8	0.81		

[b] Tested against the source's lowest order interaction if source averaged over years and the interaction is significant at 10% level

[c] Tested against Error

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 2009).

***Weight is number males from gender-tested/raceway.**

1) Main Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year[1]	105.04	7	15.01	8.66	**0.0034** [a]
Stock (HH vs NN)	7.53	1	7.53	1.26	0.2996 [b]
Year x Stock	42.00	7	6.00	3.46	**0.0515** [a]
Raceway Pair within Year[2]	13.87	8	1.73		

[1] Year treated as a random effect

[2] Differences among raceway pairs treated as random effect because each raceway within pair has same diallele cross, different raceways having different diallele crosses

[b] Tested against the Year x Stock interaction

[b] Tested against the Year x Stock interaction

2) Sub-Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Raceway Pair (within Year)[2]	13.87	8	1.73	1.48	0.2955 [c]
Hi vs Lo (2004-2006)	19.10	1	19.10	16.32	**0.0037** [c]
Stock x (Hi vs Lo)	3.74	1	3.74	3.20	0.1116 [c]
Year x (Hi vs Lo)	3.26	2	1.63	1.39	0.3026 [c]
Year x Stock x (Hi vs Lo)	2.13	2	1.07	0.91	0.4404 [c]
STF vs Vita (2007, 2009-2011)	0.00	1	0.00	0.00	1.0000 [c]
Stock x (STF vs Vita)	0.74	1	0.74	0.63	0.4494 [c]
Year x (STF vs Vita)	0.88	3	0.29	0.25	0.8587 [c]
Year x Stock x (STF vs Vita)	4.01	3	1.34	1.14	0.3890 [c]
EWOS vs Vita (2008)	0.26	1	0.26	0.22	0.6499 [c]
Stock x (STF vs Vita)	0.19	1	0.19	0.16	0.6975 [c]
Error (pooled over treatments)	9.36	8	1.17		

[b] Tested against the source's lowest order interaction if source averaged over years and the interaction is significant at 10% level

[c] Tested against Error

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 2009)

a. Unadjusted for Mini-Jack Proportion

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

1) Main Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year[1]	3599.00	7	514.14	132.94	**0.0000** [a]
Stock (HH vs NN)	20.05	1	20.05	0.83	0.3915 [b]
Year x Stock	168.30	7	24.04	6.22	**0.0098** [a]
Raceway Pair (within Year)[2]	30.94	8	3.87		

[1] Year treated as a random effect

[2] Differences among raceway pairs treated as random effect because each raceway within pair has same diallele cross, different raceways having different diallele crosses

[a] Tested against Raceway Pair

[b] Tested against the Year x Stock interaction

2) Sub-Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Raceway Pair (within Year)[2]	30.94	8	3.87	1.39	0.3156 [c]
Hi vs Lo (2004-2006)	83.96	1	83.96	9.51	0.0910 [b]
Stock x (Hi vs Lo)	0.30	1	0.30	0.11	0.7501 [c]
Year x (Hi vs Lo)	17.65	2	8.83	3.17	**0.0906** [c]
Year x Stock x (Hi vs Lo)	5.59	2	2.80	1.00	0.4037 [c]
STF vs Vita (2007, 2009-2011)	1.16	1	1.16	0.04	0.8540 [b]
Stock x (STF vs Vita)	12.89	1	12.89	0.48	0.5586 [b]
Year x (STF vs Vita)	65.26	3	7.25	2.61	0.1160 [c]
Year x Stock x (STF vs Vita)	53.28	2	26.64	9.58	**0.0059** [c]
EWOS vs Vita (2008)	5.82	1	5.82	2.09	0.1819 [c]
Stock x (STF vs Vita)	5.73	1	5.73	2.06	0.1850 [c]
Error (pooled over treatments)	25.03	9	2.78		

[b] Tested against the source's lowest order interaction if source averaged over years and the interaction is significant at 10% level

[c] Tested against Error

Table A.5. (continued)

b. Adjusted for Mini-Jack Proportion

*** Weight is for the number number-of-smolt/raceway detected leaving acclimation site is that number multiplied by {female proportion + male proportion*(1- precocial proportion of males)}, wherein proportion of males = proportion females = 0.5.**

1) Main Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year[1]	4914.99	7	702.14	85.93	**0.0000** [a]
Stock (HH vs NN)	2.04	1	2.04	0.07	0.7947 [b]
Year x Stock	195.45	7	27.92	3.42	**0.0532** [a]
Raceway Pair within Year[2]	65.37	8	8.17		

[1] Year treated as a random effect

[2] Differences among raceway pairs treated as random effect because each raceway within pair has same diallele cross, different raceways having different diallele crosses

[a] Tested against Raceway Pair

[b] Tested against the Year x Stock interaction

2) Sub-Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Raceway Pair (within Year)[2]	65.37	8	8.17	0.99	0.5078 [c]
Hi vs Lo (2004-2006)	239.63	1	239.63	28.91	**0.0007** [c]
Stock x (Hi vs Lo)	20.44	1	20.44	2.47	0.1550 [c]
Year x (Hi vs Lo)	43.68	2	21.84	2.63	0.1321 [c]
Year x Stock x (Hi vs Lo)	9.06	2	4.53	0.55	0.5991 [c]
STF vs Vita (2007, 2009-2011)	1.32	1	1.32	0.05	0.8337 [b]
Stock x (STF vs Vita)	7.58	1	7.58	0.91	0.3669 [c]
Year x (STF vs Vita)	75.61	3	25.20	3.04	**0.0926** [c]
Year x Stock x (STF vs Vita)	43.73	3	14.58	1.76	0.2325 [c]
EWOS vs Vita (2008)	12.85	1	12.85	1.55	0.2483 [c]
Stock x (STF vs Vita)	3.44	1	3.44	0.42	0.5375 [c]
Error (pooled over treatments)	66.31	8	8.29		

[b] Tested against the source's lowest order interaction if source averaged over years and the interaction is significant at 10% level

[c] Tested against Error

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 2009)

***Weight is number of smolt detected leaving acclimation site for each raceway**

1) Main Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year[1]	13543456.0	7	1934779.4	52.33	**0.0000** [a]
Stock (HH vs NN)	105924.0	1	105924.0	1.83	0.2181 [b]
Year x Stock	405032.0	7	57861.7	1.57	0.2712 [a]
Raceway Pair within Year[2]	295756.0	8	36969.5		

[1] Year treated as a random effect

[2] Differences among raceway pairs treated as random effect because each raceway within pair has same diallele cross, different raceways having different diallele crosses

[a] Tested against Raceway Pair

[b] Tested against the Year x Stock interaction

2) Sub-Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Raceway Pair (within Year)[2]	295756.0	8	36969.5	1.93	0.1863 [c]
Hi vs Lo (2004-2006)	119999.0	1	119999.0	6.25	**0.0369** [c]
Stock x (Hi vs Lo)	16425.0	1	16425.0	0.86	0.3819 [c]
Year x (Hi vs Lo)	12376.0	2	6188.0	0.32	0.7333 [c]
Year x Stock x (Hi vs Lo)	64405.4	2	32202.7	1.68	0.2462 [c]
STF vs Vita (2007, 2009-2011)	15883.0	1	15883.0	0.83	0.3895 [c]
Stock x (STF vs Vita)	11425.0	1	11425.0	0.60	0.4625 [c]
Year x (STF vs Vita)	61356.0	3	20452.0	1.07	0.4160 [c]
Year x Stock x (STF vs Vita)	29313.8	3	9771.3	0.51	0.6869 [c]
EWOS vs Vita (2008)	573.6	1	573.6	0.03	0.8670 [c]
Stock x (STF vs Vita)	13163.2	1	13163.2	0.69	0.4315 [c]
Error (pooled over treatments)	153477.1	8	19184.6		

[b] Tested against the source's lowest order interaction if source averaged over years and the interaction is significant at 10% level

[c] Tested against Error

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 2009)

Weight is expanded number of fish passing McNary

1) Main Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year[1]	1168824.0	7	166974.9	77.06	**0.0000** [a]
Stock (HH vs NN)	27745.0	1	27745.0	3.42	0.1070 [b]
Year x Stock	56847.9	7	8121.1	3.75	**0.0419** [a]
Raceway Pair within Year[2]	17333.9	8	2166.7		

[1] Year treated as a random effect

[2] Differences among raceway pairs treated as random effect because each raceway within pair has same diallele cross, different raceways having different diallele crosses

[a] Tested against Raceway Pair

[b] Tested against the Year x Stock interaction

2) Sub-Plot Analysis

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Raceway Pair (within Year)[2]	17333.9	8	2166.7	0.20	0.9826 [c]
Hi vs Lo (2004-2006)	12291.2	1	12291.2	1.13	0.3188 [c]
Stock x (Hi vs Lo)	344.6	1	344.6	0.03	0.8632 [c]
Year x (Hi vs Lo)	648.6	2	324.3	0.03	0.9707 [c]
Year x Stock x (Hi vs Lo)	241.6	2	120.8	0.01	0.9890 [c]
STF vs Vita (2007, 2009-2011)	15883.0	1	15883.0	1.46	0.2614 [c]
Stock x (STF vs Vita)	11425.0	1	11425.0	1.05	0.3354 [c]
Year x (STF vs Vita)	61356.0	3	20452.0	1.88	0.2113 [c]
Year x Stock x (STF vs Vita)	29313.8	3	9771.3	0.90	0.4830 [c]
EWOS vs Vita (2008)	502.4	1	502.4	0.05	0.8352 [c]
Stock x (STF vs Vita)	2188.4	1	2188.4	0.20	0.6656 [c]
Error (pooled over treatments)	87006.2	8	10875.8		

[b] Tested against the source's lowest order interaction if source averaged over years and the interaction is significant at 10% level

[c] Tested against Error

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Appendix D
Annual Report: Comparison of Salt-Water-Transfer Supplemented-Feed and Unsupplemented-Feed Treatments evaluated on Natural-Origin Hatchery-Reared Upper-Yakima Spring Chinook Smolt released in 2007 and 2009 through 2011

Doug Neeley, Consultant to Yakama Nation

Introduction

Prior to release of smolt in 2007 and 2009 through 2011, two feed treatments were allocated to raceways within adjacent raceway pairs. Fish from each raceway within the pairs were fed Vita prior to smoltification, then the Vita feed for one of the paired raceways was supplemented with Saltwater Transfer Feed (STF) and the other was not. The intent of the experiment was to determine whether the STF-supplement treatment increased the rate of smoltification, the unsupplemented 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) smolt-passage date, 4) mean proportion of PIT tagged fish detected volitionally leaving the acclimation ponds, 5) mean survival from volitional release to McNary.

Summary

With the inclusion of the 2011 release data, none of the five variables experienced a significant treatment effect. This is somewhat at variance from the results presented in the 2010 Annual report which reported a reduced pre-release weight but a higher release-to-McNary smolt-to-smolt survival associated with the Saltwater Transfer Treatment supplement ($P < 0.10$ based on a two-sided test for both variables) and, again for both variables, an associated Year x Site x Treatment interaction ($P < 0.10$). For these two variables, the inclusion of the 2011 release data still resulted in a Year x Site X Treatment interaction effect on release-to-McNary smolt survival ($P < 0.10$) but not on pre-release weight, and the main effect differences were not significant for either measure.

Mean Pre-Release Size

The pre-release size means (grams/fish) for the treatments are given in Table 1 and Figure 1 which indicate no significant or substantial difference between the treatments when pooled over years and acclimation sites (P = 0.56, Appendix Table A.1), there being less than an overall 1% decrease in weight associated with the STF supplement.

Table 1. 2007, 2009-2011 Mean pre-release Weight (grams) for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (STF = Vita + STF and Control = Vita)

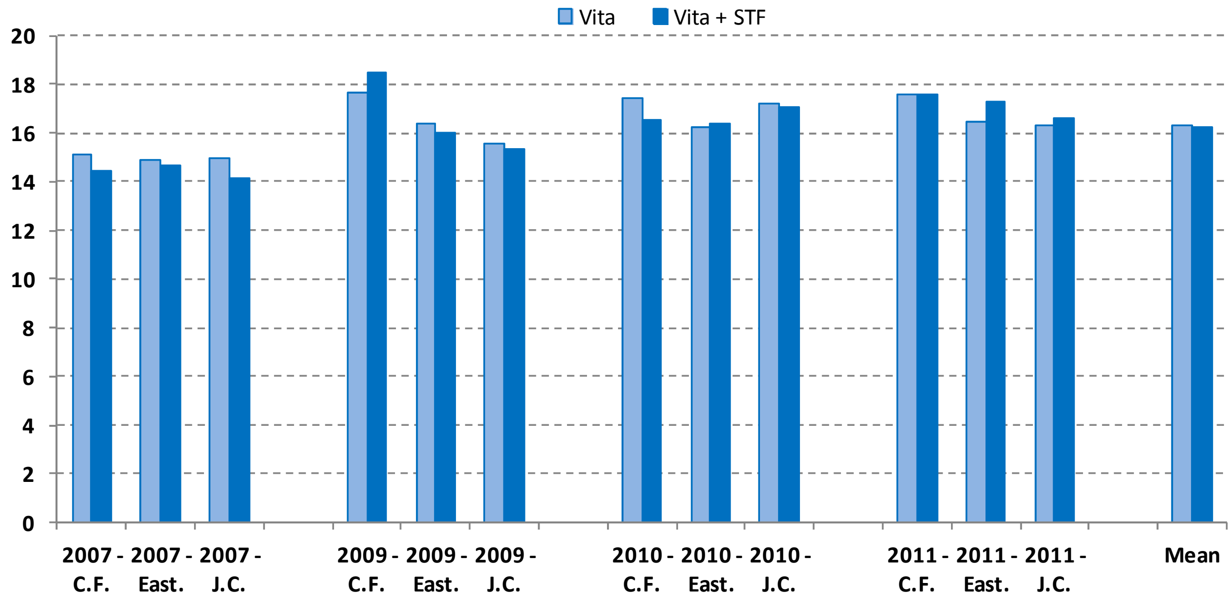
		Release Year 2007 (2005 Brood)			Release Year 2009 (2007 Brood)			Release Year 2010 (2008 Brood)			Release Year 2011 (2009 Brood)		
		Mean Pre-Release Weight		Difference as % of Control	Mean Pre-Release Weight		Difference as % of Control	Mean Pre-Release Weight		Difference as % of Control	Mean Pre-Release Weight		Difference as % of Control
Site	Measure	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control
Clark Flat	Mean Weight	14.4	15.1	-4.67%	18.5	17.6	4.78%	16.6	17.4	-5.07%	17.6	17.6	0.21%
	Number Weighed	180	180		180	180		180	180		180	180	
Easton	Mean Weight	14.7	14.9	-1.29%	16.0	16.4	-2.17%	16.4	16.2	0.95%	17.3	16.5	5.01%
	Number Weighed	180	180		180	179		180	176		180	180	
Jack Creek	Mean Weight	14.1	15.0	-5.39%	15.3	15.6	-1.68%	17.0	17.2	-0.97%	16.6	16.3	1.81%
	Number Weighed	180	180		240	120		180	180		180	180	
	Mean Weight	14.4	15.0	-3.79%	16.5	16.6	-1.05%	16.7	17.0	-1.80%	17.2	16.8	2.30%
	Number Weighed	540	540		600	479		540	536		540	540	

		Weighted* Mean over Years		
		Mean Pre-Release Weight		Difference as % of Control
Site	Measure	STF	Control	STF - Control
Clark Flat	Mean Weight	16.77	16.9	-1.05%
	Number Weighed	720	720	
Easton	Mean Weight	16.09	16.0	0.69%
	Number Weighed	720	715	
Jack Creek	Mean Weight	15.74	16.1	-1.94%
	Number Weighed	780	660	
	Mean Weight	16.2	16.3	-0.90%
	Number Weighed	2220	2095	

* Weight = Number of Fish Weighed

The significance level reported in the 2010 Annual Report was driven by 7 of the 9 year x site combinations (3 years x 3 acclimation sites) having a lower weight associated with the Saltwater Transfer Feed supplement. However, for the 2011 release, all three Saltwater Transfer Feed supplemented raceways had higher weights, resulting in less than a over-all 1% weight decrease in pre-release weight when averaged over all 12 year x site combinations (4 years x 3 acclimation sites).

Figure 1. 2007, 2009-2011 Mean pre-release Weight (grams) for Smolt from Clark Flat (C.F.), Easton (East.) and Jack Creek (J.C.) Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita and Vita + STF, Respectively)



Mean Volitional Release Date

The mean Julian volitional-release dates for the treatments are given in Table 2 and Figure 2 which indicate no significant or substantial difference between the treatments when pooled over years and acclimation sites (P = 0.48, Appendix A, Table A.2), the unsupplemented treatment's over-all mean release date being only one day earlier than that of the supplemented.

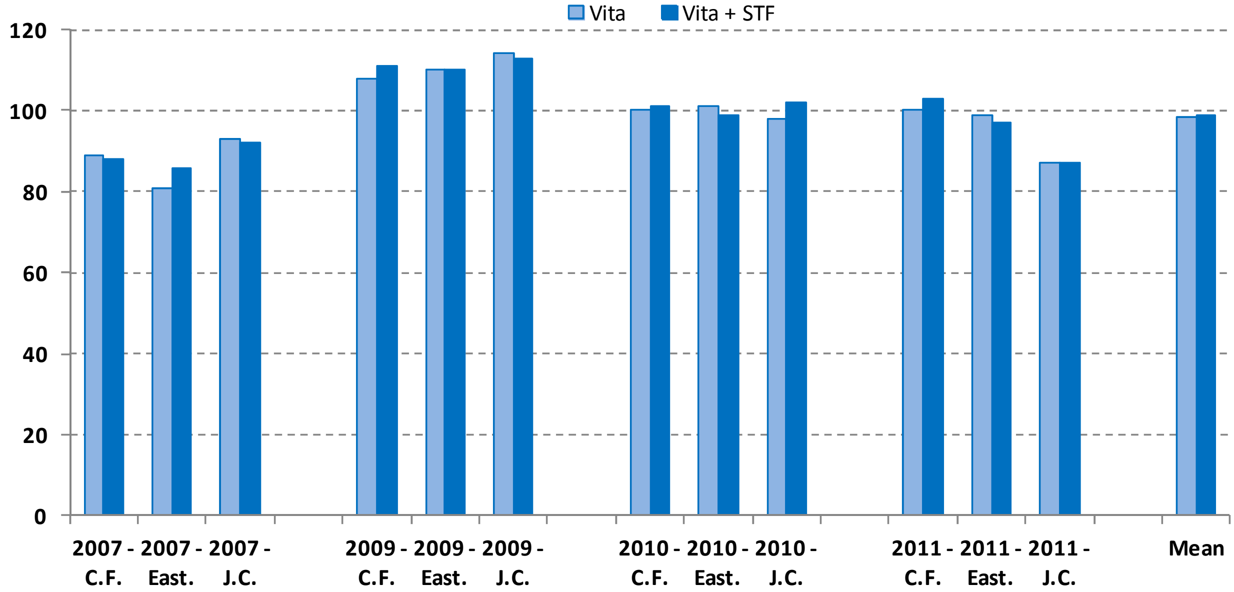
Table 2. 2007, 2009-2011 Mean Julian Release Date for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (STF = Vita + STF and Control = Vita)

		Release Year 2007 (2005 Brood)			Release Year 2009 (2007 Brood)			Release Year 2010 (2008 Brood)			Release Year 2011 (2009 Brood)		
		Acclimation-Site Mean Release Date		Difference as % of Control	Acclimation-Site Mean Release Date		Difference as % of Control	Acclimation-Site Mean Release Date		Difference as % of Control	Acclimation-Site Mean Release Date		Difference as % of Control
Site	Measure	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control
Clark Flat	Mean Release Date	88	89	-1.12%	111	108	2.78%	101	100	1.00%	103	100	3.00%
	Number Volitionally Released	6569	6546		5904	5909		5843	5841		5853	5894	
Easton	Mean Release Date	86	81	6.17%	110	110	0.00%	99	101	-1.98%	97	99	-2.02%
	Number Volitionally Released	6473	6462		5859	5824		5856	5830		5817	5824	
Jack Creek	Mean Release Date	92	93	-1.08%	113	114	-0.88%	102	98	4.08%	87	87	0.00%
	Number Volitionally Released	6574	6544		5794	5870		5828	5853		4222	4706	
	Mean Release Date	89	88	1.14%	111	111	0.00%	101	100	1.00%	97	96	1.04%
	Number Volitionally Released	19616	19552		17557	17603		17527	17524		15892	16424	

		Weighted* Mean over Years		
		Acclimation-Site Mean Release Date		Difference as % of Control
Site	Measure	STF	Control	STF - Control
Clark Flat	Mean Release Date	100.0	99.0	1.01%
	Number Volitionally Released	24169	24190	
Easton	Mean Release Date	98.00	97.00	1.03%
	Number Volitionally Released	24005	23940	
Jack Creek	Mean Release Date	99.0	98.0	1.02%
	Number Volitionally Released	22418	22973	
	Mean Release Date	99.0	98.0	1.02%
	Number Volitionally Released	70592	71103	

*** Weight = Number of Fish that were Volitionally Released**

Figure 2. 2007, 2009-2011 Mean Julian Volitional Release Date for Smolt from Clark Flat (C.F.), Easton (East.) and Jack Creek (J.C.) Acclimation Sites without and with Saltwater Transfer Feed supplement (Vita and Vita + STF, Respectively)



Mean McNary Smolt-Passage Date

The mean McNary passage-date means for the treatments given in Table 3 and Figure 3 indicate no significant or substantial difference between the treatments when pooled over years and acclimation sites (P = 0.43, Appendix Table A.3), as with volitional-release date, the unsupplemented treatment's over-all mean McNary date being only one day earlier than that of the supplemented.

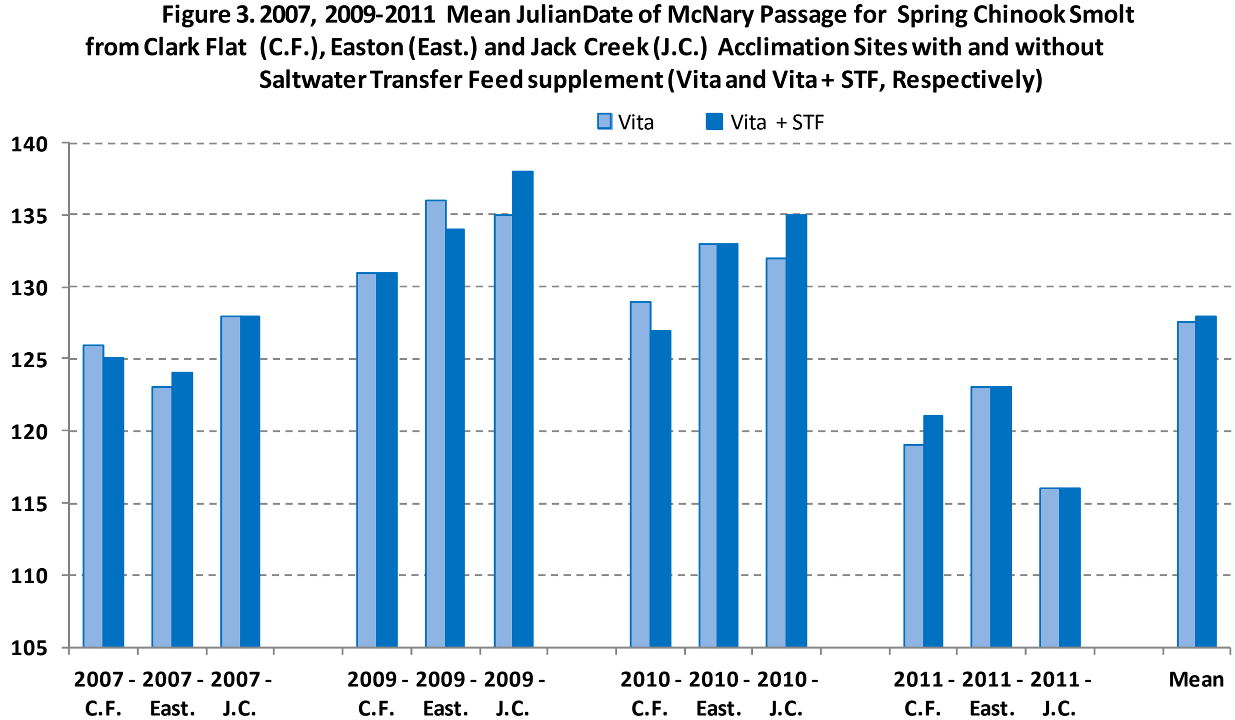
There were significant Site x Treatment and Year x Site x treatment interactions (P = 0.06 and 0.05, respectively, Appendix Table A.3) but, as mentioned, the effect overall sites and years is negligible.

Table 3. 2007, 2009-2011 Mean Julian Date of McNary Passage for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (STF = Vita + STF and Control = Vita)

		Release Year 2007 (2005 Brood)			Release Year 2009 (2007 Brood)			Release Year 2010 (2008 Brood)			Release Year 2011 (2009 Brood)		
		Weighted* McNary Dam Mean Passage Date		Difference as % of Control	Weighted* McNary Dam Mean Passage Date		Difference as % of Control	Weighted* McNary Dam Mean Passage Date		Difference as % of Control	Weighted* McNary Dam Mean Passage Date		Difference as % of Control
Site	Measure	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control	STF	Control	STF - Control
Clark Flat	Mean Passage Date	**125**	**126**	**-0.79%**	**131**	**131**	**0.00%**	**127**	**129**	**-1.55%**	**121**	**119**	**1.68%**
	Expanded Passage	2197	2317		2630	2409		1992	1877		2088	1968	
Easton	Mean Passage Date	**124**	**123**	**0.81%**	**134**	**136**	**-1.47%**	**133**	**133**	**0.00%**	**123**	**123**	**0.00%**
	Expanded Passage	1957	1850		2287	2494		1881	1679		1637	1904	
Jack Creek	Mean Passage Date	**128**	**128**	**0.00%**	**138**	**135**	**2.22%**	**135**	**132**	**2.27%**	**116**	**116**	**0.00%**
	Expanded Passage	2053	2070		2250	2118		1844	1728		1092	1264	
Weighted*	Mean Passage Date	**126**	**126**	**0.00%**	**134**	**134**	**0.00%**	**132**	**131**	**0.76%**	**121**	**120**	**0.83%**
	Expanded Passage	6207	6237		7167	7021		5717	5284		4817	5136	

		Weighted* Mean over Years		
		Weighted* McNary Dam Mean Passage Date		Difference as % of Control
Site	Measure	STF	Control	STF - Control
Clark Flat	Mean Passage Date	**126**	**126**	**0.00%**
	Expanded Passage	8907	8571	
Easton	Mean Passage Date	**129**	**129**	**0.00%**
	Expanded Passage	7762	7927	
Jack Creek	Mean Passage Date	**131**	**129**	**1.55%**
	Expanded Passage	7239	7180	
Weighted*	Mean Passage Date	**129**	**128**	**0.78%**
	Expanded Passage	23908	23678	

*** Weight = Expanded McNary-Dam Passage Number**



Mean Proportion of PIT-Tagged Fish Volitionally Leaving Acclimation Ponds

The mean volitional-release proportions (proportion of fish PIT-tagged before release actually detected leaving the acclimation sites) are given in Table 4 and Figure 4 which indicate no significant or substantial difference between the treatments when pooled over years and acclimation sites with less than an overall 1% decrease in proportion of smolt released associated the STF supplement (Type Error 1 P = 0.29, Appendix Table A.4).

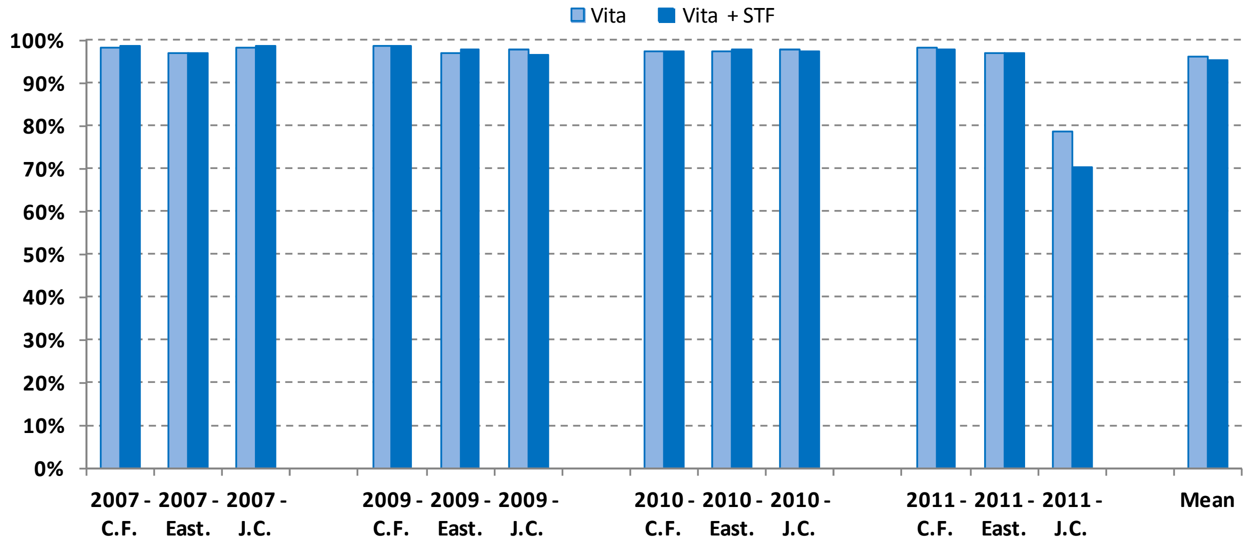
Table 4. 2007, 2009-2011 Proportion of Spring Chinook Smolt leaving Acclimation Sites at Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (STF = Vita + STF and Control = Vita)

		Release Year 2007 (2005 Brood)			Release Year 2009 (2007 Brood)			Release Year 2010 (2008 Brood)			Release Year 2011 (2009 Brood)		
		Pond Pre-Release Proportion		Difference as % of Control	Pond Pre-Release Proportion		Difference as % of Control	Pond Pre-Release Proportion		Difference as % of Control	Acclimation-Pond Pre-Release Proportion		Difference as % of Control
Site	**Measure**	**STF**	**Control**	**STF - Control**	**STF**	**Control**	**STF - Control**	**STF**	**Control**	**STF - Control**	**STF**	**Control**	**STF - Control**
Clark Flat	**Proportion Released**	**0.985**	**0.981**	**0.48%**	**0.984**	**0.985**	**-0.08%**	**0.974**	**0.973**	**0.03%**	**0.976**	**0.982**	**-0.69%**
	Number Tagged	4444	4450		4000	4000		4000	4000		4000	4000	
Easton	**Proportion Released**	**0.971**	**0.969**	**0.22%**	**0.976**	**0.969**	**0.74%**	**0.976**	**0.972**	**0.45%**	**0.969**	**0.971**	**-0.10%**
	Number Tagged	6666	6669		6001	6009		6000	6000		6000	6001	
Jack Creek	**Proportion Released**	**0.986**	**0.982**	**0.46%**	**0.966**	**0.978**	**-1.28%**	**0.971**	**0.976**	**-0.43%**	**0.704**	**0.784**	**-10.28%**
	Number Tagged	6666	6666		6000	6001		6000	6000		6000	6000	
	Proportion Released	**0.980**	**0.977**	**0.37%**	**0.974**	**0.976**	**-0.23%**	**0.974**	**0.974**	**0.01%**	**0.871**	**0.904**	**-3.58%**
	Number Tagged	17776	17785		16001	16010		16000	16000		16000	16001	

		Weighted* Mean over Years		
		Acclimation-Pond Pre-Release Proportion		Difference as % of Control
Site	**Measure**	**STF**	**Control**	**STF - Control**
Clark Flat	**Pre-Release Survival**	**0.980**	**0.980**	**-0.05%**
	Number Tagged	16444	16450	
Easton	**Pre-Release Survival**	**0.973**	**0.970**	**0.32%**
	Number Tagged	24667	24679	
Jack Creek	**Pre-Release Survival**	**0.909**	**0.931**	**-2.41%**
	Number Tagged	24666	24667	
	Pre-Release Survival	**0.951**	**0.958**	**-0.77%**
	Number Tagged	65777	65796	

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

Figure 4. 2007, 2009-2011 Proportion Released from Clark Flat (C.F.), Easton (East.) and Jack Creek (J.C.) Acclimation Sites for Smolt with and without Saltwater Transfer Feed supplement (Vita and Vita + STF, Respectively)



The proportion of tagged smolt released is presented because, in previous years, adjustments for detection efficiencies based on detection of tagged fish at down-stream sites frequently produced survival estimates greater than 100%. However, because of high flows at Jack Creek in 2011, smolt were forced out of the acclimation sites on March 3. This is reflected in Figure 3 wherein the mean Julian date of release from Jack Creek was considerably earlier than those from Easton and Clark Flat; whereas in previous years the Jack Creek mean Julian Date of release are comparable to those at the other sites. We also note that the 2011 STF-Control difference as a percent of control was rather large at Jack Creek (-10.3%, Table 4.b.).

This forced release lead to the swamping of the detector and the failure of many of the tags to be read. Since expansion of the proportion released by division by estimated detection efficiencies were not greater than 100% in 2011, the resulting expansion to adjust for the effects of the swamping gives a better index of actual pre-release survival. The 2011 estimated proportions released, detection efficiencies, and pre-release survival indices are presented in Table 4.b. The STF-Control difference as a percent of control has been reduced from -10.3% to -2.1% because of the expansion. We also note that Jack Creek Pre-release survival estimates are similar to those of the other acclimation sites, which was not true of estimated proportion released.

Table 4.b. 2011 a) Proportion of Spring Chinook Smolt leaving Acclimation Site, Acclimation Site Detection Efficiency, and Pre-release Survival Index at Acclimation Sites without and with Saltwater Transfer Feed supplement (STF = Vita + STF and Control = Vita)

	Release Year 2011 (2009 Brood)							
	a. Acclimation-Pond Pre-Release Proportion		Difference as % of Control	b. Acclimation-Pond Detection Efficiency		c. Acclimation-Pond Pre-Release Survival (c. = a./b.)		Difference as % of Control
Site	STF	Control	STF - Control	STF	Control	STF	Control	STF - Control
Clark Flat	0.976	0.982	-0.69%	0.996	0.999	0.980	0.983	-0.38%
Easton	0.969	0.971	-0.10%	1.000	0.995	0.969	0.975	-0.56%
Jack Creek	0.704	0.784	-10.28%	0.758	0.805	0.928	0.974	-4.76%
	0.871	0.904	-3.58%			0.957	0.977	-2.09%

Mean Release-to-McNary Smolt-to-Smolt Survival

The mean Julian release-to-McNary smolt-to-smolt survival rates given in Table 5 and Figure 5 indicate no significant or substantial difference between the treatments when pooled over years and acclimation sites (P = 0.58, Appendix Table A.5), the over-all survival means being almost identical for the two treatments -- 33.5% for the STF-supplemented treatment and 33.0% for the STF-unsupplemented control. The Year x Site x Treatment interaction, significant at the 10% level (Appendix A.5), reflected the STF-supplemented treatment having a somewhat higher survival rate for all sites for the 2010 releases but having inconsistent responses over sites in the other years.

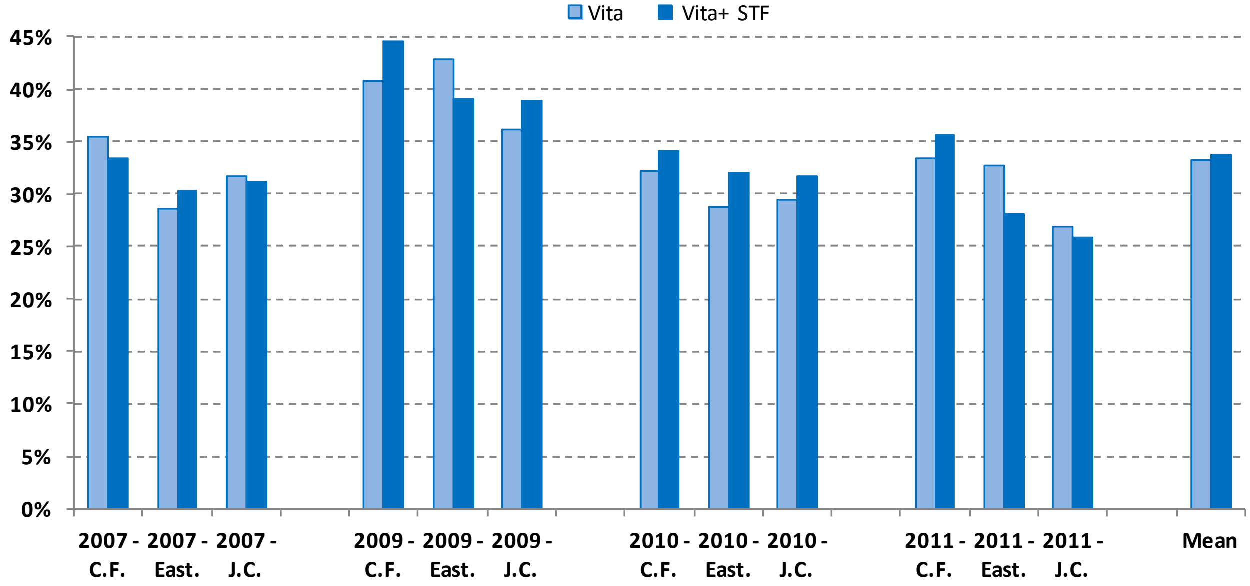
Table 5. 2007, 2009-2011 Mean Release-to-McNary Smolt-to-Smolt survival for Spring Chinook Smolt from Clark Flat, Easton and Jack Creek Acclimation Sites without and with Saltwater Transfer Feed supplement (STF = Vita + STF and Control = Vita)

		Release Year 2007 (2005 Brood)			Release Year 2009 (2007 Brood)			Release Year 2010 (2008 Brood)			Release Year 2011 (2009 Brood)		
		Release-to-Mcnary Proportion Survival		Difference as % of Control	Release-to-Mcnary Proportion Survival		Difference as % of Control	Release-to-Mcnary Proportion Survival		Difference as % of Control	Release-to-Mcnary Proportion Survival		Difference as % of Control
Site	Measure	STF	Control	STF - Control	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%	0.341	0.321	6.10%	0.357	0.334	6.83%
	Number Volitionally Released	4379	4364		3936	3939		3895	3894		3902	3929	
Easton	McNary Survival	0.302	0.286	5.59%	0.390	0.428	-8.84%	0.321	0.288	11.51%	0.281	0.327	-13.92%
	Number Volitionally Released	6473	6462		5859	5824		5856	5830		5817	5824	
Jack Creek	McNary Survival	0.312	0.316	-1.31%	0.388	0.361	7.65%	0.316	0.295	7.16%	0.259	0.268	-3.64%
	Number Volitionally Released	6574	6544		5794	5870		5828	5853		4222	4706	
Weighted*	McNary Survival	0.314	0.315	-0.16%	0.404	0.398	1.46%	0.324	0.299	8.44%	0.296	0.310	-4.58%
	Number Volitionally Released	17426	17370		15589	15633		15579	15577		13941	14459	

		Weighted* Mean over Years		
		Release-to-Mcnary Proportion Survival		Difference as % of Control
Site	Measure	STF	Control	STF - Control
Clark Flat	McNary Survival	0.369	0.354	4.00%
	Number Volitionally Released	16112	16126	
Easton	McNary Survival	0.323	0.331	-2.35%
	Number Volitionally Released	24005	23940	
Jack Creek	McNary Survival	0.323	0.313	3.32%
	Number Volitionally Released	22418	22973	
Weighted*	McNary Survival	**0.335**	**0.330**	**1.37%**
	Number Volitionally Released	62535	63039	

* Weight = Number of Fish that were Volitionally Released

Figure 5. 2007, 2009-2011 Release-to-McNary Survival from Clark Flat (C.F.), Easton (East.) and Jack Creek (J.C.) Acclimation Sites for Smolt with and without Saltwater Transfer Feed supplement (Vita and Vita+ STF, Respectively)



Jack Creek Estimates

This report focuses on comparisons in the responses to the STF-supplemented treatment with the STF-unsupplemented control treatments. It should be noted that the 2011 Jack Creek mean release date and McNary Passage dates were notably earlier then the respective means of the Clark Flat and Easton releases, this was not the case for the 2007, 2009, and the 2010 releases (refer back to Figures 2 and 3). The 2011 mean pre-release survival for Jack Creek releases were also notably lower than for the other two release sites (Figure 4). In 2011 smolt were forced out of the Jack Creek acclimation raceways on March 31 due to high water issues. Because of the “force out”, fish were crowded moving through the detectors, and it is likely that many PIT-tagged fish eluded exit detection due to a swamping effect. This likely contributed to the earlier estimated mean release and McNary passage dates and the lower mean date affected mean Julian Release Date and a biased-lower pre-release proportion estimate. It is not clear, however, how this early release would have resulted in the lowered survival from Jack Creek to McNary (Figure 5) unless there were higher survival associated with later passage in 2011.

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 of Variation	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-Ratio	Type 1 Error P
Year adjusted for Site	3004	3	1001.33	7.89	0.0166
Site adjusted for Year	588	2	294.00	7.03	0.0049
Year x Site Interaction	761	6	126.83	3.03	0.0282
Among Raceway Pairs within Year x Site	836	20	41.80	1.74	0.0245
Treatment: (STF supplemented vs unsupplementd)	**8**	**1**	**8.00**	**0.33**	**0.5640**
Treatment x Year adjusted for Treatment x Site	121	3	40.33	1.68	0.1703
Treatment x Site adjusted for Treatment x Year	23	2	11.50	0.48	0.6196
Treatment X Year x Site	120	6	20.00	0.83	0.5445
Error	480	20	24.00		

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 of Variation	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-Ratio	Type 1 Error P
Year adjusted for Site	9113193	3	3037731.00	11.94	0.0061
Site adjusted for Year	129182	2	64591.00	1.39	0.2715
Year x Site Interaction	1526976	6	254496.00	5.49	0.0017
Among Raceway Pairs within Year x Site	927635	20	46381.75	1.46	0.0822
Treatment: (STF supplemented vs unsupplementd)	**15727**	**1**	**15727.00**	**0.50**	**0.4810**
Treatment x Year adjusted for Treatment x Site	2580	3	860.00	0.03	0.9940
Treatment x Site adjusted for Treatment x Year	13078	2	6539.00	0.21	0.8134
Treatment X Year x Site	167843	6	27973.83	0.88	0.5059
Error	633363	20	31668.15		

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 of Variation	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-Ratio	Type 1 Error P
Year adjusted for Site	1198151	3	399383.67	14.14	0.0040
Site adjusted for Year	70950	2	35475.00	16.72	0.0001
Year x Site Interaction	169484.8	6	28247.47	13.32	0.0000
Among Raceway Pairs within Year x Site	42428.2	20	2121.41	1.58	0.0478
Treatment: (STF supplemented vs unsupplementd)	**847**	**1**	**847.00**	**0.63**	**0.4271**
Treatment x Year adjusted for Treatment x Site	1265.6	3	421.87	0.31	0.8151
Treatment x Site adjusted for Treatment x Year	7336.6	2	3668.30	2.73	0.0651
Treatment X Year x Site	17175.4	6	2862.57	2.13	0.0465
Error	26852.9	20	1342.65		

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

Source of Variation	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year adjusted for Site	3740.48	3	1246.83	3.91	0.0732
Site adjusted for Year	2186.24	2	1093.12	27.99	0.0000
Year x Site Interaction	1914.29	6	319.05	8.17	0.0001
Among Raceway Pairs within Year x Site	780.96	20	39.05	0.93	0.5496
Treatment: (STF supplemented vs unsupplementd)	**46.96**	**1**	**46.96**	**1.12**	**0.2908**
Treatment x Year adjusted for Treatment x Site	29.9	3	9.97	0.24	0.8705
Treatment x Site adjusted for Treatment x Year	29.19	2	14.60	0.35	0.7067
Treatment X Year x Site	11.65	6	1.94	0.05	0.9996
Error	840.59	20	42.03		

Appendix. (continued)

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

Source of Variation	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year adjusted for Site	872.51	3	290.84	20.38	0.0015
Site adjusted for Year	182.52	2	91.26	9.22	0.0015
Year x Site Interaction	85.64	6	14.27	1.44	0.2483
Among Raceway Pairs within Year x Site	198.03	20	9.90	1.80	0.0296
Treatment:					
(STF supplemented vs unsupplementd)	**1.67**	**1**	**1.67**	**0.30**	**0.5832**
Treatment x Year adjusted for Treatment x Site	33.38	3	11.13	2.02	0.1156
Treatment x Site adjusted for Treatment x Year	11.74	2	5.87	1.06	0.3484
Treatment X Year x Site	61.26	6	10.21	1.85	0.0957
Error	110.29	20	5.51		

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Appendix E
Annual Report: Smolt Survival to McNary Dam of 1999-2011
PIT-tagged Spring Chinook released or detected at Roza Dam

Doug Neeley, Consultant to the Yakama Nation

Introduction

As in previous years, survivals to McNary Dam (McNary) of hatchery-brood (hatchery) PIT-Tagged smolt released into the Roza bypass are compared to survivals of natural-brood (natural) smolt PIT-tagged and released contemporaneously with hatchery smolt. These contemporaneously Roza-passing natural smolt are referred to as "late" natural smolt. The survival of the late natural smolt is also compared to the survival of "early" natural smolt which pass Roza and are then captured, PIT-tagged, and released into the Rosa bypass prior to hatchery-smolt passage.

All smolt releases in this study were originally collected in the Roza bypass system, PIT-tagged if not previously PIT-tagged, and then all PIT-tagged fish are released back into the bypass; therefore the determination of the date that separates late from early is not a fixed date, rather it is the date on which smolt were tagged or tested for tags at Roza. If the tagged smolt could not be assigned to a given release, they were omitted from the data set.

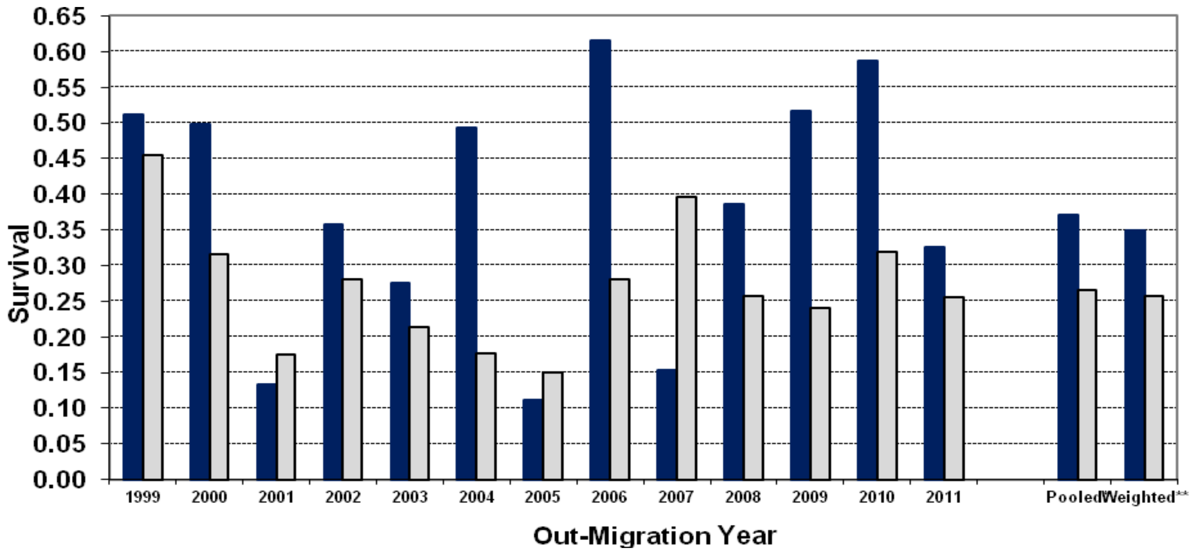
Methodology

All smolt included in the analysis were grouped into seven day intervals. Thus all smolt tagged between Julian dates 1 and 7, were treated as one release group, those between Julian dates 8 and 14 were treated as another group, etc. The last Julian date of a grouping was always evenly divisible by seven. This was done to have a sufficiently large number of released smolt. If there was not a sufficient number, then two adjacent groups were combined into a common group. Separate McNary survival estimates were made for each group, each group serving as a "replicate". Conceptual survival estimation procedures are discussed in Appendix A. Weighted logistic analysis was used to analyze survival estimates. Comparisons of late-natural and hatchery smolt were treated as paired comparisons with the release-group Julian-Date intervals treated as blocks. Comparisons between early and late natural smolt were treated as independent comparisons since they involved different groupings.

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 2011 had a higher survival rate to McNary than hatchery smolt. Figure 1 presents the late-natural- and hatchery-smolt survivals to McNary from the 1999 through 2011 Roza releases.

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



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

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

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

As can be seen from Figure and Table 1, the late natural smolt survival exceeded that of the hatchery smolt in 10 of the 13 outmigration years. Of those 10 years, 6 were significant at the 5% level (strongly bold-faced one-sided-test probabilities in the Table 1); for the additional 4 of those 10 years, 3 were significant at the 10% level (underlined in Table 1). For the three out-migration years (2001, 2005, and 2007) in which the hatchery-spawned smolt had the highest estimated survivals, the differences were not significant even at the 10% level for a two-sided test. (Note that the pooled survival and weighted survival estimates over years were significantly higher for the natural smolt [P = 0.0031 and P = 0.0068 respectively]).

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

Stock	Measure	Outmigration Year 1999	2000	2001	2002	2003	2004	2005
Natural	**Survival**	**0.5122**	**0.4987**	**0.1339**	**0.3584**	**0.2750**	**0.4935**	**0.1122**
(Nat)	Released	133	3196	1424	2114	1190	74	45
Hatchery	**Survival**	**0.4540**	**0.3155**	**0.1759**	**0.2803**	**0.2137**	**0.1768**	**0.1494**
(Hat)	Released	675	2999	1744	1503	2146	2201	1344
Difference: Nat-Hat		**0.0582**	**0.1832**	**-0.0420**	**0.0781**	**0.0613**	**0.3167**	**-0.0371**
Type 1 Error P								
(2-sided)	**(Nat ≠ Hat)**	0.1511	**0.0000**	0.5246	0.1732	0.1498	**0.0487**	0.9410
(1-sided)	**(Nat > Hat)**	0.0755	**0.0000**	0.7377	0.0866	0.0749	**0.0243**	0.5295

Stock	Measure	Outmigration Year 2006	2007	2008	2009	2010	2011	Mean Pooled*	Weighted**
Natural	**Survival**	**0.6160**	**0.1529**	**0.3857**	**0.5161**	**0.5874**	**0.3260**	**0.3715**	**0.3488**
(Nat)	Released	500	336	421	172	105	956	10666	
Hatchery	**Survival**	**0.2810**	**0.3955**	**0.2573**	**0.2405**	**0.3196**	**0.2558**	**0.2655**	**0.2576**
(Hat)	Released	3802	2477	4406	2334	1130	2802	29563	
Difference: Nat-Hat		**0.3350**	**-0.2426**	**0.1284**	**0.2756**	**0.2678**	**0.0702**	**0.1060**	**0.0913**
Type 1 Error P									
(2-sided)	**(Nat ≠ Hat)**	**0.0012**	**0.0352**	**0.0192**	**0.0726**	**0.0431**	0.1267	**0.0126**	**0.0272**
(1-sided)	**(Nat > Hat)**	**0.0006**	0.9824	**0.0096**	**0.0363**	**0.0216**	0.0633	**0.0063**	**0.0136**

* Pooled Survival Mean = [Total over Years of joint release and McNary detections]/[Total over Years of release detections]
** Weighted Survival Mean is yearly means weighted by (number of given stock released)/(Error Mean Deviance) in given year
Yearly Error Mean Deviance given in Appendix C.1Tables, number released given in Table 1.

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

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

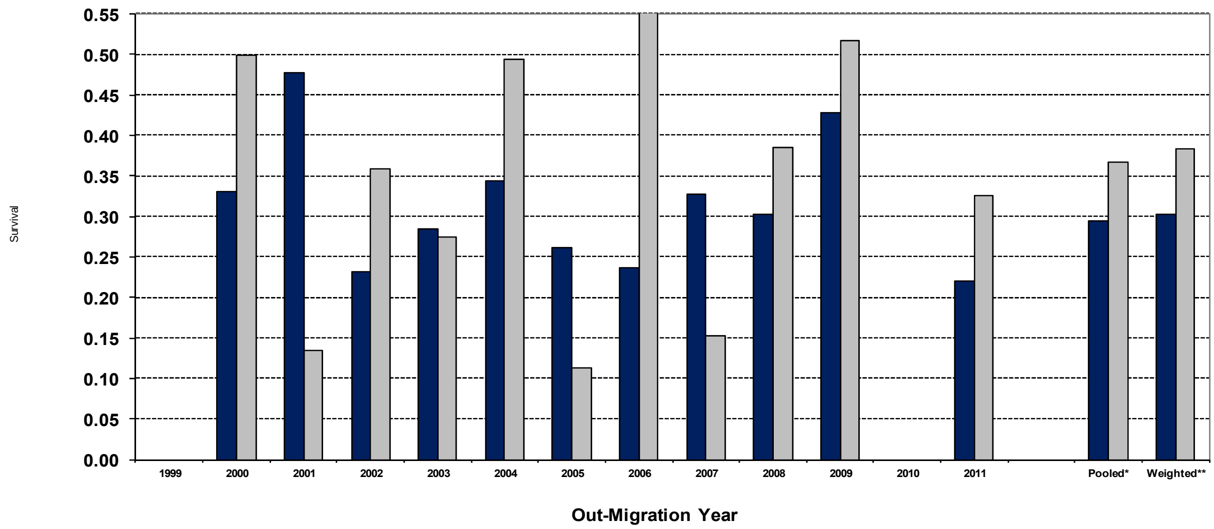
Beginning in outmigration-year 2000, Roza trapping operations began early enough to permit survival to McNary passage comparisons between early and late arriving natural smolt. In 1999 and 2010, no naturally spawned smolt were tagged at Roza prior to Prosser passage of hatchery-spawned smolt. Figure 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. The weekly release estimates of natural- and hatchery-smolt survival within each year are presented in Appendix B.

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

There is no consistency over the release years as to whether the early or late natural-smolt passage had the highest survival to McNary. Of the eleven years of early releases, seven had the highest survival associated with the late releases, and three of the four significant releases were associated with the late releases; however, the two combined over-years analyses did not indicate that the late release had over-all significantly higher survival.

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

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



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

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
Early	Survival	0.3307	0.4771	0.2314	0.2837	0.3442	0.2608
	Released	3013	755	6604	6614	3857	1688
Late	Survival	0.4987	0.1339	0.3584	0.2750	0.4935	0.1122
	Released	3196	1424	2114	1190	74	45
Difference: Early-Late		-0.1679	0.3432	-0.1270	0.0087	-0.1493	0.1485
2-sided Type 1 Error P Estimate		0.0000	0.0001	0.0004	0.8230	0.4903	0.4035

Natural Stock	Measure	Outmigration Year 2006	2007	2008	2009	2011	Mean Pooled*	Mean Weighted**
Early	Survival	0.2361	0.3273	0.3020	0.4286	0.2200	0.2945	0.3026
	Released	1833	1072	1254	1804	985	29479	
Late	Survival	0.6160	0.1529	0.3857	0.5161	0.3260	0.3676	0.3836
	Released	500	336	421	172	956	10428	
Difference: Early-Late		-0.3799	0.1744	-0.0837	-0.0875	-0.1060	-0.0731	-0.0810
2-sided Type 1 Error P Estimate		0.0010	0.0889	0.2458	0.1001	0.2176	0.1670	0.1258

* Pooled Survival Mean = [Total over Years of joint release and McNary detections]/[Total over Years of release detections]

** Weighted Survival Mean is yearly means weighted by (number of given stock released)/(Error Mean Deviance) in given year
Yearly Error Mean Deviance given in Appendix D.1 Tables, number released given in Table 1.

Appendix A. Conceptual Computation

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

1. Identifying time-of-passage strata within which estimated daily McNary detection rates are reasonably homogeneous. (Daily McNary detection rate is the proportion of all[3] Yakima PIT-tagged Spring Chinook passing McNary Dam for each day of McNary detections)

2. Estimating the McNary detection rate for each stratum

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

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

5. Taking that release's expanded total over strata and dividing it by the appropriate group's release number at Roza

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

The steps given above can be basically summarized in the following equations.

Equation 1.

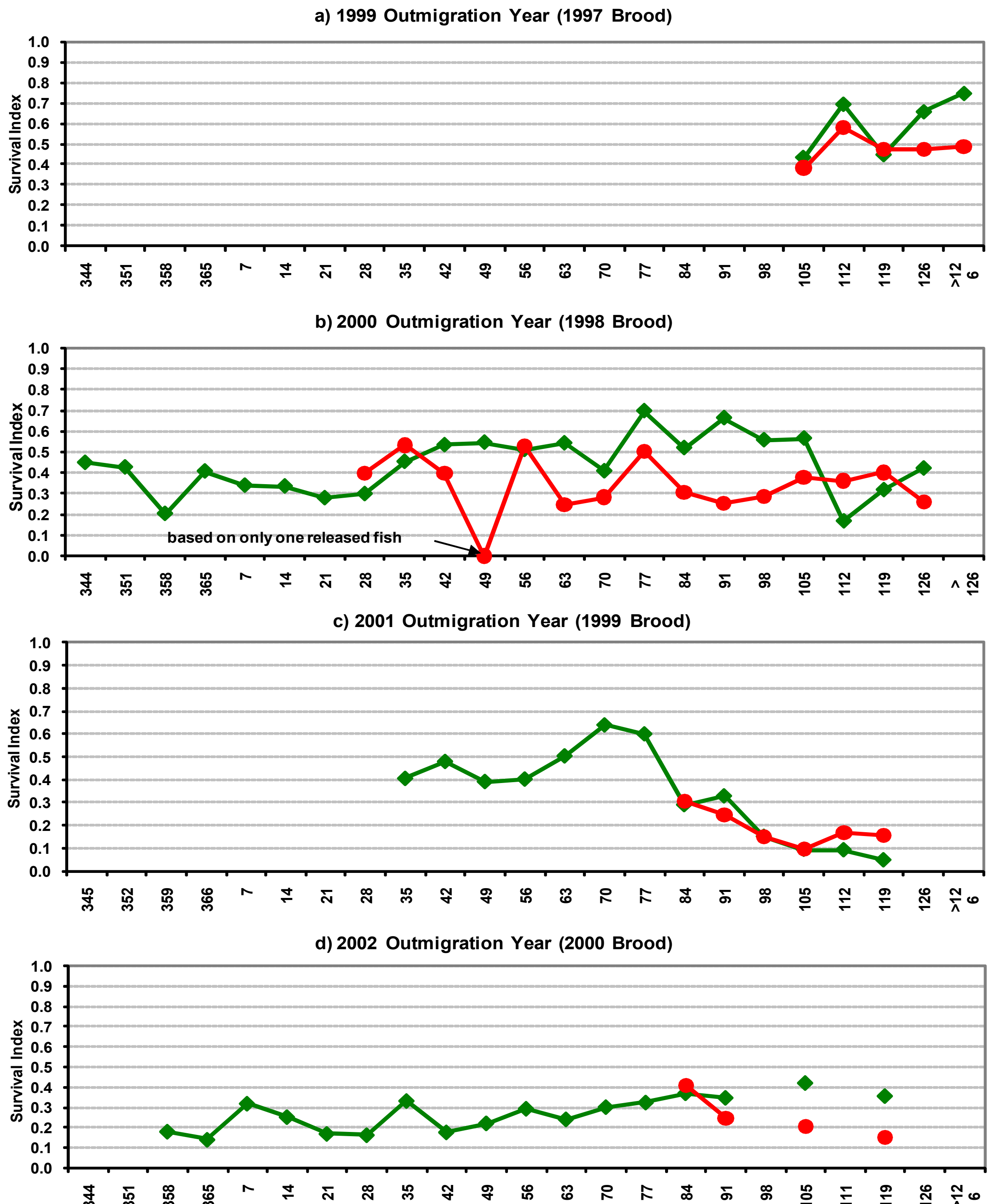
$$\text{Stratum McNary detection rate} = \frac{\text{number of joint detections at McNary and downstream dams within Stratum}}{\text{estimated total number of detections at downstream dams within Stratum}}$$

Equation 2.

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

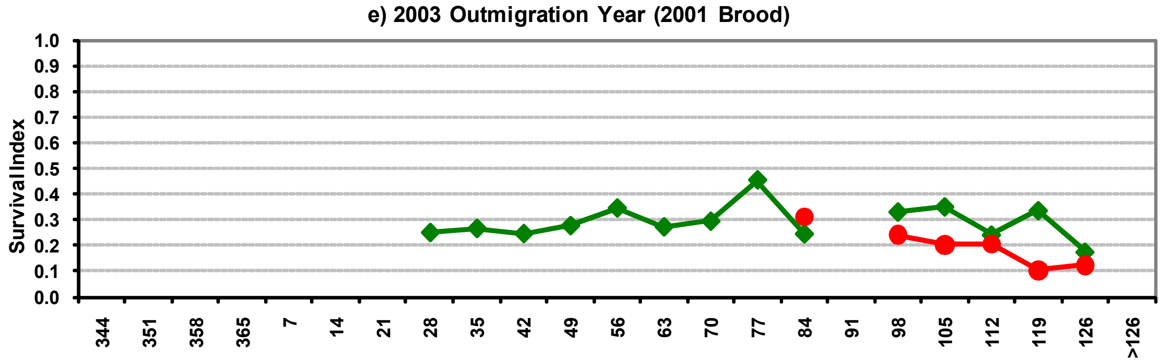
[3] All smolt PIT-tagged in the Yakima Basin, nor merely those PIT-tagged at Roza

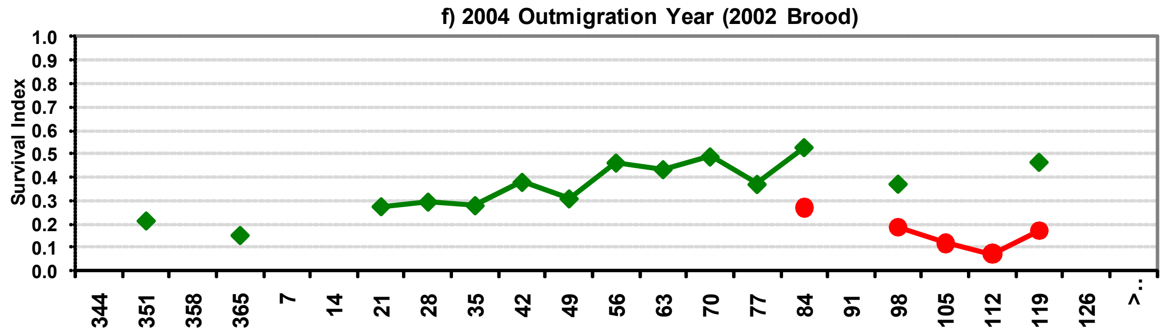
Appendix B.1. Plotted McNary Smolt Survival of Roza-Released Upper-Yakima Natural- (diamonds) and Hatchery-Brood (circles) Spring Chinook

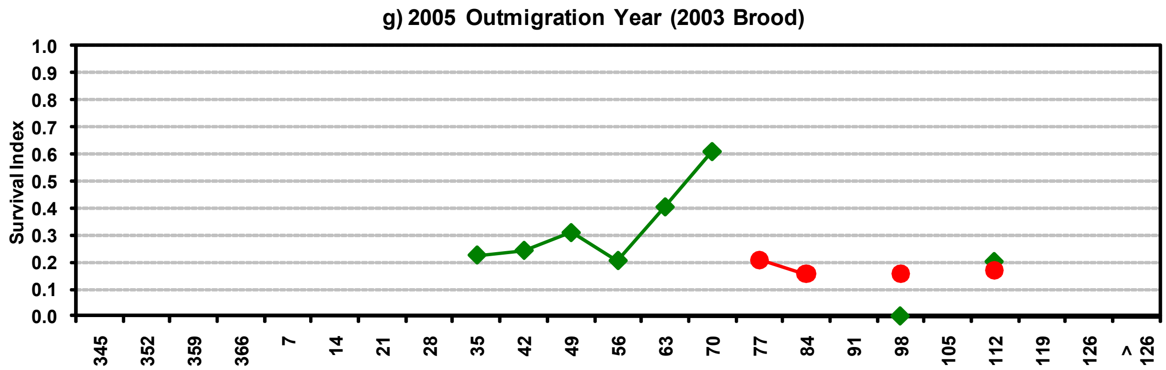


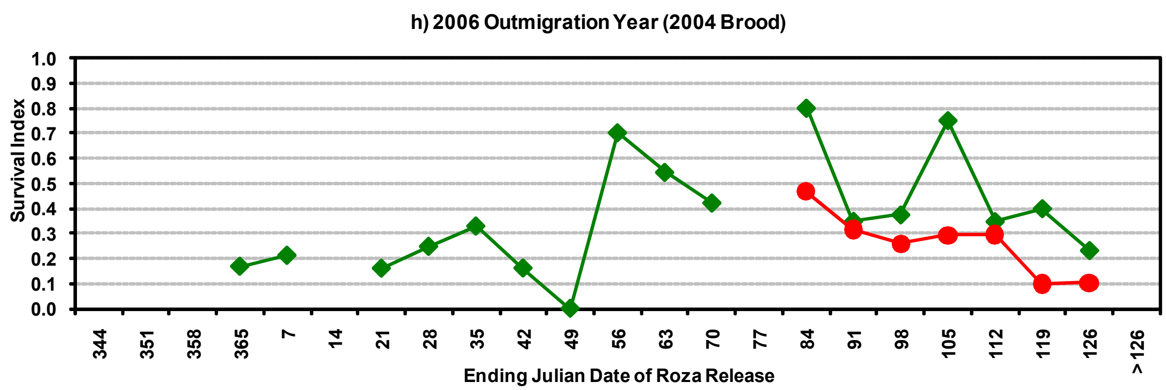
Note: The screens at the acclimation sites are generally pulled on March 15. In 2000 there was leakage that resulted in many of the hatchery smolt leaving earlier.

Appendix B.1. (continued)

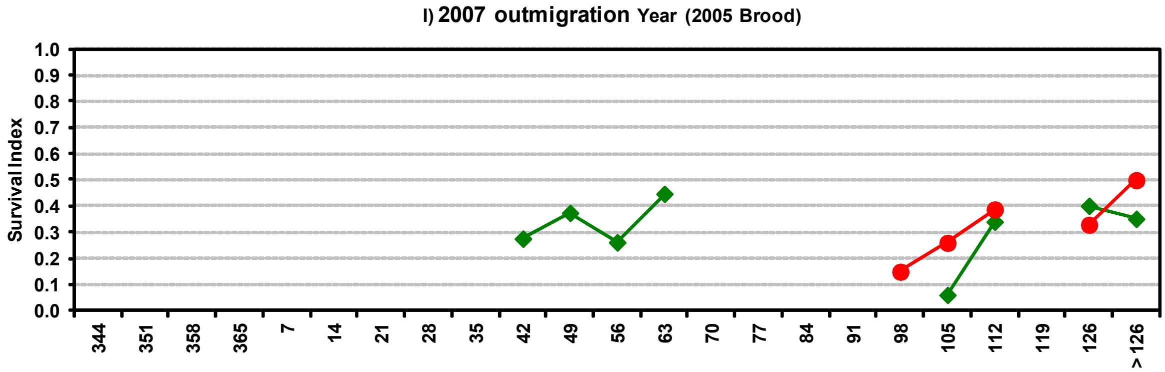


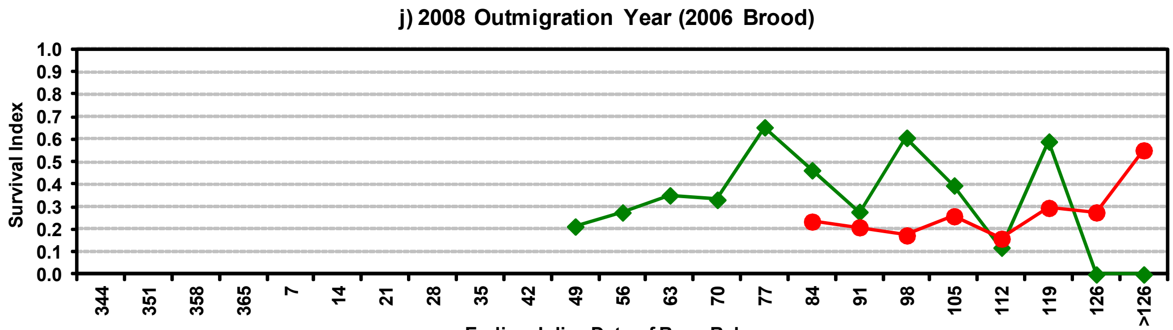


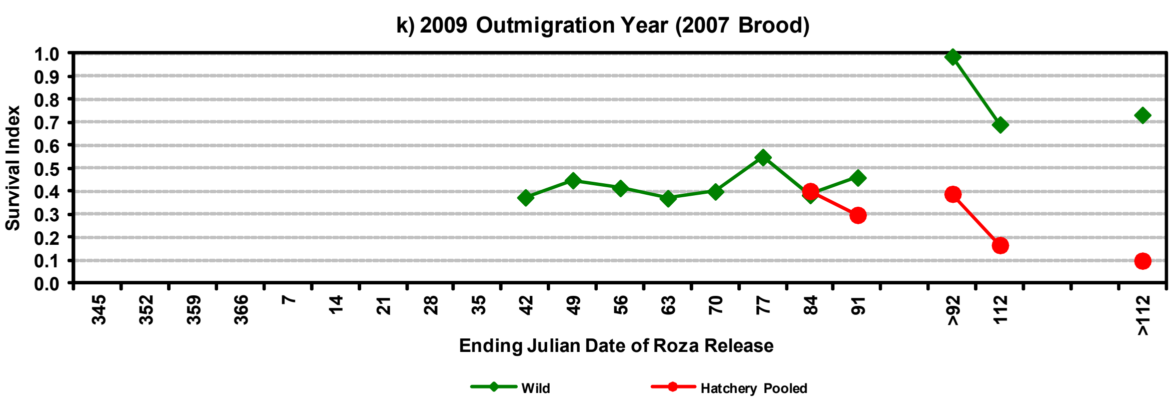


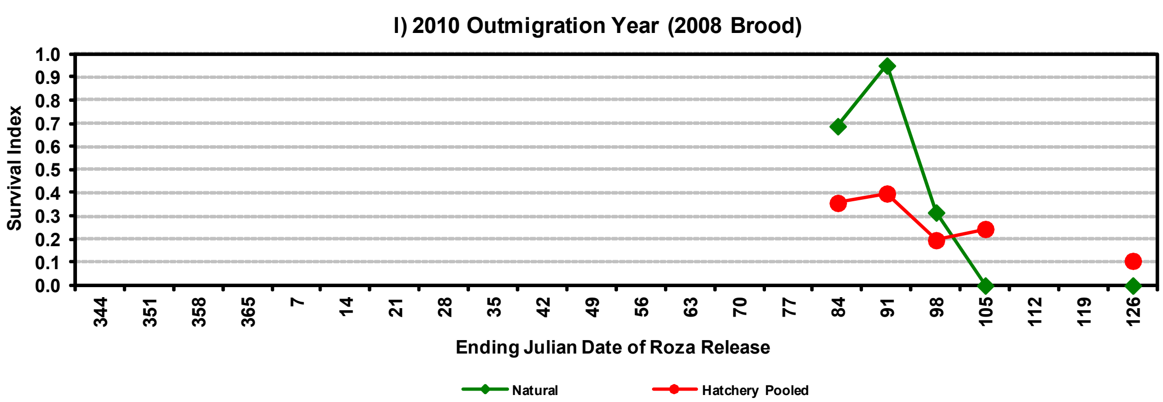


Appendix B.1. (continued)

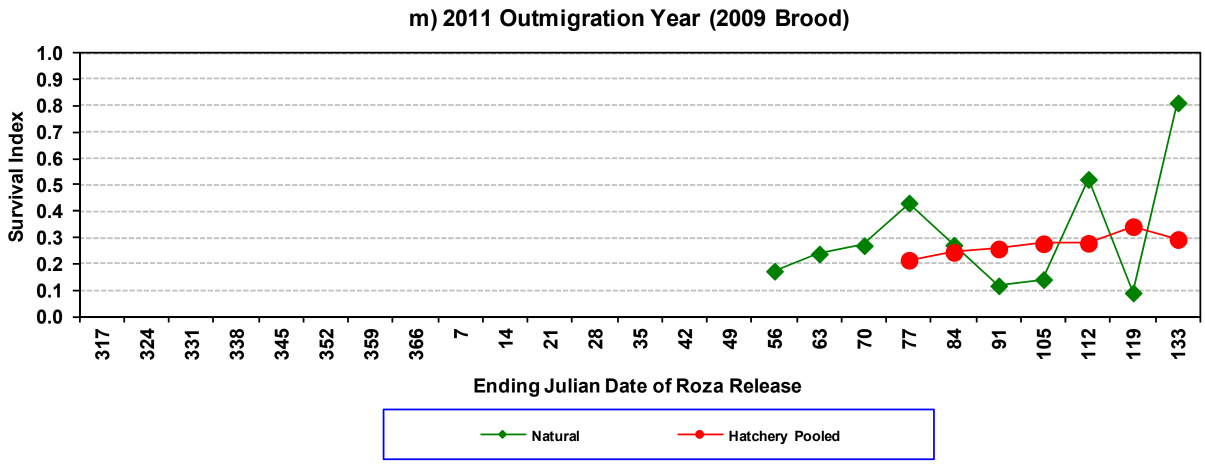








Appendix B.1. (continued)



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

a. 1999 Outmigration Year (Brood 1997)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)			04/15/99
Ending Week (ending date of week)			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 B.2. (Continued)

g. 2005 Outmigration Year (Brood 2003)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		12/24/04	03/18/05
Ending Week (ending date of week)		03/11/05	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**

l. 2010 Outmigration Year (Brood 2008)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)			03/25/10
Ending Week (ending date of week)			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.2. (Continued)

m. 2011 Outmigration Year (Brood 2009)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		02/25/12	03/17/12
Ending Week (ending date of week)		03/10/12	05/12/12
Natural Origin	Number Released	985	956
	Expanded McNary Passage Number	216.7	311.7
	Survival-Index Estimate	**0.2200**	**0.3260**
Hatchery Pooled	Number Released		2802
	Expanded McNary Passage Number		716.8
	Survival-Index Estimate		**0.2558**

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

a) 1999 Outmigration (1997 Brood)

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

b) 2000 Outmigration (1998 Brood)

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

c) 2001 Outmigration (1999 Brood)

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

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

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

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

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

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

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

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

d) 2002 Outmigration (2000 Brood)

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

e) 2003 Outmigration (2001 Brood)

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

f) 2004 Outmigration (2002 Brood)

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

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

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

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

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

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

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

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

g) 2005 Outmigration (2003 Brood)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Analysis of Variation Type 1 P	1-sided Type 1 p[4]
Block[1]	15.16	3	5.05	0.98	0.4845	
Natural Origin versus Hatchery Origin[1]	0.03	1	0.03	0.01	0.9427	
Tagged vs Untagged Hatchery Origin[1]	0.01	1	0.01	0.00	0.9669	
Error(1)	20.54	4	5.135			
Natural Origin versus Hatchery Origin[2]	0.03	1	0.03	0.01	0.9410	0.5295
Tagged vs Untagged Hatchery Origin[2]	0.01	1	0.01	0.00	0.9659	
Error(2)[3]	35.70	7	5.10			

h) 2006 Outmigration (2004 Brood)

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

i) 2007 Outmigration (2005 Brood)

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

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

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

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

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

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

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

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

j) 2008 Outmigration (2006 Brood)

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

k) 2009 Outmigration (2007 Brood)

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

l) 2010 Outmigration (2008 Brood)

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

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

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

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

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

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

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

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

m) 2011 Outmigration (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]	32.96	6	5.49	0.39	0.8684	
Natural Origin versus Hatchery Origin[1]	17.51	1	17.51	1.25	0.2867	0.1433
Tagged vs Untagged Hatchery Origin[1]	28.31	1	28.31	2.03	0.1822	
Error(1)	153.60	11	13.96			
Natural Origin versus Hatchery Origin[2]	17.51	1	17.51	1.60	0.2236	
Tagged vs Untagged Hatchery Origin[2]	28.31	1	28.31	2.58	0.1267	
Error(2)[3]	186.56	17	10.97			

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

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

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

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

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

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

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

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P (Nat ≠ Hat)	Type 1 Error P (Nat > Hat)
Nat vs Hat Stock (adjusted for Years)	303.97	1	303.97	8.59	0.0126	0.0063
Among Years (adjusted for stock)	1205.2	12	100.43	2.84	0.0416	
Stock x Year Interaction	424.67	12	35.39			

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

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error (Nat ≠ Hat)	Type 1 Error (Nat > Hat)
Nat vs Hat Stock (adjusted for Years)	55.24	1	55.24	6.32	0.0272	0.0136
Among Years (adjusted for stock)	376.66	12	31.39	3.59	0.0177	
Stock x Year Interaction	104.87	12	8.74			

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

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

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

b) 2000 Outmigration (1998 Brood Year)

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

c) 2001 Outmigration (1999 Brood Year)

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

d) 2002 Outmigration (2000 Brood Year)

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

e) 2003 Outmigration (2001 Brood Year)

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

f) 2004 Outmigration (2002 Brood Year)

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

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

Appendix D.1. (Continued)

g) 2005 Outmigration (2003 Brood Year)

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

h) 2006 Outmigration (2004 Brood Year)

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

i) 2007 Outmigration (2005 Brood Year)

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

j) 2008 Outmigration (2006 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	Highest Survival Estimate:
Natural Origin Early versus Late	72.51	11	6.59	0.00	0.0000	Late
Error	0.00	0	0.00			

k) 2009 Outmigration (2007 Brood Year)

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

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

* Weight is Number Released

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

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

Appendix D.1. (Continued)

m) 2011 Outmigration (2009 Brood Year)

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

* Weight is Number Released

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

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

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

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)	172.68	1	172.68	2.2204	0.1670
Among Years (adjusted for Brood)	664.33	10	66.43	0.8542	0.5959
Brood x Year Interaction	777.7	10	77.77		

* 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)	23.84	1	23.84	2.79	0.1258
Among Years (adjusted for Brood)	103.52	10	10.35	1.21	0.3838
Brood x Year Interaction	85.46	10	8.55		

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

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Appendix F: Prosser-Passage Estimation Issues

Introduction

A portion of outmigrating smolt from the Yakima Basin is entrained with the Yakima River flow diverted into Chandler Canal (canal) by the Prosser Irrigation Diversion Dam (Prosser). Smolt in the canal move downstream approximately ¾ mile to a screen which diverts them into a bypass. The bypass takes the smolt to the Chandler Juvenile Monitoring Facility (CJMF) where a sample is taken on a daily basis and counted. All smolt surviving the canal and sampling facility are eventually passed back into the Yakima River below Prosser Dam. The CJMF counts are expanded by predictors of the smolt entrainment rate, of the canal-survival rate, and of the sample rate from the bypass to estimate total smolt passage at Prosser. The predictors are primarily intended to estimate wild Naches-Basin and naturally-spawned Upper-Yakima smolt.

I was made aware that when past expansion predictors were applied to hatchery smolt released from three acclimation sites on the Upper Yakima, the predicted hatchery-smolt passage often greatly exceeded the total number of hatchery smolt released, and this over-prediction is a major focus of this report.

I will present the method of estimating juvenile Prosser passage for reference purposes, and then, I will discuss data issues. This will be followed by a discussion about problems associated with two of the predictors used to expand tallied sampled fish – the entrainment rate and canal-survival predictors. For each predictor, I will first discuss the predictors developed for 1999 though 2004 releases during which the predictors were relatively consistent over years. I will then discuss prediction issues associated with the 2005 through 2011 outmigrants. Sample-rate estimation is straight forward and will not be discussed in detail.

Passage Estimation

When there is a sufficient daily number of sampled smolt available from the canal bypass, subsamples are taken and PIT-tagged. One subsample is released into the forebay a sufficient distance up-stream of Prosser to give a reasonable mixing of smolt into the river's flow; the other subsample is released into Chandler Canal below the headgates. The proportions of those sub-sampled releases subsequently detected in the Chandler Canal bypass are computed. The bypass-detected proportion of the canal-released fish is an estimate of canal survival. The bypass-detected proportion of the forebay release is divided by the bypass-detected proportion of the canal release as an estimate of the entrainment rate. The entrainment-rate estimates are then logistically regressed on the proportion of Yakima Flow that is diverted into the canal (diversion rate[1]) as the entrainment-rate predictor. The canal survival estimates are logistically regressed on Julian date of release and canal flow as the canal-survival predictor. These steps are summarized below in equation form.

$$\text{Equation 1.}\quad \text{p(f)} = \text{Proportion forebay release detected} =$$

$$\frac{\text{number of forebay-released smolt detected in bypass}}{\text{number of smolt released into forebay}}$$

$$\text{Equation 2.}\quad \text{p(c)} = \text{cs(est)} = \text{Proportion canal release detected}$$

$$\frac{\text{number of canal-released smolt detected in bypass}}{\text{number of smolt released into canal}}$$

$$\text{Equation 3.}\quad \text{er(est)} = \text{Smolt Entrainment Rate} = \frac{\text{p(f)}}{\text{p(c)}}$$

wherein cs(est), Equation 2, is the estimated smolt canal-survival rate and er(est), Equation 3, is the estimated smolt entrainment rate.

NOTE: The proportions in Equations 1 and 2 are actually divided by estimates of detection efficiency which is based on the proportion of the respective release's smolt sampled fish detected by a secondary detector (the CJMF detector) prior to release below the dam that were previously detected by the bypass detector prior to sampling[2]. This detector is referred to here as the sample detector because only sampled smolt are passed through this detector. These detection efficiencies are almost always 1 (100% efficiency), and when less than 1, they are usually near 1.

The entrainment rate is predicted by the logistic relation

$$\text{Equation4.}\quad \text{ER}(\text{pred}) = \frac{1}{1+\exp\{-[\text{B0}+\text{B1}*\text{DR}]\}}$$

[1] The diversion rates are computed for the date of release and for the date following release, and these two diversion rates are averaged as the predictor variable, DR in Equation 4, because most releases are made in late afternoon or evening, and the bulk of the passing released smolt for that date are detected in the bypass on those two dates.

[2] A timer gate operates in the bypass which directs a set proportion of the bypass flow into CJMF; therefore it is the bypass flow that is sampled, not the smolt, and the detection efficiency is estimated by d(CJMF,bypass)/d(CJMF) for a given release, d(CJMF,bypass) being the number of fish jointly detected by the CJMF and the bypass detectors and n(CJMF) is the number detected by the CJMF detector for that release whether previously detected in the bypass or not.

wherein DR is the flow diversion rate (the proportion of Yakima River flow at Prosser diverted into Chandler).The canal-survival rate is predicted by the logistic relation

$$\text{Equation 5.} \quad CS(pred) = \frac{1}{1 + \exp\{-[B0 + B1 * JD + B2 * CF\}\}}$$

wherein JD is the Julian date of release and CF is the canal flow computed as the average of that day's and the next day's canal flows (the canal flow is the flow in the canal below the fish screen + the design flow of the bypass).

Note that the term "estimate" (est) is used here for the computed canal survival and entrainment estimates from Equations 2 and 3 adjusted for bypass detection efficiencies. The term "predicted" refers to a linear logistic fit based on Equation 4 and Equation 5.

The passage is the sum of passage estimates over all Julian dates (jd), the passage estimate being

$$\text{Equation 6.} \quad Passage = \sum_{jd} \frac{n(jd)}{ER(\text{Predicted for } jd) * CS(\text{Predicted for } jd) * SR(\text{est for } jd)}$$

In the above equation, n(jd) is the daily count of sample fish, SR(est,dr) is the day's sample rate which is estimated for the day's sample setting, the estimate being the number of all PIT-tagged Spring Chinook smolt detected by both the bypass detector and the sample detector divided by the total number detected by the bypass detector pooled over all days having the same sample setting[3].

Data Issues

Before proceeding, it should be mentioned that I made an exhaustive review of the data set used, and in the process determined there were data points excluded that should not have been excluded and a few data points that were included that should not have been. More of these data point issues were associated with canal survival estimates than with entrainment estimates.

The most common reason for incorrect exclusion were for outmigration years 2005-2007 when special canal releases were made to test for leakage of fish around the fish screens into the main irrigation canal before and after the replacement of those screens. The assessment of fish leakage was based on detection of those canal-released fish which were not detected at the bypass but were detected by downstream detectors at Columbia River Dams[4]. These releases could have been used for canal survival purposes but were excluded. These releases are now being included. It should be noted that fish leakage around the screens would not have affected our entrainment estimates because both forebay-

[3] In equation form, for a given timer-gate setting (footnote 2), the sample rate is estimated by d(CJMF,bypass)/d(bypass) over all days at that timer setting for all PIT-tagged Spring Chinook smolt released into the upper Yakima; d(CJMF,bypass) being the number of smolt jointly detected by the CJMF and the bypass detectors and n(bypass) is the number detected by the bypass detector for that timer-gate setting.

[4] Such detected fish could have also spilled into the river during periods of high canal flow when canal water topped the ridge of the canal and spilled down the bank into the river.

and canal-released smolt would have experienced loss to the leakage. Canal-survival estimates measure any loss of fish in the canal above the bypass, whether due to mortality before reaching the bypass detector, due to loss to the canal through fish leakage around the screens, or due to loss to the river due to leakage from the canal above the bypass.

Another common reason for exclusion occurred in outmigration year 2001. In early years, there were a few releases below Prosser Dam that were made contemporaneously with the forebay and canal releases. These three releases permitted estimation of forebay mortality based on downstream detections. It turned out that there was only one such set of releases that indicated a significant forebay mortality which could have been due to sampling error. Below-dam releases were later terminated. In 2001, there were several releases that were rejected because of low numbers of downstream detections for paired releases that did involve the third below-dam release. These data sets should not have been omitted because entrainment and canal-survival estimates do not rely on downstream detections.

A third reason for rejecting a data set was that the detection efficiency of the bypass detector was not always possible because of a failure of sample detector that returned sampled fish to the river. These rare failures were unrelated to the functioning of the bypass detector. Since available estimated detection efficiencies were almost always 1 or near 1, the decision was made to retain the Equation 1 and Equation 2 proportions even though they could not be adjusted for detection efficiency. Possible biases resulting from this decision would likely be trivial in magnitude compared to the value of having additional estimates.

Another problem associated with some entrainment-rate estimates was that sometimes there was more than one canal release made on a day when a forebay release was made but only one of the canal releases was used for the estimation of entrainment. Data from all canal releases on a given day are now combined for the purpose of estimating entrainment rates.

There were also a few less common discovered errors that have been corrected.

Entrainment

1999 through 2004 Outmigration Year Predictor

Figure 1.a. is a scatter plot of the estimated entrainment rates and flow diversion rates used for the 1999 through 2004 outmigration years[5]. While the range of diversion rates from dates of estimation varied over years, their scatter indicated that they tended to be consistent with a common trend; therefore, a single logistic regression fit was used to characterize that trend. Figure 1.b. contains the same scatter as Figure 1.a. but also presents the logistically predicted entrainment rate response for the model in Equation 4.

[5] The 2000 outmigration year was omitted because of release and data collection issues at the Chandler facility.

Figure 1.a. Scatter Plot of estimated 1999-2004 Spring Chinook Entrainment and Flow Diversion Rates

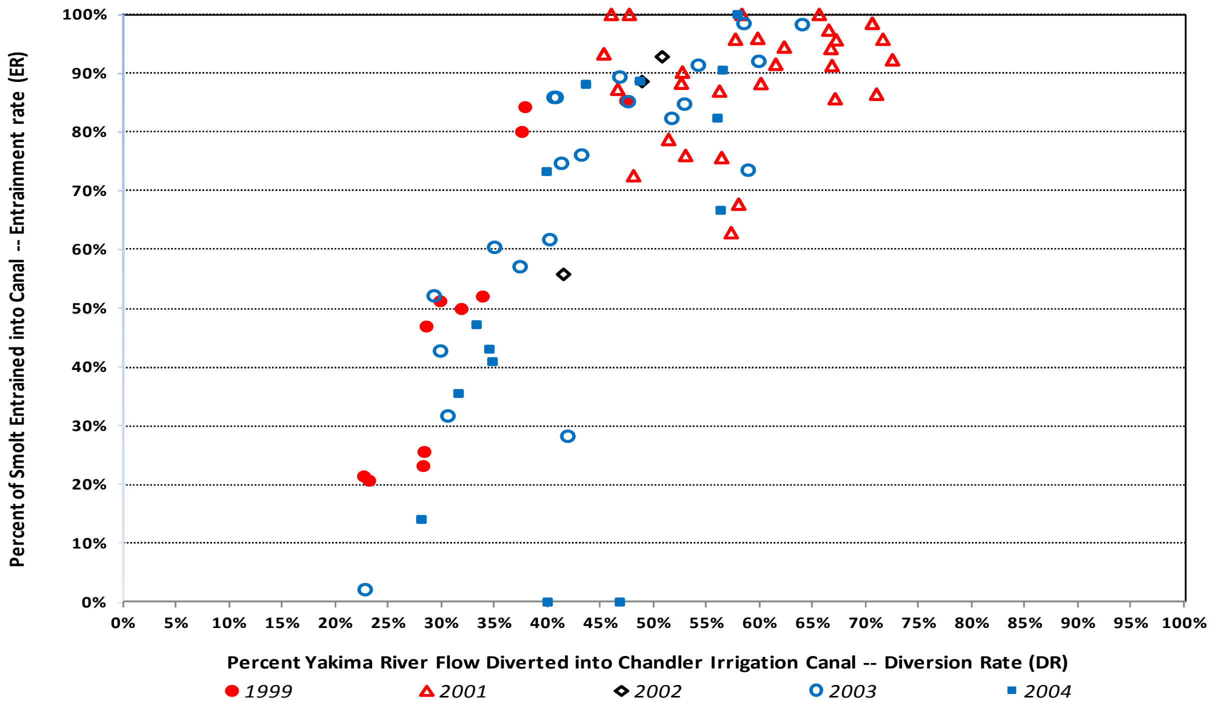
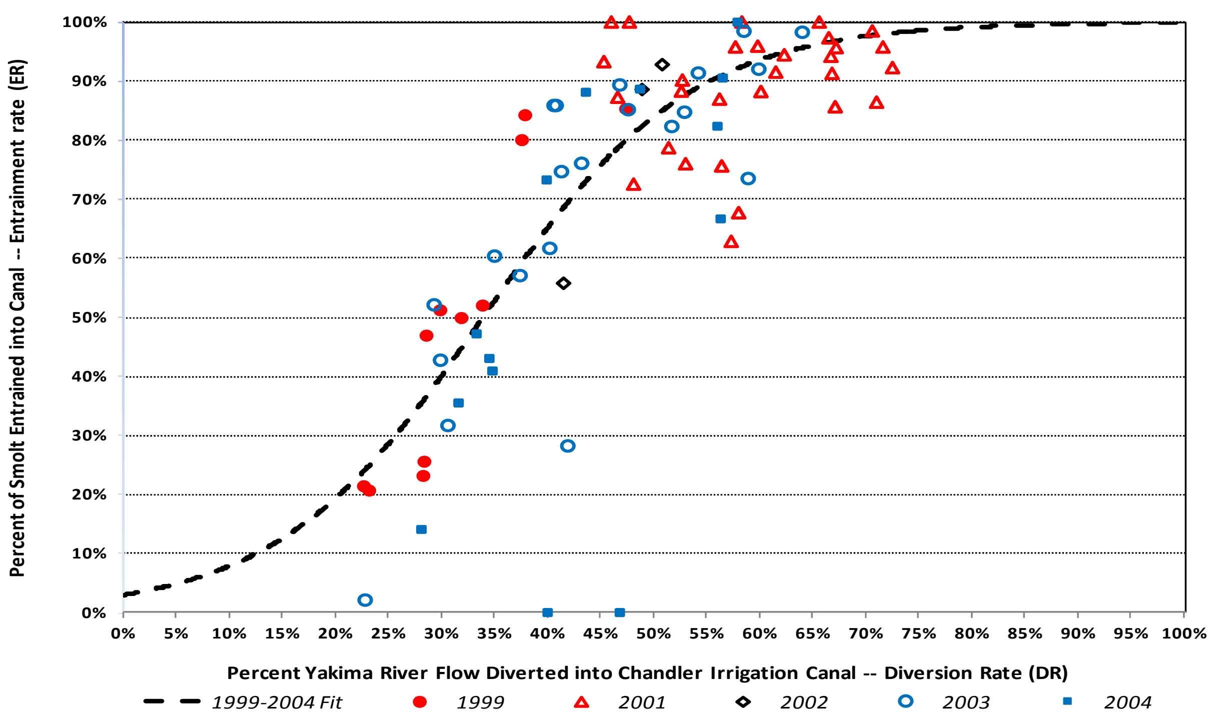


Figure 1.b. Figure 1.a. plus Logistically Regressed 1999-2004 Predicted Entrainment Rate on Flow Diversion Rate (dashed Line)



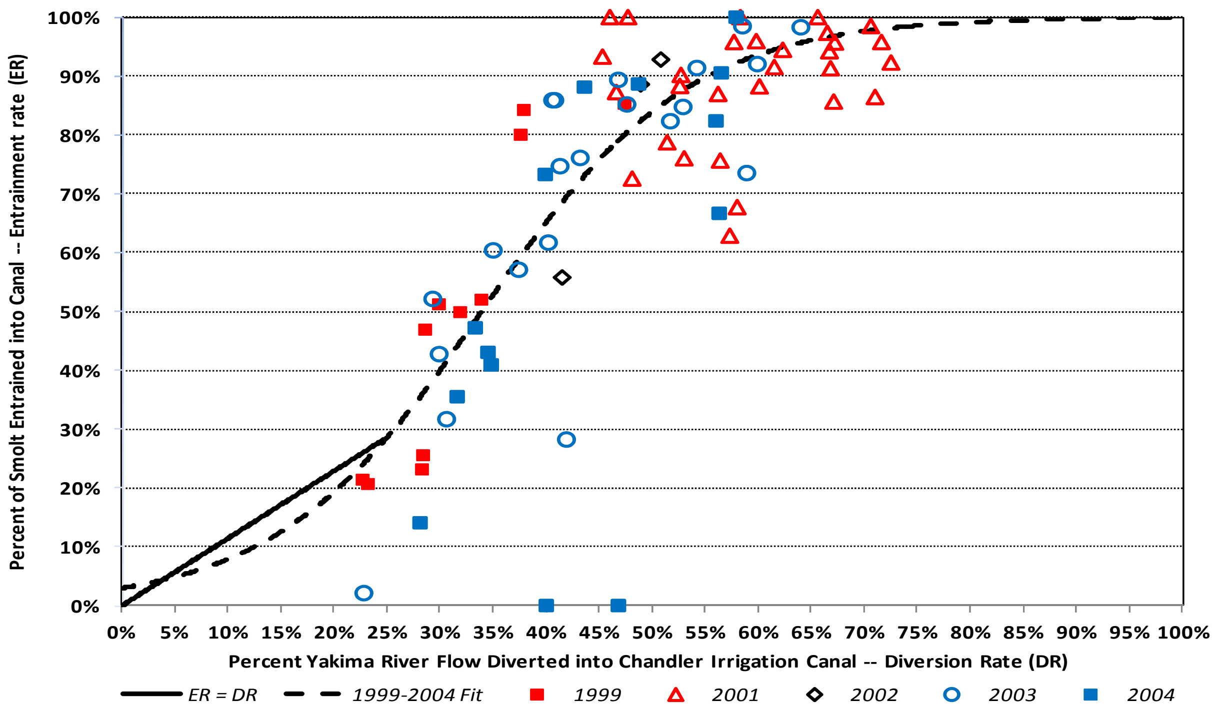
There was concern that the predicted values t lower diversion rates were under-predictors, there being many more data points for high-entrainment/high-diversion rate periods than for low-entrainment/low-diversion rate periods. The main reason for the lack of data points for low diversion rates was that there were usually insufficient numbers of smolt available in the bypass for PIT-tagging on dates with the low diversion rates, and, even when releases were made during periods of low diversion rates, the release numbers were often too small to have as great of an impact on the prediction than the higher release numbers associated with higher diversion rates[6]. The smaller release numbers associated with the lower diversion rates may be the reason for the estimated values falling below the predictor for low diversion rates.

Even with the predicted value at lower diversion rates being higher than the estimated values, the estimated hatchery passage often exceeded, sometimes dramatically, the number of smolt released from the hatchery.

As I understand it, a straight-line predictor based on the entrainment rate (ER) = diversion rate (DR) was created from the point ER = DR = 0% to the point at which ER = DR line intersected the logistically predicted entrainment-rate line to correct the over-estimated passage. Figure 1.c. indicates the nature of the extension. There will actually always be two intersection points. For this data set, one intercept is at DR ≈ 5% and the other DR ≈21%. If the ER = DR line were applied only to diversion rates 0% though 5%, it would have lead to an even larger total passage estimate than that produced by using the logistic predictor because the ER = DR straight-line prediction was uniformly lower than the logistic predictor. However, there were no days when hatchery fish were sampled during periods when DR was less than 5%. However, were the ER = DR straight line applied to the diversion rates between 0% and 25%, it would lead to smaller total passage estimates than that using the logistic predictor because there were several days when hatchery fish were tallied and the DR was less than 25%.

[6] The logistic regression weighted the entrainment estimates by effective release number which is the harmonic mean of the numbers of fish released into the forebay and the canal. Therefore estimates based on larger release numbers were generally given greater weights.

Figure 1.c. Modified Figure 1.b. with Straight Line Extension of ER = DR (solid line) from Flow Diversion Rate = 0% through the points at which Logistic Predicted Value= DR.

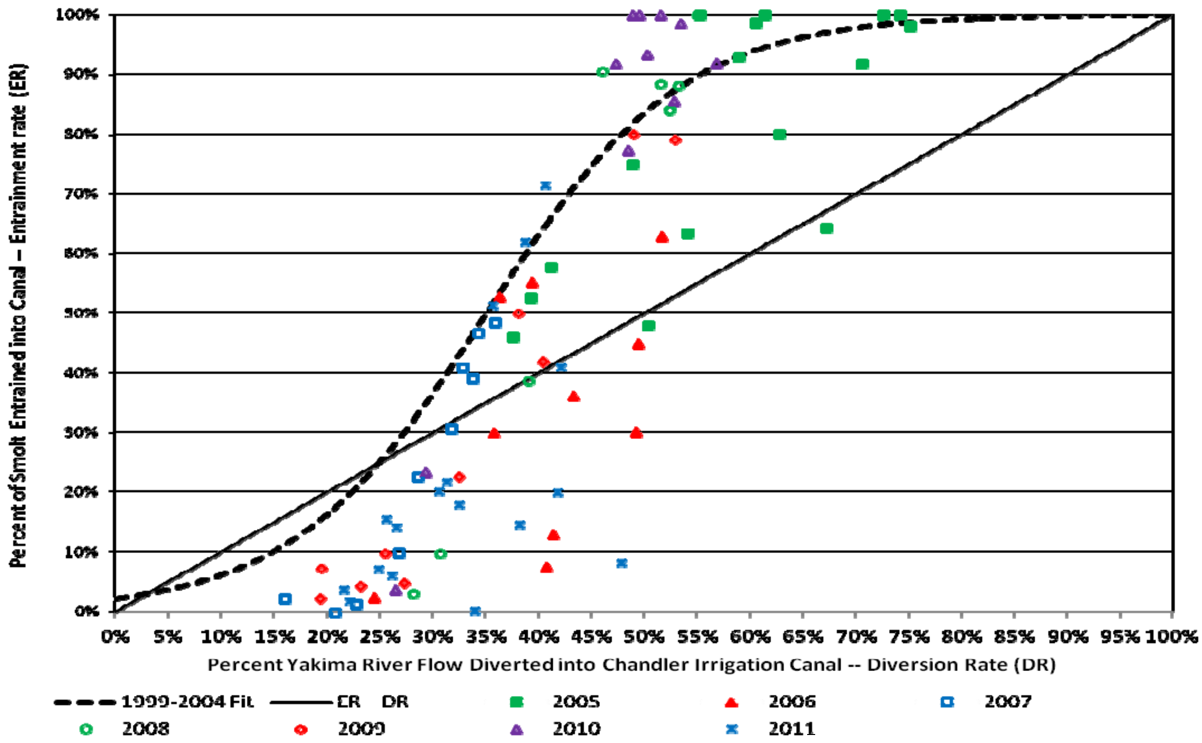


2005 through 2011 Outmigration Year Predictors

While the extension of the ER = DR line to the predicted line may have created a reasonable compromise to the extrapolation of the predicted line beyond the data points used to estimate 1999 through 2004 passages, it is unlikely to be a suitable compromise for subsequent outmigration years. Along with the outmigration-year 1999-2004 predictor and the ER = DR lines, Figure 2. presents a scatter diagram for entrainment estimators for outmigrants for years 2005 through 2011. As can be seen, the 1999-2004 predictor is not appropriate for the 2005-2011 entrainment estimates, all 2005-2011 estimators up to ER = 40% fall below the 1999-2004 predictor line.

The 2005-2011 data scatter also indicates that there will be no single logistic predictor that would be appropriate for all years. Using the ER = DR straight line extender would end up with a huge number of estimates lower than the ER = DR line; in fact all of the estimates up to 37% are lower than the ER = DR line.

Figure 2. Scatter Plot of estimated 2005-2011 Spring Chinook Entrainment and Diversion Rates with reference to the 1999-2004 and ER = DR predictors



I have explored several alternative methods including:

- Forcing higher values of the intercept to give reasonable estimates of hatchery passage. For most years, the resulting predicted entrainment lines poorly fitted the individual entrainment estimates.

- Fitting two intersecting slopes (spline fits) that gave one logistic slope for DR value less than a specific DR value and a different slope for a DR greater than the specific value. I varied the specific DR values of the point of intersection of the two slopes, using intersection DR values of 35%, 40%, 45%, … at 5% intervals. These methods provided no improvement of predicted hatchery values.

I have come to the conclusion that using an extended straight line predictor may be the best solution, but not the ER = DR extended line presented for the 1999-2004 data.

I have grouped the years based on similarities in the yearly logistic estimates of the intercept (B0) and slope (B1) coefficients. I present individual year coefficients and the coefficients for the grouped years in Table 1. I have also included the estimates of B0 and B1 used for the 1999-2004 predictors in Table 1.

The predictors from three groups [Group1 (2005-2006, 2011); Group 2 (2007, 2010); and Group 3 (2008-2009)] are graphically presented in Figure 3.a., Figure 3.b., and Figure: 3.c., respectively. Discussion of each group precedes the associated figure.

Table 1. Logistic Intercepts (B0) and Slopes (B1) used for Equation 1 Predictions used in Figures 3.a. through 3.b.

Logistic Coefficients	1999-2004	2005	2006	2005 - 2006	2011	2005-2006, 2011	2007	2010	2007, 2010	2008	2009	2008-2009
Intercept (B0)	-3.484	-3.109	-3.032	-4.526	-4.889	-4.547	-9.309	-4.889	-7.145	-8.744	-5.802	-7.827
Slope (B1)	10.279	7.978	5.518	10.129	11.252	10.206	26.743	11.252	20.321	21.099	13.907	18.984

Logistic Fits for Outmigration Years 2005, 2006, and 2011

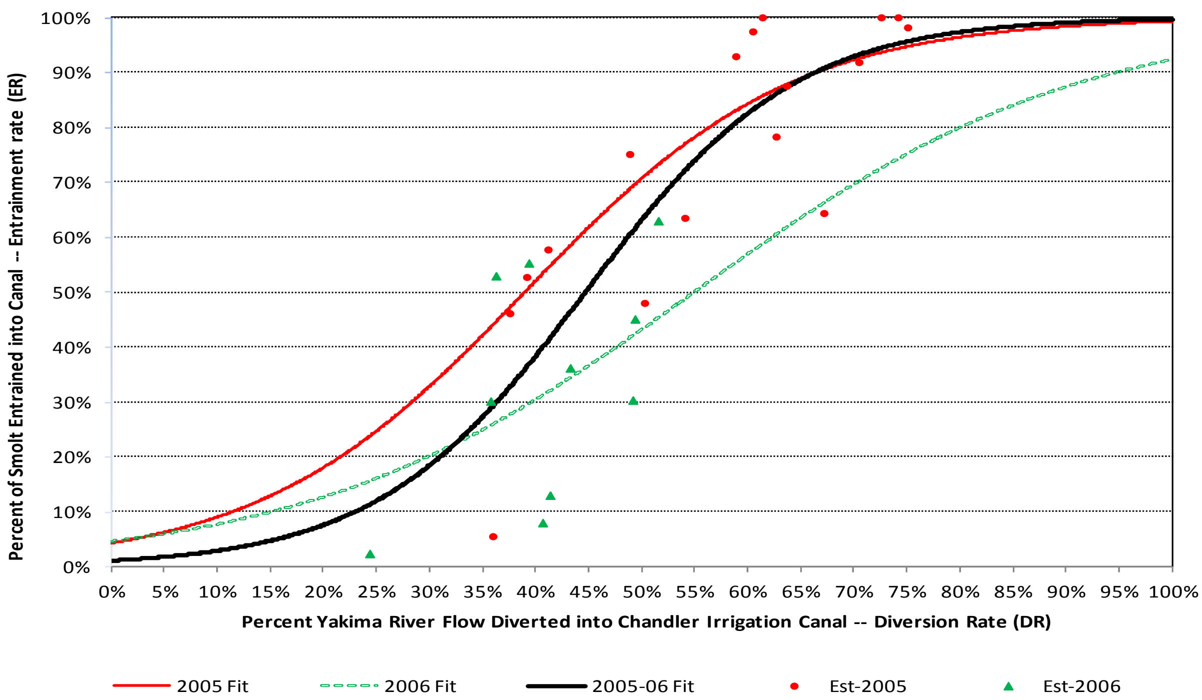
I first discuss the 2005 and 2006 logistic fits. Although the 2005 and 2006 predictors have almost identical intercepts, the 2005 and 2006 slopes clearly differ. The 2005 and 2006 responses do not differ at the 5% significance level, but do significantly differ at the 10% significance level (P = 0.093). Even so, I have combined the data sets for the following reasons [refer to Figure 3.a.1)]:

- The 2005 estimates tend to be measured at higher diversion rates and the 2006 estimates at lower diversion rates, so their diversion-rate domains complement each other. Further the overlapping 2005 and 2006 estimates are reasonably consistent with each other.

- The logistic intercepts are almost identical, and the 2005 and 2006 logistic slopes are more similar to each other than they are to other years (Table 1.)

- Further, the 2006 entrainment-rate response did not approach 100% as the flow diversion rate approached 100%; whereas, the asymptotic approach of logistic fit from the combined data set ultimately approached 100% more rapidly than either of the separate fits.

Figure 3.a.1) Scatter Plot of estimated (Est) 2005 and 2006 Spring Chinook Entrainment and Diversion Rates and associated individual and combined logistic fits.



Since there is only one 2005-2006 entrainment estimate between DR = 0% and DR = 25%, if it is necessary to use a straight line extender from the predicted response to the intercept, I suggest initially exploring straight line extenders intersecting the predictor at predicted entrainment rates of 10% or less to find reasonable passage estimates for hatchery smolt, the ER = 10% approximately being the predicted value at DR = 25%.

The 2011 data estimates indicate a poor 2011 fit because the estimates are widely scatted around the predicted logistic fit [Figure 3.a.2)].

The resulting intercept and slope from the combined 2005-2006 data set was similar to that for 2011 and the differences between the 2011 and the 2005 and 2006 responses did not differ significantly (P = 0.33). A tentative decision has been made to combine the 2011 fit with the 2005-2006 combined fit. Figure 3.a.3 presents the logistic fits and the individual data points, the combine three-year fit being effectively superimposed on the combined 2005-2006 fit; however, there is no reason to believe that the combined fit is a more accurate fit than the individual-year 2011 fit. In fact the 2010 fit did not significantly differ from the to-be-discussed logistic combined fit of the 2008-2009 outmigration data (P = 0.25). The rather arbitrary combining of the 2011 data set with the 2005-2006 data sets is because the associated P value was larger for the 2005-2006 fit comparison with the 2011 fit than was the 2008-2009 fit comparison with the 2011 fit.

Figure 3.a.2) Scatter Plot of estimated (Est) 2011 Spring Chinook Entrainment and Diversion Rates and associated logistic fit.

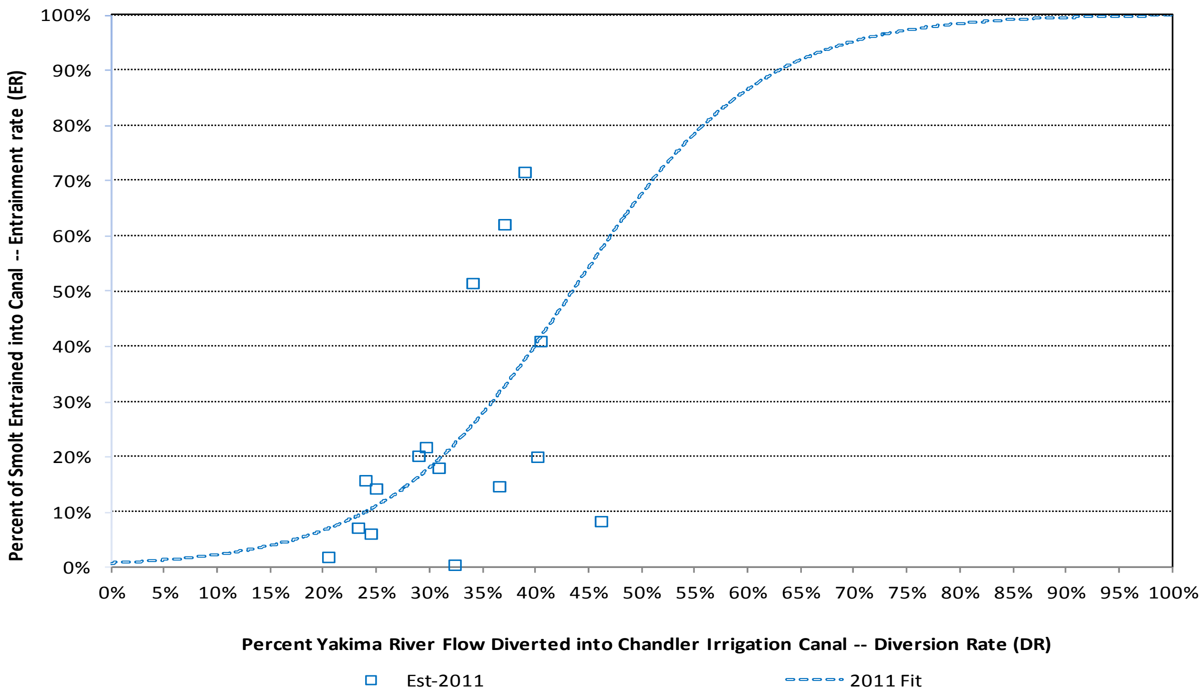
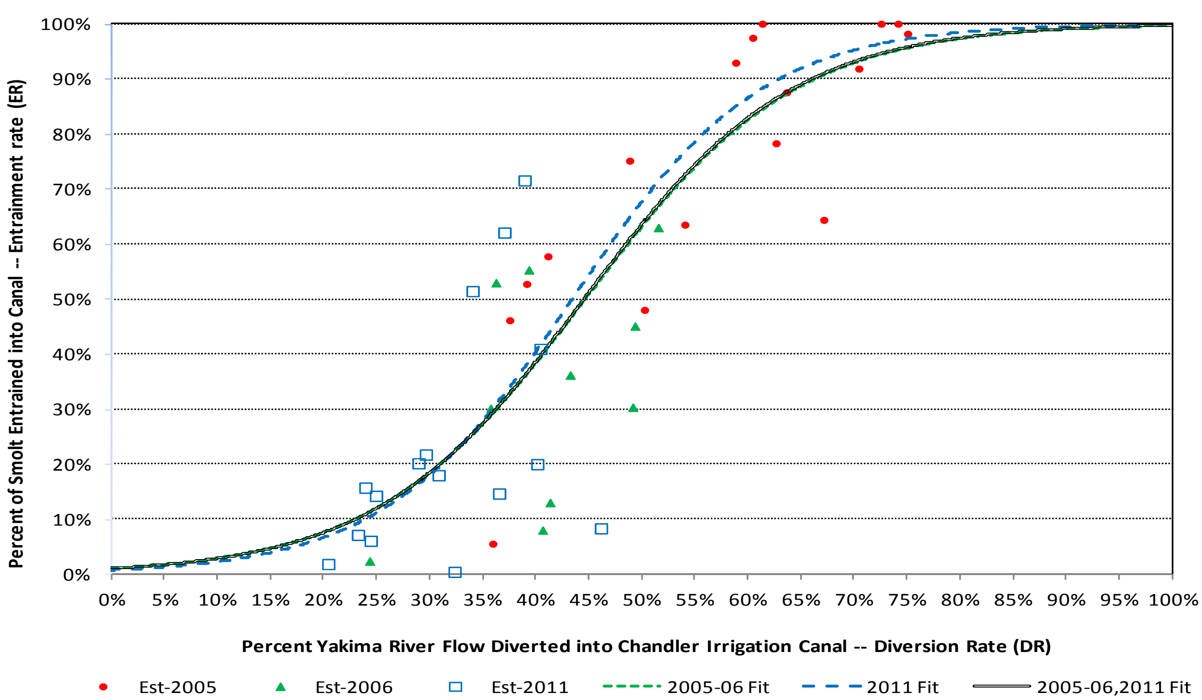


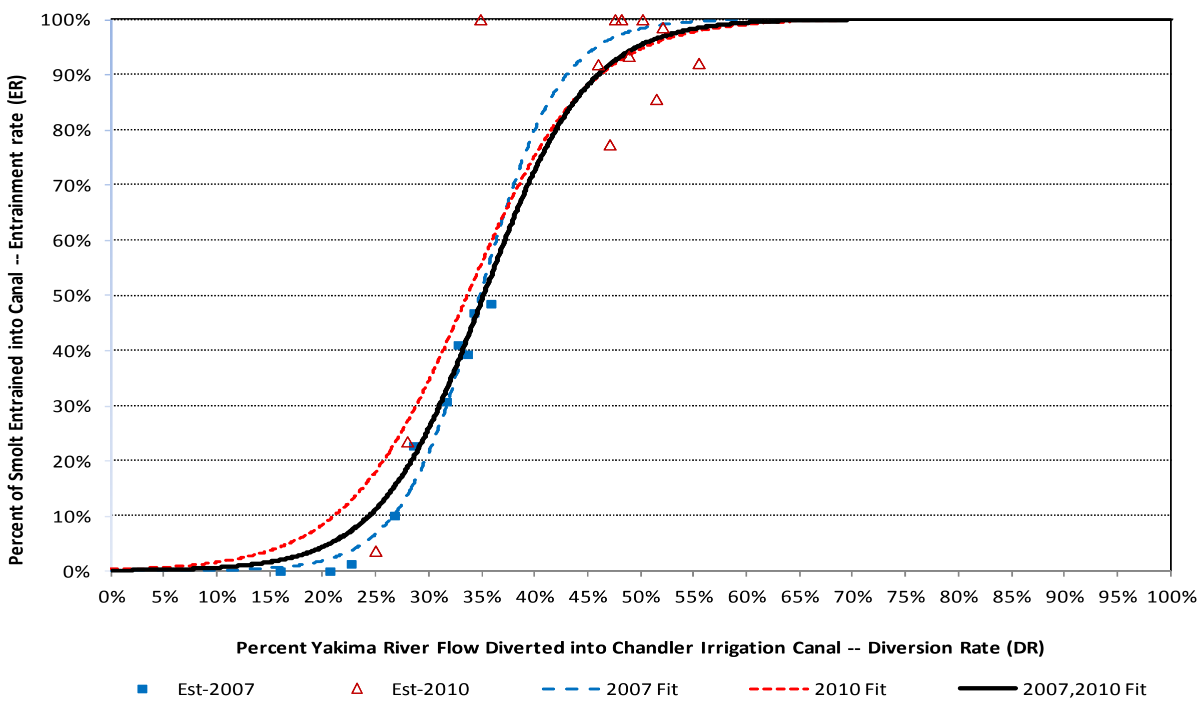
Figure 3.a.3) Scatter Plot of estimated (Est) 2005, 2006, 2011 Spring Chinook Entrainment and Diversion Rates and associated individual and combined logistic fits.



Logistic Fits for Outmigration Years 2007 and 2010

As with the 2005 and 2006 data sets, the 2007 and 2010 entrainment rate estimates data tend to cluster within different portions of the diversion-rate domain. Even so, the logistic predictors (Figure 3.b.) are very similar and do not significantly differ (P = 0.47). For predicted entrainments less than 50%, the estimates are tightly distributed around the prediction line. I will use the combined predictor for these two years. Because of tightness of the fit at lower diversion rates and the rapid approach of the predicted entrainment rate to 0% as the diversion rate decreases below 25%, I suggest initially exploring straight-line predictors intersecting the prediction line entrainment line at 5% or less to find reasonable passage estimates for hatchery smolt.

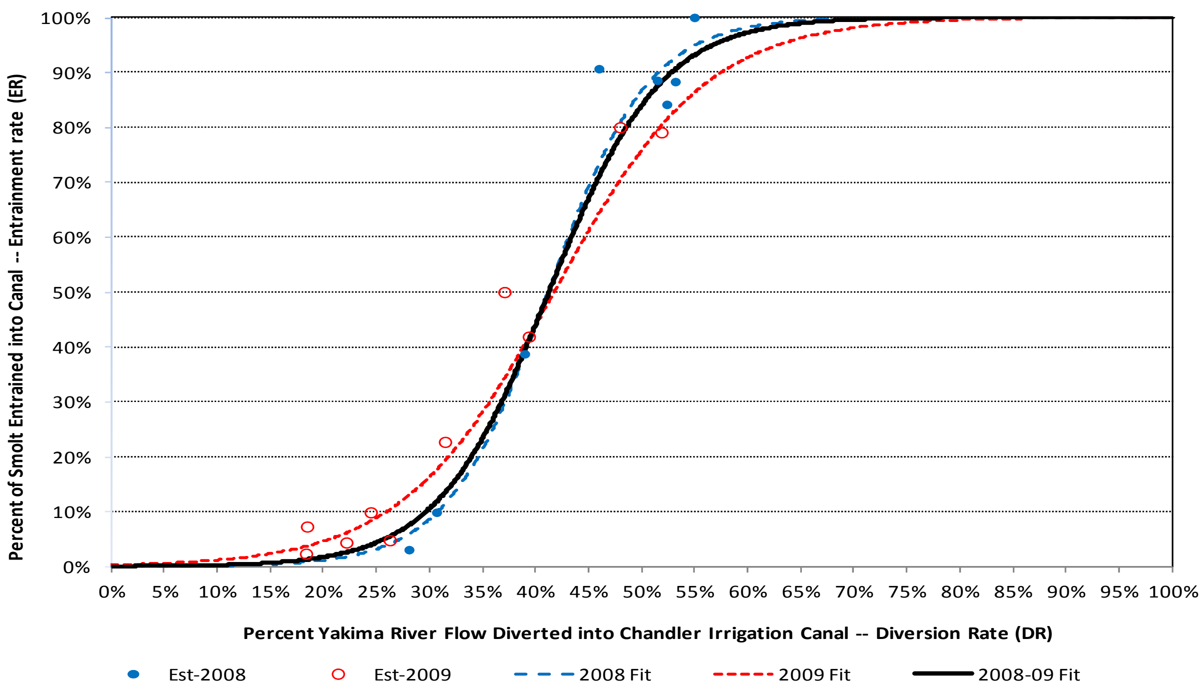
Figure 3.b. Scatter Plot of estimated (Est) 2007 and 2010 Spring Chinook Entrainment and Diversion Rates and associated individual and combined logistic fits.



Logistic Fits for Outmigration Years 2008 and 2009

The 2008 and 2009 entrainment responses do not significantly differ (P = 0.13). Even though the responses are not as similar as those for 2007 and 2010, as can be seen from Figure 3.c, the responses are quite similar, and I may use the combined 2008-2009 response for passage estimation for those two years. As with the 2005 and 2006 and the 2007 and 2010 combined predictors, the 2008 and 2009 estimates tend to cluster within different portions of the diversion rate domain, the 2009 estimates generally being from lower flow diversion rates and the 2008 from higher. As with the 2007 and 2010 combined predictor, because of the tightness of the 2008 and 2009 estimates around the predictor at low diversion rates, I again suggest initially exploring straight-line predictors intersecting the prediction line entrainment line at 10% or less to find reasonable passage estimates for hatchery smolt.

Figure 3.c. Scatter Plot of estimated (Est) 2008 and 2009 Spring Chinook Entrainment and Diversion Rates and associated individual and combined logistic fits.



Canal Survival

1999 through 2004 Outmigration Year Predictors

There was evidence that canal survival decreased as time passed. One possible reason would be increased predation in the canal or perhaps greater loss from leakage as irrigation demand increased. The decision was made to use Julian date as a surrogate for time, and the logistic regression of canal survival on Julian date did result in a significant decrease in canal survival. However, some years later the competing notion was put forward that increased canal flow may result in less time spent in the canal and could result in an increase in canal survival, which ran counter to the notion that survival would decrease with time since canal flow was increased over time to meet irrigation demands later in the season. Therefore, canal flow was included as a second variable. Logistic analyses indicated that the effect of Julian date was significant when adjusted for canal flow and that canal flow was significant when adjusted for Julian date, suggesting that both variables should be in the model. Further, the partial regression coefficient associated with Julian date was negative (an associated decrease in survival with Julian Date), and that the partial logistic regression coefficient associated with canal survival was positive (an associated increase in canal survival associated with an increase in canal flow). These estimates were consistent with the hypothesized outcome. Thus the predictor logistic equation used was that given in Equation 5.

$$\text{CS(pred)} = \frac{1}{1 + \exp\{-[\text{B0} + \text{B1} * \text{JD} + \text{B2} * \text{CF}\}\}}$$

To simplify the model, it was decided to determine to what extent the same intercept could be used for all years and to determine whether a single Julian date could be used in all years. The analysis indicated that use of a common intercept and different slopes did not substantially or significantly reduce the predictive capability of the model (P=0.69) and that the use of different intercepts but a common slope did not substantially or significantly reduce the predictive capability either (P = 0.62); however using a common intercept and a common slope did significantly reduce the predictive capability (P = 0.0046). Tables 2.a. through 2.d give the logistic coefficients for the models along with the mean deviance which is analogous to the error mean square from a least squares regression analysis of variance (the smaller the error mean square the better the fit).

In each of the model s the Julian date coefficient is negative, and since the model fit producing Table 2.b has the smallest mean deviance, it was the selected model. Note that the rejected model producing the Table 2.d resulted in a negative canal-flow coefficient, all other models produced positive canal-flow coefficients.

Table 2. Logistic Coefficient Estimates for Canal Survival as function of Julian Date and Canal Survival for Outmigration years 1999, and 2001-2004*

a. Separate Yearly Intercepts and Yearly Julian Date Slopes**

Mean Deviance = 2.36

Year	1999	2001	2002	2003	2004
Intercept	2.894	2.80951	7.06285	3.35095	4.81186
Julian Date Slope B1	-0.00663	-0.00341	-0.0403	-0.01425	-0.02191

**Common Canal Flow Slope = 0.000228

b. Common Intercept and Separate Julian Date Slopes**

Mean Deviance = 2.309

Year	1999	2001	2002	2003	2004
Intercept	3.07949	3.07949	3.07949	3.07949	3.07949
Julian Date Slope B1	-0.01103	-0.00714	-0.01059	-0.01488	-0.0087

**Common Canal Flow Slope = 0.000475

c. Separate Yearly Intercepts and Common Julian Date Slope**

Mean Deviance = 2.321

Year	1999	2001	2002	2003	2004
Intercept	3.3945	3.80504	3.4433	2.92878	3.60723
Julian Date Slope B1	-0.01269	-0.01269	-0.01269	-0.01269	-0.01269

**Common Canal Flow Slope = 0.000405

d. Common Intercept and Common Julian Date Slope**

Mean Deviance = 2

Year	1999	2001	2002	2003	2004
Intercept	4.27659	4.27659	4.27659	4.27659	4.27659
Julian Date Slope B1	-0.01333	-0.01333	-0.01333	-0.01333	-0.01333

**Common Canal Flow Slope = -2.43E-04

* Outmigtation year 2000 was omitted because of release and data collection issues in the that year.

2005 through 2011 Outmigration Year Predictors

As with the entrainment predictor, the results for outmigration years 2005-2011 were inconsistent. Comparable tables to Table 2.a through Table 2.d for entrainment prediction are given in Tables 3.a through 3.d for canal survival prediction. Discussion follows the tables.

Table 3. Logistic Coefficient Estimates for Canal Survival as function of Julian Date and Canal Survival for Outmigration years 2005-2011

a. Separate Yearly Intercepts and Yearly Julian Date Slopes*

Mean Deviance = 4.008							
Year	2005	2006	2007	2008	2009	2010	2011
Intercept	-0.07193	2.03641	6.2698	3.46715	3.43524	-0.05334	1.43959
Julian Date Slope B1	0.00792	-0.02002	-0.05397	-0.02931	-0.0314	0.00304	-0.00809

*Common Canal Flow Slope = 0.001150

b. Common Intercept and Separate Julian Date Slopes*

Mean Deviance = 4.766							
Year	2005	2006	2007	2008	2009	2010	2011
Intercept	2.86986	2.86986	2.86986	2.86986	2.86986	2.86986	2.86986
Julian Date Slope B1	-0.01194	-0.01391	-0.01414	-0.01378	-0.01521	-0.01445	-0.00724

*Common Canal Flow Slope = 0.000164

c. Separate Yearly Intercepts and Common Julian Date Slope*

Mean Deviance = 4.821							
Year	2005	2006	2007	2008	2009	2010	2011
Intercept	3.43375	3.6587	3.55156	3.5611	3.56992	3.3691	4.25151
Julian Date Slope B1	-0.01449	-0.01449	-0.01449	-0.01449	-0.01449	-0.01449	-0.01449

*Common Canal Flow Slope = -0.00029

d. Common Intercept and Common Julian Date Slope*

Mean Deviance = 4.871							
Year	2005	2006	2007	2008	2009	2010	2011
Intercept	3.24779	3.24779	3.24779	3.24779	3.24779	3.24779	3.24779
Julian Date Slope B1	-0.01521	-0.01521	-0.01521	-0.01521	-0.01521	-0.01521	-0.01521

*Common Canal Flow Slope = 0.000035

From a statistical standpoint, going from the separate coefficients and separate slopes (producing Table 3.a) to a common intercept and separate slopes (producing Table 3.b) significantly reduced the predictability (P = 0.0033), and going from the separate coefficients and separate slopes to separate intercepts and a common slope (producing Table 3.c) also significantly reduced the predictability (P = 0.0023).

In Table 3.a, it can be seen that two of the Julian date coefficients are positive, the ones for outmigration years 2005 and 2010. When canal survival for 2005 is regressed only on Julian date with canal flow removed, then the associated Julian date coefficient is negative; however, when canal survival for 2005 is regressed only on Julian date, the associated Julian date coefficient remains positive.

Table 3.b. produces negative Julian date coefficients for all years and a positive canal flow coefficient, which is consistent with the 1999-2004 fits; whereas, Table 3.c produces a negative canal flow coefficient. In spite of the poorer predictive capability of the single-intercept / separate yearly-Julian-date coefficient model (Table 3.b), , it is this model that will be chosen for the time being because of the consistently negative Julian-date coefficients and its positive canal-flow coefficient.

Future Actions

In the above discussion, I have only focused on efforts to make the hatchery passage estimates "reasonable" ones. The major purpose of the certification effort is to assess the passage of wild/naturally-produced smolt and compare them to hatchery passage and to compare Naches wild to Upper Yakima naturally-spawned passage estimates based on the inclusion of DNA analyses. The lower diversion rate estimates are often coming from smolt collected early in the season. This is the domain within which we are considering the straight line extensions, and it is the period when wild smolt are more likely to pass Prosser than Hatchery fish, hatchery release dates usually not occurring until March 15th of an outmigration year.

In Addition to making sure that the hatchery-passage estimates are reasonable (less than the number released), we also want to make sure that the wild/naturally-produced passage estimates (wild) are also reasonable. We need to look at the ratio between the Upper-Yakima naturally-spawned/hatchery-spawned smolt passage estimates, and compare them to the ratio between Upper-Yakima natural/hatchery spawners for the corresponding brood year. The smolt-passage natural/hatchery ratio is expected to be less than the brood's spawner wild/hatchery ratio because of the likely much higher pre-smolt mortality in the natural habitat than in the hatchery habitat

The reason that the focus will be on the entrainment-rate predictor is that, when extrapolation is into the low flow diversion-rate domains where actual entrainment-rate estimates are not available, the expansion of a single sampled fish resulting from the predicted entrainment rate could result in a passage estimate of several hundred smolt. Expansions based on either canal-survival-rate predictors or on sample-rate estimates result are nowhere near such entrainment-rate-based high-passage estimates.

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Appendix G

2011 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 2011 subyearling and yearling Yakima-stock Fall Chinook were released from Prosser. Summer Chinook subyearlings were released from Stiles pond in outmigration-years 2009 and 2011 and from Buckskin Slough in 2011.

The analyses presented in this report are for:

1. Outmigration-year 2008 through 2010 smolt survival and dates-of-release/McNary-Dam detection comparisons of 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 survival 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 and Yearling Fall Chinook Releases

For the 2008 through 2011 brood-years, the Release-to-McNary survival has been consistently and significantly higher for Yakima-stock yearling than subyearling releases (Figure and Table 1, $p < 0.01$ from Appendix A - Table A.1). The estimated yearling-subyearling (treatment) difference, while greater than zero, was substantially less in 2008 than in 2009 through 2011.

There was no significant or notable difference between subyearling and yearling mean pre-release survivals (Figure and Table 2, $p = 0.23$ from Appendix A - Table A.2.

While the mean Yearling–Subyearling volitional release dates did not significantly differ (Figure and Tables 3.a, $p = 0.30$, Appendix A - Table A 3.a), the sub-yearling Fall Chinook McNary passage dates were significantly later than the yearling (Figure and Table 4, $p = 0.047$ from Appendix A - Table A.3.b); even though there was a significant stock interaction with years ($p < 0.0001$) against which the subyearling-yearling difference over years was tested.

2009-2011 Summer Chinook Estimates

The Summer Chinook, released as subyearlings from Stiles Pond in 2009, had an abysmal release-to-McNary survival rate, 1.8%; whereas there have been substantial increases in survival from 2009 to 2010 and from 2010 to 2011 (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

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

Table 2 presents pre-release survivals which happened to be higher in 2009 (88.7%), the year of lowest survival to McNary than in 2010 (65.2%), but the highest pre-release survival was in 2011 (93.4%), the year of highest survival to McNary.

In 2011, releases were also made into Buckskin Slough. There was no PIT-tag detector at the release site; therefore release numbers of fish were the number of PIT-tagged fish directly released into the slough as opposed to the number of fish detected leaving a rearing pond (which was the case for releases from Stiles Pond). None the less, the release-to-McNary survival was nearly identical to volitional-release-to-McNary survival for the Stiles releases (Figure and Table 1).

Mean dates of release into Buckskin Slough were considerably earlier than mean date of volitional release from Stiles pond in 2011 (Julian Release Date 121 versus 147); however mean date of passage at McNary Dam was considerably later for the Buckskin releases than for the Stiles volitional releases (Julian McNary Passage Date 171 versus 155). It appears that the Buckskin Slough releases held much longer in the Upper Yakima River than did the Stiles releases[2]. Buckskin Slough mean Dates of Release and McNary Passage Date respectively are included in Figure and Table 3.a and in Figure and Table 3.b. (Note: For a given estimate (Fall or Summer Releases) Mean McNary Passage Date is based on all tagged fish from the release and is expanded by the estimated proportion of all tagged fish passing McNary and released in the Yakima Basin irrespective of release.)

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

Figures and Tables

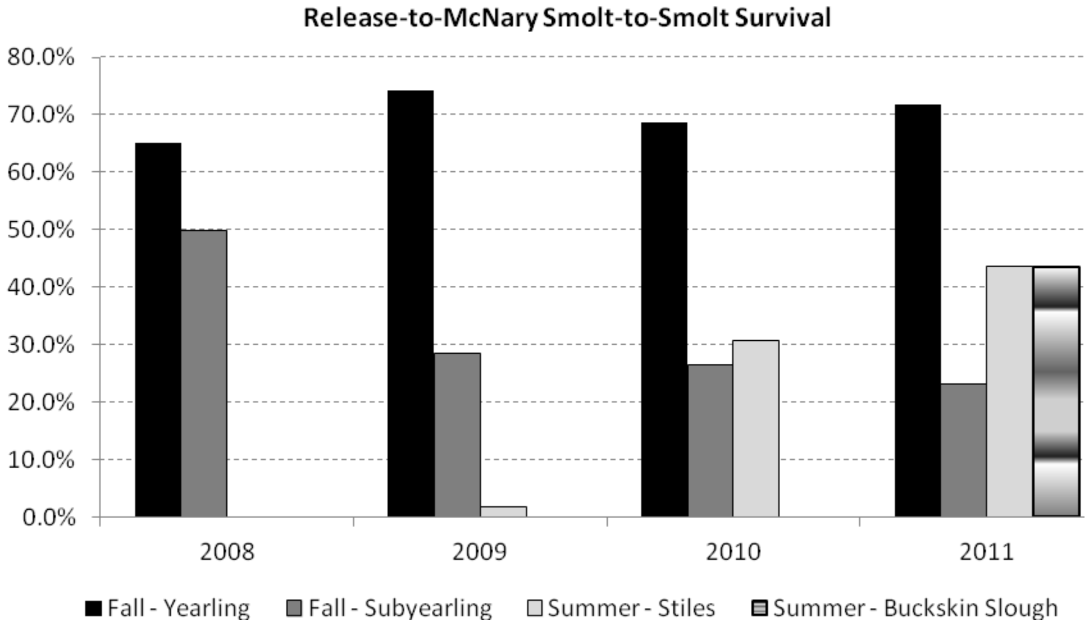


Table 1. 2008-2011 Release-to-McNary Smolt-to-Smolt Survival

Year	Measure	Fall Chinook (Prosser) Yearling	Fall Chinook (Prosser) Subyearling	Summer Chinook (Stiles)	Summer Chinook (Buckskin Slough)
2008	**Tagging-to-McNary Survival**	**65.2%**	**49.9%**		
	Number Tagged	1,706	6,187		
2009	**Tagging-to-McNary Survival**	**74.3%**	**28.4%**	**1.8%**	
	Number Tagged	4,659	5,777	17,054	
2010	**Tagging-to-McNary Survival**	**68.6%**	**26.5%**	**30.6%**	
	Number Tagged	5,327	4,324	5,669	
2011	**Tagging-to-McNary Survival**	**71.8%**	**23.2%**	**43.5%**	**43.4%**
	Number Tagged	9,442	7,007	14,748	29,894

Figures and Tables (continued)

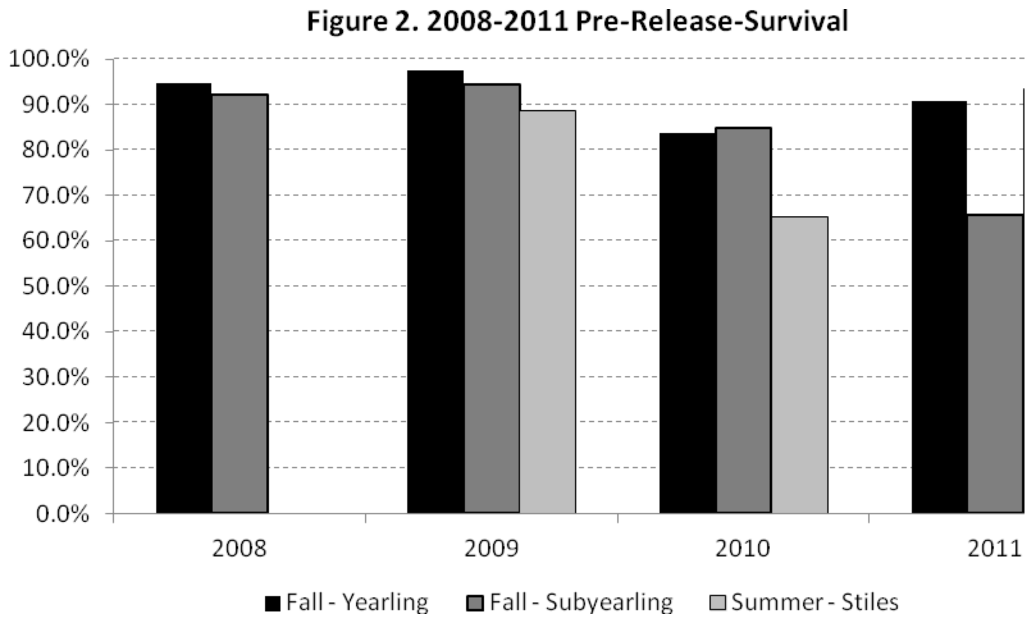
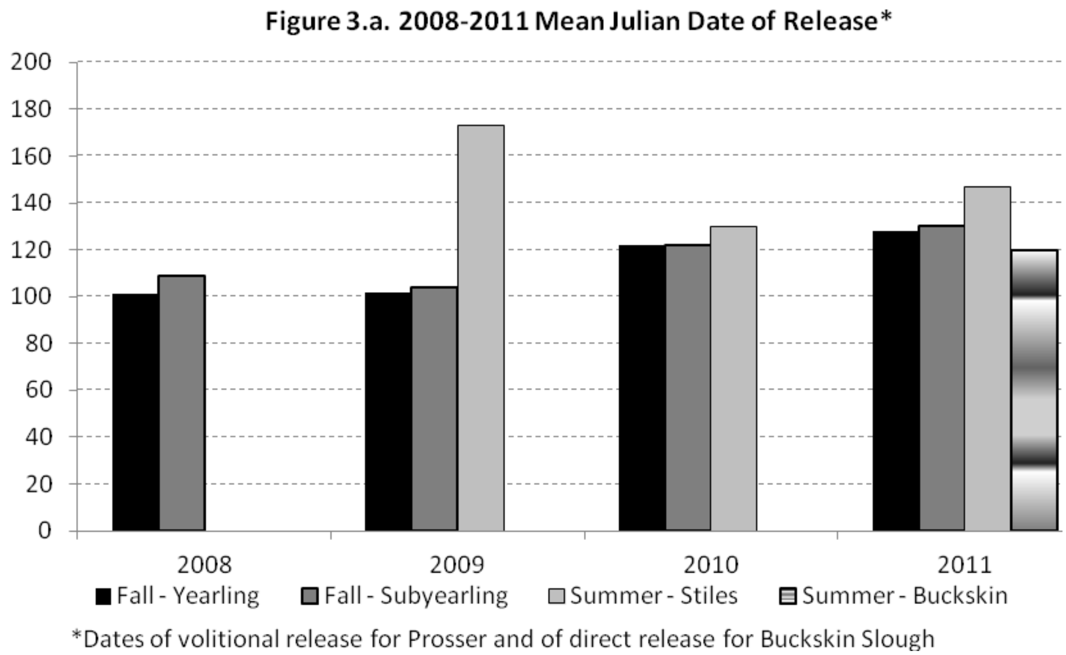


Table 2. 2008-2011 Pre-Release-Survival

Year	Measure	Fall Chinook (Prosser)		Summer Chinook (Stiles)
		Yearling	Subyearling	
2008	**Pre-Release Survival**	94.6%	92.3%	
	Number Tagged	1831	10005	
2009	**Pre-Release Survival**	97.6%	94.3%	88.7%
	Number Tagged	7516	7565	30037
2010	**Pre-Release Survival**	83.8%	84.9%	65.2%
	Number Tagged	12167	13685	29865
2011	**Pre-Release Survival**	90.9%	65.6%	92.4%
	Number Tagged	22754	22790	20000

Figures and Tables (continued)



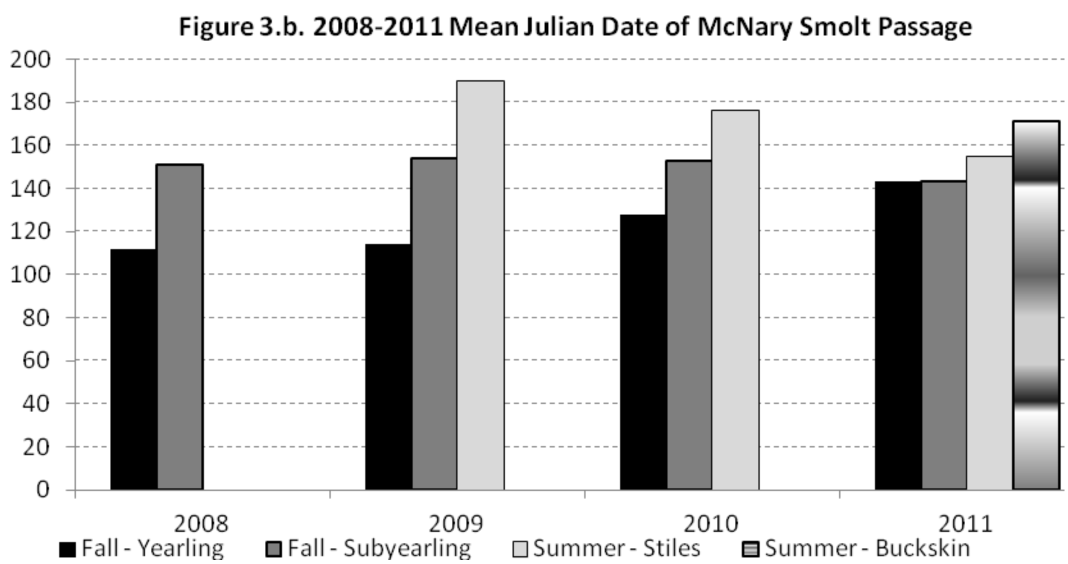


Table 3.a. 2008-2011 Mean Julian Date of Release*

Year	Measure	Fall Chinook (Prosser) Yearling	Fall Chinook (Prosser) Subyearling	Summer Chinook (Stiles)	Summer (Buckskin Slough)
2008	**Mean Release Date**	101	109		
	Expanded Passage number	1706.0	6187.0		
2009	**Mean Release Date**	102	104	**173**	
	Expanded Passage number	4659.0	5777.0	17,054	
2010	**Mean Release Date**	122	122	**135**	
	Expanded Passage number	5327.0	4324.0	5,669	
2011	**Mean Release Date**	128	130	**147**	**120**
	Number Released	9442.0	7007.0	14,748	29,894

* Dates of volitional release for Prosser and Stiles and of direct release for Buckskin Slough

Table 3.b. 2008-2011 Mean Julian Date of McNary Smolt Passage

Year	Measure	Fall Chinook (Prosser) Yearling	Fall Chinook (Prosser) Subyearling	Summer Chinook (Stiles)	Summer Chinook (Buckskin Slough)
2008	**Mean McNary Detection Date**	112	151		
	Expanded Passage number	1128.5	3743.7		
2009	**Mean McNary Detection Date**	114	154	**190**	
	Expanded Passage number	5442.4	2029.7	267	
2010	**Mean McNary Detection Date**	128	153	**176**	
	Expanded Passage number	7379.1	3116.6	1,735	
2011	**Mean McNary Detection Date**	136	145	**155**	**171**
	Expanded Passage number	13435.9	3664.3	8,065	12,989

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

Table A.1. Logistic Analysis of Variation for Release-to-McNary Smolt-to-Smolt Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Estimated Type Error P
Year	38.62	3	12.873333	0.07	0.97387
Subyearling vs Yearling	7614.72	1	7614.72	41.97	0.00746 *
Year x (Subyearling vs Yearling)	484.57	3	161.52333	0.89	0.48655
Residual	1451.34	8	181.4175		

* Tested against Residual

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

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Estimated Type Error P
Year	3998.76	3	1332.92	0.99	0.44454
Subyearling vs Yearling	2997	1	2997	2.23	0.23229 *
Year x (Subyearling vs Yearling)	1623.9	3	541.3	0.40	0.75522
Residual	10757.39	8	1344.6738		

* Tested against Residual

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

Source	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-Ratio	Estimated Type 1 Error P
Year	5273591	3	1757863.7	152.61	0.00000
Subyearling vs Yearling	43518	1	43518	1.76	0.27612
Year x (Subyearling vs Yearling)	74007.4	3	24669.133	2.14	0.17311
Residual	92150.6	8	11518.825		

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

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

Source	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-Ratio	Estimated Type 1 Error P
Year	1090951	3	363650.33	40.23	0.0000
Subyearling vs Yearling	4104300	1	4104300	10.61	0.0472 *
Year x (Subyearling vs Yearling)	1160864.5	3	386954.83	42.81	0.0000
Residual	72319.5	8	9039.9375		

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

Appendix B. Estimated Survival Index

Conceptual Computation

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

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

2. Estimating the McNary detection rate for each stratum

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

4. Totaling the release's expanded numbers over strata

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

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

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

---

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

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

[5] 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.

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

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

Equation B.3.

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

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

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

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[6], the occurrence was even less; therefore the unexpanded numbers were used.

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

Summer Chinook McNary Detection Rate Estimates

Estimates for 2008 through 2010 are given the Appendix B of the 2010 Annual Report: Smolt-to-Smolt Survival to McNary Dam of Yakima Fall and Summer Chinook. 2011 McNary Detection Rates are given below in Table B.1, and Release-to-McNary Survival and other estimates are given in table B.2.

Table B.1.a. 2011 Fall Chinook McNary Dam Detection Rates (John Day's Estimates Used because of Bonneville inconsistencies)

					Bonneville Dam			John Day Dam			Pooled (Bonneville and John day)		
Stratum	1st Julian	1st Date	Last Julian	Last Date	BO Total	BO-MCJ Total	Estimate	JD Total	JD-MCJ Tota	Estimate	DS Total	DS-MCJ Total	Estimate
1			131.0	05/11/11	32.1	5	0.155749	373.3	61	0.163390	405.4	66	0.162785
2	132.0	05/12/11	134.0	05/14/11	79.6	4	0.050235	1363.4	141	0.103414	1443.1	145	0.100480
3	135.0	05/15/11	136.0	05/16/11	45.0	11	0.244218	654.6	101	0.154304	699.6	112	0.160093
4	137.0	05/17/11	146.0	05/26/11	31.2	6	0.192537	739.4	185	0.250193	770.6	191	0.247862
5	147.0	05/27/11	242.0	08/30/11	13.1	14	1.071429	148.2	20	0.134920	161.3	34	0.210784

Table B.1.b. 2011 Summer Chinook McNary Dam Detection Rates (Pooled Estimates Used)

					Bonneville Dam			John Day Dam			Pooled (Bonneville and John day)		
Stratum	1st Julian	1st Date	Last Julian	Last Date	BO Total	BO-MCJ Total	Estimate	JD Total	JD-MCJ Total	Estimate	DS Total	DS-MCJ Total	Estimate
1			148.0	05/28/11	55.1	6	0.108809	421.5	33	0.078286	476.7	39	0.081817
2	149.0	05/29/11	167.0	06/16/11	117.5	11	0.093598	896.3	117	0.130533	1013.9	128	0.126251
3	168.0	06/17/11	171.0	06/20/11	38.3	6	0.156522	126.3	23	0.182152	164.6	29	0.176183
4	172.0	06/21/11	187.0	07/06/11	291.0	24	0.082474	559.2	78	0.139483	850.2	102	0.119971
5	188.0	07/07/11	242.0	08/30/11	59.0	11	0.186441	74.7	13	0.174107	133.7	24	0.179551

Table B.2.b. 2011 Fall Chinook Survival Estimates

Stratum	From Date	Through Date		Prosser Yearling PY1	Prosser Yearling PY2	Prosser Yearling PY3	Prosser Yearling PY4	Prosser Subyearling PS1	Prosser Subyearling PS2	Prosser Subyearling PS3	Prosser Subyearling PS4
1		05/28/11	Total	0	0	158	91	0	0	2	1
			Removed	0	0	0	0	0	0	0	0
			Subtotal	0	0	158	91	0	0	2	1
			Expanded Total	0.0	0.0	967.0	556.9	0.0	0.0	12.2	6.1
2	05/29/11	06/16/11	Total	68	6	109	80	2	5	12	3
			Removed	0	0	0	0	0	0	0	0
			Subtotal	68	6	109	80	2	5	12	3
			Expanded Total	657.5	58.0	1054.0	773.6	19.3	48.3	116.0	29.0
3	06/17/11	06/20/11	Total	53	8	65	36	27	16	19	8
			Removed	0	0	0	0	0	0	0	0
			Subtotal	53	8	65	36	27	16	19	8
			Expanded Total	343.5	51.8	421.2	233.3	175.0	103.7	123.1	51.8
4	06/21/11	07/06/11	Total	117	30	122	67	40	22	35	22
			Removed	0	0	0	0	0	0	0	0
			Subtotal	117	30	122	67	40	22	35	22
			Expanded Total	467.6	119.9	487.6	267.8	159.9	87.9	139.9	87.9
5	07/07/11	08/30/11	Total	22	1	13	7	22	7	15	19
			Removed	0	0	0	0	0	0	0	0
			Subtotal	22	1	13	7	22	7	15	19
			Expanded Total	163.1	7.4	96.4	51.9	163.1	51.9	111.2	140.8
			Total over Strata	260	45	467	281	91	50	83	53
			Expanded Total over Strata	1631.7	237.2	3026.2	1883.5	517.3	291.9	502.5	315.7
			Number Releases	3104	513	3741	2084	2588	1390	1840	1189
			Release-to-McN Survival	52.6%	46.2%	80.9%	90.4%	20.0%	21.0%	27.3%	26.6%
			Pooled Number of Releases		3617		5825		3978		3029
			Pooled Survival		51.7%		84.3%		20.3%		27.0%
			Pooled Number of Releases				**9442**				**7007**
			Pooled Survival				**71.8%**				**23.2%**
			Unexpanded McNary Number - all tagged	826	156	750	444	112	53	276	186
			Number Tagged	9626	1751	7276	4101	7620	3769	7234	4167
			Percent Detected at Ponds	**32.25%**	**29.30%**	**51.42%**	**50.82%**	**33.96%**	**36.88%**	**25.44%**	**28.53%**
			Pre-Release Survival*	1.0000	1.0000	0.8257	0.8029	0.4180	0.3909	0.8458	1.0000
			Pooled Pre-Release Survival		100.0%		81.8%		40.9%		90.2%
			Pooled Number 'Tagged		11377		11377		11389		11401
			Pooled Pre-Release Survival				**90.9%**				**65.6%**
			Pooled Number 'Tagged				**22754**				**22790**

Table B.2.b. 2011 Summer Chinook Survival Estimates

Stratum	From Date	Through Date		Stiles ES1	Stiles ES2	Buckskin Slough Release 1 WS1	Buckskin Slough Release 1 WS2	Buckskin Slough Release 2 WS3	Buckskin Slough Release 2 WS4
1		05/28/11	Total	85	108	23	23	13	6
			Removed	0	0	0	0	0	0
			Subtotal	85	108	23	23	13	6
			Expanded Total	1038.9	1320.0	281.1	281.1	158.9	73.3
2	05/29/11	06/16/11	Total	192	194	220	167	110	57
			Removed	0	0	0	0	0	0
			Subtotal	192	194	220	167	110	57
			Expanded Total	1520.8	1536.6	1742.6	1322.8	871.3	451.5
3	06/17/11	06/20/11	Total	13	13	32	32	28	12
			Removed	0	0	0	0	0	0
			Subtotal	13	13	32	32	28	12
			Expanded Total	73.8	73.8	181.6	181.6	158.9	68.1
4	06/21/11	07/06/11	Total	41	50	223	176	206	91
			Removed	0	0	0	0	0	0
			Subtotal	41	50	223	176	206	91
			Expanded Total	341.8	416.8	1858.8	1467.0	1717.1	758.5
5	07/07/11	08/30/11	Total	11	6	73	72	72	37
			Removed	0	0	0	0	0	0
			Subtotal	11	6	73	72	72	37
			Expanded Total	61.3	33.4	406.6	401.0	401.0	206.1
			Total over Strata	342	371	571	470	429	203
			Expanded Total over Strata	3036.5	3380.6	4470.7	3653.5	3307.2	1557.5
			Number Releases	7287	7461	9904	8571	7408	4011
			Release-to-McN Survival	41.67%	45.31%	45.14%	42.63%	44.64%	38.83%
			Pooled Number of Releases				18475		11419
			Pooled Survival				43.97%		42.60%
			Pooled Number of Releases		**14748**				**29894**
			Pooled Survival		**43.51%**				**43.45%**
			Unexpanded McNary Number - all tagged	438	455				
			Number Tagged	9999	10001				
			Percent Detected at Ponds	72.88%	74.60%				
			Pre-Release Survival*	93.33%	91.49%				
			Pooled Pre-Release Survival		**92.41%**				
			Pooled Number 'Tagged		**20000**				

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Appendix H
Annual Report: 2011 Coho Smolt-to-Smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin

Doug Neeley, Consultant to Yakama Nation

Introduction and Summary

In previous years, there were paired releases of Yakima-Return (Yakima) and Eagle-Creek-Hatchery (Eagle Creek) broods. In 2011, there were two paired releases, but neither were paired Yakima and Eagle Creek releases. One of the sites, Holmes Pond, had a paired release of Yakima and a Yakima x Eagle Creek cross; the other site, Easton, had a paired release of Eagle-Creek brood and a Yakima x Eagle Creek cross. For both of these paired releases, there were no PIT-tag detectors at the release sites in 2011; therefore no estimates of Pre-release survival or volitional-release-to-McNary dam were possible for these paired releases. There were two sites, Stiles and Lost Creek that had only a Yakima x Eagle Creek cross release. At all other release sites there were Yakima stock releases. Eagle Creek stock are being phased out because in their paired releases with the Yakima stock from various sites from 2006 through 2010, Yakima-brood releases consistently had a higher volitional-release-to-McNary Dam smolt-to-smolt survival.

Since the 2011 releases were not replicated either within or among release sites, no formal statistical analyses were performed. The estimates provided herein are: Pre-release survival, volitional-release to McNary Dam (McNary) survival, time-of-tagging-to-McNary survival, and mean date of McNary passage.

In addition to the 2011 release summaries, the tables and figures in this report also provide estimates from 2006 through 2010 to provide informal comparisons[1] between the Yakima and Eagle-Creek broods. Formal analyses comparing these two broods' juvenile survivals and date of McNary passage were given in the 2010 annual report. Also provided are summaries for 2010 and 2011 direct in-basin releases of Yakima brood.*

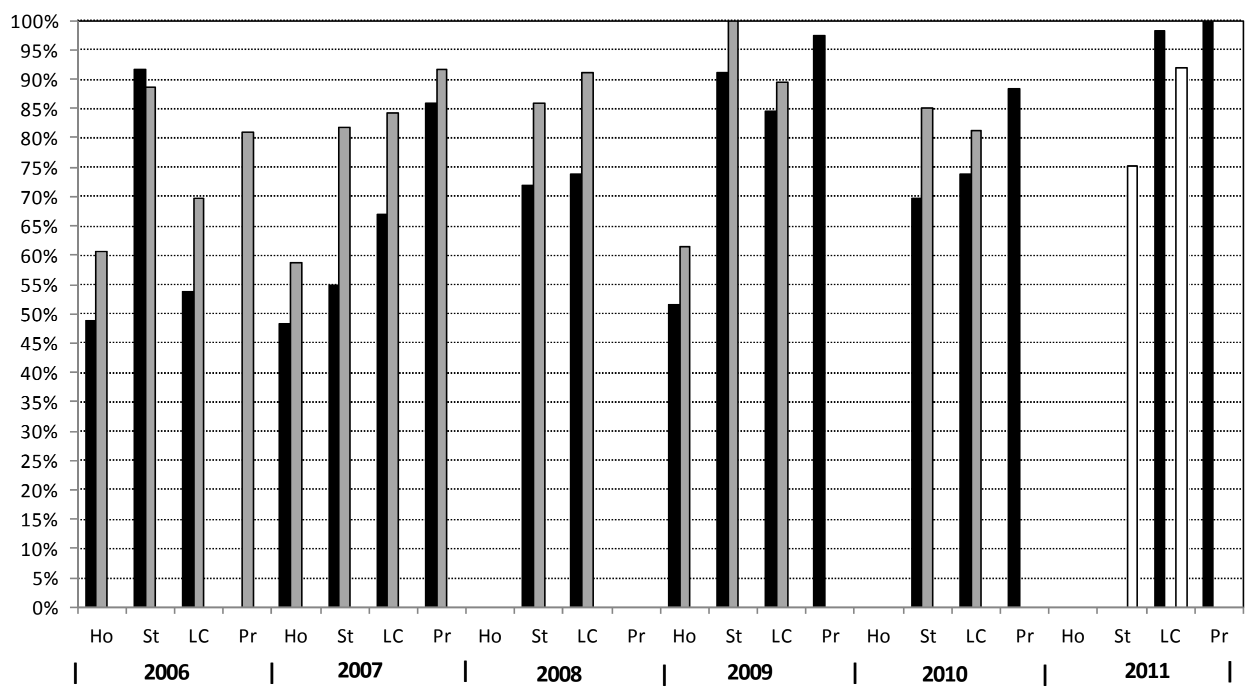
[1]Formal analyses comparing these two broods' juvenile survivals and date of McNary passage were given in the 2010 annual report.

Survival Estimates based on detected Volitional Releases

In the presence of a PIT-tag detector located in the out-falls from the releases sites it is possible to bifurcate the survival of smolt from the time of tagging to the time of McNary Passage into: 1) Survival from the time of tagging to the time of volition release (referred to herein as Pre-release Survival); and 2) survival from time of volitional release to time of McNary passage (referred to herein as Volitional-Release to McNary Survival).

Pre-release Survival: Pre-release survival estimates are the estimated proportions of juveniles that survive from the time of tagging to the time of volitional release. The estimate is the proportion of PIT-tagged smolt detected leaving the pond divided by the pond's detection efficiency. That estimated detection efficiency is the number of McNary-detected smolt previously detected leaving the rearing pond divided by the total number of the McNary-detected smolt whether or not the smolt were previously detected at the rearing pond. Estimates of Pre-release survival are presented in Figure and Table 1, from which it can seen that Eagle-Creek stock had higher Pre-release survivals than Yakima stock in all but 1 of 14 paired volitional releases made[2]. In the only releases (2011 at Lost Creek) for which the survival estimates were possible, the Yakima Stock had higher survival than did the Yakima x Eagle Creek Cross.

Figure 1. 2006-2011 Outmigration-Year (2004-2009 Brood) Coho Pre-release-Survival of Yakima Stock (black), Eagle Creek Stock (gray), and Yakima x Eagle Creek Crosses (white) from Holmes (Ho), Stiles (St), Lost Creek (LC), and Prosser (Pr).



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

Table 1. Outmigration-Year 2006-2011 (2004-2009 Brood) Pre-release Survival of Pit-Tagged Smolt

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

*** No viable estimate because of low proportion (3.68%) detected at pond and low number (4) of pond-detected fish detected at McNary compared to all Taneum PIT-tagged fish detected at McNary (109)**

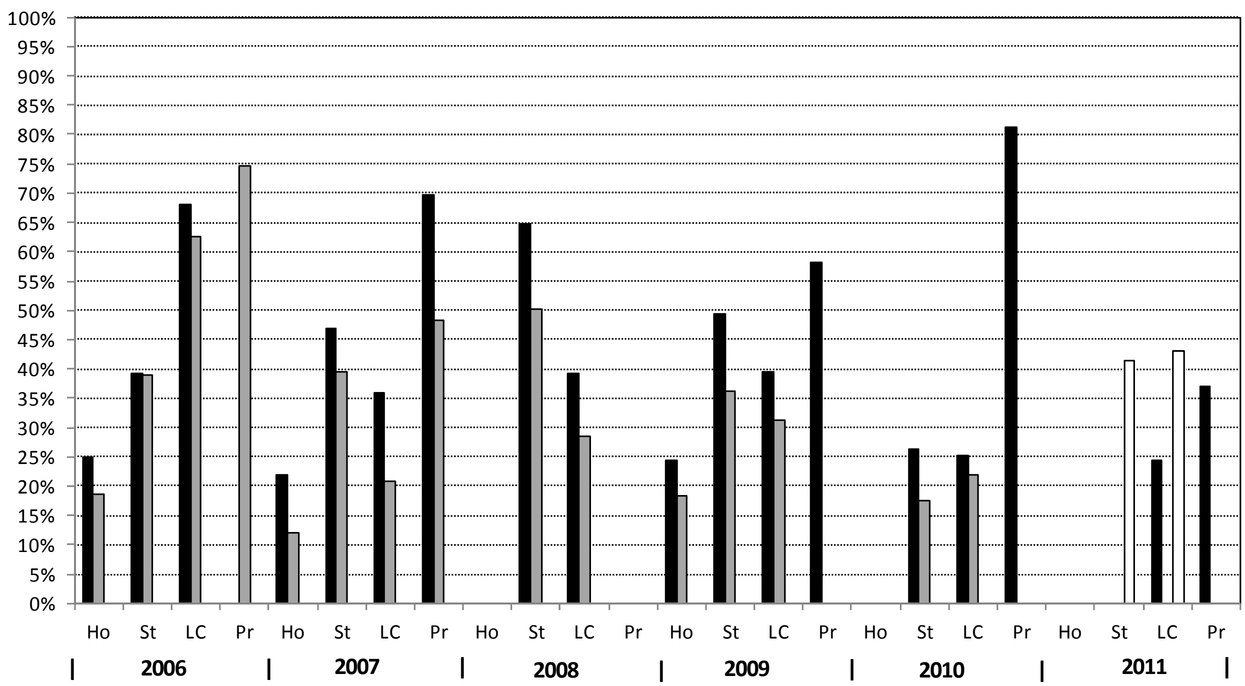
Volitional-Release to McNary Dam Survival: This is an estimate of the survival of those smolt detected leaving the rearing pond that eventually passed McNary Dam. It is basically[3] the proportion of those PIT-tagged smolt detected leaving the rearing pond that are detected at McNary Dam divided by McNary's detection efficiency. That estimated detection efficiency is

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

the number of smolt detected passing dams[4] downstream of McNary that were previously detected passing McNary divided by the total number of the smolt passing the downstream dams, whether or not the smolt were previously detected at McNary. Detection efficiencies were based on the detections of all PIT-tagged smolt released into the Yakima basin, not just the smolt associated with the releases presented in this study.

Estimates of volitional-release-to-McNary survival are presented in Figure and Table 2. As was reported in the 2010 annual report, when Yakima/Eagle Creek paired releases were made, Yakima stock had higher survival than that of Eagle Creek stock for all fourteen paired-release sites at which there were PIT-tag detectors[5]. In the only releases (2011 at Lost Creek) for which the survival estimates were possible, the Yakima Stock had a lower survival than did the Yakima x Eagle Creek Cross.

Figure 2. 2006-2011 Outmigration-Year (2004-2009 Brood) Coho Volitional-Release-to-McNary Smolt Survival for Yakima Stock (black), Eagle Creek Stock (gray), and Yakima x Eagle Creek Crosses (white) from Holmes (Ho), Stiles (St), Lost Creek (LC), and Prosser (Pr).



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[4] John Day and Bonneville

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

Table 2. 2006-2011 Outmigration-Year (2004-2009 Brood) Coho Volitional-Release-to-McNary Smolt Survival

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

Estimates based on all Releases

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

Tagging to McNary Dam Survival: This measure does not partition the survival into the Pre-release and Release-to-McNary survival components. Estimating Tagging-to-McNary survival was necessary because some release sites had no detectors at the ponds, and no such partitioning was possible.

Estimates of Tagging-to-McNary Survival are presented in Figure 3 and Table 3. It is not surprising that that the Yakima stock had higher survival than Eagle Creek Stock in only 11 of the 18 releases. Recall that, although the Yakima brood had the highest Volitional-Release-to-McNary Survival for all releases, the Eagle Creek brood had the highest Pre-release survival in all but one release for which paired estimates were available. The combination of the two components resulted in a reduced relative over-all survival from tagging for the Yakima stock. In the two sets of 2011 releases (Lost Creek and Easton) for which the survival estimates were possible, the Yakima Stock had a lower survival than did the Yakima x Eagle Creek Cross, and for the Easton Site, the Yakima Stock also had a lower survival than did the Eagle Creek Stock. The partitioning of Easton survivals into Pre-Release and Release-to-McNary components was not possible.

Figure 3. 2006-2011 Outmigration-Year (2004-2009 Brood) Coho Time-of-Tagging-to-McNary Smolt Survival for Yakima Stock (black), Eagle Creek Stock (gray), and Yakima x Eagle Creek Crosses (white) from Holmes (Ho), Stiles (St), Lost Creek (LC), and Prosser (Pr).

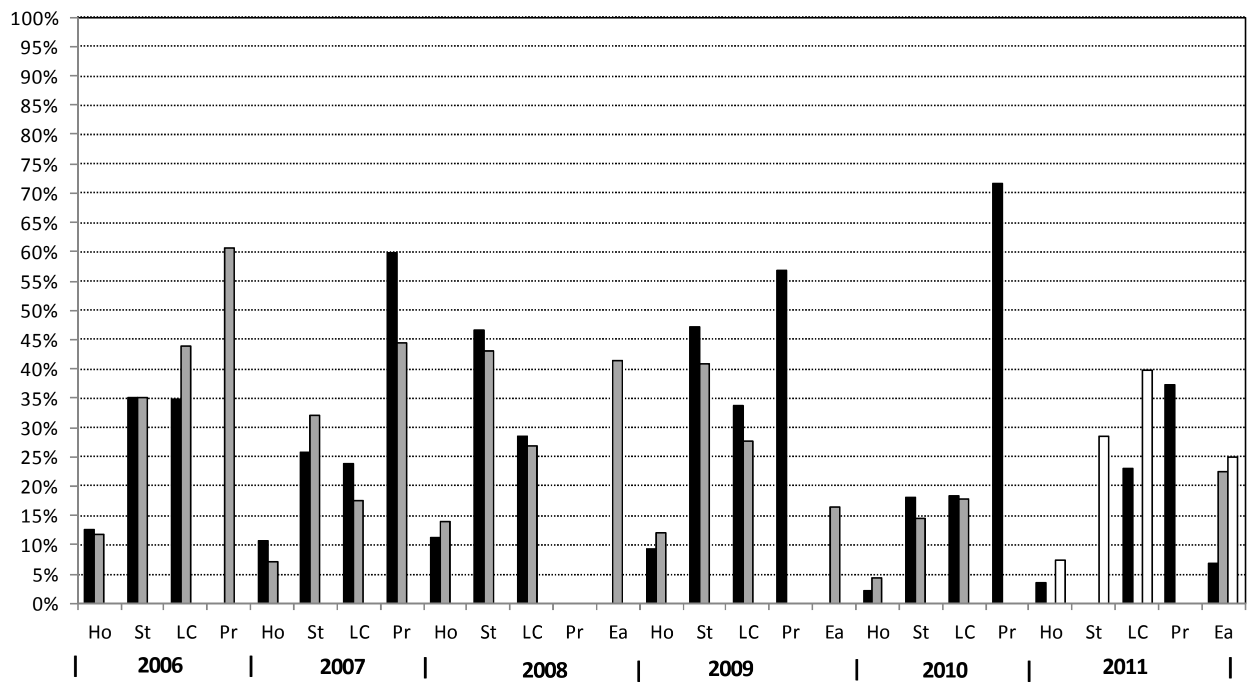

Table 3. Outmigration-Year Coho 2006-2011 (2004-2009 Brood) Time-of-Tagging-to-McNary Smolt Survival

			Release-Site Subbasin and Pond within Subbasin							
			Upper Yakima							
						Cowiche				
Release Year	Stock	Measure	Holmes	Boone	Cle Elum	South Fork	Main	Taneum Creek	Umtanum Creek	Easton Pond
2006	**Yakima**	**Tagging-to-McNary Survival**	**12.48%**	**3.69%**						
		NumberTagged	2512	2501						
	Eagle Creek	**Tagging-to-McNary Survival**	**11.82%**	**2.57%**						
		NumberTagged	2514	2500						
2007	**Yakima**	**Tagging-to-McNary Survival**	**10.77%**							
		NumberTagged	2460							
	Eagle Creek	**Tagging-to-McNary Survival**	**7.08%**							
		NumberTagged	2504							
2008	**Yakima**	**Tagging-to-McNary Survival**	**11.17%**							
		NumberTagged	2493							
	Eagle Creek	**Tagging-to-McNary Survival**	**13.89%**							**41.45%**
		NumberTagged	2508							2500
2009	**Yakima**	**Tagging-to-McNary Survival**	**9.19%**		**0.21%**		**44.32%**	**15.67%**	**44.32%**	
		NumberTagged	2512		11934		150	1300	150	
	Eagle Creek	**Tagging-to-McNary Survival**	**12.01%**							**16.38%**
		NumberTagged	1427							2524
2010	**Yakima**	**Tagging-to-McNary Survival**	**2.26%**			**23.29%**	**17.25%**	**9.89%**	**34.95%**	
		Number Tagged	2516			1248	3004	1867	42	
	Eagle Creek	**Tagging-to-McNary Survival**	**4.29%**	**3.41%**						**9.10%**
		Number Tagged	2504	1265						2532
2011	**Yakima**	**Tagging-to-McNary Survival**	**3.46%**			**31.50%**	**81.99%**	**13.64%**		**6.74%**
		Number Tagged	2516			1272	28	4515		1272
	Eagle Creek	**Tagging-to-McNary Survival**								**22.40%**
		Number Tagged								2561
	Yakima x	**Tagging-to-McNary Survival**	**7.42%**							**24.99%**
	Eagle Creek	Number Tagged	2506							**2522**

Table 3. Outmigration-Year Coho 2006-2011 Time-of-Tagging-to-McNary Smolt survival (2004-2009 Brood) (continued)

			Release-Site Subbasin and Pond within Subbasin			
			Naches		Main Stem Yakima	
Release Year	Stock	Measure	Stiles	Lost Creek	Prosser	Marion Drain
2006	**Yakima**	**Tagging-to-McNary Survival**	**34.99%**	**34.76%**		
		NumberTagged	2490	2491		
	Eagle Creek	**Tagging-to-McNary Survival**	**35.05%**	**43.81%**	**60.52%**	
		NumberTagged	2506	2515	1231	
2007	**Yakima**	**Tagging-to-McNary Survival**	**25.65%**	**23.94%**	**59.84%**	
		NumberTagged	2449	2501	2499	
	Eagle Creek	**Tagging-to-McNary Survival**	**32.07%**	**17.39%**	**44.30%**	
		NumberTagged	2513	2511	1246	
2008	**Yakima**	**Tagging-to-McNary Survival**	**46.59%**	**28.58%**		**26.18%**
		NumberTagged	2492	2499		3013
	Eagle Creek	**Tagging-to-McNary Survival**	**43.08%**	**26.76%**	**20.13%**	
		NumberTagged	2453	2524	854	
2009	**Yakima**	**Tagging-to-McNary Survival**	**47.27%**	**33.70%**	**56.76%**	
		NumberTagged	2515	2508	2506	
	Eagle Creek	**Tagging-to-McNary Survival**	**40.80%**	**27.76%**		
		NumberTagged	3755	2331		
2010	**Yakima**	**Tagging-to-McNary Survival**	**18.17%**	**18.45%**	**71.49%**	
		Number Tagged	2501	2505	1371	
	Eagle Creek	**Tagging-to-McNary Survival**	**14.43%**	**17.76%**		
		Number Tagged	2581	2520		
2011	**Yakima**	**Tagging-to-McNary Survival**		**23.10%**	**37.19%**	
		Number Tagged		2500	5036	
	Eagle Creek	**Tagging-to-McNary Survival**				
		Number Tagged				
	Yakima x Eagle Creek	**Tagging-to-McNary Survival**	**28.42%**	**39.85%**		
		Number Tagged	2524	2514		

Mean Date of McNary Dam Passage: The weighted mean Julian Date of McNary passage was estimated by weighting the Julian date by the expanded number of all passing smolt (whether or not they were previously detected leaving the rearing ponds), the expanded number being the date's detected passage divide by the McNary detection efficiency associated with that date. These weighted dates were then added over days and then divided by the total of the expanded daily passages.

For release years when there were paired releases, in 15 out of the 18 paired releases, on the average, the Yakima brood passed McNary earlier than the Eagle creek Stock.

Table 4. Outmigration-Year 2006-2011 (2004-2009 Brood) Mean Julian Passage Date of Tagged Smolt at McNary Dam

			Release-Site Subbasin and Pond within Subbasin								
			Upper Yakima								
						Cowiche					
Release Year	Stock	Measure	Holmes	Boone	Cle Elum	South Fork	Main (2011)	Taneum Creek	Umtanum Creek	Easton	Easton Pond
2006	**Yakima**	**Passage Date**	**124**	**133**							
		Expanded McNary Passage	313	92							
	Eagle Creek	**Passage Date**	**137**	**144**							
		Expanded McNary Passage	297	64							
2007	**Yakima**	**Passage Date**	**137**								
		Expanded McNary Passage	265								
	Eagle Creek	**Passage Date**	**140**								
		Expanded McNary Passage	177								
2008	**Yakima**	**Passage Date**	**138**								
		Expanded McNary Passage	278								
	Eagle Creek	**Passage Date**	**147**								**135**
		Expanded McNary Passage	348								1036
2009	**Yakima**	**Passage Date**	**139**		**164**		**143**	**160**	**143**		
		Expanded McNary Passage	230		25		66	204	66		
	Eagle Creek	**Passage Date**	**151**								**147**
		Expanded McNary Passage	171								413
2010	**Yakima**	**Passage Date**	**132**			**149**	**166**	**168**	**137**		
		Number Tagged	57			291	518	185	15		
	Eagle Creek	**Passage Date**	**145**	**155**							**144**
		Number Tagged	108	43							143
2011	**Yakima**	**Passage Date**	**147**			**156**	**144**	**162**			**144**
		Number Tagged	2516			1272	28	4515			1272
	Eagle Creek	**Passage Date**								**152**	
		Number Tagged								2561	
	Yakima x	**Passage Date**	**145**							**150**	
	Eagle Creek	Number Tagged	2506							**2522**	

Table 4. Outmigration-Year 2006-2011 (2004-2009 Brood) Mean Julian Passage Date of Tagged Smolt (continued)

			Release-Site Subbasin and Pond within Subbasin				
			Naches			Main Stem Yakima	
Release Year	Stock	Measure	Stiles	Lost Creek	Lost Creek Pond	Prosser	Marion Drain
2006	Yakima	Passage Date	132	143			
		Expanded McNary Passage	871	865			
	Eagle Creek	Passage Date	137	150		122	
		Expanded McNary Passage	878	110		744	
2007	Yakima	Passage Date	137	151		119	
		Expanded McNary Passage	628	598		1495	
	Eagle Creek	Passage Date	138	148		122	
		Expanded McNary Passage	805	436		552	
2008	Yakima	Passage Date	134	142			122
		Expanded McNary Passage	116	714			788
	Eagle Creek	Passage Date	133	148		142	
		Expanded McNary Passage	105	675		171	
2009	Yakima	Passage Date	142	148		133	
		Expanded McNary Passage	1188	845		1422	
	Eagle Creek	Passage Date	128	153			
		Expanded McNary Passage	1532	647			
2010	Yakima	Passage Date	137	148		118	
		Number Tagged	454	462		980	
	Eagle Creek	Passage Date	143	153			
		Number Tagged	372	447			
2011	Yakima	Passage Date			155	124	
		Number Tagged			2500	5036	
	Eagle Creek	Passage Date					
		Number Tagged					
	Yakima x Eagle Creek	Passage Date	143	155			
		Number Tagged	2524	2514			

Survivals of in-Basin Release: There were releases of parr directly into streams and rivers. Fish were PIT-tagged in the summer of 2010 with migration of smolts primarily occurring in the spring of 2011. The method of estimating these survivals to McNary was the same as the method used to estimate the survival of smolt volitionally leaving the rearing ponds except the number released were the number directly released into the streams. The release-to-McNary survival estimates are given below.

Table 5. Outmigration-Year 2010-2011 In-Basin Release Time-of-Tagging-to-McNary Smolt Survival

Release Year	Stock	Measure	Little Rattlsnake		Ahtanum	SF Cowiche Mobile	Big Creek	NF Little
2010	Yakima	File Extender	MRS	PRS	PAH		PBG	PNF
		Survival from Tagging to McNary	8.18%	12.06%	20.18%		10.49%	19.72%
		Number Tagged	1144	3053	3050		3006	3014
		Pooled Survival	11.00%					
		Pooled Number Tagged	4197					
2011	Yakima	File Extender	PLR		PAH	PCW	PBG	PNF
		Survival from Tagging to McNary	7.97%		18.87%	19.54%	15.81%	17.59%
		Number Tagged	3000		3050	3021	3003	3058

Release Year	Stock	Measure	Nile		Reecer	Little Naches	Buckskin Slough	Lost Creek	Wilson	Rock Creek
2010	Yakima	File Extender	PNL	WNL	PRC				PWL	WRK
		Survival from Tagging to McNary	13.79%	69.42%	21.47%				11.32%	0.00%
		Number Tagged	3055	16	3015				3050	78
2011	Yakima	File Extender	PNL		PRC	PLN	WBK	WLC	PWL	
		Survival from Tagging to McNary	7.46%		29.61%	9.54%	37.95%	57.39%	16.93%	
		Number Tagged	3110		3004	3022	216	10	2522	

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

Annual Report 2011

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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.

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 2011 produced 28,072 tags tied to smolt mortality in the Yakima Basin. PIT tag numbers for 2011 are significantly larger than the previous 21,455 from 2010 surveys. Tags detected were linked to sources of release and 28,477of these tags were from Yakima River juvenile salmonids. Predation by Herons, shown by PIT tags discovered below heronries showed correlation with river flows. High flow correlated with less PIT tag numbers which may be a function of lower opportunity for wading bird as fish move faster through the basin. Conversely low flow correlated with higher PIT tag numbers, as low flow creates higher foraging opportunities for Herons.

PIT tag analysis was developed by determining detection efficiencies in 2 diverse rookeries to assess a number of undetected PIT tags. Results showed surveys of PIT tags may have a greater than 65% detection rate.

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 these 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 and acronyms used in this document). 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.

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 1 and 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 began to include 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).

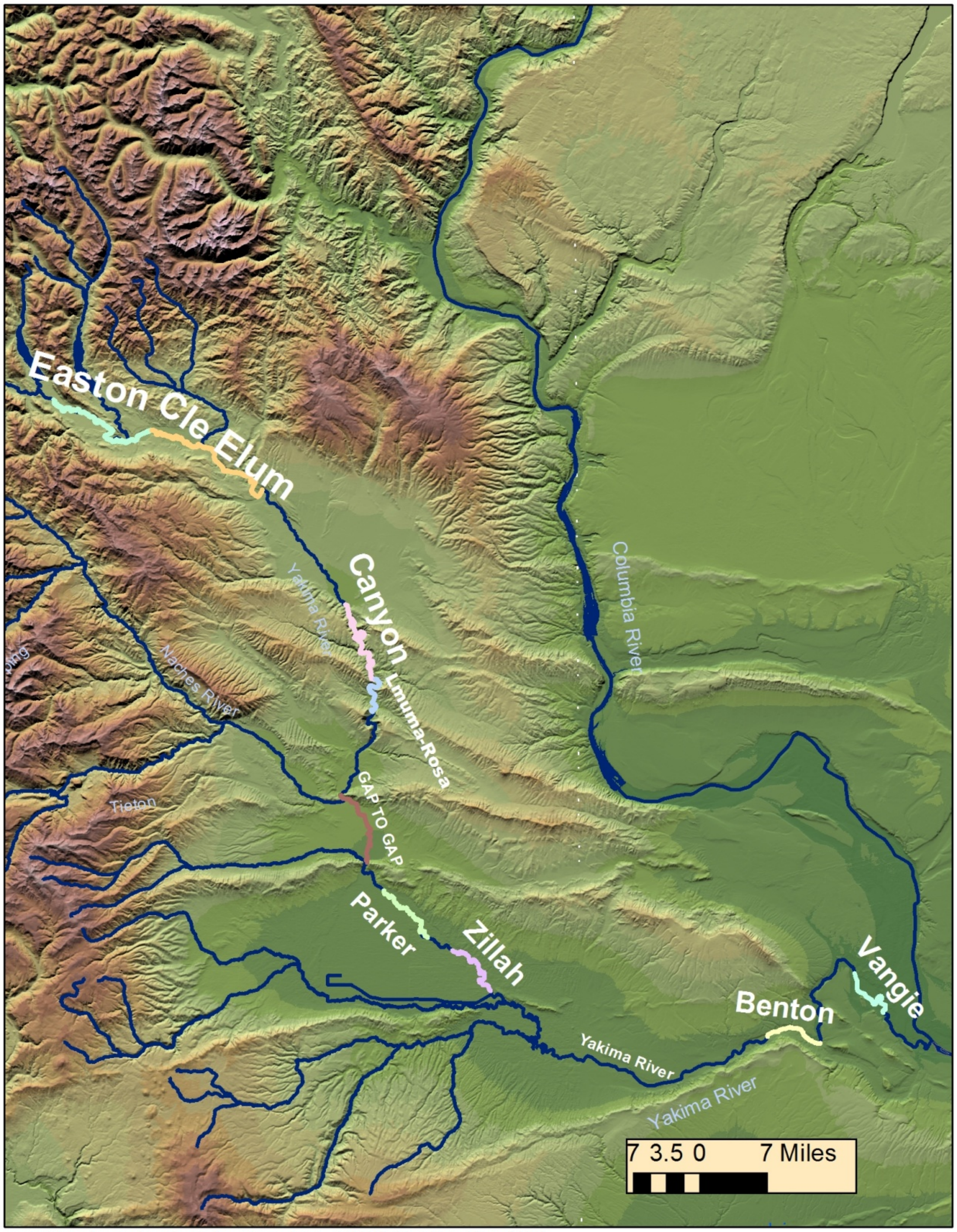


Figure 1: Yakima River Basin with locations of surveyed river reaches

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). The continuing surveys expanded number of rookeries surveyed which has expanded the number of PIT tags discovered. The 2011 survey's discovered a total of 4,609 new tags bringing the total number up to 15,358 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. 2000-2011 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.

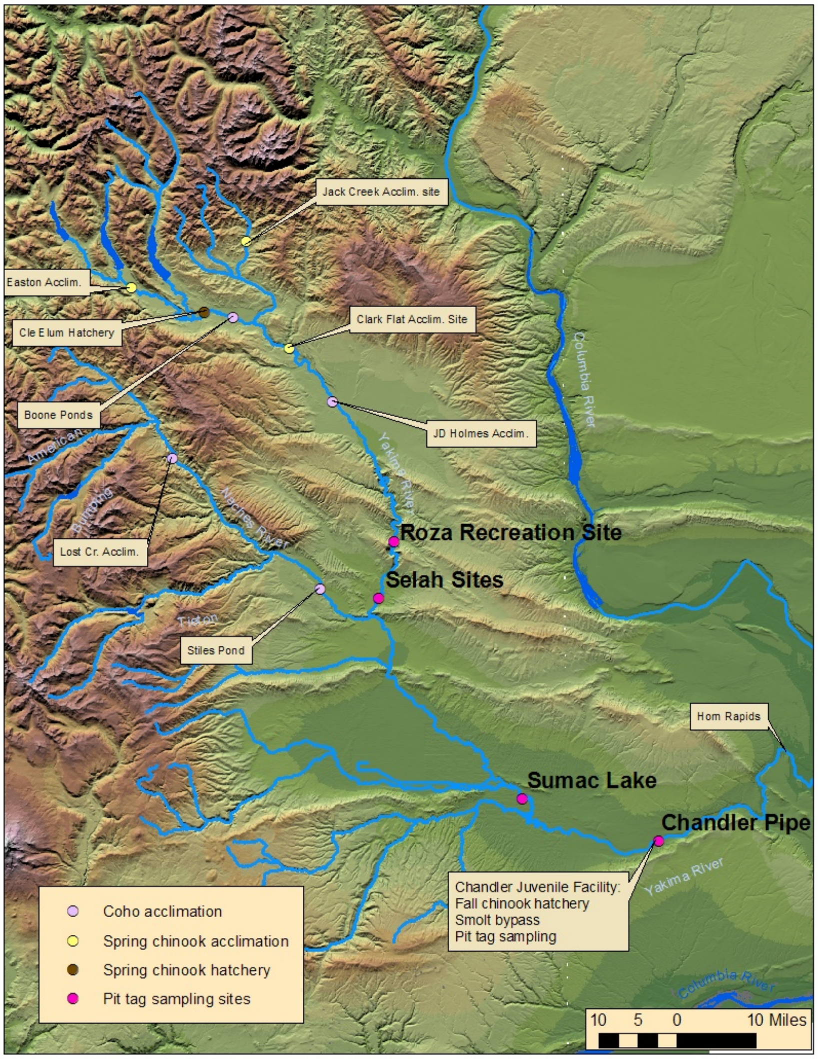
All rookeries in the Yakima Basin will be surveyed and a nest count along with bird counts will be conducted. If feasible all rookeries will be scanned for PIT tags. Selah rookery and the Wapato Wildlife rookery were chosen as sites for detection efficiency estimates.

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 2011 season. PIT tags numbers discovered within the irrigation diversions total 12,184 (information on Diversion PIT tags can be found in the 2011 YKFP annual report fish predation section). Combined numbers for total numbers of PIT tags found over all survey years and sites is 28,072.

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, pelican observations were first 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).



c:\avdata\birdpred\pelicanpoints2.mxd Paul Huffman 4/10/2007

Figure 2: Yakima River Basin with locations of hotspots (Chandler & Horn Rapids), Spring Chinook acclimation sites (Hot Spots for 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 in 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 2004-2010 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 through 2010. The study permit carried into 2010 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 include 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 2011). 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 2011 (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

Due to funding, logistical, physical and other constraints, aerial surveys are not conducted every year. No surveys were conducted in 2011. When we are able to fly, two aerial surveys are conducted to identity the abundance and distribution of pelicans. Survey areas focus 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 Heron 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 2011, 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.

Spring bird abundance are shown for each reach by average birds per kilometer in figures

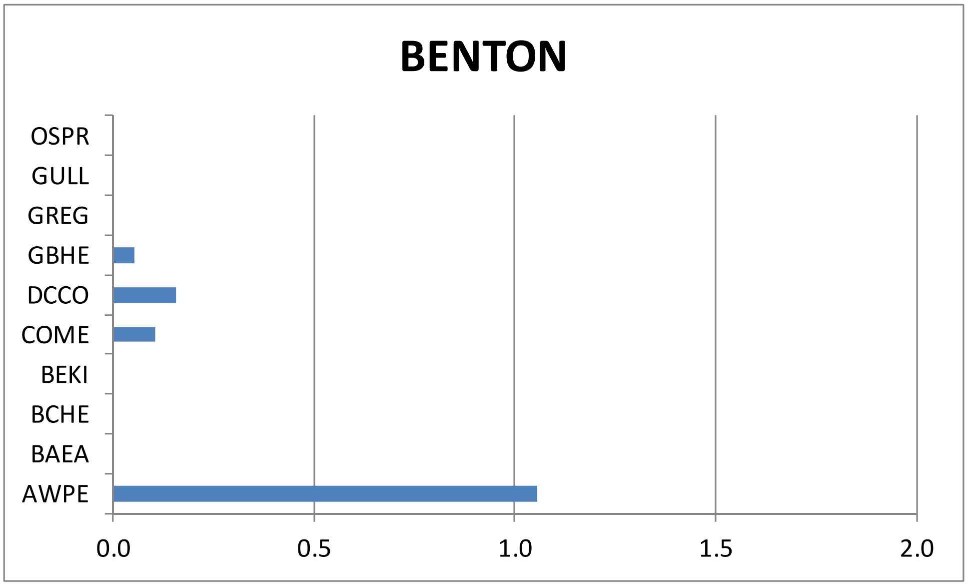


Figure 3: Benton spring bird abundance per kilometer 2011

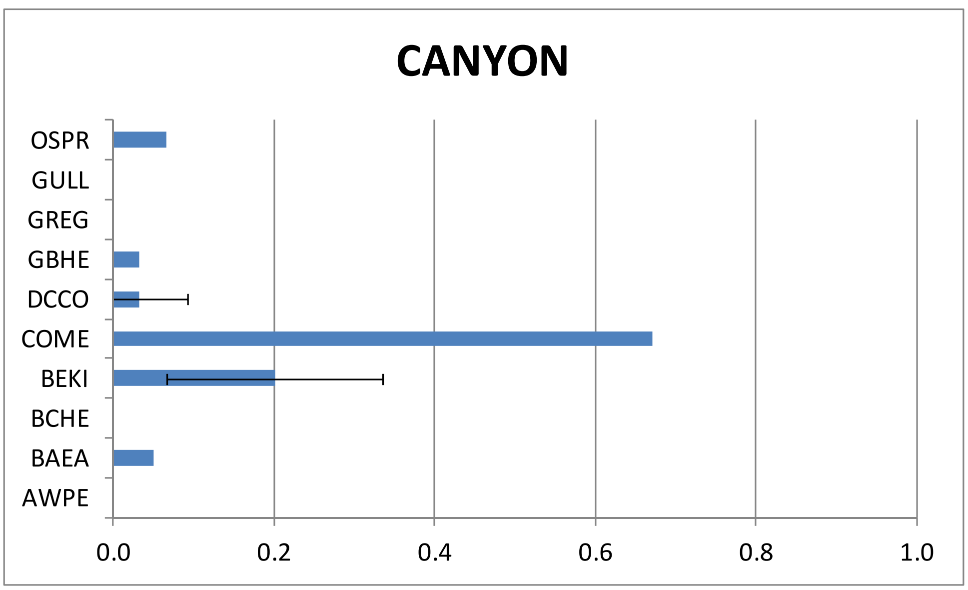


Figure 4: Yakima Canyon spring bird abundance per kilometer 2011

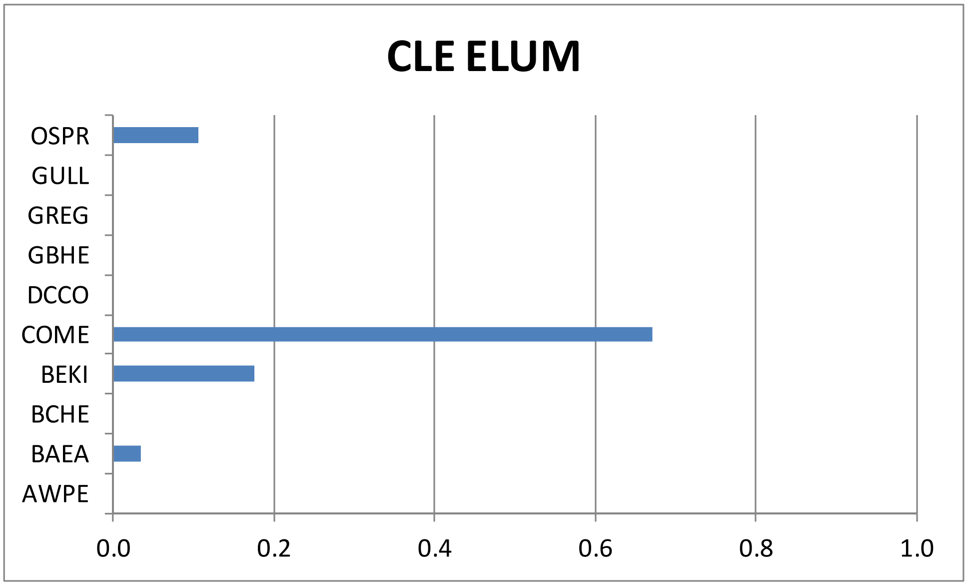


Figure 5: Cle Elum spring bird abundance per kilometer 2011

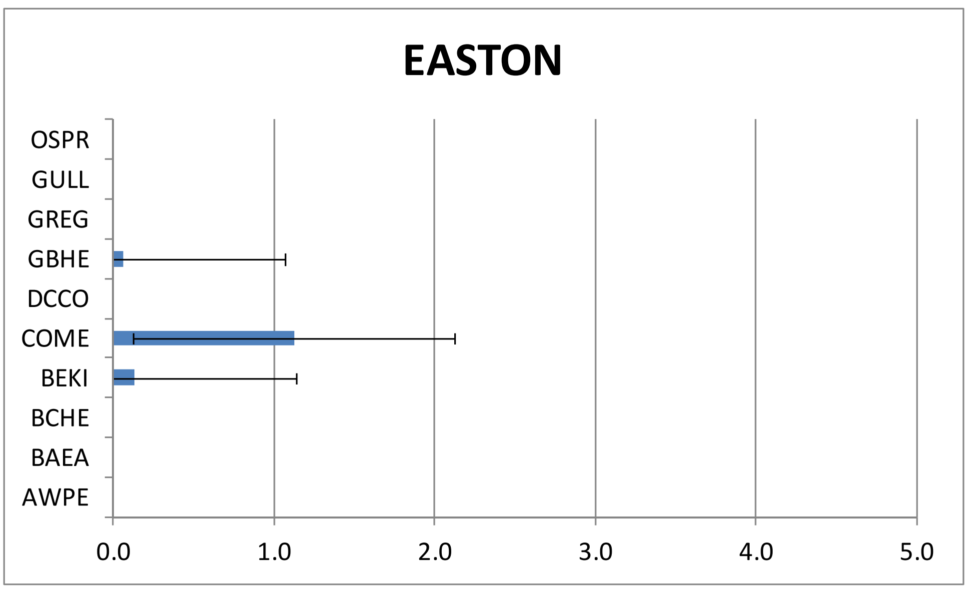


Figure 6: Easton spring bird abundance per kilometer 2011

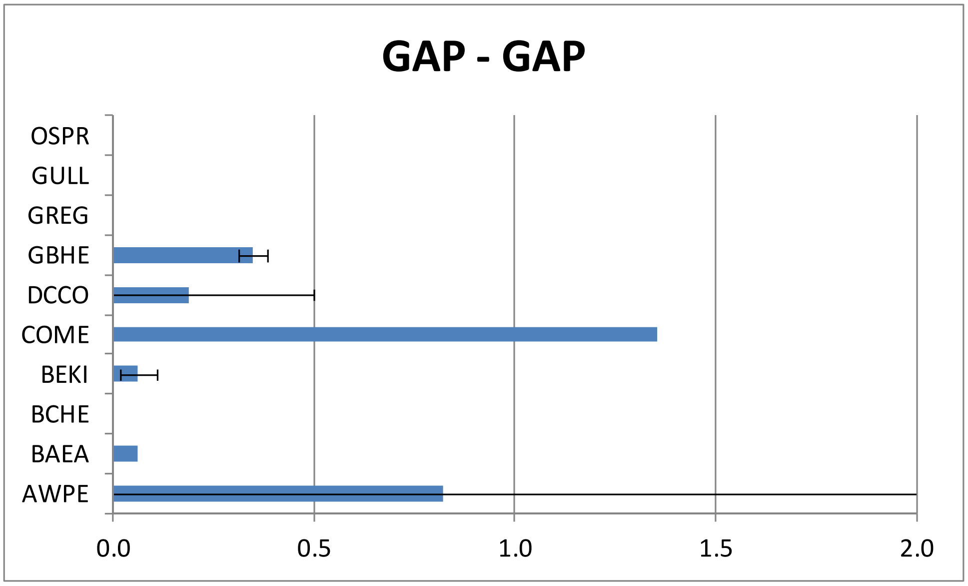


Figure 7: Gap to Gap spring bird abundance per kilometer 2011

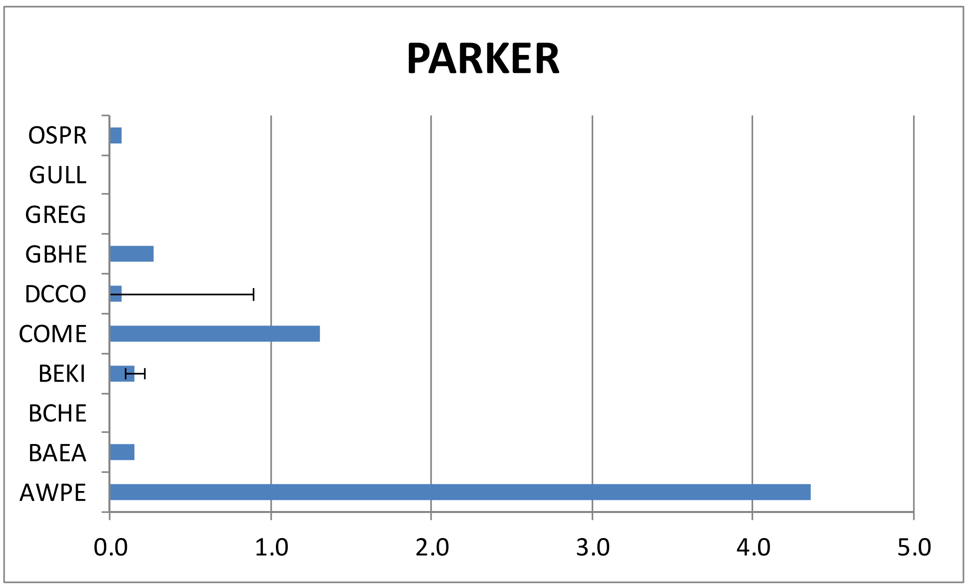


Figure 8: Parker spring bird abundance per kilometer 2011

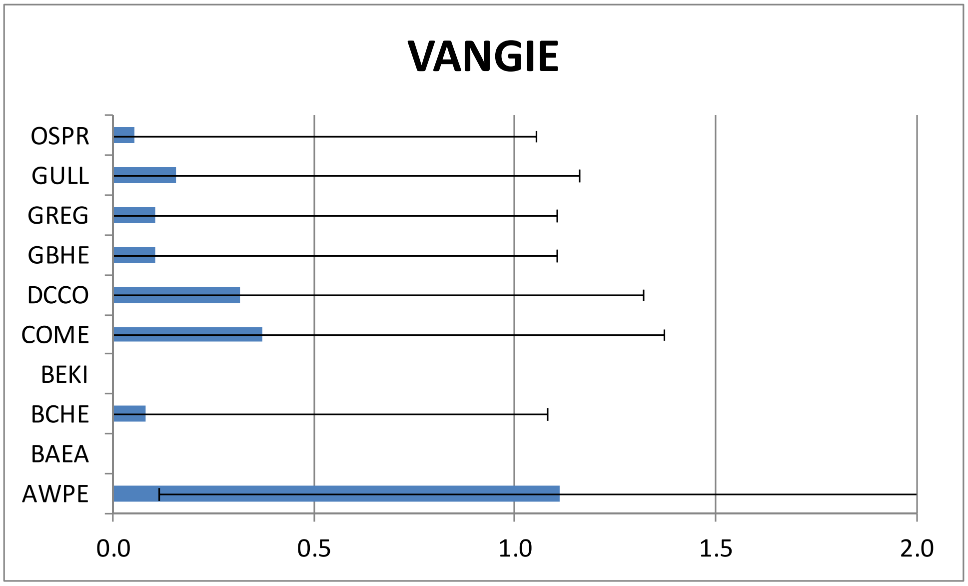


Figure 9: Vangie spring bird abundance per kilometer 2011

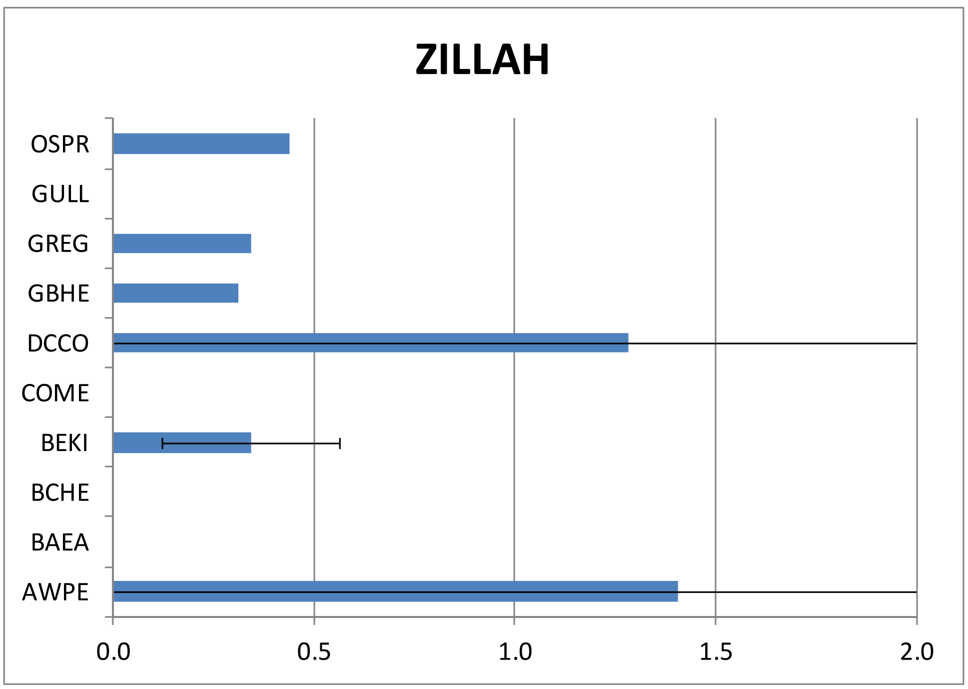


Figure 10: Zillah spring bird abundance per kilometer 2011

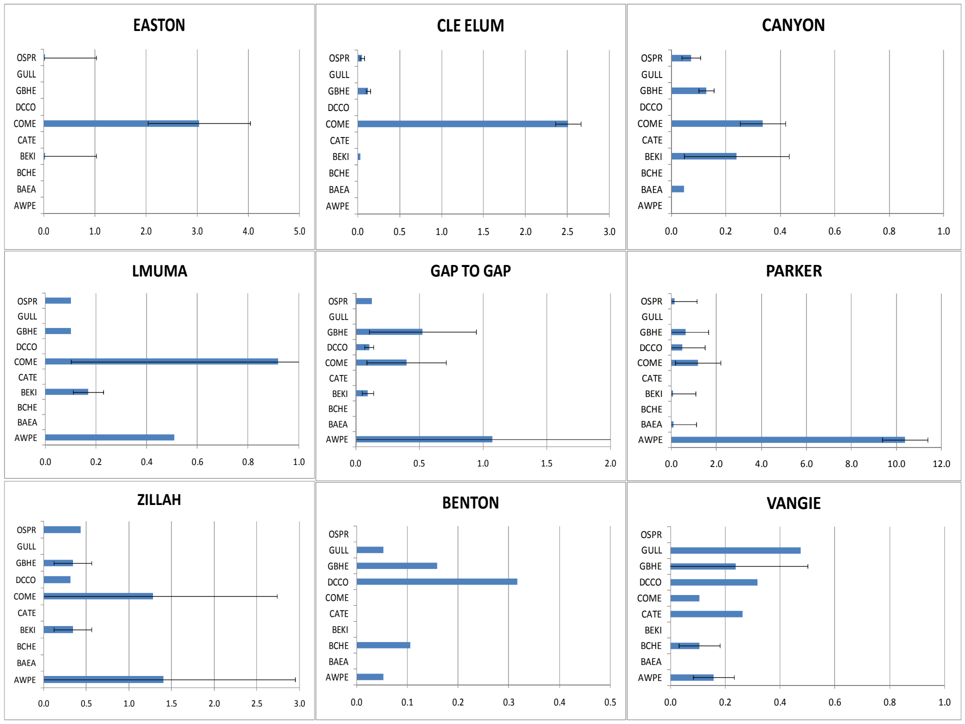


Figure 11: Spring bird abundance per kilometer for 2010

Summer bird abundances are shown for each reach by average birds per kilometer in figures

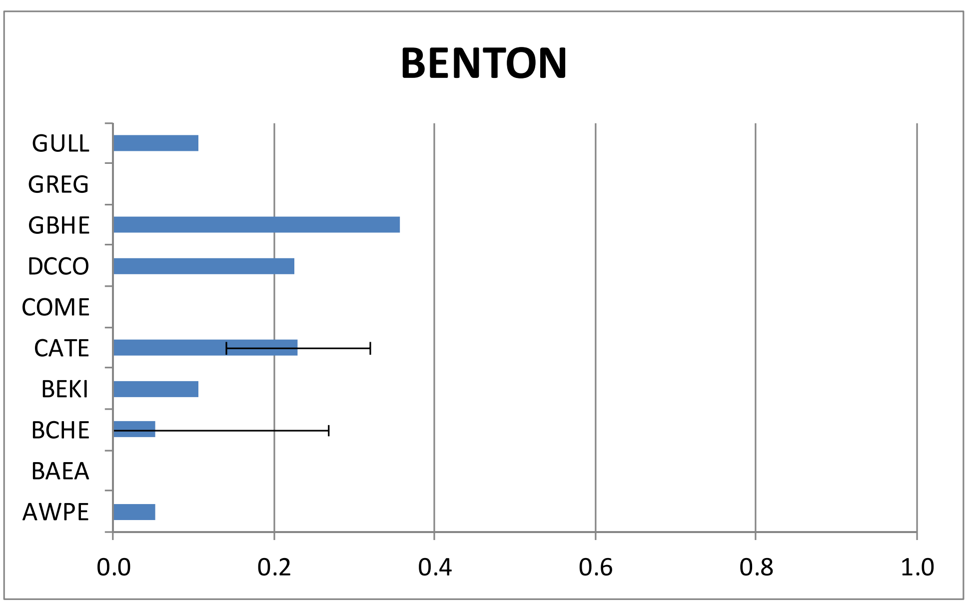


Figure 12: Benton summer bird abundance per kilometer 2011

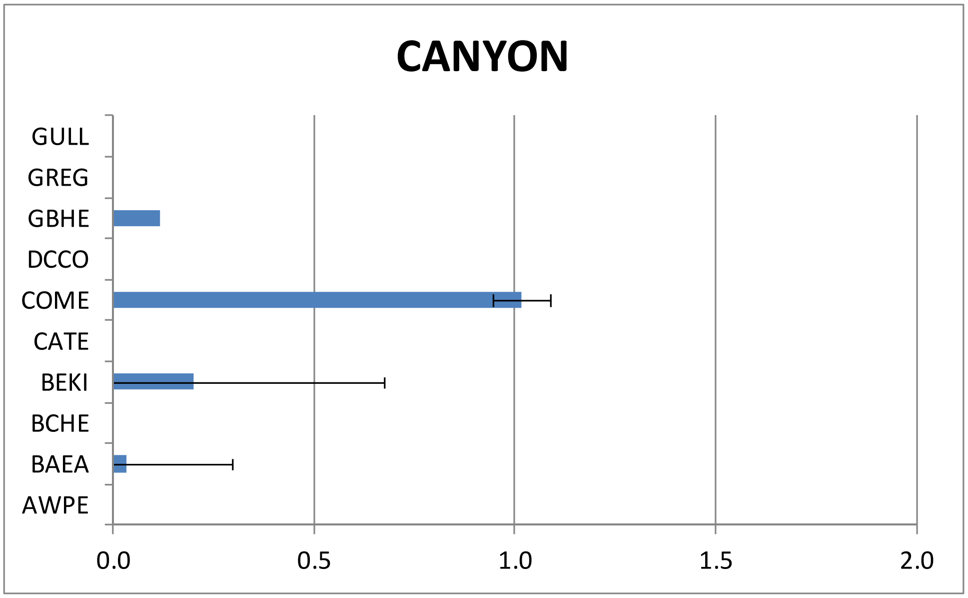


Figure 13: Yakima Canyon summer bird abundance per kilometer 2011

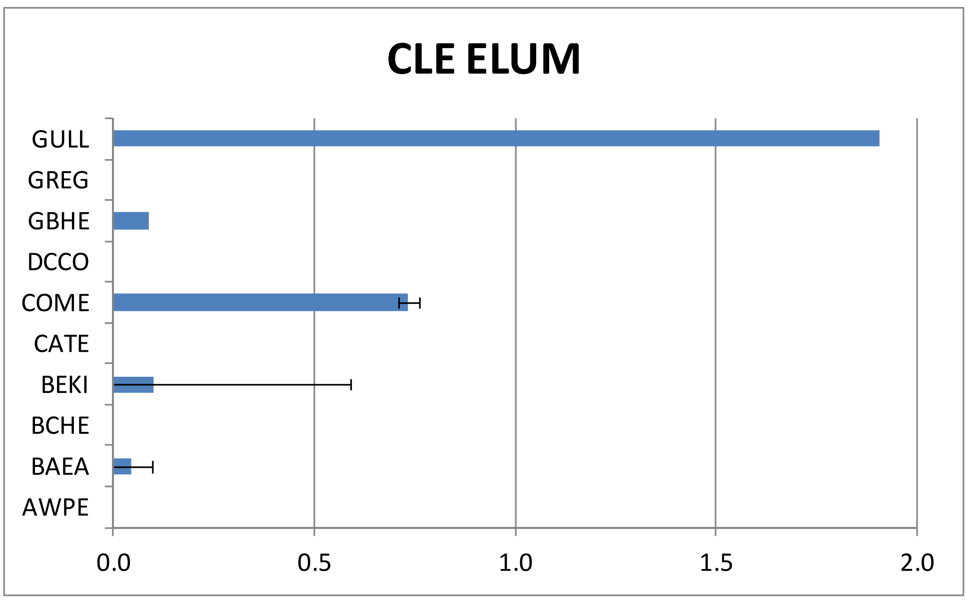


Figure 14: Cle Elum summer bird abundance per kilometer 2011

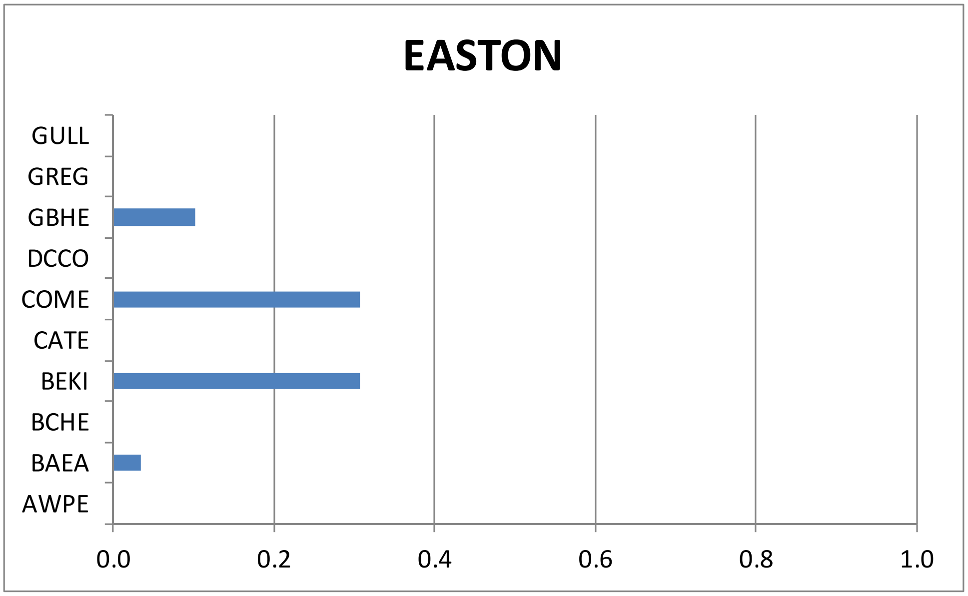


Figure 15: Easton summer bird abundance per kilometer 2011

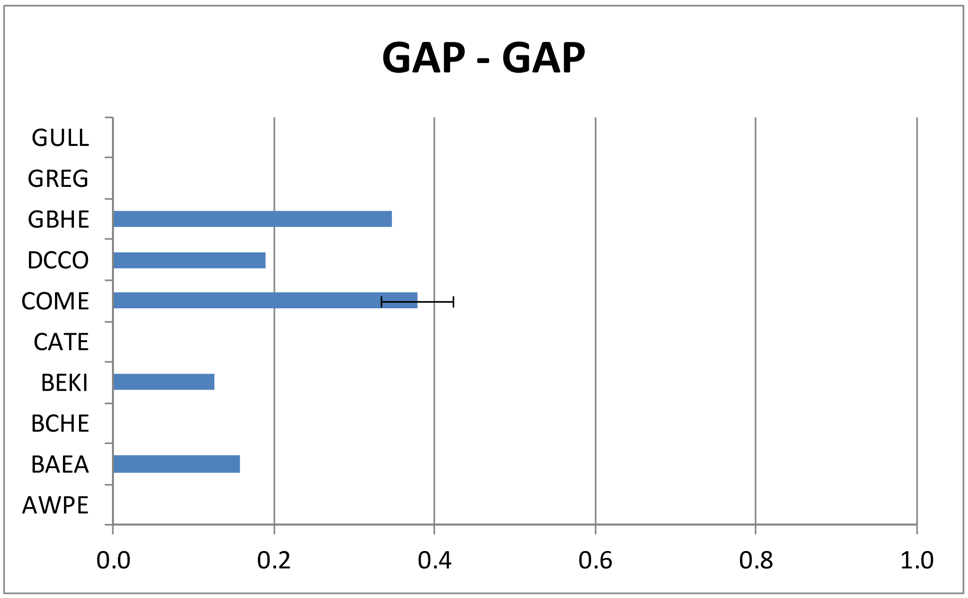


Figure 16: Gap to Gap summer bird abundance per kilometer 2011

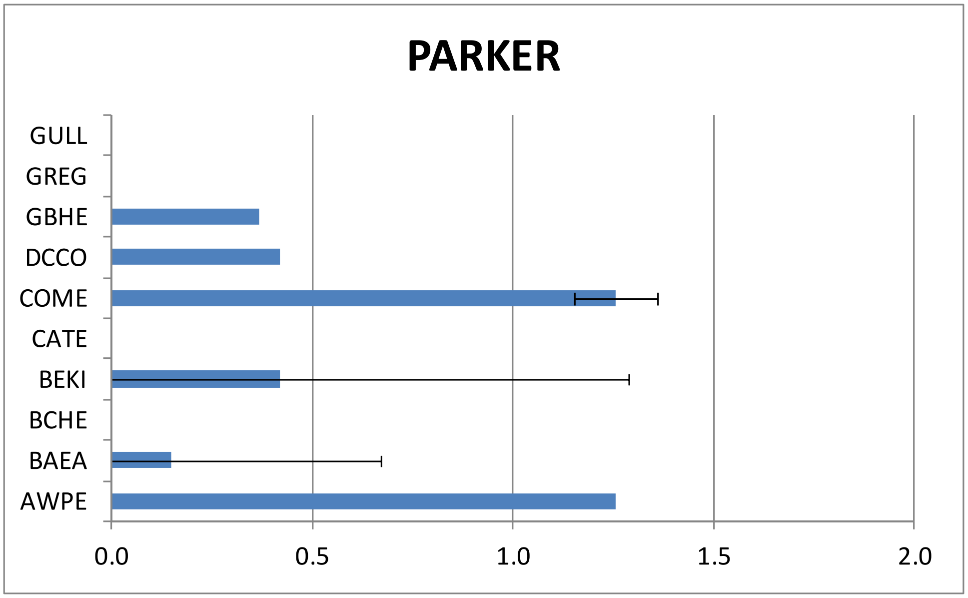


Figure 17: Parker summer bird abundance per kilometer 2011

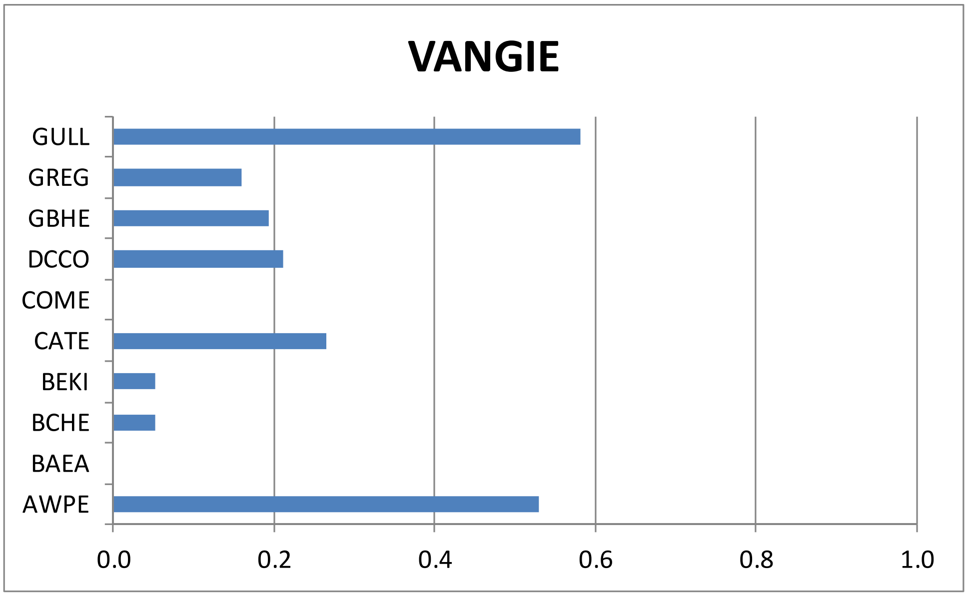


Figure 18: Vangie summer bird abundance per kilometer 2011

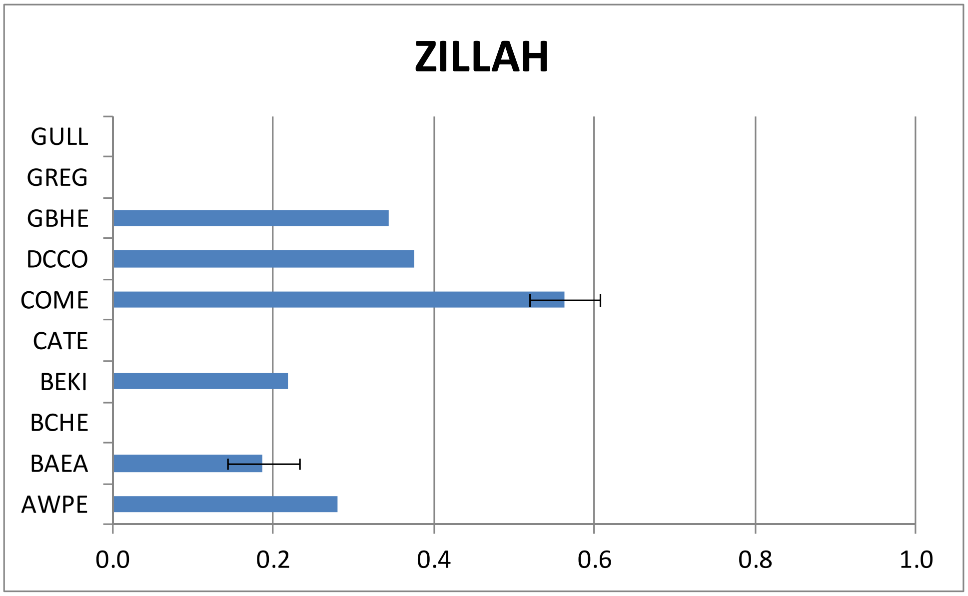


Figure 19: Zillah summer bird abundance per kilometer 2011

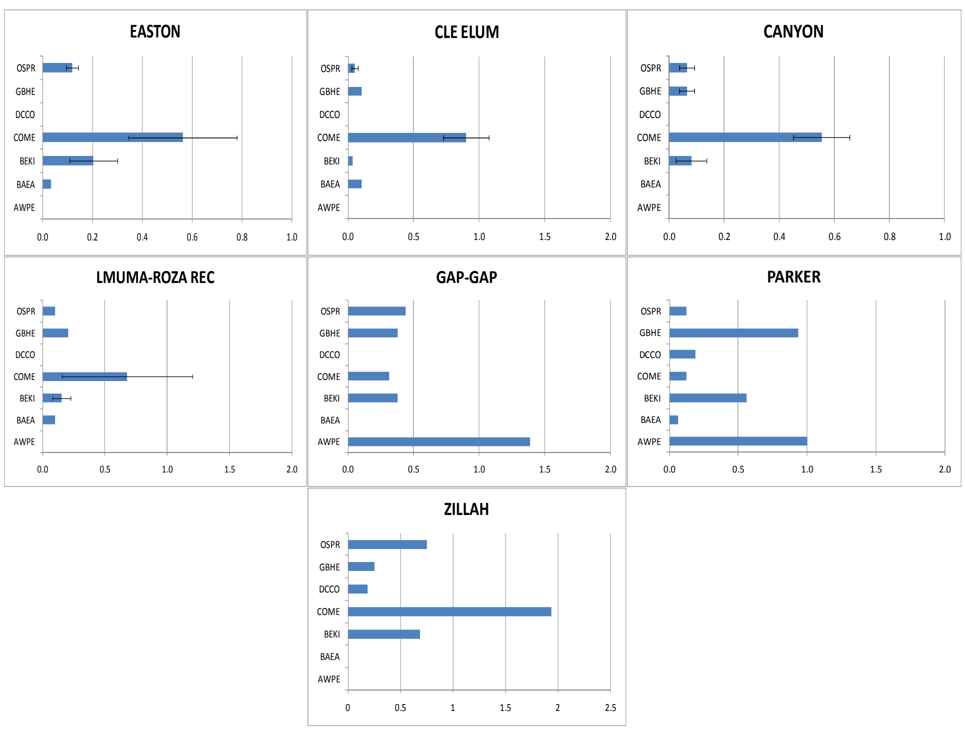


Figure 20: Summer bird abundance per kilometer shown with standard deviation error bars

Bird abundance surveys fourd that pelicans are seen in high numbers in the spring. This is evident in the Yakima river, from the Selah reach to the lower reaches of the Yakima river. Pelican numbers also show an increase in the Wapato Reach. 2010 to 2011 pelican numbers (shown in Figure 5) retained high numbers in 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	4/29/2011	4	0.21
BENTON	18.9	5/9/2011	25	1.32
CANYON	29.8	4/27/2011	24	0.81
CANYON	29.8	5/10/2011	36	1.21
CLE ELUM	28.3	4/26/2011	28	0.99
EASTON	29.3	5/3/2011	39	1.33
GAP	15.85	5/2/2011	40	2.52
GAP	15.85	5/10/2011	46	2.9
PARKER	20.3	4/18/2011	141	6.95
PARKER	20.3	5/5/2011	118	5.81
VANGIE	18.9	4/25/2011	47	2.49
VANGIE	18.9	5/9/2011	6	0.32
ZILLAH	16	4/21/2011	41	2.56
ZILLAH	16	5/5/2011	25	1.56

Table 3: 2011 spring totals of piscivorous birds per km (shown by survey date)

REACH	REACH LENGTH (KM)	Date	SumOfTOTAL NUMBER	TotalNumberBirdsPerKm
BENTON	18.9	7/11/2011	20	1.058201058
BENTON	18.9	7/19/2011	10	0.529100529
BENTON	18.9	7/28/2011	19	1.005291005
BENTON	18.9	8/17/2011	14	0.740740741
CANYON	29.8	7/14/2011	67	2.248322148
CANYON	29.8	8/9/2011	35	1.174496644
CANYON	29.8	8/30/2011	23	0.771812081
CLE ELUM	28.3	7/12/2011	12	0.424028269
CLE ELUM	28.3	7/21/2011	37	1.307420495
CLE ELUM	28.3	7/26/2011	74	2.614840989
CLE ELUM	28.3	8/15/2011	40	1.413427562
CLE ELUM	28.3	8/24/2011	28	0.989399293
EASTON	29.3	8/3/2011	26	0.887372014
GAP	15.85	7/18/2011	19	1.19873817
GAP	15.85	8/10/2011	28	1.766561514
HOLMES		7/27/2011	21	
HOLMES		8/2/2011	33	
HOLMES		8/9/2011	32	
HOLMES		8/30/2011	36	
PARKER	20.3	7/6/2011	95	4.679802956
PARKER	20.3	8/16/2011	78	3.842364532
VANGIE	18.9	7/11/2011	16	0.846560847
VANGIE	18.9	7/19/2011	48	2.53968254
VANGIE	18.9	7/28/2011	20	1.058201058
ZILLAH	16	7/6/2011	27	1.6875
ZILLAH	16	7/20/2011	33	2.0625

Table 4: 2011 summer totals of piscivorous birds per km (shown by survey date)

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. In 2010 this rookery was abandoned by the Cormorants and is not currently being used by any species.

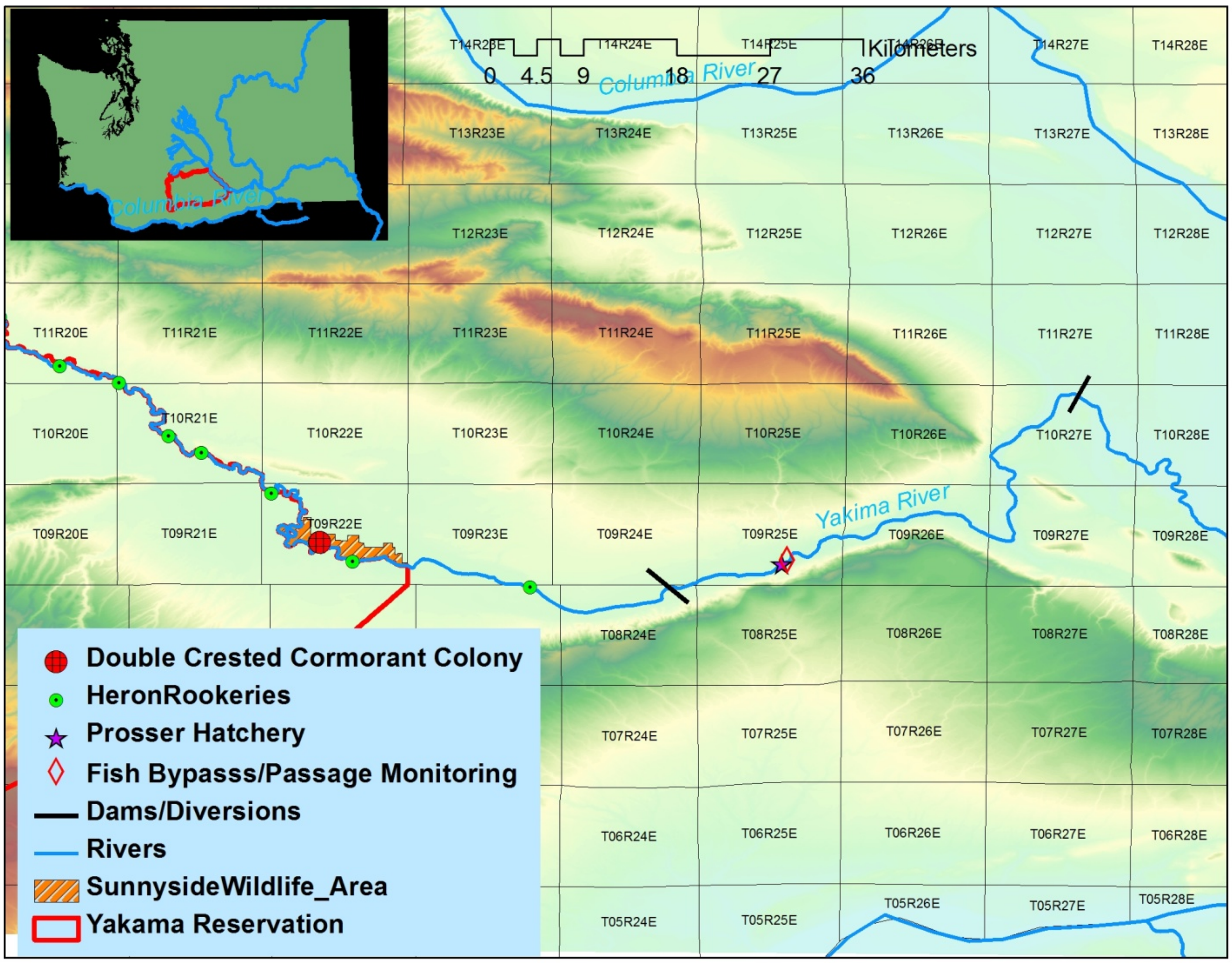


Figure 21: Double Crested Cormorant Colony

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. PIT tag studies have shown the Great Blue heron may have a more significant impact to juvenile salmonids than previously believed.

Common Mergansers along River Reaches

Abundance of Common Merganser in 2011 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.

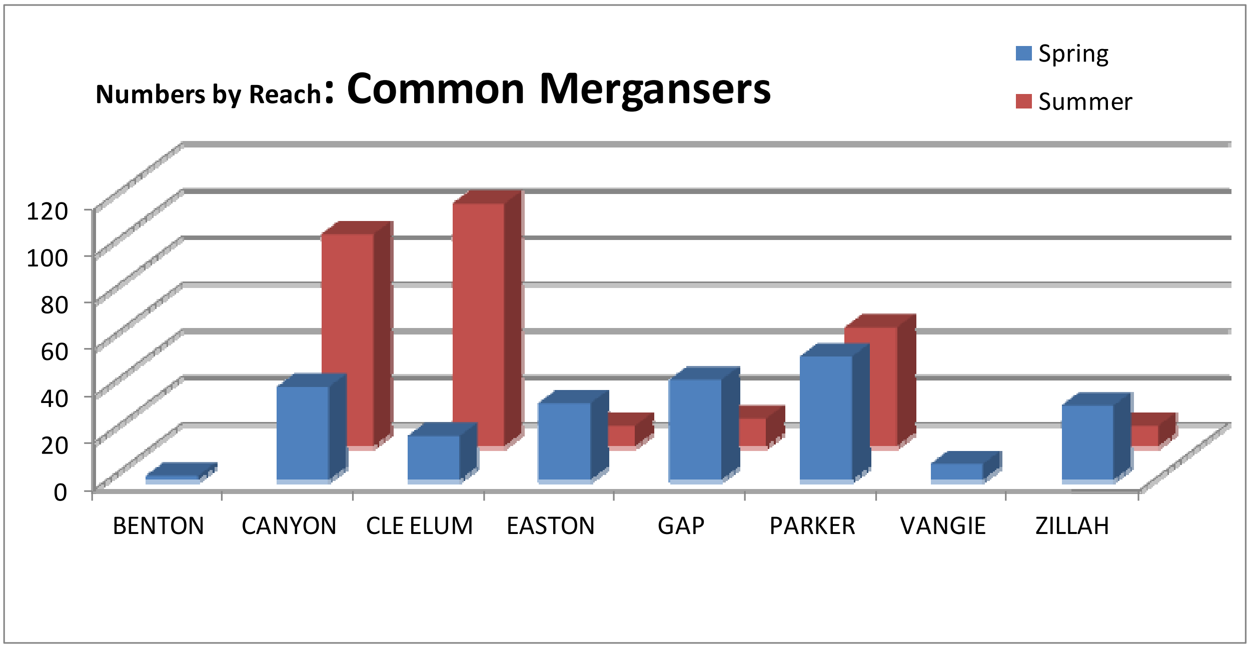


Figure 22: River reaches total number of surveyed COME for spring and summer of 2011

Figure 23: 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 2011, 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 2010 yet river surveys during 2011 show high numbers only in the Parker reach for 2011 (Figure 7).

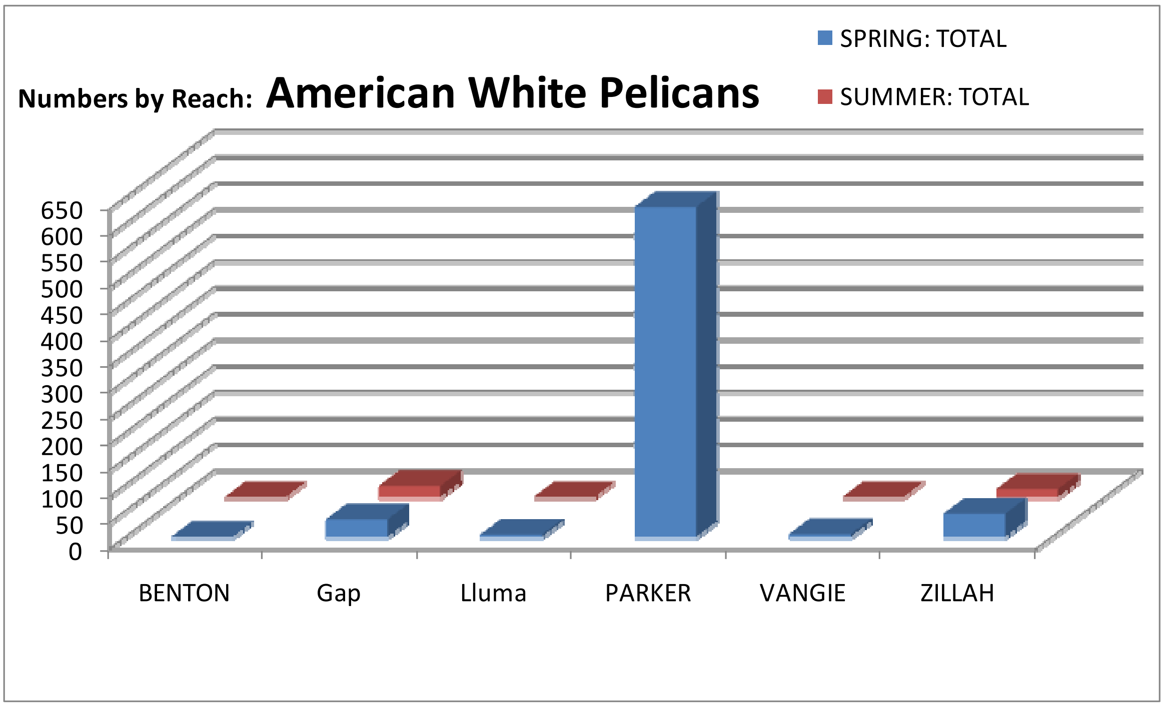


Figure 24: River reaches total number of surveyed American White Pelicans for spring and summer of 2011

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.

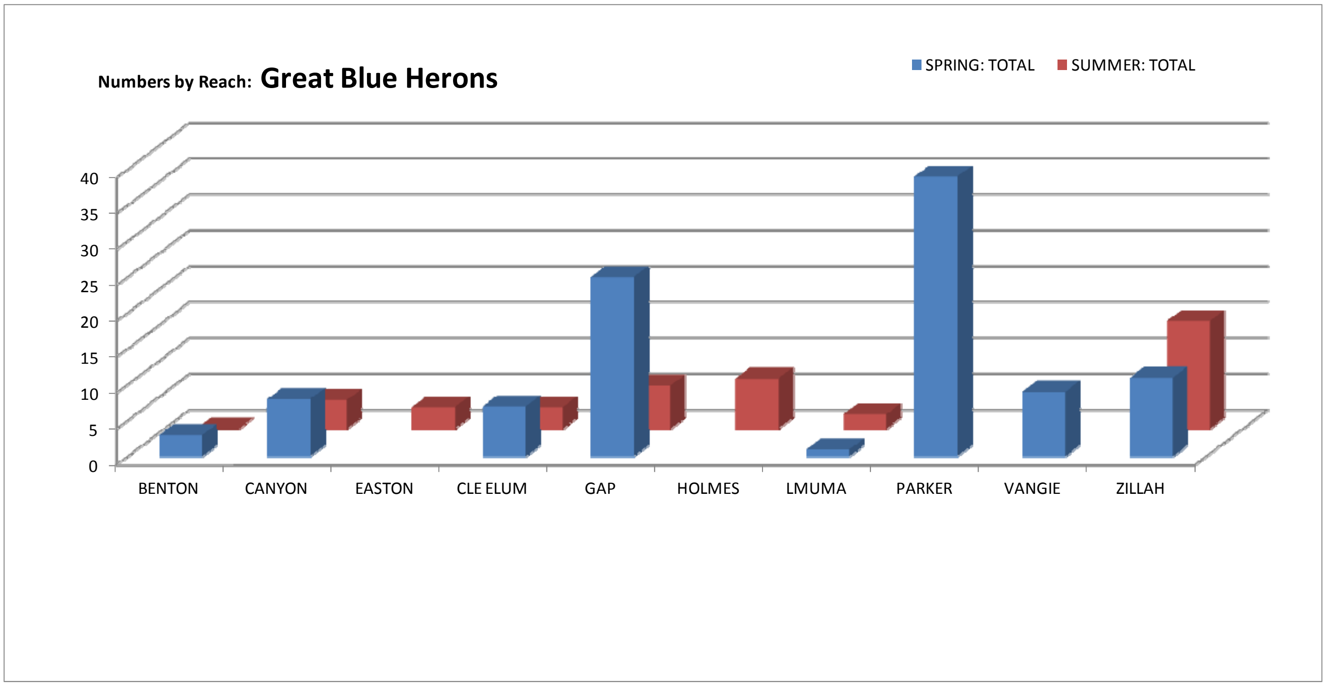


Figure 25: River reaches total number of surveyed Great Blue Herons for spring and summer of 2011

Smolts Consumed at Acclimation Sites

At the three Spring Chinook and five Coho salmon acclimation sites, in the upper Yakima River and tributaries, piscivorous bird surveys were conducted over a 3-5 month period. The survey period coincided with fish acclimation in the winter and spring of 2011. The most common birds seen preying on smolts were Bald Eagle, Belted Kingfishers, Common Merganser, and Great Blue Heron. Using the assumption that birds feeding in acclimation ponds are consuming only smolts when bird are 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 by a combination of in-basin and out-basin stocks for Coho acclimation sites.

For the Yakama Nation Spring Chinook acclimation sites (Clark Flat, Easton and Jack Creek), it was estimated that bird species together consumed 364 smolts at Clark Flat, 959 smolts at Easton, and 58 smolts at Jack Creek. In 2010, Bald Eagle, Belted Kingfishers, Common Merganser, Great Blue Heron and Ospreys consumed; 519 smolts at Clark Flat, 1,704 smolts at Easton, and 55 smolts at Jack Creek.

At two Coho acclimation sites (Easton Pond and Holmes), the most common birds preying on smolts were Bald Eagles, Belted Kingfishers, Common Mergansers, Great Blue Herons, and Ospreys. It is estimated that these bird species together consumed 66,668 smolts. Breakdown of smolts consumed for each acclimation site was, 27,667 smolts at Holmes and 39,001 smolts at Easton Pond. In 2010 at five Coho sites ((Boone, Easton Pond, Holmes, Lost Creek and Stiles) the Bald Eagle, Belted Kingfisher, Common Merganser and Great Blue Heron 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.

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.

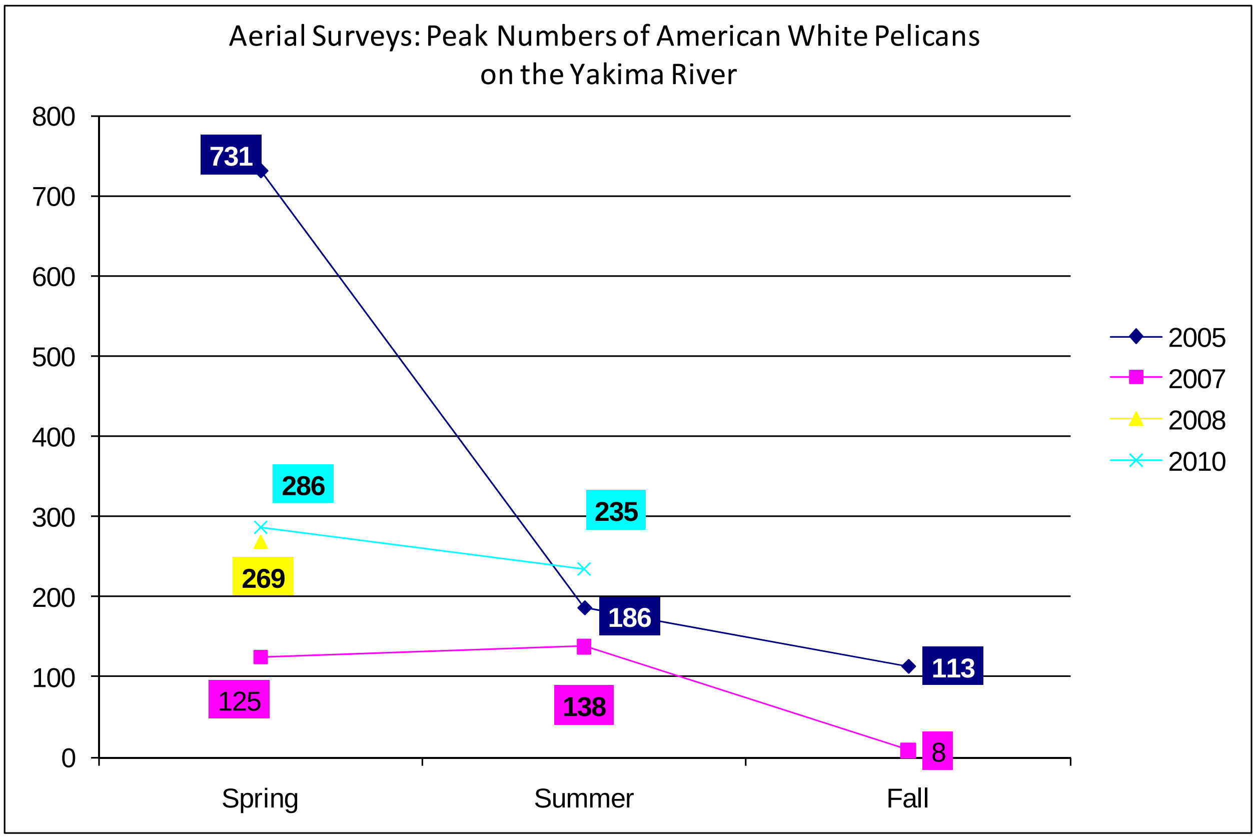


Figure 26: Aerial Surveys: American White Pelican numbers for the Yakima River

PIT Tag Surveys

In 2011 PIT tag surveys yielded a total of 21,455 distinct tags over all survey years this is up from 2010 number of 14,350. These were discovered within the 14 survey sites (Figure 27). 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 2011 are represented by Table 5 (includes fish tagged by other organizations which were found during surveys).

YKFP Predation Study: Total PIT tag Numbers For 2011

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	2012
		23															
Sockeye	Summer	9												1		8	
Chinook	Fall	5915			9	10	14	34	236	449	1645	1218	1804	190	277	29	
Chinook	Spring	10761		3	242	472	273	414	655	1318	1136	1570	2020	1690	701	267	
Chinook	Summer	3516								1			1	2199	703	612	
Chinook	Unknown	4					1	1	1					1			
Coho	Fall	803	1	2	172	216	142	270									
Coho	Spring	1			1												
Coho	Unknown	5825							265	926	559	896	1407	781	504	142	345
Steelhead	N/A	1													1		
Steelhead	Resident	12										3	3	5			1
Steelhead	Summer	381					9	24	69	73	13	30	35	58	46	24	
Steelhead	Unknown	5							1						4		

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. 2011 PIT tag surveys discovered 1293 new YINN juvenile salmonid tags within the Yakima Basin. These associated files contained 1,237,133 fish released since 1999 (overall there is close to 2.1 million of these tagged fish). The total number of PIT tags surveyed is 1.78% 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 2011 - 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	2011	2012
		8															
Sockey	Summer	2												1		1	
Chinook	Fall	2467			2	2	13	13	53	218	1027	407	565	61	77	29	
Chinook	Spring	6259		2	156	364	191	263	418	885	657	935	882	1008	379	119	
Chinook	Summer	1354								1			1	619	307	426	
Chinook	Unknown	2							1					1			
Coho	Fall	691	1	2	146	196	120	226									
Coho	Spring	1			1												
Coho	Unknown	3739							215	742	380	503	929	496	385	87	2
Steelhead	N/A	1													1		
Steelhead	Resident	9										2	3	4			
Steelhead	Summer	339					7	22	67	61	11	25	25	55	46	20	
Steelhead	Unknown	2							1						1		
Steelhead	Winter	1								1							

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 produced 12,184 PIT tags for the 2011 survey year. Yakama Nation Juvenile PIT tags which produced a tagging detail are shown in Table 7 which numbered 11877. 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 2011 - 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	2012
Chinook	*Fall*	2977		7	8	1	27	124	379	515	893	747	76	200		
Chinook	Spring	4336	1	91	151	84	162	202	498	402	593	1017	605	382	148	
Chinook	Summer	2444											1824	434	186	
Chinook	Unknown	2				1	1									
Coho	Fall	136		27	24	23	62									
Coho	Unknown	1922						29	154	148	338	370	285	198	57	343
Sockeye	Summer	7													7	
Steelhead	Resident	2									1					1
Steelhead	Summer	48				2	1	1	9	1	5	13	5	3	8	
Steelhead	Unknown	3													3	

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

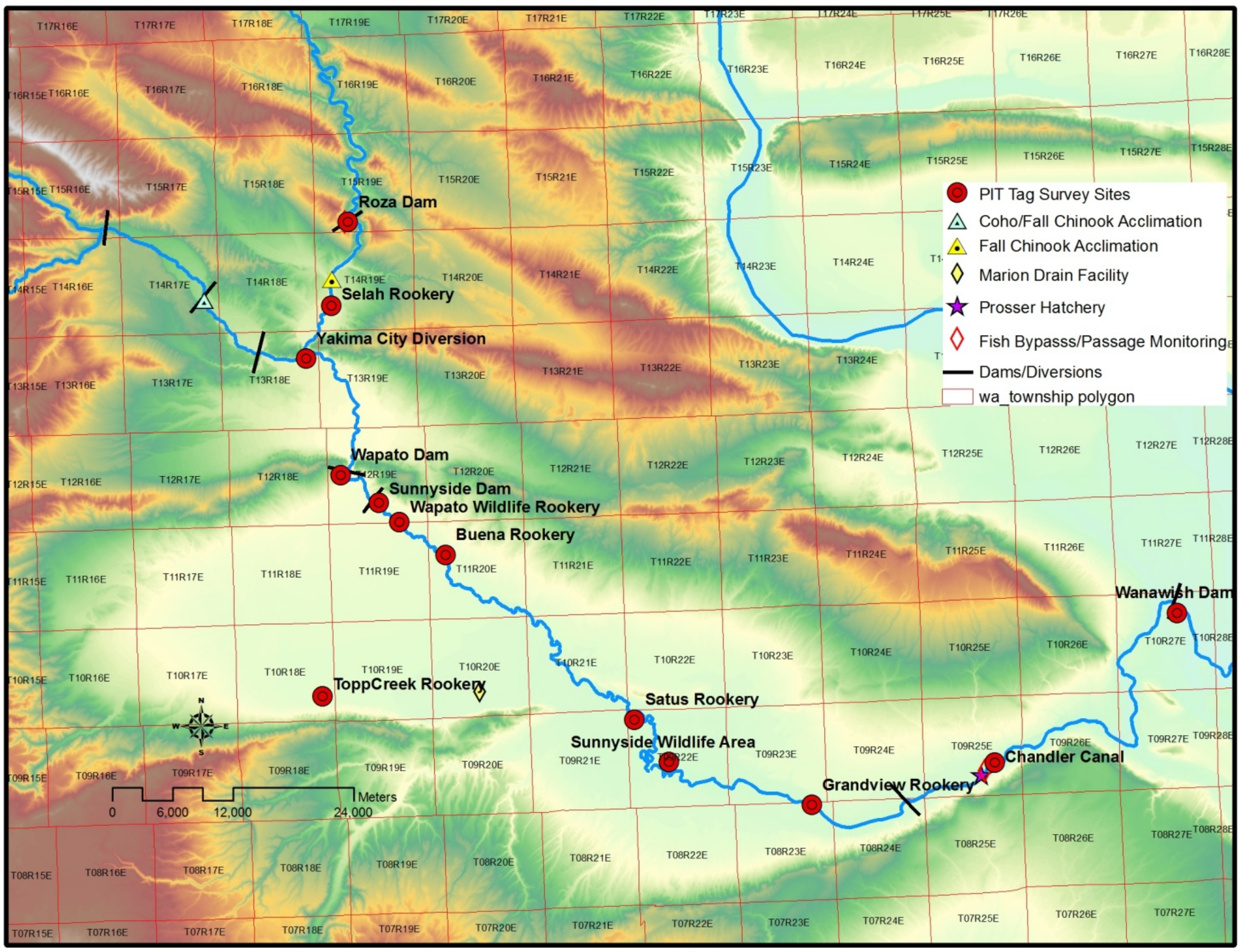


Figure 27: YKFP PIT Tag Survey Sites

Selah Heron Rookery

A total of 2436 PIT tags returned a tagging detail from the Selah rookery (Table 8). 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 28).

YKFP Predation Study: Rookeries PIT tag Numbers For 2011 - 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	2011
Chinook	Fall	272						6	165	16	85			
Chinook	Spring	1340	41	33	73	45	153	234	172	72	210	187	77	43
Chinook	Summer	226										14	30	182
Coho	Fall	91	28	23	22	18								
Coho	Unknown	827					63	244	87	69	181	96	63	24
Steelhead	N/A	1											1	
Steelhead	Resident	4									1	3		
Steelhead	Summer	2					1				1			

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

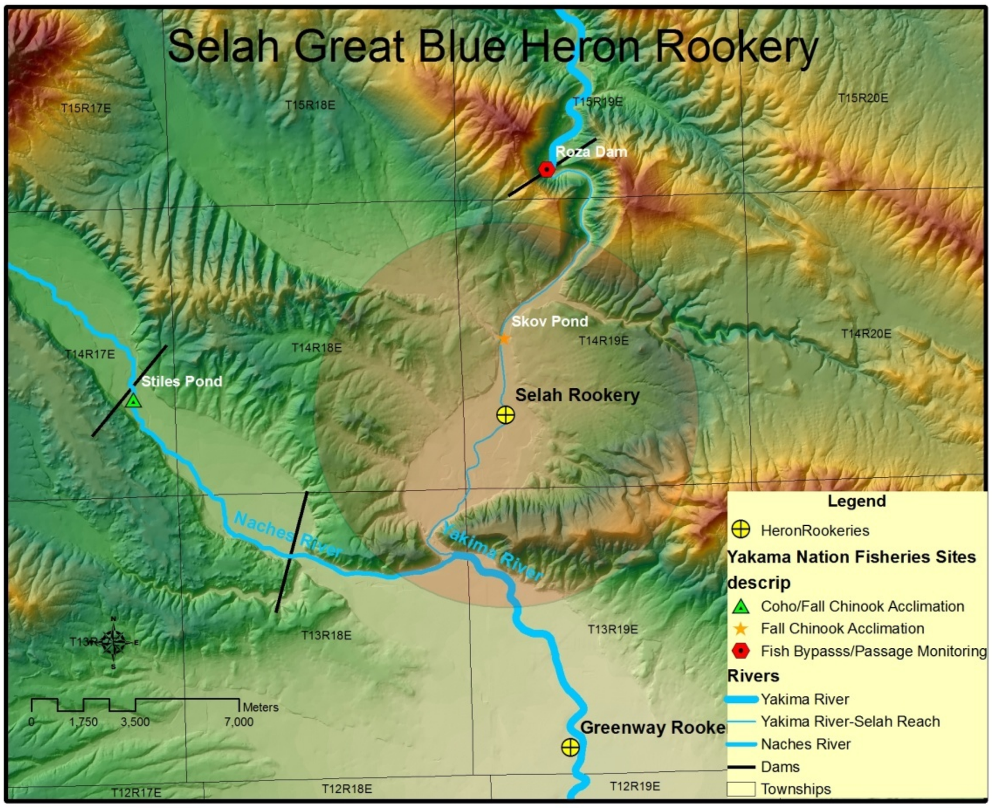


Figure 28: Selah Great Blue Heron Rookery

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 2010).

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 9 shows number of flushing flows within the Roza Reach by year and month.

Number of Flushing Flows									
	2010		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 2007, combined with PIT tags found for the corresponding years is shown in figure 29. 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 2007, consistently above 1000 CFS by the third week of March, only 80 tags of release year 2007 were found at the Selah rookery.

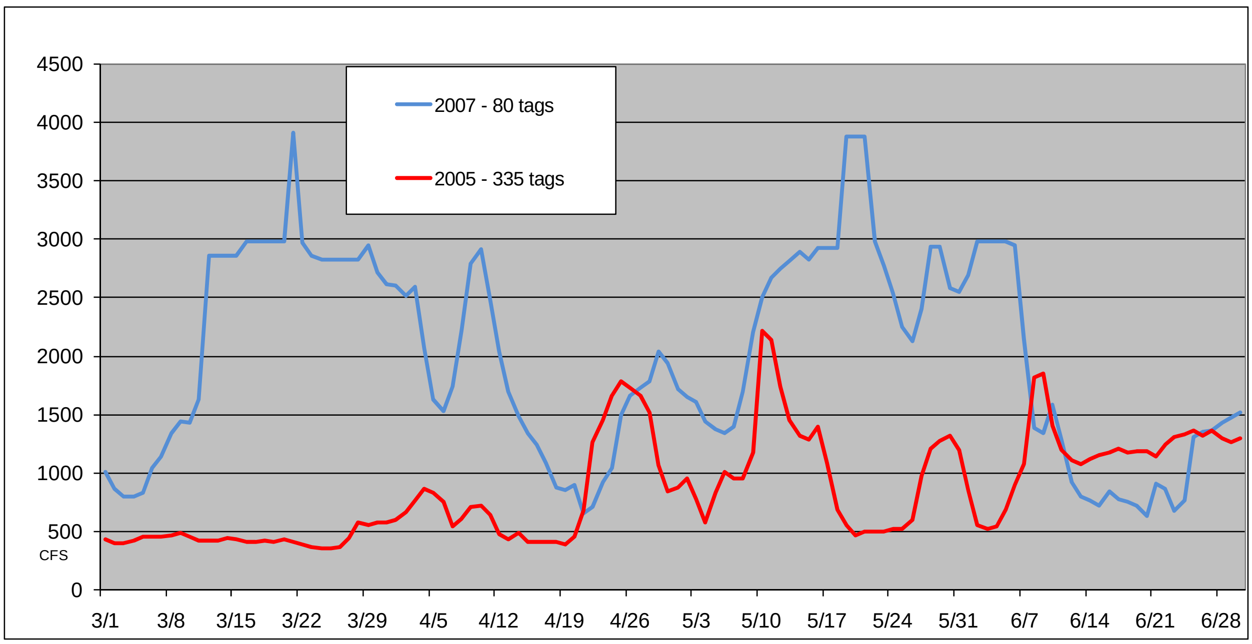


Figure 29: Yakima River water flow (CFS) below Roza dam for years of 2005 and 2007. Shown with number of tags found at the Selah Rookery for corresponding years

Analysis of Species Composition within the Selah rookery found that over 50 percent of the tags belonged to Spring Chinook salmon smolts (Figure 30). Because of this observation and the value of this species, the Selah Rookery Study has focused on Spring Chinook Salmon. Analysis of Spring Chinook tag data is aided 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.

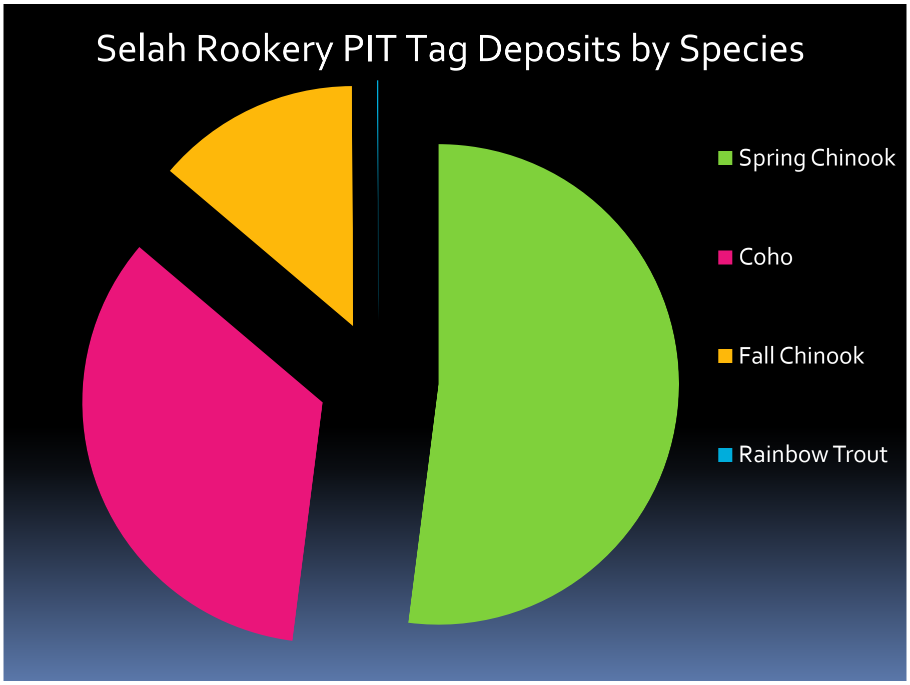


Figure 30. Selah Heron Rookery PIT tags pie chart of species composition.

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 2011. Of these overall releases 1,262 were found in Selah Rookery.

Rookeries: PIT tag Survey Sites Data

Surveys for PIT tags linked to avian predation in 2011 were carried out in 5 Great Blue Heron Rookeries. Rookery surveys were first conducted in 2008 in limited areas to test whether they would yield PIT tags.

YKFP Predation Study: Rookeries PIT tag Numbers For 2011 - 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	2011	2012
Chinook	Fall	137		1	2	4	7	8	1	37	27	9	12	29	
Chinook	Spring	390	3	18	10	41	28	15	33	59	52	50	33	48	
Chinook	Summer	42										27	9	6	
Coho	Fall	31		11	6	14									
Coho	Unknown	196					10	8	11	69	35	26	25	10	2
Steelhead	Summer	7						4			1	1		1	
Steelhead	Unknown	1											1		
Steelhead	Summer	2					1				1				

Table 10: Pit tag numbers by species surveyed in Grandview Rookery

Sunnyside Rookery

YKFP Predation Study: Rookeries PIT tag Numbers For 2011 - Sunnyside Rookeries

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**	392			1		14	13	36	78	190	34	26	
Chinook	**Spring**	1769	1	2	1	8	55	66	268	494	264	499	110	1
Chinook	**Summer**	20									1	2	3	14
Chinook	**Unknown**	1										1		
Coho	**Fall**	5	2	1		2								
Coho	**Unknown**	480					10	50	76	54	123	138	26	3
Sockeye	**Summer**	1										1		
Steelhead	**Resident**	1									1			
Steelhead	**Summer**	29					5	4	2	2	5	9	2	

Table 11: Pit tag numbers by year/species surveyed in Sunnyside Rookeries

YKFP Predation Study: Rookeries PIT tag Numbers For 2011 - Toppenish Creek Rookery

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Chinook	**Spring**	2			2							
Coho	**Unknown**	265							264			1
Steelhead	**Summer**	124	1	2	4	9	3	8	13	25	40	19

Table 12: Pit tag numbers by year/species surveyed in Toppenish Creek Rookery

Out of these 391 PIT tags which returned a tagging detail, over 215 belonged to one tag file. These 215 were Coho released from a net pen in Cle Elum Lake in 2008 and it is thought that these Coho were late migrants (Tags were not detected at Cle Elum passage detector).

Wapato Wildlife Rookery

YKFP Predation Study: Rookeries PIT tag Numbers For 2011 - Wapato Wildlife Rookery

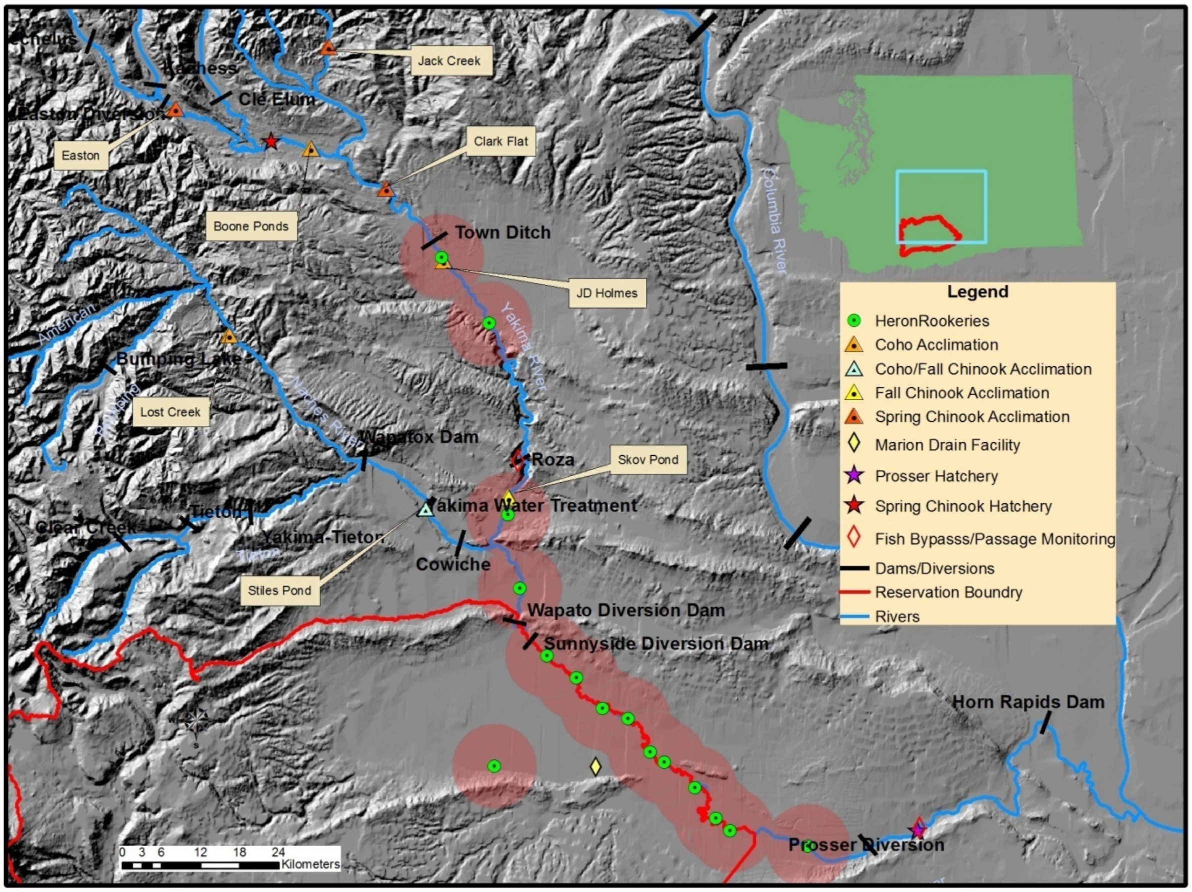
PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Chinook	**Fall**	698					1	73	275	167	178		4	
Chinook	**Spring**	1236	21	115	36	53	52	263	71	112	243	144	114	12
Chinook	**Summer**	885										512	175	198
Coho	**Fall**	169	32	34	33	70								
Coho	**Unknown**	960					31	142	90	156	180	144	178	39
Sockeye	**Summer**	1												1
Steelhead	**Resident**	2								1	1			
Steelhead	**Summer**	8					2	2			2		2	

Table 13: Pit tag numbers by year/species surveyed in Wapato Wildlife Rookery

Yakima Basin Rookeries Surveyed

In Between 2008 and 2011 Great Blue Herons Rookeries in the Yakima Basin were surveyed to determine populations and yearly trends. Figure 31 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 31. 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 area's primary predator, the American White Pelican.

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).

YINN Smolts: Badger Island PIT tag Numbers For 2011

PIT Tags Sorted by Migration Year

species	*run*	*Total PIT Tag Numbers*	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sockeye	**Summer**	1								1	
Sockeye	**Unknown**	6								6	
Chinook	**Fall**	592		1	5	4	29	4	234	315	
Chinook	**Spring**	431	2			2	10	8	119	290	
Chinook	**Summer**	601						17	208	376	
Coho	**Unknown**	256	2	1		1	8	5	130	100	9
Steelhead	**Summer**	9						1		8	

Table 14: **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 2011 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 2012 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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