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 dire situation of many salmon and steelhead stocks, and the heavy reliance on artificial propagation as a recovery tool, YKFP monitoring results will have great region-wide significance.

Supplementation is envisioned as a means to enhance and sustain the abundance of wild and naturally-spawning populations at levels exceeding the cumulative mortality burden imposed on those populations by habitat degradation and by natural cycles in environmental conditions. A supplementation hatchery is properly operated as an adjunct to the natural production system in a watershed. By fully integrating the hatchery with a naturally-producing population, high survival rates for the component of the population in the hatchery can raise the average abundance of the total population (hatchery component + naturally-producing component) to a level that compensates for the high mortalities imposed by human development activities and fully seeds the natural environment.

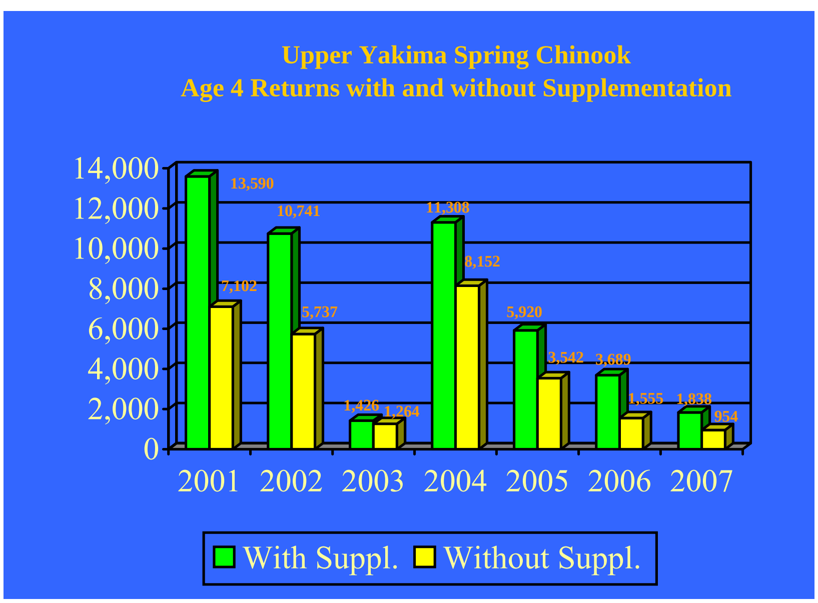
The objectives of the YKFP are to: use Ecosystem Diagnosis and Treatment (EDT) and other modeling tools to facilitate planning for project activities, enhance existing stocks, re-introduce extirpated stocks, protect and restore habitat in the Yakima Subbasin, and operate using a scientifically rigorous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

Spring Chinook

The Cle Elum Supplementation and Research Facility (CESRF) collected its first spring Chinook brood stock in 1997, released its first fish in 1999, and age-4 adults have been returning since 2001, with the first F2 generation (offspring of CESRF and wild fish spawning in the wild) returning as adults in 2005. In these initial years of CESRF operation, recruitment of hatchery origin fish has exceeded that of fish spawning in the natural environment, but early indications are that hatchery origin fish are not as successful at spawning in the natural environment as natural origin fish. Preliminary results indicate that significant differences have been detected among hatchery and natural origin fish in about half of the traits measured in our monitoring plan and that these differences can be attributed to both environmental and genetic causes. For example, we have detected differences in hatchery and natural origin fish after only one generation of hatchery exposure for the following variables measured on adults: age composition, size-at-age, sex ratio, spawning timing, fecundity, egg weight, adult morphology at spawning, spawning success. Significant differences in juvenile traits have also been detected: food conversion efficiency, length-weight relationships, agonistic competitive behavior, predator avoidance, and incidence of precocious maturation. Most of the differences have been 10% or less.

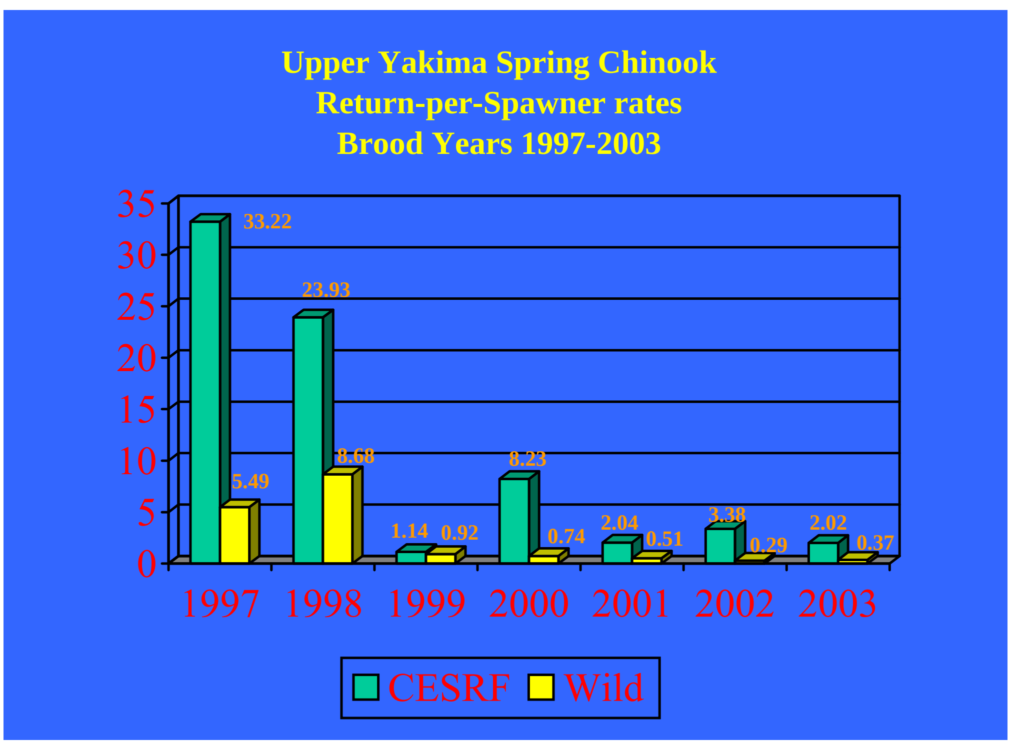
Distribution of spawners has increased as a result of acclimation site location and salmon homing fidelity. Semi-natural rearing and predator avoidance training have not resulted in significant increases in survival of hatchery fish. Growth manipulations in the hatchery appear to be reducing the number of precocious males produced by the YKFP and consequently increasing the number of migrants, however post-release survival of treated fish appears to be significantly lower than conventionally reared fish. Genetic impacts to non-target populations appear to be low because of the low stray rates of YKFP fish. 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. Fish and bird piscivores consume large numbers of salmonids in the Yakima Basin. Natural production of Chinook salmon in the upper Yakima Basin appears to be density dependent under current conditions and may constrain the benefits of supplementation. However, such constraints could be countered by YKFP habitat actions that have resulted in: the protection of almost 1,000 acres of prime floodplain habitat, reconnection and screening of over 15 miles of tributary habitat, substantial water savings through irrigation improvements, and restoration of over 80 acres of floodplain and side channels. Additional habitat improvements implemented by other entities, including the Conservation Districts, counties and private interests are also continuing in the basin. Harvest opportunities for tribal and non-tribal fishers have also been enhanced, but are variable among years.

Figure 1. Actual returns (green bar) of age-4 Upper Yakima spring Chinook to the Yakima River mouth compared to estimated returns (yellow bar) if the Cle Elum Supplementation and Research Facility (CESRF) had not been constructed. Data are for age-4 return years 2001-2007.



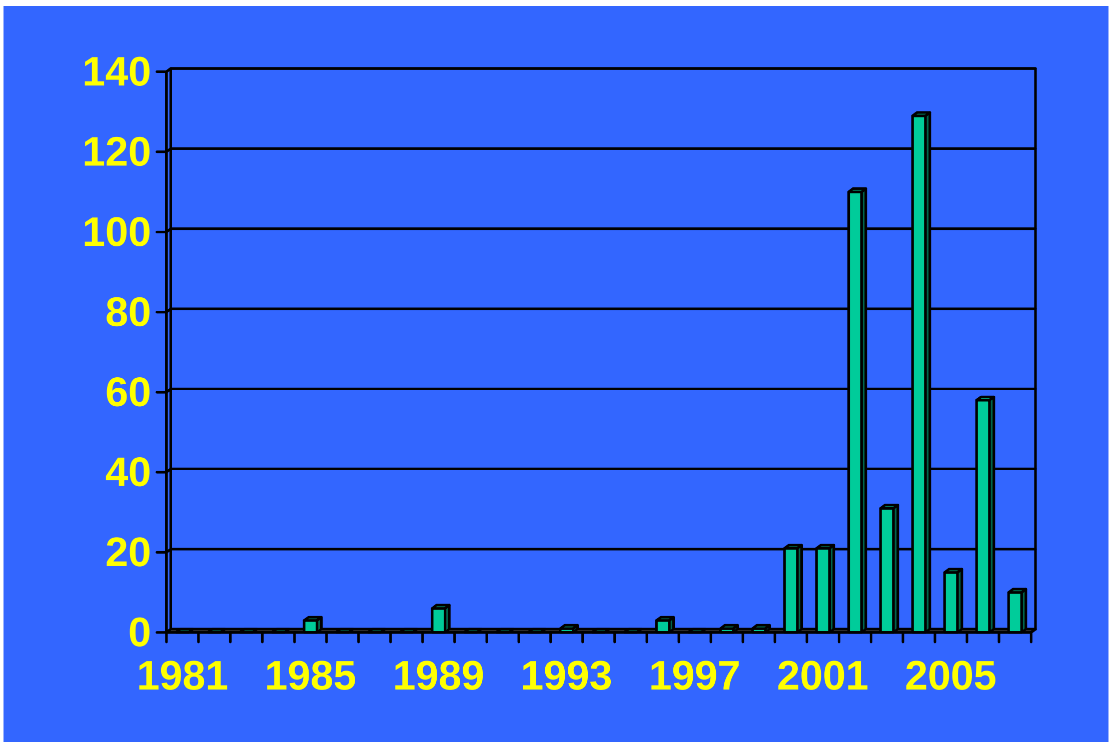
Methods and Discussion: For all years, actual returns with supplementation (green bars) are derived from actual counts of marked (CESRF) and unmarked (wild/natural) fish at Roza Dam backed through harvest to the Yakima River mouth. For F1 returns (returns from wild fish spawned in the hatchery) in 2001-2004, the yellow bars (estimated returns without supplementation) are calculated as the actual returns of unmarked (wild) fish at Roza backed to the river mouth plus estimated returns from fish taken for CESRF broodstock had these fish been allowed to spawn in the wild and returned at observed wild/natural return per spawner rates. For F2 and later generation returns from 2005 forward (where wild/natural returns are comprised of crosses of wild/natural and CESRF fish spawning together in the wild), estimated returns without supplementation are calculated as if the estimated "without supplementation" return four years earlier had been the total escapement, spawned in the wild, and their progeny returned at observed wild/natural return per spawner rates. Using this method the estimated benefit (increase in abundance of natural spawners) from supplementation ranged from 13% in return year 2003 to 137% in return year 2006 and averaged 75% from 2001-2007.

Figure 2. Yakima River mouth return per spawner (adult-to-adult productivity) rates of Cle Elum Supplementation and Research Facility (CESRF) and wild/natural upper Yakima spring Chinook for brood years 1997-2003. Note: Age-5 returns are not yet included for brood year 2003.



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

Figure 3. Teanaway River Spring Chinook Redd Counts, 1981 – 2007.



Methods and Discussion: Redd surveys in the Teanaway River have been conducted annually by Yakama Nation staff since 1981. The Jack Creek acclimation site began releasing CESRF spring chinook in 2000, with the first age-4 females returning from these releases in 2002. Redd counts in this tributary have increased from a pre-supplementation average of 3 redds per year to a post supplementation average of 59 redds per year. In addition, the number of natural origin spawners has increased in the targeted Teanaway River indicating this approach may be successful for reintroduction of salmonids into underutilized habitat.

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

Fall Chinook

The YKFP is presently studying the release of over 2.0 million Upriver Bright fall Chinook smolts annually from the Prosser and Marion Drain Hatcheries. 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. Marion Drain broodstock are collected from adult returns to a fishwheel in the drain. 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.

Coho

The YKFP is presently studying the release of over 1.0 million coho smolts annually from acclimation sites in the Naches and Upper Yakima subbasins. These fish are a combination of in-basin production from brood stock collected in the vicinity of Prosser Dam plus out-of-basin stock generally reared at Willard or Eagle Creek National Fish Hatcheries and moved to the Yakima Subbasin for final rearing and release. YKFP monitoring of these efforts to re-introduce a sustainable, naturally spawning coho population in the Yakima Basin have indicated that adult coho returns averaged over 3,400 fish from 1997-2007 (an order of magnitude greater than the average for years prior to the project) including estimated returns of wild/natural coho averaging nearly 1,300 fish since 2001. Coho re-introduction research has demonstrated that hatchery-reared coho can successfully reproduce in the wild. The project is working to further develop a locally adapted broodstock and to establish specific release sites and strategies that optimize natural reproduction and survival.

Habitat

The project objectives include habitat protection and restoration in the most productive reaches of the Yakima Subbasin. The YKFP's Ecosystem Diagnosis Treatment (EDT) analysis will provide additional information related to habitat projects that will improve salmonid production in the Yakima Subbasin. Major accomplishments to date include protection of almost 1,000 acres of prime floodplain habitat, reconnection and screening of over 15 miles of tributary habitat, substantial water savings through irrigation improvements, and restoration of over 80 acres of floodplain and side channels.

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), numerous technical reports (such as these annual reports) and publications, and other means. Data and results are published in the peer-reviewed literature as they become ripe. Since its inception, the YKFP has generated a number of technical manuscripts that are either in final internal review, in peer review, are in press, or are published. Please refer to the project web site for a complete list of project technical reports and publications. Project publications for this performance period relevant to this specific contract include:

Busack, C. A., C. M. Knudsen, G. Hart, and P. Huffman. 2007. Morphological differences between adult wild and first-generation hatchery upper Yakima River spring Chinook salmon. Transactions of the American Fisheries Society 136:1076-1087.

May, D., D. Larsen, M. Moser, D. Fast, M. Johnston, and A. Dittman. 2007. Spatial patterns of Yakima River Spring Chinook spawning before and after supplementation. Presented at National Conference of American Fisheries Society, San Francisco, August, 2007.

Introduction

While the statement of work for this contract period was provided in work element format, we believe that annual progress is best organized and communicated by task as presented in our FY2007-2009 proposal. The monitoring and evaluation program for the YKFP was organized into four categories- Natural Production (tasks 1.a - 1.p), Harvest (tasks 2.a and 2.b), Genetics (tasks 3.a and 3.b) and Ecological Interactions (tasks 4.a – 4.d). This annual report specifically discusses tasks directly conducted by the Yakama Nation during fiscal year 2007. Those tasks that are conducted directly by the Washington State Department of Fish and Wildlife cite the written report where a complete discussion of that task can be found. International Statistical Training and Technical Services (IntStats) provides the biometrical support for the YKFP and IntStats' written reports for tasks 1.c, 1.d, 1.f, and 1.g are included in full as appendices to this report. Some tasks have been completed or have been discontinued; information regarding these tasks was published in prior annual reports.

Contributing authors from the Yakama Nation YKFP in alphabetical order are: Michael Berger, 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 the "Ecosystem Diagnosis and Treatment" (EDT) and All-H analyzer (AHA) models. Additional information about these models can be obtained through Mobrand, Jones, and Stokes (see www.mobrand.com).

Progress:

Early run Fall Chinook Reintroduction modeling analysis:
A combination of the Eco-systems Diagnostic & Treatment (EDT) and the All-H-Analysis (AHA) models were used to analyze the theoretical performance of a reintroduced early run fall Chinook stock in the Yakima River Subbasin. The analysis is intended to provide the basis for developing a biological hypothesis regarding the long term viability of the reintroduced stock founded upon the spatial and temporal relationships between the current habitat conditions of the Yakima River and the life history characteristics of the donor stock. Information derived from the analysis can be used as a management tool in the reintroduction effort for various components of artificial production and planning including broodstock management, juvenile rearing/release strategies and the size and duration of the program. Potential limiting factors effecting the productivity and capacity of the river system will also be identified for the stock given the projected spawning and rearing distribution in the modeling analysis.

The EDT model uses an assortment of biological information in its model platform for characterizing a population's demographics and life history characteristics. These include adult & juvenile age structures, sex ratios, fecundity, spawn timing and distribution, adult migration & holding patterns and juvenile rearing & migration patterns. Most of these traits were held constant in the analysis with the exception of juvenile rearing patterns. Several scenarios were conducted to reflect the range and/or combination of potential juvenile rearing strategies manifested in the reintroduced stock. Defining the juvenile rearing strategies was based upon the observed rearing and movement patterns of the likely donor stock. The likely donor stock to be used for the reintroduction effort has been identified as the Wells integrated hatchery stock which uses a combination of hatchery and natural origin fish for its programmatic broodstock needs. Natural origin fish incorporated into the program are made up of fish destined for the Methow and Okanogan watersheds located above Wells dam and hatchery. Juvenile rearing patterns between these natural producing populations are similar in nature, and include three distinct rearing strategies consisting of two "ocean type" strategies and one "stream type" rearing strategy. Further detail of these three different rearing strategies is provided below:

1.) Ocean type 1 (OT1)- This pattern is considered the classic ocean type where sub-yearlings exhibit spring and early summer movement from the natal freshwater areas down into the Columbia River. Once in the Columbia River, juveniles have the tendency to continue moving downstream through the mainstem until reaching the Columbia estuary.

2.) Ocean type 2 (OT2)- Juveniles of this rearing type consist of sub-yearlings exhibiting a late spring to mid summer movement from their natal headwaters downstream toward the Columbia River. Rate of movement of these juveniles may be protracted with intermittent periods of rearing resulting in juveniles over wintering in lower river segments of the subbasin or the Columbia mainstem before continuing on to the estuary the following spring.

3.) Stream type (ST)- This rearing pattern is similar in nature to the classic stream type juvenile rearing pattern observed in spring run populations of chinook. Juveniles of this rearing type will take up resident rearing in the vicinity of emergence for an entire year before migrating the following spring as a yearling.

From a modeling perspective, some of the demographics and life history characteristics are simplistic and fairly straight forward. These include the adult age structures, sex ratios, fecundity and spawn timing. For these types, empirical data from the donor stock was used to populate the attributes and were held constant throughout the analysis. The spawning distribution of the reintroduced stock assumed a similar distribution to the known historical distribution once present in the Yakima River. Scant literature suggests the primary spawning distribution was located in the gap to gap reach near the city of Yakima but most likely extended upstream into the canyon reach above Roza dam on the Yakima River and up the Naches to the confluence with Tieton River.

Adult migration and holding patterns associated with timing of arrival and movement through the lower Yakima River is a critical uncertainty in the reintroduction effort. In terms of estimating the arrival time to the mouth of the Yakima River, run timing and distribution could be calibrated with the use of Upper Columbia summer Chinook PIT-tagged information at McNary Dam. For the combined years of 2006 & 2007, roughly 50% of the run had passed by the middle of July with another 36% of the total run migrating over the last two weeks of July (Figure 4). Super imposing this run timing information on top of the Lower Yakima temperature profile raises additional questions about a potential thermal barrier resulting in delayed migration into the Yakima River.

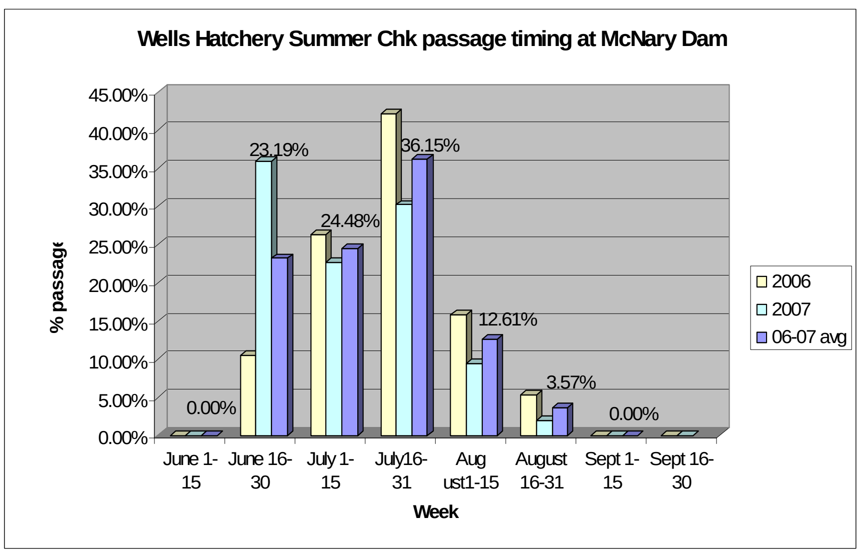


Figure 4. Run-timing distribution of Upper Columbia Summer/Fall Chinook at McNary Dam for 2006-2007.

Upon arrival to the mouth of the Yakima, average temperatures will be above 22 degrees Celsius or 71 degrees Fahrenheit when the majority of fish show up. Ironically, the temperature profiles in the Okanogan River are very similar to the Yakima for the months of July and August. Up in that particular system, the fish simply hold in the Columbia until the temperatures subside below 21 before migrating upstream. Some radio telemetry work done by WDFW showed very few Chinook to move into the system when temperatures were above 21 degrees Celsius (WDFW 2007). Based on the observed movement and holding patterns of the donor stock in the Upper Columbia, a similar pattern was assumed for the reintroduced stock in the Yakima River. 100% of adults were held at the mouth of the Yakima River until the middle of August when temperatures are expected to subside below 21 degrees Celsius.

As previously mentioned, several model scenarios were conducted to reflect the range and/or combination of potential juvenile rearing strategies manifested in the reintroduced stock. We wanted to test the viability of each juvenile life history pattern as a function of the spatial and temporal habitat characteristics. In order to do so, we forced the population to exhibit 100% of each juvenile pattern. We also created a composite population consisting of 75% Ocean type 1, 20% Ocean type 2, and 5% of the Stream type rearing patterns. The composite population is meant to represent a best-guess estimate of what you might observe in the Yakima River based upon the inherited genetic predisposition and the environmental conditions influencing them. Modeling 100% expression of each juvenile rearing pattern and creating one composite rearing pattern results in a total of four different model scenarios for the modeling analysis. For each of them, the same assumptions about adult migration and holding patterns were applied. Average harvest rates and cumulative exploitation across all Fisheries were also included in the analysis. The projected equilibrium abundance of each scenario represents on average, the number of adults escaping to the spawning grounds post fisheries. Results of the modeling scenarios are listed below in Table 1. These results are the first in a series of Yakima River reintroduction modeling analysis of early-run fall Chinook. Future work will incorporate additional scenarios regarding adult movement patterns and timing into the Yakima River, and altered spawn timing/emergence timing based on the temperature profiles of various river segments.

Table 1. Model scenario results for each juvenile rearing pattern

Juvenile Rearing pattern/scenario	Equilibrium Abundance
100% Ocean Type 1 (OT1)	1,325
100% Ocean Type 2 (OT2)	0
100% Stream Type (ST)	187
Composite (75%, 20%, 5%)	1,223

2007 field work:
No field work was conducted in 2007 targeting attributes in the EDT and AHA models for the Yakima Subbasin.

Task 1.b Percent habitat saturation and limiting factors

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

Pearsons, T. N., C. L. Johnson, and G. M.Temple. 2008. Spring Chinook Salmon Interactions Indices and Residual/Precocious Male Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report 2007. DOE/BP-00034450.

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 returned from this experiment in 2006. For brood years 2002-2004, the YKFP is testing 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 being tested are a normal (HI) growth regime resulting in fish which are about 30/pound at release and a slowed growth regime (LO) resulting in fish which are about 45/pound at release. For brood year 2005, we are testing a saltwater transition feed during the acclimation rearing phase to see if it improves survival to returning adult relative to standard nutritional feeds. For brood year 2006, we are testing a moist feed (EWOS, Canada) against a standard feed (BioVita, BioOregon, Inc., Oregon). However, because of high mortality rates associated with the EWOS feed, all fish were put on the same BioVita diet on May 3, 2007 after approximately two months of experimental and control diets. In addition to these treatments, the YKFP initiated a hatchery-control line in 2002 to test differences in fish that have only one generation of exposure to the hatchery environment (supplementation line whose parents are always natural-origin fish) to fish that have multiple generations of hatchery exposure (hatchery control line whose parents are always hatchery-origin fish).

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

Progress: Tagging of brood year 2006 fish began at the Cle Elum hatchery on October 15, 2007 and was completed on November 29, 2007. Marking results are summarized in Table 2. Appendix A contains mark summary data for brood years since 2002 (see previous annual reports for earlier brood years). As in prior years, all fish were adipose fin-clipped. Between 2,000 and 4,000 fish (4.8% to 13.1% of the fish) in each of 18 raceways were CWT tagged in the snout and then PIT tagged. The remaining progeny of natural brood parents (~579,400 fish) had a CWT placed in their snout, while the remaining progeny of hatchery brood parents (hatchery contol line; ~68,900 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, green = Easton, and orange = Jack Creek). Fish with the elastomer dye in the left eyelid corresponded to the EWOS diet or experimental treatment and the right eyelid to the normal feed (BioVita) or control treatment. A final quality control check by YN staff took place on December 18, 2007 (ponds 1-9) and January 2, 2008 (ponds 10-18). Estimated tag retention was generally good, ranging from 93-100% for CWT and 84-99% for elastomer tags.

Smolt-to-smolt and smolt-to-adult survival data and analyses for brood years 1997-2001 OCT/SNT treatments are being 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. *In Press.* Survival Comparison of Spring Chinook Salmon Reared in a Production Hatchery Under Optimum Conventional and Semi-Natural Conditions. Transactions of the American Fisheries Society.

Appendix B contains an analysis of saltwater transfer feed (STF) and control smolt-to-smolt survival for release year 2007 (brood year 2005). Appendix C contains an analysis of smolt-to-smolt survival for supplementation (natural-by-natural crosses) and hatchery-control (hatchery-by-hatchery crosses) fish for release years 2004-2007 (brood years 2002-2005). Additional survival data across years are given in Appendix A.

Table 2. Summary of 2006 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	BIO	CFJ04	WW	Right	Red	Snout	36945	2000	38945	15-Oct-07	17-Oct-07
CLE02	EWS	CFJ03	WW	Left	Red	Snout	31027	2000	33027	17-Oct-07	22-Oct-07
CLE03	BIO	ESJ02	WW	Right	Green	Snout	36931	2000	38931	22-Oct-07	24-Oct-07
CLE04	EWS	ESJ01	WW	Left	Green	Snout	29635	2000	31635	24-Oct-07	26-Oct-07
CLE05	BIO	JCJ02	WW	Right	Orange	Snout	36735	2000	38735	29-Oct-07	31-Oct-07
CLE06	EWS	JCJ01	WW	Left	Orange	Snout	28984	2000	30984	31-Oct-07	02-Nov-07
CLE07	BIO	ESJ04	WW	Right	Green	Snout	38212	2000	40212	05-Nov-07	07-Nov-07
CLE08	EWS	ESJ03	WW	Left	Green	Snout	32726	2000	34726	07-Nov-07	09-Nov-07
CLE09	BIO	CFJ02	WW	Right	Red	Snout	36485	2000	38485	13-Nov-07	15-Nov-07
CLE10	EWS	CFJ01	WW	Left	Red	Snout	29907	2000	31907	15-Nov-07	19-Nov-07
CLE11	BIO	JCJ04	WW	Right	Orange	Snout	39491	2000	41491	20-Nov-07	27-Nov-07
CLE12	EWS	JCJ03	WW	Left	Orange	Snout	33418	2000	35418	27-Nov-07	29-Nov-07
CLE13	BIO	ESJ06	WW	Right	Green	Snout	38609	2000	40609	19-Nov-07	26-Nov-07
CLE14	EWS	ESJ05	WW	Left	Green	Snout	31573	2000	33573	14-Nov-07	19-Nov-07
CLE15	BIO	JCJ06	WW	Right	Orange	Snout	36844	2000	38844	08-Nov-07	14-Nov-07
CLE16	EWS	JCJ05	WW	Left	Orange	Snout	29857	2000	31857	05-Nov-07	08-Nov-07
CLE17	BIO	CFJ06	HH	Right	Red	Posterior Dorsal	34299	4000	38299	31-Oct-07	05-Nov-07
CLE18	EWS	CFJ05	HH	Left	Red	Posterior Dorsal	26643	4000	30643	29-Oct-07	31-Oct-07

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 6, 2007 through May 18, 2007. 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 3,874 (1,401 wild and 2,473 hatchery) juvenile spring Chinook were PIT tagged from fish collected at the Roza juvenile fish bypass trap. Wild fish were tagged from February 7, 2007 through May 18, 2007; and hatchery fish April 4 through May 18, 2007.

Appendix D contains a detailed analysis of wild/natural and CESRF (hatchery) smolt-to-smolt survival for Roza-tagged releases for brood year 2005 (migration year 2007) and summarizes these data for prior brood years 1997-2004 (migration years 1999-2006). Additional data on this task are provided in Appendix A.

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

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

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

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

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

Replicate releases of PIT tagged smolts were made in order to estimate the fish entrainment and canal survival rates in relation to river conditions. The entrainment rate estimates were used in concert with a suite of independent environmental variables to generate a multi-variate smolt passage relationship and subsequently to derive passage estimates with confidence intervals (see Appendix F in our 2005 annual report for details).

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

Progress: The 2007 smolt passage estimates were as follows: wild spring Chinook–130,263; control (standard diet) spring Chinook– 163,151 (Easton: 60,524; Jack Creek: 50,591; Clark Flat: 52,041); treatment (saltwater transition feed) spring Chinook– 162,197 (Easton: 65,061; Jack Creek: 48,074; Clark Flat: 49,135); unmarked fall Chinook– 28,989; Marion Drain hatchery fall Chinook– 14,817; wild coho– 8,665; hatchery coho– 88,575; and wild steelhead– 31,898. These estimates are provisional and subject to change as better entrainment estimates are developed. Appendix F in our 2005 annual report contains a detailed analysis of data obtained from these studies. Additional data on this task are also provided in Appendix A.

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

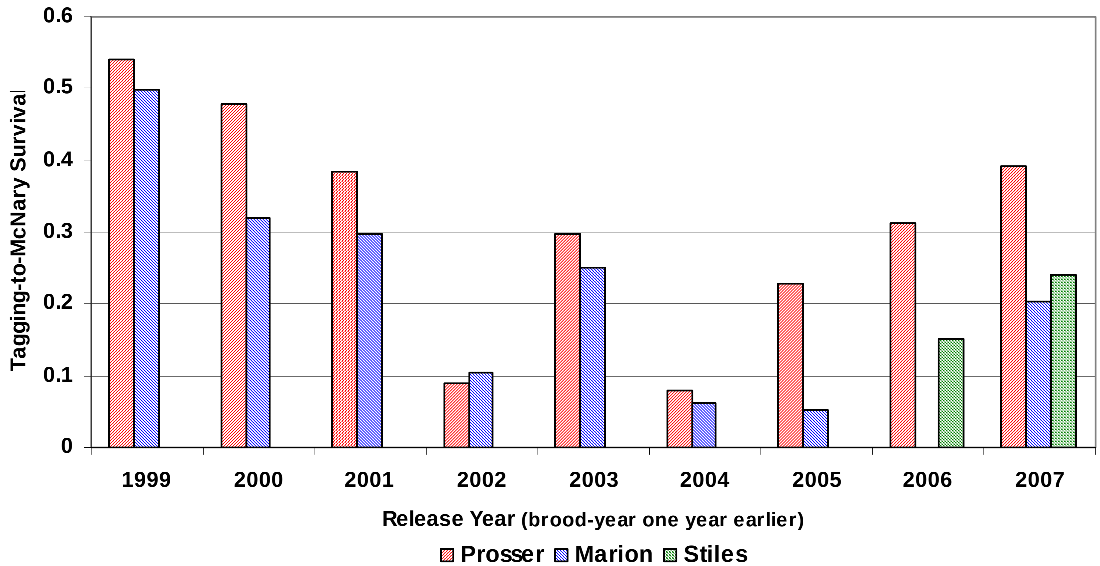
Task 1.f Yakima River Fall Chinook Survival Monitoring & Evaluation

Rationale: To determine optimal rearing treatments and acclimation site location(s) to increase overall smolt and smolt-to-adult survival. Previous modeling of subyearling chinook growth and survival in the lower Yakima River suggests that juvenile survival through the lower Yakima River may be higher for the lowermost portions of the mainstem (Mabton-to-Horn and Horn-to-delta reaches), and that smolt-to-smolt survival is perhaps the major limitation on natural production in the Yakima.

Method: Beginning in brood year 1998, approximately 330,000 fall chinook smolts from adult fall Chinook spawned during the prior fall, were used for an ongoing rearing treatment experiment that would last until 2005 (BY2004). These fish were divided into two equal groups. One group, released later in May, was reared under conventional methods using ambient river temperature incubation and rearing profiles. The other group, released in April, was incubated and reared with warmer well water to accelerate emergence and rearing and ultimately smoltification. Both groups of fish were spawned, incubated and reared at the Prosser Hatchery. Fish from both groups were 100% marked using ventral fin clips. A portion of each group was PIT tagged to evaluate survival and migration timing to the lower Columbia River. The ventral mark was discontinued after BY2004 due to the inability to collect the data both at the viewing windows at Prosser Dam and on the spawning grounds. The majority of fish for BY2005 and BY2006 were reared and released using the accelerated treatment. For BY2006, to further maximize hatchery production, we transferred in and accelerated a portion of "eyed-eggs" from the out-of-basin Fall Chinook (John Day Mitigation fish) we normally receive as parr from the Little White Salmon Hatchery, located on the lower Columbia River. The objective for this year was to compare the smolt survival of in-basin fall Chinook vs out-of-basin fall Chinook released at Prosser under accelerated conditions. The out-of-basin fish in prior years have not been PIT tagged due to the size limitation. For BY2006, we were able to accelerate growth and PIT tag a portion of these fish. In BY2007 we plan to accelerate these fish and compare smolt survival to the later arriving "pre-smolt" cohorts.

Progress: The fish reared under accelerated conditions outperformed the conventional reared fish in all years except those released in 2000. A historical summary for all brood years is given for accelerated-rearing tagging-to-McNary survival index for multi-year sites with the Yakima brood-stock source is given in Figure 5 (data source: Neeley, Appendix E). These results focus on the 2004 and 2005 broods, so the past conventional survival indices are not shown. Other brood years are discussed in earlier annual reports. As a result of the accelerated/conventional rearing experiment, the majority of in-basin fall Chinook from BY2006 were reared under accelerated conditions. In 2007 (BY2006), 50,000 in-basin Fall Chinook were released at Prosser Hatchery. In addition to the Prosser release, 15,731 were released from Marion Drain, 5,002 were released from Billy's Pond located on the Yakima River approximately RM 110 and 75,000 fish were transferred to Stiles acclimation pond located approximately RM 3.4 off the lower Naches River. Based on PIT tags, smolt survival from Prosser, Marion Drain, Billy's Pond and Stiles Pond to McNary Dam were: 40.7%, 20.3%, 10.9% and 29.4% respectively. Smolt survival to McNary for the Little White Salmon release was 33.8% (Neeley, Appendix E).

Figure 5. Historic Tagging-to-McNary Survivals of Fall Chinook from multi-year release Sites in the Yakima Basin.



* Brood-years 1998-2006, respectively.

** Groups are: 1) Main-Stem-Yakima Stock under Accelerated Rearing, 2) Marion Drain Stock, and 3) Main-stem Stock acclimated at Stiles pond (lower Naches).

In BY2007, we implemented two new experiments: 1) Using our in-basin stock, we compared a group of the accelerated subyearlings versus a group of yearling releases (BY2006). Both groups were 100% adipose clipped and PIT tagged for monitoring and 2) Using our out-basin (Little White Salmon) stock, we compared a group brought in as eyed eggs and reared under accelerated conditions versus the current group that comes in as pre-smolts reared conventionally with final acclimation at Prosser Hatchery. Both experimental groups will be monitored using PIT tags.

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

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

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

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

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

Bosch, W. J., T. H. Newsome, J. L. Dunnigan, J. D. Hubble, D. Neeley, D. T. Lind, D. E. Fast, L. L. Lamebull, and J. W. Blodgett. 2007. Evaluating the Feasibility of Reestablishing a Coho Salmon

Population in the Yakima River, Washington. North American Journal of Fisheries Management 27:198-214.

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

Progress:

The program completed an interim phase 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 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).

Hatchery coho smolt passage decreased in 2007, but redd counts increased dramatically due to tributary out-plants. 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 increased spawning in areas above Wapato Dam. Radio telemetry is showing 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 Acclimation Site 2004 and Easton Acclimation Site in 2003).

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.

2007 Methods

The 2007 juvenile coho releases again tested in-basin vs. out of basin stocks within acclimation sites Approximately, 2,500 pit tags (two 1,250 independent replicates) of each stock were put in each acclimation site, totaling 5,000 PIT tags per site. Each acclimation site was fitted with multiple outlet PIT tag detectors. The fish were released volitionally on the first Monday in April. Adult returns were monitored at the Prosser Right Bank Alaskan Steep Pass Denil, Roza Dam and by radio tracking. Redd surveys were conducted from October through December in the maintsem Yakima and Naches Rivers as well as select tributaries.

2007 Results

Juvenile Survival

In 2007, dual PIT tag detectors were used at Prosser, Holmes, 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. Prosser, Lost Creek and Stiles had tag detection efficiencies between 95% and 100%. The Holmes acclimation site averaged 80%, which was a significant gain in detection efficiency at this site compared to the prior two years.

Juvenile smolt release to McNary survival estimates were calculated for detected releases from the acclimation pond outlets to McNary Dam. Survival was greater for Naches subbasin releases than for upper Yakima River releases (Table 3). This was true for both out-of-basin (Eagle Creek NFH) and local brood source fish. Within the Naches subbasin, the Stiles Pond survival index was higher than Lost Creek. The Boone acclimation site was not used in 2007 to let it rest after experiencing extremely heavy bird predation on smolts over the past 3 years and subsequent low survival. Release-to-McNary Dam survival of smolts migrating in 2007 was lower at all release sites with the exception of Stiles when compared to 2006 migrant survival (D. Neeley, Appendix F). The mean estimated survival over all 3 upriver release sites was 36% for the Yakima (local) brood source compared to about 25% for Eagle Creek brood source smolts. This survival advantage for Yakima (local) brood source fish was significant (P = 0.0025; D. Neeley, Appendix F). For Prosser releases, survival to McNary Dam was considerably higher, estimated at 70% for Yakima (local) brood source and 48% for Eagle Creek brood source. See Appendix F for a detailed report and analysis of coho juvenile survival indices for 2007 and prior year releases.

Table 3. Estimated percentage of 2007 smolts released from acclimation sites that survived to McNary Dam (juvenile survival indices) by brood source and acclimation site (D. Neeley, Appendix F).

	Acclimation Site[1]			Pooled
Brood Source	Stiles	Lost Cr.	Holmes	Mean
Yakima (local)	46.8	35.8	22.0	36.0
Eagle Creek	39.4	20.7	12.0	25.2

[1] Boone pond was not used in 2007.

Parr Releases

Summer Parr were released into tributaries throughout both the Upper Yakima and Naches basins. About 3,000 PIT-tagged parr were released in North Fork Little Naches, Cowiche Creek, Nile Creek, Wilson Creek, Reecer 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. In addition, one last release of parr into Boone Pond was done to assess over winter release; however, instead of planting the pond in late July the release was done in mid October.

Adult Outplants

Adult Coho were out planted in Nile Creek, Cowiche Creek and Taneum Creek. Twenty pairs of coho were put into Nile and Cowiche Creeks in mid November. Approximately, 300 adults were planted into 3 separate sections of Taneum Creek. Each section contained 50 males and 50 females. All adults were of unknown hatchery origin and collected off the right bank Steep Pass Denil at Prosser Dam. The fish were held until 300 adults were captured.

Large 2,000 gallon fish hauling trucks were used to haul up to 50 adults at a time over a 3 day period. Spawning was initiated within days and continued for at least 4 weeks. Redd characteristics were measured in December. Approximately, 25 redds were found in each section for a total of 75 redds (Figure 6). The adults experienced very low mortality due to transportation and movement into the stream, however, adults did experience mortality from animals such as bear, bobcat and otter.

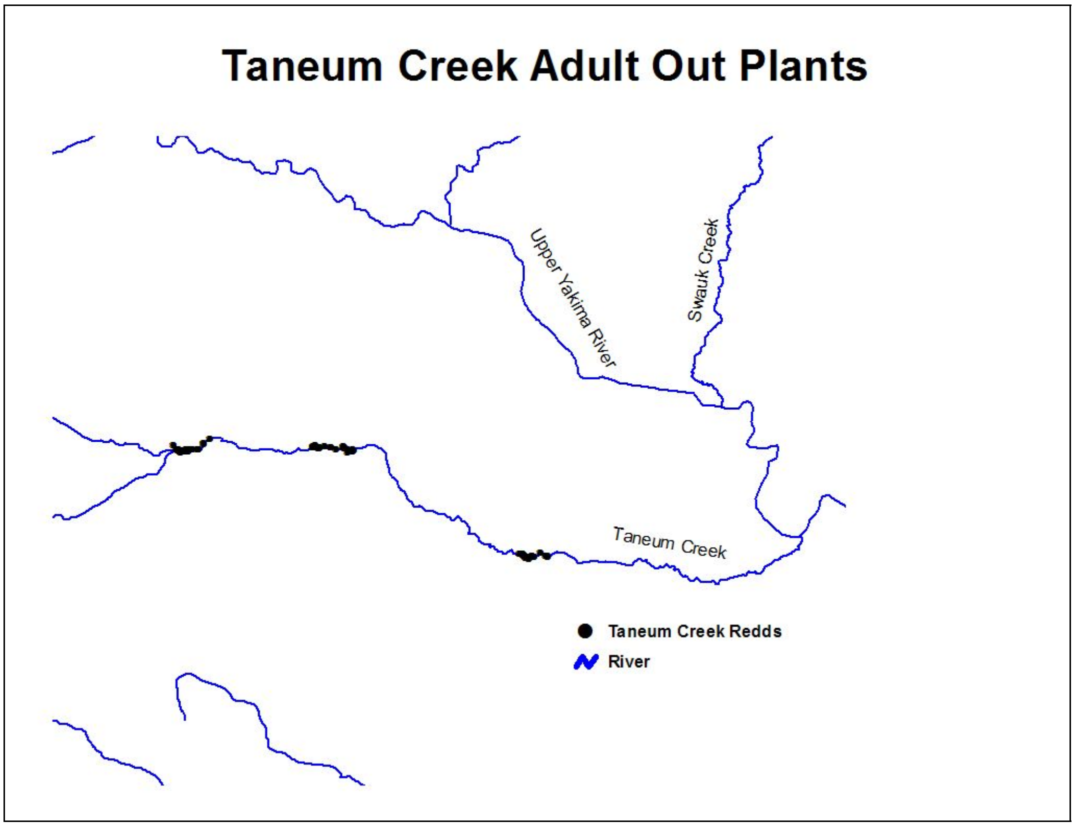


Figure 6. Redds observed in Taneum Creek resulting from out-plants of hatchery-origin adults captured at Prosser Dam in 2007.

A total of 6 redds were found in Nile Creek and 4 in Cowiche Creek. We believe the fish were planted too early, thus subjecting them to high mortality from predators. In 2008, we will be planting later in November with riper fish. This should increase spawning success and reduce excess mortality.

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

Overall smolt passage at Prosser in 2007 was estimated at nearly 225,000 coho (adjusted from Chandler counts using PIT tag survival to McNary Dam). This compared to a range of 14,000 to 240,000 coho smolts for the 2002-2006 migration years. In 2007, the estimated smolt-to-adult survival rate for 31,631 wild/natural origin coho smolts (counted at CJMF in 2005) was 5.3%. The estimated smolt-to-adult survival rate for 239,414 hatchery coho smolts (counted at CJMF in 2005) from releases in the Upper Yakima and Naches Rivers was 1%. This is down from a 2006 SAR estimate for hatchery-origin fish of 1.3%.

The 2007 adult coho run was comprised of 1,049 wild/natural (32%) and 2,211 (67%) hatchery adult coho. This was the seventh year this break down has been possible. The entire hatchery release group was 100% adipose fin clipped. Unfortunately, we believe that hatchery-origin coho from this program are subjected to very high harvest rates in marine and lower Columbia River fisheries due to the selective nature of these fisheries (designed to target adipose-fin-clipped fish). PIT-tagged hatchery-origin adults which were not adipose-fin-clipped showed an average smolt to adult return rate of 2.7% in 2007, compared to a SAR of 1% for all hatchery-origin coho adults returning to Prosser Dam in 2007.

Results of 2007 Radio Telemetry Studies for Yakima Basin

For the 2007 adult migration season it was decided to only radio tag adult coho that had PIT tags from their juvenile migration. This would give managers much more information than randomly tagging large groups of coho. In addition, we were able to radio tag 10 natural-origin coho adults at Roza Dam.

A total of 16 adult coho were radio tagged each containing a juvenile PIT tag. Of the 16, six radio tags were regurgitated or quit, 5 adults homed back to or near the acclimation area, 3 were subsequent mortalities and 2 spawned in the maintsem Yakima River below Sunnyside Dam. All 10 wild coho were radio tagged at Roza Dam on one day. Of the 10 radio tags active, 3 were mortalities or fish which regurgitated their tags, 2 spawned in the Roza Canyon, 4 spawned in and near the Holmes Acclimation Site and one spawned in the Cle Elum Slough near the Cle Elum Spring Chinook Facility. Coho were acclimated in Cle Elum Slough 7 years ago.

Spawning Ground Observations

Since 1999 all smolts have been released in the Naches and the Upper Yakima Rivers, and in 1998 a portion of the smolts were released from Lost Creek in the Upper Naches River. Acclimation sites are now located in the Upper Yakima and Naches Rivers. Despite this, the majority of spawning appears to occur in sections of the mainstem Yakima River and in the lower Naches River. However, there continues to be evidence that coho are establishing themselves in areas that were previously unused. In 2005, two redds and a wild female carcass was found in Nile Creek. In 2006, 30 redds were found in Cowiche Creek and 3 redds were found in Reecer Creek in the Upper Yakima River. In 2007, over 60 redds were found in Nelson Springs, Cowiche Creek had 10 redds, and coho were again found spawning at the Lost Creek acclimation site on the Naches River. See task 1.j below for additional data on 2007 coho redd surveys.

Snorkel Surveys

Snorkel surveys to look for residualized juvenile coho were also conducted again in 2007. Surveys were conducted on the Upper Yakima River (Cle Elum Reach) from the Cle Elum Hatchery (Rkm 299) to the confluence of the Teanaway River (Rkm 283). In the Naches River (Lost Creek reach), surveys were done from the Lost Creek acclimation site (Rkm 61.8) to the confluence with Rock Creek (Rkm 53.9). A total of 1,500 meters of river was snorkeled in these surveys in 2005 and we found no incidence of age-0 precocials. There were significant numbers of sub yearling coho observed in the lower Naches River in 2007 surveys, indicating good natural production occurring. In 2007, we again used the yearly snorkel surveys to locate areas of wild rearing coho parr, but were unable to PIT tag any wild coho.

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, Denny Nagle, Nate Pinkham, Germaine Hart and Marlin Colfax. Also, thanks to the staff at the Prosser Fish Hatchery for their excellent fish culturing skills and year round cooperation. Ida Sohappy is the YKFP book keeper 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 (2007)

An estimated 4,293 spring Chinook passed upstream of Prosser Dam in 2007. The total adult count was 2,867 (67%) fish, while the jack count was 1,426 (33%) fish. Of the adult count, 823 were identified as hatchery origin. Returning hatchery adults this year comprised 4 and 5 year olds (brood years 2002 and 2003). The ratios of wild to hatchery fish were 71:29 and 39:61, for adults and jacks respectively. The 25%, 50% and 75% dates of cumulative passage were May 10, May 18 and May 27, respectively.

Fall Run (coho and fall chinook)

Coho (2007)

The estimated coho return to Prosser Dam was 3,213 fish. Adults comprised 98% and jacks 2% of the run. Of the estimated run, 38.8% were processed at the Denil and mark sampling there indicated the run was comprised of approximately 34.6% wild/natural and 65.4% hatchery-origin coho. The 25%, 50% and 75% dates of cumulative passage were October 12, October 19, and October 26, 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 (2007)

Estimated fall chinook passage at Prosser Dam was 1,132 fish. Adults comprised 78.8% of the run, and jacks 21.2%. Of the total number of fish, 180 were adipose clipped or otherwise identified as of definite hatchery-origin (114 adults and 66 jacks). The median passage date was October 11, while the 25% and 75% dates of cumulative passage were September 23 and October 19, respectively. Of the total fish estimate, 125 (11.0%) were counted at the Denil.

Steelhead (2006-07 run)

The estimated steelhead run was 1,537 fish. Of the total, 14 (0.9%) were adipose clipped fish, which were all out-of-basin strays (hatchery-origin steelhead have not been released in the Yakima River since the early 1990s). The median passage date was November 12th, 2006, while the 25% and 75% cumulative dates of passage were October 11th, 2006 and February 8th, 2007 respectively.

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

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

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

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

Progress:

Roza Dam

Steelhead

A total of 60 steelhead were counted past Roza Dam for the 2006-07 run. As shown in Figure 7, most steelhead migrated past Roza Dam from February through early May of 2007.

Spring Chinook

At Roza Dam 3,025 (66% adults and 34% jacks) spring Chinook were counted at the adult facility between May 1 and September 24, 2007. The adult return was comprised of natural- (55%) and CESRF-origin (45%) fish. The jack return was comprised of natural- (18.7%) and CESRF-origin (81.3%) fish. Figure 8 shows spring Chinook passage timing at Roza in 2007.

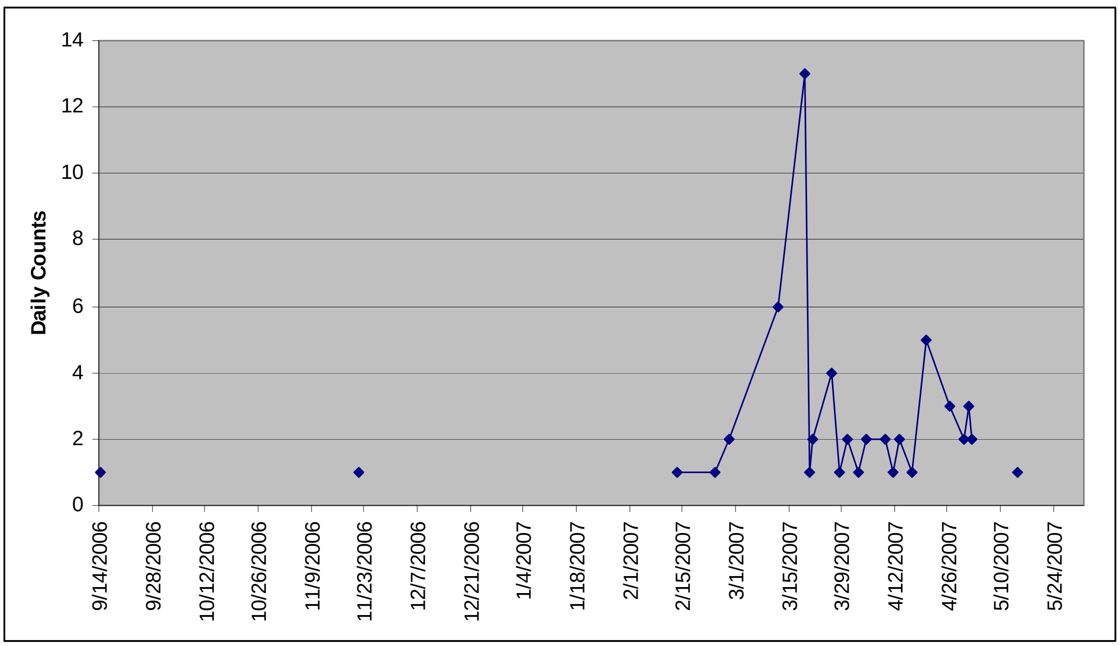


Figure 7. Daily steelhead passage at Roza Dam, 2006-07.

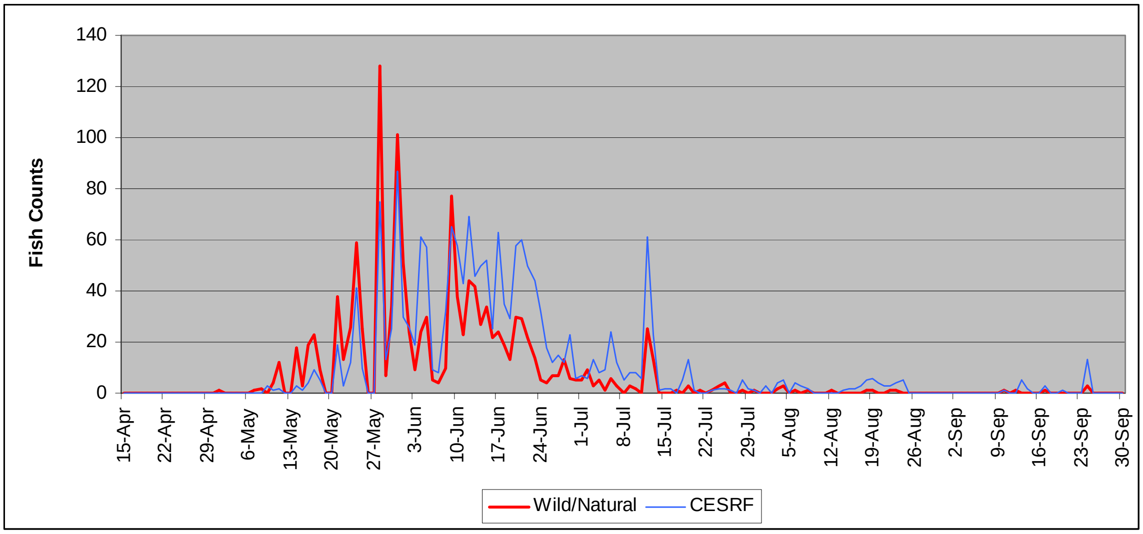


Figure 8. Daily passage counts for natural- and CESRF-origin spring Chinook at Roza Dam, 2007.

Coho

Based on video observations, a total of 91 adult and no jack coho were observed passing Roza Dam from October 2, 2007 through January 7, 2008. Of the total, 69 adults (76%) were observed to have an adipose fin clip (hatchery-origin). Video observations at Roza during the fall and winter months are known to be an incomplete accounting due to debris and lighting problems in the video counting area.

Cowiche Dam

Coho

Video observations were not conducted at Cowiche Dam in 2007.

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 2008. Total redd counts by subbasin were as follows: Satus basin- 110, Toppenish basin- 68, and Ahtanum Creek- 8. For all three basins a total of 186 redds were counted. Only partial surveys were completed in the Toppenish and Ahtanum basins because of high water and poor access to headwater reaches. No surveys were conducted in Harrah and Marion drains this year due to poor survey conditions. Steelhead redd surveys in the Naches River system in the spring of 2008 were conducted jointly by the U.S. Forest Service and the Washington Dept. of Fish and Wildlife. Because of unusually late high flows in the Little Naches River drainage and other streams, survey coverage was limited to 2 passes each on Nile and Oak Creeks. Eight (8) redds were observed in Nile Creek and three (3) redds were observed in Oak Creek during these surveys (G. Toretta, USFS, personal communication). 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 2007 in the American River and ended in early October 2007 in the upper Yakima River. Total counts for the American, Bumping, Little Naches, Naches, and Rattlesnake rivers were respectively: 166, 60, 28, 48, and 12 redds. Redd counts in the upper Yakima, Teanaway and the Cle Elum rivers were: 665, 10, and 51, respectively. The entire Yakima basin had a total of 1,040 redds (Naches- 314 redds, upper Yakima- 726). Historical spring Chinook redd count data are provided in Appendix A.

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

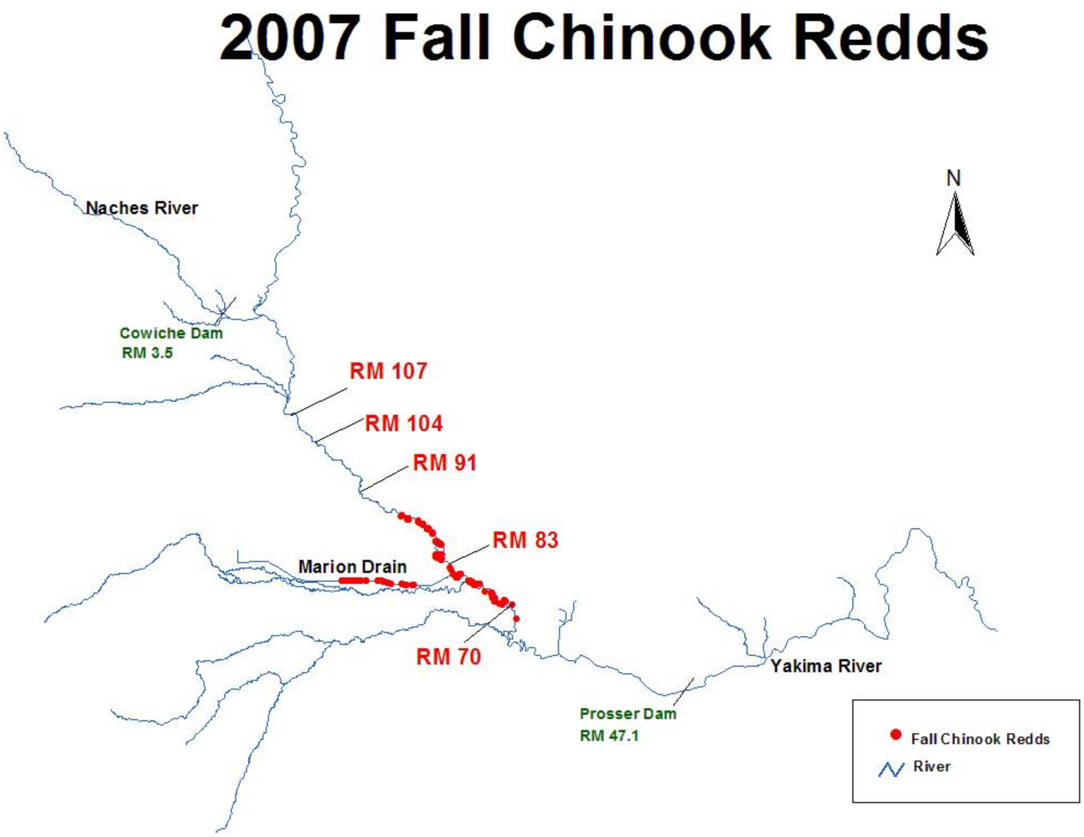
Yakima R.: 321 redds. All redds were located between RM 70 and RM 91. 55.1% were located between RM 70 and 83 and 44.9% were located between RM 83 and 91.

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

Marion Drain: 67 redds. 68.7% of the redds were located above Hwy 97 up to Old Goldendale Road. The remaining 31.3% were located below Hwy 97 down to the Hwy 22 bridge.

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

Figure 9. Distribution of fall Chinook redds in the Yakima River Basin in 2007.

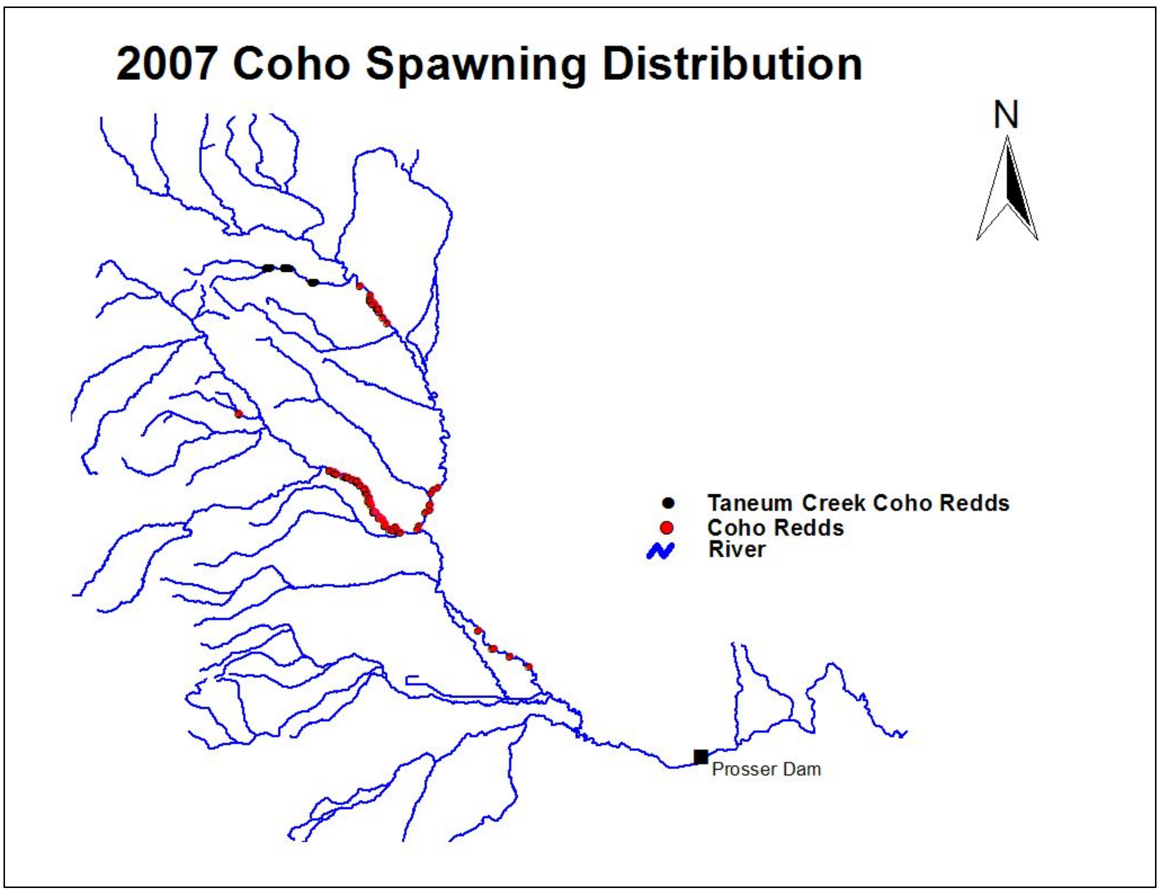


Coho: Surveys began the third week of October and ended in late December. Redd surveys were conducted daily in conjunction with fall Chinook surveys. The Yakima and Naches Rivers are broken into sections that are checked by boat or ground surveys. Winter freshets and weather did not hinder the spawning surveys in 2007, thus, the coho redd count was the highest the YN has recorded, and there seemed to be excellent production. Since 2004, tributary spawning has exceeded 90 redds annually. With the beginning of Phase II of the Coho Program we expect to observe large increases in tributary spawning. Many redds were located intermixed with fall Chinook redds, tucked under cut banks and/or were found in many 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.

Table 4. Yakima Basin Coho Redd Counts, 1998-2007.

River	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Yakima River	53	104	142	27	4	32	78	107	109	63
Naches River	6	NA	137	95	23	56	87	72	44	87
Tributaries	193	62	67	29	16	21	92	93	99	153
Total	252	166	346	151	43	109	257	272	252	303

Figure 10. Distribution of coho redds in the Yakima River Basin, 2007.



Task 1.k Yakima Spring Chinook Residual/Precocial Studies

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

Pearsons, T. N., C. L. Johnson, and G. M. Temple. 2008. Spring Chinook Salmon Interactions Indices and Residual/Precocious Male Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report 2007. DOE/BP-00034450.

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

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

Schroder, S. L., C.M. Knudsen, T. N. Pearsons, T. W. Kassler, S. F. Young, E. P. Beall, and D. E. Fast. 2008. Behavior and breeding success of wild and first generation hatchery spring Chinook salmon males spawning in an artificial stream. Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report 2007.

Schroder, S. L., C. M. Knudsen, T. N. Pearsons, T. W. Kassler, S. F. Young, C. A. Busack, and D. E. Fast. *In Press*. Breeding Success of wild and first generation hatchery female spring Chinook salmon spawning in an artificial stream. Transactions of the American Fisheries Society.

Schroder, S. L., C. M. Knudsen, T. N. Pearsons, S. F. Young, T. W. Kassler, D. E. Fast, and B. D. Watson. 2006. Comparing the Reproductive Success of Yakima River Hatchery- and Wild-Origin Spring Chinook. Yakima/Klickitat Fisheries Project Monitoring and Evaluation, Annual Report 2005. BPA Report DOE/BP-00022370-3.

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 2007 are summarized in Table 5. Age-0 (sub-yearling migrant) Chinook are presumed to be fall Chinook while age-1 (yearling migrant) Chinook are presumed to be spring Chinook. Adult scale sample results for 2007 are summarized in Table 6 by species and sampling method. Historical data from age and length sampling activities of adult spring Chinook in the Yakima Basin are presented in Appendix A.

Table 5. Age composition (number of fish) of juvenile salmonids sampled at the Chandler Juvenile Monitoring Facility in 2007.

Species	Age-0	Age-1	Age-2	Age-3
Hatchery-origin Coho		98		
Natural-origin Coho		8		
Unknown-origin Coho		6		
Hatchery-origin Chinook		103		
Natural-origin Chinook	155	109		
Natural-origin Steelhead		16	23	2

Table 6. Age composition of salmonid adults sampled in the Yakima Basin in 2007.

	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	54	15.5	175	41.4	231	59.4	19	70.4
Upper Yakima Wild/Natural			32	43.2	363	60.6	52	69.8
Spawner Survey Samples								
Upper Yakima Supplementation			4	44.3	11	60.3		
Upper Yakima Wild/Natural					13	59.6		
American River Wild/Natural			2	37.0	27	60.7	38	74.2
Naches River Wild/Natural					14	57.9	9	71.6
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: Ground survey work accomplished pursuant to this task in fiscal year 2007 was discussed under Task 1.a, Modeling.

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 2007. 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 119 samples were collected and processed from the Little Naches drainage this past year (10 reaches, 119 samples). All of the regular sites in the Little Naches were sampled. One sample from Little Naches Reach 4, Riffle 2 was removed from the data set because a portion of the sample was lost. With this year's monitoring work, the data set for the Little Naches drainage now covers a time period of 23 years for the two historical reaches, and 16 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 was not significantly different from results for the prior four years (Figure 11). For the last five years, overall fine sediment conditions in the Little Naches drainage have been stable and just under 12% fines. The relatively low level of fine sediment is encouraging and should lessen mortality on eggs and alevins.

The factors that have improved recent spawning conditions are not entirely known. In the early 1990's, overall average fine sediment levels in the Little Naches were quite high and peaked at 19.7% fines in 1993. At that time, a considerable amount of road building and timber harvest was taking place in the upper portions of the drainage. Due to the high level of fine sediment found in spawning substrate, significant road improvement, abandonment and drainage work was accomplished by landowners in 1994 and 1995. In addition, more protective measures were instituted for logging practices near streams through the Northwest Forest Plan (1994) and the Plum Creek Habitat Conservation Plan (1996). From 1995 through 2001 fine sediment levels dropped and remained relatively constant at about 14-15.5% average overall fines in the spawning substrate. Since 2002, overall average fine sediment levels have further declined in the Little Naches to approximately 11.5-13%. Possible explanations for the latest conditions may be attributed to sediment abatement work on roads and trails, better logging practices, reduced precipitation and stream flows, and/or forest re-growth in previously harvested areas. These factors and others need to be evaluated to better determine how much they are affecting fine sediment levels and to ensure that fine sediment conditions do not deteriorate in the future.

At the reach scale, several of the sampling sites had similar results to those in 2006. Five, or half, of the sampling reaches had comparable average fine sediment conditions between 2007 and 2006, with less than 1.0% point difference (Little Naches Reach 1, Little Naches Reach 3, Bear Creek Reach 2, Pyramid Creek Reach 1, and North Fork Reach 2). Three other reaches had greater than a 1.0% point increase in average fines from the previous year (South Fork Reach 1, Bear Creek Reach 1, and North Fork Reach 1). Conversely, the remaining two reaches had a lower level of average fine sediment compared to 2006 (Little Naches Reach 2 and Little Naches Reach 4). Overall sampling variability within individual reaches was somewhat higher in 2007. Six of the reaches had a higher standard deviation, one reach had a similar standard deviation, and three reaches had a lower standard deviation than in 2006. Some of the increased variability appeared to be due to observable channel changes at a few of the sampling riffles.

Monitoring information from individual reaches can sometimes help identify site-specific sediment conditions or factors. This past year, the highest average fine sediment levels were found at North Fork Reach 1 (15.1%) and Pyramid Creek Reach 1 (14.6%). The Pyramid Creek reach has continued to slowly increase in fine sediment over the last four years, but the changes have been small and no major causal factors have been identified yet. North Fork Reach 1 is downstream of areas with localized bank erosion, beaver activity and a dirt bike trail crossing which may be elevating fine sediment levels. The greatest increase in average fine sediment was found at South Fork Reach 1 (3.1% point increase from 2006). A dirt bike trail and some dispersed camping activity occur adjacent to this stream. In addition, the stream channel has shifted in places and caused localized bank erosion. The lowest average fine sediment in 2006 was found at the bottom sampling reach, Little Naches Reach 1. This reach also had the least amount of variability between samples.

A review of the data from the two historical reaches (Little Naches Reach 1 and North Fork Reach 1) provides a greater time period of record for assessing sediment trends in the drainage. Sampling began on these two reaches in 1985. In the early years of 1985-1986 average fine sediment levels were fairly low (8-10%). From 1987 until 1993, reach average fine sediment increased dramatically up to about 19-20%. Considerable road building and timber harvest activity was taking place in this time frame. The Falls Creek Fire also occurred during this period (1988?) and burned substantial portions of the North Fork, Pyramid, and Blowout Creek sub-watersheds. After 1993, the fine sediment levels receded for two or three years at these historical sampling reaches, before moving back up. From 1998 through 2001 the rate of fine sediment in these two reaches remained relatively constant between 16 and 18 percent for reach average fines. The last three to four years the average percentage of fine sediment declined to a range of 11-13%. This year the average fine sediment levels in these two reaches were divergent when compared to 2006 (9.1% at Little Naches Reach 1 and 15.1% at North Fork Reach 1). Little Naches Reach 1 was very similar to the previous year, while North Fork Reach 1 had a noticeable increase in average fine sediment. Further investigation and evaluation of sediment delivery in the North Fork Little Naches is recommended.

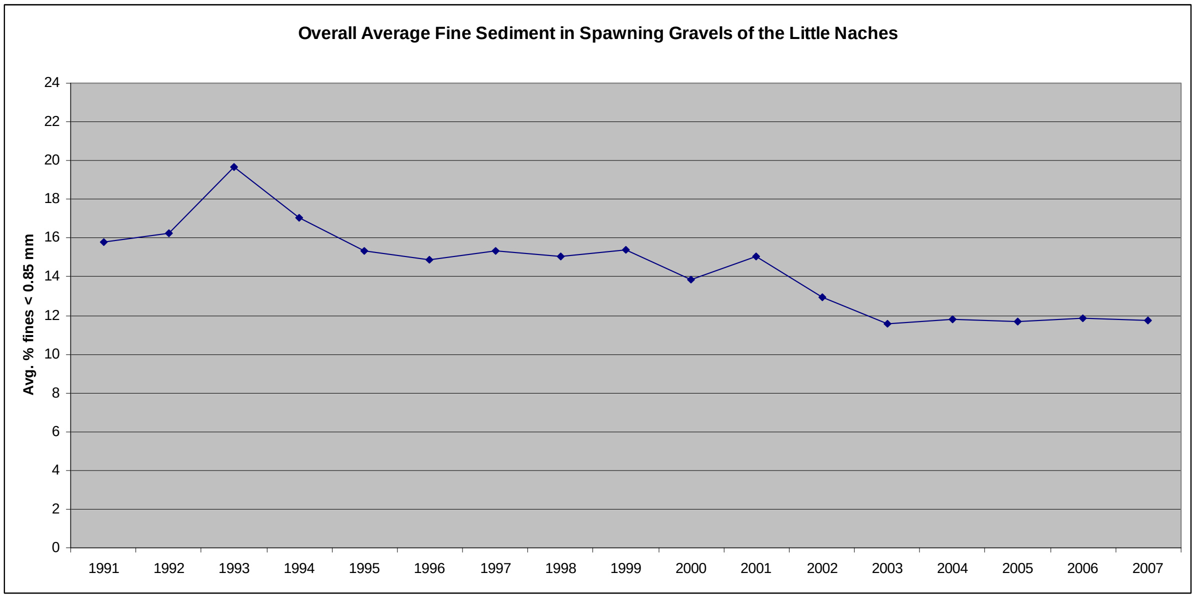


Figure 11. Overall Fine Sediment (<0.85mm) Trends in the Little Naches River Drainage, 1991-2007.

<u>South Fork Tieton</u>

One riffle (Reach 1- Riffle 2) on the South Fork Tieton River (in the vicinity of Minnie Meadows) was sampled again this past season by the U.S. Forest Service. Credit goes to the Forest Service for their continued efforts to collect data in other drainages outside the Little Naches River. This area typically receives considerable bull trout spawning activity and the sampling provides additional information on spawning conditions. The small sample size (four samples) precludes the ability to draw any major conclusions on conditions in 2007, but the information does give some indication on fine sediment levels. This particular sampling riffle had very similar fine sediment when compared to 2006 (riffle average of 12.1% in 2007 versus 12.4% in 2006). This suggests that spawning substrate conditions have changed little this past year.

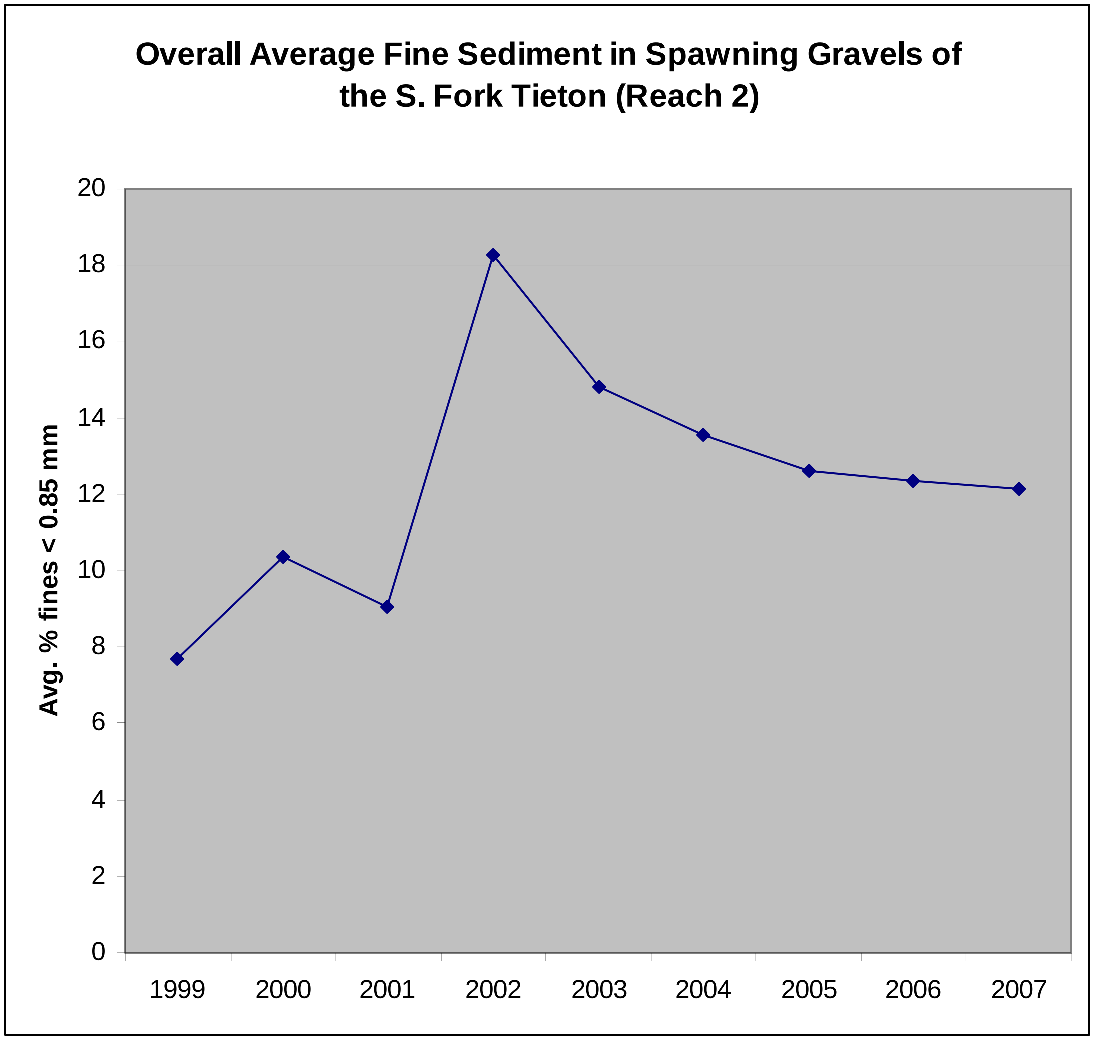


Figure 12. Fine Sediment Trends in the South Fork Tieton River (Reach 2), 1999-2007.

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 11 years. With the exception of the Elk Meadows reach, average percent fine sediment less than 0.85mm by reach and for the combined Upper Yakima drainage was slightly higher than the average observed over the eleven years of sampling (Figure 13).

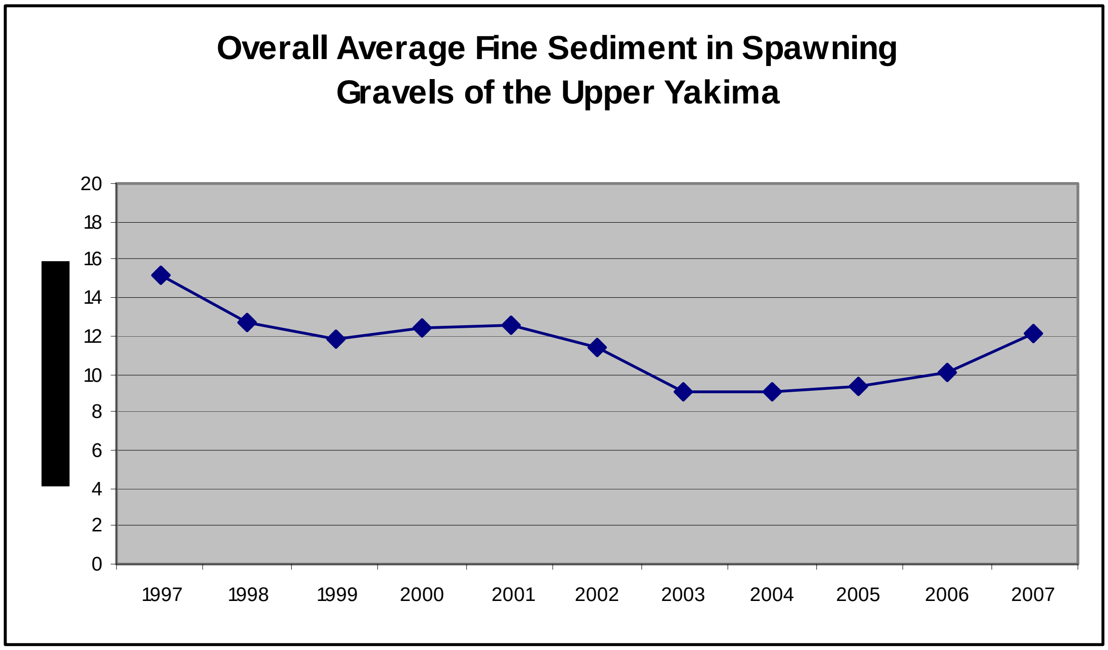


Figure 13. Fine Sediment Trends in the Upper Yakima River, 1997-2007.

Summary

The overall average fine sediment level in the Little Naches this past season was very similar to the previous four years. Overall average fine sediment in 2007 was 11.8%. This marks five years of stable and improved fine sediment conditions for spawning activity in the Little Naches drainage. These conditions should minimize impacts on egg and alevin survival. Further monitoring is needed to determine if this is a continuing trend or just a short term anomaly. While the fine sediment conditions in the Little Naches have improved in the last few years, they are still somewhat higher than what was found in a neighboring, unmanaged watershed (American River). The sampling in the South Fork Tieton River by the USFS in 2007 was limited, but does suggest similar fine sediment conditions to those in 2006. The average fine sediment in 2007 for Riffle 2 was 12.1% compared to 12.4% in 2006 for this same riffle. For the Upper Yakima system, overall fine sediment in 2007 was 12.2%.

Fine sediment sources and their causes should continue to be investigated, identified and addressed in all drainages. Without information on fine sediment delivery sources it is difficult to manage and correct problem conditions. In particular, dispersed camping and off road vehicle activities near streams, stream-adjacent roads, eroding banks, unstable slope areas, and timber harvest activities should be evaluated for their delivery capability and effect on spawning conditions.

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

Personnel Acknowledgements: Credit needs to go to all parties involved with this last year's sampling effort. The U.S. Forest Service staff collected all the samples from the upper South Fork Tieton River this past season. Fisheries technicians from the Yakama Nation did another great job coring the samples from the Little Naches and processing all the samples this winter.

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: 2007 Smolt-to-smolt Survival of Brood-Year 2005 Upper Yakima Spring Chinook (See Appendix B)

- 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 2002-2005 (See Appendix C)

- Annual Report: Smolt Survival to McNary Dam of Year-2007 Spring Chinook Releases at Roza Dam (See Appendix D)

- 2007 Annual Report: Smolt-to-smolt Survival to McNary Dam of Main-stem Yakima Fall Chinook (See Appendix E)

- Annual Report: 2006-2007 Coho Smolt-to-smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin (Appendix F)

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

HARVEST

Task 2.a Out-of-basin Harvest Monitoring

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

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

Progress: Additional detail about methods used to evaluate harvest of Yakima Basin spring Chinook in Columbia Basin and marine fisheries is given in Appendix A. Historical results of this evaluation including results for the present year are given in Tables 47 and 48 of Appendix A.

Task 2.b Yakima Subbasin Harvest Monitoring

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

Method: The two co-managers, Yakama Nation and WDFW, are responsible for monitoring their respective fisheries in the Yakima River. Each agency employs fish monitors dedicated to creel surveys and/or fisher interviews at the most utilized fishing locations and/or boat ramps. From these surveys, standard techniques are employed to expand fishery sample data for total effort and open areas and times to derive total harvest estimates. Fish are interrogated for various marks. This information is used along with other adult contribution data (i.e. broodstock, dam counts, spawner ground surveys) to determine overall project success.

Progress: Yakima River in-basin Tribal harvest for salmon and steelhead are presented in Table 7.

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

Table 7. A summary of Yakama Nation tributary estimated harvest in the Yakima Subbasin, 2007.

River	Dates	Weekly Schedule	Notes	Chinook	Jacks	Steelhead	Coho
Yakima River	4/10-6/30	Noon Tues to 6 PM Saturday		146	133	0	0
Yakima River	9/18-11/24	Noon Tues to 6 PM Saturday		0	0	0	0

GENETICS

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

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

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

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

Blankenship, S., C. Busack, A. Fritts, D. Hawkins, T. Kassler, T. Pearsons, S. Schroder, J. Von Bargen, C. Knudsen, W. Bosch, D. Fast, M. Johnston, and D. Lind. 2008. Yakima/Klickitat Fisheries Project Genetic Studies, Yakima/Klickitat Fisheries Project Monitoring and Evaluation, Annual Report 2007. Project No. 1995-063-25; BPA Report DOE/BP-00034450.

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 2007 were consistent with the techniques used in 2001-2006. Consumption by gulls at hotspots was based on direct observations of gull foraging success and modeled abundance. Consumption by pelicans and all other piscivorous birds on river reaches and hotspots were estimated using published dietary requirements and modeled abundance. Seasonal patterns of avian piscivore abundance were identified, diurnal patterns of gull and pelican abundance at hotspots were identified, and predation indices were calculated for hotspots and river reaches for the spring and summer. In addition three aerial surveys for pelicans were conducted on the lower Yakima River from Union Gap to the mouth of the Columbia River.

A new method was also instituted in 2006 and continued in 2007: 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 both years 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, cormorant and heron rookeries at Satus Wildlife Management Area on the Yakama Reservation were also surveyed.

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

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

- Pelican and cormorant populations declined significantly in the Yakima Basin from 2006 levels. Pelican numbers at Chandler were far reduced, with moderate numbers only after smolt passage had ceased. This is the second year in a row of declining pelican numbers.

- Pelicans continued to dominate fish consumption in spring, taking 64% of the small fish biomass (all species) eaten by birds, equal to the percentage taken in 2006. Mergansers consumed 21.2% of the small fish biomass taken by birds in spring, up from 12% in 2006.

- Cormorant populations consumed only 0.8% of the small fish biomass taken by birds in spring 2007, down from 13.5% in 2006 and the 3.5% taken in 2004-2005. Great Blue Herons consumed 12.5% of the small fish biomass, up from the 9% they took in 2006 and 5.3% in 2005. Heron and cormorant numbers may indicate competition for nesting sites year to year.

- Based on a behavioral model, Horn Rapids gulls consumed 67,535 smolts, predominately fall chinook, down from 93,000 smolts consumed in 2006. The model indicated that Chandler gulls consumed very few smolts in 2007, similar to the low numbers consumed in 2006.

- Correlation analysis 2004-2007 suggests that Horn Rapids gulls are tracking coho passage and are not tracking spring chinook, fall chinook, or steelhead passage.

- Chandler pelicans did not closely track any smolt run in 2007, unlike 2004-2006 when they appeared to track the passage of coho smolts. There was a low but significant negative correlation between flow at Chandler and pelican numbers: the higher the flow the fewer the pelicans congregating at the site.

- Chandler Bypass pipe orientation makes fish vulnerable to predation only at low water (<4,000 cfs). At high water, smolts exiting Chandler pipe are largely secure from bird predation. As a result, the higher the river volume during peak smolt out-migration the lower the predation rate by birds. A simple reconfiguring of the outfall could largely eliminate smolt vulnerability at Chandler.

- Smolts reared in the six spring chinook and coho acclimation sites were largely secure from predation by birds in 2006-2007. Only limited bird monitoring appears warranted at acclimation sites at the present time.

Monitoring of avian predation on juvenile salmonids in the Yakima River as part of the Yakima Klickitat Fisheries Project has been on-going since 1997. In 2007, the American White Pelican population in the Yakima Basin declined significantly to under 150 animals, a drop of over 400% from 2005-2006 levels, matching levels in 2002.

Because of high water in spring, avian presence was greatly diminished at the traditional hotspots at Chandler and Horn Rapids. Pelicans only began to consistently visit Chandler as the water level dropped in summer, apparently feeding on chiselmouths and suckers, and possibly wild fall chinook exiting from the fish bypass pipe. Gull numbers at Horn Rapids were also consistently low at high water.

In 2007, as in previous years, piscivorous birds were monitored along river reaches, at salmon smolt predation hotspots (Chandler Fish Bypass and Horn Rapids Dam) and at smolt acclimation sites. Smolt consumption estimates of Ring-billed and California Gulls at hotspots were based on direct observations of foraging success and modeled abundance. Consumption by all piscivorous birds on river reaches were estimated based on dietary requirements and modeled abundances. Consumption by birds at smolt acclimation ponds were estimated from daily counts and dietary requirements. Pelicans appear to be the most significant predator on salmon smolts in the lower river and mergansers in the upper river under the present conditions.

As in all the previous years, Common Mergansers were the most significant small fish predator in the upper river, consuming over 98.6% of the fish biomass consumed by birds in spring and 91.6% during the summer in these reaches. In the middle river, they consumed 87.7% of the small fish biomass in spring and 54.6% in the summer. Dietary analysis of Yakima River Common Mergansers suggests that breeding mergansers eat a broad range of small fish, ranging from sculpin to chiselmouth, with juvenile trout and other salmonids predominating in their fall/winter diet.

Bird densities are highest in the lower river, resulting in 97.3% of the fish biomass consumed by birds in the entire river taken in this stratum alone. As in the previous four years, American White Pelicans were the dominant bird consumer of fish in the lower river in spring, consuming 65.8% of the fish consumed by birds. By way of their dominance in the lower river, pelicans consumed 64% of the fish biomass consumed by birds in the entire river in spring. These totals are equal to percentages in 2006. Pelicans inhabiting the lower river could potentially consume the entire hatchery production of fall chinook smolts released in the lower river (nearly two million smolts) and yet only supply a small portion of their dietary requirements, indicating they must be eating other fish (ie. sucker, carp and bullhead) in addition to any salmonids consumed. Knowledge of the actual fish consumption of both Common Mergansers and American White Pelicans along river reaches is limited by incomplete fish biomass estimates and the general lack of direct observation of birds feeding on smolts or other fish.

Pelicans are the dominant avian predator at Chandler Fish Bypass, while gulls dominate at Horn Rapids Dam. Pelicans averaged 9.9 birds per day, down from 17.5 birds per day in 2006 and 57 birds per day in 2005. Based on the assumptions that Chandler pelicans are fulfilling their entire daily dietary requirements at the site, are consuming only salmon smolts, and consume smolts in proportion to their availability, Chandler pelicans potentially consumed 90% of the fall chinook smolts in 2007. However a number of lines of evidence including correlation analysis and anecdotal observations call these assumptions into question. Thus the huge smolt consumption estimates for pelicans in 2005-2007 that are based on these assumptions should be viewed as hypothetical worst case scenarios.

Correlation analysis in 2007 suggests pelicans did not track any smolt run, unlike 2004-2006 when they tracked the coho run. The size of smolts may be an important factor in the bioenergetics of pelican consumption. Coho smolts average over 30 g, while fall chinook smolts average under 10 g. Although the run is large, the fall chinook smolts may be far too small to be an efficient food source for pelicans. Anecdotal observations at Chandler bypass pipe, Selah Pond, and the Yakima Canyon suggest pelicans are also consuming significant numbers of other fish species of size classes larger than salmon smolts, including sucker, chiselmouth, pikeminnow and bullhead.

There was a low but significant negative correlation between flow at Chandler and pelican numbers. Only with flows under 4,000 cfs can pelicans congregate at Chandler to prey on fish exiting from the Fish Bypass. Above 4,000 cfs at

Chandler salmon smolts are largely invulnerable from predation by pelicans. As a result, the higher the river volume during peak smolt out-migration the lower the predation rate by birds. A simple reconfiguring of the outfall could largely eliminate smolt vulnerability at Chandler.

Gulls numbers at Horn Rapids in 2007 remained similar to the levels in 2005-2006, averaging about 5 birds per day. Gulls were estimated to have consumed 67,535 fish, a 27.4% decline from totals in 2006, but still 290% higher than estimates in 2005. Like in 2005-2006, gull presence and predation at Chandler was minimal.

In a pattern similar to 2004-2006, gull numbers at Horn Rapids showed the highest correlation with the coho smolt run (counted at Chandler), with lowest correlations for the spring chinook, fall chinook and steelhead runs. Predation by Common Merganser, Belted Kingfisher and Great Blue Heron at the 3 spring chinook and 2 of the coho smolt acclimation ponds appeared to be relatively minor in 2007, as it was in 2004-2006.

One pelican was captured with a padded leg-hold trap, winged tagged and radio-collared to facilitate monitoring pelican movements and diet in the Yakima River in Selah and at Chandler Fish Bypass. No stomach samples were obtained from the bird. Unfortunately it was never relocated after tagging, presumably relocating to the Columbia River.

Pelican, Double-crested Cormorant, Great Blue Heron and Common Merganser roosting and nesting sites were examined for the presence of salmon PIT tags in fall and winter. Areas surveyed included: Chandler Fish Bypass; the heron-cormorant colony on the Yakima River in Selah (Selah Heronry); a gravel bar near the Selah colony used by roosting pelicans (Selah Bar); islands in the Selah Pond used by roosting cormorants and pelicans (Selah Pond); and Roza Recreation Area site gravel bar in the Yakima River used by roosting pelicans and mergansers (Roza Bar).

Plans for the 2008 field season include a greater emphasis on cormorant and pelican consumption, with continued monitoring of river reaches and at hotspots. Pelicans will be color-marked and radio-collared at hotspots, river reaches and other locations to gather information on diet, movements and nesting. Heron and cormorant nesting colonies will be surveyed, monitoring which has not been done systematically in 5 years. PIT tags found at pelican, cormorant, heron and merganser nesting and roosting sites will be used to assign smolt predation estimates to specific bird species.

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

Task 4.b Fish Predation Index

Rationale: Monitor, evaluate, and index impact of piscivorous fish on annual smolt production of Yakima Subbasin salmon and steelhead. Fish predators are capable of significantly depressing smolt production. By indexing the mortality rate of upper Yakima spring chinook attributable to piscivorous fish in the lower Yakima River, the contribution of in-basin predation to fluctuations in hatchery and wild smolt-to-adult survival rate can be deduced.

Methods: Monthly mark-recapture Northern pikeminnow (NPM, *Ptychocheilus oregonensis*) population estimates are attempted from March through June at Selah Gap to Union Gap (Section 1-4), Parker Dam to Toppenish (Sections 5-8), and Toppenish to Granger (Sections 9-13). Transects were adjusted to 1 mile sections separated by 2 mile gaps at start of the 2006 season. We sampled the entire transect for presence of NPM. No pit tags were used, only fin clips for visual identification of recaptures was applied. The less invasive marking technique was employed to improve survival and increase the possibility of recapture. Sampling transects was much more efficient this way.

In addition to population estimates, stomach samples were collected from every 5th fish greater than 200 cm 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.

Progress:
The predation crew adjusted the transect locations and refined the lengths for accuracy in Spring 2006 (Figure 14). These one mile sites and associated habitats are the areas that receive intensive electro-shocking treatment for the various size classes of NPM. All fish received a dorsal fin clip on at least half

of the fin rays present. These same fish were recaptured in subsequent weeks and tallies were kept for estimating population numbers based on equations given by Ricker 1975. Using the equation for multiple censuses, the estimated population for NPM from the Naches confluence to the Granger boat ramp (39Rm) was 9,900. With the 95% confidence interval the population was between 5,526 and 20,162. While the interval would seem large it represents the best approximation given the difficulties associated with sampling such a large riverine system.

A summary of NPM stomach contents collected in 2007 is presented in Table 8. A total of 77 stomachs were collected during the spring 2007 field season. Of these, invertebrates seemed to be the main prey species found in the gut. All stomachs with fish present were further analyzed to determine the species using diagnostic bones to identify them. Out of the 77 stomachs, the ones with fish species actually contained 9 Chinook and 2 Steelhead. Expanded consumption numbers indicate that 4,217 salmon smolts are eaten per day between the Naches River confluence and Prosser Dam.

Table 8. Summary of species found in Northern pikeminnow stomachs sampled in the Yakima Basin in 2007.

Species	**Count found in NPM stomachs**
Sculpin	3
Large scale sucker	1
Whitefish	5
Sucker	1
Chiselmouth	4
Chinook	9
Steelhead	2
Insect	16
Total Salmonids	**11**

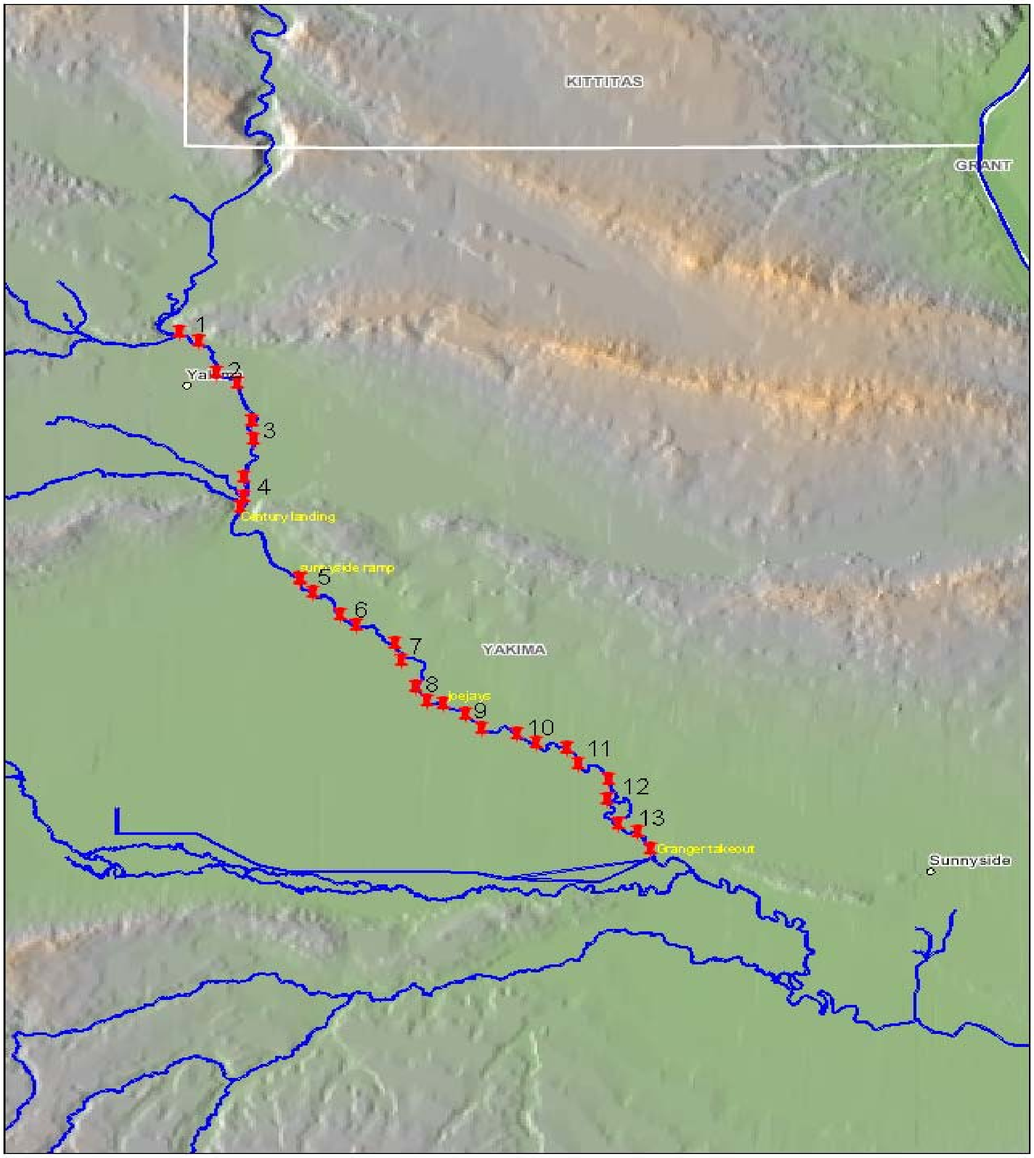


Figure 14. Current location of Northern pikeminnow sample sites.

[a] Each site is 1 mile long and 2 miles separate them.

Task 4.c Upper Yakima Spring Chinook NTTOC Monitoring

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

Pearsons, T. N., G. M. Temple, A. L. Fritts, C. L. Johnson, and T. D. Webster. 2008. Ecological Interactions between Non-target Taxa of Concern and Hatchery Supplemented Salmon. Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report. Annual Report 2007, Project No. 199506325, DOE/BP-00034450. Bonneville Power Administration, Portland, Oregon.

Task 4.d Pathogen Sampling

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

Thomas, J. B. 2007. Pathogen Screening of Naturally Produced Yakima River Spring Chinook Smolts; Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report. Annual Report 2006. DOE/BP-00027871.

Literature Cited

Busack, Craig, Todd Pearsons, Curt Knudsen, Steve Phelps, Washington Department of Fish and Wildlife, Bruce Watson, Mark Johnston, Yakama Nation, U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. 1997. Yakima Fisheries Project spring Chinook supplementation monitoring plan. Project Number 195-065, Contract Number DE-BI79-1996 BPA64878. http://www.efw.bpa.gov/Publications/P64878-1.pdf

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

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, 2004.

Larsen, D. A., B. R. Beckman, C. R. Strom, P. J. Parkins, K. A. Cooper, D. E. Fast, and 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.

APPENDICES A through G

	Task	
A.		Yakima River / CESRF Spring Chinook Salmon – Yakama Nation Data Summary
B.	1.c.	IntStats, Inc. Annual Report: 2007 Smolt-to-Smolt Survival of Brood-Year 2005 Upper Yakima Spring Chinook
C.	1.c.	IntStats, Inc. 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 2002-2005
D.	1.d.	IntStats, Inc. Smolt Survival to McNary Dam of Year-2007 Spring Chinook Releases at Roza Dam
E.	1.f.	IntStats, Inc. Smolt-to-Smolt Survival to McNary Dam of Main-Stem-Yakima Fall Chinook
F.	1.g.	Intstats, Inc. 2006-2007 Coho Smolt-to-Smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin
G.	4.a.	Avian Predation Annual Report

Appendix A

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

2007 Annual Report

June, 2008

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Contract Numbers: 00035037

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: Dr. Dave Fast, Mark Johnston, Bill Bosch, David Lind, Paul Huffman, Joe Hoptowit, Jerry Lewis, and a number of technicians from the YN; Charles Strom and a number of assistants from the CESRF; Dr. Todd Pearsons, Dr. Craig Busack, Dr. Steve Schroder, Anthony Fritts, Gabe Temple, Christopher Johnson, and a number of assistants from the WDFW; Curt Knudsen from Oncorh Consulting and Dr. Doug Neeley from IntSTATS Consulting; Ray Brunson and assistants from the USFWS; and Dr. Don Larsen, Dr. 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 three former members of the Yakima/Klickitat Fisheries Project, Bruce Watson, Joel Hubble, and Bill Hopley. These three individuals put in many long, hard days during the planning, design, and initial implementation of this project. Their hard work 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 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 2007. This report is not intended to be a scientific evaluation of spring Chinook supplementation efforts in the Yakima Basin. Rather, it is a summary of methods and data (additional information about methods used to collect these data may be found in the main section of this annual report) relating to Yakima River spring Chinook collected by Yakama Nation biologists and technicians from 1982 (when the Yakama Nation fisheries program was implemented) to present. Data summarized in this report include:

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

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

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Introduction

Program Objectives

The CESRF was authorized in 1996 under the NPCC's Fish and Wildlife Program with the stated purpose being "to test the assumption that new artificial production can be used to increase harvest and natural production while maintaining the long-term genetic fitness of the fish population being supplemented and keeping adverse genetic and ecological interactions with non-target species or stocks within acceptable limits". The CESRF became operational in 1997. The experimental design calls for a total release of 810,000 smolts annually from each of three acclimation sites associated with the facility (see facility descriptions). The first program cycle (brood years 1997 through 2001) also included testing new Semi-Natural rearing Treatments (SNT) against the Optimum Conventional Treatments (OCT) of existing successful hatcheries in the Pacific Northwest. The second program cycle (beginning with brood year 2002) is testing whether a slower, more natural growth regime can be used to reduce the incidence of precocialism that may be occurring in hatchery releases without adversely impacting overall survival to adult returns. 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 experimental sampling and hatchery control line broodstock. Through 2006, all wild/natural fish passing through the Roza trap were returned directly to the river with the exception of fish collected for broodstock or fish with metal tag detections which were sampled for marks and biological characteristics. Beginning in 2007, all wild/natural fish were sampled (as described above) and tissue samples were collected for a "Whole Population" Pedigree Study of Upper Yakima Spring Chinook.

The CESRF is located on the Yakima River just south of the town of Cle Elum (rkm 295.5). It is used for adult broodstock holding and spawning, and early life incubation and rearing. Fish are spawned in September and October of a given brood year (BY). Fish are typically ponded in March or April of BY+1. The juveniles are reared at Cle Elum, marked in October through December of BY+1, and moved to one of three acclimation sites for final rearing in January to February of BY+2. Acclimation sites are located at Easton (ESJ, rkm 317.8), Clark Flats near the town of Thorp (CFJ, rkm 266.6), and Jack Creek (JCJ, approximately 32.5 km north of Cle Elum) on the North Fork Teanaway River (rkm 10.2). Fish are volitionally released from the acclimation sites beginning on March 15 of BY+2, with any remaining fish "flushed out" of the acclimation sites by May 15 of BY+2. The annual production goal for the CESRF program is 810,000 fish for release as yearlings at 30 g/fish or 15 fish per pound (fpp) although size-at-release may vary depending on experimental protocols (see Program Objectives).

Yakima River Basin Overview

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

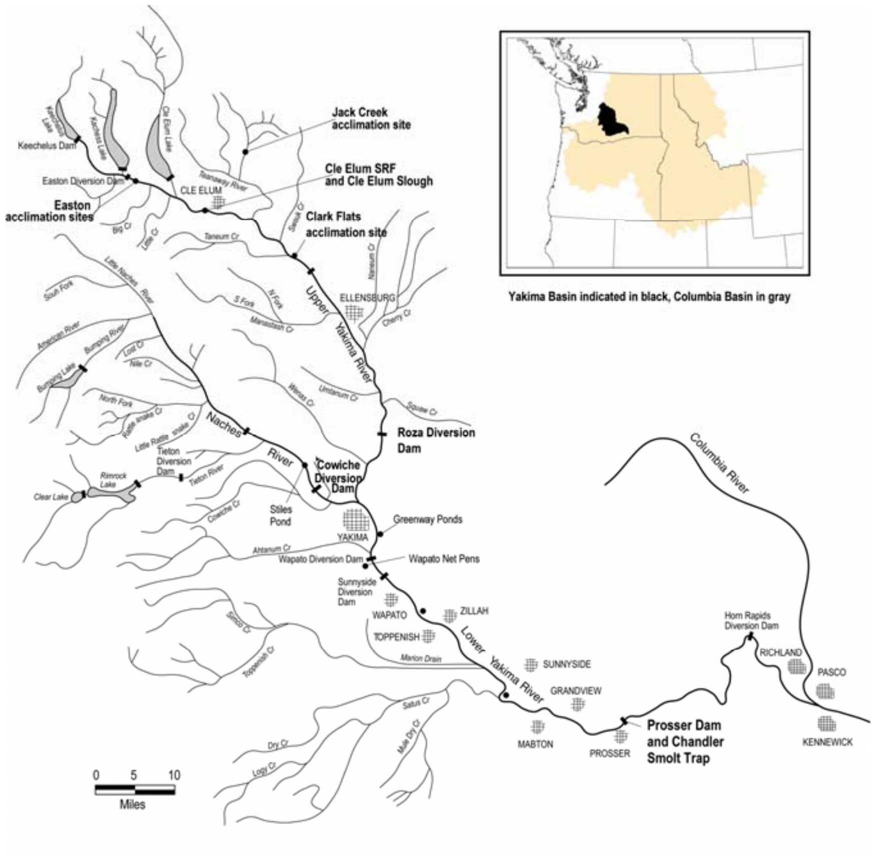


Figure 1. Yakima River Basin.

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

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

Adult Salmon Evaluation

Broodstock Collection and Representation

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

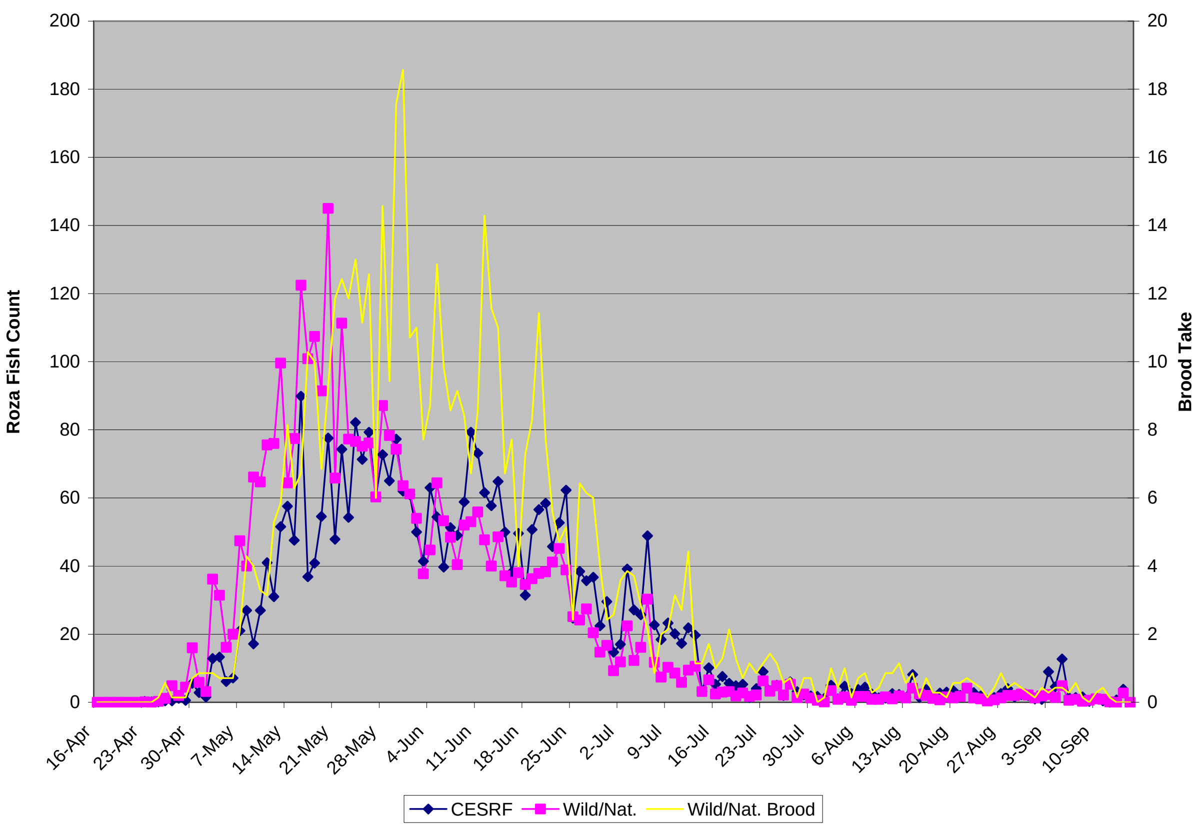


Figure 2. Mean spring Chinook run timing and broodstock collection at Roza Dam, 2001-2007.

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%

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

Originally the project intended to manage the proportion of natural- to hatchery-origin adults allowed to spawn naturally. However, we have concluded that actively managing for a specific spawning escapement proportion (natural- to hatchery-origin adults) is infeasible or undesirable. A number of factors went into this decision: the political climate regarding surplusing of fish, conflicts with overall production goals of the project, our inability to find clear guidance from the literature equating 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 finally, the numerous risk containment measures already in place in the project. However, the State of Washington is using mark-selective fisheries in the lower Columbia and, when possible, in the lower Yakima Rivers in part as a tool to manage escapement proportions. 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	HoR	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%
Mean[3]	2,936	295	3,231	2,718	527	3,244	5,546	846	6,392	52.3%	66.8%

1. Proportion Natural Influence equals Proportion Natural-Origin Broodstock (PNOB; 1.0 as only NoR fish are used for supplementation line brood stock) divided by PNOB plus Proportion Hatchery-Origin Spawners (PHOS; % HoR).
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, 1982-present.

Year	River Mouth Run Size[1] Adults	Jacks	Total	Harvest Below Prosser	Prosser Count	Harvest Above Prosser	Spawners Below Roza[2]	Roza Count	Roza Removals[3]	Est. Escapement Upper Y.R.[4]	Naches[5]	Redd Counts Upper Y.R.	Naches
1982	1,681	142	1,822	88	1,499	346	134	1,146	0	1,146	*108*	573	54
1983	1,231	210	1,441	72	867	12	118	1,007	0	1,007	*232*	360	83
1984	2,251	407	2,658	119	2,539	170	180	1,619	84	1,535	570	634	220
1985	4,109	451	4,560	321	4,239	544	247	2,428	97	2,331	1,020	860	427
1986	8,841	598	9,439	530	8,909	810	709	3,267	16	3,251	4,123	1,472	1,313
1987	4,187	256	4,443	359	4,084	158	269	1,928	194	1,734	1,729	903	677
1988	3,919	327	4,246	333	3,913	111	60	1,575	235	1,340	2,167	424	490
1989	4,640	274	4,914	560	4,354	187	135	2,515	184	2,331	1,517	915	541
1990	4,280	92	4,372	131	*2,255*	532	282	2,047	31	2,016	*1,380*	678	464
1991	2,802	104	2,906	27	2,879	5	131		40	*1,583*	*1,121*	582	460
1992	4,492	107	4,599	184	4,415	161	39	3,027	18	3,009	1,188	1,230	425
1993	3,800	119	3,919	44	3,875	85	56	1,869	0	1,869	1,865	637	554
1994	1,282	20	1,302	0	1,302	25	10	563	0	563	704	285	272
1995	526	140	666	0	666	79	9	355	0	355	223	114	104
1996	3,060	119	3,179	100	3,079	375	26	1,631	0	1,631	1,047	801	184
1997	3,092	81	3,173	0	3,173	575	20	1,445	261	1,184	1,133	413	339
1998	1,771	132	1,903	0	1,903	188	3	795	408	387	917	147	330
1999	1,513	1,268	2,781	8	2,773	596	55	1,704	738	966	418	212	186
2000	17,519	1,582	19,101	90	19,011	2,368	204	12,327	667	11,660	4,112	3,770	887
2001	21,225	2,040	23,265	1,793	21,472	2,838	286	12,516	718	11,798	5,832	3,260	1,192
2002	14,616	483	15,099	328	14,771	2,780	29	8,922	878	8,044	3,041	2,816	943
2003	4,883	2,074	6,957	59	6,898	381	83	3,842	584	3,258	2,592	868	935
2004	13,976	1,313	15,289	135	15,154	1,544	90	11,005	718	10,287	2,515	3,414	719
2005	8,067	691	8,758	34	8,724	440	28	6,352	667	5,685	1,904	2,009	576
2006	5,951	362	6,314	0	6,314	600	14	4,028	664	3,364	1,672	1,245	444
2007	2,982	1,321	4,303	10	4,293	269	13	3,025	716	2,309	986	722	314
Mean[6]	9,250	1,003	10,264	245	10,019	1,231	81	6,294	630	5,663	2,414	1,815	655

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 (1998-2007).

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

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

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns				Returns/ Spawner
		Age-3	Age-4	Age-5	Total	
1982	1,280	324	4,016	411	4,751	3.71
1983	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	147	3,383	8.68
1999	1,021[1]	164	733	45	942	0.92
2000	11,864	869	7,780	126	8,776	0.74
2001	12,084	784	5,097	233	6,115	0.51
2002	8,073	225	1,965	151	2,342	0.29
2003	3,341[1]	166	1,057		1,223	0.37
2004	10,377	211				
2005	5,713					
2006	3,378					
2007	2,322					
Mean	3,761	295	3,075	135	3,502	0.93

1. Approximately 45-50% of these fish were jacks.

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	86	85	1,275	324	0	1,683	19.57
1983	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	1,145	0	2,850	5.66
1999	358[1]	113	327	193	0	633	1.77
2000	3,862	72	2,084	216	0	2,372	0.61
2001	3,914	127	1,255	517	0	1,899	0.49
2002	1,861	59	775	152		986	0.53
2003	1,400	55	247			302	0.22
2004	2,197	109					
2005	1,434						
2006	1,260						
2007	743						
Mean	1,288	81	1,015	463	4	1,532	1.19

1. Approximately 48% of these fish were jacks.

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

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns Age-3	Age-4	Age-5	Age-6	Total	Returns/ Spawner
1982	22	42	223	248	0	513	23.32
1983	101	67	359	602	0	1,028	10.21
1984	187	54	301	458	0	813	4.36
1985	337	81	149	360	0	590	1.75
1986	1,457	36	134	329	11	509	0.35
1987	567	12	71	134	0	216	0.38
1988	827	19	208	661	5	892	1.08
1989	524	11	69	113	0	193	0.37
1990	425	15	113	84	0	213	0.50
1991	414	3	5	22	0	30	0.07
1992	335	23	157	237	0	417	1.24
1993	721	8	218	405	8	639	0.89
1994	230	7	36	16	0	59	0.26
1995	98	33	32	98	0	163	1.65
1996	159	30	176	760	0	967	6.07
1997	371	13	1,544	610	0	2,167	5.84
1998	414	120	766	1,153	0	2,039	4.92
1999	61	72	100	165	0	337	5.55
2000	250	62	165	112	0	339	1.35
2001	1,918	18	369	276	0	664	0.35
2002	1,180	19	276	262		557	0.47
2003	1,192	23	186			209	0.18
2004	318	123					
2005	469						
2006	412						
2007	243						
Mean	528	35	276	332	1	618	1.17

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	108	127	1,274	601	0	2,002	18.54
1983	232	190	1,257	1,257	8	2,713	11.68
1984	570	164	1,109	1,080	0	2,354	4.13
1985	1,020	213	667	931	0	1,811	1.77
1986	4,123	103	670	852	31	1,657	0.40
1987	1,729	39	231	400	0	669	0.39
1988	2,167	51	815	1,557	11	2,434	1.12
1989	1,517	39	332	371	0	741	0.49
1990	1,380	40	326	168	0	533	0.39
1991	1,121	10	32	144	127	314	0.28
1992	1,188	52	1,034	661	0	1,747	1.47
1993	1,865	53	603	817	17	1,489	0.80
1994	704	21	160	167	0	348	0.49
1995	223	73	201	498	0	771	3.46
1996	1,047	209	4,010	2,360	0	6,580	6.29
1997	1,133	220	4,645	1,377	0	6,242	5.51
1998	917	364	2,167	2,350	0	4,882	5.32
1999	418[1]	185	375	283	0	843	2.02
2000	4,112	134	2,323	347	0	2,805	0.68
2001	5,832	146	1,605	857	0	2,608	0.45
2002	3,041	78	987	453		1,518	0.50
2003	2,592	78	394			472	0.18
2004	2,515	232					
2005	1,904						
2006	1,672						
2007	986						
Mean	1,817	117	1,251	827	11	2,145	1.18

1. Approximately 48% of these fish were jacks.

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

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

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns				Returns/ Spawner
		Age-3	Age-4	Age-5	Total	
1997	261	741	7,753	176	8,670	33.22
1998	408	1,242	7,939	584	9,765	23.93
1999	738[1]	134	693	16	843	1.14
2000	567	1,071	3,528	68	4,667	8.23
2001	595	383	822	8	1,214	2.04
2002	629	336	1,724	64	2,124	3.38
2003	441	110	781		891	2.02
2004	597	783				
2005	510					
2006	419					
2007	449					
Mean	510	600	3,320	153	4,025	7.89

1. 357 or 48% of these fish were jacks.

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 2007, age composition of American River spring Chinook has averaged 0, 40, 58, and 2 percent age-3, -4, –5, and -6, respectively (Table 9). Naches system spring Chinook averaged 2, 56, 42 and 1 percent age-3, -4, –5 and -6, respectively (Table 10). The upper Yakima River natural origin fish averaged 6, 88, and 6 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	
Mean	1.5	46.9	51.2	0.5			38.6	59.5	1.9		0.5	40.3	57.5	1.7

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	
Mean	2.9	63.9	32.2	1.0		0.8	50.8	47.9	0.5		1.6	56.2	41.5	0.6

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		100.0		3		100.0		10		100.0	
Mean	12.2	83.4	4.3		1.4	92.6	6.0		6.4	88.2	5.4

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 17, 81, and 2 percent age-3, -4, and –5, respectively (Table 12) from 2001-2007 compared to 9, 85, and 6 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	80.0	20.0		5		100.0		10	26.7	73.3	
Mean	41.5	57.0	1.5		0.1	96.7	2.6		17.0	80.9	2.1

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
Mean	20.6	73.4	5.9		0.2	92.7	7.1		10.6	82.9	6.5

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

Return	Males				Females				Total		
Year	3	4	5	n	3	4	5	n	3	4	5
2001	12.5	87.5		40		100.0		75	5.1	94.9	
2002	14.7	83.8	1.5	68		98.3	1.7	115	5.5	92.9	1.6
2003	36.1	34.7	29.2	72		61.2	38.8	67	18.7	47.5	33.8
2004	19.6	80.4		46		100.0		60	8.5	91.5	
2005	17.8	75.6	6.7	45		88.1	11.9	59	7.7	82.7	9.6
2006	18.3	80.0	1.7	60		100.0		65	8.8	90.4	0.8
2007	33.3	60.8	5.9	51		87.5	12.5	56	15.9	74.8	9.3
Mean	21.8	71.8	6.4			90.7	9.3		10.0	82.1	7.9

Sex Composition

In the American River, the mean proportion of males to females in wild/natural carcasses sampled on the spawning grounds from 1986-2007 was 46:54 for age-4 and 33:67 for age-5 spring Chinook (Table 15). In the Naches River, the mean proportion of males to females was 44:56 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 32:68 for age-4 and 26:74 for age-5 fish (Table 17).

For upper Yakima fish collected at Roza Dam for brood stock or research purposes from 1997-2007, the mean proportion of males to females was 38:62 and 37:63 for age-4 fish from the wild/natural and CESRF populations, respectively (Tables 19 and 20). For these same samples, the mean proportion of males to females was 37:63 and 35:65 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		
mean			45.5	54.5	32.8	67.2		

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		
mean			43.6	56.4	25.7	74.3		

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

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
1986			20.0	80.0		100.0
1987	100.0		35.1	64.9	15.2	84.8
1988	64.3	35.7	43.8	56.3	30.0	70.0
1989	50.0	50.0	34.0	66.0	44.4	55.6
1990	60.0	40.0	31.3	68.7	45.5	54.5
1991	100.0		32.7	67.3	14.3	85.7
1992	100.0		33.1	66.9	62.5	37.5
1993	66.7	33.3	30.4	69.6	27.3	72.7
1994			24.6	75.4		100.0
1995	100.0		25.0	75.0		
1996	87.5	12.5	33.3	66.7	40.0	60.0
1997			31.1	68.9	28.6	71.4
1998	60.0	40.0	35.3	64.7		100.0
1999	100.0		27.7	72.3		100.0
2000	100.0		24.2	75.8		
2001	100.0		24.4	75.6	13.0	87.0
2002	33.3	66.7	32.9	67.1	76.2	23.8
2003	95.8	4.2	44.1	55.9		100.0
2004	100.0		33.9	66.1		100.0
2005	78.6	21.4	34.2	65.8	25.0	75.0
2006	87.5	12.5	34.6	65.4	50.0	50.0
2007			23.1	76.9		
mean	82.4	17.6	31.8	68.2	26.2	73.8

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		9.1	90.9		
mean	97.0	3.0	21.0	79.0		

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
mean	98.1	1.9	38.3	61.7	37.3	62.7

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
mean	100.0	0.0	37.4	62.6	34.5	65.5

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 39, 60, and 77 cm for age-3, -4, and -5 males, and averaged 62 and 73 cm for age-4 and -5 females, respectively, from carcasses sampled on the spawning grounds in the American River from 1996-2007 (Table 21). In the Naches River, mean POHP lengths averaged 41, 60, and 75 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 43, 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 2001-2007, CESRF fish returning to the upper Yakima have been generally smaller in size-at-age than their wild/natural counterparts (Tables 23-28).

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

	Males								Females					
Return	Age 3		Age 4		Age 5		Age 6		Age 4		Age 5		Age 6	
Year	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP	Count	MEHP
1986			5	57.1	16	80.9			4	65.8	39	75.2	2	74.0
1987			17	58.0	6	80.8	1.0	86.0	9	64.5	12	76.9		
1988					1	79.0			1	63.0				
1989			19	61.1	29	77.4			5	63.0	45	73.5		
1990	1	41.0	10	63.6	29	77.3			13	62.5	33	73.6		
1991			10	59.5	32	77.1			8	65.1	52	73.4		
1992			37	60.6	12	76.2	3.0	86.7	22	64.1	26	76.4		
1993	1	47.0	3	64.0	17	80.2			6	63.7	69	75.5		
1994			8	67.3	10	83.0			15	70.8	14	76.4	1	85.0
1995	1	44.4	1	70.0	4	83.5					12	76.4		
		POHP		POHP		POHP		POHP		POHP		POHP		POHP
1996			2	56.3					5	59.0	1	67.0		
1997[1]			2	62.0	1	63.0			4	62.8	14	64.4	5	71.0
1998			4	58.3	29	79.1			5	64.0	71	73.4		
1999			2	50.5					2	61.0	2	73.0	1	77.0
2000			10	57.9	5	83.2			8	63.9	5	76.2		
2001			59	65.9	31	77.6			72	63.6	34	73.0		
2002	1	40.0	31	63.0	26	77.3			62	64.4	48	74.7		
2003			6	63.0	68	79.4			12	64.3	139	76.7		
2004			3	56.0					1	58.0	4	77.5		
2005			11	60.6	6	80.2			21	62.6	4	74.8		
2006			8	60.8	5	75.4			17	61.8	18	71.7		
2007	2	37.0	6	62.8	11	76.5			21	60.0	27	73.3		
Mean[2]		38.5		59.7		76.8				62.1		73.0		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 1996-2007 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		
Mean[2]		40.9		60.0		75.4		78.0		41.0		60.9		72.5		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 1996-2007 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			3	59.0					10	59.8		
Mean[1]		42.9		59.7		71.9		44.4		59.5		68.7

[1] Mean of mean values for 1996-2007 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	1	60.0					10	60.3		
Mean		44.4		59.1		69.2				60.5		70.4

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

Return	Males						Females					
	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
Mean		42.2		59.1		70.5				59.8		68.3

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

Return	Males						Females					
	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
Mean		40.1		58.7		71.4				58.8		68.0

[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
Mean				42.2		60.4		70.6

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
Mean		15.4		40.2		59.3		70.1

Migration Timing

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

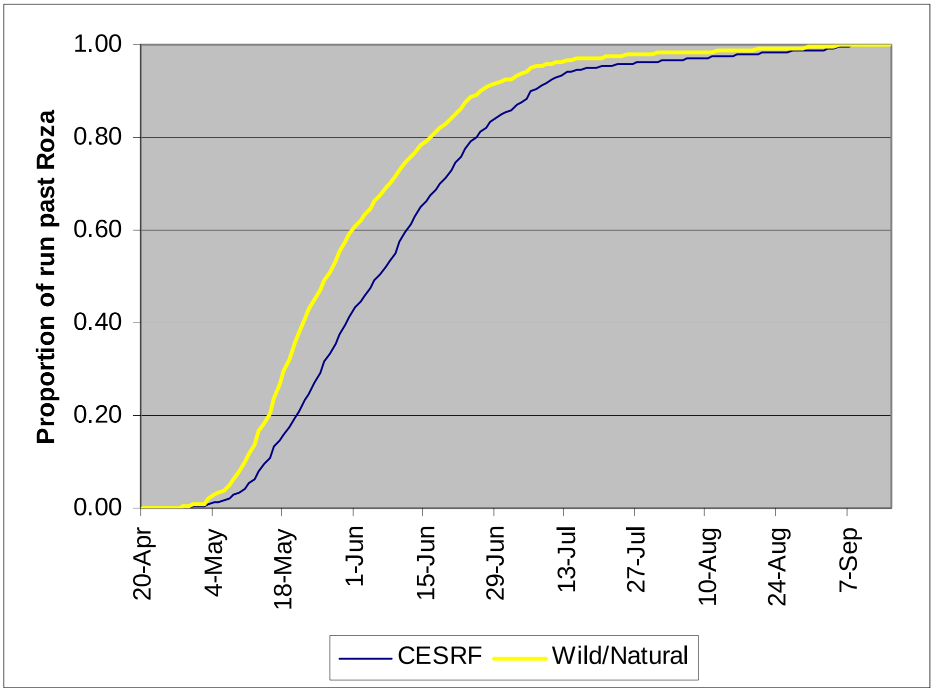


Figure 3. Proportionate passage timing at Roza Dam of wild/natural and CESRF adult spring Chinook (including jacks), 2001-2007.

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

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
Mean	13-Aug	12-Sep	25-Sep	21-Sep

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

Redd Counts and Distribution

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

	Upper Yakima River System				Naches River System				
Year	Mainstem[1]	Cle Elum	Teanaway	Total	American	Naches[1]	Bumping	Little Naches	Total
1981	237	57	0	294	72	64	20	16	172
1982	610	30	0	640	11	25	6	12	54
1983	387	15	0	402	36	27	11	9	83
1984	677	31	0	708	72	81	26	41	220
1985	795	153	3	951	141	168	74	44	427
1986	1,716	77	0	1,793	464	543	196	110	1,313
1987	968	75	0	1,043	222	281	133	41	677
1988	369	74	0	443	187	145	111	47	490
1989	770	192	6	968	187	200	101	53	541
1990	727	46	0	773	143	159	111	51	464
1991	568	62	0	630	170	161	84	45	460
1992	1,082	164	0	1,246	120	155	99	51	425
1993	550	105	1	656	214	189	88	63	554
1994	226	64	0	290	89	93	70	20	272
1995	105	12	0	117	46	25	27	6	104
1996	711	100	3	814	28	102	29	25	184
1997	364	56	0	420	111	108	72	48	339
1998	123	24	1	148	149	104	54	23	330
1999	199	24	1	224	27	95	39	25	186
2000	3,349	466	21	3,836	53	483	278	73	887
2001	2,932	386	21	3,339	392	436	257	107	1,192
2002	2,441	275	110	2,826	366	226	262	89	943
2003	772	87	31	890	430	228	216	61	935
2004	2,985	330	129	3,444	91	348	205	75	719
2005	1,717	287	15	2,019	142	203	163	68	576
2006	1,077	100	58	1,235	133	163	115	33	444
2007	665	51	10	726	166	60	60	28	314
Mean	1,005	124	15	1,144	158	180	108	47	493

[1] Including minor tributaries.

Homing

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

Straying

The regional PTAGIS (PIT tag) and RMIS (CWT) databases were queried in February 2008 to determine the number of CESRF releases not returning to the Yakima River Basin. For adult (age-3, -4, or -5) PIT tagged fish, a stray is defined as detection at an out-of-basin facility in the Snake (Ice Harbor or Lower Granite) or Upper Columbia (Priest Rapids, Rock Island, or Wells) without a subsequent detection at Prosser or Roza Dam. For coded-wire tagged fish, a stray is generally defined as a tag recovery in tributaries of the Columbia River upstream (and including the Snake River Basin) of its' confluence with the Yakima River. Marked (adipose fin clipped) fish are occasionally found during carcass surveys in the Naches River system. All marked fish observed in spawning ground carcass surveys in the Naches Basin are assumed to be CESRF fish and are used to estimate in-basin stray rates.

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

	CESRF PIT-Tagged Fish			All CESRF Fish			CESRF Age-4 Fish		
Brood Year	Roza Adult Returns	Adult Strays	Stray Rate	Yakima River Mth Return	CWT Strays	Stray Rate	Yak R. MthRtn	In-Basin Strays	Stray Rate
1997	598	2	0.33%	8,670	1	0.01%	7,753		
1998	398	0	0.00%	9,765			7,939	1	0.01%
1999	23	0	0.00%	843			693		
2000	150	4	2.67%	4,667	3	0.06%	3,528	4	0.11%
2001	80	1	1.25%	1,214			822	2	0.24%
2002	97	4	4.12%	2,124			1,724	1	0.06%

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	Live-Egg-Fry Survival	Smolts Released[4]	Fry-Smolt Survival	Live-Egg-Smolt Survival
1997	261	23	91.2%	106	132	2.6%	500,750	463,948	7.3%	456,981	98.5%	386,048	84.5%	83.2%
1998	408	70	82.8%	140	198	1.4%	739,802	664,125	10.2%	655,249	98.7%	589,683	90.0%	88.8%
1999	738[5]	24	96.7%	213	222	2.7%	818,816	777,984	5.0%	756,592	97.3%	758,789	100.0%	97.5%
2000	567	61	89.2%	170	278	9.2%	916,292	851,128	7.1%	828,055	97.3%	834,285	100.0%	98.0%
2001	595	171	71.3%	145	223	53.2%	341,648	316,254	7.4%	311,751	98.6%	370,236	100.0%	100.0%
2002	629	89	85.9%	125	261	10.0%	919,776	817,841	11.1%	801,141	98.0%	749,067	93.5%	91.6%
2003	441	54	87.8%	115	200	0.0%	856,574	787,933	8.0%	775,619	98.4%	735,959	94.9%	93.4%
2004	597	70	88.3%	125	245	0.4%	873,815	806,375	7.7%	789,028	97.8%	691,109[6]	87.6%	85.7%
2005	526	57	89.2%	136	241	0.0%	907,199	835,890	7.9%	819,861	98.1%	769,484	93.9%	92.1%
2006	519	45	91.3%	122	239	1.7%	772,357	703,657	8.9%	684,918	97.3%	574,361	83.9%	81.6%
2007	473	49	89.6%	149	216	0.9%	798,729	760,189	4.8%	751,586	98.9%			
Mean	523	65	87.6%	141	223	7.5%	767,796	707,757	7.8%	693,707	98.1%	645,902	92.8%	91.2%

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. May be greater than fry ponded due to adjusted counts from marking operations.
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. 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.
8. 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[7]	Live Eggs[8]	% Egg Loss[3]	Fry Ponded	Live-Egg-Fry Survival	Smolts Released[4]	Fry-Smolt Survival	Live-Egg-Smolt Survival
2002	201	22	89.1%	26	72	4.2%	258,226	100,011	7.8%	98,294	98.3%	87,837	89.4%	87.8%
2003	143	12	91.6%	30	51	0.0%	219,901	83,128	7.3%	82,021	98.7%	88,733	100.0%	100.0%
2004	126	19	84.9%	22	49	0.0%	187,406	94,659	5.9%	92,960	98.2%	94,339	100.0%	99.7%
2005	109	6	94.5%	26	45	0.0%	168,160	89,066	12.2%	87,299	98.0%	90,518	100.0%	100.0%
2006	136	21	84.6%	28	41	2.4%	112,576	80,121	8.6%	78,291	97.7%	68,434	87.4%	85.4%
2007	110	15	86.4%	26	35	0.0%	125,755	90,162	3.2%	89,399	99.2%			
Mean	138	16	88.5%	26	49	1.1%	178,671	89,525	7.5%	88,044	98.3%	85,972	95.4%	94.6%

See footnotes for Table 33 above.

Female BKD Profiles

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

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

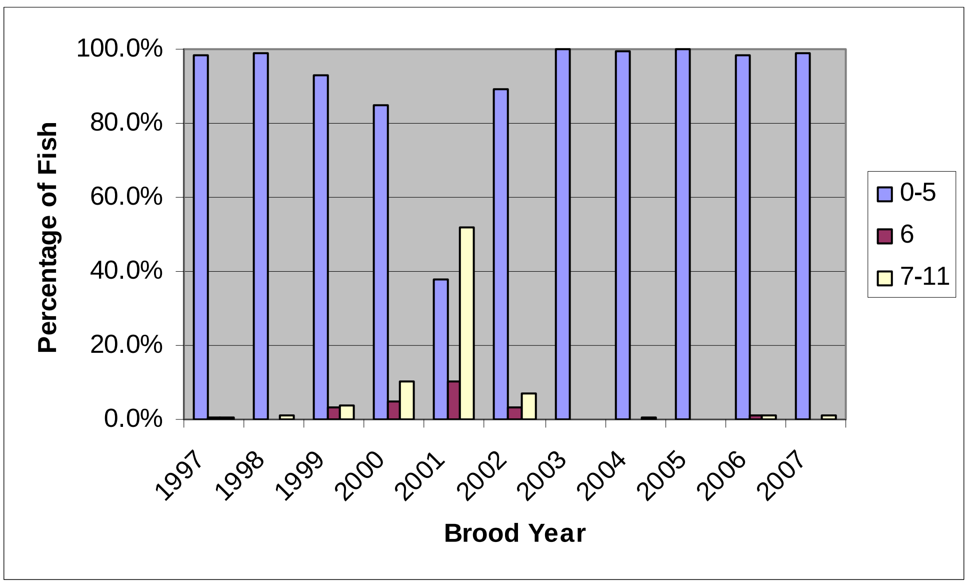


Figure 4. Proportion of wild/natural females spawned at CESRF by BKD rank, 1997 – present.

Fecundity

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

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

	Wild/Natural (SN)						CESRF (HC)					
Brood	Age-3		Age-4		Age-5		Age-3		Age-4		Age-5	
Year	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity	N	Fecundity
1997			105	3,842.0	4	4,069.9						
1998			161	3,730.3	15	4,322.5						
1999			183	3,968.1	14	4,448.6						
2000			224	3,876.5	2	5,737.9						
2001			72	3,966.9	9	4,991.2			18	4,178.9		
2002	1	1,038.0	205	3,934.7	7	4,329.4			60	3,820.0	1	4,449.0
2003			163	4,160.2	31	5,092.8			30	3,584.1	19	5,459.9
2004			224	3,555.4	2	4,508.3			42	3,827.2		
2005	1	1,769.0	218	3,815.5	5	4,675.1			38	3,723.9	5	4,014.7
2006			196	3,396.4	24	4,338.9			36	3,087.3		
2007			178	3,658.3	24	4,403.3			29	3,553.6	2	4,381.9
Mean				3,809.5		4,628.9				3,682.1		4,576.4

Juvenile Salmon Evaluation

Food Conversion Efficiency

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

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

Brood Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1997	2.2		1.1	0.8	1.2	0.8	1.5	1.5		1.9		5.3	0.7
1998		1.0	0.9	1.0	0.9	0.8	2.4	1.4	2.1	-0.3	1.0	1.2	0.8
1999		1.0	1.1	1.1	1.2	1.5	1.8	1.0		-0.5	0.3	1.7	0.7
2000	0.8	0.8	1.0	1.5	1.2	1.4	2.2	2.0	1.6	2.1	2.5	2.4	
2001	1.1	1.1	2.6	1.1	1.3	1.2	1.6	2.0	2.3	2.5	2.8	0.9	
2002	0.9	1.0	1.4	1.2	1.4	1.1	1.5	2.2	4.0	-1.4	2.9	1.0	
2003	0.6	1.0	0.9	1.4	1.2	1.2	4.6	0.7	0.9	-0.2	1.8	1.0	
2004	0.9	1.0	1.2	1.6	2.4	1.2	1.7	2.0	2.8	0.9	-2.6	1.1	
2005	0.8	0.7	1.3	1.0	1.3	1.2	1.5	-0.8	0.4	-0.4	2.2		
2006	0.8	0.7	0.6	0.9	0.8	1.0	1.6	-1.0	10.1	-2.6	0.6	0.6	
Mean	1.0	0.9	1.2	1.2	1.3	1.1	2.0	1.1	2.0	0.5	1.3	1.3	0.7

Length and Weight Growth Profiles

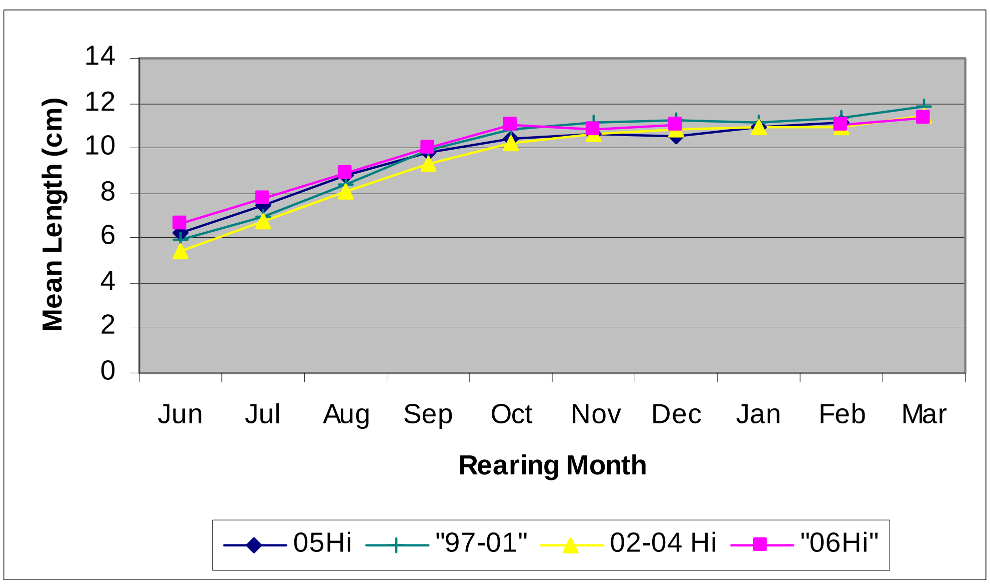


Figure 5. Mean length (cm) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.

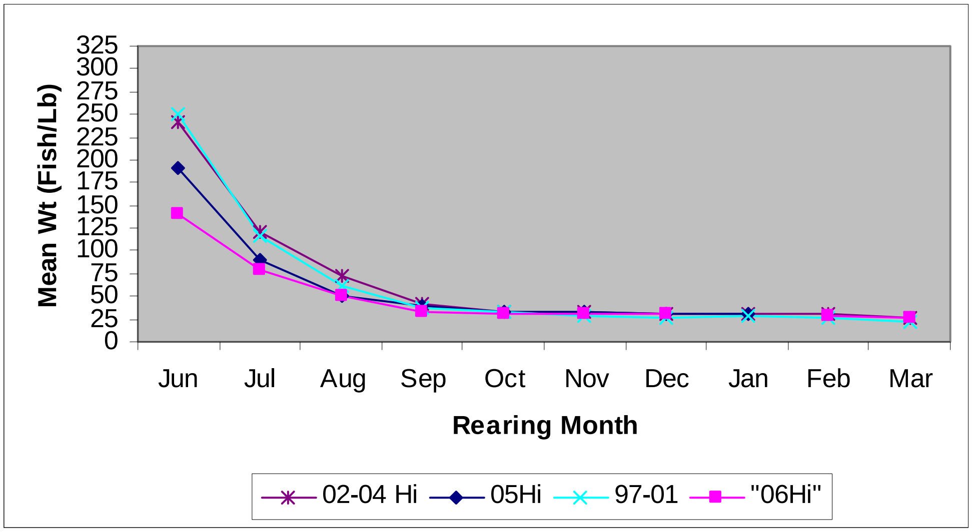


Figure 6. Mean Weight (fish/lb) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - present.

Juvenile Fish Health Profile

Approximately 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	Mean
CFJ01	0.80	0.53	2.17	1.90	0.28	0.28	0.99
CFJ02	1.08	1.88	1.33	1.10	0.18	0.25	0.97
CFJ03	2.38	0.82	1.50		0.22	0.28	1.04
CFJ04	1.15	0.58	1.18		0.16	0.14	0.64
CFJ05	0.85	0.78	1.20		0.06	0.75	0.73
CFJ06	1.05	0.70	1.02		0.21	0.02	0.60
ESJ01	2.03	0.50	1.97	1.19	0.10	0.55	1.05
ESJ02	1.68	0.53	1.17	1.50	0.05	0.43	0.89
ESJ03	2.23	1.37	2.47	0.86	0.07	0.33	1.22
ESJ04	1.33	0.55	1.35	0.79	0.15	0.60	0.79
ESJ05		1.15	3.12	0.73	0.04	0.68	1.15
ESJ06		0.67	1.30	0.80	0.05	0.23	0.61
JCJ01		0.67	1.93	1.47	0.04	0.10	0.84
JCJ02		0.48	1.30	1.52	0.19	0.08	0.71
JCJ03		0.33	1.45	1.62	0.06	0.20	0.73
JCJ04		0.62	1.50	1.56	0.05	0.13	0.77
JCJ05			1.55	1.67	0.00	1.35	1.14
JCJ06			1.25	1.46	0.03	0.10	0.71
Clark Flat	1.22	0.88	1.40	1.50	0.18	0.29	0.91
Easton	1.81	0.80	1.89	0.98	0.08	0.47	1.00
Jack Creek		0.53	1.50	1.55	0.06	0.33	0.79
All Ponds	1.46	0.76	1.60	1.30	0.11	0.36	0.93

1. Antibody problems were encountered and the USFWS was unable to re-process the samples due to the small amount of tissue collected. Therefore, no data are available for the 1999, 2004 or 2005 broods.
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, 2004.

Larsen, D.A., B.R. Beckman, C.R. Strom, P.J. Parkins, K.A. Cooper, D.E. Fast, W.W. Dickhoff. 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, 2006.

Beckman, B.R. and Larsen D.A. 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, 2005.

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
Mean	348,147	340,741	236,729	229,007	247,947	688,888

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

Brood	Treatment		Acclimation Site		
Year	Control[1]	Treatment[2]	CFJ	ESJ	JCJ
1997	41,487	35,722	38,215	39,190	
1998[3]	35,584	38,126	36,910	38,477	34,341
1999	42,729	41,581	38,761	44,917	42,787
2000	47,173	45,526	47,659	43,844	47,545
2001[4]	41,116	41,667	40,391	6,518	41,725
2002	46,752	46,238	44,427	48,425	46,632
2003	46,019	45,613	45,563	44,619	47,267
2004[5]	42,082	45,190	46,766	45,573	38,568
2005	47,948	47,607	47,855	46,858	48,621
2006	39,007	32,415	34,929	36,322	35,881
Mean	42,990	41,968	42,148	43,136	42,596

1. Brood years 1997-2001: Optimum Conventional Treatment (OCT). Brood Years 2002-2004: Normal (High) growth. Brood Years 2005-2006: Normal feed at accl. sites.
2. Brood years 1997-2001: Semi-natural Treatment (SNT). Brood Years 2002-2004: Slowed (Low) growth. Brood Year 2005: 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.

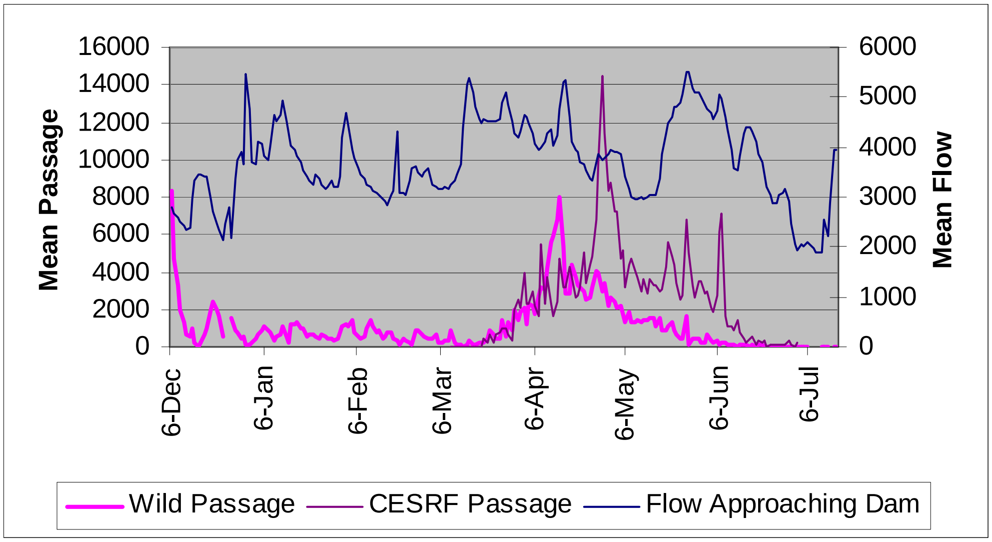


Figure 7. Mean flow approaching Prosser Dam versus mean estimated smolt passage at Prosser of aggregate wild/natural and CESRF spring Chinook for outmigration years 1999-2007.

Smolt-to-Smolt Survival

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

The 2003 outmigration year was the last outmigration year for the five-year experimental releases of fish reared using one of two treatments: the semi-natural treatment (SNT) and the optimum conventional treatment (OCT). Smolt-to-smolt survival indices from release[1] to McNary Dam passage were estimated for PIT-tag releases for each treatment from each rearing pond within each acclimation site within each year. In previous years there was no attempt to adjust survival-index estimates for fish that were removed at McNary Dam (McNary) and not returned to the river. Further, over the broods, inconsistent methods of estimating McNary detection efficiencies were inadvertently used to expand numbers of fish detected at McNary to obtain the estimates of the survival indices. The smolt-to-smolt survival-index data from all five outmigration years were reviewed, and, where needed, corrected and reanalyzed.

There is insufficient evidence that the SNT treatment resulted in higher smolt-to-smolt survival index than did the OCT treatment over the five broods (the hypothesis to be tested). Based on a one-sided sign test, the SNT fish had a significantly higher smolt-to-smolt survival index than did the OCT fish for the first three broods; however, other statistical tests did not result in the same level of significance. For the fourth brood, there was an elevated level of BKD infestation. The SNT-treated smolts had a significantly higher mean BKD index than did the OCT and also had a lower smolt-to-smolt survival index. When the survival index was adjusted for a BKD index as a covariate, there was no significant difference between the SNT and OCT smolt-to-smolt survival indices. For the last brood, there was no significant difference between the SNT and OCT survival indices.

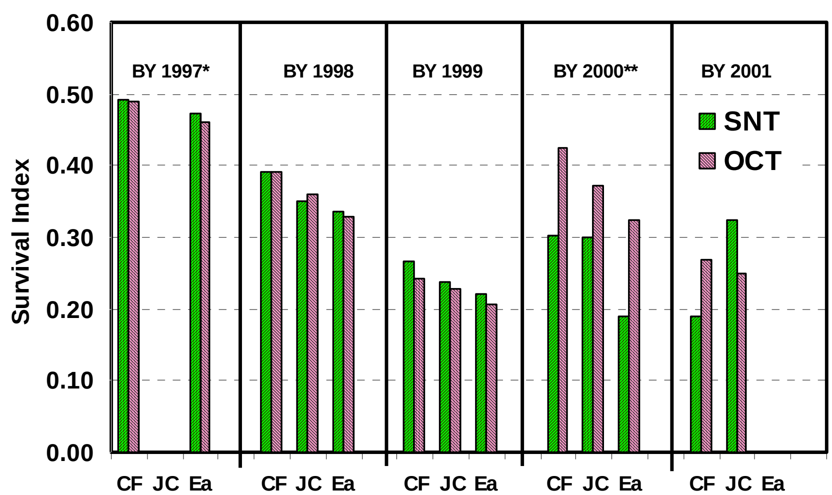
[1] From the 1998 brood on, survival index was based on volitional releases (only those fish detected leaving the acclimation ponds were used to estimate survival index and the number detected at the ponds serves as the release number); however for the 1997 brood it was not possible to use data from the acclimation site detectors; therefore, the survival index for the 1997 brood is actually based on number of fish tagged adjusted for PIT-tagged mortalities detected in the ponds prior to release.

Table 40. Total release numbers[1] and release-to-McNary smolt-to-smolt survival indices (as proportions) for PIT-tagged OCT and SNT Spring Chinook released into the Upper Yakima.

Treatment		Brood Year 1997 Acclimation Site Clark Flat	Brood Year 1997 Acclimation Site Easton	Brood Year 1998 Acclimation Site Clark Flat	Brood Year 1998 Acclimation Site Jack Creek	Brood Year 1998 Acclimation Site Easton
OCT	Volitional Release Number	11978	7979	7194	3732	7309
	Survival Index	**0.4884**	**0.4607**	**0.3901**	**0.3608**	**0.3288**
SNT	Volitional Release Number	11974	7961	7196	4693	7261
	Survival Index	**0.4916**	**0.4734**	**0.3907**	**0.3496**	**0.3356**

Treatment		Brood Year 1999 Acclimation Site Clark Flat	Brood Year 1999 Acclimation Site Jack Creek	Brood Year 1999 Acclimation Site Easton	Brood Year 2000 Acclimation Site Clark Flat	Brood Year 2000 Acclimation Site Jack Creek	Brood Year 2000 Acclimation Site Easton	Brood Year 2001 Acclimation Site Clark Flat	Brood Year 2001 Acclimation Site Jack Creek
OCT	Volitional Release Number	6519	6473	6480	6340	6480	6512	3559	11601
	Survival Index	**0.2425**	**0.2287**	**0.2055**	**0.4239**	**0.3716**	**0.3249**	**0.2683**	**0.2501**
SNT	Volitional Release Number	6454	6410	6455	5858	6466	5924	3372	11555
	Survival Index	**0.2673**	**0.2370**	**0.2216**	**0.3030**	**0.3001**	**0.1899**	**0.1901**	**0.3244**

1. See textual footnote 1 above.



Acclimation Sites: CF--Clark Flat, JC--Jack Creek, Ea--Easton

SNT-Semi-Natural Treatment, OCT-Optimal Conventional Treatment

* BY-1997 release number = number tagged corrected for pre-release mortalities, BY-1998 through BY-2001 release numbers = number detected volitionally leaving ponds

** Unadjusted for BKD index (discussed in text)

Figure 8. Release-to-McNary smolt-to-smolt survival indices for OCT and SNT Spring Chinook released into the Upper Yakima [release/outmigration years 2 years following brood year (BY)].

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 treatment had a significantly lower smolt-survival index than the high treatment; however fish subjected to this treatment had similar volitional release times. Low-treated fish were smaller fish at the time of release and had somewhat later McNary passage times than high-treated fish.

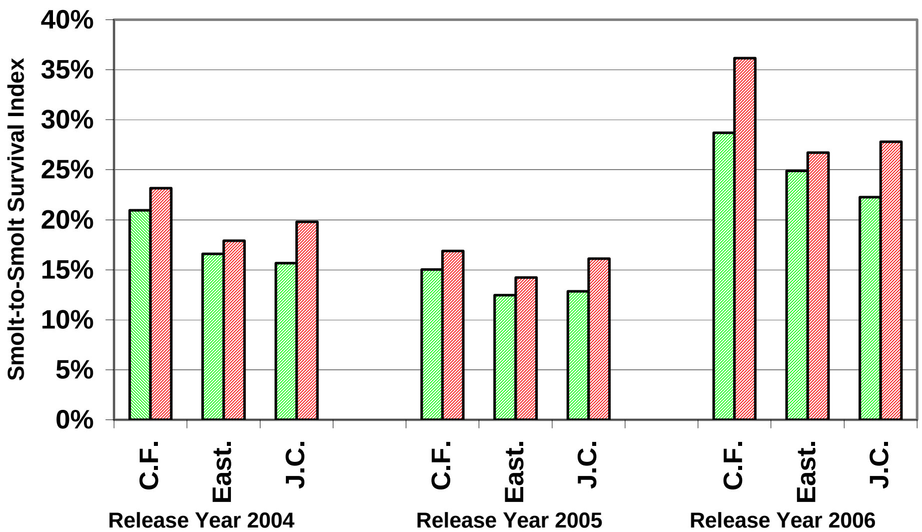


Figure 9. Volitional-Release-to-McNary Smolt-to-Smolt Survival Indices for Brood-Year 2002, 2003, 2004 Low- and High-Nutrition treated Upper Yakima Spring Chinook Smolts in release-year 2004, 2005, and 2006 (Low, downward slash; High, upward slash).

Control versus Saltwater Transfer Treatment (Brood Year 2005, Migration Year 2007)

An STF feed (intended to facilitate smolt fresh-water to salt-water transition) was tested at the Cle Elum facility and compared to the control feed. These two treatments were assigned to different raceways within adjacent raceway pairs, there being up to nine raceway pairs. Each raceway pair was assigned to juvenile progeny from the same diallele crosses, the different raceway pairs being from different diallele crosses. Juveniles were transported to three acclimation sites (Clark Flat, Easton, and Jack Creek), up to three pairs of adjacent Cle Elum raceways assigned to corresponding adjacent raceways at a given site, different Cle Elum raceway pairs to different sites. There were no significant or substantial differences between the two feeding treatments (Figure 10; Appendix B of main annual report).

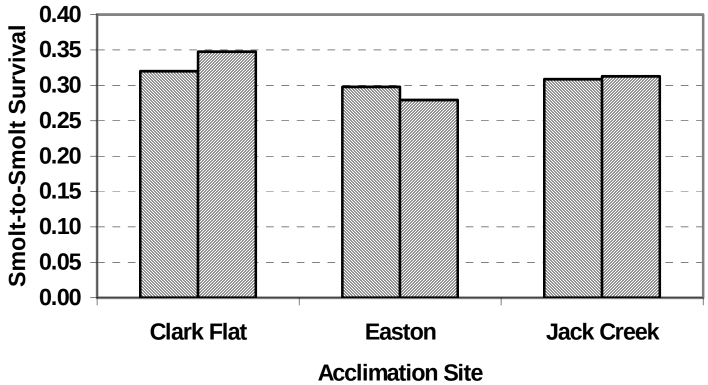


Figure 10. **Volitional-Release-to-McNary Smolt-to-Smolt Survival Indices for Brood-Year 2005 Control and saltwater-transfer treated Upper Yakima Spring Chinook Smolts in release-year 2007 (control, upward slash; saltwater-transfer, downward slash).**

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 can not 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 presently 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. No attempt has yet 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 44-45). 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 44 and only as an adult return in Table 45. Knudsen et al. (in press) estimated that PIT tags were lost on average in 17% of adults returning 8 months to 4 years after release; however, after correcting PIT tag recoveries for tag loss, recoveries were no longer significantly lower than expected (X^2-test $p>0.05$) indicating that there was no significant reduction in post-release survival due directly to the effects of PIT tags. Thus, it is likely that the data in Table 44 under-represent "true" SAR values for PIT-tagged fish. Therefore, SAR values for PIT-tagged and non-PIT-tagged fish could be closer than those reported in Tables 44 and 45.

Given these complicating factors, Tables 41-45 present what we believe to be the best 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.

Table 41. Estimated smolt passage at Chandler and smolt-to-adult survival rates (Chandler smolt to Yakima R. mouth adult).

Brood Year	Migr. Year	Mean Flow[1]	Estimated Smolt Passage at Chandler: Wild/ Natural[2]	Control[3]	Treatment[4]	CESRF Total	CESRF smolt-to-smolt survival[5]	Yakima R. Mouth Adult Returns[6]: Wild/ Natural[2]	CESRF Total	Smolt-to-Adult Survival[6]: 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	291,557					21,151		7.3%	
1997	1999	5925	277,087	42,668	55,176	97,844	25.3%	12,855	8,670	4.6%	8.9%
1998	2000	4946	77,009	109,087	116,020	225,107	38.2%	8,265	9,765	10.7%	4.3%
1999	2001	1321	105,422	233,921	216,649	450,570	59.4%	1,786	843	1.7%	0.2%
2000	2002	5015	481,414	193,515	132,228	325,743	39.0%	11,581	4,667	2.4%	1.4%
2001	2003	3504	261,707	49,845	62,232	112,077	30.3%	8,688	1,214	3.3%	1.1%
2002	2004	2439	137,343	155,031	145,056	300,087	35.9%	3,894	2,124	2.8%	0.7%
2003	2005	1285	157,057	124,412	106,253	230,665	28.0%	1,696[7]	891[7]	1.1%[7]	0.4%[7]
2004	2006	5652	92,175	86,308	73,044	159,352	20.3%				
2005	2007	4551	130,263	163,151	162,197	325,348	37.8%				

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 2002-2004 : Normal (High) growth.
4. Brood years 1997-2001: Semi-natural Treatment (SNT). Brood Years 2002-2004 : Slowed (Low) growth.
5. Estimated smolt-to-smolt (release from upper Yakima River acclimation sites to Chandler) survival for CESRF juveniles.
6. CESRF adult returns and smolt-to-adult survival values are understated relative to wild/natural values since these figures are not adjusted for differential harvest rates in mark selective fisheries in marine and lower Columbia River fisheries.
7. Preliminary; data do not include age-5 adult returns.

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

		Wild/Natural smolts tagged at Roza				
		Adult Returns at Age[1]				
Brood Year	Number Tagged	Age 3	Age 4	Age 5	Total	SAR[1]
1997	310	0	1	0	1	0.32%[2]
1998	6,209	15	171	14	200	3.22%
1999	2,179	2	8	0	10	0.46%
2000	8,718	1	51	1	53	0.61%
2001	7,804	9	52	3	64	0.82%
2002	3,931	2	41	4	47	1.20%
2003	1,733	0	6		6	0.35%
2004	2,333	1				

Table 43. Estimated CESRF smolt-to-adult return rates (SAR) based on adult detections of PIT tagged fish. Roza tagged smolts to Bonneville Dam adult returns.

		CESRF smolts tagged at Roza				
		Adult Returns at Age[1]				
Brood Year	Number Tagged	Age 3	Age 4	Age 5	Total	SAR[1]
1997	407	0	2	0	2	0.49%[2]
1998	2,999	5	42	2	49	1.63%
1999	1,744	1	0	0	1	0.06%
2000	1,503	0	1	0	1	0.07%
2001	2,146	0	4	0	4	0.19%
2002	2,201	4	5	0	9	0.41%
2003	1,418	0	3		3	0.21%
2004	4,194	3				

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 44. 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		44	0.11%	3	27		30	0.08%
2004	36,426	37					24				

1. For brood years 1998-2001, this is the number of unique PIT tags physically detected leaving the acclimation sites. For other brood years, 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 45. 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	130	2,232	0.28%
2003	785,776	115	1,573		1,689	0.21%
2004	749,022	689				

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 CWT presence information 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 46. 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	64	376	0	0	64	376	440	6.3%
2004	157	844	569	109[2]	726	953	1,679	11.0%
2005	12	462	0	0	12	462	474	5.4%
2006	49	551	0	0	49	551	600	9.5%
2007	73	206	0	0	73	206	279	6.5%
Mean	329	608	330	131	659	648	827	11.9%

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 47. 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	3,764	66	280	1,822	434	780	780	0	20.7%	
1983	2,401	122	105	1,441	84	311	311	0	12.9%	
1984	3,879	143	277	2,658	289	709	709	0	18.3%	
1985	5,396	207	194	4,560	865	1,266	1,266	0	23.5%	
1986	13,554	286	835	9,439	1,340	2,461	2,461	0	18.2%	
1987	6,310	100	421	4,443	517	1,038	1,038	0	16.4%	
1988	6,078	419	438	4,246	444	1,301	1,301	0	21.4%	
1989	8,732	224	704	4,914	747	1,675	1,675	0	19.2%	
1990	6,203	332	432	4,372	663	1,427	1,427	0	23.0%	
1991	4,240	180	274	2,906	32	486	486	0	11.5%	
1992	5,811	100	371	4,599	345	816	816	0	14.0%	
1993	4,430	37	288	3,919	129	454	454	0	10.2%	
1994	2,051	88	109	1,302	25	223	223	0	10.9%	
1995	1,216	0	74	666	79	153	153	0	12.6%	
1996	5,362	4	290	3,179	475	769	769	0	14.3%	
1997	5,132	2	372	3,173	575	950	950	0	18.5%	
1998	2,654	2	151	1,903	188	342	342	0	12.9%	
1999	3,801	3	193	2,781	604	800	800	0	21.0%	
2000	26,795	54	1,692	19,100	2,458	4,203	4,083	121	15.7%	
2001	29,753	996	3,903	23,265	4,630	9,529	5,476	4,053	32.0%	30.7%
2002	22,562	1,386	2,535	15,099	3,108	7,029	2,582	4,446	31.2%	26.5%
2003	10,226	349	889	6,957	440	1,678	1,067	611	16.4%	16.1%
2004	21,522	1,094	1,911	15,289	1,679	4,684	2,697	1,988	21.8%	17.4%
2005	12,214	382	886	8,758	474	1,741	1,387	354	14.3%	13.5%
2006	11,353	346	898	6,314	600	1,844	1,262	582	16.2%	16.7%
2007[1]	5,409	232	452	4,303	279	963	506	457	17.8%	16.7%
Mean	8,879	275	730	6,208	827	1,832	1,347	1,784	17.9%	17.4%

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 48 gives the results of a query of the RMIS database run on Feb. 2, 2008 for CESRF spring Chinook CWTs released in brood years 1997-2004. Based on the information reported to RMIS to date, it is believed that marine harvest accounts for about 0-2% of the total harvest of Yakima Basin spring Chinook.

Table 48. Marine and freshwater recoveries of CWTs from brood year 1997-2004 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) 2 Feb, 2008.

Brood	Observed CWT Recoveries			Expanded CWT Recoveries		
Year	Marine	Fresh	Marine %	Marine	Fresh	Marine %
1997	5	56	8.2%	8	336	2.3%
1998	2	53	3.6%	2	239	0.8%
1999		2	0.0%		9	0.0%
2000		14	0.0%		35	0.0%
2001		1	0.0%		1	0.0%
2002		7	0.0%		36	0.0%
2003[1]		3	0.0%		6	0.0%
2004[1]		3	0.0%		21	0.0%

1. Reporting of CWT recoveries to the RMIS database typically lags actual fisheries by one to two years. Therefore, CWT recovery data for brood years 2003-2004 are considered incomplete.

Literature Cited

BPA (Bonneville Power Administration). 1990. Yakima-Klickitat Production Project Preliminary Design Report and Appendices. Bonneville Power Administration, Portland, OR.

C.M. Knudsen, S.L. Schroder, T.N. Pearsons, J.A. Rau, A.L. Fritts, and C.R. Strom. 2003. Monitoring Phenotypic and Demographic Traits of upper Yakima River Hatchery and Wild Spring Chinook: Gametic and juvenile Traits. YKFP Annual Report 2002.

Knudsen, C.M. (editor). 2004. Reproductive Ecology of Yakima River hatchery and wild spring Chinook. Annual Report 2003, Project Number 1995-063-25. BPA Report DOE/BP-00013756-3.

Knudsen, C. M., M. V. Johnston, S. L. Schroder, W. J. Bosch, D. E. Fast, and C. R. Strom. In press. Long Term Loss of Passive Integrated Transponder Tags and Effects on Survival, Growth, and Behavior of Yakima River Hatchery Spring Chinook Salmon. North American Journal of Fisheries Management.

Maynard, D. J., T. A. Flagg, and C. V. W. Mahnken. 1995. A review of seminatural culture strategies for enhancing the post-release survival of anadromous salmonids. Am. Fish. Soc. Symp. 15:307-314.

Neeley, D. 2000. Annual Report: Outmigration Year 2000, Part 2- Chandler Certification and Calibration (Spring Chinook and Coho). Appendix E in Sampson and Fast, Yakama Nation "Monitoring And Evaluation" Project Number 95-063-25, The Confederated Tribes And Bands Of The Yakama Nation, "Yakima/Klickitat Fisheries Project" Final Report 2000, Report to Bonneville Power Administration, Contract No. 00000650, Project No. 199506325, 265 electronic pages (BPA Report DOE/BP-00000650-1).

NPPC (Northwest Power Planning Council). 1982. Columbia River Basin Fish and Wildlife Program. Adopted November 15, 1982. Northwest Power Planning Council, Portland, OR.

TAC (United States versus Oregon Technical Advisory Committee). 1997. 1996 All Species Review, Columbia River Fish Management Plan. August 4, 1997. Columbia River Inter-Tribal Fish Commission, Portland, Oregon.

Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2002-2006.

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

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[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 2002-2006.

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

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[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 2002-2006.

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
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.

Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 2002-2006.

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 2002-2006.

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 B

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Annual Report: 2007 Smolt-to-Smolt Survival of Brood-Year 2005 Upper Yakima Spring Chinook

Doug Neeley, Consultant to Yakama Nation

Introduction

An STF feed (intended to facilitate smolt fresh-water to salt-water transition) was tested at the Cle Elum facility and compared to the control feed. These two treatments were assigned to different raceways within adjacent raceway pairs, there being up to nine raceway pairs. Each raceway pair is assigned to juvenile progeny from the same diallele crosses, the different raceway pairs being from different diallele crosses. Juveniles are transported to three acclimation sites (Clark Flat, Easton, and Jack Creek), up to three pairs of adjacent Cle Elum raceways assigned to corresponding adjacent raceways at a given site, different Cle Elum raceway pairs to different sites.

The protocol for the hatchery was that only naturally produced adults would be used for brood-stock. A domestication selection study was initiated and superimposed on the two-treatment raceways at Clark Flat. Two pairs of Clark Flat raceways followed the protocol in that they were stocked from crosses of naturally spawned parents from the supplementation program (Natural x Natural or NxN crosses), standard hatchery-production protocol stock; the other pair of raceways at Clark Flat (and the associated rearing raceway at Cle Elum) was stocked with progeny from hatchery x hatchery crosses (HxH treatment), the progeny from the HxH crosses serving as the HxH brood-stock for all subsequent brood years to assess the effect of domestication selection over time. The two other acclimation sites, Easton and Jack Creek, did not have the HxH domestication-selection superimposed (all raceways were stocked with NxN crosses).

Analysis Methods

Methods of estimating Release-to-McNary smolt-to-smolt survival from volitional release at the acclimation sites (Clark Flat, Easton, and Jack Creek) are discussed in the section of the annual report entitled "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

2002-2005". These survivals were analyzed using a weighted logistic analysis[1], the weights being the number of fish volitionally released at the acclimation sites.

Results

The logistic analysis of variation is given in Table 1. As can be seen there were no significant or substantial differences between the two feeding treatments nor any significant or substantial interactions between the treatment comparisons and other sources of variation (site and HxH versus NxN comparisons).

The means are presented in Table 2 and site means[2] in Figure 1.

Table 1. Weighted* Logistic Analysis of Variation of Smolt-to-Smolt Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Site	62.24	2	31.120	8.76	**0.0077**
STF vs. Control (Treatment)	0.89	1	0.890	0.16	0.6950
Site x Treatment	15.92	2	7.960	2.27	0.1590
HxH vs. NxN	5.51	1	5.510	1.87	0.2045
HxH vs. NxN x Treatment	4.54	1	4.540	0.88	0.3722
Error	31.99	10	3.199		

Table 2. Weighted* Smolt-to-Smolt Survival Estimates of STF- and Control-Fed smolt for sites

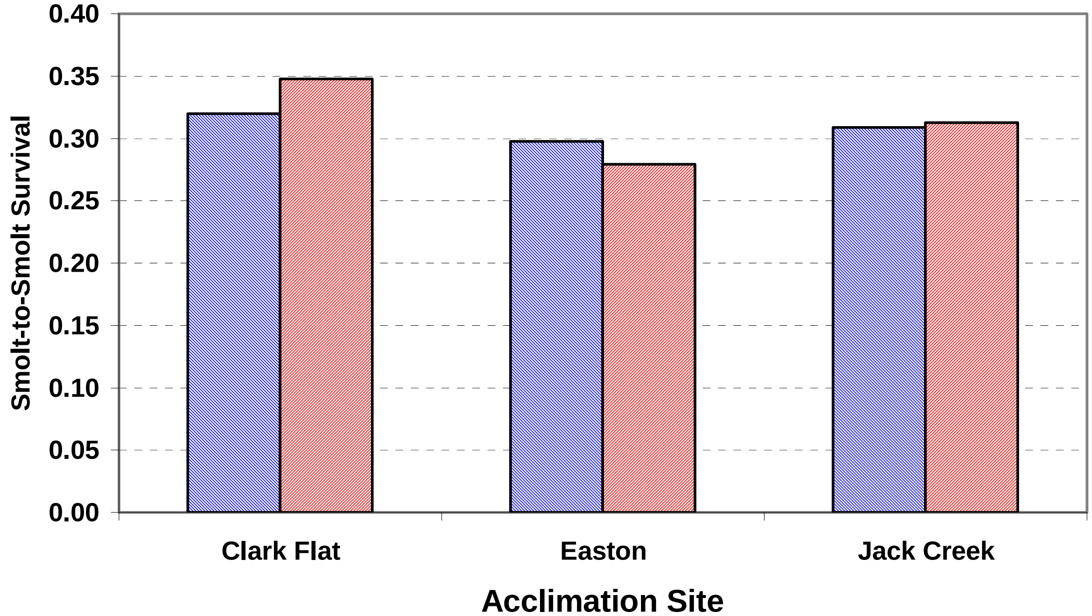
		Clark Flat			Easton	Jack Creek	Pooled over Sites
Treatment	**Measure**	**HxH**	**NxN**	**Total**	**NxN**	**NxN**	**NxN**
Control	**Survival**	**0.346**	**0.348**	**0.348**	**0.279**	**0.313**	**0.309**
	Number Released	2,172	4,364	6,536	6,462	6,544	17,370
STF	**Survival**	**0.294**	**0.333**	**0.320**	**0.298**	**0.309**	**0.311**
	Number Released	2,150	4,379	6,529	6,473	6,574	17,426
Over Treatments	**Survival**	**0.320**	**0.341**	**0.334**	**0.289**	**0.311**	**0.310**
	Number Released	4,322	8,743	13,065	12,935	13,118	34,796

*** Weights are number of fish detected at release**

[1] Logistic regression assumes that the underlying distribution of the survival is binomial-like.

[2] Means for Clark Flat in Figure 1. are pooled over HxH and NxN since there were no significant nor substantial HxH versus NxN comparisons (Tables 1 and 2)

Figure 1. BY 2005 Release to McNary Survival for STF-Fed (downward slash) and Control-Fed (upward slash) Smolt



Appendix C

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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 2002-2005

Doug Neeley, Consultant to Yakama Nation

Introduction

Two-treatment studies have been conducted at the Cle Elum supplementation hatchery facility each year since the supplementation program was initiated with brood-year 1997. These two treatments have been assigned to different raceways within adjacent raceway pairs, there being up to nine raceway pairs. Each raceway pair is assigned to juvenile progeny from the same diallele crosses, the different raceway pairs being from different diallele crosses. Juveniles are transported to three acclimation sites (Clark Flat, Easton, and Jack Creek), up to three pairs of adjacent Cle Elum raceways assigned to corresponding adjacent raceways at a given site, different Cle Elum raceway pairs to different sites.

One protocol for the hatchery was that only naturally produced adults would be used for brood-stock. Beginning with brood-year 2002 this protocol was slightly modified. A domestication selection study was initiated and superimposed on the two-treatment raceways at Clark Flat. Two pairs of Clark Flat raceways followed the protocol in that they were stocked from crosses of naturally spawned parents from the supplementation program (Natural x Natural or NxN crosses), standard hatchery-production protocol stock; the other pair of raceways at Clark Flat (and the associated pair at Cle Elum) was stocked with progeny from hatchery x hatchery crosses (HxH treatment), the progeny from the HxH crosses serving as the HxH brood-stock for all subsequent brood years for this raceway pair to assess the effect of domestication selection over time[1].

[1] Any HxH adult returns not used for brood-stock are sacrificed so that they cannot escape to the spawning grounds. With the exception of HxH Raceway pair at Clark Flat, all other raceways at all sites are stocked with NxN stock.

The conceptual design layout at Clark Flat is given schematically in Table 1. Since, prior to the domestication selection study, there have been years within which there were significant among-site differences in survivals, all comparisons between HxH and NxN crosses (or lines) are within Clark Flat site comparisons[2].

Table 1. Hatchery x Hatchery and Natural x Natural cross assignments to Clark Flat Acclimation Ponds superimposed on Treatments* unrelated to the domestication Selection Study.

Raceway Pair 1		Raceway Pair 2		Raceway Pair 3	
Treatment 1	Treatment 2	Treatment 1	Treatment 2	Treatment 1	Treatment 2
H x H Cross	H x H Cross	N x N Cross	N x N Cross	N x N Cross	N x N Cross

* The treatments differed over years:

Brood-years 1997 through 2001 (release years 1999-2003) Treatment Set 1 levels (HxH and NxN not superimposed)

Level 1. Semi-natural treatment (SNT)

Level 2. Control: Optimum conventional treatment (OCT)

Brood-years 2002 through 2004 (release years 2004-2006) Treatment Set 2 levels (HxH and NxN superimposed)

Level 1. Low nutrition-feeding rate (intended to reduce the precocial rate or mini-jack proportion in juveniles)

Level 2. Control: Conventional feeding rate

Brood year 2005 (release year 2007) Treatment Set 3 levels (HxH and NxN superimposed)

Level 1. Saltwater Transfer Feed (STF): a feed treatment intended to facilitate smolt fresh-water to salt-water transition. The STF was Bio-Oregon's BioTransfer diet, see http://www.bio-oregon.com/b_transfer.html.

Level 2. Control: Conventional feed treatment

Analysis Methods

The analyses of three measures are discussed:

1. Male Proportion of smolt sampled prior to release;

[2] Inclusion of other sites in the comparisons could bias HxH versus NxN comparisons with possible site, site x year, site x treatment, and site x year x treatment interactions associated with NxN stock.

2. Mini-jack proportion of the pre-release sampled males; and
3. Release-to-McNary smolt-to-smolt survival.

An overall assessment of each of these variables involves conducting a weighted logistic analysis[3] of variation on each of the above variables with the respective weights being

1. Number of fish sampled for assessing male and mini-jack proportions.
2. Number of males in the sample in 1.
3. Number of smolt detected leaving acclimation site, the release-to-McNary survival being based on the number of McNary detections previously detected at McNary

The logistic analyses of variation partitions the variability of the above measures into comparisons among the factor levels [Year, Treatment, and Stock (HxH versus NxN)] and interactions among factors within the Clark Flat site and are presented in Appendix A, along with mean proportions. The methods of estimating smolt-survivals from the individual raceways and the resulting estimates for all sites are presented in Appendix B.

Results

Male Proportion of smolt

The logistic analysis of variation among the male proportions and the mean male proportion estimates are presented in Appendix Table A.1. along with male-proportion estimates. None of F-tests of the eight tested sources of variation in the logistic analysis of variation exceeded the 5% significance level, and none of the four tested sources that involved HxH versus NxN comparisons had estimated Type 1 error probabilities less than 0.2 (not significant at the 20% level). There is no evidence that the distribution differs from what would be expected from a binomial[4]. The overall mean male proportion of 0.548 does not significantly differ from 0.5 (P = 0.52).

[3] Logistic analysis of variation operates on the logit transform, ln[p/(1-p)] using iterative maximum likelihood procedures, of the estimated proportion (p) and assumes that the underlying distribution of the estimated proportion is binomial.

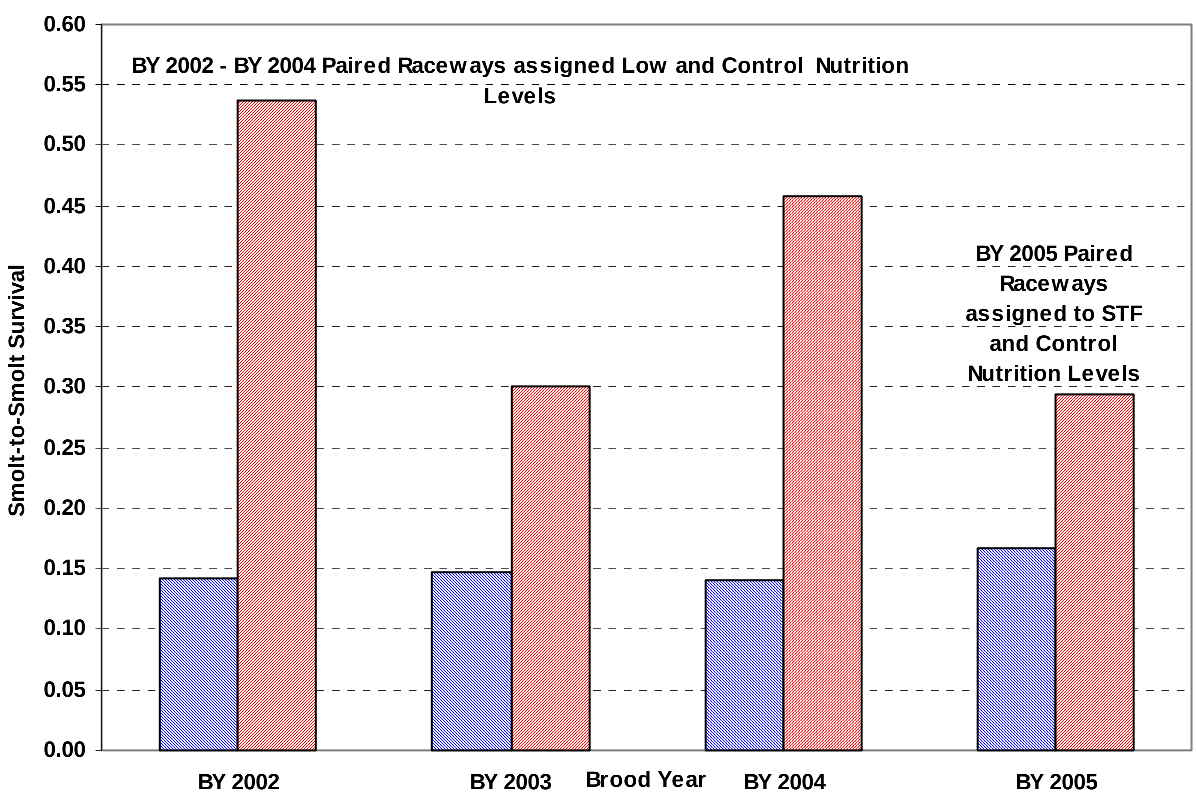
[4] For a binomial distribution, the error mean deviance (analogous to the error mean square in a least squares analysis of variance) would be expected to be 1.0; the error mean deviance of 0.923 in Appendix A.1 does not significantly differ from 1.0 (chi-square test for error deviance not significant, P = 0.51).

Mini-jack proportion of the sampled males

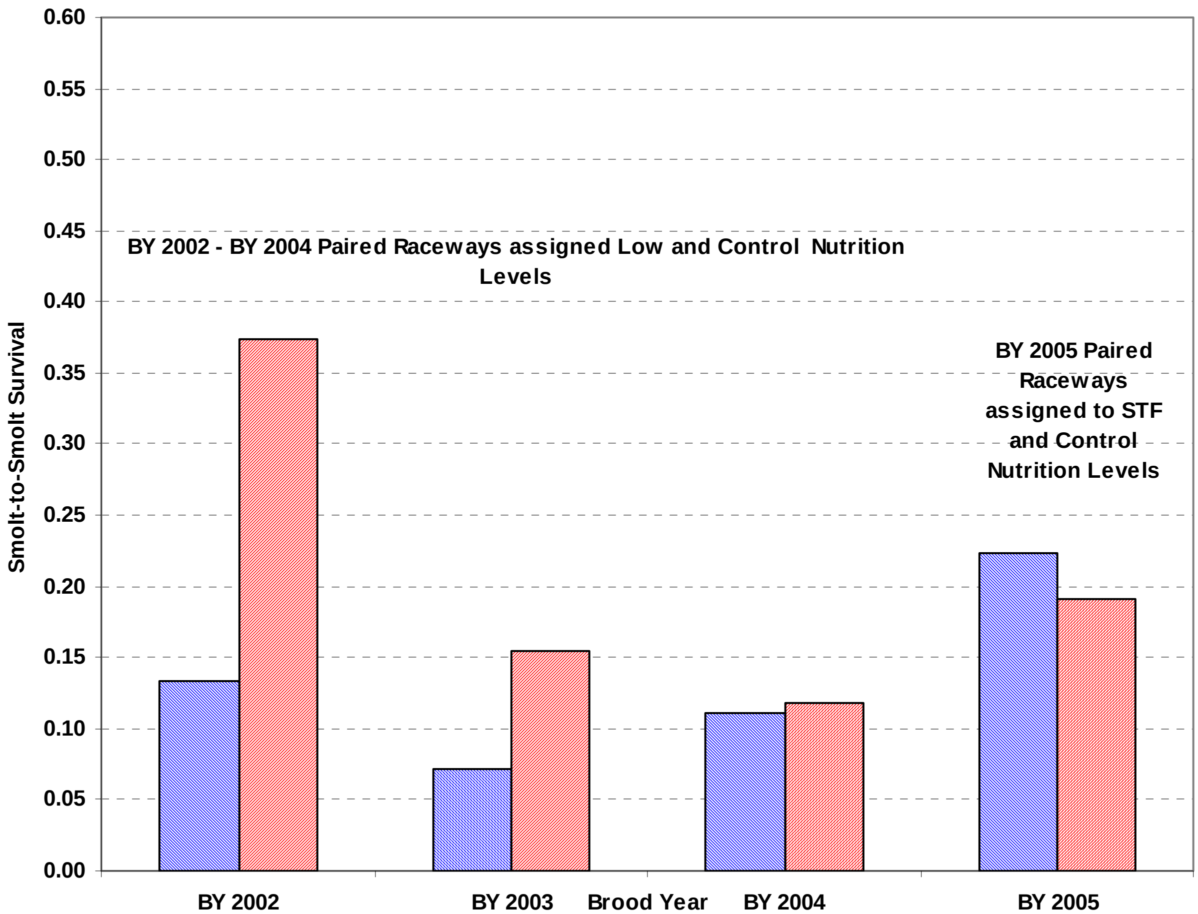
The logistic analysis of variation among the mini-jack proportion of male smolt and their mean proportions are presented in Appendix Table A.2. As was noted in the 2006 annual report for all sites, the brood-year 2002–2004 low nutrition-level mini-jack proportions were significantly and substantially lower than those of the control. Also the 2006 annual report noted that HxH mini-jack proportion was significantly lower than that for the NxN stock. The inclusion of the 2005 brood year in the analysis still indicates that the HxH mini-jack proportion is significantly lower than that of the NxN stock ($P = 0.0007$, Appendix Table A.2.a., also see Figure 1) and indicates that there are no significant HxH versus NxN interactions with years or nutritional treatments ($P's < 0.1$, Appendix Table A.2.a.). However, as can be seen in Figure 1.b, the estimated HxH proportion is somewhat higher than that of the NxN for the non-control STF nutrition treatment in brood-year 2007. This may have been a chance occurrence, or it may be that the statistical tests were not powerful enough to detect possible interactions of HxH versus NxN with brood years having different treatments or with the 2007 feed treatments (control and STF treatments in 2007, Trt 2 in Appendix Table A.2.a.).

Figure 1. BY 2002 - 2005 Proportion of Males that are Mini-Jacks for Hatchery x Hatchery and Natural x Natural Crosses (HxH, downward slash; NxN, upward slash):

a. For Control Treatments



b. For non-Control Treatments



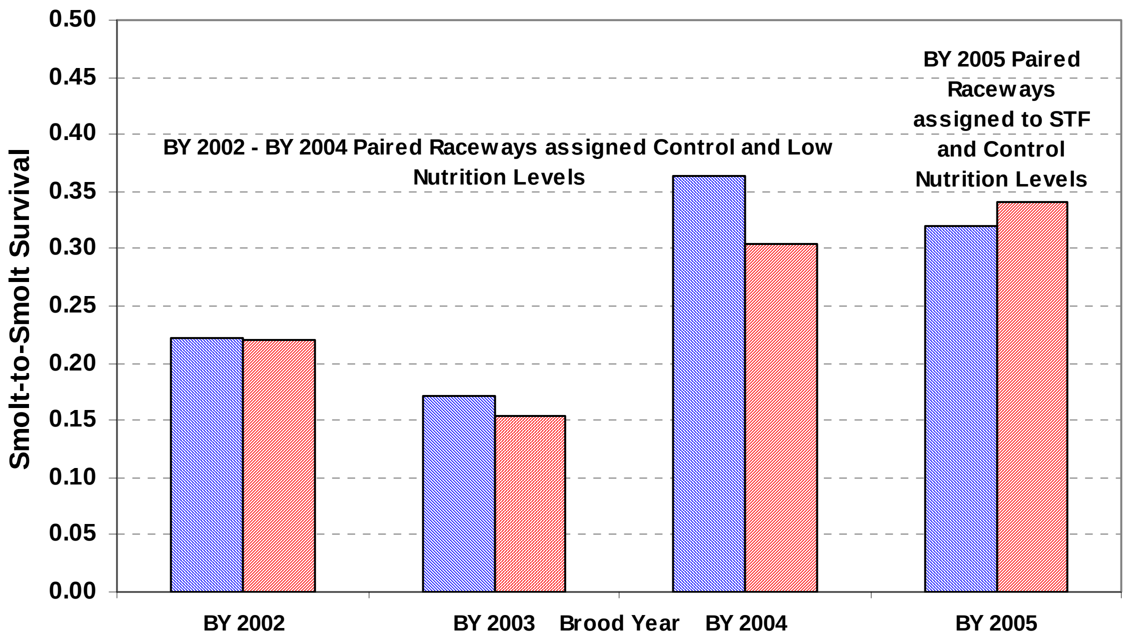
Release-to-McNary smolt-to-smolt survival

The logistic analysis of variation for smolt-to-smolt survival and associated mean proportions are presented in Appendix Table A.3. The 2006 annual report for brood years 2002-2004 indicated higher survival for the HxH stock. The inclusion of the 2005 brood year in the analysis resulted in an HxH versus NxN interaction with year (P = 0.018, Appendix Table 3.b.), an interaction not indicated in the 2002-2004 analysis. It can be seen in Figure 2 that the HxH estimated smolt-to-smolt survival to McNary was higher than the NxN estimates in brood-year 2002-2004[5] (consistent with the significant difference reported in 2006) but that the brood-year 2005 HxH estimate was lower. The brood-year 2005 HxH estimates were lower than NxN estimates for both the Control and STF treatments, the difference being almost imperceptibly slight for the Control treatment (Appendix Table A.b.3.).

[5] For brood-years 2002-2004, the three control-nutrition treatment HxH estimates were higher than the NxN and two of the three low-nutrition HxH estimates were also higher.

A second analysis was conducted using the proportion of the total released fish that were mini-jacks[6] as a covariate to determine whether any HxH versus NxN differences in survival could result from a possible correlation between the survival and mini-jack proportions. The covariate's coefficient was not significant, and its inclusion actually increased the error mean deviance; therefore, that analysis is not presented here.

Figure 2. BY 2002 - 2005 Smolt-to-Smolt Survival to McNary for Hatchery x Hatchery and Natural x Natural Crosses (HxH, downward slash; NxN, upward slash)



[6] This is the proportion of all sampled fish that were mini-jack, not the proportion of males that were min-jacks, because fish surviving to McNary could not be distinguished as to gender.

Appendix A. Logistic Analyses of Variation and Mean Proportions

A.1. Male Proportion of Smolt

Table A.1.a. Weighted* Logistic Analysis of Variation of Male Proportions

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio (P)	Estimated Type 1 Error P
Year	1.56	3	0.52	0.56	0.6513
Hi vs Low (Trt 1, 2004-2006)	0.07	1	0.07	0.08	0.7886
Hi vs Low x Year	6.07	2	3.04	3.29	0.0799
STF vs Control (Trt 2, 2007)	0.03	1	0.03	0.03	0.8605
HxH vs NxN	0.46	1	0.46	0.50	0.4963
HxH vs NxN x Year	2.21	3	0.74	0.80	0.5226
HxH vs NxN xTrt 1	1.71	1	1.71	1.85	0.2034
HxH vs NxN xTrt 2	1.21	1	1.21	1.31	0.2789
Error	9.23	10	0.92		

Table A.1.b. Weighted* Male Mean Proportions of HxH and NxN stock for different treatments and years

Treatment Set 1	Stock	Measure	BY 2002	BY 2003	BY 2004	Mean over BY 2002-2005	Treatment Set 2	Stock	Measure	BY 2005
Control	HxH	Proportion	0.467	0.683	0.538	0.556	Control	HxH	Proportion	0.500
		Number Sampled	60	60	119	239			Number Sampled	120
	NxN	Proportion	0.450	0.525	0.492	0.489		NxN	Proportion	0.567
		Number Sampled	120	120	120	360			Number Sampled	120
Low	HxH	Proportion	0.500	0.467	0.525	0.504	STF	HxH	Proportion	0.558
		Number Sampled	60	60	120	240			Number Sampled	120
	NxN	Proportion	0.558	0.483	0.492	0.511		NxN	Proportion	0.525
		Number Sampled	120	120	120	360			Number Sampled	120
Mean over Low and Control	HxH	Proportion	0.483	0.575	0.531	0.530	Mean over STF and Control	HxH	Proportion	0.529
		Release Number	120	120	239	479			Release Number	240
	NxN	Proportion	0.504	0.504	0.492	0.500		NxN	Proportion	0.546
		Release Number	240	240	240	720			Release Number	240

* Weights are number of fish sampled

A.2. Mini-jack proportion of the sampled males

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio (P)	Estimated Type 1 Error P
Year	15.22	3	5.07	4.32	**0.0338**
Hi vs Low (Trt 1, 2004-2006)	16.07	1	16.07	13.69	**0.0041**
Hi vs Low x Year	2.29	2	1.15	0.98	0.4103
STF vs Control (Trt 2, 2007)	0.27	1	0.27	0.23	0.6419
HxH vs NxN	26.89	1	26.89	22.90	**0.0007**
HxH vs NxN x Year	8.10	3	2.70	2.30	0.1394
HxH vs NxN xTrt 1	3.40	1	3.40	2.90	0.1196
HxH vs NxN xTrt 2	2.36	1	2.36	2.01	0.1866
Error	11.74	10	1.17		

Table A.2.a. Weighted** Logistic Analysis of Variation of Mini-Jack Proportions

Table A.2.b. Weighted** Mini-Jack Proportions of HxH and NxN Males for different treatments and years

Treatment Set 1	Stock	Measure	BY 2002	BY 2003	BY 2004	Mean over BY 2002-2005	Treatment Set 2	Stock	Measure	BY 2005
Control	HxH	Proportion	0.143	0.146	0.141	0.143	Control	HxH	Proportion	0.167
		Number of Males	28	41	64	133			Release Number	60
	NxN	Proportion	0.537	0.302	0.458	0.426		NxN	Proportion	0.294
		Number of Males	54	63	59	176			Release Number	68
Low	HxH	Proportion	0.133	0.071	0.111	0.107	STF	HxH	Proportion	0.224
		Number of Males	30	28	63	121			Release Number	67
	NxN	Proportion	0.373	0.155	0.119	0.223		NxN	Proportion	0.190
		Release Number	67	58	59	184			Release Number	63
Mean over Low and Control	HxH	Proportion	0.138	0.116	0.126	0.126	Mean over STF and Control	HxH	Proportion	0.197
		Release Number	58	69	127	254			Release Number	127
	NxN	Proportion	0.446	0.231	0.288	0.322		NxN	Proportion	0.244
		Release Number	121	121	118	360			Release Number	131

** Weights are number of male fish in sample

A.3. Proportion of Released Smolt Surviving to McNary Dam (Smolt-to-Smolt Survival)

Table A.3.a. Weighted*** Logistic Analysis of Variation of Smolt-to-Smolt Survival

				Using Clark Flat Error		Using All Sites' Error	
Source	**Deviance (Dev)**	**Degrees of Freedom (DF)**	**Mean Dev (Dev/DF)**	**F-Ratio**	**Estimated Type 1 Error P**	**F-Ratio**	**Estimated Type 1 Error P**
Year	1477.04	3	492.347	99.28	**0.0000**	107.45	**0.0000**
Hi vs Low (Trt 1, 2004-2006)	82.29	1	82.290	16.59	**0.0022**	17.96	**0.0005**
Hi vs Low x Year	17.75	2	8.875	1.79	0.2166	1.94	0.1730
STF vs Control (Trt 2, 2007)	11.10	1	11.100	2.24	0.1655	2.42	0.1370
HxH vs NxN	12.77	1	12.770	2.58	0.1396	2.79	0.1123
HxH vs NxN x Year	45.60	3	15.200	3.07	0.0780	3.32	**0.0434**
HxH vs NxN xTrt 1	0.30	1	0.300	0.06	0.8107	0.07	0.8010
HxH vs NxN xTrt 2	4.53	1	4.530	0.91	0.3617	0.99	0.3333
Clark Flat Error*	49.59	10	4.959				
All Site's Error*	82.48	18	4.582				

* Includes variation among HxH raceway pairs with Clark Flat

Table A.3.b. Weighted** Smolt-to-Smolt Survival Estimates of HxH and NxN stock for different treatments and years

Treatment Set 1	Stock	Measure	BY 2002	BY 2003	BY 2004	Mean over BY 2002-2005	Treatment Set 2	Stock	Measure	BY 2005
Control	HxH	Survival Index	0.241	0.174	0.397	0.271	Control	HxH	Survival Index	0.346
		Release Number	2,162	2,135	2,147	6,444			Release Number	2,172
	NxN	Survival Index	0.227	0.166	0.344	0.246		NxN	Survival Index	0.348
		Release Number	4,352	4,343	4,344	13,039			Release Number	4,364
Low	HxH	Survival Index	0.202	0.167	0.331	0.234	STF	HxH	Survival Index	0.294
		Release Number	2,124	2,134	2,164	6,422			Release Number	2,150
	NxN	Survival Index	0.213	0.142	0.265	0.206		NxN	Survival Index	0.333
		Release Number	4,355	4,294	4,307	12,956			Release Number	4,379
Mean over Low and Control	HxH	Survival Index	0.222	0.171	0.364	0.252	Mean over STF and Control	HxH	Survival Index	0.320
		Release Number	4,286	4,269	4,311	12,866			Release Number	4,322
	NxN	Survival Index	0.220	0.154	0.304	0.226		NxN	Survival Index	0.341
		Release Number	8,707	8,637	8,651	25,995			Release Number	8,743

** Weights are number of fish detected at release

Appendix B. Estimated Survival Index

Note: This appendix applies to other acclimation-pond release-to-McNary smolt-to-smolt Upper Yakima Spring Chinook survival estimates for releases made from 2004 through 2007 (brood-years 2002 through 2005).

Survival estimates to McNary are based on McNary powerhouse bypass detections of released fish. The number of detections for each release must be expanded by the proportion of McNary passage detected in the bypass (detection rate). For brood-years 2002-2005 (release years 2004-2007), Section B.1 discusses the method of estimating the detection rates, Section B.2 presents the detection rate estimates, and Section B.3 discusses the estimation of smolt-to-smolt survival and presents the survival estimates.

B.1. Estimation Of Detection Rates

Conceptual Computation

Detection rate is estimated as follows:

Equation B.1.

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

The downstream-dam counts actually represent a pooling of counts from John Day and Bonneville dams.

The methods used were similar to those developed by Sandford and Smith[7]. The steps are given below.

Step 1. For each downstream dam, joint McNary and downstream detections were cross-tabulated by McNary Dam's first date and downstream-dams' first date of detections [Table B.1.a)].

Step 2. Within each downstream dam's detection date, the relative distribution of joint counts over McNary-detection dates was estimated [Table B.1.b)].

[7] Sandford, B.P. and S.G. Smith. 2002. Estimation of smolt-to-adult return percentages for Snake River Basin anadromous salmonids, 1990-1997. J. Agric. Biol. Environ. Stat. 7:243-263.

Step 3. The resulting relative distribution frequencies from Table B.1.b) were then multiplied by the total downstream dam's detections for a given down-stream dam date to obtain estimates of the numbers for the McNary dates of passage for those fish detected downstream on that downstream-dam date [Table B.1.c)].

Step 4. There were cases where there were downstream detections for a given date, but there were no joint downstream and McNary detections for that downstream date. In such cases there was no direct way of allocating the downstream detections to a given McNary date. What was done was to obtain a pseudo-distribution for McNary detection dates by offsetting the six previous downstream dates' and the six following downstream-dates' McNary-date distributions, and applying their pooled offset distributions to the downstream-dam detection date having no joint McNary distribution. (This step differed from Sandford and Smith's. Their generated daily detection rates were based on a far larger number of total releases from the Snake River basin than those given here for the Yakima basin.)

Step 5. Once the above was done for each downstream dam's detection date, the estimated total downstream detections that were allocated to a given McNary-detection date were then added over downstream-dam detection dates [Table B.1.c), far-right-hand column]. This gave the estimated total downstream-dam detections that passed McNary on the given McNary date.

Step 6. The total joint downstream-dam McNary detections on a given McNary-detection date [Table B.1.a), far-right column] were then divided by the respective downstream-dam total from step 4 above [Table B.1.c), far-right column], giving an estimated McNary-detection efficiency associated with the McNary date [Table B.1.d), far-right-hand column].

Before the last step, Table B.1.a)'s and Table B.1.b)'s numbers were pooled over John Day and Bonneville Dams.

Daily detection rates were then stratified into contiguous days of relatively homogeneous detection rates, and the daily detection rates were pooled over days within the strata. This was done to increase the precision of detection-efficiency estimates. This was done using modified forward step-wise logistic regression. The strata's beginning and ending dates were selected in a manner that minimized the variation among daily detection rates within strata, thereby maximizing the detection-rate variation among strata. In the first step, the partitioning between all possible sets of two strata that minimized the variation among daily detection rates within strata was selected. With that partitioning fixed, establishing two initial strata, the second partitioning was then selected in a similar manner among all possible sets of two strata within the strata that were already created in the first partitioning. Again, the partitioning that minimized variation among daily detection rates within the strata was selected. This second partitioning was then fixed and, along with the first fixed partitioning, established three initial strata. A third partitioning was similarly developed within the three established strata to form a fourth initial stratum. The process was continued as long as the difference between the step's created detection rates was significant at the 10% significance level ($P \leq 0.1$).

In the stratification process, there were three exceptions that would lead to the rejection of a given partitioning:

1. If either one of the resulting strata had less than twenty joint McNary detections.

2. If the difference between the John Day Dam-based and Bonneville Dam-based detection-rate estimates were inconsistent in sign. For example, if the combined Bonneville-based McNary detection rate in one of the created strata was greater than that in an adjacent stratum, but the John Day-based McNary detection rate in the one was less than that in the adjacent, then the partitioning was not accepted.

3. When the logistic variation[8] of daily detection rates within strata was less than 25% of that expected from the binomial (mean deviance < 0.25).

On completion of the stepwise process, each partitioning was shifted at one-day increments between the two adjacent partitionings to see if the variation within strata could be further reduced. If so, the partitioning that resulted in the greatest reduction was selected.

There was an occasional downstream-dam date for which there was a downstream-dam count but no joint downstream-dam and McNary Dam count within +/- six days of the date (refer Step 4, earlier). Such dates were either very early or very late in the passage period. The downstream count for such days were added into the pooled downstream count for either the first stratum or the last stratum, whichever was appropriate, and the respective detection rates were adjusted accordingly.

[8] As measured by mean deviance = residual deviance/(residual degrees of freedom).

Table B.1. Conceptual method of estimating detection rates (detection efficiencies)

a) Joint McNary Dam (McN) and Downstream Dam (D.S.) Detections (n) by McN and D.S. Detection Dates

McN Date (Julian)	D.S. Date (Julian)								
	…	98	99	100	101	**102**	103	….	Total
90	…	0	0	0	0	**0**	0	…	n(90,.)
…	…	…	…	…	…	**…**	…	…	…
94	…	n(94,98)	n(94,99)	n(94,100)	n(94,101)	**0**	0	…	n(94,.)
95	…	0	n(95,99)	n(95,100)	n(95,101)	**n(95,102)**	0	…	n(95,.)
96	…	0	0	n(96,100)	n(96,101)	**n(96,102)**	n(96,103)	…	n(96,.)
97	…	0	0	0	0	**n(97,102)**	n(97,103)	…	n(97,.)
98	…	0	0	0	0	**n(98,102)**	n(98,103)	…	n(98,.)
99	…	0	0	0	0	**0**	0	…	n(99,.)
…	…	…	…	…	…	**…**	…	…	…
200	…	0	0	0	0	**0**	0	…	n(200,.)
Total	…	n(.,98)	n(.,99)	n(.,100)	n(.,101)	**n(.,102)**	n(.,103)	…	

b) For Each Downstream Site, Estimate Distribution of McNary Date Contributions

McN Date (Julian)	p(McN,D.S.) = n[McN,D.S.)/n(., D.S.)					
	D.S. Date (Julian)					
	…	100	101	**102**	103	…
90	…	…	…	**…**	…	…
…	…	…	…	**…**	…	…
94	…	p(94,100)	p(94,101)	**0**	0	…
95	…	p(95,100)	p(95,101)	**p(95,102)=n(95,102)/n(.,102)**	0	…
96	…	p(96,100)	p(96,101)	**p(96,102)=n(96,102)/n(.,102)**	p(96,103)	…
97	…	0	0	**p(97,102)=n(97,102)/n(.,102)**	p(97,103)	…
98	…	0	0	**p(98,102)=n(98,102)/n(.,102)**	p(98,103)	…
99	…	0	0	**p(99,102)=n(99,102)/n(.,102)**	p(99,103)	…
…	…	…	…	**…**	…	…
200	…	0	0	**0**	0	…
Total		1.000	1.000	**1.000**	1.000	

Table B.1. Conceptual method of estimating detection rates (continued)

c) Allocate Daily Lower Site Counts [N(D.S.)] over McNary Dates using above Distributions and total over Lower Dam Dates within McNary Dates

McN	N'(McN,D.S.) = N(D.S.)*P(McN,D.S.)						McN
Date	D.S. Date (Julian)						Dam
(Julian)	…	100	101	102	103	…	Total
90	…	0	0	**0**	0	…	**N'(90,.)**
…	…	…	…	**…**	…	…	**…**
94	…	N'(94,100)	N'(94,101)	**0**	0	…	**N'(94,.)**
95	…	N'(95,100)	N'(95,101)	**N'(95,102)=p(95,102)*N(.,102)**	0	…	**N'(95,.)**
96	…	N'(96,100)	N'(96,101)	**N'(96,102)=p(96,102)*N(.,102)**	N'(96,103)	…	**N'(96,.)**
97	…	0	0	**N'(97,102)=p(97,102)*N(.,102)**	N'(97,103)	…	**N'(97,.)**
98	…	0	0	**N'(98,102)=p(98,102)*N(.,102)**	N'(98,103)	…	**N'(98,.)**
99	…	0	0	**N'(99,102)=p(99,102)*N(.,102)**	N'(99,103)	…	**N'(99,.)**
…	…	…	…	**…**	…	…	**…**
200	…	0	0	**0**	0	…	**N'(200,.)**
Total		N(100)	N(101)	**N(102)**	N(103)	…	

d) Use Total Joint McNary and Downstream Dam Detections [Table a)] and Total Downstream Dam Detections [Table c)] to estimate McNary Detection Efficiencies (McN D.E.)

McNary Dam Date (Julian)	Table a) n Total	Table c) N' Total	McNary Detection Efficiency McN D.E. = n/N'
90	n(90,.)	N'(90,.)	**McN D.E.(90,.)=n(90,.)/N'(90,.)**
…	…	…	**…**
94	n(94,.)	N'(94,.)	**McN D.E.(94,.)=n(94,.)/N'(94,.)**
95	n(95,.)	N'(95,.)	**McN D.E.(95,.)=n(95,.)/N'(95,.)**
96	n(96,.)	N'(96,.)	**McN D.E.(96,.)=n(96,.)/N'(96,.)**
97	n(97,.)	N'(97,.)	**McN D.E.(97,.)=n(97,.)/N'(97,.)**
98	n(98,.)	N'(98,.)	**McN D.E.(98,.)=n(98,.)/N'(98,.)**
99	n(99,.)	N'(99,.)	**McN D.E.(99,.)=n(99,.)/N'(99,.)**
…	…	…	**…**
200	n(200,.)	N'(200,.)	**McN D.E.(200,.)=n(200,.)/N'(200,.)**

B.2. Rate Estimates

Estimates for 2004-2007-detection rates are given in Table B.2.

Table B.2. Estimated McNary (McN.) Detection (Det) Rates based on Bonneville (Bonn.) and John Day (J.D.) Detections and their Pooled Detections.

Year	Julian Date Strata		Bonneville (Bonn.) Based			John Day (J.D.) Based			Pooled over Bonn. and J.D.		
	Beginning	Ending	Total Bonn.Det.	Joint Bonn. McN.Det.	McN. Det. Rate	Total J.D.Det.	Joint J.D. McN.Det.	McN. Det. Rate	Pooled Total Det.	Pooled Joint Det.	McN. Det. Rate
2004		103	29	19	0.6631	72	48	0.6673	101	67	0.6661
	104	121	409	247	0.6046	905	507	0.5604	1313	754	0.5742
	122	124	112	58	0.5186	246	122	0.4958	358	180	0.5029
	125	127	72	32	0.4463	142	62	0.4369	214	94	0.4400
	128	131	83	35	0.4207	312	123	0.3941	395	158	0.3997
	132		184	57	0.3096	337	113	0.3350	521	170	0.3260
	Total		888	448	0.5045	2014	975	0.4841	2902	1423	0.4904
2005	85.0	112.0	53	29	0.5434	251	106	0.4228	304	135	0.4440
	113.0	126.0	648	265	0.4089	1865	730	0.3915	2513	995	0.3960
	127.0	128.0	38	17	0.4523	126	55	0.4378	163	72	0.4411
	129.0	141.0	73	36	0.4934	219	107	0.4890	292	143	0.4901
	Total		812	347	0.4273	2460	998	0.4057	3272	1345	0.4111
2006		109	18	3	0.1638	100	19	0.1908	118	22	0.1866
	110	117	118	30	0.2545	443	123	0.2778	561	153	0.2729
	118	123	452	148	0.3274	1262	397	0.3145	1715	545	0.3179
	124	126	251	101	0.4016	569	194	0.3409	821	295	0.3595
	127	138	423	185	0.4376	990	382	0.3857	1413	567	0.4012
	139		36	12	0.3294	305	73	0.2396	341	85	0.2492
	Total		1299	479	0.3687	3669	1188	0.3238	4968	1667	0.3355
2007		113	172	43	0.2503	569	177	0.3113	740	220	0.2971
	114	117	171	51	0.2977	748	267	0.3571	919	318	0.3460
	118	125	535	225	0.4209	2475	913	0.3690	3009	1138	0.3782
	126	133	445	119	0.2672	1547	497	0.3212	1992	616	0.3092
	134	147	342	145	0.4239	1389	521	0.3752	1731	666	0.3848
	148	152	8	7	0.8698	89	45	0.5058	97	52	0.5360
	153		21	6	0.2870	45	18	0.3975	66	24	0.3626
	Total		1694	596	0.3518	6861	2438	0.3553	8555	3034	0.3546

The assumptions behind the detection rate estimation procedures are as follows:

1. Detected and undetected fish passing McNary on a given date are temporally and spatially mixed before reaching the downstream detectors so that their proportional composition at the time of McNary passage will be the same for the surviving fish passing through downstream detectors;

2. Survivals from McNary to downstream-dam detectors are the same for all routes of McNary passage (e.g., survival is the same for fish whether they pass through the bypass, the turbines, or the spillway);

3. The allocations of total downstream dam counts to McNary days of passage are accurate; and

4. The detection rates estimated from John Dam and Bonneville Dams are estimating the same parameters.

Assumption 2 is unlikely to hold, but separate survival-rate estimates for each route of passage are not currently possible.

Assumption 3 is also unlikely to hold because the method of allocation assumes that the McNary detection rates for a given day of downstream-dam detection are homogeneous. It is unlikely that all fish detected on a given downstream date passed McNary on days for which the detection rates were homogeneous. The estimated detection rates are probably biased, but the bias would be less than assuming a single detection-rate value for the whole of McNary passage.

For Assumption 4 to hold for the methods used in this report, the probability of a fish being entrained into the bypass at Bonneville would have to be independent of whether or not that fish was entrained into a bypass at John Day or McNary, and the probability of a fish being entrained into the bypass at John Day would have to be independent of whether or not that fish was entrained into the bypass at McNary.

B.3. Estimation of Survival Index

The survival index is estimated as follows for each raceway release:

Equation B.2.

$$\text{Release - to - McNary Survival Index} = \frac{\sum_{\text{strata}} \text{For Stratum}\left[\dfrac{(\text{McNary Detections - Detections Removed})}{\text{Stratum's McNary Detection Rate}} + \text{Detections Removed}\right]}{\text{Number of PIT - Tagged Fish Released}}$$

wherein

1) "Stratum" is a group of contiguous McNary detection dates among which the daily detection rates[9] were sufficiently homogeneous to permit the use of a pooled estimate of the detection rate for that stratum;

[9] The daily McNary detection efficiency is the proportion of PIT-tagged fish passing McNary that are actually detected at McNary. It is the total number of fish jointly detected at McNary on the McNary date and that are also detected at downstream dams (John Day and Bonneville) divided by the total detected at the downstream dams that are estimated to have passed McNary on that date.

2) "McNary Detections" is the number of the release's fish detected at McNary during the stratum;

3) "Detections Removed" is the number of the stratum's "McNary Detections" for the release that were removed for transportation or for sampling and not returned to the river (Fish detected at McNary's Raceways A and B not subsequently detected at McNary); and

4) "Detection Rate" is the estimated proportion of all[10] those Yakima PIT-tagged Spring Chinook passing McNary Dam during the stratum that were detected at McNary (discussed in next session).

Table B.3 presents the estimated stratum detections and expanded detections (expanded using the detection rates from Table B.2) along with the survival index estimates for each release.

[10] The detection efficiencies are based on all PIT-tagged Spring Chinook releases into the Yakima, upper Yakima, and Naches Rivers, not only the low and high nutritional treatment fish tagged prior to release.

Table B.3. Stratum McNary Detection Numbers and Detection Rates and Resulting Survival Indices for Each Spring Chinook Acclimation Site

a. Brood-Year 2002, Release Year 2004

	Acclimation Site	Clark Flat					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	Low	High	High	Low	Low	High
	Cross	HxH	HxH	NxN	NxN	NxN	NxN
Stratum 1	Total	1	0	3	0	0	0
	Removed	0	0	0	0	0	0
	Subtotal	1	0	3	0	0	0
	Expanded Total	1.50	0.00	4.50	0.00	0.00	0.00
Stratum 2	Total	84	151	188	122	87	116
	Removed	2	4	2	2	1	4
	Subtotal	82	147	186	120	86	112
	Expanded Total	144.81	260.02	325.95	211.00	150.78	199.06
Stratum 3	Total	41	37	40	48	42	32
	Removed	1	1	1	1	0	0
	Subtotal	40	36	39	47	42	32
	Expanded Total	80.53	72.58	78.55	94.45	83.51	63.63
Stratum 4	Total	20	14	13	25	33	24
	Removed	0	1	0	0	2	0
	Subtotal	20	13	13	25	31	24
	Expanded Total	45.45	30.54	29.54	56.81	72.45	54.54
Stratum 5	Total	29	32	20	20	22	28
	Removed	0	1	1	0	1	3
	Subtotal	29	31	19	20	21	25
	Expanded Total	72.55	78.55	48.53	50.04	53.54	65.54
Stratum 6	Total	27	26	20	24	26	19
	Removed	0	0	0	0	1	1
	Subtotal	27	26	20	24	25	18
	Expanded Total	82.81	79.74	61.34	73.61	77.68	56.21
	Expanded Total over Strata	427.66	521.44	548.41	485.91	437.96	438.98
	Volitional Releases	2124	2162	2171	2177	2178	2181
	Release-to-McN Survival	0.2013	0.2412	0.2526	0.2232	0.2011	0.2013
	Tagged	2223	2223	2223	2223	2223	2223
	Proportion Released	0.9555	0.9726	0.9766	0.9793	0.9798	0.9811

Table B.3. (continued)

a. Brood-Year 2002, Release Year 2004

	Acclimation Site	**Easton**					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	High	Low	High	Low	Low	High
	Cross	NxN	NxN	NxN	NxN	NxN	NxN
Stratum 1	Total	2	0	0	0	0	0
	Removed	0	0	0	0	0	0
	Subtotal	2	0	0	0	0	0
	Expanded Total	3.00	0.00	0.00	0.00	0.00	0.00
Stratum 2	Total	119	46	76	39	65	82
	Removed	1	1	2	0	1	3
	Subtotal	118	45	74	39	64	79
	Expanded Total	206.51	79.37	130.88	67.92	112.46	140.59
Stratum 3	Total	25	27	19	19	22	18
	Removed	0	0	0	0	0	0
	Subtotal	25	27	19	19	22	18
	Expanded Total	49.71	53.69	37.78	37.78	43.74	35.79
Stratum 4	Total	16	19	16	13	10	9
	Removed	0	0	0	0	0	0
	Subtotal	16	19	16	13	10	9
	Expanded Total	36.36	43.18	36.36	29.54	22.73	20.45
Stratum 5	Total	24	26	21	19	30	17
	Removed	0	1	2	0	2	1
	Subtotal	24	25	19	19	28	16
	Expanded Total	60.04	63.54	49.53	47.53	72.05	41.03
Stratum 6	Total	34	58	35	40	37	33
	Removed	4	1	0	4	2	1
	Subtotal	30	57	35	36	35	32
	Expanded Total	96.01	175.82	107.35	114.42	109.35	99.15
	Expanded Total over Strata	451.64	415.61	361.90	297.20	360.33	337.01
	Volitional Releases	2157	2176	2182	2171	2161	2114
	Release-to-McN Survival	0.2094	0.1910	0.1659	0.1369	0.1667	0.1594
	Tagged	2223	2223	2224	2224	2223	2223
	Proportion Released	0.9703	0.9789	0.9811	0.9762	0.9721	0.9510

Table B.3. (continued)

a. Brood-Year 2002, Release Year 2004

Acclimation Site		Jack Creek					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	High	Low	Low	High	Low	High
	Cross	NxN	NxN	NxN	NxN	NxN	NxN
Stratum 1	Total	0	0	3	0	0	2
	Removed	0	0	0	0	0	0
	Subtotal	0	0	3	0	0	2
	Expanded Total	0.00	0.00	4.50	0.00	0.00	3.00
Stratum 2	Total	87	46	58	124	36	110
	Removed	0	0	0	1	0	4
	Subtotal	87	46	58	123	36	106
	Expanded Total	151.52	80.12	101.02	215.22	62.70	188.61
Stratum 3	Total	25	22	27	24	10	28
	Removed	0	0	1	0	0	0
	Subtotal	25	22	26	24	10	28
	Expanded Total	49.71	43.74	52.70	47.72	19.88	55.67
Stratum 4	Total	9	14	12	16	10	13
	Removed	0	1	0	0	0	0
	Subtotal	9	13	12	16	10	13
	Expanded Total	20.45	30.54	27.27	36.36	22.73	29.54
Stratum 5	Total	25	33	27	21	21	21
	Removed	0	1	0	2	2	1
	Subtotal	25	32	27	19	19	20
	Expanded Total	62.54	81.06	67.55	49.53	49.53	51.04
Stratum 6	Total	37	32	40	38	52	32
	Removed	1	0	0	2	0	1
	Subtotal	36	32	40	36	52	31
	Expanded Total	111.42	98.15	122.68	112.42	159.49	96.08
	Expanded Total over Strata	395.64	333.61	375.72	461.25	314.33	423.95
	Volitional Releases	2175	2165	2184	2177	2183	2163
	Release-to-McN Survival	0.1819	0.1541	0.1720	0.2119	0.1440	0.1960
	Tagged	2223	2223	2223	2223	2223	2222
	Proportion Released	0.9784	0.9739	0.9825	0.9793	0.9820	0.9734

Table B.3. (continued)

b. Brood-Year 2003, Release Year 2005

Acclimation Site		**Clark Flat**					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	Low	High	High	Low	High	Low
	Cross	NxN	NxN	HxH	HxH	NxN	NxN
Stratum 1	Total	1	2	5	0	1	0
	Removed	0	0	0	0	0	0
	Subtotal	1	2	5	0	1	0
	Expanded Total	2.25	4.50	11.26	0.00	2.25	0.00
Stratum 2	Total	98	147	130	121	110	98
	Removed	0	0	1	1	1	0
	Subtotal	98	147	129	120	109	98
	Expanded Total	247.50	371.26	326.80	304.07	276.29	247.50
Stratum 3	Total	2	5	7	7	3	10
	Removed	0	0	0	0	0	0
	Subtotal	2	5	7	7	3	10
	Expanded Total	4.53	11.33	15.87	15.87	6.80	22.67
Stratum 4	Total	16	10	9	18	14	25
	Removed	0	0	1	0	0	0
	Subtotal	16	10	8	18	14	25
	Expanded Total	32.65	20.40	17.32	36.73	28.57	51.01
	Expanded Total over Strata	286.94	407.50	371.25	356.66	313.91	321.19
	Volitional Releases	2139	2166	2135	2134	2177	2155
	Release-to-McN Survival	0.1341	0.1881	0.1739	0.1671	0.1442	0.1490
	Tagged	2222	2223	2222	2222	2222	2223
	Proportion Detected	0.9626	0.9744	0.9608	0.9604	0.9797	0.9694

Table B.3. (continued)

b. Brood-Year 2003, Release Year 2005

	Acclimation Site	Easton					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	High	Low	High	Low	High	Low
	Cross	NxN	NxN	NxN	NxN	NxN	NxN
Stratum 1	Total	1	0	0	0	1	0
	Removed	0	0	0	0	0	0
	Subtotal	1	0	0	0	1	0
	Expanded Total	2.25	0.00	0.00	0.00	2.25	0.00
Stratum 2	Total	92	70	109	79	103	77
	Removed	0	1	0	0	0	1
	Subtotal	92	69	109	79	103	76
	Expanded Total	232.35	175.26	275.29	199.52	260.13	192.94
Stratum 3	Total	5	6	6	5	4	12
	Removed	0	0	0	0	0	0
	Subtotal	5	6	6	5	4	12
	Expanded Total	11.33	13.60	13.60	11.33	9.07	27.20
Stratum 4	Total	19	32	12	30	26	32
	Removed	0	0	0	0	1	1
	Subtotal	19	32	12	30	25	31
	Expanded Total	38.77	65.30	24.49	61.21	52.01	64.25
	Expanded Total over Strata	284.71	254.16	313.37	272.07	323.46	284.40
	Volitional Releases	2136	2170	2180	2178	2158	2151
	Release-to-McN Survival	0.1333	0.1171	0.1437	0.1249	0.1499	0.1322
	Tagged	2222	2224	2221	2222	2222	2222
	Proportion Detected	0.9613	0.9757	0.9815	0.9802	0.9712	0.9680

Table B.3. (continued)

b. Brood-Year 2003, Release Year 2005

Acclimation Site		Jack Creek					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	High	Low	High	Low	High	Low
	Cross	NxN	NxN	NxN	NxN	NxN	NxN
Stratum 1	Total	0	0	0	0	0	0
	Removed	0	0	0	0	0	0
	Subtotal	0	0	0	0	0	0
	Expanded Total	0.00	0.00	0.00	0.00	0.00	0.00
Stratum 2	Total	88	55	103	77	103	60
	Removed	0	0	1	0	1	0
	Subtotal	88	55	102	77	102	60
	Expanded Total	222.25	138.91	258.61	194.47	258.61	151.53
Stratum 3	Total	15	17	20	17	7	4
	Removed	0	0	1	0	0	0
	Subtotal	15	17	19	17	7	4
	Expanded Total	34.00	38.54	44.07	38.54	15.87	9.07
Stratum 4	Total	43	53	28	36	35	42
	Removed	1	0	0	0	0	1
	Subtotal	42	53	28	36	35	41
	Expanded Total	86.70	108.15	57.13	73.46	71.42	84.66
	Expanded Total over Strata	342.95	285.59	359.81	306.46	345.89	245.26
	Volitional Releases	2186	2183	2161	2178	2167	2160
	Release-to-McN Survival	0.1569	0.1308	0.1665	0.1407	0.1596	0.1135
	Tagged	2223	2222	2222	2222	2222	2222
	Proportion Detected	0.9834	0.9824	0.9725	0.9802	0.9752	0.9721

Table B.3. (continued)

c. Brood-Year 2004, Release Year 2006

Acclimation Site		Clark Flat					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	High	Low	High	Low	High	Low
	Cross	HxH	HxH	WxW	WxW	WxW	WxW
Stratum 1	Total	2	2	1	0	3	0
	Removed	0	0	0	0	0	0
	Subtotal	2	2	1	0	3	0
	Expanded Total	10.72	10.72	5.36	0.00	16.08	0.00
Stratum 2	Total	28	13	25	19	23	9
	Removed	0	0	0	0	0	0
	Subtotal	28	13	25	19	23	9
	Expanded Total	102.59	47.63	91.60	69.61	84.27	32.97
Stratum 3	Total	87	67	81	36	82	36
	Removed	0	0	0	0	0	0
	Subtotal	87	67	81	36	82	36
	Expanded Total	273.70	210.78	254.82	113.26	257.97	113.26
Stratum 4	Total	53	39	41	31	50	42
	Removed	0	0	0	0	0	0
	Subtotal	53	39	41	31	50	42
	Expanded Total	147.42	108.48	114.05	86.23	139.08	116.83
Stratum 5	Total	113	112	105	104	87	93
	Removed	0	0	0	0	0	0
	Subtotal	113	112	105	104	87	93
	Expanded Total	281.65	279.16	261.71	259.22	216.85	231.80
Stratum 6	Total	9	15	7	10	6	19
	Removed	0	0	0	0	0	0
	Subtotal	9	15	7	10	6	19
	Expanded Total	36.12	60.20	28.09	40.13	24.08	76.25
	Expanded Total over Strata	852.21	716.97	755.63	568.45	738.33	571.11
	Volitional Releases	2147	2164	2166	2143	2178	2164
	Release-to-McN Survival	0.3969	0.3313	0.3489	0.2653	0.3390	0.2639
	Tagged	2222	2224	2222	2223	2222	2222
	Proportion Detected	0.9662	0.9730	0.9748	0.9640	0.9802	0.9739

Table B.3. (continued)

c. Brood-Year 2004, Release Year 2006

Acclimation Site		Easton					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	High	Low	High	Low	High	Low
	Cross	WxW	WxW	WxW	WxW	WxW	WxW
Stratum 1	Total	1	0	1	1	0	0
	Removed	0	0	0	0	0	0
	Subtotal	1	0	1	1	0	0
	Expanded Total	5.36	0.00	5.36	5.36	0.00	0.00
Stratum 2	Total	6	8	15	6	9	6
	Removed	0	0	0	0	0	0
	Subtotal	6	8	15	6	9	6
	Expanded Total	21.98	29.31	54.96	21.98	32.97	21.98
Stratum 3	Total	51	31	70	46	57	40
	Removed	0	0	0	0	0	0
	Subtotal	51	31	70	46	57	40
	Expanded Total	160.44	97.53	220.22	144.71	179.32	125.84
Stratum 4	Total	39	31	41	27	35	38
	Removed	0	0	0	0	0	0
	Subtotal	39	31	41	27	35	38
	Expanded Total	108.48	86.23	114.05	75.10	97.36	105.70
Stratum 5	Total	82	88	67	87	78	63
	Removed	0	0	0	0	0	0
	Subtotal	82	88	67	87	78	63
	Expanded Total	204.39	219.34	167.00	216.85	194.42	157.03
Stratum 6	Total	17	22	12	19	11	24
	Removed	0	0	0	0	0	0
	Subtotal	17	22	12	19	11	24
	Expanded Total	68.23	88.29	48.16	76.25	44.15	96.32
	Expanded Total over Strata	568.88	520.70	609.74	540.26	548.21	506.87
	Volitional Releases	2151	2111	2169	2099	2142	2089
	Release-to-McN Survival	0.2645	0.2467	0.2811	0.2574	0.2559	0.2426
	Tagged	2222	2222	2223	2224	2222	2222
	Proportion Detected	0.9680	0.9500	0.9757	0.9438	0.9640	0.9401

Table B.3. (continued)

c. Brood-Year 2004, Release Year 2006

Acclimation Site		Jack Creek					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	High	Low	High	Low	Low	High
	Cross	WxW	WxW	WxW	WxW	WxW	WxW
Stratum 1	Total	0	1	0	0	1	3
	Removed	0	0	0	0	0	0
	Subtotal	0	1	0	0	1	3
	Expanded Total	0.00	5.36	0.00	0.00	5.36	16.08
Stratum 2	Total	13	5	0	10	13	41
	Removed	0	0	0	0	0	0
	Subtotal	13	5	0	10	13	41
	Expanded Total	47.63	18.32	0.00	36.64	47.63	150.22
Stratum 3	Total	41	45	3	31	47	72
	Removed	0	0	0	0	0	0
	Subtotal	41	45	3	31	47	72
	Expanded Total	128.98	141.57	9.44	97.53	147.86	226.51
Stratum 4	Total	26	38	5	26	25	32
	Removed	0	0	0	0	0	0
	Subtotal	26	38	5	26	25	32
	Expanded Total	72.32	105.70	13.91	72.32	69.54	89.01
Stratum 5	Total	93	73	1	66	62	64
	Removed	0	0	0	0	0	0
	Subtotal	93	73	1	66	62	64
	Expanded Total	231.80	181.95	2.49	164.51	154.54	159.52
Stratum 6	Total	11	13	0	12	13	7
	Removed	0	0	0	0	0	0
	Subtotal	11	13	0	12	13	7
	Expanded Total	44.15	52.17	0.00	48.16	52.17	28.09
	Expanded Total over Strata	524.89	505.07	25.84	419.15	477.10	669.43
	Volitional Releases	2140	2127	85	2101	2068	2164
	Release-to-McN Survival	0.2453	0.2375	0.3040	0.1995	0.2307	0.3094
	Tagged	2222	2222	2224	2222	2222	2222
	Proportion Detected	0.9631	0.9572	0.0382	0.9455	0.9307	0.9739

Table B.3. (continued)

d. Brood-Year 2005, Release Year 2007

	Acclimation Site	Clark Flat					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	STF	Control	STF	Control	STF	Control
	Cross	HxH	HxH	NxN	NxN	NxN	NxN
Stratum 1	Total	34	42	29	30	27	28
	Removed	0	0	0	0	0	0
	Subtotal	34	42	29	30	27	28
	Expanded Total	114.43	141.35	97.60	100.97	90.87	94.24
Stratum 2	Total	29	44	38	22	34	22
	Removed	0	0	0	0	0	0
	Subtotal	29	44	38	22	34	22
	Expanded Total	83.81	127.17	109.83	63.58	98.27	63.58
Stratum 3	Total	86	87	73	85	81	98
	Removed	0	0	0	0	0	0
	Subtotal	86	87	73	85	81	98
	Expanded Total	227.41	230.05	193.03	224.76	214.18	259.14
Stratum 4	Total	39	39	29	38	41	54
	Removed	0	0	0	0	0	0
	Subtotal	39	39	29	38	41	54
	Expanded Total	126.14	126.14	93.80	122.91	132.61	174.66
Stratum 5	Total	34	50	83	80	78	81
	Removed	0	0	0	0	0	0
	Subtotal	34	50	83	80	78	81
	Expanded Total	88.36	129.93	215.69	207.89	202.70	210.49
Stratum 6	Total	1	6	3	5	4	4
	Removed	0	0	0	0	0	0
	Subtotal	1	6	3	5	4	4
	Expanded Total	1.87	11.19	5.60	9.33	7.46	7.46
Stratum 7	Total	1	1	1	1	0	1
	Removed	0	0	0	0	0	0
	Subtotal	1	1	1	1	0	1
	Expanded Total	2.76	2.76	2.76	2.76	0.00	2.76
	Expanded Total over Strata	644.77	644.77	644.77	644.77	644.77	644.77
	Volitional Releases	2150	2150	2150	2150	2150	2150
	Release-to-McN Survival	0.2999	0.2999	0.2999	0.2999	0.2999	0.2999
	Tagged	2223	2223	2223	2223	2223	2223
	Proportion Detected	0.9672	0.9672	0.9672	0.9672	0.9672	0.9672

Table B.3. (continued)

d. Brood-Year 2005, Release Year 2007

Acclimation Site		Easton					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	STF	Control	STF	Control	STF	Control
	Cross	NxN	NxN	NxN	NxN	NxN	NxN
Stratum 1	Total	18	24	18	27	31	19
	Removed	0	0	0	0	0	0
	Subtotal	18	24	18	27	31	19
	Expanded Total	60.58	80.77	60.58	90.87	104.33	63.95
Stratum 2	Total	19	22	27	44	41	23
	Removed	0	0	0	0	0	0
	Subtotal	19	22	27	44	41	23
	Expanded Total	54.91	63.58	78.03	127.17	118.50	66.47
Stratum 3	Total	81	86	82	85	87	78
	Removed	0	0	0	0	0	0
	Subtotal	81	86	82	85	87	78
	Expanded Total	214.18	227.41	216.83	224.76	230.05	206.25
Stratum 4	Total	46	44	58	35	45	45
	Removed	0	0	0	0	0	0
	Subtotal	46	44	58	35	45	45
	Expanded Total	148.78	142.32	187.60	113.21	145.55	145.55
Stratum 5	Total	45	48	39	16	34	40
	Removed	0	0	0	0	0	0
	Subtotal	45	48	39	16	34	40
	Expanded Total	116.94	124.74	101.35	41.58	88.36	103.95
Stratum 6	Total	1	5	2	0	3	1
	Removed	0	0	0	0	0	0
	Subtotal	1	5	2	0	3	1
	Expanded Total	1.87	9.33	3.73	0.00	5.60	1.87
Stratum 7	Total	4	3	2	1	1	2
	Removed	0	0	0	0	0	0
	Subtotal	4	3	2	1	1	2
	Expanded Total	11.03	8.27	5.52	2.76	2.76	5.52
	Expanded Total over Strata	644.77	644.77	644.77	644.77	644.77	644.77
	Volitional Releases	2150	2150	2150	2150	2150	2150
	Release-to-McN Survival	0.2999	0.2999	0.2999	0.2999	0.2999	0.2999
	Tagged	2223	2223	2223	2223	2223	2223
	Proportion Detected	0.9672	0.9672	0.9672	0.9672	0.9672	0.9672

Table B.3. (continued)

d. Brood-Year 2005, Release Year 2007

	Acclimation Site	Jack Creek					
	Acclimation Raceway	01	02	03	04	05	06
	Treatment	STF	Control	STF	Control	STF	Control
	Cross	NxN	NxN	NxN	NxN	NxN	NxN
Stratum 1	Total	32	12	18	17	13	13
	Removed	0	0	0	0	0	0
	Subtotal	32	12	18	17	13	13
	Expanded Total	107.70	40.39	60.58	57.21	43.75	43.75
Stratum 2	Total	27	13	23	26	19	18
	Removed	0	0	0	0	0	0
	Subtotal	27	13	23	26	19	18
	Expanded Total	78.03	37.57	66.47	75.14	54.91	52.02
Stratum 3	Total	63	68	81	94	76	88
	Removed	0	0	0	0	0	0
	Subtotal	63	68	81	94	76	88
	Expanded Total	166.59	179.81	214.18	248.56	200.96	232.69
Stratum 4	Total	35	55	45	43	54	52
	Removed	0	0	0	0	0	0
	Subtotal	35	55	45	43	54	52
	Expanded Total	113.21	177.89	145.55	139.08	174.66	168.19
Stratum 5	Total	65	82	58	68	58	45
	Removed	0	0	0	0	0	0
	Subtotal	65	82	58	68	58	45
	Expanded Total	168.91	213.09	150.72	176.71	150.72	116.94
Stratum 6	Total	15	17	19	9	14	10
	Removed	0	0	0	0	0	0
	Subtotal	15	17	19	9	14	10
	Expanded Total	27.98	31.72	35.45	16.79	26.12	18.66
Stratum 7	Total	9	8	11	3	4	5
	Removed	0	0	0	0	0	0
	Subtotal	9	8	11	3	4	5
	Expanded Total	24.82	22.06	30.34	8.27	11.03	13.79
	Expanded Total over Strata	644.77	644.77	644.77	644.77	644.77	644.77
	Volitional Releases	2150	2150	2150	2150	2150	2150
	Release-to-McN Survival	0.2999	0.2999	0.2999	0.2999	0.2999	0.2999
	Tagged	2223	2223	2223	2223	2223	2223
	Proportion Detected	0.9672	0.9672	0.9672	0.9672	0.9672	0.9672

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Annual Report: Smolt Survival to McNary Dam of Year-2007

Spring Chinook Releases at Roza Dam

Doug Neeley, Consultant to Yakama Nation

As in 2006, fewer natural-origin (natural) than hatchery-origin (hatchery) smolt were PIT-tagged and released at Roza Dam in 2007. The only year other than 2006 in which this happed was 1999, and in that year there was no sampling of natural smolt prior to the passage of hatchery fish.

Comparison of Natural- and Hatchery-Origin Smolt Contemporaneously Passing Prosser

For those natural fish that were contemporaneously released with hatchery fish at Roza, there were only 336 natural smolt released in 2007 compared to 2,477 released hatchery smolt. The contemporaneous natural/hatchery release ratio was 0.14, which was comparable to 0.13 in 2006 but higher than those ratios in 2005 and 2004 when the natural/hatchery-release ratios were both 0.03. The natural/hatchery release ratios for these four years were all lower than those in release years 1999 through 2003, which ranged from 0.20 to 1.41.

Smolt-to-smolt survivals from Roza release to McNary passage are summarized in Table 1 and graphically presented in Figure 1 for all release years. Unlike all previous years, over which contemporaneous survivals of the natural smolt were either not significantly different or were significantly greater than that of hatchery smolt, the contemporaneous natural smolt had a significantly lower survival than hatchery in 2007. Logistic analyses of variation tables for Roza-to-McNary survival are given in Appendix Table A.1 for all release years.

Comparison of Early and Late Roza Passage of Natural-Origin Smolt

Beginning in 2002, more natural fish were trapped, tagged, and released prior to the period of hatchery passage at Roza (early-released natural smolt) than during the period of hatchery passage (late-released natural smolt); there being 1072 early- and 336 late-released natural fish in 2007.

There is no consistency over the release years as to whether the early or late natural-smolt passage has the highest survival to McNary (Table 1. and Table A.2. in Appendix A.). The 2007 survival of late-passage natural smolt was less than that of the early-passage (P = 0.07, Table A.2. in Appendix A.). As stated in earlier reports, these early versus late comparisons may not be particularly meaningful because some of the earlier released smolt may have passed McNary Dam before McNary Dam's bypass system was watered up. In any case, for those fish detected at McNary, the travel time from day of release to mean date of McNary passage is much longer for early released than late released natural smolt. Figure 2 presents the 2006 out-migration-year travel times to McNary as well at those for 2007 because of the much earlier Roza passages in 2006.

Table 1. Roza-to-McNary Smolt-to-Smolt Survival Indices for Natural- and Hatchery-Origin Pit-Tagged Fish

a. 1999 Outmigration Year (Brood-Year 1997)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)			04/15/99
Ending Week (ending date of week)			05/13/01
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-Year 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)		01/21/00	05/05/00
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-Year 1999)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		02/04/01	03/25/01
Ending Week (ending date of week)		03/18/01	04/29/01
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-Year 2000)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		12/24/01	03/25/02
Ending Week (ending date of week)		03/18/02	04/29/02
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-Year 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)		03/18/03	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-Year 2002)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		12/17/03	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

Table 1. (continued)

g. 2005 Outmigration Year (Brood-Year 2003)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		02/04/05	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-Year 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	03/25/06
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-Year 2005)

		Before Hatchery Passage	During Hatchery Passage
Beginning Week (ending date of week)		02/07/07	04/04/07
Ending Week (ending date of week)		03/02/07	05/18/07
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

Figure 1. Spring Chinook Roza-Release-to-McNary-Dam-Detection Smolt-to-Smolt Survival Index

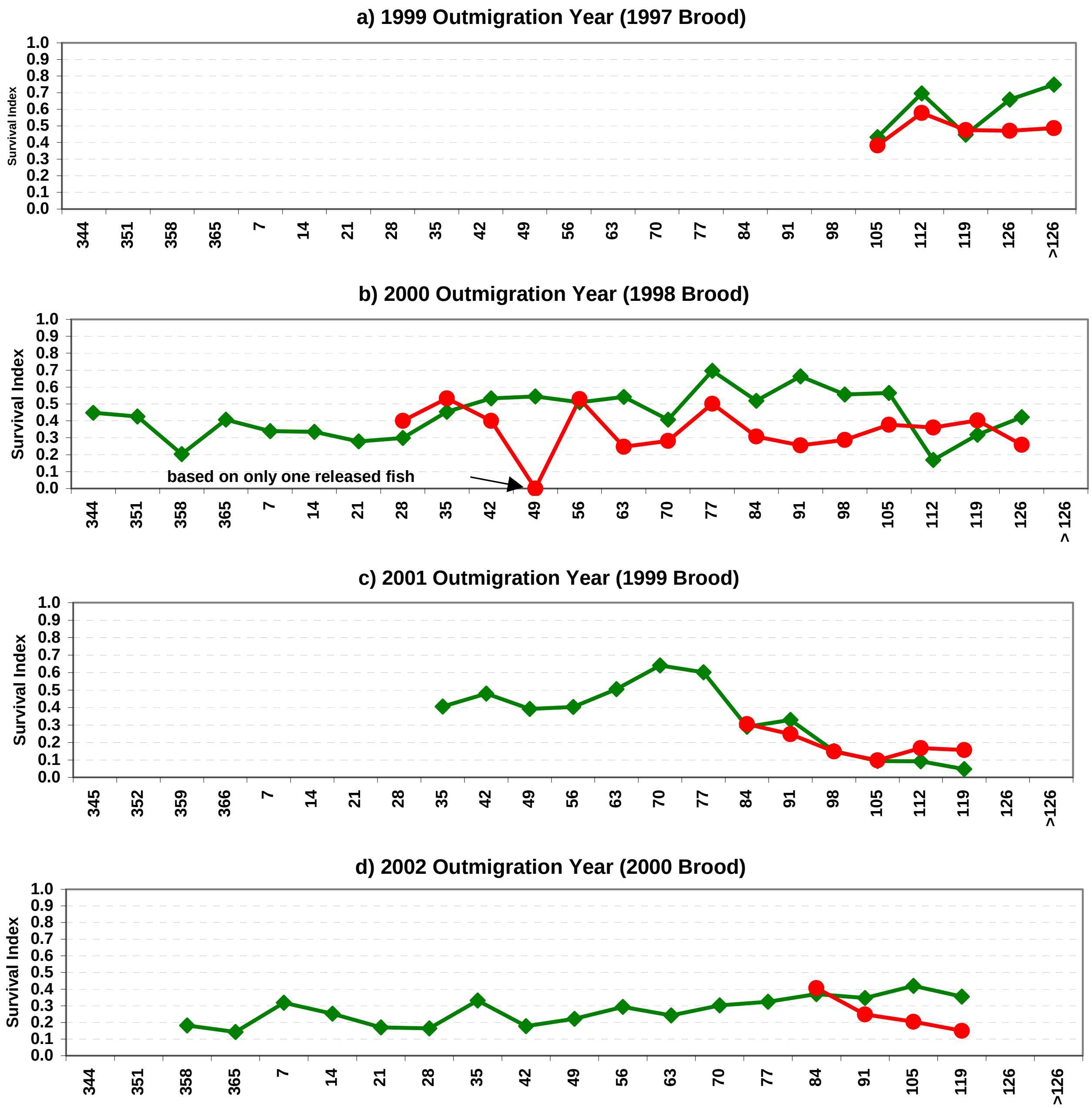


Figure 1. (continued)

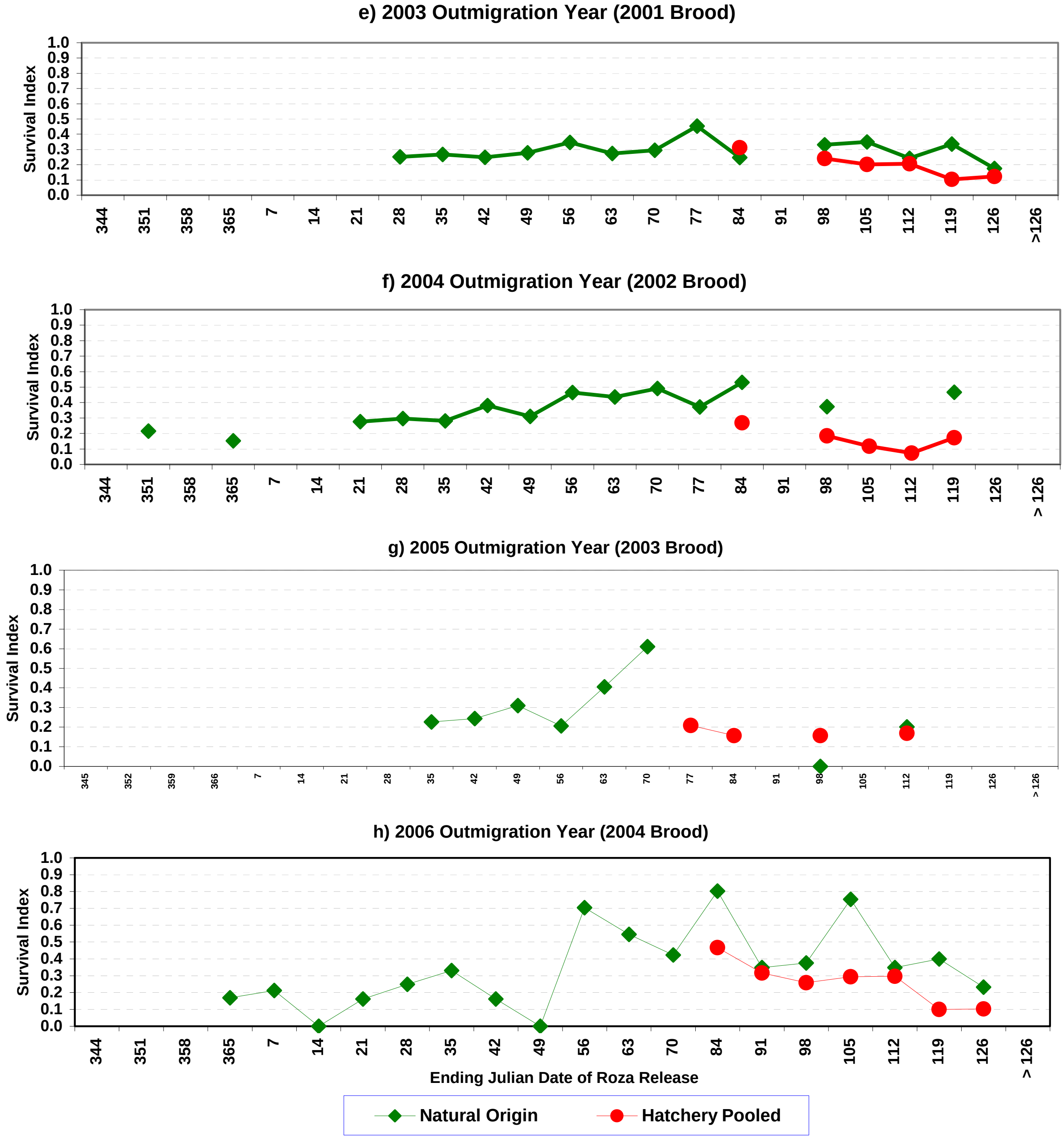
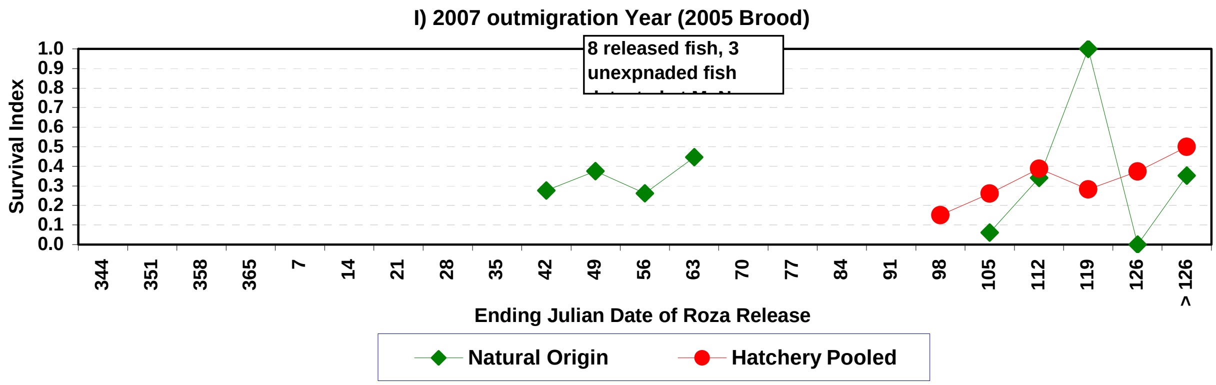
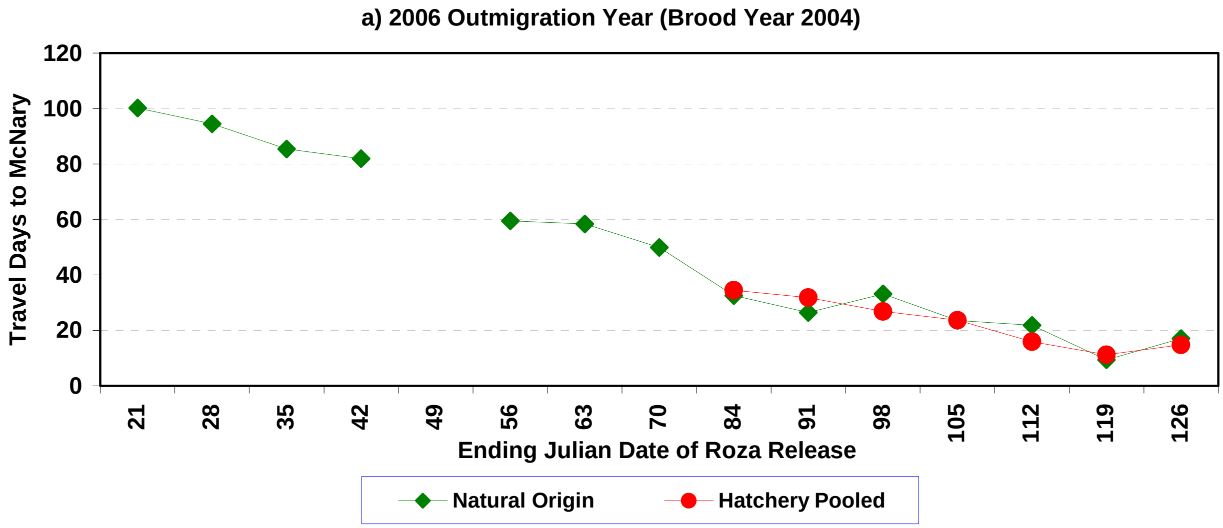


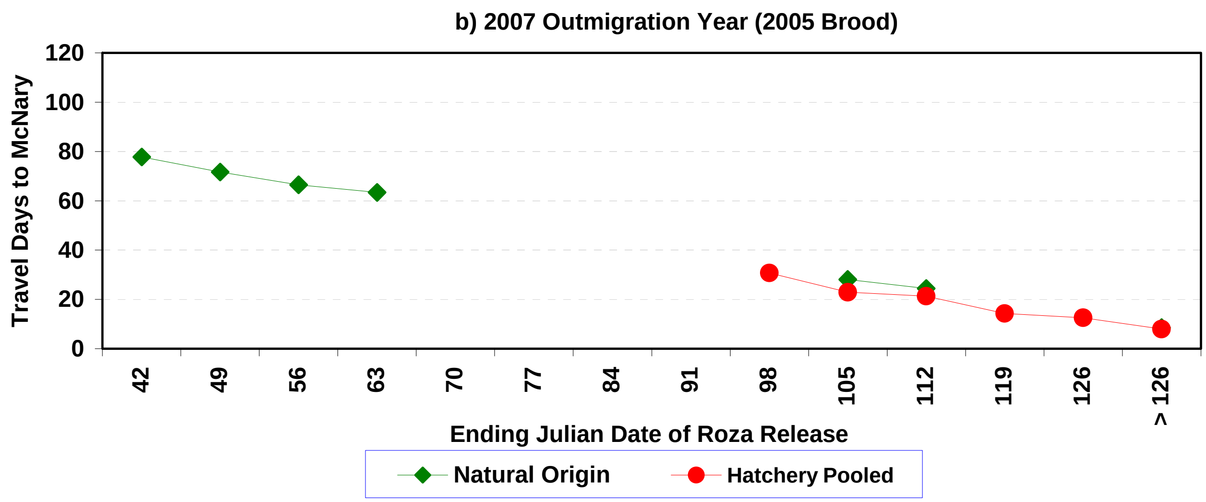
Figure 1. (continued)



Note: The 100% survival for the Julian-Date-119 Wild Release is based on only 8 released smolt and 3 unexpanded McNary detections

Figure 2. Spring Chinook Roza-Release-to-McNary-Dam-Detection Travel Time (days)





Appendix A. Weighted* Logistic Analyses of Variation of Smolt-to-Smolt Survival**

Table A.1. Contemporaneous Natural versus pooled Hatchery-Origin smolt (pooled being combining hatchery fish whether or not previously tagged at hatchery)

a) 1999 Outmigration (1997 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P	1-sided Type 1 *p****
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 Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	1-sided Type 1 *p****
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 Origin1	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 Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	1-sided Type 1 *p****
Block1	119.01	5	23.80	11.89	0.0006	
Wild versus Hatchery1	0.87	1	0.87	0.43	0.5246	0.8160
Tagged vs Untagged Hatchery1	1.78	1	1.78	0.89	0.3679	
Error(1)	20.02	10	2.002			
Wild versus Hatchery2	0.87	1	0.87	0.09	0.7635	
Tagged vs Untagged Hatchery2	1.78	1	1.78	0.19	0.6675	
Error(2)3	139.03	15	9.27			

d) 2002 Outmigration (2000 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	1-sided Type 1 *p****
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			

Table A.1. (continued)

e) 2003 Outmigration (2001 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	1-sided Type 1 *p****
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 Origin1	0.62	1	0.62	0.12	0.7337	
Error(1)	50.65	10	5.065			
Natural Origin versus Hatchery Origin[2]	12.33	1.00	12.33	1.91	0.1873	
Tagged vs Untagged Hatchery Origin[2]	0.62	1.00	0.62	0.10	0.7610	
Error(2)[3]	96.90	15.00	6.46			

f) 2004 Outmigration (2002 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	1-sided Type 1 *p****
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 Origin1	21.85	1	21.85	6.17	0.0476	
Error(1)	21.25	6	3.54166667			
Natural Origin versus Hatchery Origin[2]	21.55	1.00	21.55	1.99	0.1889	
Tagged vs Untagged Hatchery Origin[2]	21.85	1.00	21.85	2.02	0.1861	
Error(2)[3]	108.39	10.00	10.84			

g) 2005 Outmigration (2003 Brood Year)

Source	**Deviance (Dev)**	**Degrees of Freedom (DF)**	**Mean Deviance (Dev/DF)**	**F-Ratio**	**P**	**1-sided Type 1** *p****
Block[1]	112.78	9	12.53	2.44	0.2025	
Natural Origin versus Hatchery Origin[1]	0.03	1	0.03	0.01	0.9427	
Tagged vs Untagged Hatchery Origin1	0.01	1	0.01	0.00	0.9669	
Error(1)	20.54	4	5.135			
Natural Origin versus Hatchery Origin[2]	0.03	1.00	0.03	0.00	0.9577	0.5212
Tagged vs Untagged Hatchery Origin[2]	0.01	1.00	0.01	0.00	0.9756	
Error(2)[3]	133.32	13.00	10.26			

h) 2006 Outmigration (2004 Brood Year)

Source	**Deviance (Dev)**	**Degrees of Freedom (DF)**	**Mean Deviance (Dev/DF)**	**F-Ratio**	**P**	**1-sided Type 1** *p****
Block[1]	295.37	6	49.23	7.70	0.0020	
Natural Origin versus Hatchery Origin[1]	94.71	1	94.71	14.82	0.0027	0.0014
Tagged vs Untagged Hatchery Origin[1]	0.26	1	0.26	0.04	0.8438	
Error(1)	70.30	11	6.39090909	0.00		
Natural Origin versus Hatchery Origin[2]	94.71	1.00	94.71	4.40	0.0511	
Tagged vs Untagged Hatchery Origin[2]	0.26	1.00	0.26	0.01	0.9137	
Error(2)3	365.67	17.00	21.51			

Table A.1. (continued)

i) 2007 Outmigration (2005 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	1-sided Type 1 *p****
Block[1]	1018.28	4	254.57	27.24	0.0001	
Natural Origin versus Hatchery Origin[1]	142.21	1	142.21	15.22	0.0045	0.9977
Tagged vs Untagged Hatchery Origin[1]	0.28	1	0.28	0.03	0.8669	
Error(1)	74.77	8	9.34625	0.00		
Natural Origin versus Hatchery Origin[2]	142.21	1.00	142.21	1.56	0.2353	
Tagged vs Untagged Hatchery Origin[2]	0.28	1.00	0.28	0.00	0.9567	
Error(2)3	1093.05	12.00	91.09	0.00	0.0000	

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

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

[3] Error (2) is pooling of Error(1) and Block

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

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

*** Test for Hatchery Survival less than Wild Survival

Note: Decision of selection of test: If Block P <= 0.2, Error(2) is basis of test, otherwise Error (1) is basis of analysis.

Table A.2. Pre-Contemporaneous (Early) Natural versus Contemporaneous Natural Smolt (no 1999 early release)

a) 1999 Outmigration (1997 Brood Year)
[No early Roza releases]

b) 2000 Outmigration (1998 Brood Year)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	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	0.0000	

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			

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	4.69	0.0671	Early
Error	62.24	7	8.89			

* 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

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2007 Annual Report: Smolt-to-Smolt Survival to McNary Dam of Main-Stem-Yakima Fall Chinook

Doug Neeley, Consultant to Yakama Nation

1. Introduction

In previous years, two sources of brood-stock were used for hatchery production: 1) main-stem-Yakima Fall Chinook adult returns that were sampled from Prosser Diversion Dam on the Lower Yakima River and 2) Marion Drain returns. For brood-years 1998 through 2004, progeny from crosses of the main-stem-Yakima brood-stock reared at Prosser were assigned to one of two treatments: a) a conventional-rearing treatment as a control or b) a rearing treatment designed to accelerate smolting, permitting an earlier release and outmigration during a period believed to be more optimal for survival. Fish from these treatments were released into the Yakima River downstream of Prosser Diversion Dam on the lower Yakima.

Beginning with brood-year 2005 (release-year 2006), there was a shift in focus: The accelerated treatment was adopted as a standard rearing procedure, and a new production site was established at the upper Stiles Pond on the Naches River with the long-term goal of establishing a new brood-stock that spawns in the higher reaches of the lower Yakima and in the lower reaches of the Naches Rivers, reaches that were historically utilized by Summer Chinook, a stock that is probably extinct in the Yakima basin. In Brood Year 2006 (release year 2007), another stock was introduced, Little White, which was raised and volitionally released at Prosser along with the Main-Stem Yakima stock. And in brood-year 2006, another release site upstream of the Marion Drain confluence with the Yakima but below the confluence of the Naches and Upper Yakima Rivers was introduced (Billy Pond at Union Gap).

A portion of each of the releases from these sites and years was PIT-tagged, and smolt-to-smolt survival indices of the PIT-tagged fish to McNary Dam (Tagging-to-McNary survival) were estimated using stratified PIT-tag detection tallies at McNary expanded by estimates of McNary's detection efficiencies for the strata. The expanded strata tallies were totaled over strata and then divided by the total number of PIT-tagged fish as an estimated index of survival. The daily-expanded passage estimates were also used to estimate the mean passage date at McNary for each release based on all tagged fish.

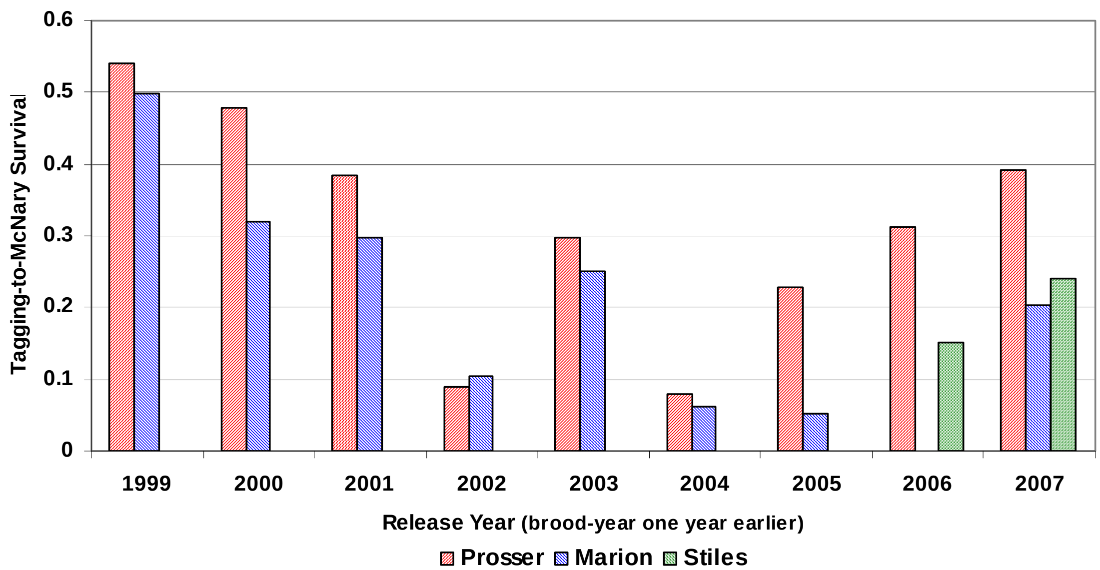
For the 2005 and 2006 broods, detection efficiencies for PIT-tag detectors installed in the Prosser and Stiles pond outfalls were sufficiently high to permit the estimation of in-river survival based on those fish detected exiting the ponds. Estimation procedures, similar to those discussed for Tagging-to-McNary survival, were used to estimate Release-to-McNary survival based on the fish detected leaving the rearing ponds. Mean dates-of-passage were also estimated for the volitionally released fish.

Pre-release survival was also estimated for these two sites by expanding (dividing) the proportion of tagged fish that were detected at the rearing site by the rearing-pond detection efficiency for each tag group, the detection efficiency being the estimated proportion of McNary detection of tagged fish that were previously detected at the ponds.

Detailed stratification methods are presented in my annual report Hatchery x Hatchery and Natural x Natural Smolt-to-Smolt Survival and Mini-Jack Proportions of Upper Yakima Spring Chinook for Brood-Years 2002-2005 and are summarized in Appendix A of this report which also gives the survival estimates for brood-year 2004 and 2005 Fall Chinook releases.

A historical summary across all brood years and sites for the Yakima (local) brood source accelerated-rearing tagging-to-McNary survival index is given in Figure 1. This report focuses on the 2004 and 2005 broods. Other brood years are discussed in earlier annual reports.

Figure 1. Historic Tagging-to-McNary Survivals of Fall Chinook from multi-year release Sites in the Yakima Basin



2. Analysis

The number of replications was limited. There were only independent replicated releases at the Marion Drain and Prosser sites. At these sites, the dates of release were separated by three to four days to minimize the mixing of the two releases. Mixing would have probably negated an assumption that survival estimates from the two releases were independent, a necessary assumption if the releases are to be used as a measure of experimental error for statistical tests.

Three sets of summaries are presented, the first for all release sites based on all tagged fish, the second for Prosser and Stiles based on volitional releases, and the third for comparisons for the two brood sources (Yakima and Little White) at Prosser based on volitional releases.

Analysis for all Release Sites

This was an analysis to compare release sites and years, and since the Little White stock was only evaluated at Prosser in 2007, it was omitted from this analysis.

Summaries of survival to McNary, mean date of Detection at McNary, and date that screens were pulled for all release sites are given in Table 1.a. These summaries are based on all tagged fish since two of the sites did not have PIT-tag detectors. An associated logistic analysis of variation on tagging-to-McNary survival is presented in Table 1.b.

The significant difference among locations in tagging-to-McNary survival (P = 0.04) is attributable primarily to the much higher survival rates from the Prosser releases (Table 1.a.). Prosser is located the furthest downstream of all release sites. The fact the mean detection date at McNary for the Prosser release is earlier in 2007 (Table 1.a) may not be a factor since the screens were pulled earlier at that site. However, the screens at Prosser and Stiles were pulled within a day of each other in 2006, and for that release year, the mean detection date for Prosser was a full 19 days earlier than for Stiles.

Table 1.a. Mean Tagging-to-McNary Smolt-to-Smolt Survivals and McNary Detection Dates for 2006 and 2007 Releases (respective brood years 2005 and 2006)

	2006 Release (Brood-Year 2005)			2007 Release (Brood-Year 2006)		
Site	**Tagging-to-McNary Survival**	**McNary Detection Date***	**Date* Screens Pulled**	**Tagging-to-McNary Survival**	**McNary Detection Date***	**Date* Screens Pulled**
Stiles	15.07%	06/14/06	04/27/06	24.00%	06/09/07	05/18/07
Union Gap				10.90%	06/03/07	05/18/07
Marion Drain				20.26%	06/06/07	04/29/07
Prosser	31.24%	05/26/06	04/26/06	39.26%	06/01/07	04/25/07

* Mean Date

Table 1.b. **Weighted Logistic Regression of Mean Tagging-to-McNary Smolt-to-Smolt Survivals for 2006 and 2007 Releases (respective brood years 2005 and 2006)**

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type Pooled Error P(Pooled)
Year	418.92	1	418.92	7.25	0.0773
Location (Loc)	2190.31	4	547.58	9.47	0.0400
Year x Loc	22.30	1	22.30	0.39	0.6144
Error*	231.18	4	57.80		

* Includes replicate differences between releases within stock within location within year

Analysis for Prosser and Stiles Release Sites

This analysis involves survival estimates based on volitional releases. It also excludes the new Little White stock at Prosser which is discussed in the next section.

Table 2.a. presents release-to-McNary survivals, pre-release survival, mean date of McNary detections, and mean volitional-release date of Yakima stock for fish released at Prosser and Stiles. Table 2.b.1) and 2.b.2) respectively present the logistic analyses of variation for release-to-McNary survival and prerelease survival.

The Release-to-McNary survivals do not significantly differ between Stiles and Prosser at the 5% level [P = 0.09, significance at 10% level, Table 2.b.1)]. This lack of significance for release-to-McNary survival at the 5% level when the tagging-to-McNary survival difference was significant is because the release-to-McNary survival difference between the two sites is somewhat smaller than that for the Tagging-to-McNary survival difference and the Tagging-to-McNary Survival comparison involved comparison of more upriver sites to Prosser than did Release-to-McNary survival which increased the power of the statistical Tagging-to-McNary survival comparison . While the pre-release survival was also higher at the Prosser site than the Stiles site, that difference was also not significant at either the 5% or 10% significance levels [P = 0.16, Table 2.b.2)]. The mean date of McNary Passages for all tagged fish (Table 1) and for volitionally released fish (Table 2) were within one day of each other, suggesting that the pond detection efficiencies were reasonably constant over the time that fish were leaving the ponds.

Table 2.a. Mean Release-to-McNary Smolt-to-Smolt Survivals and Pre-Release Survivals and McNary Detection Dates for 2006 and 2007 Releases (respective brood years 2005 and 2006)

1) 2006 Release (Brood-Year 2005)

Site	Release-to-McNary Survival	Pre-Release Survival	McNary Detection Date*	Volitional Release Date*
Stiles	15.16%	84.30%	06/15/06	05/23/06
Union Gap				
Marion Drain				
Prosser	28.04%	96.43%	05/26/06	04/27/06

2) 2007 Release (Brood-Year 2006)

Site	Release-to-McNary Survival	Pre-Release Survival	McNary Detection Date*	Volitional Release Date*
Stiles	29.42%	81.50%	06/09/07	05/14/07
Union Gap				
Marion Drain				
Prosser	41.15%	96.18%	06/01/07	05/03/07

* Mean Date

Table 2.b. Weighted Logistic Regression of Mean Release-to-McNary Smolt-to-Smolt Survivals and Pre-Release Survivals for 2006 and 2007 Releases (respective brood years 2005 and 2006)

1) Release-to-McNary Smolt Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type Pooled Error P(Pooled)
Year	567.79	1	567.79	31.74	0.0174
Location (Loc)	283.94	2	141.97	7.94	0.0949
Year x Loc	10.80	1	10.80	0.60	0.5569
Error*	53.67	3	17.89		

* Includes replicate differences between releases within stock within location within year

2) Pre-Release Survival (Tagging-to-Release adjusted for Pond Detection Efficiency)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type Pooled Error P(Pooled)
Year	35.95	1	35.95	0.21	0.7344
Location (Loc)	1863.88	2	931.94	5.33	0.1598
Year x Loc	1.74	1	1.74	0.01	0.9399
Error*	524.19	3	174.73		

* Includes replicate differences between releases within stock within location within year

Comparison between Yakima and Little White Brood at Prosser

Comparisons between survival and detection times are given in Table 3.a. Statistical tests for significance were essentially meaningless since the 1 x 1 table of release and stock yielded only one degree of freedom for error. The survival estimates are given for each release so that consistency between stock comparisons can be visualized. For all three measures of survival (Tagging-to-McNary, Release-to-McNary, and Pre-Release survival) the survival estimates for the Yakima brood was higher than for the Little White brood. The Yakima brood may also volitionally leave ponds and pass McNary Dam earlier than the Little White brood.

Table 3.a. Mean Tagging-to-McNary, Release-to-McNary, and Pre-Release Survivals for 2007 Releases and associated Detection Dates for Yakima and Little White Brood (2006)

1) Tagging-McNary Survival

Stock	Measure	Release 1 Survival	Release 2 Survival	Mean Survival	McNary Detection Date*
Little White	**Survival**	**31.23%**	**27.99%**	**29.61%**	**06/08/07**
	Number Tagged	2505	2504	5009	
Yakima	**Survival**	**44.50%**	**34.03%**	**39.26%**	**06/01/07**
	Number Tagged	2501	2501	5002	

2) Release-McNary Survival

Stock	Measure	Release 1 Survival	Release 2 Survival	Mean Survival	McNary Detection Date*
Little White	**Survival**	**35.27%**	**32.34%**	**33.82%**	**06/08/07**
	Number Released	2097	2045	4142	
Yakima	**Survival**	**45.96%**	**35.41%**	**41.15%**	**06/01/07**
	Number Released	2288	1921	4209	

3) Pre-Release-McNary Survival

Stock	Measure	Release 1 Survival	Release 2 Survival	Mean Survival	Release Site Detection Date*
Little White	**Survival**	**88.62%**	**86.39%**	**87.50%**	**05/07/07**
	Number Tagged	2505	2504	5009	
Yakima	**Survival**	**97.03%**	**95.33%**	**96.18%**	**05/03/07**
	Number Tagged	2501	2501	5002	

* Mean Date

Appendix A. Estimated Survival Index

Conceptual Computation

The smolt-to-smolt survival to McNary estimation method for Fall 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[1] 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[2]

4. Totaling the release's expanded numbers over strata

5. Taking that release's expanded total and dividing it by the appropriate "population number[3]"

The methods of identifying strata and estimating the individual stratum detection rates at McNary are discussed in my annual report <u>Hatchery x Hatchery and Natural x Natural Smolt-to-Smolt Survival and Mini-Jack Proportions of Upper Yakima Spring Chinook for Brood-Years 2002-2005 (Appendix C above)</u>.

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.)

---

[1] 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.

[2] Adjustment is given in Equation B.2, but so few (usually none) of the fish detected at McNary were transported in 2006 and 2007 that the adjustment was not made.

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

Equation A.1.

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

Equation A.2.

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

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

Equation A.3.

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

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

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

The denominator in the above equation is a measure of the detection efficiency at the acclimation site for the release in question. Initial 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 estimates in which the resulting estimated pre-release survival slightly exceeded 1 (100%).

While this also happened using the unexpanded numbers[4], it was even more unusual; therefore the unexpanded numbers were used.

Detection Rate Estimates

Estimates for 2006 and 2007 detection rates for Equation A.1 are given Table A.1.

Table A.1. McNary Dam Detection Rates for 2006 and 2007 Fall Releases.

			Bonneville (Bonn.) Based			John Day (J.D. based)			Pooled over Bonn.and J.D.		
	Julian Date Strata		Total	Joint Bonn.	McN. Det.	Total	Joint J.D.	McN. Det.	Pooled	Pooled	Pooled McN.
Year	Beginning	Ending	Bonn. Det.	McN. Det.	Rate	J.D. Det.	McN. Det.	Rate	Total Det.	J.D. Det	Det. Rate
2006		156	122.4	28.0	0.2287	548.8	123.0	0.2241	671.3	151.0	0.2249
	157	162	43.6	5.0	0.1148	142.2	29.0	0.2039	185.8	34.0	0.1830
	163		157.0	54.0	0.3439	299.9	105.0	0.3501	456.9	159.0	0.3480
	Total		323.0	87.0	0.2693	991.0	257.0	0.2593	1314.0	344.0	0.2618
2007		139	41.2	9.0	0.2185	114.8	28.0	0.2439	156.0	37.0	0.2372
	140	143	17.2	7.0	0.4060	62.5	22.0	0.3521	79.7	29.0	0.3637
	144	155	100.0	31.0	0.3101	371.2	107.0	0.2882	471.2	138.0	0.2929
	156		505.6	187.0	0.3698	1177.5	420.0	0.3567	1683.1	607.0	0.3606
	Total		664.0	234.0	0.3524	1726.0	577.0	0.3343	2390.0	811.0	0.3393

In the Table A.1, individual stratum's pooled detection rates, pooled over downstream dams, are the detection rate estimates from Equation A.1. that were applied to the stratum McNary detections for each release in Equation A.2 to produce survival estimates, which are detailed in Table A.2.

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

Survival Rate Estimates

Within-stratum detection numbers, expanded numbers, and other within-stratum numbers, totals over strata and survival estimates are given for each release in Table A.2.

Table A.2. Detection Numbers and Resulting Survival Indices

a. Tagging-to-McNary 2006 Survival

2006 Released (Brood Year 2005) based on All PIT-Tagged Fish

	Rearing Pond >	Stiles		Prosser		Horn Rapids (not analyzed in report)
	Tagging Group (File Extender) >	FS1	FS2	PR1	PR2	HRN
Stratum 1	Total	47	44	309	298	9
	Removed	0	0	0	0	0
	Subtotal	47	44	309	298	9
	Expanded Total	208.9	195.6	1373.7	1324.8	40.0
Stratum 2	Total	69	64	28	31	2
	Removed	0	0	0	0	0
	Subtotal	69	64	28	31	2
	Expanded Total	377.0	349.7	153.0	169.4	10.9
Stratum 3	Total	330	320	16	20	2
	Removed	0	0	0	0	0
	Subtotal	330	320	16	20	2
	Expanded Total	948.4	919.6	46.0	57.5	5.7
Stratum 4	Total	0	0	0	0	0
	Total over Strata	446	428	353	349	13
	Expanded Total over Strata	1534.3	1464.9	1572.7	1551.6	56.7
	Number Tagged	9999	9902	5001	5000	191
	Tagging-to-McNary Survival	0.1534	0.1479	0.3145	0.3103	0.2968
	Pooled Number Tagged		19901		10001	
	Pooled Tagging-to-McNary Survival		0.1507		0.3124	

Table A.2. (continued)

b. Volitional Release-to-McNary 2006 Survival (and pre-release survival)

2006 Released (Brood Year 2005) based on Volitionally Released PIT-Tagged Fish

	Rearing Pond >	Stiles		Prosser		Horn Rapids (not analyzed)
	Tagging Group (File Extender) >	FS1	FS2	PR1	PR2	HRN
Stratum 1	Total	47	44	309	298	9
	Removed	0	0	0	0	0
	Subtotal	47	44	309	298	9
	Expanded Total	208.9	195.6	1373.7	1324.8	40.0
Stratum 2	Total	69	64	28	31	2
	Removed	0	0	0	0	0
	Subtotal	69	64	28	31	2
	Expanded Total	377.0	349.7	153.0	169.4	10.9
Stratum 3	Total	330	320	16	20	2
	Removed	0	0	0	0	0
	Subtotal	330	320	16	20	2
	Expanded Total	948.4	919.6	46.0	57.5	5.7
Stratum 4	Total	0	0	0	0	0
	Removed	0	0	0	0	0
	Subtotal	0	0	0	0	0
	Expanded Total	0.0	0.0	0.0	0.0	0.0
	Total over Strata	250	248	28	66	13
	Expanded Total over Strata	726.2	723.1	105.9	255.5	56.7
	Number Released	4897	4662	411	878	191
	Released-to-McNary Survival	0.1483	0.1551	0.2577	0.2911	0.2968
	Pooled Number Released		9559		1289	
	Pooled Tagging-to-McNary Survival		0.1516		0.2804	
	Pre-Rel Survival**		0.8433		0.9643	
	Total Tagged		19901		10001	

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

** Weighted by Number Tagged over Tagging Groups with Site

Table A.3. (continued)

c. Tagging-to-McNary 2007 Survival

2007 Released (Brood Year 2006) based on All PIT-Tagged Fish

	Rearing Pond >	Union Gap	Marion Drain		Stiles	Prosser: Little White		Prosser: Yakima	
	Tagging Group (File Extender) >	BY1	MD1	MD3	ST1	LW1	LW3	PR1	PR3
Stratum 1	Total	10	1	0	0	11	13	57	26
	Removed	0	0	0	0	0	0	0	0
	Subtotal	10	1	0	0	11	13	57	26
	Expanded Total	42.2	4.2	0.0	0.0	46.4	54.8	240.3	109.6
Stratum 2	Total	14	1	0	7	14	8	28	15
	Removed	0	0	0	0	0	0	0	0
	Subtotal	14	1	0	7	14	8	28	15
	Expanded Total	38.5	2.7	0.0	19.2	38.5	22.0	77.0	41.2
Stratum 3	Total	41	56	12	87	24	35	95	67
	Removed	0	0	0	0	0	0	0	0
	Subtotal	41	56	12	87	24	35	95	67
	Expanded Total	140.0	191.2	41.0	297.1	81.9	119.5	324.4	228.8
Stratum 4	Total	117	186	89	749	222	182	170	170
	Removed	0	0	0	0	0	0	0	0
	Subtotal	117	186	89	749	222	182	170	170
	Expanded Total	324.4	515.7	246.8	2076.8	615.6	504.6	471.4	471.4
Stratum 5	Total	0	0	0	0	0	0	0	0
	Total over Strata	182	244	101	843	271	238	350	278
	Expanded Total over Strata	545.1	713.9	287.8	2393.1	782.4	701.0	1113.0	851.0
	Number Tagged	5002	2638	2305	9970	2505	2504	2501	2501
	Tagging-to-McNary Survival	0.1090	0.2706	0.1248	0.2400	0.3123	0.2799	0.4450	0.3403
	Pooled Number Tagged	5002		4943	9970		5009		5002
	Pooled Tagging-to-McNary Survival	0.1090		0.2026	0.2400		0.2961		0.3926

Table A.3. (continued)

d. Volitional Release-to-McNary 2007 Survival (and pre-release survival)

2007 Released (Brood Year 2006) based on Volitionally Released PIT-Tagged Fish

	Rearing Pond >	Union Gap	Marion Drain		Stiles	Prosser: Little White		Prosser: Yakima	
	Tagging Group (File Extender) >	BY1	MD1	MD3	ST1	LW1	LW3	PR1	PR3
Stratum 1	Total				0	11	11	55	19
	Removed				0	0	0	0	0
	Subtotal				0	11	11	55	19
	Expanded Total				0.0	46.4	46.4	231.9	80.1
Stratum 2	Total				7	13	7	26	13
	Removed				0	0	0	0	0
	Subtotal				7	13	7	26	13
	Expanded Total				19.2	35.7	19.2	71.5	35.7
Stratum 3	Total				76	22	34	90	50
	Removed				0	0	0	0	0
	Subtotal				76	22	34	90	50
	Expanded Total				259.5	75.1	116.1	307.3	170.7
Stratum 4	Total				694	210	173	159	142
	Removed				0	0	0	0	0
	Subtotal				694	210	173	159	142
	Expanded Total				1924.3	582.3	479.7	440.9	393.7
	Total over Strata				777	256	225	330	224
	Expanded Total over Strata				2203.1	739.5	661.4	1051.5	680.3
	Number Released				7489	2097	2045	2288	1921
	Released-to-McNary Survival				0.2942	0.3527	0.3234	0.4596	0.3541
	Pooled Number Released				7489		4142		4209
	Pooled Tagging-to-McNary Survival				0.2942		0.3382		0.4115
	Pre-Rel Survival**				0.8150		0.8750		0.9618
	Total Tagged				12471		5009		5002

Appendix F

IntSTATS

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Annual Report: 2006-2007 Coho Smolt-to-Smolt Survival of Eagle Creek and Yakima Brood Releases into the Yakima Basin

Doug Neeley, Consultant to Yakama Nation

Introduction and Summary

This annual report focuses on the comparisons between early-release[1] smolt-to-smolt survivals to McNary Dam (McNary) based on PIT-tagged fish from the two different primary[2] brood-stock sources used for the 2004 and 2005 broods (respectively released in 2006 and 2007), the primary brood-stocks being Yakima-return and Eagle Creek Hatchery sources. Other primary hatchery sources were used in prior years, and a brief historic smolt-to-smolt-survival summary is presented in Figure 1 for those years within which primary hatchery and Yakima-return sources could be compared. The Cascade hatchery brood-stock used for the 1997 brood (release year 1999) had a significantly[3] higher smolt-to-smolt survival than the Yakima-return brood-stock (discussed in previous annual reports). In subsequent comparison years prior to the introduction of the Eagle Creek brood-stock, the Willard brood-stock was used, and it had a significantly lower smolt-to-smolt survival than did the Yakima-return brood-stock (discussed in previous annual reports).

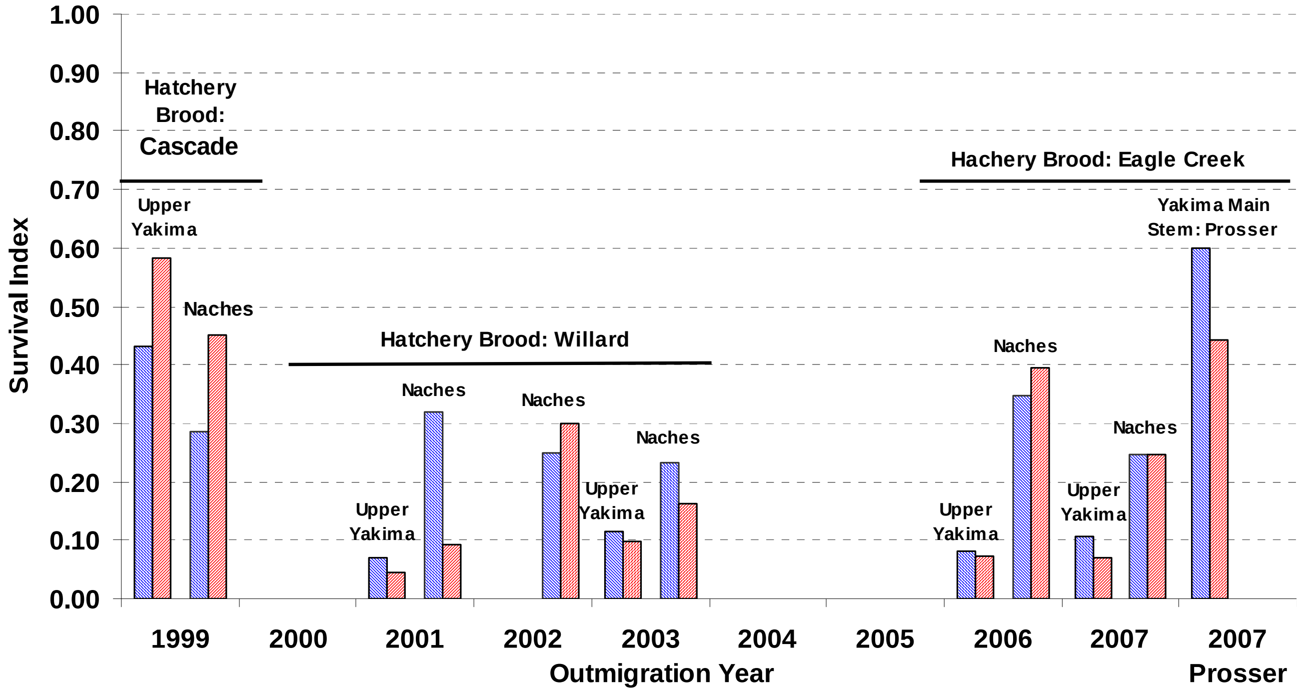
The discussion of the 2006 and 2007 survival comparisons between the Yakima-return and Eagle Creek brood-stock sources (also presented in Figure 1) will be the focus of subsequent sections in this report.

[1] In earlier years, treatments were compared that involved early and late releases of Coho. Those early releases had higher smolt-to smolt survivals and have become standard releases in later years. The term "early-release" is still used here because those survivals from the earlier years that are presented in this report for reference purposes are those from the early-release not the late-release treatments.

[2] There was were some brood years in which a third brood source was used; however this third sources were not used at all sites used for the primary hatchery source and are not included in this presentation, although they were included in the annual report for the release year in which they used.

[3] Significant refers to a difference in survival estimates that is significantly different from 0 at the 5% level (probability = 0.05 of incorrectly concluding that there is a difference between the estimated survivals when there is no real difference in the population survivals).

Figure 1. Coho Early-Release: Tagging-to-McNary Smolt Survival (Downward Slant- Yakima Source; Upward Slant - Hatchery Source)



The Eagle Creek versus Yakima return brood-stock comparisons for these three survival estimates are summarized below:

> The first comparison, which is based on all tags detected at McNary, is the brood-source difference between tagging-to-McNary mean survivals, and this difference is not significantly different than 0.
>
> The second comparison, which is based on McNary detection of tags previously detected exiting rearing ponds, is the brood-source difference between release-to-McNary mean survivals and is significantly different than 0 with the Eagle Creek source having a lower survival estimate than the Yakima return source.
>
> The third comparison, which is based on an expanded proportion of the release's tagged fish that are detected at the acclimation site, is the brood source difference between pre-release survivals and is significantly different than 0 with Eagle Creek source having a higher pre-release survival.

These survivals are detailed in the following sections and associated tables and figures.

Tagging-to-McNary Survival

There is no significant difference in the 2006 and 2007 smolt-to-smolt survivals from time of tagging to McNary passage between the Eagle Creek and the Yakima-return brood sources (P = 0.70, Appendix Table A.1.). The survival means and their graph are respectively presented in Table 1 and Figure 2 (Figure 2 is the same as the 2006 and 2007 portion of the survival presentation in Figure 1). The method of tagging-to-McNary survival estimation is presented in Appendix B along with individual site survival estimates.

Release-to-McNary Survival

The smolt-to-smolt survival from detection at time of volitional release from acclimation site to McNary passage is significantly lower for the Eagle Creek brood source than for Yakima-return brood source ($P = 0.0025$, Appendix Table A.2.). The survival means and their graph are respectively presented in Table 2.a. and Figure 3. The method of release-to-McNary survival estimation is presented in Appendix B along with individual site survival estimates.

Since this is the survival measure of greatest interest, the decision was made to compare each site separately. The significant difference reported above was based on a two-sided test for the means pooled over all sites and both years. Since the Yakima release-to-McNary survivals was greater than those for each site, I deemed it appropriate to conduct a more powerful one-sided test for whether the Yakima stock survival was significantly greater than that for Eagle Creek. Those tests are summarized in Table 2.b. As can be seen, the differences are significant ($P < 0.05$) for all sites in 2007 but not in 2006 (although the 2006 survival estimates were greatest for the Yakima brood in 2006 as they were in 2007).

Pre-release Survival

The inconsistency between the tagging-to-McNary and release-to-McNary survivals in terms of the significance of the difference between the brood sources and in terms of the relative magnitudes of the differences over sites and years[4] may be explained by the pre-release-survival difference between the two brood-stock sources. Pre-release survival was the proportion of tagged fish detected at the acclimation sight divided by the rearing-pond detection efficiency for each tag group (detailed in Appendix B.).

The pre-release survival from the Eagle Creek brood-stock was significantly <u>higher</u> than that for Yakima-return brood-stock ($P = 0.0007$, Appendix Table A.3.). The pre-release survival means and their graph are respectively presented in Table 3 and Figure 4.

The combined effects of the significantly higher pre-release survival and the significantly lower release-to-McNary survival of the Eagle Creek brood-stock probably contributed to the failure to detect a significant difference between the two brood sources' tagging-to-McNary survival which is a combination of pre-release and release-to-McNary survivals.

---

[4] Eagle Creek survival is not consistently less than Yakima return over sites and years for Tagging-to-McNary survival, Table 1, but is consistently less for Release-to-McNary survival, Table 2.

Table 1. Coho Tagging-to-McNary Smolt-to-Smolt Survival

2006 Tagging-to-McNary Survival-Index Means of Brood Year 2004 Coho

	Subbasin >	Upper Yakima		Naches		Subbasin Means		Yakima Main Stem (Prosser)
Stock	**Measure**	**Holmes**	**Boone**	**Stiles**	**Lost Creek**	**Upper Yakima**	**Naches**	
Yakima	**Survival**	**0.1248**	**0.0369**	**0.3499**	**0.3476**	**0.0810**	**0.3487**	
	Number Tagged	2512	2501	2490	2491	5013	4981	
Eagle Creek	**Survival**	**0.1182**	**0.0257**	**0.3505**	**0.4381**	**0.0721**	**0.3944**	**0.6052**
	Number Tagged	2514	2500	2506	2515	5014	5021	1231
Eagle Creek and Yakima Main	**Survival**	**0.1215**	**0.0313**	**0.3502**	**0.3931**	**0.0765**	**0.3717**	
	Number Tagged	5026	5001	4996	5006	10027	10002	

2007 Tagging-to-McNary Survival-Index Means of Brood Year 2005 Coho

	Subbasin >	Upper Yakima		Naches		Subbasin Means		Main Stem (Prosser)
Stock	**Measure**	**Holmes**	**Boone**	**Stiles**	**Lost Creek**	**Upper Yakima**	**Naches**	
Yakima	**Survival**	**0.1077**		**0.2565**	**0.2394**	**0.1077**	**0.2479**	**0.5984**
	Number Tagged	2460		2449	2501	2460	4950	2499
Eagle Creek	**Survival**	**0.0708**		**0.3207**	**0.1739**	**0.0708**	**0.2473**	**0.4430**
	Number Tagged	2504		2513	2511	2504	5024	1246
Eagle Creek and Yakima Main	**Survival**	**0.0891**		**0.2890**	**0.2066**	**0.0891**	**0.2476**	**0.5467**
	Number Tagged	4964		4962	5012	4964	9974	3745

Figure 2. Coho Tagging-to-McNary Smolt Survival (Downward Slant – Yakima Brood-Stock, Upward Slant - Hatchery Brood-Stock)

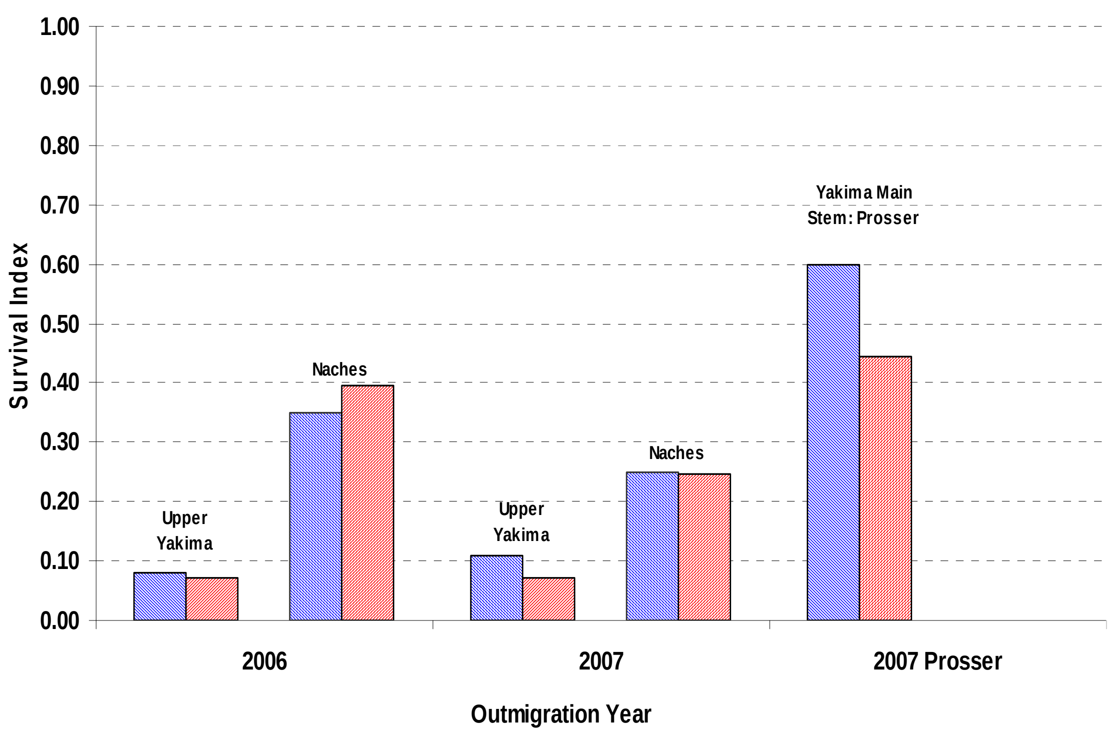


Table 2.a. Coho Release-to-McNary Smolt-Smolt Survival

2006 Release-to-McNary Survival-Index Means of Brood Year 2004 Coho

	Subbasin >	Upper Yakima		Naches		Subbasin Means		Main Stem
Stock	**Measure**	**Holmes**	**Boone**	**Stiles**	**Lost Creek**	**Upper Yakima**	**Naches**	**(Prosser)**
Yakima	**Survival**	**0.2501**		**0.3915**	**0.6802**	**0.2501**	**0.5064**	
	Number Tagged	781		1598	1057	781	2655	
Eagle Creek	**Survival**	**0.1862**		**0.3881**	**0.6266**	**0.1862**	**0.4972**	**0.7478**
	Number Tagged	636		1974	1663	636	3637	912
Eagle Creek and Yakima Main	**Survival**	**0.2214**		**0.3896**	**0.6474**	**0.2214**	**0.5011**	
	Number Tagged	1417		3572	2720	1417	6292	

2007 Release-to-McNary Survival-Index Means of Brood Year 2005 Coho

	Subbasin >	Upper Yakima		Naches		Subbasin Means		Main Stem
Stock	**Measure**	**Holmes**	**Boone**	**Stiles**	**Lost Creek**	**Upper Yakima**	**Naches**	**(Prosser)**
Yakima	**Survival**	**0.2201**		**0.4676**	**0.3583**	**0.2201**	**0.4041**	**0.6975**
	Number Tagged	920		1204	1671	920	2875	2112
Eagle Creek	**Survival**	**0.1202**		**0.3939**	**0.2068**	**0.1202**	**0.2953**	**0.4835**
	Number Tagged	1293		1881	2092	1293	3973	1136
Eagle Creek and Yakima Main	**Survival**	**0.1617**		**0.4227**	**0.2741**	**0.1617**	**0.3410**	**0.6226**
	Number Tagged	2213		3085	3763	2213	6848	3248

Table 2.b. Individual Site Comparisons: Yakima versus Eagle Creek -McNary Smolt-Smolt Survival

Year	Site	Measure	Yakima	Eagle Creeak	Difference (Diff)	Standard Error [SE(Diff)]	Diff/ SE(Diff)	One Sided Type 1 Error P
2006	**Holmes**	logit transforms	-1.09794	-1.47481	0.37687	0.26337	1.43	0.1012
		survival estimate	0.25013	0.18621	0.06391			
	Lost Creek	logit transforms	-0.44111	-0.45516	0.01405	0.13854	0.10	0.4613
		survival estimate	0.39148	0.38813	0.00334			
	Stiles	logit transforms	0.75461	0.51756	0.23705	0.16704	1.42	0.1028
		survival estimate	0.68018	0.62658	0.05361			
2007	**Holmes**	logit transforms	-1.26525	-1.99018	0.72493	0.23454	3.09	**0.0107**
		survival estimate	0.22007	0.12024	0.09983			
	Lost Creek	logit transforms	-0.12968	-0.43110	0.30142	0.14977	2.01	**0.0454**
		survival estimate	0.46763	0.39386	0.07376			
	Stiles	logit transforms	-0.58257	-1.34459	0.76202	0.14917	5.11	**0.0011**
		survival estimate	0.35834	0.20676	0.15159			
	Prosser	logit transforms	0.83539	-0.06622	0.90161	0.15252	5.91	**0.0005**
		survival estimate	0.69749	0.48345	0.21404			

Figure 3. Coho Release-to-McNary Smolt Survival (Downward Slant – Yakima Brood-Stock, Upward Slant - Hatchery Brood-Stock)

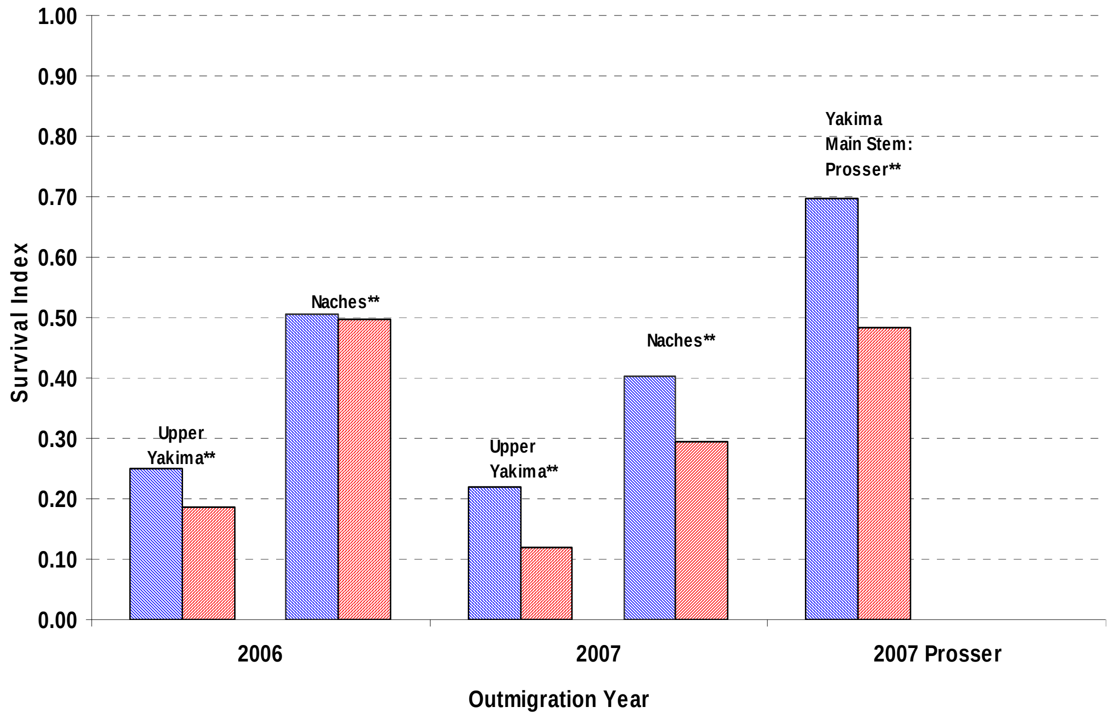


Table 3. Coho Pre-Release Survival

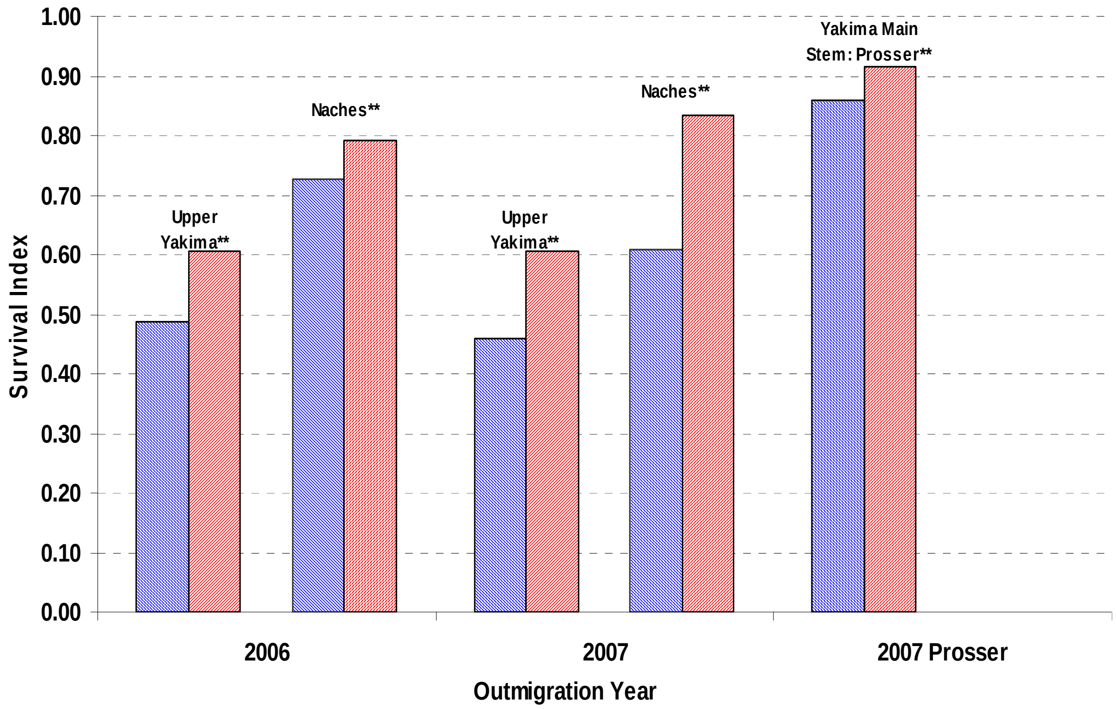
2006 Pre-Release Survival Means of Brood Year 2004 Tagged Coho

	Subbasin >	Upper Yakima		Naches		Subbasin Means		Main Stem (Prosser)
Stock	Measure	Holmes	Boone	Stiles	Lost Creek	Upper Yakima	Naches	
Yakima	Survival	0.4869		0.9175	0.5384	0.4869	0.7279	
	Number Tagged	2512		2490	2491	2512	4981	
Eagle Creek	Survival	0.6050		0.8855	0.6956	0.6050	0.7904	0.8082
	Number Tagged	2514		2506	2515	2514	5021	1231
Eagle Creek and Yakima Main	Survival	0.5460		0.9014	0.6174	0.5460	0.7593	
	Number Tagged	5026		4996	5006	5026	10002	

2007 Pre-Release Survival Means of Brood Year 2005 Tagged Coho

	Subbasin >	Upper Yakima		Naches		Subbasin Means		Main Stem (Prosser)
Stock	Measure	Holmes	Boone	Stiles	Lost Creek	Upper Yakima	Naches	
Yakima	Survival	0.4583		0.5495	0.6681	0.4583	0.6095	0.8588
	Number Tagged	2460		2449	2501	2460	4950	2499
Eagle Creek	Survival	0.6070		0.8254	0.8413	0.6070	0.8333	0.9167
	Number Tagged	2504		2513	2511	2504	5024	1246
Eagle Creek and Yakima Main	Survival	0.5333		0.6892	0.7549	0.5333	0.7222	0.8781
	Number Tagged	4964		4962	5012	4964	9974	3745

Figure 4. Coho Pre-Release Smolt Survival (Downward Slant – Yakima Brood-Stock, Upward Slant - Hatchery Brood-Stock)



Appendices

A. Weighted Logistic Analyses of Variation of Coho Juvenile Survivals[5]

A.1. Tagging-to-McNary Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev = Dev/DF)	F-Ratio	Type 1 Error P
Year (unadjusted for Site)	90.370	1	90.370	3.10	0.1215
Year (adjusted for Site)	4.800	1	4.800	0.16	0.6968
Site (unadjusted for Year)	5018.730	4	1254.683	43.10	0.0001
Site (adjusted for Year)	4933.160	4	1233.290	42.36	0.0001
Year x Site	486.160	2	243.080	8.35	0.0140
Stock (adjusted for Year x Site)	4.830	1	4.830	0.17	0.6959
Error*	203.790	7	29.113		

* F-Tests Denominator Mean Deviance confounded with Brood x Site, Brood xYear, Brood x Site x Year Interaction

A.2. Release-to-McNary Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev = Dev/DF)	F-Ratio	Type 1 Error P
Year (unadjusted for Site)	86.700	1	86.700	4.74	0.0276
Year (adjusted for Site)	375.390	1	375.390	20.52	0.0040
Site (unadjusted for Year)	1448.650	3	482.883	26.40	0.0002
Site (adjusted for Year)	1737.340	3	579.113	31.66	0.0001
Year x Site	564.140	2	282.070	15.42	0.0011
Stock (adjusted for Year x Site)	211.600	1	211.600	11.57	0.0025
Error*	109.750	6	18.292		

* F-Tests Denominator Mean Deviance confounded with Brood x Site, Brood xYear, Brood x Site x Year Interaction

A.3. Pre-release Survival

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev = Dev/DF)	F-Ratio	Type 1 Error P
Year (unadjusted for Site)	7.100	1	7.100	0.42	0.8563
Year (adjusted for Site)	0.020	1	0.020	0.00	0.9735
Site (unadjusted for Year)	1441.490	3	480.497	28.74	0.0002
Site (adjusted for Year)	1434.410	3	478.137	28.60	0.0002
Year x Site	334.230	2	167.115	10.00	0.0037
Stock (adjusted for Year x Site)	305.180	1	305.180	18.26	0.0007
Error*	100.300	6	16.717		

* F-Tests Denominator Mean Deviance confounded with Brood x Site, Brood xYear, Brood x Site x Year Interaction

[5] Logistic analysis of variation assumes that survival estimates have an underlying binomial-like distribution with a variance proportional to what would be expected from a binomial. Weights used were the number of fish tagged (for tagging-to-McNary survival and pre-release survival estimates) or number of fish detected at acclimation site (for release-to-McNary survival).

Appendix B. Estimated Survival Index

Conceptual Computation

The smolt-to-smolt survival to McNary estimation method for Coho involves

1. Identifying time-of-passage strata within which estimated daily McNary detection rates of Coho are reasonably homogeneous. (Daily McNary detection rate is the proportion of all Yakima PIT-tagged Coho 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[6] 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[7]

4. Totaling the release's expanded numbers over strata

5. Taking that release's expanded total and dividing it by the appropriate "population number[8]"

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 Survival and Mini-Jack Proportions of Upper Yakima Spring Chinook for Brood-Years 2002-2005.

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

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[6] 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.

[7] Adjustment is given in Equation B.2, but so few (usually none) of the fish detected at McNary were transported in 2006 and 2007 that the adjustment was not made.

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

Equation B.1.

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

Equation B.2.

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

Pre-release survival was estimated using the Equation B.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 in the above equation is a measure of the detection efficiency at the acclimation site for the release in question. Initial estimates for this detection efficiency was based on expanded detection numbers using the detection rate in Equation B.1 as the expansion factor rather than the unexpanded detections; however, there were occasional estimates in which the resulting estimated pre-release survival slightly exceeded 1 (100%). While this also happened using the unexpanded numbers[9], it was even more unusual; therefore the unexpanded numbers were used.

Detection Rate Estimates

Estimates for 2006 and 2007 detection rates for Equation B.1 are given Table B.1.

Table B.1. McNary Dam Detection Rates for 2006 and 2007 Coho Releases.

	Julian Date Strata		Bonneville (Bonn.) Based			John Day (J.D. based)			Pooled over Bonn.and J.D.		
Year	Beginning	Ending	Total Bonn. Det.	Joint Bonn. McN. Det.	McN. Det. Rate	Total J.D. Det.	Joint J.D. McN. Det.	McN. Det. Rate	Pooled Total Det.	Pooled J.D. Det	Pooled McN. Det. Rate
2006		132	197.4	64.0	0.3242	379.5	107.0	0.2819	576.9	171.0	0.2964
	133	142	72.6	9.0	0.1240	352.6	38.0	0.1078	425.2	47.0	0.1105
	143	148	18.0	7.0	0.3884	112.2	38.0	0.3385	130.3	45.0	0.3454
	149		56.0	11.0	0.1964	277.7	35.0	0.1261	333.7	46.0	0.1379
	Total		344.0	91.0	0.2645	1122.0	218.0	0.1943	1466.0	309.0	0.2108
2007		127	201.9	67.0	0.3319	605.0	221.0	0.3653	806.9	288.0	0.3569
	128	137	233.5	59.0	0.2526	422.8	111.0	0.2625	656.4	170.0	0.2590
	138	149	237.3	41.0	0.1728	320.1	71.0	0.2218	557.4	112.0	0.2010
	150	156	121.4	20.0	0.1647	152.7	26.0	0.1703	274.1	46.0	0.1678
	157		130.9	31.0	0.2367	124.4	32.0	0.2572	255.4	63.0	0.2467
	Total		723.1	151.0	0.2088	1020.0	240.0	0.2353	1743.1	391.0	0.2243

In the Table B.1, individual stratum's pooled detection rates, pooled over downstream dams, are the detection rate estimates from Equation B.1. that were applied to the stratum McNary detections for each release in Equation B.2 to produce survival estimates, which are detailed in Table B.2.

[9] This happened for Fall Chinook, not Coho. When this occurred, the pre-release survival was equated to 1 (100%).

Survival Rate Estimates

Within-stratum detection numbers, expanded numbers, and other within-stratum numbers, totals over strata and survival estimates are given for each release in Table B.2.

Table B.2. Detection Numbers and Resulting Survival Indices

a. Tagging-to-McNary 2006 Survival

	Rearing Pond >	Holmes		Boone		Stiles		Lost Creek		Prosser
	Stock >	Yakima	Eagle Creek	Yakima	Eagle Creek	Yakima	Eagle Creek	Yakima	Eagle Creek	Eagle Creek
		HMY	HME	BNY	BNE	STY	STE	LCY	LCE	PRE
Stratum 1	Total	76	28	16	2	126	45	29	1	194
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	76	28	16	2	126	45	29	1	194
	Expanded Total	256.4	94.5	54.0	6.7	425.1	151.8	97.8	3.4	654.5
Stratum 2	Total	6	16	2	3	45	64	32	19	10
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	6	16	2	3	45	64	32	19	10
	Expanded Total	54.3	144.7	18.1	27.1	407.1	578.9	289.5	171.9	90.5
Stratum 3	Total	1	5	2	3	11	41	40	57	0
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	1	5	2	3	11	41	40	57	0
	Expanded Total	2.9	14.5	5.8	8.7	31.8	118.7	115.8	165.0	0.0
Stratum 4	Total	0	6	2	3	1	4	50	105	105
	Removed	0	0	0	0	0	0	0	0	0
	Subtotal	0	6	2	3	1	4	50	105	105
	Expanded Total	0.0	43.5	14.5	21.8	7.3	29.0	362.7	761.6	761.6
	Total over Strata	83	55	22	11	183	154	151	182	204
	Expanded Total over Strata	313.6	297.2	92.4	64.3	871.3	878.5	865.8	1101.9	745.0
	Number Tagged	2512	2514	2501	2500	2490	2506	2491	2515	1231
	Tagging-to-McN Survival	0.1248	0.1182	0.0369	0.0257	0.3499	0.3505	0.3476	0.4381	0.6052

Table B.2. (continued)

b. Volitional Release-to-McNary 2006 Survival (and pre-release survival)

	Rearing Pond >	Holmes		Boone		Stiles		Lost Creek		Prosser
	Stock >	Yakima	Eagle Creek	Yakima	Eagle Creek	Yakima	Eagle Creek	Yakima	Eagle Creek	Eagle Creek
		HMY	HME	BNY	BNE	STY	STE	LCY	LCE	PRE
Stratum 1	Total	49	13			83	38	9	0	178
	Removed	0	0			0	0	0	0	0
	Subtotal	49	13			83	38	9	0	178
	Expanded Total	165.3	43.9			280.0	128.2	30.4	0.0	600.5
Stratum 2	Total	3	6			35	55	29	15	9
	Removed	0	0			0	0	0	0	0
	Subtotal	3	6			35	55	29	15	9
	Expanded Total	27.1	54.3			316.6	497.5	262.3	135.7	81.4
Stratum 3	Total	1	2			10	41	37	55	0
	Removed	0	0			0	0	0	0	0
	Subtotal	1	2			10	41	37	55	0
	Expanded Total	2.9	5.8			28.9	118.7	107.1	159.2	0.0
Stratum 4	Total	0	6			1	4	50	105	105
	Removed	0	0			0	0	0	0	0
	Subtotal	0	6			1	4	50	105	105
	Expanded Total	0.0	43.5			7.3	29.0	362.7	761.6	761.6
	Total over Strata	53	23			128	137	119	173	187
	Expanded Total over Strata	195.3	118.4			625.6	766.2	719.0	1042.0	682.0
	Volitional Release	781	636			1598	1974	1057	1663	912
	Release-to-McN Survival	0.2501	0.1862			0.3915	0.3881	0.6802	0.6266	0.7478
	Pre-Rel Survival*	0.4869	0.6050			0.9175	0.8855	0.5384	0.6956	0.8082

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

Table B.3. (continued)

c. Tagging-to-McNary 2007 Survival

	Rearing Pond >	Holmes				Stiles				Lost Creek				Prosser	
	Stock >	Yakima		Eagle Creek		Yakima		Eagle Creek		Yakima		Eagle Creek		Yakima	Eagle Creek
	Extender) >	HY1	HY2	HM1	HM3	SY1	SY2	ST1	ST3	LY1	LY2	LC1	LC3	PRY	PRE
Stratum 1	Total	11	5	2	2	6	6	0	1	0	1	0	0	431	148
	Removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	11	5	2	2	6	6	0	1	0	1	0	0	431	148
	Expanded Total	30.8	14.0	5.6	5.6	16.8	16.8	0.0	2.8	0.0	2.8	0.0	0.0	1207.5	414.6
Stratum 2	Total	13	12	15	5	67	22	53	65	5	2	7	4	63	33
	Removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	13	12	15	5	67	22	53	65	5	2	7	4	63	33
	Expanded Total	50.2	46.3	57.9	19.3	258.7	84.9	204.6	251.0	19.3	7.7	27.0	15.4	243.2	127.4
Stratum 3	Total	14	4	5	4	32	10	24	31	7	18	15	22	9	2
	Removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	14	4	5	4	32	10	24	31	7	18	15	22	9	2
	Expanded Total	69.7	19.9	24.9	19.9	159.2	49.8	119.4	154.3	34.8	89.6	74.6	109.5	44.8	10.0
Stratum 4	Total	2	1	3	1	4	1	4	5	25	19	9	14	0	0
	Removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	2	1	3	1	4	1	4	5	25	19	9	14	0	0
	Expanded Total	11.9	6.0	17.9	6.0	23.8	6.0	23.8	29.8	148.9	113.2	53.6	83.4	0.0	0.0
Stratum 5	Total	4	0	3	2	2	1	4	1	23	22	6	12	0	0
	Removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	4	0	3	2	2	1	4	1	23	22	6	12	0	0
	Expanded Total	16.2	0.0	12.2	8.1	8.1	4.1	16.2	4.1	93.2	89.2	24.3	48.6	0.0	0.0
	Total over Strata	44	22	28	14	111	40	85	103	60	62	37	52	503	183
	Expanded Total over Strata	178.8	86.2	118.4	58.9	466.7	161.5	364.1	441.9	296.3	302.5	179.6	257.0	1495.5	552.0
	Number Tagged	1250	1210	1253	1251	1251	1198	1261	1252	1237	1264	1259	1252	2499	1246
	Tagging-to-McN Survival	0.1430	0.0712	0.0945	0.0471	0.3730	0.1348	0.2887	0.3529	0.2395	0.2393	0.1427	0.2053	0.5984	0.4430
	Pooled Number Tagged		2460		2504		2449		2513		2501		2511		3745
	Pooled Tagging-to_McN Survival		0.1077		0.0708		0.2565		0.3207		0.2394		0.1739		0.5467

Table B.3. (continued)

d. Volitional Release-to-McNary 2007 Survival (and pre-release survival)

	Rearing Pond >	Holmes				Stiles				Lost Creek				Prosser	
	Stock >	Yakima		Eagle Creek		Yakima		Eagle Creek		Yakima		Eagle Creek		Yakima	Eagle Creek
	Tagging Group (File Extender) >	HY1	HY2	HM1	HM3	SY1	SY2	ST1	ST3	LY1	LY2	LC1	LC3	PRY	PRE
Stratum 1	Total	8	5	2	1	6	5	0	1	0	1	0	0	423	147
	Removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	8	5	2	1	6	5	0	1	0	1	0	0	423	147
	Expanded Total	22.4	14.0	5.6	2.8	16.8	14.0	0.0	2.8	0.0	2.8	0.0	0.0	1185.1	411.8
Stratum 2	Total	8	12	15	5	59	19	42	63	5	2	7	4	63	33
	Removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	8	12	15	5	59	19	42	63	5	2	7	4	63	33
	Expanded Total	30.9	46.3	57.9	19.3	227.8	73.4	162.2	243.2	19.3	7.7	27.0	15.4	243.2	127.4
Stratum 3	Total	7	4	4	4	29	9	23	29	7	18	15	22	9	2
	Removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	7	4	4	4	29	9	23	29	7	18	15	22	9	2
	Expanded Total	34.8	19.9	19.9	19.9	144.3	44.8	114.5	144.3	34.8	89.6	74.6	109.5	44.8	10.0
Stratum 4	Total	2	1	3	0	4	1	4	5	25	19	9	14	0	0
	Removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	2	1	3	0	4	1	4	5	25	19	9	14	0	0
	Expanded Total	11.9	6.0	17.9	0.0	23.8	6.0	23.8	29.8	148.9	113.2	53.6	83.4	0.0	0.0
Stratum 5	Total	4	0	2	1	2	1	4	1	23	22	6	11	0	0
	Removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	4	0	2	1	2	1	4	1	23	22	6	11	0	0
	Expanded Total	16.2	0.0	8.1	4.1	8.1	4.1	16.2	4.1	93.2	89.2	24.3	44.6	0.0	0.0
	Total over Strata	29	22	26	11	100	35	73	99	60	62	37	51	495	182
	Expanded Total over Strata	116.3	86.2	109.4	46.1	420.9	142.2	316.7	424.2	296.3	302.5	179.6	252.9	1473.1	549.2
	Volitional Releases	401	519	642	651	919	285	945	936	796	875	1048	1044	2112	1136
	Release-to-McN Survival	0.2899	0.1661	0.1704	0.0708	0.4579	0.4988	0.3351	0.4532	0.3723	0.3457	0.1714	0.2423	0.6975	0.4835
	Pooled Number Released		920		1293		1204		1881		1671		2092		3248
	Pooled Release-to-McN Survival		0.2201		0.1202		0.4676		0.3939		0.3583		0.2068		0.6226
	Pre-Rel Survival*	0.4867	0.4289	0.5518	0.6623	0.8154	0.2719	0.8726	0.7778	0.6435	0.6922	0.8324	0.8502	0.8588	0.9167
	Pre-Rel Survival**		0.4583		0.607		0.5495		0.8254		0.6681		0.8413	0.8588	0.9167

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

** Weighted by Number Tagged over Tagging Groups with Site

Appendix G

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

Annual Report 2007

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EXECUTIVE SUMMARY

- ***Pelican and cormorant populations declined significantly in the Yakima Basin from 2006 levels. Pelican numbers at Chandler were far reduced, with moderate numbers only after smolt passage had ceased. This is the second year in a row of declining pelican numbers.***

- ***Pelicans continued to dominate fish consumption in spring, taking 64% of the small fish biomass (all species) eaten by birds, equal to the percentage taken in 2006. Mergansers consumed 21.2% of the small fish biomass taken by birds in spring, up from 12% in 2006.***

- ***Cormorant populations consumed only 0.8% of the small fish biomass taken by birds in spring 2007, down from 13.5% in 2006 and the 3.5% taken in 2004-2005. Great Blue Herons consumed 12.5% of the small fish biomass, up from the 9% they took in 2006 and 5.3% in 2005. Heron and cormorant numbers may indicate competition for nesting sites year to year.***

- ***Based on a behavioral model, Horn Rapids gulls consumed 67,535 smolts, predominately fall chinook, down from 93,000 smolts consumed in 2006. The model indicated that Chandler gulls consumed very few smolts in 2007, similar to the low numbers consumed in 2006.***

- ***Correlation analysis 2004-2007 suggests that Horn Rapids gulls are tracking coho passage and are not tracking spring chinook, fall chinook, or steelhead passage.***

- ***Chandler pelicans did not closely track any smolt run in 2007, unlike 2004-2006 when they appeared to track the passage of coho smolts. There was a low but significant negative correlation between flow at Chandler and pelican numbers: the higher the flow the fewer the pelicans congregating at the site.***

- ***Chandler Bypass pipe orientation makes fish vulnerable to predation only at low water (<4,000 cfs). At high water, smolts exiting Chandler pipe are largely secure from bird predation. As a result, the higher the river volume during peak smolt out-migration the lower the predation rate by birds. A simple reconfiguring of the outfall could largely eliminate smolt vulnerability at Chandler.***

- ***Smolts reared in the six spring chinook and coho acclimation sites were largely secure from predation by birds in 2006-2007. Only limited bird monitoring appears warranted at acclimation sites at the present time.***

Monitoring of avian predation on juvenile salmonids in the Yakima River as part of the Yakima Klickitat Fisheries Project has been on-going since 1997. In 2007, the American White Pelican population in the Yakima Basin declined significantly to under 150 animals, a drop of over 400% from 2005-2006 levels, matching levels in 2002.

Because of high water in spring, avian presence was greatly diminished at the traditional hotspots at Chandler and Horn Rapids. Pelicans only began to consistently visit Chandler as the water level dropped in summer, apparently feeding on chiselmouths and suckers, and possibly wild fall chinook exiting from the fish bypass pipe. Gull numbers at Horn Rapids were also consistently low at high water.

In 2007, as in previous years, piscivorous birds were monitored along river reaches, at salmon smolt predation hotspots (Chandler Fish Bypass and Horn Rapids Dam) and at smolt acclimation sites. Smolt consumption estimates of Ring-billed and California Gulls at hotspots were based on direct observations of foraging success and modeled abundance. Consumption by all piscivorous birds on river reaches were estimated based on dietary requirements and modeled abundances. Consumption by birds at smolt acclimation ponds were estimated from daily counts and dietary requirements. Pelicans appear to be the most significant predator on salmon smolts in the lower river and mergansers in the upper river under the present conditions.

As in all the previous years, Common Mergansers were the most significant small fish predator in the upper river, consuming over 98.6% of the fish biomass consumed by birds in spring and 91.6% during the summer in these reaches. In the middle river, they consumed 87.7% of the small fish biomass in spring and 54.6% in the summer. Dietary analysis of Yakima River Common Mergansers suggests that breeding mergansers eat a broad range of small fish, ranging from sculpin to chiselmouth, with juvenile trout and other salmonids predominating in their fall/winter diet.

Bird densities are highest in the lower river, resulting in 97.3% of the fish biomass consumed by birds in the entire river taken in this stratum alone. As in the previous four years, American White Pelicans were the dominant bird consumer of fish in the lower river in spring, consuming 65.8% of the fish consumed by birds. By way of their dominance in the lower river, pelicans consumed 64% of the fish biomass consumed by birds in the entire river in spring. These totals are equal to percentages in 2006. Pelicans inhabiting the lower river could potentially consume the entire hatchery production of fall chinook smolts released in the lower river (nearly two million smolts) and yet only supply a small portion of their dietary requirements, indicating they must be eating other fish (ie. sucker, carp and bullhead) in addition to any salmonids consumed. Knowledge of the actual fish consumption of both Common Mergansers and American White Pelicans along river reaches is limited by incomplete fish biomass estimates and the general lack of direct observation of birds feeding on smolts or other fish.

Pelicans are the dominant avian predator at Chandler Fish Bypass, while gulls dominate at Horn Rapids Dam. Pelicans averaged 9.9 birds per day, down from 17.5 birds per day in 2006 and 57 birds per day in 2005. Based on the assumptions that Chandler pelicans are fulfilling their entire daily dietary requirements at the site, are consuming only salmon smolts, and consume smolts in proportion to their availability, Chandler pelicans potentially consumed 90% of the fall chinook smolts in 2007. However a number of lines of evidence including correlation analysis and anecdotal observations call these assumptions into question. Thus the huge smolt consumption estimates for pelicans in 2005-2007 that are based on these assumptions should be viewed as hypothetical worst case scenarios.

Correlation analysis in 2007 suggests pelicans did not track any smolt run, unlike 2004-2006 when they tracked the coho run. The size of smolts may be an important factor in the bioenergetics of pelican consumption. Coho smolts average over 30 g, while fall chinook smolts average under 10 g. Although the run is large, the fall chinook smolts may be far too small to be an efficient food source for pelicans. Anecdotal observations at Chandler bypass pipe, Selah Pond, and the Yakima Canyon suggest pelicans are also consuming significant numbers of other fish species of size classes larger than salmon smolts, including sucker, chiselmouth, pikeminnow and bullhead.

There was a low but significant negative correlation between flow at Chandler and pelican numbers. Only with flows under 4,000 cfs can pelicans congregate at Chandler to prey on fish exiting from the Fish Bypass. Above 4,000 cfs at Chandler salmon smolts are largely invulnerable from predation by pelicans. As a result, the higher the river volume during peak smolt out-migration the lower the predation rate by birds. A simple reconfiguring of the outfall could largely eliminate smolt vulnerability at Chandler.

Gulls numbers at Horn Rapids in 2007 remained similar to the levels in 2005-2006, averaging about 5 birds per day. Gulls were estimated to have consumed 67,535 fish, a 27.4% decline from totals in 2006, but still 290% higher than estimates in 2005. Like in 2005-2006, gull presence and predation at Chandler was minimal.

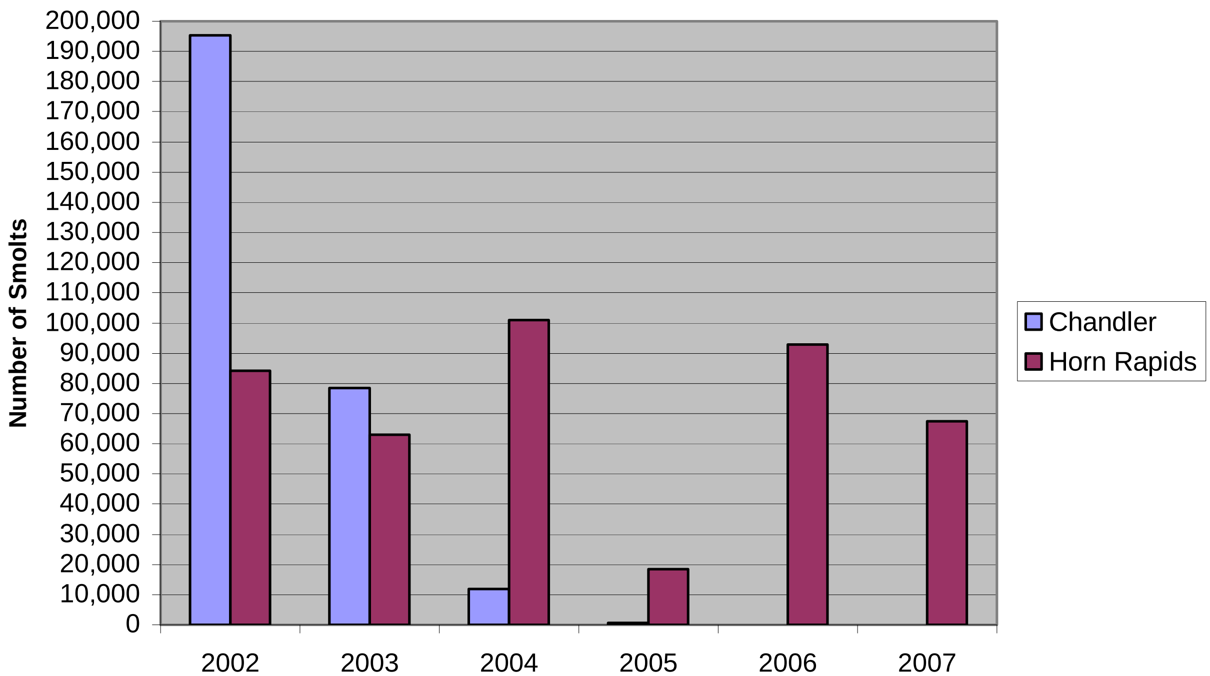


Figure 11. Smolt consumption estimates by gulls at Horn Rapids and Chandler, 2002-2007.

In a pattern similar to 2004-2006, gull numbers at Horn Rapids showed the highest correlation with the coho smolt run (counted at Chandler), with lowest correlations for the spring chinook, fall chinook and steelhead runs. Predation by Common Merganser, Belted Kingfisher and Great Blue Heron at the 3 spring chinook and 2 of the coho smolt acclimation ponds appeared to be relatively minor in 2007, as it was in 2004-2006.

One pelican was captured with a padded leg-hold trap, winged tagged and radio-collared to facilitate monitoring pelican movements and diet in the Yakima River in Selah and at Chandler Fish Bypass. No stomach samples were obtained from the bird. Unfortunately it was never relocated after tagging, presumably relocating to the Columbia River.

Pelican, Double-crested Cormorant, Great Blue Heron and Common Merganser roosting and nesting sites were examined for the presence of salmon Passive Integrated Transponder (PIT) tags in fall and winter. Areas surveyed included: Chandler Fish Bypass; the heron-cormorant colony on the Yakima River in Selah (Selah Heronry); a gravel bar near the Selah colony used by roosting pelicans (Selah Bar); islands in the Selah Pond used by roosting cormorants and pelicans (Selah Pond); and Roza Recreation Area site gravel bar in the Yakima River used by roosting pelicans and mergansers (Roza Bar).

Plans for the 2008 field season include a greater emphasis on cormorant and pelican consumption, with continued monitoring of river reaches and at hotspots. Pelicans will be color-marked and radio-collared at hotspots, river reaches and other locations to gather information on diet, movements and nesting. Heron and cormorant nesting colonies will be surveyed, monitoring which has not been done systematically in 5 years. PIT tags found at pelican, cormorant, heron and merganser nesting and roosting sites will be used to assign smolt predation estimates to specific bird species.

INTRODUCTION

Note:

For the purposes of this document the phrase "juvenile salmonids" refers to immature fish of the following stocks: spring chinook and fall chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), and summer steelhead (*O. mykiss*). Please review the 2005 report for the goals and history of the avian predation project. For a more detailed description of previous years' results and the statistical methods involved in this monitoring effort please refer to this project's previous annual reports located on the Yakima Klickitat Fisheries Project's website, www.ykfp.org or the Bonneville Power Administration's fish and wildlife technical publications and draft reports website, http://www.efw.bpa.gov/IntegratedFWP/reportcenter.aspx.

Avian Predation of Juvenile Salmon

The impacts of avian predators on juvenile salmonids within the Yakima River were assessed using index-based methods from 1997-2007. Bird predation of juvenile salmonids is common throughout the Columbia River Basin, which supports some of the highest populations of piscivorous birds in North America and Europe (Ruggerone 1986; Roby et al. 1998). Many piscivorous birds within this basin are colonial nesters, including Ring-billed and California Gulls, Caspian and Forster's Terns, Double-crested Cormorants, Great Blue Herons, Black-crowned Night-herons, Great Egrets and American White Pelicans (See table 1 for Latin names). Colonial nesters are particularly suited to the exploitation of prey fish with fluctuating densities (Alcock 1968; Ward and Zahavi 1996). Prey fish density fluctuations can result from large migratory accumulations, releases from hatcheries, physical obstructions that concentrate or disorient fish, and other features and events which occur in complex river systems.

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*)
Caspian Tern (*Sterna caspia*)

Table 49. Piscivorous birds observed along the Yakama River (note codes for graphs)

Re-colonization of the American White Pelican in the Mid-Columbia Region

After a 60 year absence, American White Pelicans (pelican) re-appeared as a Washington breeder in 1994, when 50 birds nested on Crescent Island in the Columbia River, near Burbank, WA. They are currently listed as a Washington State endangered species. At present, the only breeding site in Washington is on Badger Island on the Columbia River, downstream from the mouth of the Yakima River. The Badger Island colony consists of about 500 breeding pairs. These colonial nesters are known to travel 50-80 km in search of food, so some of the birds observed on the Yakima River could be coming from this colony (Motschenbacher 1984). However, the behavior of the birds at Chandler and other Yakima River sites suggests most of these individuals are non-breeders. Leg bands that were recovered from three pelicans found dead on the lower Yakima Basin in recent years indicated the birds came from British Columbia, eastern Montana, and the Klamath National Wildlife Refuge in Oregon border (Tracy Hames, YNWRP, personal communication). Those findings suggest that Yakima River pelicans are birds dispersing from much of the western breeding range of the species.

In the YKFP study, pelicans were first recorded during hotspot surveys at Chandler 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.

There was a dramatic increase in the number of pelicans found at Chandler Fish Bypass in Prosser between 2002 and 2004 with some leveling off in numbers in 2005. Between 2002 - 2005, spring and summer water levels were low and abundant rocks were exposed giving pelicans numerous sites to rest and launch foraging attempts at disoriented fish exiting from the bypass pipe. Based on the river reach model, pelicans accounted for over 70% of the total fish biomass depredated by piscivorous birds in the entire Yakima River in spring 2004-2005. During the years 2006-2007, spring water levels were high, and pelicans had few sites to rest and feed. Subsequently fewer pelicans were found at Prosser and elsewhere, with a particularly significant drop in 2007. However pelicans still consumed about 64% of the total fish biomass consumed by birds along the entire Yakima River in 2006-2007.

Fish Biomass Estimates in the Yakima River

To understand the potential impact of pelicans and other piscivorous birds, salmonid biomass estimates for the Yakima River are needed. In 2007, Yakima Nation salmon hatcheries alone contributed over 3.53 million salmon smolts (between 6-31 g) to the Yakima Basin, including fall chinook, spring chinook and coho. In the river reach surveyed areas there was an estimated introduction of 139.3 kg/km of fish biomass in the form of spring chinook smolts in the upper river, 487.22 kg/km of coho smolts in the middle river, and 77.6 kg/km in the form of fall chinook and coho smolts in the lower river.

Estimates of the wild salmon biomass produced in the Yakima River can be partially measured by using production estimates of wild spring chinook, the most abundant salmon species spawning in the river. In 2005, 2,569 spring chinook redds were located in the entire Yakima Basin, including the Upper Yakima River and Naches Basin. If each redd is assumed to represent the successful spawning of one female and it is also assumed that the fecundity of each Upper Yakima female was 3,976 and each Naches Basin female was 5,232, (fecundity estimated from the average productivity 1980-96) than together fish spawned nearly 11 million eggs. Those eggs have a 59.6% chance of surviving to become 0.3 gram fry the next year, representing 6.5 million fish. In the upper Yakima River alone, an estimated 13.3 million spring chinook eggs were deposited in 1,996 redds in 2005, leading to the production of an estimated 7.9 million fry above Roza Dam. Spring chinook fry weighing 0.3 grams are far too small to be food items of the most important piscivorous birds on the Yakima River: the pelican, Common Merganser, Double-crested Cormorant, both gull species and Great Blue Heron. Smolts of spring chinook, coho, and steelhead are of the appropriate size (>20g) to be consumed by them. Fall chinook smolts weighing 7 grams or less may be near the lower limit of prey size for these piscivores. Survivors from the 2006 cohort of fry make up the wild smolts enumerated at Chandler Bypass in 2007.

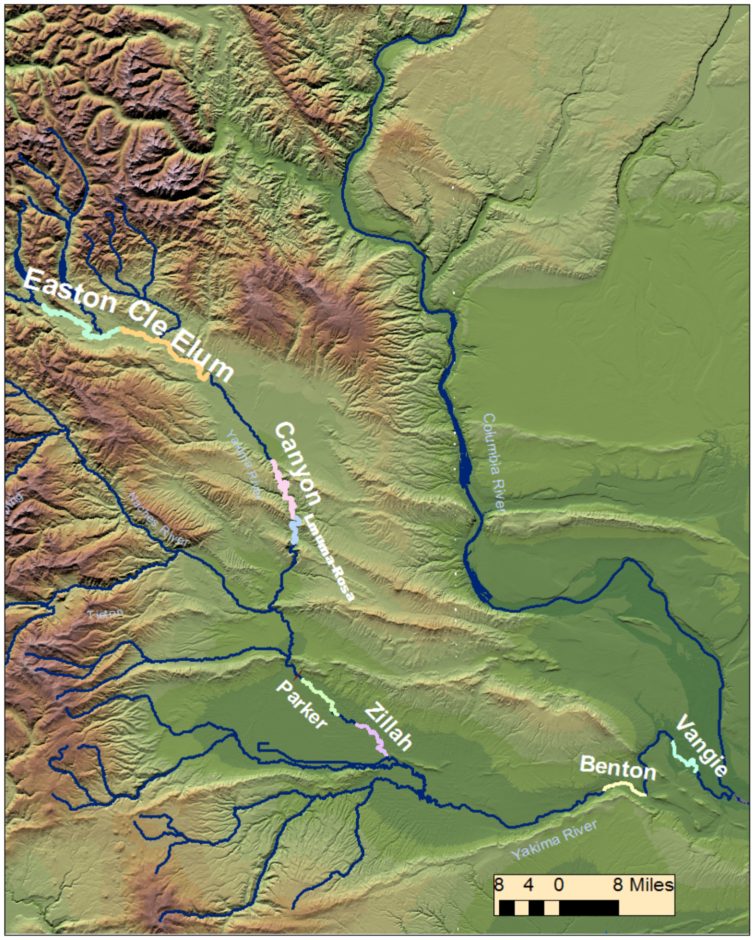
Another line of fish biomass evidence comes from a 5-year Washington Department of Fish and Wildlife study (1997-2001, Gabriel Temple, personal communication), which has important limitations as the investigators consider the number of salmon smolts to be underestimated. That data indicates that juvenile salmonids potentially suitable as prey for avian predators (defined here as between 5-75 g) made up an estimated 3.6% of the total fish biomass in the upper river in spring and summer, with 5-75 g fish of all other taxa making up another 9.0% of the fish biomass in the upper river. In the middle river, juvenile salmonids made up 2.5% of the fish biomass spring and summer, with 5-75 g fish of all other taxa making up another 6.8%. In the lower river – upper section, from Roza Dam to Prosser Dam, juvenile salmonids made up an estimated 1.7% of the total fish biomass in spring with 5-75 g fish of all other taxa making up another 21.0% of the fish biomass. In the lowest section of the river in the spring from Prosser Dam to the Yakima River mouth on the Columbia River, juvenile salmonids made up 10.2% of the fish biomass with all other taxa of 5-75 g making up another 15.7%. In total, small fish suitable as prey for even the smallest avian predator made up an average estimated 21.0% of the fish biomass in the entire Yakima River in spring (2.3% salmonids and 18.7% other taxa).

METHODS

Study Area

The Yakima River Basin encompasses a total of 15,900 square kilometers in south-central Washington State. The Yakima River runs along the eastern slopes of the Cascade mountain range for a total length of approximately 330 kilometers (Figures 2 & 3). 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.



c:\avdata\birdpred\reaches3.mxd Paul Huffman Yakama fisheries 4/10/2007

Figure 12. Yakima River Basin with locations of surveyed reaches.

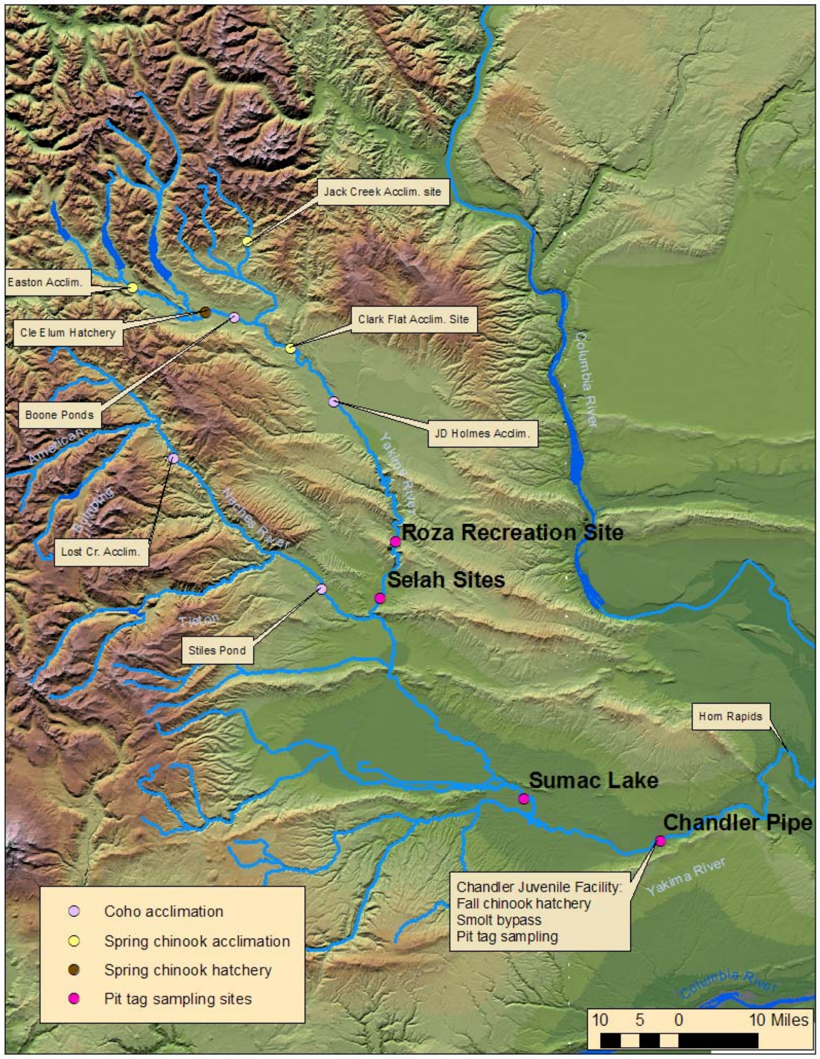


Figure 13. Yakima River Basin with locations of hotspots (Chandler & Horn Rapids), acclimation sites and PIT tag sampling sites.

Survey Seasonality

This effort was 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 residualized 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.

Data Collection Methods

Hotspot Surveys

At Chandler Bypass and Horn Rapids Dam the abundance of gulls, pelicans and other predatory birds was estimated. Seasonal and diurnal patterns of gull abundance at hotspots were identified. For heuristic purposes, all fish consumed by gulls and pelicans were assumed to be salmonids. Estimated consumption of smolts by gulls was based on direct observation. Gull abundance and consumption estimates were expanded across larger time frames to create an index of smolt consumption by gulls. A smolt biomass consumption index for pelicans was based on average daily abundance estimates and dietary requirements extrapolated over the entire 3 month pelican residency period.

In 2007, 16 hotspot surveys were conducted at Chandler Bypass and 14 at Horn Rapids between April 2 and June 26. Both sites were generally surveyed on the same day at the same time period by different individuals. Leica 10x42 binoculars were used to help monitor bird behavior. The survey area for Chandler included 50 meters of river above the outfall pipe and 150 meters of river below the outfall pipe. All birds resting upon the shoreline lateral to the specified area at both hotspots were included in the abundance counts. The survey area for Horn Rapids included the area 50 meters of river above the dam and 150 meters below the dam. The buoy located above the dam was not included within the survey area; therefore any birds resting upon the buoy were not included in abundance counts. Observations at both sites were made from the shore. At Horn Rapids observations were made from the south bank of the river, either inside or outside an automobile. At Chandler observations were made from a blind just downstream of the outlet pipe from the juvenile fish facility.

The hotspot survey design for 2007 was consistent with methods used since 2001 (Table 2). Observations either began on the nearest 15-minute interval after sunrise and ran for eight hours, or began at midday and ended on the nearest 15-minute interval before sunset. This allowed for observations during all periods of the day, to account for the diurnal patterns of avian piscivores. Regionally calibrated tables obtained from the National Oceanic and Atmospheric Administration were used to determine sunrise and sunset times at Richland, WA. Depending upon the length of the day and the start time, between seven and eight 2-hour windows existed for each day. Each day was divided into 2-hour survey windows, consisting of three 15-minute abundance and feeding blocks. Between each of these three blocks was a 15-minute period of no observation, unless a feeding interval was still being measured, in which case the observation period was extended into the next 15 minutes. This 75-minute cycle of blocks was followed by a 45-minute rest period before a new 2-hour window was begun. Within each 15-minute survey block the abundance of all piscivorous birds was counted. Sometimes survey periods were truncated because no birds were present for 1-2 hours, usually because of high water.

Gull Consumption Estimates

Within the 15 minute survey blocks the foraging ratios of gulls, the number feeding to the total number present, and the number of fish consumed per minute, were determined (Table 2). Any gull flying within the study area was considered foraging. Gulls within the study area foraging on terrestrial prey items, such as insects, seeds, plants, were not considered feeding, but were included in total abundance counts. Gulls sitting or standing on rocks emerging from the river or along the river's edge were not counted as part of the foraging fraction. Although gulls sometimes utilized such rocks as fishing platforms, more frequently such platforms were used for loafing and other non-foraging activities. It was not feasible to distinguish foraging gulls standing on rocks from those loafing.

The gull chosen to be observed for foraging rate was the first individual observed consuming a fish within the study area. Once a gull was chosen it was followed continuously until a second successful capture occurred or a maximum of 30 minutes had passed. Initial successful feeding attempts were those in which a foraging bird captured a fish by plunging from the air into the water. Second takes were counted regardless of the means of capture. This accounted for the very rare instance in which the second successful take by a gull was accomplished by stealing from another bird or jumping from an exposed rock or log into the water to catch a fish. Past surveys where a gull was randomly chosen for observation did not provide enough foraging intervals.

Window	Block	Activity
1	1 Observation (15-minute)	Abundance of all piscivorous birds and ratio of gulls present to gulls foraging determined at beginning of block. First gull observed successfully capturing a fish followed continually until second successful capture. Time of foraging interval recorded. Abundance of all piscivorous birds and ratio of gulls present to gulls foraging determined at end of block
1	Rest (15-minute)	Any ongoing foraging interval was continued into this period until a second successful capture or the end of the 15-minute rest period. If there was no interval ongoing then no data were collected.
1	2 (15-minute)	Same activities as block 1.
1	Rest (15-minute)	Same as previous rest period.
1	3 (15-minute)	Same as blocks 1 and 2.
1	Rest (45-minute)	Any ongoing foraging interval was continued into the first 15-minutes of this period and ended according to the above criteria. The observer then rested for 30 minutes with no data collection activity.
2	1 (15-minute)	Repeat as Window 1.

Table 50. Hotspot Survey Design.

Pelican Consumption Estimates

At Chandler between April 2 and June 26, the pelican counts in the 15 minute survey blocks were used to calculate the number of pelicans per day. In addition another 11 spot surveys were conducted for pelicans at Chandler July 5 to July 24 during pelican trapping periods. Pelicans were also counted during 3 other spot surveys at Chandler and during 3 aerial surveys over the site. This data was combined with daily pelican consumption estimates from the literature and extrapolated over the entire 3 month pelican residency period to calculate an index of salmonid biomass consumption by pelicans at Chandler.

River Reach Surveys

River reach surveys were designed to estimate bird abundance and indirectly measure consumption. Total consumption in fish biomass of all birds was estimated through a model which combines bird abundance estimates and published daily caloric requirements for individual bird species. Estimates of consumption of individual fish species have not been calculated, although some conclusions can be drawn from salmonid biomass estimates from hatchery and wild salmon production, and from total fish species biomass estimates collected by the WDFW, 1997-2001.

The spring river surveys included seven river reaches (Figure 2, Table 3). 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 reach, Parker, added in 2006. 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.

The original plan was to survey each reach every 4 weeks in spring, however very high water and windy conditions in April, May and June often meant some reaches were only surveyed once during the spring period. Easton was surveyed once in May, once in July and three times in August. Cle Elum was surveyed twice in May, three times in July and three times in August. The Canyon was surveyed once in April, once in May, three times in July and two times in August. Parker was surveyed twice in April, twice in May and twice in June, tracking large numbers of pelicans observed. Zillah, Benton and Vangie were each surveyed once in April and once in May.

Name	Start	End	Length (km)
Easton	Easton Acclimation Site	South Cle Elum 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
Parker	Below Parker Dam	US Hwy 97/St. Hwy 8 Bridge	20.3
Zillah	US Hwy 97/St. 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 51. 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 on all reaches except Easton, which was surveyed from a two-person 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 2007 (Figure 3). 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

Three aerial surveys were conducted to identity the abundance and distribution of pelicans along the Yakima River from its mouth on the Columbia River to Ellensburg between May 30 and September 4. 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.

Pelican Radiotelemetry

Padded leg-hold traps were set for 1,081 trap hours over 11 days at Chandler, June 19 to July 18. The trap array consisted of traps set on rocks in the Yakima River, 15-25 traps were opened for an average of 5-6 hours a day. Data collected on captured birds included weight, culmen (bill) length, tarsus length and wing chord (length). Pelicans with culmen lengths of greater than 305 mm are characteristically male. Captured birds were intubated to try to induce regurgitation of stomach contents.

Salmon PIT Tag Surveys at Nesting and Roosting Sites

A Passive Integrated Transponder (PIT) tag reader was used to survey for PIT tags deposited in various Yakima River nesting colonies and gravel bar roosts in late summer and early fall. Areas surveyed included: Chandler Fish Bypass; the heron-cormorant colony on the Yakima River in Selah (Selah Heronry); a gravel bar near the Selah colony used by roosting pelicans (Selah Bar); islands in the Selah Pond used by roosting cormorants and pelicans (Selah Pond); and Roza Recreation Area site gravel bar in the Yakima River used by roosting pelicans and mergansers (Roza Bar). Based on the salmon tags found at these sites consumption could be assigned to one or two bird species. For example, the Chandler Bypass has been heavily used by pelicans since 2003; Roza Recreation Site is used by mergansers and pelicans in early spring; while the Selah Heronry supports herons and sometimes cormorants.

RESULTS & DISCUSSION

River Reach Surveys

In 2007, 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 (5) and the Zillah drift in the lower river had the highest (9). 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 9 previous years surveyed, followed by Belted Kingfishers (Figure 4 & 5). In the middle reach, Common Mergansers were the most common species in spring and summer as well (Figure 6). The species distribution along the lower reaches were 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 7). The number of pelicans counted during the river reach surveys was significantly reduced from the counts in 2006.

Double-crested Cormorants, a major fish predator on the Lower Columbia River, were found in low numbers in the lower river and occasionally in the middle river. 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 (Table

4). 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. Lastly, Great Blue Heron, although the third most common piscivore in the Yakima Basin, are generally 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.

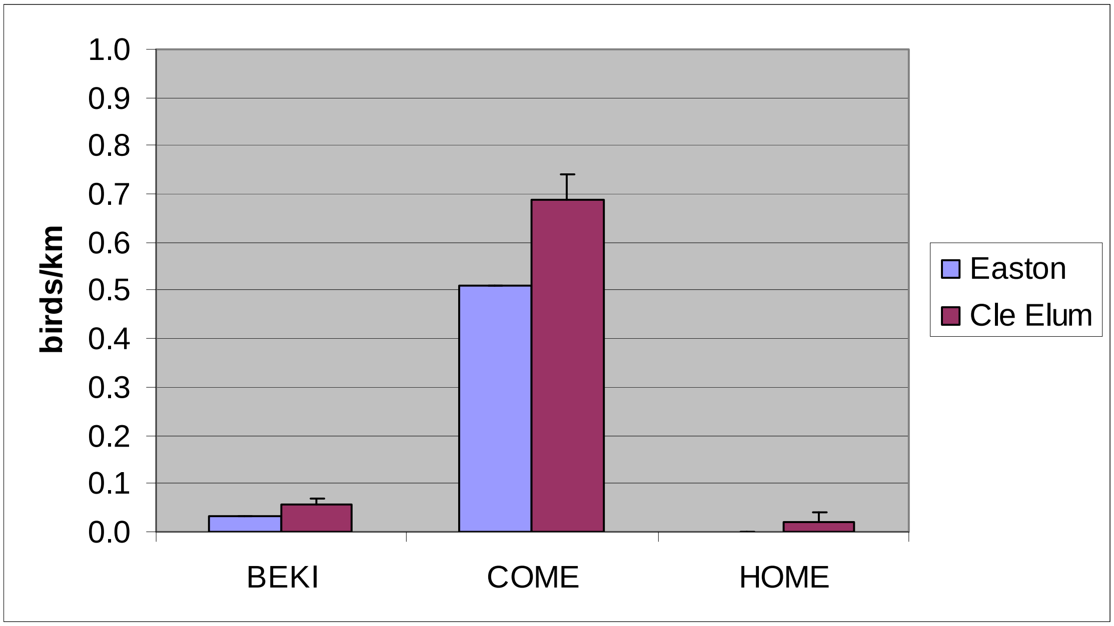


Figure 14. Average spring bird abundance on the Upper Yakima River. Bars indicate standard error.

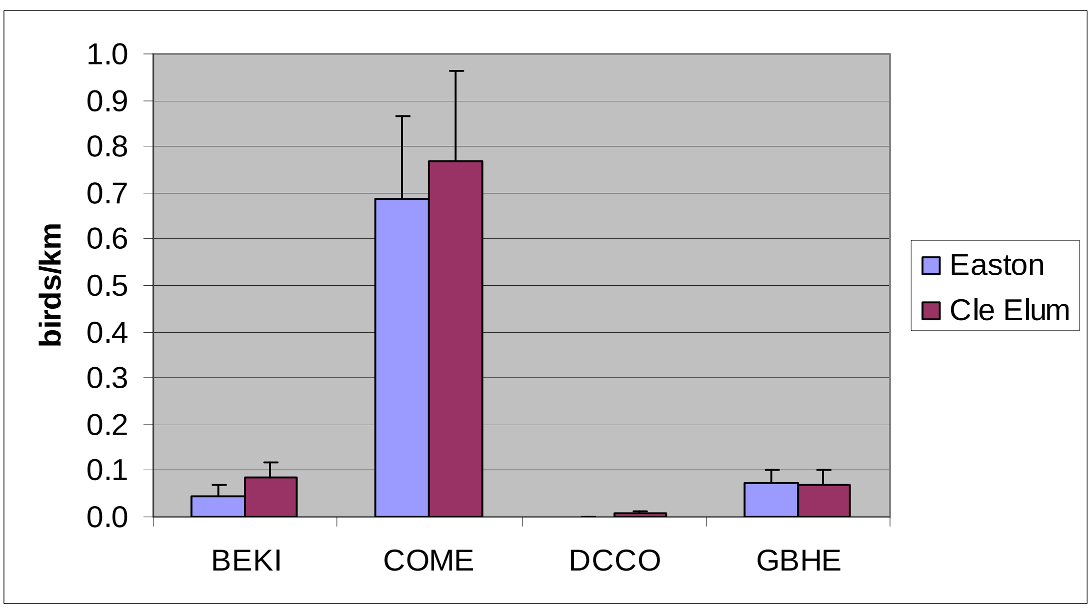


Figure 15. Average summer bird abundance on the Upper Yakima River. Bars indicate standard error.

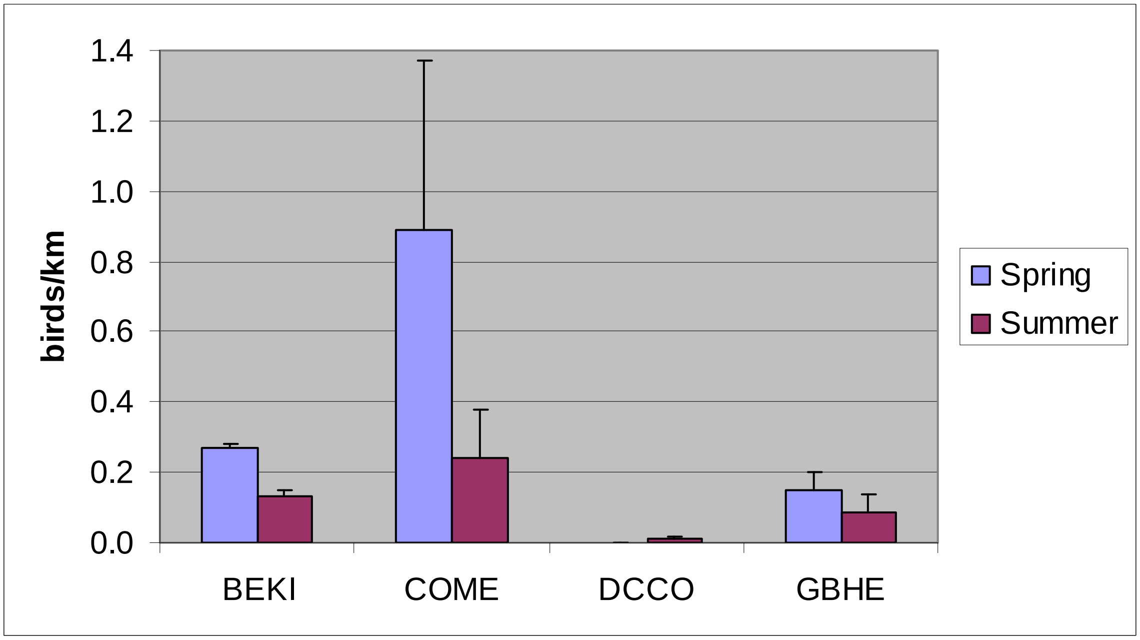


Figure 16. Average spring and summer bird abundance on the Middle Yakima River. Bars indicate standard error.

Species	Daily Intake (kilograms)	Daily Intake (pounds)
American White Pelican	1.339	2.952
Black-Crowned Night-Heron	0.138	0.304
Belted Kingfisher	0.059	0.130
Caspian Tern	0.231	0.509
Common Merganser	0.455	1.003
Double-crested Cormorant	0.499	1.100
Forster's Tern	0.057	0.126
Great Blue Heron	0.415	0.915
Great Egret	0.145	0.320
All Gull Species	0.094	0.207
Osprey	0.35	0.772

Table 52. Daily Dietary Requirements of Avian Piscivores (from Major et al. 2003).

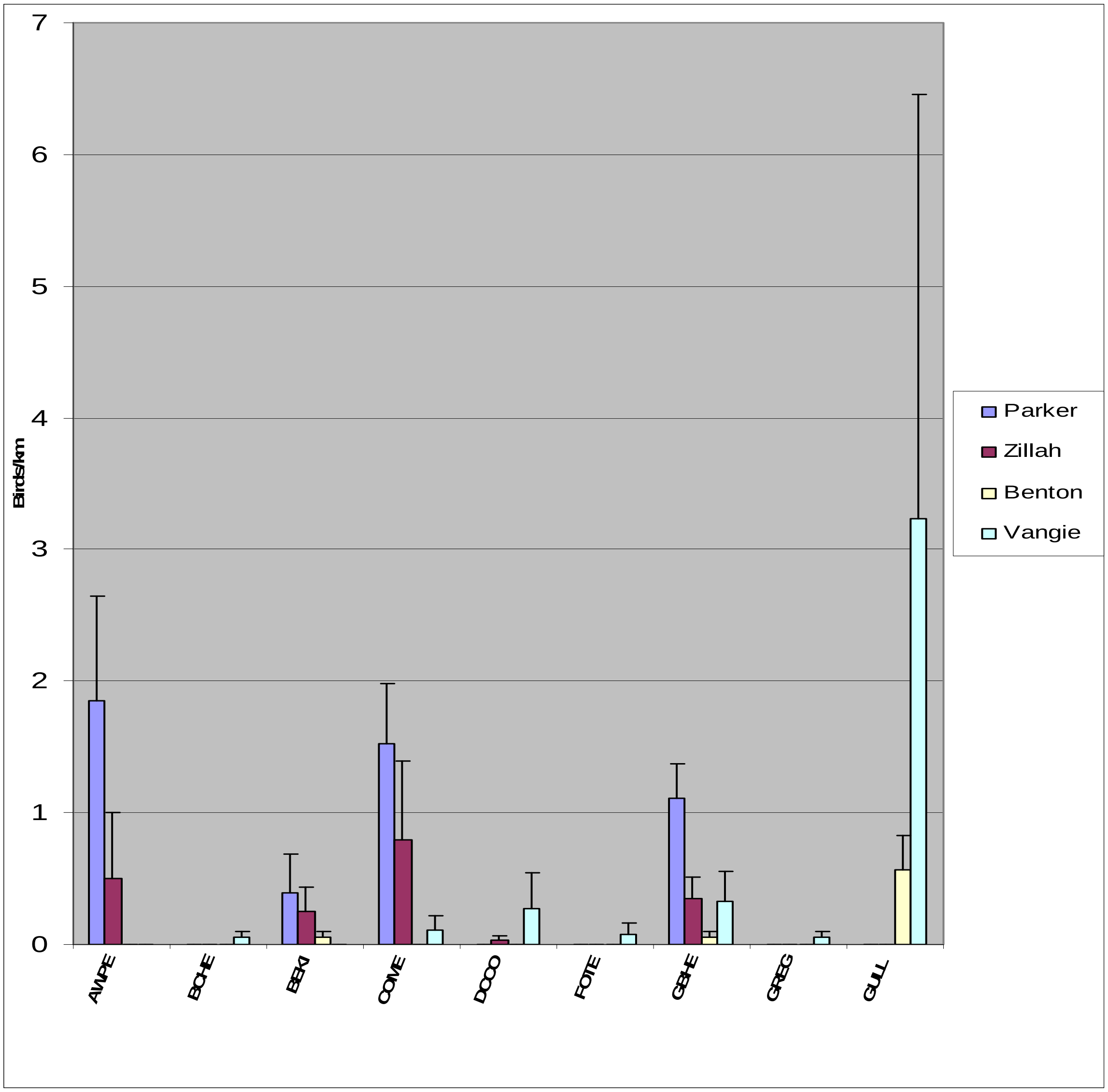


Figure 17. Average spring bird abundance on the Lower Yakima River. Bars indicate standard error.

Common Mergansers along River Reaches

In the upper river in spring, mergansers averaged 0.60 birds/km, while on the middle river they averaged 0.89 birds/km. In the lower river in spring, they averaged 1.53 birds/km in Parker, 0.79 birds/km in Zillah, 0.11 birds/km at Vangie, with none observed at Benton. In summer, mergansers averaged 0.73 birds/km on the upper river and 0.24 birds/km on the middle river. Overall spring and summer counts were similar or slightly lower than counts in 2005-2006, although the sampling effort in 2006-2007 was lower than in 2005. High water in spring may have depressed breeding attempts by mergansers in the upper and middle river and driven birds down into the lower river to nest and forage.

A breeding pair of Common Mergansers

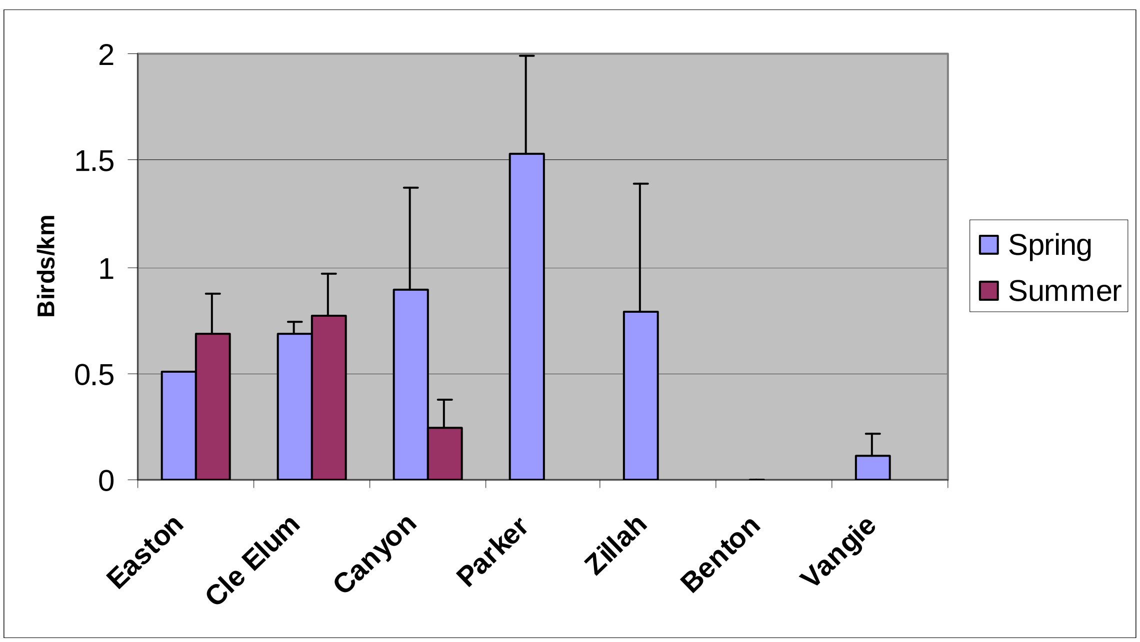


Figure 18. Average abundance of Common Mergansers on the Yakima River. Bars indicate standard error.

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 2004-2007 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 2007 estimated consumption of fish biomass by mergansers in the upper river was 24.7 kg/km in the upper river, 21.6 kg/km in the middle river and 68.1 kg/km in the lower river (spring only for the lower strata). This represented 98.6% of the fish biomass consumed by birds in the upper river in spring and 91.6% of the fish consumed by birds in the upper river in summer. In the middle river, mergansers consumed 87.8% of the fish biomass taken by birds in the spring and 54.6% of the fish biomass taken during the summer period. In the lower river, mergansers consumed 19.2% of the fish biomass taken by birds in spring.

These estimates are much lower than estimates in the upper and middle river in 2006, but are almost twice the consumption in the lower river that year. In 2006 mergansers consumed 72.1 kg/km in the upper river, 37.2 kg/km in middle river, and 35.4 kg/km in the lower river. Overall, 2007 consumption estimates are generally less than those in 2004-2006. In 2004-2005, mergansers consumed an average of 133.9 kg/km in the upper river, 53.0 kg/km in the middle river and 25.7 kg/km in the lower river. Decreased sampling efforts and a new sampling reach in 2006-2007 make direct comparisons to 2005 or 2004 problematic. However with the exception of pelicans in the middle river in 2006 and the high biomass consumed by mergansers in the lower river in 2007, the percentages of biomass consumed by mergansers from 2005 to 2007 are very similar. In 2004-2007 mergansers consumed between 53-99% of the fish biomass taken by birds in the upper and middle river, spring and summer. Their take in the lower river in spring ranged from 8-19%.

Based on our estimates, a minimum of 139.3 kg/km of hatchery spring chinook smolt biomass were present in the upper river and 308.2 kg/km of hatchery coho smolt biomass in the middle river in spring and summer 2007. If upper river Common Mergansers fed entirely on hatchery spring chinook in spring and summer, their consumption of an average of 24.7kg/km would represent removal of 17% of the spring chinook smolt biomass present in the upper strata. Likewise, if middle river mergansers fed entirely on hatchery coho smolts their consumption of 21.6 kg/km would represent removal of 7% of the of the hatchery coho biomass present in middle strata. This worse case scenario helps set the upper bounds for merganser predation on hatchery salmon smolts in the upper and middle Yakima River. It does not include merganser consumption of salmon at smolt acclimation sites.

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 then 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 of 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.

American White Pelicans along River Reaches

Pelicans were the major avian fish consumer in the lower river in spring 2007, as in 2003-2006, because they were both relatively abundant and have high daily dietary requirements. Pelicans were common in the lower and middle river in spring. A flock of 73 pelicans were observed roosting in the Yakima Canyon in late April and early May and 82 roosted in Selah Ponds during late April. Fifty-seven birds were observed on Toppenish National Wildlife Refuge on June 28. They remained largely absent north of the upper Yakima Canyon.

It is important to note that in May nearly all pelicans observed in Yakima Canyon, Selah Ponds and elsewhere on the Yakima River appeared to be adults in breeding condition, with bill knobs and mature plumage. However, by mid-June all adults were replaced by immature animals without bill knobs or adult plumage characteristics. Presumably all adults left to breed on Badger Island on the Columbia River.

Pelicans averaged 1.85 birds/km at Parker and 0.50 birds/km in Zillah. Pelicans were not found on the two surveys conducted at Benton and Vangie. These are lower than counts in 2004-2006, although sampling efforts have varied between 2004-2005 and 2006-2007. In 2006, pelicans averaged 2.6 birds/km at Parker, 1.5 birds/km in Zillah, 0.8 birds/km in Vangie and 0.02 birds/km in Benton. In 2004-2005, pelicans averaged 6.4 birds/km at Zillah and 0.9 birds/km and 0.4 birds/km at Benton and Vangie, respectively. Parker was not surveyed prior to 2006.

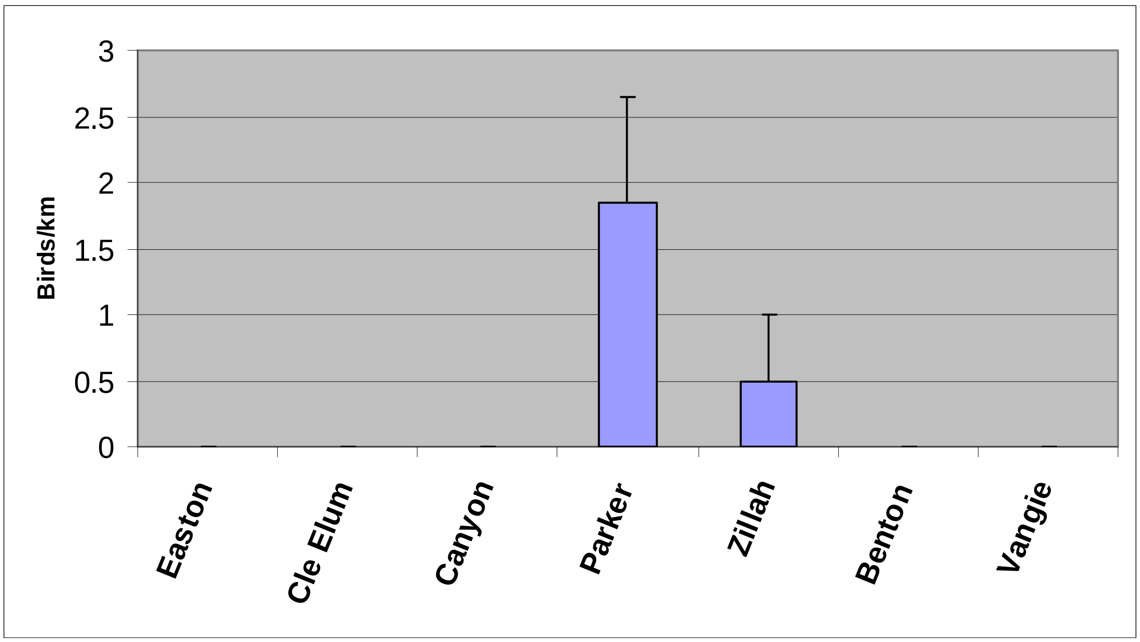


Figure 19. Average spring abundance of American White Pelicans along the Yakima River. Bars indicate standard error.

Three aerial survey counts of pelicans between Ellensburg and the Yakima River mouth on the Columbia River were conducted on May 30 (125 birds counted), July 20 (138 birds) and September 4 (8 birds). No radio-collared birds were located. The great majority of the pelicans were observed between Mabton Bridge and Selah Gap. Pelicans were often observed in backwater sloughs and oxbows off the mainstem of the river, where it is suspected they fed on carp and bullhead. The 2007 totals are a sharp decline from 2005-2006 when highs of 660 and 550 birds were observed in late May, but are similar to pelican numbers observed in 2002.

Based on the river reach predation model, the total estimated fish consumption by pelicans during the spring 2007 was 216.6 kg/km representing 65.8% of the total estimated fish biomass consumed by birds in the lower river. This is similar to the estimates in 2006 when pelicans consumed 245.2 kg/km representing 64.2% of the total estimated fish biomass consumed by birds in the lower river and 85.4% of the fish biomass in the middle river in the spring period.
Pelican consumption in the lower river in spring 2007 was so predominant that their total from the lower river represents 64% of the total estimated fish biomass consumed by birds in the entire river in the spring, the same percentage as in spring 2006. Because

of less sampling effort in 2006-2007, comparisons to 2004-2005 are difficult. However, there was a decrease from 2004-2005 levels, when estimated fish consumption by pelicans was 320.4 kg/km and 482.7 kg/km, respectively, accounting for 70.5% and 72.8% of the total fish biomass consumed by birds in the entire river in spring.

From pelicans observed foraging at hotspots and from the handful of pelican carcasses collected along the lower Yakima River during this study over the last 5 years, it is known that Yakima River pelicans frequently consume other fish species of size classes larger than salmon smolts, including chiselmouth, sucker, pikeminnow, carp, and bullhead. Estimates of salmon and other fish taken by pelicans at Chandler Bypass, which serves a vulnerable bottleneck for smolts, would appear to be a better indicator of smolt consumption by this species than the river reach model, which may be too broad scale to serve as an accurate consumption index. Smolt PIT tags found at pelican roosting sites can also be used to analyze the percentage of pelican consumption of specific runs: fall or spring chinook, coho and steelhead.

Double-Crested Cormorant and Great Blue Heron along River Reaches

Double-crested Cormorants were only relatively common in the lower river while Great Blue Herons are common throughout the Yakima Basin. Cormorant numbers were very low in 2007 compared to 2005-2006. However they were observed widely in the Yakima Basin, being readily seen in the upper and middle river in summer. Cormorants were most common in Vangie, with an estimate of 0.27 birds/km with a few birds observed in Parker, Zillah and Benton. In 2006, cormorants were the most common bird at Benton, averaging 0.6 birds/km and were the second most common bird at Parker, averaging 1.7 birds/km. The low numbers in 2007 at Zillah are similar to estimates in 2005.

Cormorants are estimated to have consumed 2.6 kg/km of small fish consumed by birds in spring 2007 representing 0.8% of the small fish consumed by birds in the spring in the lower river and 0.8% of the fish consumed in the entire river in spring. This is a huge decline in the consumption compared to 2006 when cormorants are estimated to have consumed 62.6 kg/km below Roza Dam in spring representing 15.6% of the small fish consumed by birds in the spring in the lower river and 13.5% of the fish in the entire river in spring. This is also a huge decline in the estimated cormorant consumption from spring 2005, when they consumed 22.5 kg/km in the lower river and a negligible amount in the upper and middle river, representing 3.8% of the fish biomass consumed by birds in the lower river in spring and 3.5% of the biomass in the entire river in spring.

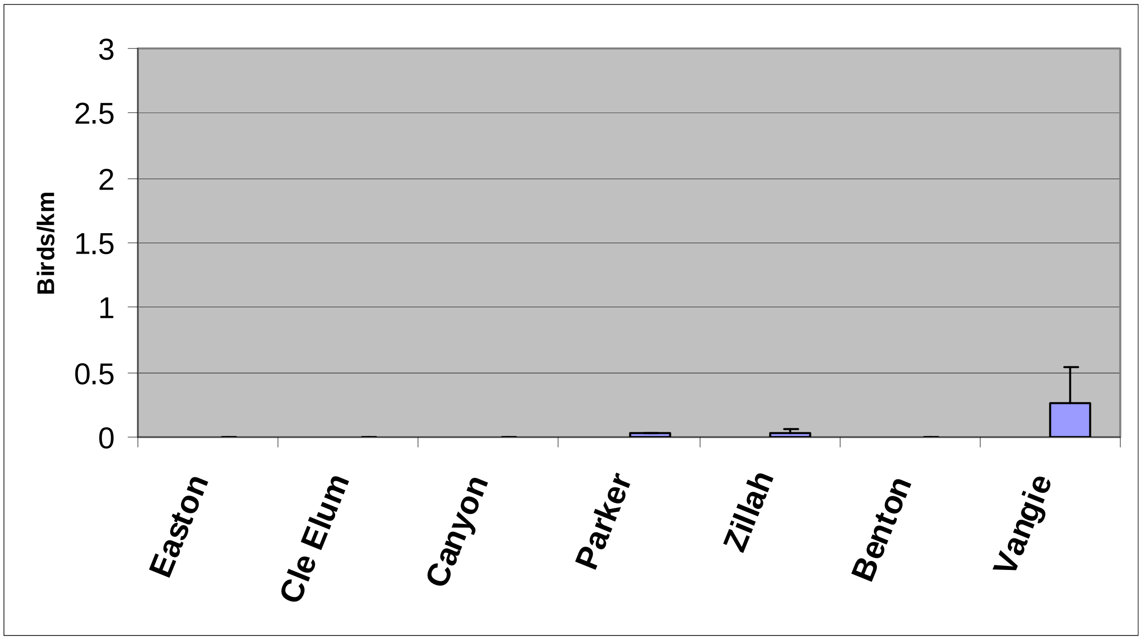


Figure 20. Average spring abundance of Double-crested Cormorants along the Yakima River. Bars indicate standard error.

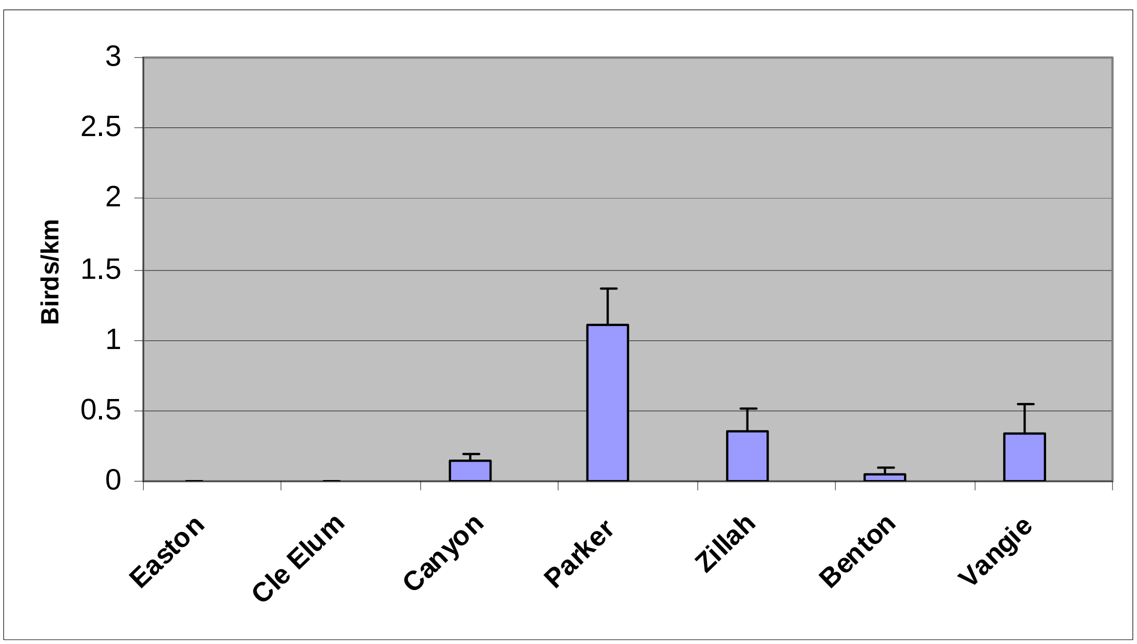


Figure 21. Average spring abundance of Great Blue Herons along the Yakima River. Bars indicate standard error.

On average, the number of Great Blue Herons in the lower river declined from 2006, averaging 0.5 birds/km, a drop from an average of 0.8 birds/km in 2006. Declines were also observed in the upper and middle river. In the upper river no herons were seen in spring and 0.1 birds/km in summer, while in the middle river the number of birds declined from 0.2 birds/km in 2006 to 0.1 birds/km.

Herons consumed an estimated 41.8 kg/km in the lower river in spring, representing 12.7% of the fish consumed in that reach. This is similar to totals in 2006, when they consumed 34.7 kg/km, representing 8.8% of the fish consumed in the lower river. In the middle river, they consumed 5.8 kg/km in spring and summer, a 280% decline from 2006 when they consumed 16.4 kg/km. In the upper river herons consumed a negligible 1.1 kg/km in spring and summer, a 400% decline in consumption from the estimate in 2006 of 4.6 kg/km. Herons consumed an estimated 12.5% of the small fish consumed in the entire river in spring 2007, up from 8.0% in 2006 and 5.3% in 2005.

Hotspot Surveys

Chandler

Over the last 5 years, pelicans have completely displaced gulls as the dominant predatory bird at Chandler. However, over the last three years, pelican numbers have dropped from an average of 56.5 birds/day (high of 256) in 2005 and an average of 17.5 birds/day (high of 66) in 2006, to an average of 9.9 birds/day (high of 38) in 2007.

Gull numbers remained low, averaging 0.7 birds/day, compared to 0.5 birds/day in 2006 and 1.4 birds/day in 2005. The estimated consumption of smolts by gulls at Chandler continued to decrease from previous years, declining to near zero in 2007, similar to estimates in 2006.
Other piscivorous bird species observed at Chandler include Great Blue Heron, Caspian Tern, Black-crown Night-Heron, Double-crested Cormorant, Common Merganser and Osprey. These 7 species as well as Foster's Tern, Great Egret and Osprey were also observed at Horn Rapids.

Pelicans at Chandler

The year 2007 was characterized by frequent days of high water in the early April, mid May and early June at Chandler, with peak freshets on April 1 (9,138 cfs), April 10 (7,738 cfs), May 19 (7,377 cfs) and June 6 (9,273 cfs), giving pelicans few places to roost and feed for long periods during the spring smolt run. When Chandler water levels finally declined in early June exposing numerous perching sites, pelicans would often roost and preen for long periods without attempting to feed, a pattern similar to that in 2004-2006. Foraging pelicans attempted to catch fish discharged directly out of the Chandler fish bypass pipe with most attempts unsuccessful. Pelicans in the foraging group often jostled each other for discharged fish. Because pelicans typically feed by grabbing and engulfing fish in their pouch, it was usually difficult to identify prey items before they disappear into their gullet. However, pelicans were observed foraging on both non-salmonid fish and salmon smolts at Chandler bypass pipe. Non-salmonids consumed include sucker, chiselmouth, and pikeminnow, typically of size classes larger than that of any smolts. Observers periodically visited the bypass facility to see what species were moving through the system. It often seemed pelican numbers were higher during times of decreased flow in summer when large numbers of chiselmouth and sucker were being bypassed. However, counts of chiselmouth and sucker were not systematic enough to correlate with pelican numbers.

The design of the Chandler Bypass Pipe caused fish to exit at right angles to the current disorienting them and making them vulnerable to bird predation. On various days in July, immature pelicans at Chandler were observed taking fish from the bypass pipe. Inside the facility, significant numbers of chiselmouths, suckers and wild fall chinook smolts were passing through. Some suckers and chiselmouths were dying on the separator and when exiting the pipe were presumably consumed by pelicans waiting at the other end. This may have served as an undesirable attractant for the birds.

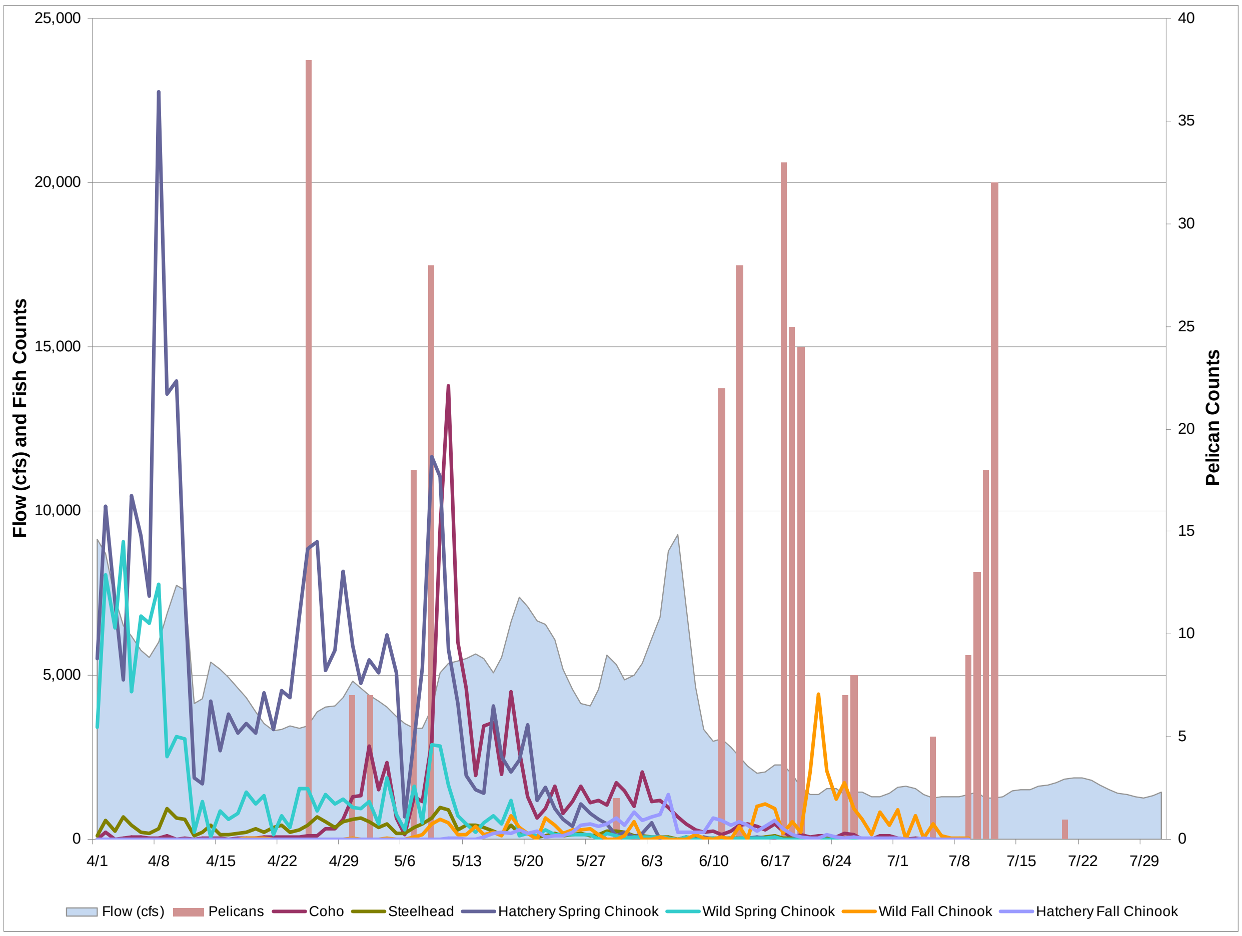


Figure 22. Comparison of pelican numbers and smolt passage estimates at Chandler. This data does not include fish released from Prosser Acclimation Ponds, predominately fall chinook.

If it is assumed pelicans at Chandler are obtaining their entire daily dietary requirements at the site, an estimate of their consumption of fish can be derived from their average daily abundances and dietary requirements extrapolated over the entire survey period. It is important to reiterate that pelican consumption estimates at Chandler are not based on direct foraging observations as the gull consumption estimates have been calculated. Based on the above assumptions, pelicans are estimated to have consumed a total of

1,326 kg of fish at Chandler, down from 1,968 kg of fish in 2006, 6,582 kg in 2005 and 9,637 kg in 2004. If it is further assumed that all fish biomass consumed by pelicans at Chandler consists of salmon smolts predated there, that sets the upper limit of pelican predation on smolts, a worse case scenario.

However correlation analysis for 2004-2007 brings into question any huge fall chinook consumption estimates. Fall chinook smolts weighing 4-7 grams may be too small for pelicans to efficiently consume them and sustain themselves. Examining the degree of correlation between the various smolt runs and pelican numbers may indicate which runs, if any, are being targeted by pelicans.

Smolt – Pelican Correlations at Chandler

In 2007, only 16 pelican counts could be correlated with fish passage. The small sample showed no correlations between any smolt run and pelican numbers, with the highest yet statistically insignificant correlation with the total fall chinook run (0.252). There was a low but significant negative correlation (-0.456) between flow at Chandler and pelican numbers, indicating the importance of roosting sites on predation by birds at Chandler. Only at flows under 4,000 cfs can pelicans congregate at Chandler to prey on fish exiting from the Fish Bypass. Above flows of 4,000 cfs at Chandler smolts are largely secure from pelican predation.

In 2006 there was a moderate correlation between coho passage and pelican numbers, suggesting that about 1/5 of the pelican count variability could be explained by coho passage. In 2006, fall chinook passage and pelican numbers showed weak correlations with spring chinook and steelhead showing negative correlations, suggesting that pelicans only arrive in large numbers after the spring chinook have passed. In 2006 other non-salmonid species, such as chiselmouth and sucker also show low or negative correlations.

The correlation analysis for the 2004-2005 fish passage and pelican data shows a roughly similar pattern as in 2006 with the highest correlation of pelican numbers with coho runs. There is also lower yet moderate correlation with the total salmonid run, the fall chinook run and steelhead run. There is no correlation with the total spring chinook run, with a weak correlation with the hatchery spring chinook run and a negative correlation with the wild spring chinook run. Again it is important to state that the best 2004-2005 correlations are only moderate, with between 1/4 and 1/3 of the pelican count variability being explained by differences in coho passage (Table 5).

Table 53. Smolt – Bird Correlations 2004- 2007. Correlations between Smolt passage and Pelicans and Gull counts at Chandler Bypass & Horn Rapids Dam. Numbers in bold are the highest correlations of that year.

	Pelicans (Chandler)	Gulls (Horn Rapids)
Wild Spring Chinook		
2004	-0.412	-0.198
2005	0.221	0.250
2006	-0.181	0.051
2007	-0.214	-0.093

Hatchery Spring Chinook		
2004	0.241	0.235
2005	0.345	0.582
2006	-0.016	0.222
2007	-0.052	0.341
Total Spring Chinook		
2004	0.058	0.132
2005	0.337	0.538
2006	-0.016	0.185
2007	-0.123	0.197
Total Fall Chinook		
2004	0.447	0.442
2005	0.360	0.453
2006	0.276	0.699
2007	**0.252***	0.100
Wild Coho		
2004	0.492	0.716
2005	**0.486***	**0.663***
2006	0.417	0.684
2007	-0.064	0.520
Hatchery Coho		
2004	**0.564***	**0.792***
2005	0.466	0.609
2006	**0.455***	**0.835***
2007	0.050	**0.957***
Total Coho		
2004	**0.564***	0.790
2005	0.470	0.617
2006	0.453	0.832
2007	0.042	**0.948***
Steelhead		
2004	0.232	0.322
2005	0.306	0.496
2006	-0.087	0.364
2007	-0.020	0.220
Total Salmonids		
2004	0.482	0.493
2005	0.425	0.650
2006	0.148	0.476
2007	-0.103	0.330

The correlation analysis 2004-2007 gives credence to rejecting any assumption that pelicans (or gulls) are responding indiscriminately to peak runs of any or all salmon species and presumably consuming large numbers of them (Table 5). The correlations from 2004-2006 do suggest that pelicans may respond to the relatively large run of coho smolts that are of sufficient size (> 30 g.) to serve as an energy efficient food source (Table 5). However, the data from 2007 are anomalous to that pattern.

Gulls at Chandler and Horn Rapids

Based on observed foraging by gulls over 16 days of observation at Chandler, the birds are estimated to have consumed few smolts this field season. In over 25 hours of observation in the Chandler blind, gulls took only 7 fish, an average of 0.28 fish per hour. The low number of sampling days makes year to year observations difficult. Yet, this is less than 11% of the predation level of gulls at Chandler in 2005, when 672 smolts were estimated to have been consumed based on 30 days of observation.

Gulls remained the primary fish predator at Horn Rapids Dam as in all previous years, with an average high of 7.9 birds/day (high of 47). If the highest day of 47 is removed from the data set, an average high of 4.5 birds/day were observed, similar to the average of 5.1 birds/day (high of 25) observed in 2006 and 5.8 birds/day (high of 36.3) in 2005. Gulls were sampled during 14 days in 2007, 13 days in 2006 and 30 days in 2005. Horn Rapids had low pelican activity as it has in other years.

Consumption of smolts by gulls at Horn Rapids was estimated to be 67,535 fish in 2007, a moderate decrease from 93,000 fish in 2006, but still over 3 times the 18,526 fish taken in 2005. However the decreased sampling effort in 2006-2007 makes comparisons to 2005 difficult. Prior to 2006 there has been a declining trend in total gull consumption every year since 2002 (18,526 fish in 2005, 112,850 fish in 2004, 141,349 in 2003 and 279,482 in 2002).

The estimated total gull consumption in 2007 represents 1.9% of the more than 3.53 million hatchery smolts released in the Yakima River in 2007. In 2006, gulls were estimated to have consumed 2.7% of the nearly 3.4 million hatchery smolts released.

In 2007, the only highly significant correlation between fish passage and gull numbers at Horn Rapids was for the hatchery coho run (0.957) and total coho run (0.948) (Table 5). The lowest and statistically insignificant correlations were for the wild spring chinook, total fall chinook and steelhead runs. The high correlation with coho suggest that about 92% of the variability in gull numbers at Horn Rapids can be explained by differences in the coho run counted at Chandler. This mirrors the pattern in 2006 when about 70% of the variability in gull numbers at Horn Rapids could be explained by differences in the coho run at Chandler, with no correlations with spring chinook, fall chinook or steelhead runs.

Although the 2006-2007 correlation analysis is based on a small data set, correlation data based on a larger data set in 2004-2005 appeared to show a similar pattern. In 2005, except for the low correlations for wild spring chinook, all other runs showed moderate correlations. However, the highest correlations were between gull numbers and the coho and total salmonid runs indicate that 44% of the variability in gull numbers can be explained by differences in the wild coho run or 42% of the variability can be explained by differences in the total salmonid run (Table 5).

The 2004 correlation analysis of fish passage and gull numbers at Horn Rapids, also showed the highest correlation between coho passage and bird numbers. This correlation was strong, indicating a high level of significance. The strong correlations between coho passage and gull numbers indicate that nearly 63% of the variability in gull numbers could be explained by differences in the hatchery or total coho run. Fall chinook correlations were moderate as were those of the total salmonid passage. About ¼ of the variability in gull numbers could be explained by differences in the total salmon run. Correlations for spring chinook were weak and insignificant as were correlations with steelhead passage (Table 5). For at least four years in a row, Horn Rapid gulls appear to respond to the passage of coho smolts with an increase in their numbers using the site during the peak smolt movement period. The passage of no other smolt run appears to stimulate the same behavior.

Smolts Consumed at Acclimation Sites

As in the years 2004-2006, smolt consumption in 2007 at the three spring chinook acclimation sites in the upper Yakima Basin (Clark Flat, Easton and Jack Creek), was insignificant. The most common smolt-eating birds present were Common Merganser, Great Blue Heron and Belted Kingfisher. If it is assumed that birds feeding in acclimation ponds were subsisting solely on smolts, based on the average number of counts at each site conducted over a three month period, daily energy requirements of birds, and the average size of smolts, it was estimated that these three bird species together consumed 352-895 smolts per site (average 560). Mergansers, herons and kingfishers consumed 55%, 37% and 8% of the smolts, respectively at the three sites. However, these avian predation rates represent only 0.21% of the 785,457 smolts present in the ponds in 2007. These totals are similar to 2006, when birds consumed 169-635 smolts per site (average 418) and to 2005 when it was estimated that these same three bird species together consumed 703-832 smolts per site (average 757).

Of the three coho acclimation sites (Holmes, Lost Creek and Stiles) only Holmes was systematically surveyed in 2007. Lost Creek and Stiles have not been systematically surveyed since 2005. Boone Pond, the scene of high merganser predation in 2005-2006 (estimated at 64% in 2005), was subsequently not utilized for acclimating smolts this year. In 2007, only mergansers and herons were observed at Holmes, with mergansers being common numbering 2.8 birds/day and herons 0.4 birds/day. Together both birds were estimated to have consumed 5,363 smolts, 1.9% of the 288,127 smolts present in the pond in 2007, with mergansers consuming nearly 90%. Bird consumption in 2007 at Holmes was up from 0.8% in 2006, and 0.02% in 2005. Smolts reared in the six spring chinook and coho acclimation sites are largely secure from predation by birds. Only limited bird monitoring appears warranted at the present time.

Pelican Radiotelemetry

Only one bird was caught this year, on June 19 at Chandler. It appeared to be an immature female, based on culmen length. It received a radio transmitter, yellow numbered patagial wing marker and a metal FWS band. The bird was intubated but no stomach contents were obtained. The bird was never subsequently re-sighted, nor were any of the four 2006 tagged birds re-sighted.

Pelican Aerial Surveys

Aerial surveys for American White Pelican on the Yakima River began in 2004. Flights were used to look at the abundance and distribution of American White Pelicans along the Yakima River and allow for a 100% survey of the lower river. Surveys were initially conducted monthly in the spring and summer. In 2007 three aerial surveys were carried out between May and September. Survey data has shown a dramatic increase of American White Pelicans from 2004-2006 with a drop of numbers in 2007. Pelican numbers peaked in the spring of 2006 at approximately 550 pelicans within the aerial survey area. In 2007, numbers in the spring totaled just over 100 a drop of over 400 pelicans from the previous year, this drop is most likely due to high water flows. High, fast moving water, limiting gravel bar and rock exposure within the river, eliminates perches and severely restrains pelican ability to prey on smolts. Pelican numbers are expected to vary with amount of yearly flows.

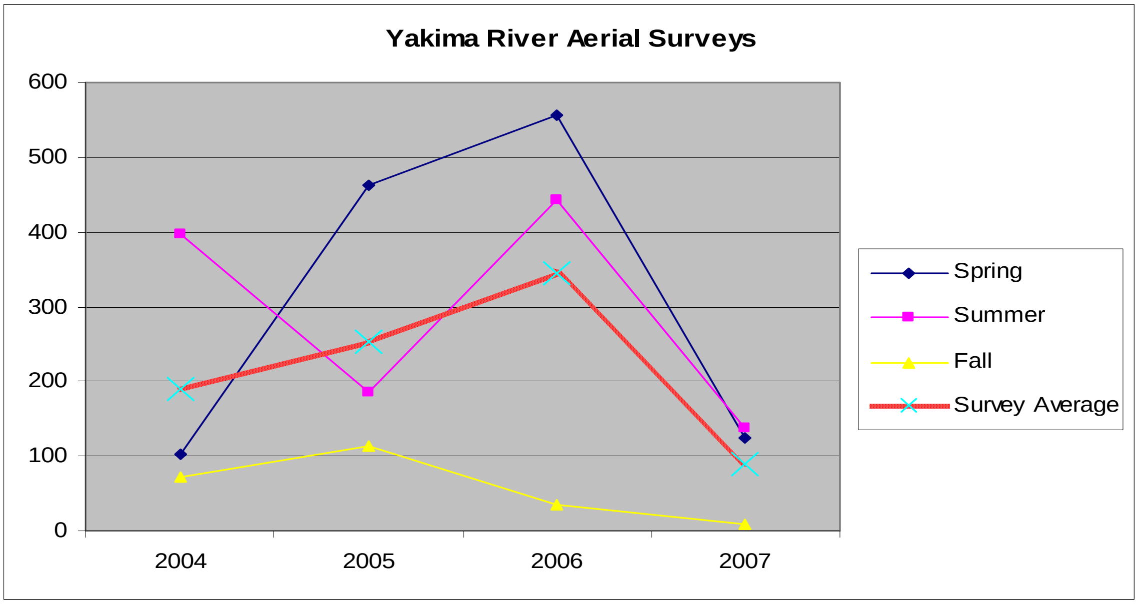


Figure 23. Yakima River Aerial Survey of pelican abundance, 2004-2007. Y-axis is number of pelicans observed.

Notable Pelican Observations

Pelican survey observations during the 2007 field season, including hotspot survey, spot surveys, banding, aerial surveys and observations by other Yakama Nation programs are summarized in Figure 14. The first large group of pelicans observed was a flock of 38 at Chandler on April 25. Seventy-three pelicans observed in the Yakima Canyon on April 30 and May 7 roosted on gravel bars and logs and did not appear to actively forage nearby, although a large sucker run at Roza was reported by Yakama Nation Fisheries Program staff during this period. These animals were all adult birds. Eighty-two adult pelicans used the Selah Pond on April 30, roosting and foraging for fish on the northern side of the flooded gravel pit. Forty-five birds were observed foraging on Selah Pond on May 24. On May 30, 44 pelicans were seen along the Parker reach of the Yakima River. Between June 11 and 20, 22-33 pelicans were seen at Chandler trying to forage at the bypass and roosting. These were all immature birds. On July 20, a high of 47 birds were observed on the Parker reach of the Yakima River. A roosting flock of 57 immature birds were located on an impoundment on the Toppenish National Wildlife Refuge on June 28. The last large group of birds observed was a flock of 32 immature birds at Chandler on July 12.

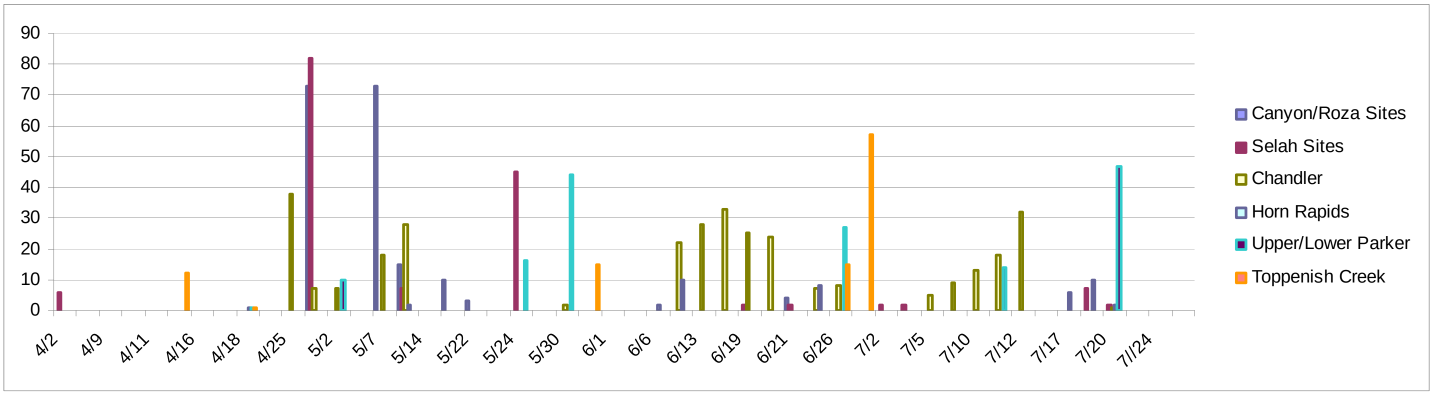


Figure 24. Pelican numbers at 6 Yakima Basin locations.

PIT Tag Surveys

The Selah Great Blue Heron colony grew in size in 2007, occupying living, dying and dead cottonwood and willow trees on both sides of the Yakima River. The colony consisted of about 40 or more active heron nests, with good fledgling success (about 2 birds per nest). In 2006, some, if not most, of the heron nests were occupied by cormorants. Data for 2007 surveys are given in Tables 6 and 7.

		Smolt Release Year							
		2000	2001	2002	2003	2004	2005	2006	2007
Roza Gravel Bar	Coho					1	1	5	4
	Spring Chinook		2			1	3	9	2
	Fall Chinook								
Chandler Pipe Outfall	Coho						1		
	Spring Chinook				1		3	2	1
	Fall Chinook					1	2	1	17
	Unknown (possibly steelhead)								6
Selah Heron Colony	Coho				1	2	13	5	1
	Spring Chinook	1	1	3	1	4	6	12	1
	Fall Chinook						1	8	1
	Unknown (possibly steelhead)								1

Table 54. PIT tags found in 2007 surveys by species and year of smolt release.

PIT tag surveys for 2007 recovered a limited number of 2007 smolt released PIT tags. In table 7 PIT tags have been differentiated by species and site found. An estimate of the number of smolts represented by the PIT tag by species has been included. Expanded observations give a number of actual PIT tag represented smolts at each site, but not an overall consumption estimate.

	Raw Observations			Expanded Observations		
	Coho	Spring Chinook	Fall Chinook	Coho	Spring Chinook	Fall Chinook
Roza Gravel Bar	4	2		288	39	0
Chandler Pipe Outfall		1	17	0	20	557
Selah Heron Colony	1	1	1	72	20	33
Number Released	901238	785498	1845731			
Number PIT tagged	12500	40000	56383			
% PIT tagged	1%	5%	3%			

Table 55. PIT Survey data for 2007 smolt releases by site and species.

CONCLUSIONS

The 2007 river reach surveys indicated that pelican and cormorant populations declined significantly from 2004-2006 levels. Aerial surveys in 2007 showed that pelican numbers peaked at less than 150 birds in the Yakima Basin this year, as low as populations in 2002, down from highs of 660 birds in 2005. 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.

Observations of pelicans feeding at Chandler, Selah Pond and elsewhere challenge popular perceptions of them as predominately feeding on salmon smolts. 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. Selah Pond pelicans were observed readily taking bullhead, and their presence at impoundments on Toppenish National Wildlife Refuge and on Satus oxbow lakes suggest they are feeding on warm water fish such as carp, shiners, and bullhead as water levels receded in summer. High numbers of pelicans in Yakima Canyon in spring appeared to correlate with sucker runs.

Correlation analysis from 2004-2007 suggests that gull and pelican predation of smolt runs at hotspots is selective by run and not simply proportionate to the availability of smolts (ranging in size from 4-77 g). The correlations with the coho smolt run were the highest for gulls at Horn Rapids from 2004-2007, and pelicans at Chandler for 2004-2006, suggesting selection for coho and avoidance of fall or spring chinook. The only limitation comparing 2006-2007 to the previous two years is a decrease in the number of bird counts on which the 2006-2007 correlations are based. Despite differences in sampling, the correlative pattern in 2006-2007 for gulls followed that of 2004-2005. Only

2007 data are an anomaly for pelicans, with no significant correlation with any salmon smolt run. In 2007, pelican numbers appear to correlate with flow at Chandler only, with low flow correlating with higher pelican numbers, suggesting the importance of perching sites to feed on smolts exiting the Fish Bypass. There was a low but significant negative correlation (-0.456) between flow at Chandler and pelican numbers. Only with flows under 4,000 cfs can pelicans congregate at Chandler to prey on fish exiting from the Fish Bypass.

Gulls at Horn Rapids appear to be closely tracking the coho smolt run, increasing in numbers at this site (and presumably consuming more coho smolts) when the fish are moving through the system. Coho smolts disoriented by water infrastructure at hotspots may be of sufficient body size (>30 g.), with their run occurring in high enough volume, to be an important spring food resource for gulls and pelicans.

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 survivorship. 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. Also, the bypass facility separator must allow large sucker, chiselmouth and other native non-salmonid fish to successfully move downstream. The presence of large dead and disabled fish exiting from the bypass pipe may attract avian predators to the site.

Plans for the 2008 field season include continued monitoring of river reaches and at hotspots with a focus on Pelican foraging. Pelicans will be color-marked and radio-collared at hotspots, river reaches and other locations to gather information on diet, movements and nesting. Heron and cormorant nesting colonies will be surveyed, monitoring which has not been done systematically in 5 years. PIT tags found at pelican, cormorant, heron and merganser nesting and roosting sites will be used to assign smolt predation estimates to specific bird species.

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LITERATURE CITED

Alcock, J. 1968. Observational learning in three species of birds. Ibis 111:308-321.

Grassley, J. M. and C. E. Grue 2001. Development of an Index to Bird Predation of Juvenile Salmonids within the Yakima River, Annual Report 1999. Submitted to Washington Department of Fish and Wildlife by the Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, WA. 39 pp.

Major III, Walter, J.M. Grassley, K. Ryding, C. Grue, T. Pearsons, and A. Stephenson. 2003. Abundance, distribution and Estimated Consumption (kg fish) of

Piscivorous Birds Along the Yakima River, Washington State, Implications for Fisheries Management, Annual Report 2002. Project No. 1995-06424. BPA Report DOE/DP-00004666-11.

Motschenbacher, M.D. 1984. The feasibility of restoring a breeding white pelican population in the state of Washington. Thesis, Washington State University, Pullman, Washington, USA.

Phinney, D.D., S.B. Mathews and T.N. Pearsons 1998. Development of a Bird Predation Index, Annual Report 1998. Report to Bonneville Power Administration, Contract No. 1998AT02689, Project No. 199506408, (BPA Report DOE/BP-64878-3) 133 pp.

Roby, D.D., D.P. Craig, K. Collis, and S.L. Adamany. 1998. Avian predation on juvenile salmonids in the lower Columbia River. Annual Report for 1997. Bonneville Power Administration, Portland, Oregon.

Ruggerone, G.T. 1986. Consumption of migrating juvenile salmonids by gulls foraging below a Columbia River Dam. Transactions of the American Fisheries Society 115:736-742.

Ward, P. and A. Zahavi. 1973. The importance of certain assemblages of birds as "information centers" for food finding. Ibis 115:517-534.

White, H. C. 1957. Food and natural history of mergansers on salmon waters in the maritime provinces of Canada. Bulletin of the Fisheries Research Board of Canada 116:19-35

Wood, C.C. and C.M. Hand. 1985. Food-searching behavior of the common merganser (Mergus merganser) I: Functional responses to prey and predator density. Canadian Journal of Zoology 63:1260-1270.

http://www.efw.bpa.gov/IntegratedFWP/reportcenter.aspx.

www.ykfp.org