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 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.

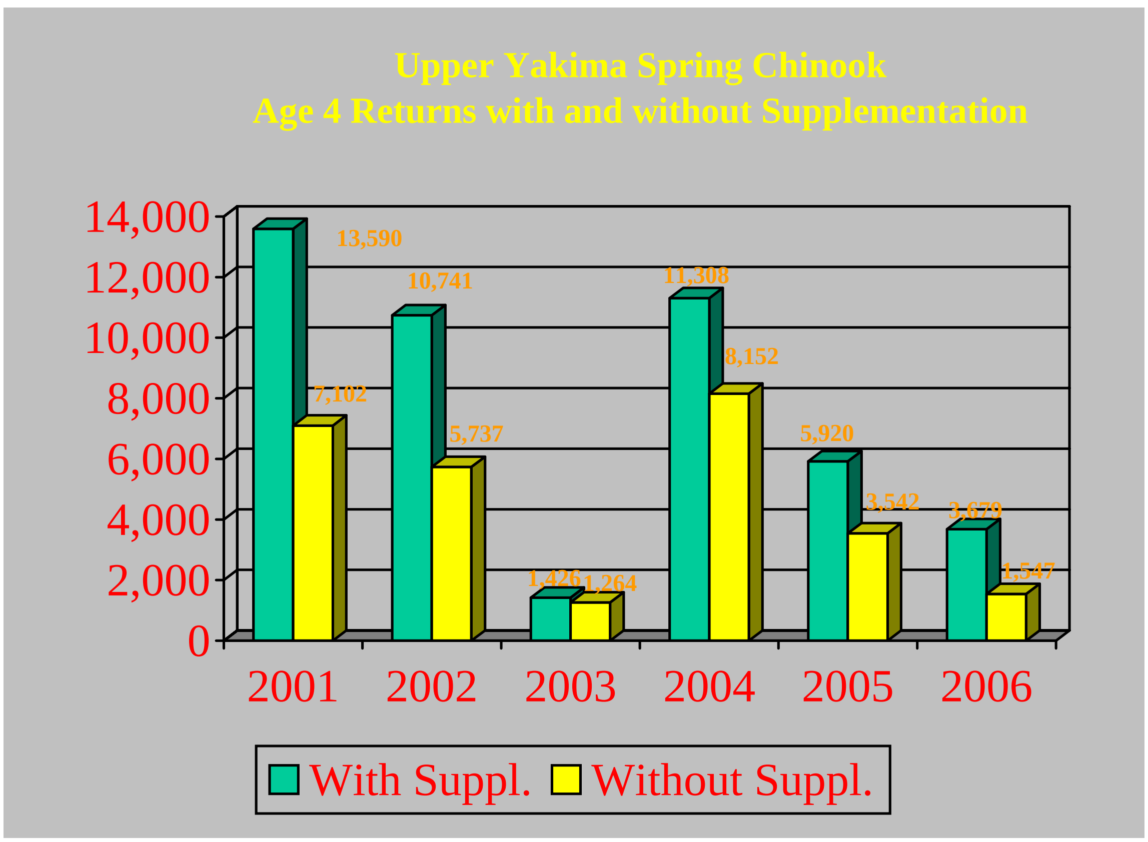
Supplementation is envisioned as a means to enhance and sustain the abundance of wild and naturally-spawning populations at levels exceeding the cumulative mortality burden imposed on those populations by habitat degradation and by natural cycles in environmental conditions. A supplementation hatchery 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

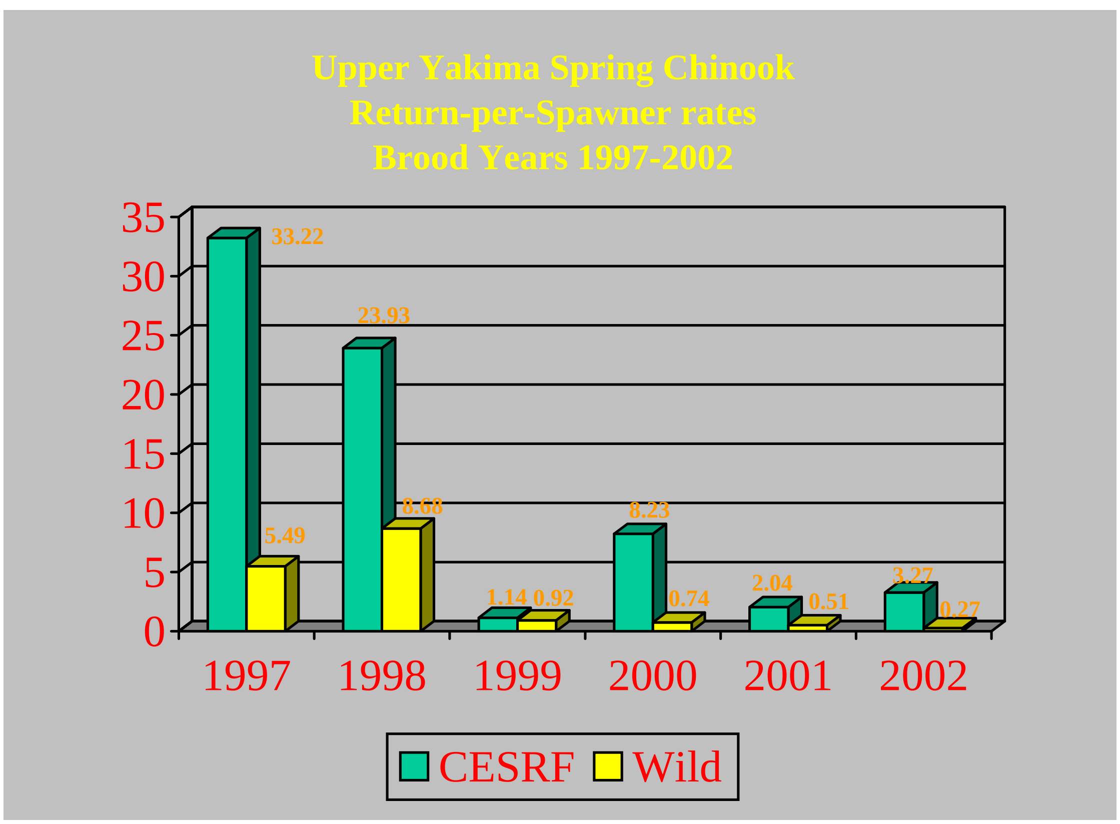
The Cle Elum Supplementation and Research Facility (CESRF) collected its first spring Chinook brood stock in 1997, released its first fish in 1999, and age-4 adults have been returning since 2001, with the first F2 generation (offspring of CESRF and wild fish spawning in the wild) returning as adults 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 when competition is relatively high. When competition is reduced, hatchery fish produced similar numbers of progeny as their wild counterparts. Passage timing at Roza Adult Monitoring Facility (RAMF), reproductive effort, and emergent fry size and survival were similar between natural and hatchery origin fish, however hatchery origin fish were smaller-at-age, showed an increase in the proportion of age 3 male returns over time, spawned earlier at CESRF, had lower fecundity, and lower total gamete mass than natural origin fish and were morphologically different. Long-term fitness of the target population is being evaluated by a large-scale test of domestication. Slight changes in predation vulnerability and competitive dominance, caused by domestication, were documented. 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 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 which may constrain the benefits of supplementation. However, such constraints could be countered by YKFP habitat actions. 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 2001-2006.



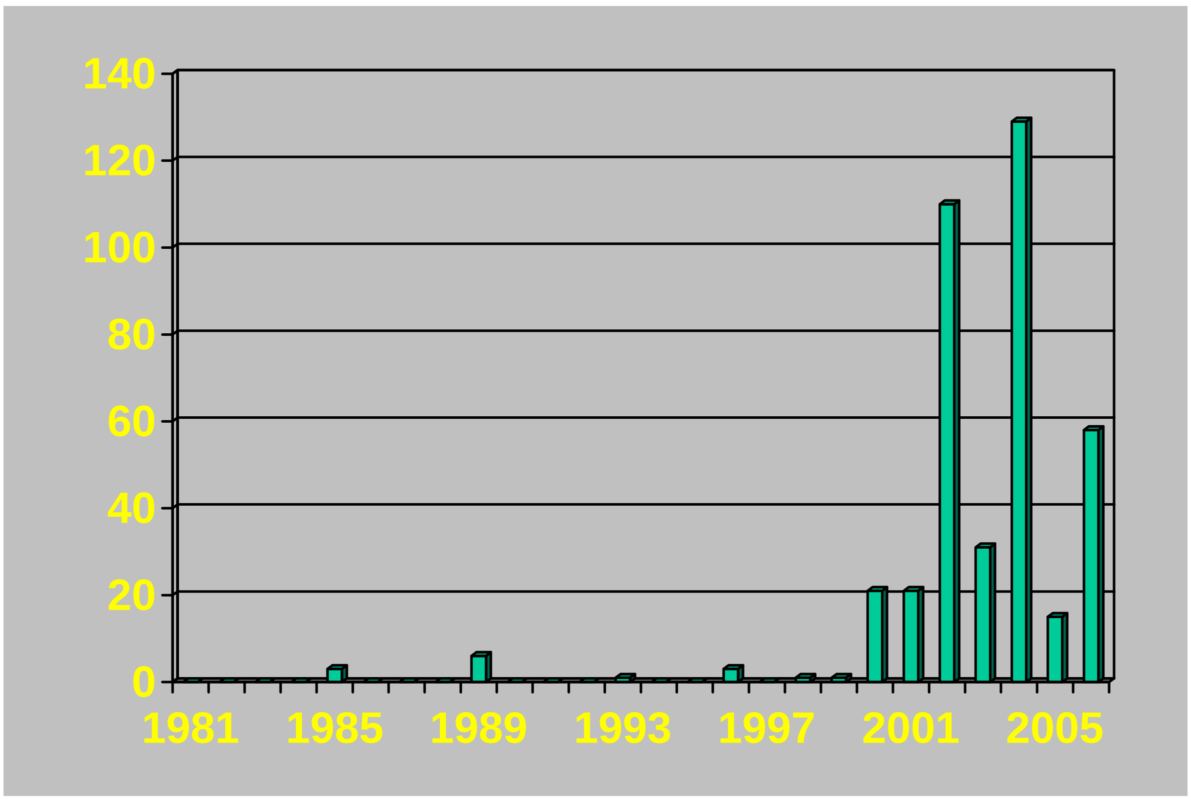
Methods and Discussion: For all years, actual returns with supplementation (green bars) are derived from actual counts of marked (CESRF) and unmarked (wild/natural) fish at Roza Dam backed through harvest to the Yakima River mouth. For F1 returns (returns from wild fish spawned in the hatchery) in 2001-2004, 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 138% in return year 2006 and averaged 73% from 2001-2006.

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 1997-2002. Note: Age-5 returns are not yet included for brood year 2002.



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 – 2006.



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 70 redds per year increasing the spatial distribution of natural spawners on the spawning grounds. The natural productivity of these spawners is dependent on improving habitat conditions in the Teanaway, which are being addressed through a number of projects funded by a variety of organizations.

For detailed data and supporting information, see Appendix A of this report and the references to WDFW reports shown under tasks 1c, 1j, 1p, 1q, 1r, 3a-3c, and 4d-4f 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 1997-2006 (an order of magnitude greater than the prior 10-year average) including estimated returns of wild/natural coho at or exceeding 1,500 fish in four of the six years 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:

Knudsen, C. M., S. L. Schroder, C. A. Busack, M. V. Johnston, T. N. Pearsons, W. J. Bosch, and D. E. Fast. 2006. Comparison of life history traits between first-generation hatchery and wild upper Yakima River spring Chinook salmon. Transactions of the American Fisheries Society 135:1130-1144.

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.

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.

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 the work generally falls under two broad work element ids: 157) Collect / Generate / Validate Field and Lab Data, and 158) Mark / Tag Animals. Therefore, the monitoring and evaluation program for the YKFP was organized into four categories- Natural Production (tasks 1.a - 1.y), Harvest (task 2.a), Genetics (tasks 3.a – 3.c) and Ecological Interactions (tasks 4.a – 4.f). This annual report specifically discusses tasks directly conducted by the Yakama Nation during fiscal year 2006. 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.d, 1.e, 1.g, and 1.h 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, and Jim Siegel. 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: Develop methods of detecting indices of increasing natural production, as well as methods of detecting a realized increase 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:

Salmon Recovery Planning: The 2005 EDT model run used for the Klickitat draft recovery plan was refined in 2006 for the final Klickitat Salmon Recovery Plan. The purpose of this additional work was to reconfigure the EDT geographic areas of analysis that identify major limiting factors affecting natural production of steelhead in the Klickitat. The geographic areas of analysis were defined according to the Major and Minor spawning areas (MSAs & mSAs) identified by NOAA Fisheries Intrinsic Habitat Potential analysis. NOAA's defined MSAs provide the basis for assessing the Klickitat steelhead population's viability risk rating associated with the spatial structure and diversity VSP parameters. The reconfigured model results allowed biologists to prioritize MSAs in order of importance for targeted restoration and preservation management actions. Restoration and preservation projects within a single MSA could also be prioritized from the major and minor limiting factors identified in the EDT analysis.

For a review of the analysis and methods used for the Klickitat Salmon Recovery Plan, a draft recovery plan is expected to be available in July 2007 for public review at: http://www.governor.wa.gov/gsro/regions.

YKFP Quantitative Objectives: Several models including EDT and the All-H-Analyzer (AHA) are currently being used to assist the YKFP in development of numerical objectives for the indigenous Spring Chinook stock. EDT outputs characterizing the natural production potential of a subbasin function as input variables into the All-H-Analyzer model. The All-H-analyzer is a life cycle model that integrates the interactions between the "four H" components of habitat, hatcheries, hydro operations and harvest. Outputs from the AHA model provide a simplistic understanding regarding the complex relationships between the state of habitat, magnitude and type of hatchery practices, differential smolt to adult return rates and exploitation rates on a given population. For our purposes, simultaneous use of the two models allowed us to quantify future habitat restoration scenarios, differential harvest rates for both the Columbia and terminal fisheries, and expected survival increases through the hydro system outlined in the 2004 Biological Opinion on the Federal Columbia River Power System. Because EDT is capable of describing the freshwater habitat's capacity and productivity for both the current and historic landscapes, scenarios restoring different proportions of the historic landscape were modeled for representative time frames related to short term, intermediate and long term goals for the program. These time frames include a ten year (2003-2013), 20 year (2003-2024) and long term goal extending well beyond 2024. The ten year goal expands upon recent trends in return numbers with the intent of maximizing natural production by fully seeding the current freshwater spawning and rearing capacity through the use of supplementation while maintaining harvest augmentation for treaty and sport fishermen. Intermediate and long term goals are driven by the assumption that habitat restoration activities prior to, or within the given time frames will grossly enhance freshwater productivity and capacity in concurrence with an increased rate of out of basin survival. Stock performance objectives within each time frame consist of several components linked to the desired success of the program, stock conservation, and cultural/economic benefits. These components include natural smolt production, escapement to the spawning grounds, Columbia River harvest, and Yakima Basin harvest. The final analysis was conducted and reviewed in July and August 2006. Results from this work can be viewed at http://www.efw.bpa.gov/Publications/P00023618-1.pdf titled: Yakama/Klickitat Fisheries Project; Spring Chinook Salmon Supplementation in Upper Yakima Basin Executive Summary, 2005-2006 Annual Report, Project No. 199506425.

Klickitat Anadromous Fishery Master Plan: Results from the EDT and AHA models assisted in the design phase of the proposed hatchery programs for the Klickitat Anadromous Fishery Master Plan. The purpose of using these models was to characterize the interactions between the 4 H components throughout a given species life cycle and quantify the expected performance of the proposed hatchery programs. The expected performance was then compared to the program's goals and objectives specifically developed for each individual species that included either conservation, harvest augmentation or both. Several scenarios were run for each species using the AHA model that varied the size of the program, broodstock source, exploitation rate and smolt to adult survival. Programs for species native to the Klickitat, including Spring Chinook and Steelhead, are being designed for conservation and harvest augmentation purposes while programs for Fall chinook and coho focused on harvest augmentation.

Developing an integrated hatchery program for the purpose of both conservation and harvest must consider the habitat potential for natural production and the desired number of fish available for harvest. A variety of scenarios were modeled for spring chinook and steelhead that varied the overall size of the program, number of wild fish used for broodstock on an annual basis and expected smolt to adult survival of hatchery and wild fish. The preferred management alternative will be determined by a proposed program's ability to meet both the goals for conservation and harvest augmentation. The Fall Chinook and Coho programs, which function as harvest augmentation programs, considered alternatives that would reduce interactions with native stocks in the form of predation or competition by moving the release locations to a lower proximity in the watershed. The modeling scenarios also looked at the potential improvements in smolt to adult survival by implementing best management practices from a culturing perspective which could influence the overall size of the program in terms of smolt release numbers. These programs will be designed to maintain current levels of harvest while potentially reducing the overall release numbers of smolts due to an increase in smolt to adult survival. Results from these modeling scenarios for all four species and their preferred management alternative will be available for review in the fall of 2007 when the Klickitat Anadromous Fishery Master Plan has been submitted to BPA for a three step review process.

2006 field work:
No field work was conducted in 2006 targeting attributes in the EDT and AHA models for either the Yakima Subbasin or Klickitat Subbasin.

Task 1.b Yakima River Fall Chinook Fry Survival Study

Rationale: To determine the optimal locations within the lower Yakima basin where fall Chinook production is feasible, and to guide location of future acclimation and release sites.

Methods: The feasibility of beach seining for wild juvenile fall Chinook was initiated in 2001, with the long-term objective of initiating a Passive Integrated Transponder (PIT) tag study to evaluate smolt-smolt survival between different reaches of the Yakima River. In April of 2004 and 2005, beach seine sites were established at Richland, Granger and Union Gap to target wild juvenile fall Chinook for growth profiling and marking via PIT tag or caudal clip. In 2006, beach seine efforts were reduced at Richland and re-sited between Prosser Dam and the Chandler outfall. The majority of returning adults (BY2005) spawned in this section.

Progress: Growth profiles of naturally rearing fall Chinook juveniles in the lower Yakima River were monitored via beach seining efforts from April 12th through May 8th, 2006. After this date, high flows prevented any more seine attempts during the fall Chinook out-migration period. Beach seine locations are in four sections of the Yakima River; below Van Giessen Street Bridge (RM 8.4-7.9), Benton City (RM 29.8), above Granger (RM 83-100.3) and Union Gap (RM 107.1-111.6). In 2006, a fifth section was added below Prosser Dam (RM 35.8-47). Seining was conducted using a 30 ft beach seine. All fish >=55 mm were PIT tagged and a sub-sample of 100 fork lengths were taken per daily effort if enough fish were captured. PIT tag detections were monitored at Prosser Dam and McNary Dam.

The number of fish captured and PIT tagged for 2006 in Van Giessen, below Prosser Dam and Granger were as follows: 119 with 26 PIT tagged, 92 with 54 PIT tagged and 401 19 PIT tagged, respectively. Due to lack of redds, no effort was made in Union Gap.

The average fork lengths (mm) for April at Van Giessen, below Prosser and Granger were: 48.9, 57.6 and 47.5, respectively (Figures 4 and 5). The average fork length for May within the Granger reach was 42.5 mm. No sampling for May was conducted Van Giessen/Benton or Prosser reach due to hatchery releases from Prosser Hatchery.

Figure 4. Wild/Natural Fall Chinook fork lengths, April-May 2006.

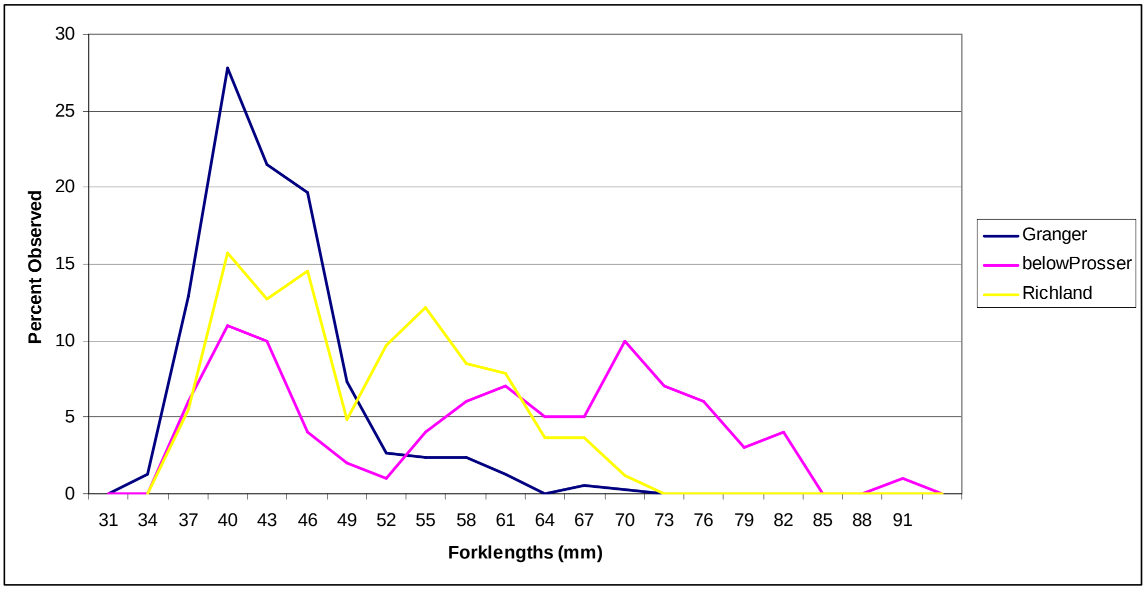
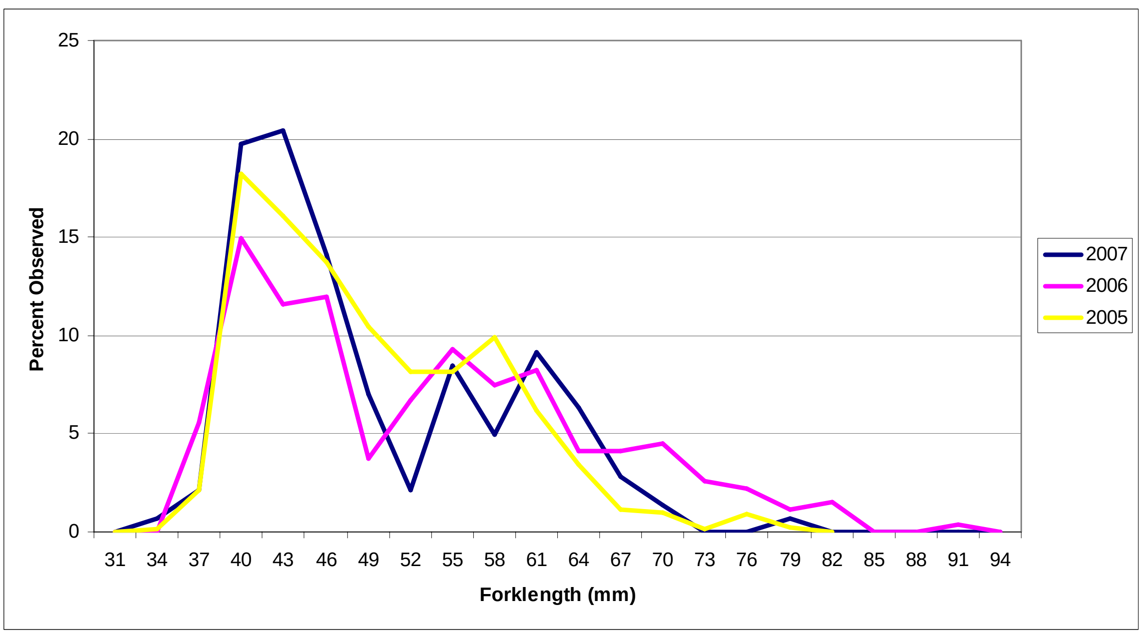


Figure 5. Wild/Natural Fall Chinook fork lengths at outmigration, 2005-2007.



We are unable to determine survival indices due to our inability to catch significant numbers of wild fall Chinook. It is difficult given the short amount of time from emergence to emigration. The limiting factor for survival estimates are the size of the fish during out-migration. We need fish that are >= to 55 mm to be able to safely PIT tag. The majority of fish captured during the sampling period are <55 mm. The collection of fork lengths over weekly sampling periods continues to give us good insight regarding size differences in fish rearing between Union Gap downstream to Van Giessen. Observed differences in fork length are likely due to differences in water temperature. The earliest PIT tag detection of a wild/natural fish at McNary Dam was May 4th, 2006. All other detections were between May 19th and June 20th, 2006. The Prosser Hatchery releases were detected at McNary Dam between May 1st and July 7th, 2006. Prosser hatchery fish acclimated at Stiles Pond on the lower Naches River were detected between May 16th and July 7th, 2006.

Personnel Acknowledgements: Melinda Davis is the project biologist for this task. Technicians Andrew Lewis, Delbert Nagle, Conan Northwind and Quincy Wallahee conducted all field activities.

Task 1.c Yakima River Juvenile Spring Chinook Micro-habitat Utilization

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, B. B. James, and G. M.Temple. 2007. Spring Chinook Salmon Interactions Indices and Residual/Precocious Male Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report 2006. DOE/BP-00027871.

Task 1.d 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.

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 multiple body placement coded wire tags unique 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 2005 fish began at the Cle Elum hatchery on October 16, 2006 and was completed on December 7, 2006. Marking results are summarized in Table 2. Appendix A contains mark summary data for all brood years to date. As in prior years, all fish were adipose fin-clipped. Approximately 2,200 fish (4.2% to 5.0% 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 (~737,000 fish) had a CWT placed in their snout, while the remaining progeny of hatchery brood parents (hatchery contol line; ~86,500 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). With the exception of Cle Elum raceways 1 and 2, fish with the elastomer dye in the left eyelid corresponded to the saltwater feed or experimental treatment and the right eyelid to the normal feed or control treatment. A final quality control check by YN staff took place December 18-20, 2006. Estimated tag retention was generally good, ranging from 94-100% for CWT and 86-100% for elastomer tags.

Smolt-to-smolt and smolt-to-adult survival data and analyses for brood years 1997-2001 OCT/SNT treatments are in the process of being peer-reviewed for publication. Appendix B contains an analysis of HI and LO smolt-to-smolt survival for release years 2004-2006 (brood years 2002-2004). Additional survival data across years are given in Appendix A.

Table 1. Summary of 2005 brood year marking activities at the Cle Elum Supplementation and Research Facility.

CE RW ID	Treat-ment	Accl ID	Comment	Elastomer Eye Site	Elastomer Eye Color	CWT Body site	Number Tagged CWT	Number Tagged PIT	Number Tagged Total	Start Date	Finish Date
CLE01	CON	JCJ06	WW	Left	Orange	Snout	45991	2222	48213	16-Oct-06	18-Oct-06
CLE02	STF	JCJ05	WW	Right	Orange	Snout	46172	2222	48394	19-Oct-06	23-Oct-06
CLE03	CON	JCJ04	WW	Right	Orange	Snout	47604	2222	49826	23-Oct-06	26-Oct-06
CLE04	STF	JCJ03	WW	Left	Orange	Snout	47852	2222	50074	26-Oct-06	31-Oct-06
CLE05	CON	CFJ06	WW	Right	Red	Snout	46258	2222	48480	31-Oct-06	02-Nov-06
CLE06	STF	CFJ05	WW	Left	Red	Snout	47129	2222	49351	03-Nov-06	08-Nov-06
CLE07	CON	ESJ06	WW	Right	Green	Snout	41808	2222	44030	08-Nov-06	14-Nov-06
CLE08	STF	ESJ05	WW	Left	Green	Snout	42094	2222	44316	14-Nov-06	17-Nov-06
CLE09	CON	CFJ02	HH	Right	Red	Posterior Dorsal	43580	2222	45802	20-Nov-06	28-Nov-06
CLE10	STF	CFJ01	HH	Left	Red	Posterior Dorsal	42971	2222	45193	22-Nov-06	04-Dec-06
CLE11	CON	ESJ02	WW	Right	Green	Snout	50108	2222	52330	05-Dec-06	07-Dec-06
CLE12	STF	ESJ01	WW	Left	Green	Snout	44487	2222	46709	30-Nov-06	05-Dec-06
CLE13	CON	ESJ04	WW	Right	Green	Snout	45040	2222	47262	22-Nov-06	29-Nov-06
CLE14	STF	ESJ03	WW	Left	Green	Snout	45132	2222	47354	17-Nov-06	22-Nov-06
CLE15	CON	JCJ02	WW	Right	Orange	Snout	46178	2222	48400	14-Nov-06	17-Nov-06
CLE16	STF	JCJ01	WW	Left	Orange	Snout	45804	2222	48026	08-Nov-06	14-Nov-06
CLE17	CON	CFJ04	WW	Right	Red	Snout	46476	2222	48698	02-Nov-06	07-Nov-06
CLE18	STF	CFJ03	WW	Left	Red	Snout	48638	2222	50860	30-Oct-06	02-Nov-06

Task 1.e 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 December 30, 2005 through May 5, 2006. The trap was fished five days per week, 24 hours per day. Fish were removed from the trap each morning, PIT tagged on site, and released the following day after recovery. Fish tagged on Friday mornings were released on Friday afternoons.

Progress: A total of 6,527 (2,333 wild and 4,194 hatchery) juvenile spring Chinook were PIT tagged from fish collected at the Roza juvenile fish bypass trap. Wild fish were tagged from December 30, 2005 through May 5, 2006; and hatchery fish March 17 through May 5, 2006.

Appendix C contains a detailed analysis of wild/natural and CESRF (hatchery) smolt-to-smolt survival for Roza-tagged releases for brood year 2004 (migration year 2006) and summarizes these data for prior brood years 1997-

2003 (migration years 1999-2005). Additional data on this task are provided in Appendix A.

Task 1.f 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 2006 smolt passage estimates were as follows: wild spring Chinook–92,175; LO spring Chinook– 73,044 (Easton: 29,034; Jack Creek: 21,220; Clark Flat: 22,730); HI spring Chinook– 86,308 (Easton: 42,139; Jack Creek: 18,346; Clark Flat: 25,828); unmarked fall Chinook– 43,716; Marion Drain hatchery fall Chinook– 5,387; wild coho– 8,298; hatchery coho– 41,260; and wild steelhead– 18,838. 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.

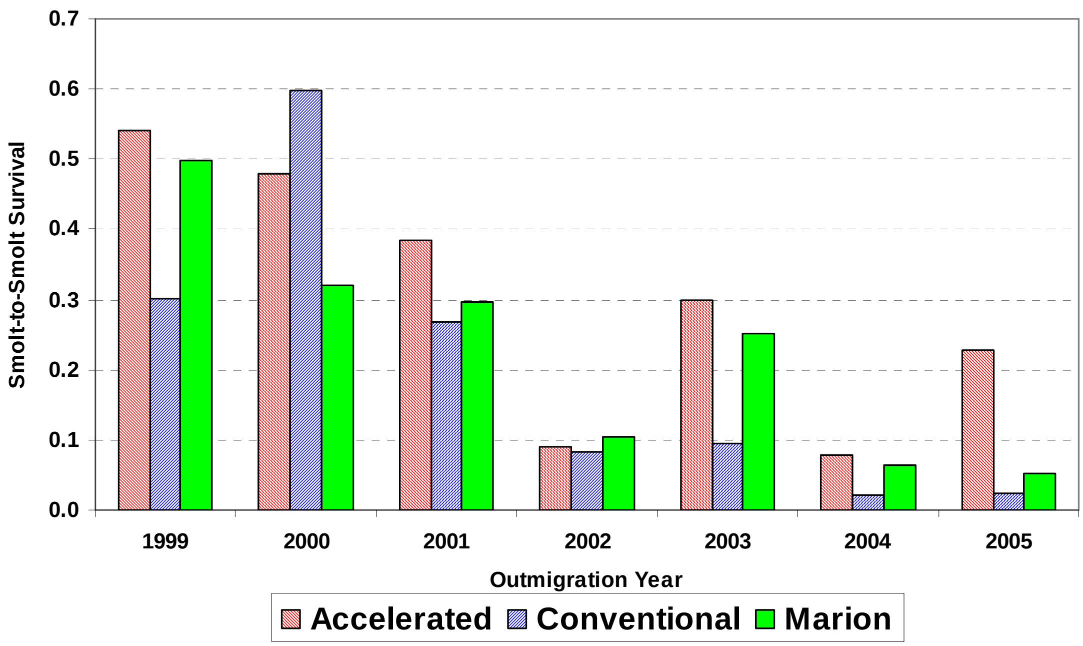
Task 1.g Yakima River Fall Chinook Monitoring & Evaluation

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

Method: Beginning in 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. 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. For brood years 2005 and 2006, we discontinued the external mark due to the inability to collect the data both at the viewing windows at Prosser Dam and on the spawning grounds. We still continue to mark a portion of all release groups via PIT tag.

Progress: The fish reared under accelerated conditions outperformed the conventional reared fish in all years except those released in 2000. The combined survival indices to McNary Dam are given below in Figure 6 (Neeley, 2005 annual report, Appendix G). As a result of this experiment, the majority of in-basin fall Chinook released are reared under accelerated conditions. In 2006 (BY2005), 130,000 in-basin Fall Chinook were released at Prosser Hatchery. In addition, 118,835 fish were transferred to Stiles acclimation pond located approximately RM 3.4 off the lower Naches River. Based on PIT tags, smolt survival for Prosser and Stiles releases from tagging to McNary Dam was 31.2% and 15.1%, respectively (Neeley, Appendix D). There were no fish PIT tagged at the Marion Drain Hatchery in 2006.

Figure 6. Weighted Tagging-to-McNary-Passage Smolt-to-Smolt Survival Indices for 1999-2005* Outmigrants of three Groups of Fall Chinook (weights are release numbers)**



* Brood-years 1998-2004, respectively.

** Groups are: 1) Main-Stem-Yakima Stock under Accelerated Rearing, 2) Main-Stem-Yakima Stock under Conventional Rearing, and 3) Marion Drain Stock.

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 Little White Hatchery, located on the lower Columbia River. The objective is to compare the smolt and smolt-adult 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 2006, we were able to accelerate growth and PIT tag a portion of these fish. We hope to increase survival of these fish as well as compare the survival to our in-basin fall Chinook.

We acclimated in-basin fish at Stiles pond and at a new site, Billy's pond, located approximately RM 110 off the Yakima Mainstem. These results are pending as fish are still leaving the system.

Task 1.h 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.

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 (2004-2010) 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 high quality spawning areas.

Progress:

As the current Master Plan awaits final environmental coverage, the coho program maintains interim goals.

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 and wild coho smolt passage increased again in 2006; redd counts increased slightly; our 100% local coho brood source continues to be developed; and smolt-to-adult return rates are remaining stable. 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).

2006 Results:

To improve our estimates of juvenile survival, we have been attempting to install devices to detect PIT-tagged coho as they migrate from the acclimation ponds. However, variable water flows, vandalism, and the configuration of natural pond outlets (i.e. lacking concrete infrastructure and appropriate detection equipment) have made implementation with high detection efficiency very difficult. In 2006, newer devices became available and were deployed at the acclimation ponds. These new detection capabilities brought detection efficiencies up to an average of nearly 62%. This is a substantial increase from 2004 when 36% was the highest efficiency. In 2007, we intend to install an additional detector at each site outlet (one is used presently) which will increase detection efficiencies and the accuracy of our survival rate estimates.

Survival of juveniles from acclimation site release to McNary Dam was greater for Naches subbasin releases than for upper Yakima River releases (Table 2). This was true for both out-of-basin (Eagle Creek NFH) and local brood source fish. Analysis was done within each sub-basin and showed that in the Upper Yakima, the Holmes (acclimation site) survival index was higher than that of Boone. In the Naches, the Lost Creek survival index was nearly twice as high as the traditionally higher Stiles Pond. Reasons for this reversal in survival for Naches subbasin releases are still being evaluated. A special transition feed used at Lost Creek in 2006 could have contributed to this and therefore will be used again at Lost Creek in 2007 for replication. The Boone acclimation site again experienced extremely heavy bird predation on smolts, keeping survival very low. Upwards of 150 common mergansers were counted on the pond at any time. See Appendix E for a detailed report and analysis of coho juvenile survival indices for 2006 releases.

Overall smolt passage estimates at Prosser continued a recent increasing trend with passage (adjusted for missed counts during periods of high flow) estimated at nearly 240,000 coho smolts in 2006 (other recent smolt passage estimates were: 30,000 in 2002, 13,900 smolts in 2003, 164,000 in 2004, and 214,700 in 2005). Additionally, we have continued releasing late summer parr into acclimation sites to assess over winter survival and possible winter acclimation. Approximately 1,025 PIT-tagged parr coho have been released into three of the acclimation ponds, Holmes, Boone and Lost Creek. The first year's results were partly encouraging with Holmes over winter survival to smolt being 2%, but over-winter survival was minimal at Lost Creek (.008%) and Boone Pond (0%; D. Neeley, IntStats Inc., personal communication).

The upward trends in overall smolt passage have resulted in increased adult returns of hatchery-origin fish. Estimates of hatchery-origin coho adults returning to Prosser Dam were: 500 in 2004, 2,341 in 2005, and 2,650 in 2006. The increase in adult returns is attributed to higher survival of juvenile coho and better ocean conditions. The increase in adults will further the objectives of Phase II of the Coho Feasibility Study, which calls for placing pre-spawn adult coho into select tributaries to study stream seeding and interactions with resident fish.

Survival of smolts migrating in 2006 was much higher than observed in previous years at Holmes (19-25%), and very high at Lost Creek (63-81%; Table 2). Release to McNary survival estimates are from the acclimation pond outlets to McNary Dam. The mean estimated survival over all 3 sites for both Yakima (local) and Eagle Creek brood source smolts was 45%. The Washougal stock is used primarily for over winter survival tests at Lost Creek and Holmes and for "late run" genetic augmentation.

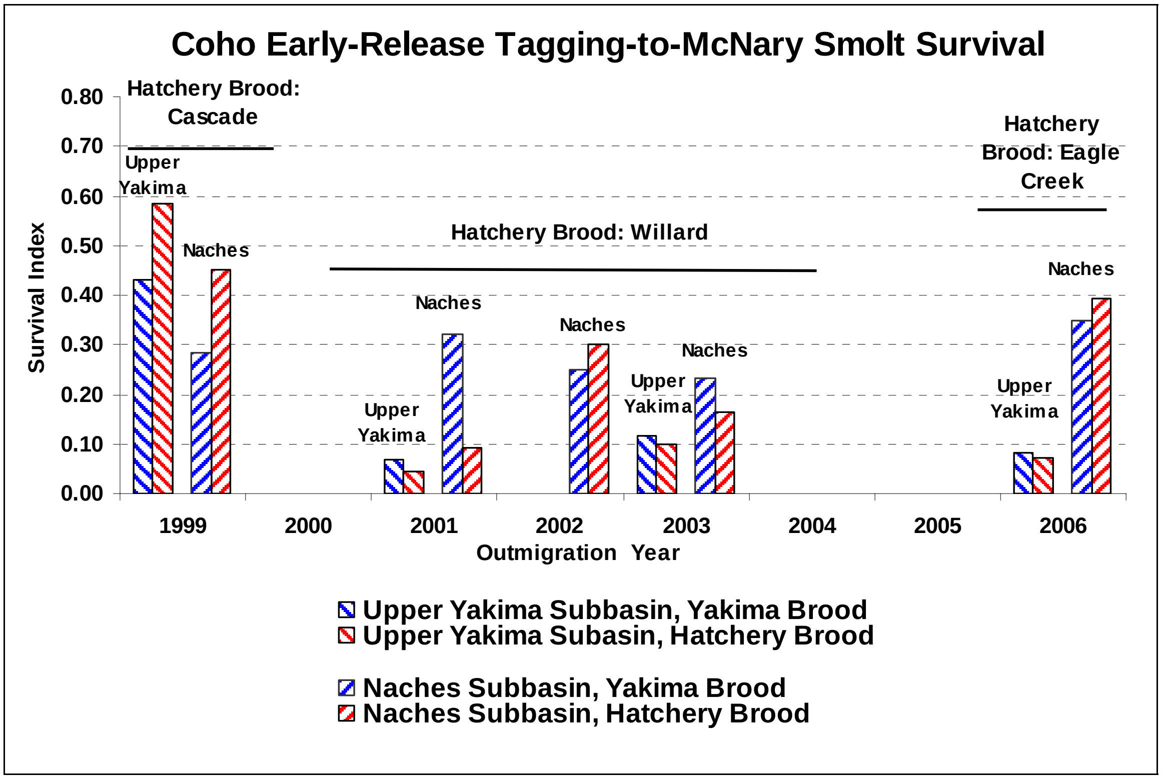
Table 2. Estimated percentage of 2006 smolts released from acclimation sites that survived to McNary Dam (juvenile survival indices) by brood source and acclimation site (D. Neeley, Appendix E).

	Acclimation Site[1]			Pooled
Brood Source	Stiles	Lost Cr.	Holmes	Mean
Eagle Creek	38.8	62.7	18.6	45.1
Washougal		81.3		
Yakima (local)	39.2	68.0	25.0	44.8

[1] Boone pond did not have any detectors at the acclimation site. Therefore, it was analyzed using total PIT tag numbers that were put into the pond. Survival of coho smolts released from Boone Pond to McNary Dam for 2006 was estimated at approximately 2%.

Stock Comparisons:
Brood source comparisons show that the Yakima brood source has survived at a higher percentage than out-of-basin brood source coho in 2001, 2003 and in the Upper Yakima in 2006. A different release strategy was implemented in 2004 and 2005, therefore comparisons between brood sources within acclimation sites was not possible. In 2006, there was no statistical difference between Yakima and Eagle Creek brood source coho, both survived very well.

Figure 7. Comparison of estimated survival rates to McNary Dam for Yakima (local) and out-of-basin brood source coho smolts for migration years 1999-2006 (D. Neeley, Appendix E).



Other highlights from 2006 include:

- We estimated that the smolt-to-adult survival rate for 31,631 natural-origin coho smolts (counted at CJMF in 2005) was 5.3%. This remains consistent with the previous 3 years, and it continues to remain higher than the hatchery-origin coho (next bullet).

- The estimated smolt-to-adult survival rate for 214,694 hatchery-origin coho smolts (counted at CJMF in 2005) from releases in the Upper Yakima and Naches Rivers was 1.3%. This is similar to last year's 1.4% smolt-to-adult survival.

- There were no statistical differences observed in juvenile survival from release to McNary Dam between local (Yakima) and out-of-basin hatchery-origin coho brood sources.

- The 2006 adult coho return was comprised of 1,562 natural-origin (37%) and 2,612 (62%) hatchery-origin coho. This was the sixth year this distinction could be made. The entire hatchery release group was 100% fin clipped (out-of-basin brood source fish were adipose fin-clipped, local brood source fish were left ventral fin-clipped).

• During the 2006 upstream migration, approximately 40 radio tags were inserted into adult coho salmon passing the right bank Alaskan Steep Pass Denil. Radio tag locations represent areas of resting or spawning before the fish moved back down stream. Radio tag distribution was highly variable in 2006. Very few (3) radio tagged adults were found in the Naches River (Table 3). This is a very low number and it is most likely attributed to: fewer fish being radio-tagged than in prior years, shortened acclimation time in 2005, and the very high November flows. Of the final detections of radio-tagged coho, only 8% were observed in the upper Yakima River while 5% were observed in the Naches system. The two largest percentages of radio tag observations were from Prosser Dam to the Naches Confluence (52%) and Sulfur Drain (15%). False attraction from Sulfur Drain could have played a role. Approximately, 320 adult coho were taken out of Sulfur Drain; therefore, it is very probable a larger number of fish were stalled at the mouth of this (Roza) irrigation return drain and thus remained lower in the Yakima system for an extended amount of time.

Table 3. Results of 1999-2006 Radio Telemetry Studies for Yakima Basin Coho.

	1999	2000	2001	2002	2003	2004	2005	2006	Average
Number Radio Tagged	86	102	105	52	71	90	76	40	78
Never Seen	3.5%	5.9%	5.7%	3.8%	11.3%	6.7%	47.4%	18.0%	12.8%
Mortality/Regurgitated Tag	3.5%	2.0%	7.6%	5.8%	8.5%	2.2%	0.0%	0.0%	3.7%
Fell back at Prosser	4.7%	7.8%	5.7%	7.7%	5.6%	12.2%	1.3%	3.0%	6.0%
Prosser Dam to Naches conf.	79.1%	58.7%	49.5%	51.9%	36.6%	51.1%	26.3%	67.5%	52.6%
Lower Naches	4.7%	2.0%	3.8%	1.9%	0.0%	0.0%	1.3%	0.0%	1.7%
Naches above Cowiche Dam	3.5%	1.0%	13.3%	11.5%	26.8%	5.6%	13.2%	5.0%	10.0%
Naches conf. To above Roza Dam		7.9%	9.5%	15.4%	2.8%	9.9%	7.9%	7.5%	8.7%
Mid-Yakima Tributaries	1.2%	14.6%	4.8%	1.0%	8.5%	12.2%	2.6%	0.0%	5.6%
Total above Naches Confluence	**8.2%**	**10.9%**	**26.7%**	**28.8%**	**29.6%**	**15.5%**	**22.4%**	**12.5%**	**20.4%**

• 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. In 2006 water conditions were extremely variable and conducting spawning surveys was difficult. The flows in the Yakima River reached nearly 15,000 cfs on November 9th 2006. The Naches River went from 1,000 cfs on November 5th 2006 to nearly 11,000 cfs on November

7th 2006. Normally large amounts of water like this would be a disaster for the spawning population; fortunately, only about 10% of the coho had spawned when the freshet occurred. In the upper Yakima River (above Roza Dam), redd counts rose from the previous year of 56 to approximately 76 in 2006 (see task 1.n). The majority of these fish were found spawning in the Holmes cottonwood gallery. This is located just downstream of the Holmes acclimation site. The total number of coho estimated in the gallery in 2006 was 150 fish.

- There continues to be evidence that the coho are establishing themselves in desired tributaries. In 2005, two redds and a wild female carcass were found in Nile Creek. This creek is thought to have historically contributed large numbers of coho into the Naches system. In 2006, 30 redds were found in Cowiche Creek and 3 redds were found in Reecer Creek in the Upper Yakima River. Both tributaries are included in Phase II of the Coho Feasibility Study, and will have both adults and juveniles stocked in them.

- Available data suggest that a substantial number of coho still do not make it back to natal spawning areas (acclimation sites). There are varying beliefs of why this occurs. These include: 1) lack of stamina, primarily by females trying to reach their release locations, 2) water temperatures, 3) unspecific acclimation (all four acclimation sites use mainstem river water), 4) straying and delay due to false attraction from irrigation returns, and 5) natural production occurring above Granger to the confluence of the Naches River. Nevertheless, we continue to be encouraged by the percentage of adult coho spawning above the Yakima River's confluence with the Naches River (average of over 20% since 1999).

- In 2003, it is estimated that approximately 4% of the entire coho run spent various amounts of time in Sulfur Drain, this percentage increased in 2004 to 6.6% percent. This is consistent with 2001, when approximately 7% of the coho run entered the drain. In 2005, the drought conditions pushed water users to conserve and cut back on total irrigation with drawls. Thus, only 1 coho was seen in the drain and only 2 fish were tracked into the mouth. There were 4 successfully attempted salmon rescues in 2004 with a total capture of 150 adult coho salmon (4.5% of the overall coho run), 6 fall Chinook and 4 steelhead. There were no rescues conducted in Sulfur Drain in 2005. In 2006, 320 adult coho were rescued from Sulfur Drain. The last rescue was conducted on October 17, 2006. By that date nearly 2,105 adult coho had passed over Prosser Dam. Using these numbers, we estimate approximately 15% of the run may have been falsely attracted into the drain. This delay could have contributed to the lack of homing fidelity in returning adults.

• Snorkel surveys were conducted to look for residualized juvenile coho. Surveys were conducted on the Upper Yakima River (Cle Elum Reach) from the Cle Elum Hatchery (Rkm 299) to the confluence of the mouth 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 (Rkm53.9). 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 substantial numbers of sub yearling coho observed in the lower Naches River 2005 residual surveys, indicating natural production occurring.

• Using annual snorkel surveys we try to locate and document areas of naturally rearing coho parr. In 2006, YN personnel PIT-tagged 30 wild coho parr from the Upper Yakima River and 5 wild coho parr from the Naches River. This was less than the 70 and 30 parr we PIT-tagged in the Upper Yakima and Naches Rivers respectively, in 2005. These data will contribute to evaluation of juvenile survival and smolt-to-adult returns in subsequent years.

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.j Yakima Spring Chinook Juvenile Morphometric/Coloration

Information related to this task can be located on the BPA website: http://www.efw.bpa.gov/searchpublications/

Knudsen, C. M. (editor). 2007. Reproductive Ecology of Yakima River Hatchery and Wild Spring Chinook. Annual Report 2006, Project Number 1995-063-25. BPA Report DOE/BP-00027798.

And in:

Busack, C., 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.

Task 1.1 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: Monitoring is accomplished through use of time-lapse video recorders (VHS) and a video camera located at each of the three fishways. The videotapes are played back and various types of data are recorded for each fish that migrates upstream via the ladders. These data are recorded on paper, 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:

<u>Spring Chinook (2006 run)</u>

An estimated 6,314 spring Chinook passed upstream of Prosser Dam in 2006. The total adult count was 6,012 (95%) fish, while the jack count was 302 (5%) fish. Of the adult count, 2,448 were identified as hatchery origin. Returning hatchery adults this year comprised 4 and 5 year olds (brood years 2001 and 2002). The ratios of wild to hatchery fish were 59:41 and 50:50, for adults and jacks respectively. The 25%, 50% and 75% dates of cumulative passage were May 21, May 25 and May 30, respectively.

<u>Fall Run (coho and fall chinook)</u>

Coho (2006)

The estimated coho return to Prosser Dam was 4,510 fish. Adults comprised 96% and jacks 4% of the run. Of the estimated run, 33.5% were processed at the Denil and mark sampling there indicated the run was comprised of approximately 40.6% wild/natural and 59.4% hatchery-origin coho. The 25%, 50% and 75% dates of cumulative passage were October 4, October 17, and October 23, respectively.

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

Fall Chinook (2006 run)

Estimated fall chinook passage at Prosser Dam was 1,528 fish. Adults comprised 98.1% of the run, and jacks 1.9%. Of the total number of fish, 86 were adipose clipped (76 adults and 10 jacks). The median passage date was October 16, while the 25% and 75% dates of cumulative passage were October 4 and October 19, respectively. Of the total fish estimate, 202 (13.2%) were counted at the Denil.

Steelhead (2005-06 run)

The estimated steelhead run was 2,005 fish. Of the total, 10 (0.5%) 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 October 18th, 2005, while the 25% and 75% cumulative dates of passage were October 9th, 2005 and January 2nd, 2006 respectively.

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

Task 1.m Adult Salmonid Enumeration and Broodstock Collection at Roza/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 117 steelhead were counted past Roza Dam for the 2005-06 run. As shown in Figure 8, most steelhead migrated past Roza Dam from March through mid May of 2006.

Spring Chinook

At Roza Dam 4,028 (93.3% adults and 6.7% jacks) spring Chinook were counted at the adult facility between May 22 and September 14, 2006. The adult return was comprised of natural- (87.0%) and CESRF-origin (13.0%) fish. The jack return was comprised of natural- (50.9%) and CESRF-origin (49.1%) fish. Figure 9 shows spring Chinook passage timing at Roza in 2006.

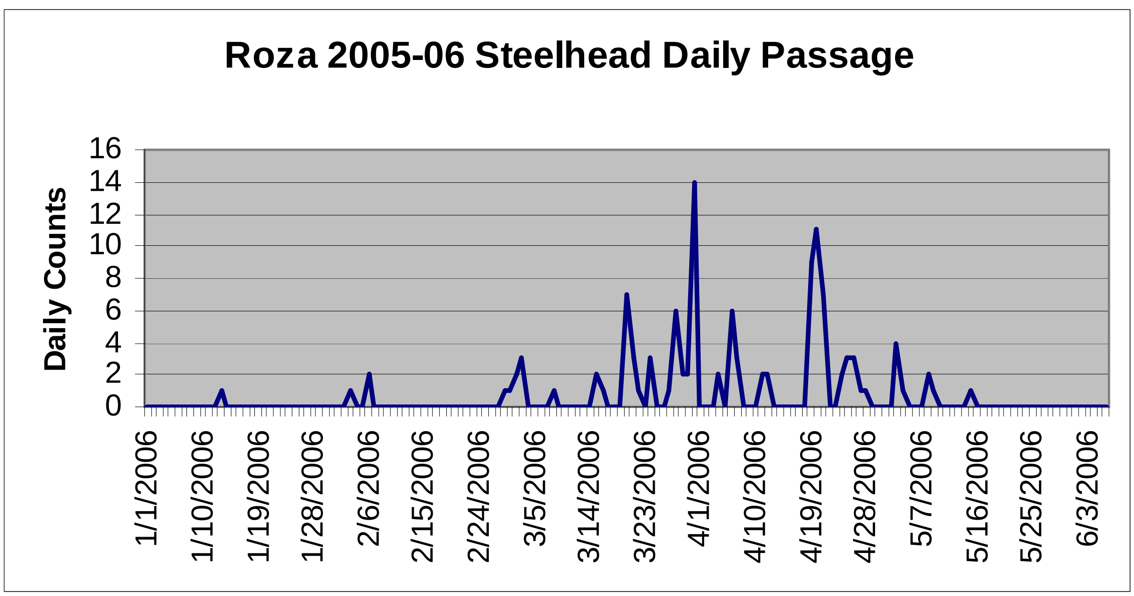


Figure 8. Daily steelhead passage at Roza Dam, 2005-06.

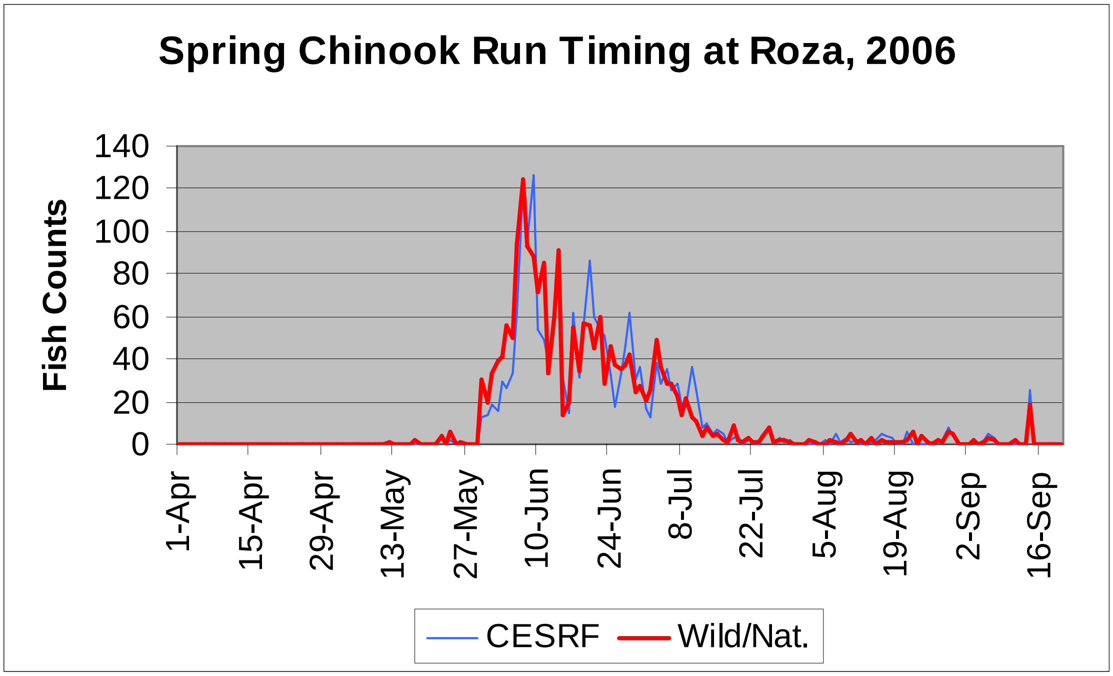


Figure 9. Daily passage counts for natural- and CESRF-origin spring Chinook at Roza Dam, 2006.

Coho

Based on video observations, a total of 9 adult and no jack coho were observed passing Roza Dam from September 27, 2006 through November 22, 2006. Of the total, three adults 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.

<u>Cowiche Dam</u>

Coho

Video observations were not conducted at Cowiche Dam in 2006.

Task 1.n Spawning Ground Surveys (Redd Counts)

Rationale: To enumerate the temporal-spatial distribution of spring Chinook, fall Chinook, steelhead and coho redd deposition in the Klickitat and Yakima basins. To collect biological information from spawned out carcasses.

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 are 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 2007. Total redd counts by subbasin were as follows: Satus basin- 87, Toppenish basin- 42, and Ahtanum Creek- 4. For all three basins a total of 133 redds were counted. 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 2007 were conducted jointly by the U.S. Forest Service and the Washington Dept. of Fish and Wildlife. These surveys counted 44 total redds in the Naches system (G. Torretta, USFS, personal communication). Sub-optimal conditions again likely resulted in an underestimation of steelhead redd counts throughout the Yakima Subbasin. Snow pack prevented access to some areas early in the season. High flows in some areas later in the season delayed access and resulted in poor visibility. 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 2006 in the American River and ended in early October 2006 in the upper Yakima River. Total counts for the American, Bumping, Little Naches, Naches, and Rattlesnake rivers were respectively: 133, 115, 33, 148, and 14 redds. Redd counts in the upper Yakima, Teanaway and the Cle Elum rivers were: 1,077, 58, and 100, respectively. The entire Yakima basin had a total of 1,679 redds (Naches- 444 redds, upper Yakima- 1,235). 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:

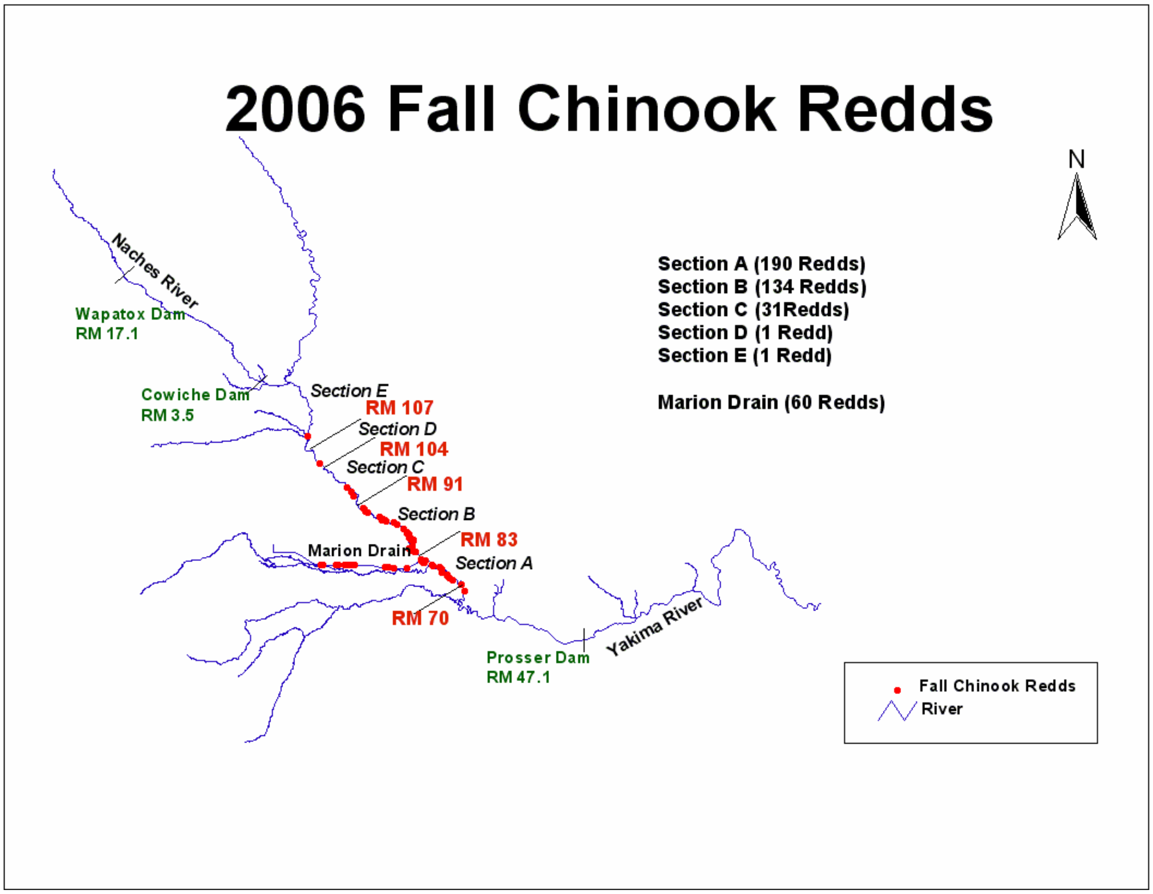
Yakima R.: 357 redds. 91% of the redds were located between RM 70 and RM 95.

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

Marion Drain: 60 redds. 73% of the redds were located above Hwy 97 between Old Goldendale and Robbins Rd. The remaining 27% were located below Hwy 97 between the Hwy97 and Hwy 22 bridges.

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

Figure 10. Distribution of fall Chinook redds in the Yakima River Basin in 2006.

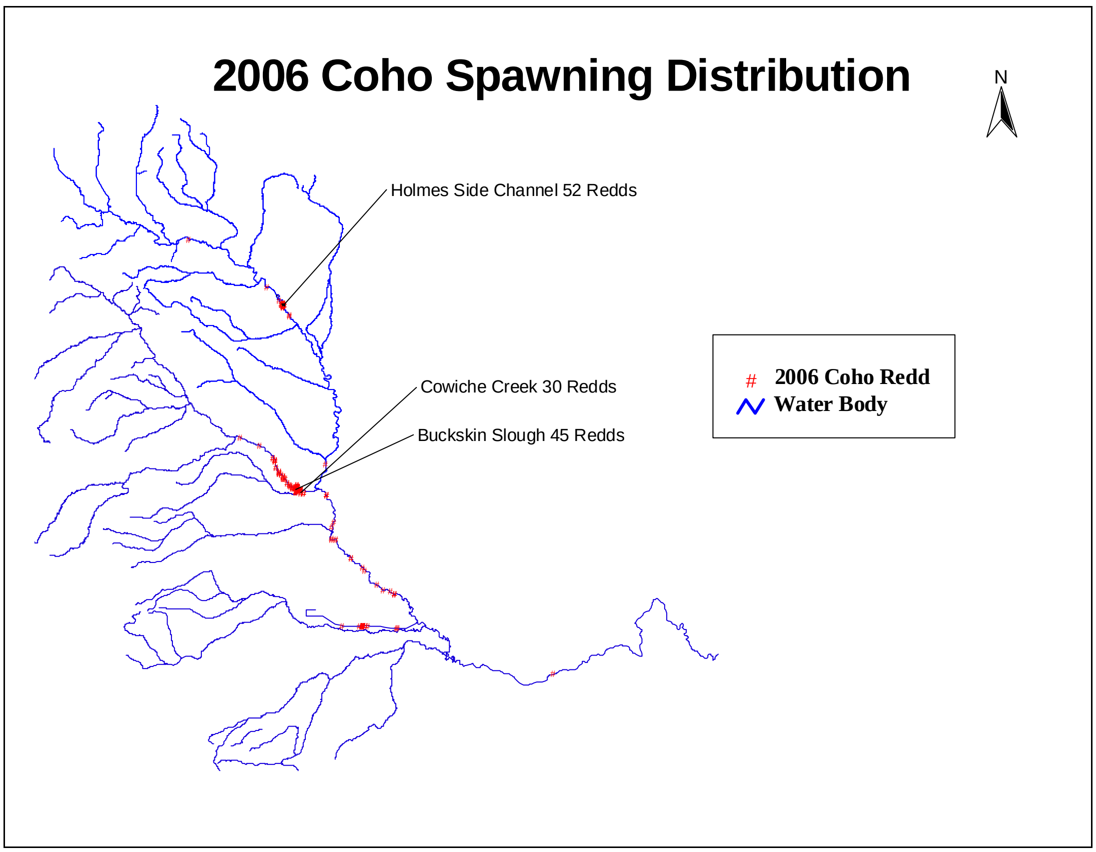


Coho: Surveys began the third week of October and ended in late December. Redd surveys were conducted daily in conjunction with fall Chinook surveys. The Yakima and Naches Rivers are broken into sections that are checked via boat or foot daily. Winter freshets and weather did not hinder the spawning surveys in 2006, thus the coho redd count was the third highest the YN has recorded. The majority of the 109 redds in the Yakima River were in the upper Yakima River above Roza Dam in and near the Holmes acclimation site (72 redds). This was a substantial increase from 2005 when there were 57 redds located in the entire upper Yakima River. Many redds were located intermixed with fall chinook redds, tucked under cut banks or were found in side channels. Tributary redd enumeration and identification continues to be accurate due to low water levels in the autumn, improving interagency cooperation, and relatively good weather.

Table 4. Yakima Basin Coho Redd Counts, 1998-2006.

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

Figure 11. Distribution of coho redds in the Yakima River Basin, 2006.



Task 1.p 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, B. B. James, and G. M. Temple. 2007. Spring Chinook Salmon Interactions Indices and Residual/Precocious Male Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report 2006. DOE/BP-00027871.

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

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

Schroder, S.L., C.M. Knudsen, T. N. Pearsons, S. F. Young, T. W. Kassler, D. E. Fast, and B. D. Watson. 2007. Comparing the reproductive success of Yakima River hatchery-and wild-origin spring Chinook. Annual Report 2006, Project Number 1995-063-25. BPA Report DOE/BP-00027871.

Task 1.r Yakima Spring Chinook Gamete Quality Monitoring

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

Knudsen, C.M. (editor). 2007. Reproductive Ecology of Yakima River hatchery and wild spring Chinook. Annual Report 2006, Project Number 1995-063-25. BPA Report DOE/BP-00027798.

Task 1.s Scale Analysis

Rationale: To determine age/length and stock (hatchery vs. wild) composition of adult salmonids 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: Adult scale sample results for 2006 are summarized in Table 5 by species and sampling method. Historical data from age and length sampling activities of spring Chinook in the Yakima Basin are presented in Appendix A.

Table 5. The 2006 adult scale sample data summary for salmonids in the Yakima Basin.

	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	26	14.5	26	40.4	407	57.6	2	70.5
Upper Yakima Wild/Natural			28	41.5	413	58.9	49	70.9
Spawner Survey Samples								
Upper Yakima Supplementation			4	43.5	53	56.5		
Upper Yakima Wild/Natural			3	39.0	45	58.6		
American River Wild/Natural					23	60.8	23	72.7
Naches River Wild/Natural					15	59.8	10	73.7
Yakima R. Fall Chinook								
Hatchery	7	31.9	6	55.8	3	63.0		
Wild/Natural	6	37.7	43	58.9	61	68.9	16	75.1
Yakima R. Coho								
Hatchery	59	31.9	819	57.1				
Wild/Natural	31	30.9	312	57.7				

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.w 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 2006. 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 120 samples were collected and processed from the Little Naches drainage this past year (10 reaches, 120 samples). All of the regular sites in the Little Naches were sampled. The continued sampling efforts in the Little Naches extend our knowledge of trends and conditions in spawning habitat. With this year's monitoring work, the data set for the Little Naches drainage now covers a time period of 22 years for the two historical reaches, and 15 years for the expanded sampling area, which 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 three years (Figure 12). For the last four 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. Due to the high rate of fine sediment at that time, considerable 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 compiled and analyzed to better understand factors affecting in-channel fine sediment levels.

At the reach scale, some sampling sites were similar to 2005, while others had changed. Four of the sampling reaches had comparable average fine sediment conditions between 2006 and 2005, with less than 1.0% point difference (South Fork Little Naches Reach 1, Little Naches Reach 3, North Fork Little Naches Reach 1, and North Fork Little Naches Reach 2). Three other reaches had greater than a 1.0% point increase in average fines from the previous year (Little Naches Reach 2, Little Naches Reach 4, and Pyramid Creek Reach 1). Conversely, the remaining three reaches had a lower level of average fine sediment compared to 2005 (Little Naches Reach 1, Bear Creek Reach 1, and Bear Creek Reach 2). Overall sampling variability within individual reaches was not much different than 2005. Five of the reaches had a slightly higher standard deviation, one reach had the same standard deviation, and four reaches had a somewhat lower standard deviation than in 2005.

Monitoring results and changes at individual reaches can sometimes help identify site-specific sediment conditions or factors. This past year, the highest average fine sediment levels were found at Pyramid Creek Reach 1 (14.0%) and Little Naches Reach 4 (13.7%). The Pyramid Creek reach has gradually been increasing in fines, but the changes have been small and no major causal factors have been identified yet. Little Naches Reach 4 is in proximity to a major log jam and downstream from the landslide event that took place in the winter of 2001/2002. The sampling riffles above the log jam and closer proximity to the landslide had the highest fine sediment levels. The greatest increase in average fine sediment was found at Little Naches Reach 2 (approximately 4% point increase from 2005). Above this reach considerable bank erosion has taken place and trees have recruited to the channel. The beaver dams above this reach may also be failing in places. The lowest average fine sediment in 2006 was found at Bear Creek Reach 1. This reach also had the greatest reduction in fine sediment compared to 2005 (approximately 3.6% point decrease). It is not clear what has caused the much cleaner conditions. Some trail improvement work (trail relocation and bridges) was completed by the USFS upstream of this reach.

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 does not appear to be significantly different than in 2005 (9.7% at Little Naches Reach 1 and 12.3% at North Fork Reach 1). Little Naches Reach 1 did have a noticeable decrease in fines, but also had considerable variability between riffles. The average fine sediment in these historical reaches has improved and is approaching the earliest years of monitoring in 1985 (9.45% for LN Reach 1, 8.79% for NF Reach 1) and 1986 (8.45% for LN Reach 1, 9.33% for NF Reach 1).

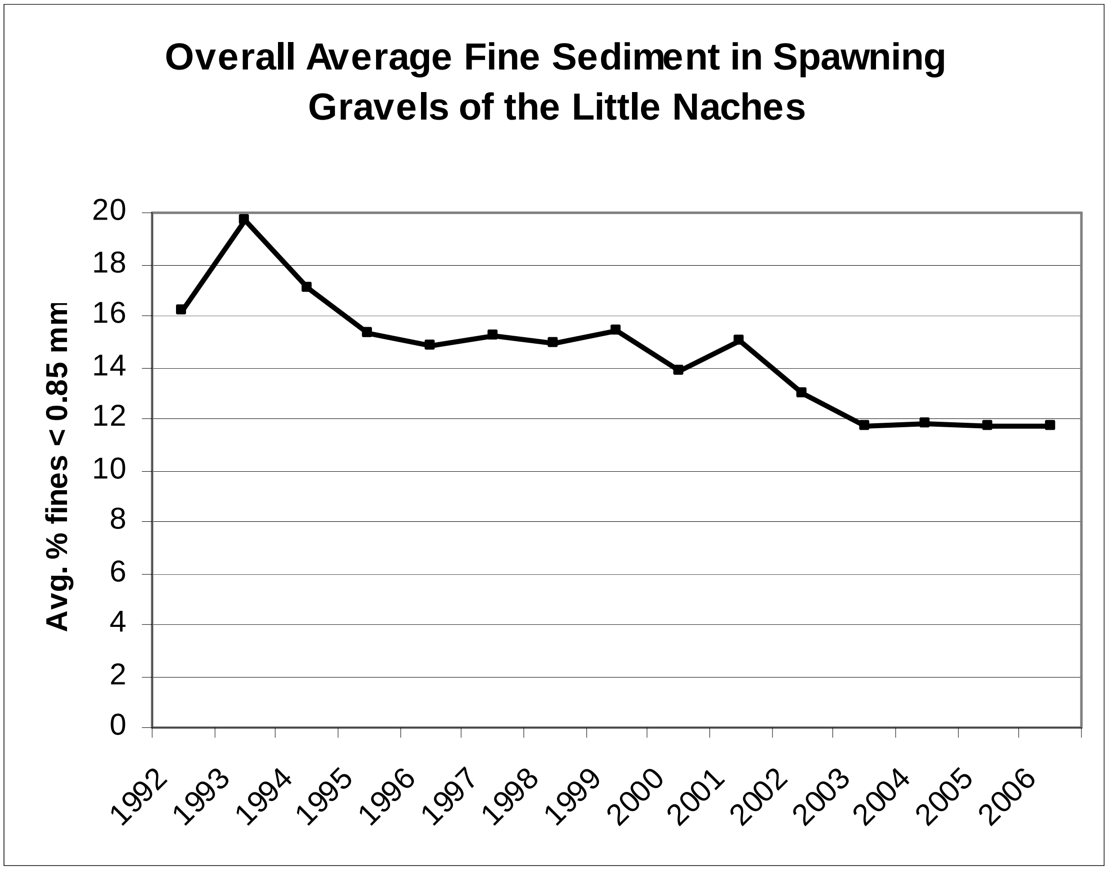


Figure 12. Overall Fine Sediment (<0.85mm) Trends in the Little Naches River Drainage, 1992-2006.

South Fork Tieton

One reach on the South Fork Tieton River (in the vicinity of Minnie Meadows) was sampled again this past season by the U.S. Forest Service. 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. This reach has now been sampled for eight consecutive years. This past year the reach average fine sediment, less than 0.85mm in size, is slightly higher than in 2005, but is not statistically significant (Figure 13). The latest conditions should moderate impacts on incubating eggs, but are still considerably higher than found in 1999. Upstream sediment sources should still be identified and corrected to ensure that favorable bull trout spawning conditions are achieved.

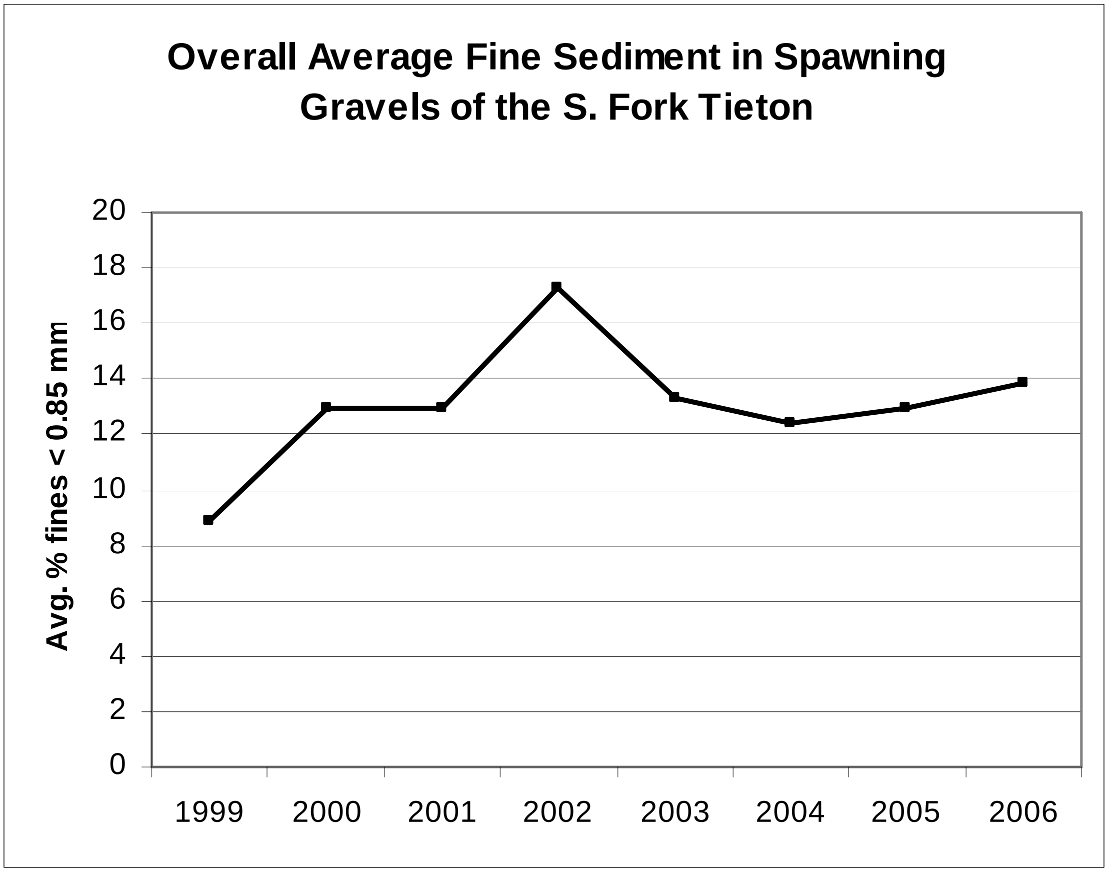


Figure 13. Fine Sediment Trends in the South Fork Tieton River, 1999-2006.

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 10 years. Average percent fine sediment less than 0.85mm by reach and for the combined Upper Yakima drainage samples has remained relatively constant over the past four years (Figure 14).

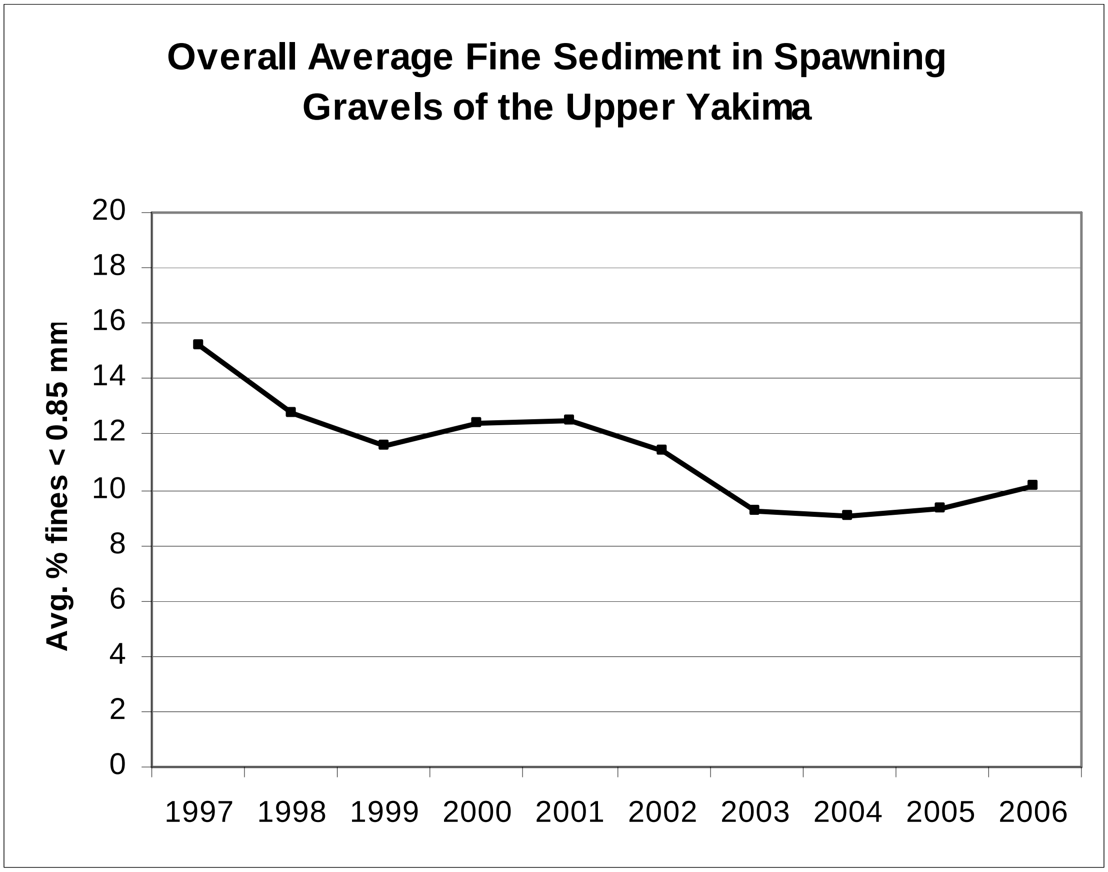


Figure 14. Fine Sediment Trends in the Upper Yakima River, 1997-2006.

Summary

The overall average fine sediment level in the Little Naches this past season was very similar to the previous three years. Overall average fine sediment in 2006 was 11.7%. This marks four years of reduced overall fine sediment conditions in the Little Naches drainage. The lower fine sediment levels should lessen impacts on egg and alevin survival. However, the latest improvement in spawning conditions only covers a short time frame. Further monitoring is needed to determine if this is a continuing trend or just a short term anomaly. Additional investigations of sediment sources and their contribution to the stream system is also very much needed. Without information on fine sediment delivery sources in the drainage it will be difficult to manage and correct problem conditions. In particular, dispersed camping and off road vehicle activities near streams, stream-adjacent roads, eroding banks, isolated unstable areas, and timber harvest should be evaluated for their delivery capability and effect on spawning conditions.

The sampling in the South Fork Tieton River by the USFS showed a similar level of fine sediment as found in the previous three years. Overall average fine sediment in 2006 for this reach was 13.8%. These conditions would be expected to have minor impacts on bull trout egg incubation and fry emergence. However, overall fine sediment levels remain considerably higher than those observed in 1999 (~9%) which are considered more favorable for egg and fry survival. For the Upper Yakima system, overall fine sediment in 2006 was 10.1%. Fine sediment sources and their causes should continue to be investigated, identified and addressed in all drainages.

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.y Biometrical Support

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

- 2006 Annual Report HI-LO smolt-to-smolt Survival (See Appendix B)
- 2006 Annual Report, Wild and Hatchery Smolt Survival of Roza Spring Chinook Releases (See Appendix C)
- Annual Report: Smolt Survival to McNary of Year-2006 Fall Chinook (Appendix D) and Coho (Appendix E) Releases into the Yakima Basin

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 Yakima Subbasin Harvest Monitoring

Rationale: To develop a database to track the contribution of target stocks to in-basin fisheries.

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 6.

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

Table 6. A summary of Yakama Nation tributary estimated harvest in the Yakima Subbasin, 2006.

River	Dates	Weekly Schedule	Notes	Chinook	Jacks	Steelhead	Coho
Yakima River	4/11-7/1	Noon Tues to 6 PM Saturday		579	21	0	0
Yakima River	9/19-11/25	Noon Tues to 6 PM Saturday		0	0	0	0

GENETICS

Overall Objective: Develop methods of detecting significant PAPS genetic changes in extinction risk, within-stock genetic variability, between-stock variability and domestication selection.

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   Allozyme/DNA data collection and analysis.
- Task 3.b   Stray recovery on Naches and American river spawning grounds.
- Task 3.c   Yakima spring Chinook domestication.

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

Busack, C., A. Fritts, T. Kassler, J. Loxterman, T. Pearsons, S. Schroder, M. Small, S. Young, C. M. Knudsen, G. Hart, and P. Huffman. 2007. Yakima Fisheries Project Genetic Studies, Yakima/Klickitat Fisheries Project Monitoring and Evaluation, Annual Report 2006. Project No. 1995-063-25; BPA Report DOE/BP-00027871.

ECOLOGICAL INTERACTIONS

Overall Objective: To develop monitoring methods to determine if supplementation and enhancement efforts keep ecological interactions on non-target taxa of concern within prescribed limits and to determine if ecological interactions limit supplementation or enhancement success.

Task 4.a   Avian Predation Index

Rationale: To assess the annual impact of avian predation upon juvenile salmonid populations on the Yakima River.

Methods: The methods used to monitor avian predation on the Yakima River in 2006 were consistent with the techniques used in 2001-2005. 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: Pelican, Double-crested Cormorant, Great Blue Heron and Common Merganser roosting and nesting sites were examined for the presence of salmon PIT tags in August and September. Sites surveyed included the Yakima River Canyon above Roza Dam, areas near the Selah gravel ponds (both pond islands and a gravel bar in the Yakima River itself) and cormorant and heron rookeries along the Yakima River near Selah and at Satus Wildlife Management Area on the Yakama Reservation.

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

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

- Merganser, pelican and heron populations slightly declined from 2004-2005 levels. Gulls remain common in only one lower river reach.

- Cormorant populations are increasing in the middle and lower river, consuming 13.5% of the small fish biomass (all species) taken by birds in spring 2006, up from 3.5% in 2004-2005.

- Pelicans dominate fish consumption in spring, taking 64% of the small fish biomass (all species) eaten by birds. Mergansers consumed 12% of the small fish biomass taken by birds in spring.

- Pelicans could potentially consume the entire hatchery production of fall chinook smolts and yet only supply 26% of their diet. Mergansers could potentially consume 35% of the hatchery spring chinook biomass.

- Pelican numbers at Chandler were far reduced in 2006 compared to 2004-2005, with moderate numbers only after smolt passage had ceased.

- Based on energetics alone, Chandler pelicans could consume up to 286,000 smolts, predominately fall chinook. Based on a behavioral model, Horn Rapids gulls consumed 93,000 smolts, also predominately fall chinook. These totals give an extreme upper limit of smolt consumption of about 10% of the total hatchery smolt production. The actual total is far lower, with field observations of pelicans indicating they often feed on fish at Chandler and Selah Ponds far larger than salmon smolts, including suckers, pikeminnow and bullhead.

- Correlation analysis 2004-2006 suggests that Chandler pelicans and Horn Rapids gulls are tracking coho passage and are not tracking spring chinook, fall chinook, or steelhead passage.

- The higher the river volume during peak smolt out-migration the lower the predation rate by birds. Chandler Bypass pipe orientation makes fish vulnerable to predation at low water. At high water, Chandler smolts are largely invulnerable from bird predation.

- PIT tags found at 6 predatory bird sites in the Yakima River indicate that cormorants and pelicans are expanding in the mid-Yakima River area, feeding on more hatchery coho and spring chinook smolts than hatchery fall chinook and steelhead. 559 tags were found representing 11,771 smolts consumed between the years 2000-2006, 41.5% by cormorants, 30% by pelicans and 26% by herons. The growth of cormorant numbers in the Yakima River follows increases in their populations in the Mid-Columbia River and Columbia River Estuary.

- PIT tag detections from a lower river heron colony suggest that under low water conditions, coho smolts may be vulnerable to predation in river sloughs. Cormorants may have begun displacing herons in the Selah nesting colony.

- PIT tag detections in Selah and Roza indicate that pelicans on the Yakima River are part of the larger Mid-Columbia River pelican population, moving between the two rivers, and also moving up and down the Yakima River.

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 2006, American White Pelicans appeared to have expanded their range in the Yakima Basin, becoming more common in the Yakima River Canyon, Selah, Toppenish Creek, and the Naches River, possibly searching for new island nesting sites. Because of their growing presence throughout the Basin, we directed greater efforts to monitoring pelicans in the middle Yakima River in Selah and the Yakima River Canyon, and in lower river reaches below Parker.

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, suckers and wild fall chinook exiting from the fish bypass pipe. Gull numbers at Horn Rapids were also consistently low at high water.

In 2006, as in the previous 6 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, while consumption estimates of American White Pelicans were based on abundance estimates and daily food requirements. 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 and cormorants appear to be the only significant predators on salmon smolts in the lower river and mergansers in the upper river during normal conditions at present.

As in all the previous years, Common Mergansers were the most significant fish predator in the upper river, consuming 92% of the fish biomass consumed by birds in these reaches, potentially consuming 35% of the hatchery spring chinook and 32% of the hatchery coho smolts present. However, an earlier 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.

As in the previous three years, American White Pelicans were the dominant bird consumer of fish in the lower river in spring, consuming over 64% of the fish consumed by birds in the lower river and 64% of the fish biomass consumed by birds on the entire river. Pelicans inhabiting the lower river could potentially consume the entire hatchery production of fall chinook smolts released in the lower river (2.1 million smolts) and yet only supply 26% 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 17.5 birds per day at

Chandler, down from 57 birds per day in 2005, but this was based on a smaller data set with less systematic surveys. 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 an estimated 247,000 to 286,000 (over 90% fall chinook) in 2006, down from an estimated 826,000 smolts in 2005. However a number of lines of evidence including correlation analysis and anecdotal observations clearly call these assumptions into question, making these huge smolt consumption estimates for pelicans in 2005-2006 highly doubtful.

Correlation analysis suggests pelicans are not primarily tracking fall chinook at Chandler, but instead may be tracking coho smolts. Pelican numbers at Chandler showed the highest, moderate correlations with the coho smolt runs in 2004-2006, and the weakest correlations with fall chinook, spring chinook and steelhead smolt runs. The size of smolts may be an important factor in the bioenergetics of pelican consumption. Coho smolts averaged 31 g, while fall chinook smolts averaged about 6 g. The fall chinook smolts may be far too small to be an efficient food source for pelicans. Anecdotal observations at Chandler bypass pipe and Selah Pond suggest pelicans are also consuming significant numbers of other fish species of size classes larger than salmon smolts, including sucker, chiselmouth, northern pikeminnow and bullhead.

Gulls numbers at Horn Rapids in 2006 remained similar to the levels in 2005, declining from about 6 birds per day to about 5 birds per day. Gulls were estimated to have consumed 93,000 fish this past year at Horn Rapids, an increase of 400% from the totals in 2005. Like in 2005, gull presence and predation at Chandler was minimal. The increase in predation at Horn Rapids alters the declining trend in gull consumption at the hotspots between 2002-2005. The total gull consumption in 2006 represents about 2.7% of the more than 3.4 million smolts that passed Chandler. In a pattern similar to the pelicans at Chandler, gull numbers at Horn Rapids in 2004-2006 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 2006, as it was in 2004-2005.

Pelicans were captured with padded leg-hold traps to facilitate monitoring their movements and diet in the Yakima River in Selah and at Chandler Fish Bypass. A total of four immature pelicans were wing-tagged and leg banded at Chandler and Selah; 3 were fitted with radio-transmitters. Radio-tagged animals were relocated during river reach surveys in the lower river, at Chandler, and during aerial surveys of the lower Yakima Basin. No stomach samples could be obtained from captured pelicans.

A total of 559 PIT tags from smolts marked between 2000-2006 were recovered at the 6 sites, 276 spring chinook, 171 coho, 95 fall chinook, and 6 steelhead. Most of the tags were from the last three years. These 559 tags represent at least 11,771 smolts consumed by birds, 39% by cormorants, 28% by pelicans and 24% by herons. The Selah Rookery, a cormorant and heron site, had nearly 46% of the tags collected, with the Chandler Fish Bypass, a pelican site, yielding another 21%. The 171 coho tags represent 6,240 fish or 53%, predominately taken by cormorants and herons. The 276 spring chinook tags represent 4,388 fish or 37%, predominately taken by cormorants and pelicans. The 95 fall chinook tags represent 1,100 fish, with pelicans surprisingly taking 70%.

The high number to tags recovered from heron colonies is surprising, given the fish consumption estimates developed for herons using the river reach model are relatively low (5-8% of small fish biomass eaten by birds per year 2005-2006). Herons consumed an estimated 36% of the coho smolts, 15% of the spring chinook and 8% of the fall chinook smolts sampled by PIT tag returns. Coho smolts may be vulnerable to heron predation in river sloughs during low water. The tag recoveries from the Selah Rookery, dominated by cormorants in 2006, contribute to the findings of the river reach survey that suggest that cormorants are increasingly becoming a major factor in fish predation and more specifically smolt predation in the middle and lower Yakima River between Roza and Zillah. Based on tag returns, cormorants took an estimated 39% of the smolts eaten by birds, while the data from the river reach survey suggests that in 2006 they took 13.5% of the small fish consumed by birds in the entire river, up from 3.5% in 2005. PIT tags collected from Roza and Selah Bars indicate the expansion of pelicans in the Canyon and in the lower river between Roza and Parker. They also show movements of pelicans and cormorants between the Columbia and Yakima Rivers as well as broad movement of pelicans within the Yakima River Basin.

Plans for the 2007 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 4 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 is the project biologist 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 (Yakama Nation Portion Only)

Rationale: Develop an index of the mortality rate of upper Yakima spring Chinook attributable to non-salmonid piscivorous fish in the lower Yakima. This index will be used to estimate the contribution of in-basin predation to fluctuations in hatchery and wild smolt-to-adult survival rate.

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 for the 2006 season. Unlike previous years where we tried to select pool habitat, 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 work associated with population estimates, stomach samples were collected in separate trials and all fish greater than 200 cm in fork length were collected within the population estimate 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 15). 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 later the same week 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 12,197. With the 95% confidence interval the population was between 7,430 and 27,106. While the interval would seem large it represents the best approximation given the difficulties associated with sampling such a large riverine system.

In spring of 2006 30 NPM were radio-tagged to determine their movement patterns. Movement pattern data was needed to determine if the assumption of mark recapture for a closed system was being met. It was widely believed that out migration might be a factor in limiting the success of mark/recapture methodology used in the Toppenish area in previous years. The results of the tracking appeared to indicate that movement by NPM was limited. Limited fish movement would not interfere with our research as long as a large enough sample was marked.

For the summer of 2006, few stomach samples were taken due to missing an out migration window for smolt prey. Normally stomachs would have been collected while recapturing. Last year it was decided that stomach samples would be postponed until population estimates were completed. A summary of NPM stomach contents collected in 2005 is presented in Table 8. A total of 41 stomachs were collected during the spring 2005 field season. Of these, 11 stomachs were empty. All stomachs with fish present were further analyzed to determine the species using diagnostic bones to identify them. Only about 1 in 5 fish found in NPM stomachs with fish were salmonid species.

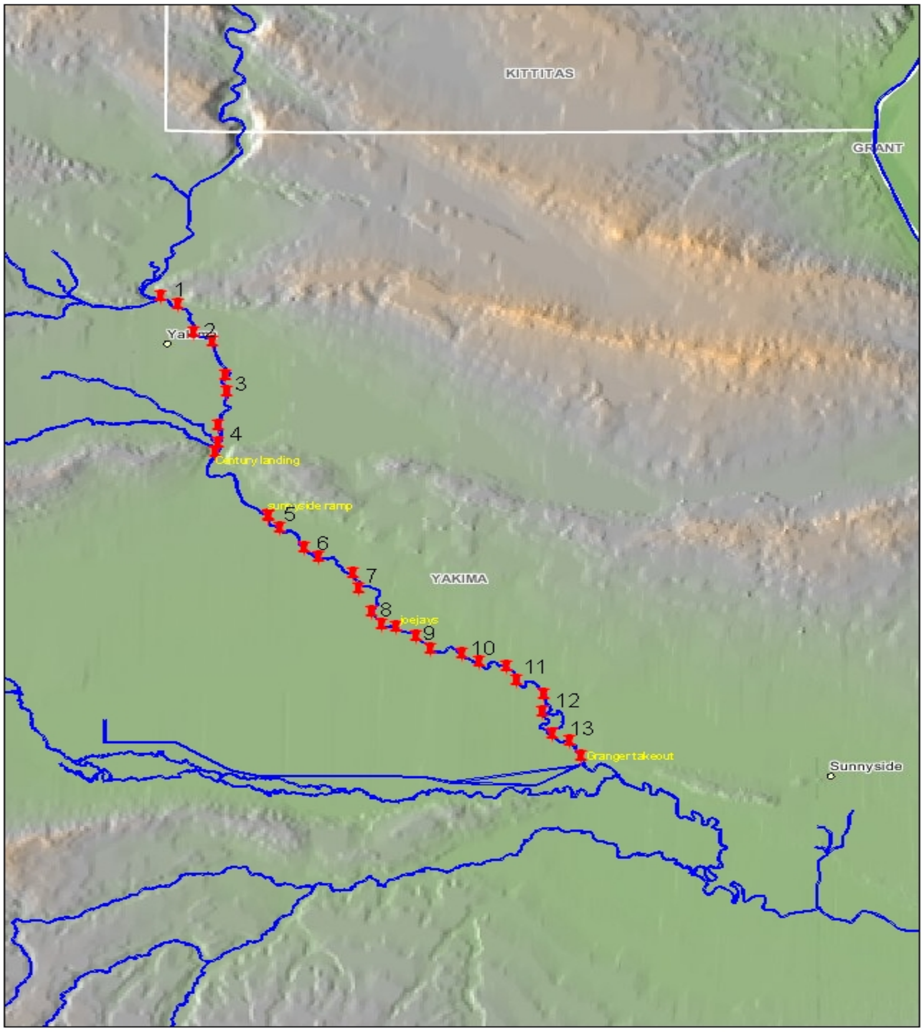


Figure 15. Current location of Northern pikeminnow sample sites.
[a] Each site is 1 mile long and 2 miles separate them.

Table 7. Summary of species found in Northern pikeminnow stomachs sampled in the Yakima Basin in 2005.

Species	Count found in NPM stomachs
Sculpin	4
Red Side Shiner	6
Stickle Back	1
Sucker	1
Lamprey	1
Salmon (unknown species)	4
Steelhead	1
Pumpkin Seed	1
Total All Species	**19**

Task 4.d Yakima River Spring Chinook Competition/Prey Index

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, B. B. James, and G. M.Temple. 2007. Spring Chinook Salmon Interactions Indices and Residual/Precocious Male Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation. Annual Report 2006. DOE/BP-00027871.

Task 4.e 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. 2007. Ecological Interactions between Non-target Taxa of Concern and Hatchery Supplemented Salmon. Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report. 2006 Annual Report, Project No. 199506325, DOE/BP-00027871. Bonneville Power Administration, Portland, Oregon.

Task 4.f Pathogen Sampling

The 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.

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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 F

	Task	
A.		Yakima River / CESRF Spring Chinook Salmon – Yakama Nation Data Summary
B.	1.d.	IntStats, Inc. Annual Report: 2004 through 2006 Smolt-to-Smolt Survival of Upper Yakima Spring Chinook from Release to McNary Dam Smolt Passage for Brood Years 2002-2004
C.	1.e.	IntStats, Inc. Annual Report: Smolt Survival to McNary Dam of Year-2006 Spring Chinook Releases at Roza Dam
D.	1.g.	IntStats, Inc. 2006 Annual Report: Smolt-to-Smolt Survival to McNary Dam of Main-Stem-Yakima Fall Chinook
E.	1.h.	IntStats, Inc. Annual Report: 2006 Smolt Survival Index to McNary [for] Coho Releases into the Yakima Basin
F.	4.a.	Monitoring and Evaluation of Avian Predation on Juvenile Salmonids on the Yakima River, Washington. Annual Report 2006.

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

2006 Annual Report

July 20, 2007

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Project Numbers: 1995-063-25
Contract Numbers: 00027798

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, Jim Siegel, 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 2006. 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 latest 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. All wild/natural fish passing through the Roza trap are returned directly to the river with the exception of fish collected for broodstock or fish with a metal tag detection which are sampled for marks and biological characteristics. 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).

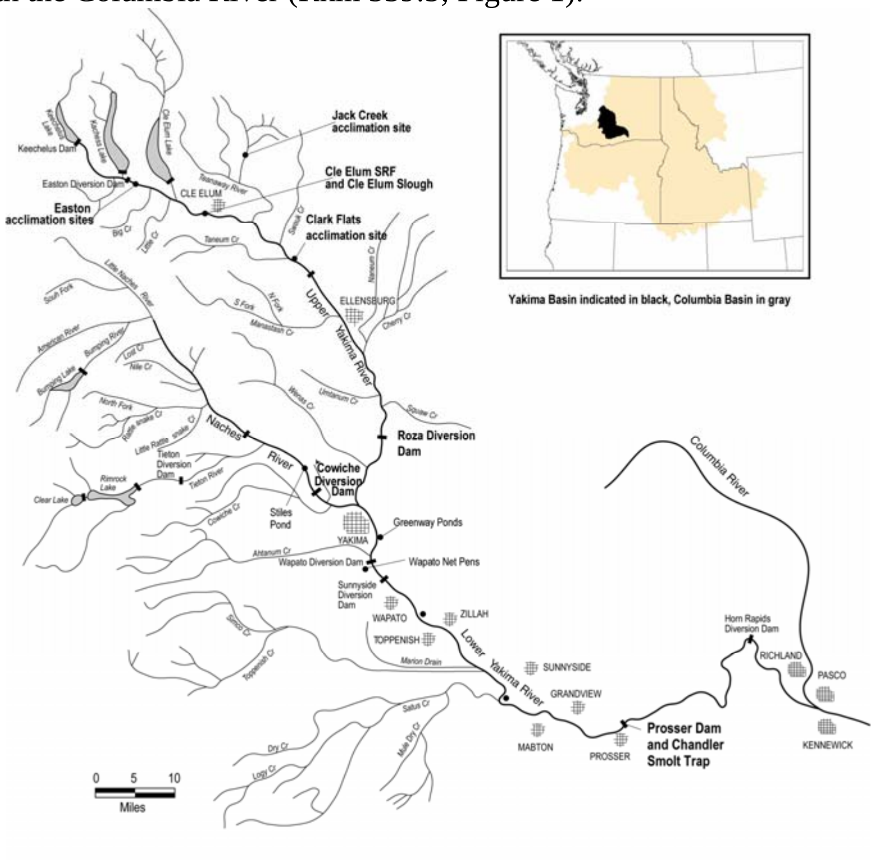


Figure 1. Yakima River Basin.

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).

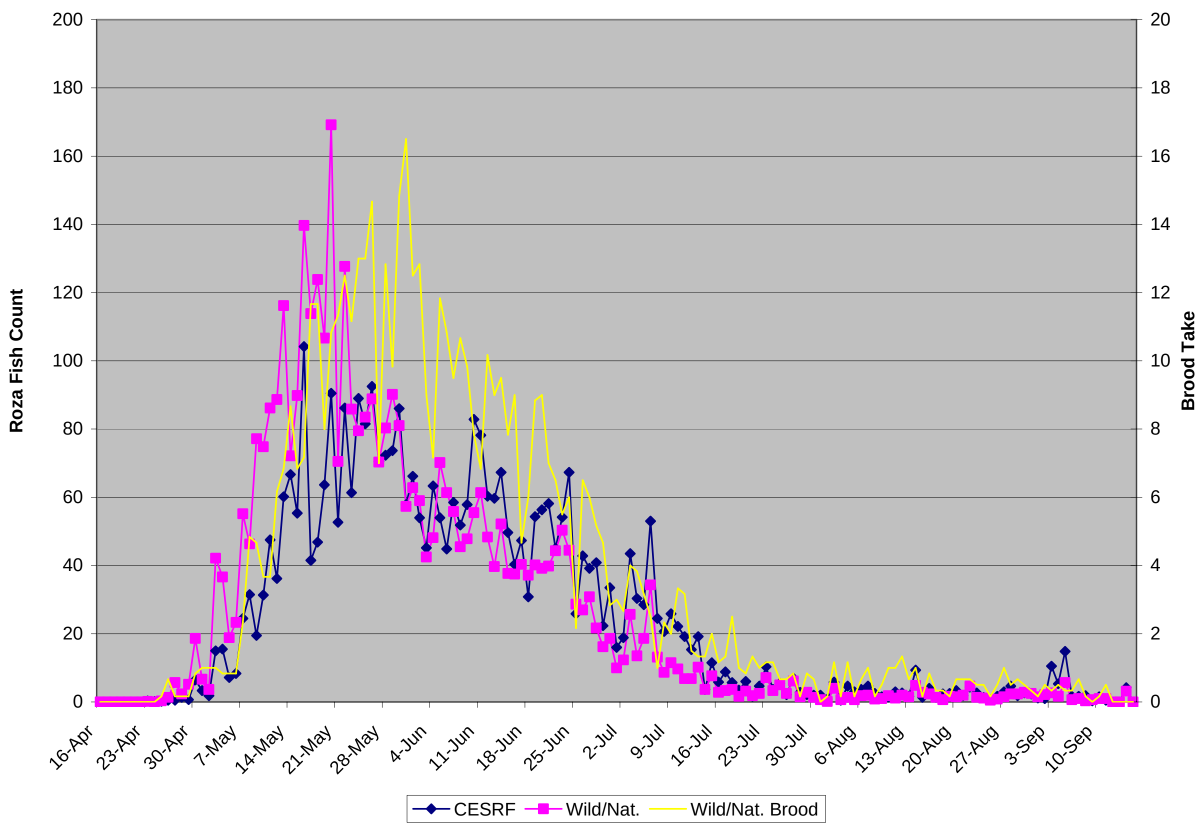


Figure 2. Mean spring Chinook run timing and broodstock collection at Roza Dam, 2001-2006.

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

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

Year	Trap Count	Brood Take	Brood %	Portion of run collected:[1] Early[3]	Middle[3]	Late[3]	Portion of collection from:[2] Early[3]	Middle[3]	Late[3]
1997	1,445	261	18.1%	26.4%	17.6%	17.7%	7.3%	83.1%	9.6%
1998	795	408	51.3%	51.1%	51.3%	51.9%	5.6%	84.3%	10.0%
1999	1,704	738	43.3%	44.6%	44.1%	35.9%	5.6%	86.3%	8.1%
2000	11,639	567	4.9%	10.7%	4.5%	4.4%	12.5%	77.8%	9.7%
2001	5,346	595	11.1%	6.9%	11.4%	10.7%	3.0%	87.7%	9.2%
2002	2,538	629	24.8%	15.7%	25.2%	26.1%	3.2%	86.3%	10.5%
2003	1,558	441	28.3%	52.5%	25.9%	36.4%	9.5%	77.8%	12.7%
2004	7,804	597	7.6%	2.6%	7.4%	12.8%	2.0%	81.6%	16.4%
2005	5,086	526	10.3%	2.2%	9.5%	21.9%	1.3%	77.0%	21.7%
2006	2,050	519	25.3%	48.5%	22.2%	41.0%	9.1%	75.1%	15.8%

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%
Mean[3]	3,161	309	3,470	3,048	493	3,541	6,234	839	7,073	50.4%	67.7%

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

Table 3. Yakima River spring Chinook run (CESRF and wild, adults and jacks combined) reconstruction, 1982-present.

	River Mouth Run Size[1]			Harvest	Prosser	Harvest	Spawners	Roza	Roza	Est. Escapement		Redd Counts	
Year	Adults	Jacks	Total	Below Prosser	Count	Above Prosser	Below Roza[2]	Count	Removals[3]	Upper Y.R.[4]	Naches[5]	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	5,952	361	6,314	0	6,314	600	0	4,028	664	3,364	1,686	1,235	444
Mean[6]	9,261	1,003	10,264	245	10,019	1,231	80	6,294	630	5,663	2,415	1,814	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 (1997-2006).

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

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

Brood	Estimated	Estimated Yakima R. Mouth Returns				Returns/
Year	Spawners	Age-3	Age-4	Age-5	Total	Spawner
1982	1,280	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	251	6,133	0.51
2002	8,073	225	1,936		2,161	0.27
2003	3,341[1]	165				
2004	10,377					
2005	5,713					
2006	3,364					
Mean	3,836	300	3,208	135	3,643	0.95

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	Estimated	Estimated Yakima R. Mouth Returns					Returns/
Year	Spawners	Age-3	Age-4	Age-5	Age-6	Total	Spawner
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	520		1,902	0.49
2002	1,861	59	780			839	0.45
2003	1,400	55					
2004	2,197						
2005	1,434						
2006	1,270						
Mean	1,318	80	1,066	486	4	1,605	1.22

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					Returns/ Spawner
		Age-3	Age-4	Age-5	Age-6	Total	
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	278		666	0.35
2002	1,180	19	278			297	0.25
2003	1,192	24					
2004	318						
2005	469						
2006	416						
Mean	543	30	282	337	1	628	1.16

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	862		2,613	0.45
2002	3,041	78	993			1,071	0.35
2003	2,592	79					
2004	2,515						
2005	1,904						
2006	1,686						
Mean	1,861	110	1,308	854	12	2,228	1.20

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	Estimated	Estimated Yakima R. Mouth Returns				Returns/
Year	Spawners	Age-3	Age-4	Age-5	Total	Spawner
1997	261	741	7,753	176	8,670	33.22
1998	408	1,242	7,939	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	13	1,218	2.05
2002	629	336	1,719		2,055	3.27
2003	441	110				
2004	597					
2005	510					
2006	419					
Mean	517	574	3,742	171	4,536	8.78

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 2006, 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 Year	Males					Females					Total			
	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		45.5	54.5		33		50.0	50.0	
Mean	1.1	47.6	50.8	0.5			38.2	59.8	2.0		0.4	40.2	57.7	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		58.3	41.7		12		60.0	40.0	
Mean	3.1	63.4	32.5	1.0		0.8	50.3	48.4	0.5		1.7	55.9	41.7	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
Mean	12.8	82.6	4.5		1.5	92.3	6.3		6.7	87.7	5.6

Carcasses from upper Yakima River CESRF origin fish allowed to spawn naturally have also been sampled since age-4 adults began returning in 2001. These fish averaged 15, 82, and 3 percent age-3, -4, and –5, respectively (Table 12) from 2001-2006 compared to 10, 83, and 7 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	
Mean	35.1	63.1	1.8		0.2	96.1	3.0		15.3	82.2	2.5

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

Return	Males				Females				Total		
Year	3	4	5	n	3	4	5	n	3	4	5
1997	4.5	92.0	3.4	88		94.6	5.4	111	2.0	93.5	4.5
1998	22.4	73.1	4.5	134		91.6	8.4	179	9.6	83.7	6.7
1999	71.1	26.1	2.8	425		92.6	7.4	215	48.8	47.0	4.2
2000	17.8	81.7	0.4	230		98.7	1.3	313	7.5	91.5	0.9
2001	12.4	77.4	10.3	234	0.9	90.5	8.5	328	5.7	85.2	9.2
2002	16.4	78.3	5.3	226	0.6	94.8	4.7	343	6.9	88.2	4.9
2003	27.4	60.2	12.4	201		83.3	16.7	228	12.8	72.6	14.7
2004	15.1	84.5	0.4	239	0.3	99.0	0.7	305	6.8	92.6	0.6
2005	15.5	82.3	2.2	181	0.4	97.1	2.5	276	6.3	91.2	2.4
2006	11.1	77.4	11.5	226		89.4	10.6	255	5.2	83.8	11.0
Mean	21.4	73.3	5.3		0.2	93.2	6.6		11.2	82.9	5.9

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
Mean	19.8	73.7	6.5			91.3	8.7		9.0	83.3	7.6

Sex Composition

In the American River, the mean proportion of males to females in wild/natural carcasses sampled on the spawning grounds from 1986-2006 was 47:53 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 45:55 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 1997-2006, the mean proportion of males to females was 39:61 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 36:64 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			34.8	65.2	21.7	78.3		
mean			46.7	53.3	33.0	67.0		

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			53.3	46.7	50.0	50.0		
mean			44.8	55.2	26.4	73.6		

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
mean	82.4	17.6	32.3	67.7	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		
mean	96.5	3.5	23.0	77.0		

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
mean	97.9	2.1	38.6	61.4	37.2	62.8

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

Return	Age-3		Age-4		Age-5	
Year	M	F	M	F	M	F
2001	100.0	0.0	31.8	68.2		
2002	100.0	0.0	33.5	66.5	33.3	66.7
2003	100.0	0.0	37.9	62.1	44.7	55.3
2004	100.0	0.0	38.1	61.9		
2005	100.0	0.0	39.5	60.5	30.0	70.0
2006	100.0	0.0	42.5	57.5	100.0	
mean	100.0	0.0	37.2	62.8	52.0	48.0

Size at Age

Prior to 1996, samplers were instructed to collect mid-eye to hypural plate (MEHP) lengths from carcasses surveyed on the spawning grounds. From 1996 to present the method was changed and post-eye to hypural plate (POHP) lengths have been recorded. Mean POHP lengths averaged 40, 59, 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 1996-2006 (Table 21). In the Naches River, mean POHP lengths averaged 41, 60, and 76 cm for age-3, -4, and -5 males, and averaged 61 and 73 cm for age-4 and -5 females, respectively (Table 22). For wild/natural spring Chinook sampled on the spawning grounds in the upper Yakima River, mean POHP lengths averaged 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 2001-2006, 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			15	60.8	18	71.9		
Mean[2]		40.0		59.5		76.9				62.2		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 1996-2006 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					7	63.1	5	71.4		
Mean[2]		40.9		59.9		76.2		78.0		41.0		61.2		72.6		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 1996-2006 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
Mean[1]		42.9		59.8		71.9		44.4		59.5		68.7

[1] Mean of mean values for 1996-2006 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		
Mean		44.4		59.0		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.

	Males						Females					
Return	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP
1997	4	39.7	81	59.7	3	73.3			105	60.5	6	68.9
1998	28	43.0	95	57.3	6	67.0			161	59.2	15	65.6
1999	124	41.4	75	59.5	10	64.6			199	60.4	16	67.4
2000	19	42.0	145	59.0	1	77.0			263	59.4	3	69.4
2001	17	42.9	115	59.6	14	74.1			196	60.5	19	69.8
2002	23	42.1	113	60.6	5	72.9	1	36.6	233	61.2	9	70.9
2003	37	42.7	92	60.4	19	73.7			164	61.4	31	69.4
2004	18	42.4	108	58.9	1	67.8			225	58.3	2	66.5
2005	19	42.1	113	60.0	2	67.3	1	42.6	223	59.8	5	67.8
2006	17	41.0	82	56.7	20	70.4			197	57.8	24	68.1
Mean		41.9		59.2		70.8				59.8		68.4

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

	Males						Females					
Return	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2001			4	61.3					33	60.4		
2002	2	40.2	25	59.6					63	59.4	2	66.1
2003	17	42.6	16	57.8	15	74.0			31	59.7	19	70.4
2004	6	39.4	9	57.1					42	59.3		
2005	6	37.9	21	58.4	2	68.7			38	58.6	5	68.0
2006[1]			3	57.2					3	56.3		
Mean		40.0		58.6		71.3				59.0		68.2

[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			26	41.0	409	58.7	53	71.2
Mean				42.1		60.4		70.7

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

Return	Age 2		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2000	66	15.9	633	38.3				
2001	893	15.2	474	40.0	2343	59.3		
2002	475	15.2	26	38.7	1535	59.2	34	67.0
2003	137	15.7	394	41.8	255	60.6	215	71.4
2004	83	15.5	49	40.4	451	59.5	2	71.0
2005	137	15.6	98	40.4	218	59.3	18	70.1
2006	26	14.5	26	40.4	406	57.5	3	71.0
Mean		15.4		40.0		59.2		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).

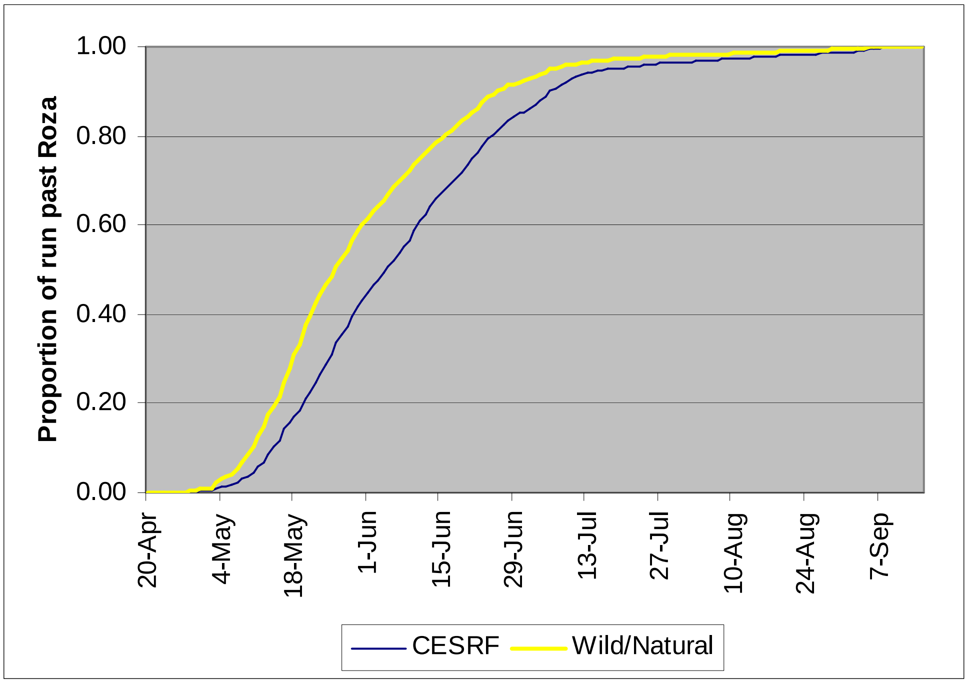


Figure 3. Proportionate passage timing at Roza Dam of wild/natural and CESRF adult spring Chinook (including jacks), 2001-2006.

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

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
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
Mean	1,018	127	15	1,160	158	185	110	48	500

[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 late May, 2006 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	95	4	4.21%	2,049			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. 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%			
Mean	528	66	87.4%	140	224	8.1%	764,703	702,513	8.1%	687,919	98.0%	653,851	93.8%	92.3%

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%			
Mean	143	16	88.9%	26	52	1.3%	189,254	89,397	8.4%	87,773	98.2%	90,357	97.3%	96.9%

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.

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.

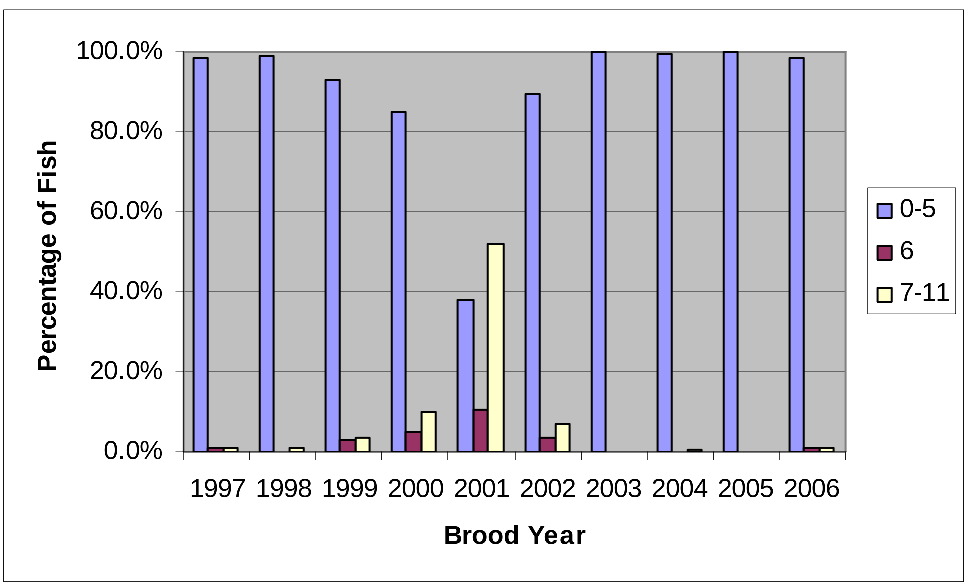


Figure 4. Proportion of wild/natural females spawned at CESRF by BKD rank, 1997 – present.

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 (SH)					
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			181	3,371.7	23	4,683.8			32	3,115.4		
Mean				3,822.1		4,686.0				3,708.2		4,641.2

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		
Mean	1.0	1.0	1.3	1.2	1.3	1.2	2.1	1.6	2.3	0.6	1.2	1.3	0.7

Length and Weight Growth Profiles

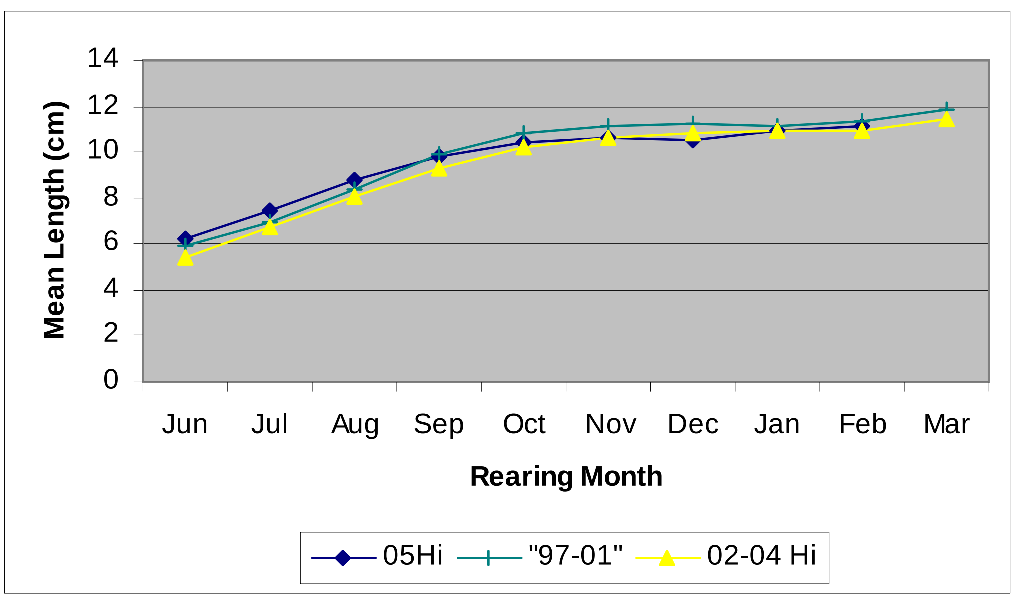


Figure 5. Mean length (cm) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - 2005.

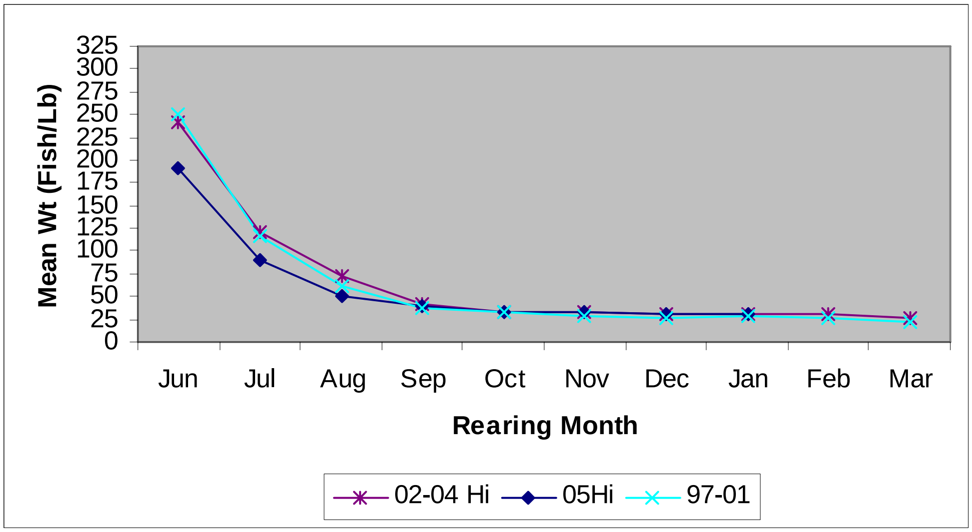


Figure 6. Mean Weight (fish/lb) of "standard growth treatment (Hi)" CESRF juveniles by brood year and growth month, 1997 - 2005.

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 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
Mean	347,823	346,187	239,746	230,238	252,029	694,010

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
Mean	43,432	43,030	42,950	43,988	43,436

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

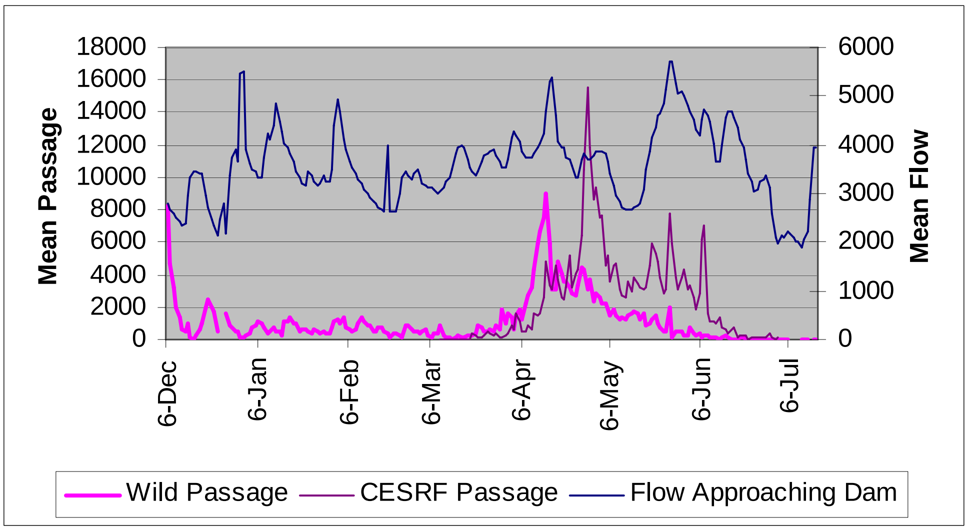


Figure 7. Mean flow approaching Prosser Dam versus mean estimated smolt passage at Prosser of aggregate wild/natural and CESRF spring Chinook for outmigration years 1999-2006.

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.

[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.

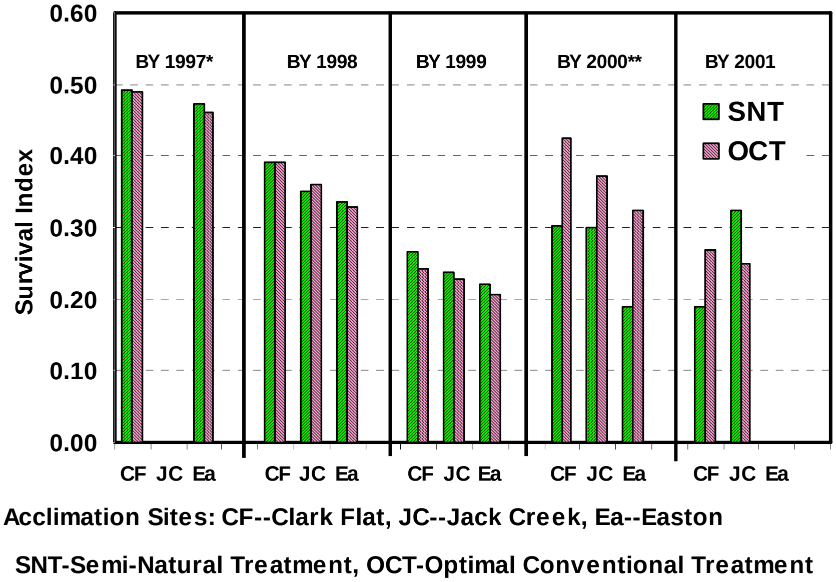
There is insufficient evidence that the SNT treatment resulted in higher smolt-to-smolt survival index than did the OCT treatment over the five broods (the hypothesis to be tested). Based on a one-sided sign test, the SNT fish had a significantly higher smolt-to-smolt survival index than did the OCT 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.

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.

		Brood Year 1997		Brood Year 1998		
		Acclimation Site		Acclimation Site		
Treatment		Clark Flat	Easton	Clark Flat	Jack Creek	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**

		Brood Year 1999			Brood Year 2000			Brood Year 2001	
		Acclimation Site			Acclimation Site			Acclimation Site	
Treatment		Clark Flat	Jack Creek	Easton	Clark Flat	Jack Creek	Easton	Clark Flat	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.



* 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 10grams/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.

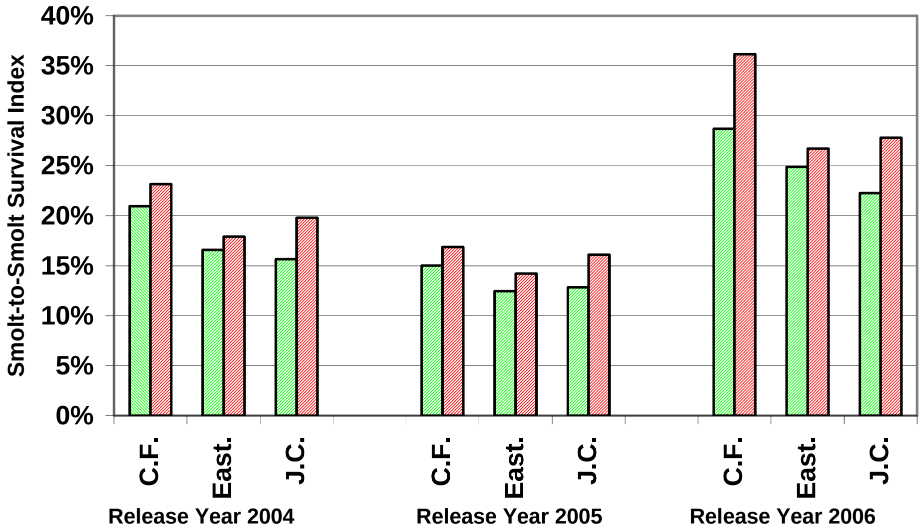


Figure 9. Volitional-Release-to-McNary Smolt-to-Smolt Survival Indices for Brood-Year 2002, 2003, 2004 Low- and High-Nutrition treated Upper Yakima Spring Chinook Smolts in release-year 2004, 2005, and 2006 (Low, downward slash; High, upward slash).

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. In years such as 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 (X2-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%	8,746	1,218	3.3%	1.1%
2002	2004	2439	137,343	155,031	145,056	300,087	35.9%	3,233[7]	2,055[7]	2.4%[7]	0.7%[7]
2003	2005	1285	157,057	124,412	106,253	230,665	28.0%				
2004	2006	5652	92,175	86,308	73,044	159,352	20.3%				

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.

Brood Year	Number Tagged	Wild/Natural smolts tagged at Roza Adult Returns at Age[1] Age 3	Age 4	Age 5	Total	SAR[1]
1997	310	0	1	0	1	0.32%[2]
1998	6,209	15	171	14	200	3.22%
1999	2,179	2	8	0	10	0.46%
2000	8,718	1	51	1	53	0.61%
2001	7,804	9	52	3	64	0.82%
2002	3,931	2	41		43	1.09%
2003	1,733	0				

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.

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

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 Age3	Age4	Age5	Total	SAR	Adult Detections at Roza Dam Age3	Age4	Age5	Total	SAR
1997[2]	39,892	18	182	4	204	0.51%	65	517	16	598	1.50%
1998	37,385	49	478	48	575	1.54%	54	310	34	398	1.06%
1999	38,791	1	25	1	27	0.07%	1	22	0	23	0.06%
2000	37,580	42	159	2	203	0.54%	37	112	1	150	0.40%
2001	30,087	32	71	0	103	0.34%	22	58	0	80	0.27%
2002[3]	39,996	25	119		144	0.36%	15	80		95	0.24%
2003	39,996	7					3				

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	551,217	936	5,834	534	7,304	1.33%
1999	718,990	103	652	13	768	0.11%
2000	794,228	1,005	2,764	69	3,837	0.48%
2001	340,149	290	791	14	1,095	0.32%
2002[3]	796,908	332	1,766		2,098	0.26%
2003	784,696	115				

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%
Mean	371	625	386	153	757	665	849	12.1%

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	2,052	88	110	1,302	25	223	223	0	10.9%	
1995	1,243	0	75	666	79	155	155	0	12.5%	
1996	5,686	4	308	3,179	475	787	787	0	13.8%	
1997	5,216	2	378	3,173	575	956	956	0	18.3%	
1998	2,709	2	155	1,903	188	345	345	0	12.7%	
1999	3,974	3	201	2,781	604	809	809	0	20.3%	
2000	27,434	55	1,732	19,100	2,458	4,245	4,123	122	15.5%	
2001	30,010	1,004	3,937	23,265	4,630	9,572	5,499	4,072	31.9%	30.5%
2002	22,865	1,388	2,569	15,099	3,108	7,065	2,600	4,464	30.9%	26.3%
2003	10,360	354	901	6,957	440	1,694	1,076	618	16.4%	16.0%
2004	21,857	1,109	1,941	15,289	1,679	4,728	2,724	2,005	21.6%	17.3%
2005	12,380	387	897	8,758	474	1,759	1,400	359	14.2%	13.5%
2006[1]	11,649	330	928	6,314	600	1,858	1,286	573	16.0%	16.5%
Mean	9,024	275	743	6,283	859	1,878	1,392	2,304	17.8%	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 May 24, 2007 for CESRF spring Chinook CWTs released in brood years 1997-2002. 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 1997-2002 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) May 24, 2007.

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	246	0.8%
1999		2	0.0%		10	0.0%
2000		14	0.0%		35	0.0%
2001[1]		1	0.0%		1	0.0%
2002[1]		5	0.0%		17	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 2001-2002 are considered incomplete.

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Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 1997-2005.

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]
1997	CLE01	ESJ04	OCT	1.4	Left	cheek	Anterior Dorsal	3/15/1999	5/31/1999	630863	3,996	35,935	39,787
1997	CLE02	ESJ03	SNT	1.4	Right	cheek	Anterior Dorsal	3/15/1999	5/31/1999	630901	3,990	32,508	36,293
1997	CLE03	CFJ01	SNT	1.9	Right	cheek	Anal Fin	3/15/1999	5/31/1999	630902	3,996	35,558	39,317
1997	CLE04	CFJ02	OCT	1.9	Left	cheek	Anal Fin	3/15/1999	5/31/1999	630903	3,990	38,231	41,631
1997	CLE05	ESJ01	SNT	1.9	Right	cheek	Posterior Dorsal	3/15/1999	5/31/1999	630904	3,995	34,102	37,849
1997	CLE06	ESJ02	OCT	1.9	Left	cheek	Posterior Dorsal	3/15/1999	5/31/1999	630905	3,989	38,971	42,829
1997	CLE07	CFJ03	SNT	1.7	Right	cheek	Caudal Fin	3/15/1999	5/31/1999	630906	3,998	29,549	33,389
1997	CLE08	CFJ04	OCT	1.7	Left	cheek	Caudal Fin	3/15/1999	5/31/1999	630907	4,020	36,528	40,377
1997	CLE09	CFJ05	SNT	1.6	Right	cheek	Nape	3/15/1999	5/31/1999	630908	4,001	27,971	31,763
1997	CLE10	CFJ06	OCT	1.6	Left	cheek	Nape	3/15/1999	5/31/1999	630909	4,005	39,091	42,813
1998	CLE01	JCJ04	OCT	1.4	Left	cheek	Anterior Dorsal	3/15/2000	5/31/2000	631242	2,478	39,026	21,696
1998	CLE02	JCJ03	SNT	1.4	Right	cheek	Anterior Dorsal	3/15/2000	5/31/2000	631243	2,484	38,864	39,220
1998	CLE03	CFJ01	SNT	1.4	Right	cheek	Anal Fin	3/15/2000	5/31/2000	631244	2,439	35,328	37,604
1998	CLE04	CFJ02	OCT	1.4	Left	cheek	Anal Fin	3/15/2000	5/31/2000	631245	2,480	33,905	36,184
1998	CLE05	CFJ05	SNT	1.6	Right	cheek	Posterior Dorsal	3/15/2000	5/31/2000	631246	2,474	36,821	39,091
1998	CLE06	CFJ06	OCT	1.6	Left	cheek	Posterior Dorsal	3/15/2000	5/31/2000	631247	2,431	35,022	37,266
1998	CLE07	JCJ01	SNT	2.1	Right	cheek	Caudal Fin	3/15/2000	5/31/2000	631248	2,472	36,012	38,192
1998	CLE08	JCJ02	OCT	2.1	Left	cheek	Caudal Fin	3/15/2000	5/31/2000	631249	2,477	36,027	38,255
1998	CLE09	CFJ03	SNT	2.2	Right	cheek	Nape	3/15/2000	5/31/2000	631250	2,481	35,195	37,303
1998	CLE10	CFJ04	OCT	2.2	Left	cheek	Nape	3/15/2000	5/31/2000	631251	2,482	31,695	34,012
1998	CLE11	ESJ05	SNT	2.2	Right	cheek	Adipose Fin	3/15/2000	5/31/2000	631111	2,495	33,672	35,848
1998	CLE12	ESJ06	OCT	2.2	Left	cheek	Adipose Fin	3/15/2000	5/31/2000	631112	2,476	35,778	38,035
1998	CLE13	ESJ01	SNT	1.6	Right	Red	Right Cheek	3/15/2000	5/31/2000	631113	2,490	37,272	39,467
1998	CLE14	ESJ02	OCT	1.6	Left	Green	Left Cheek	3/15/2000	5/31/2000	631114	2,476	37,536	39,802
1998	CLE15	ESJ03	SNT	1.6	Right	Green	Right Cheek	3/15/2000	5/31/2000	631205	2,477	36,150	38,285
1998	CLE16	ESJ04	OCT	1.6	Left	Red	Left Cheek	3/15/2000	5/31/2000	631206	2,473	37,148	39,423

[1] Optimum Conventional (OCT) or Semi-Natural (SNT) for brood years 1997-2001. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. “Avg BKD” denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

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

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Brood Year	C.E. Pond	Accl. Pond	Treatment[1] /Avg BKD		Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
1999	CLE01	ESJ04	OCT	3.3	Right	Red	Posterior Dorsal	3/15/2001	5/31/2001	630480	2,225	43,078	44,782
1999	CLE02	ESJ03	SNT	3.3	Left	Red	Anterior Dorsal	3/15/2001	5/31/2001	630481	2,225	42,246	43,945
1999	CLE03	JCJ03	SNT	3.4	Left	Orange	Anterior Dorsal	3/15/2001	5/31/2001	630486	2,225	40,732	42,426
1999	CLE04	JCJ04	OCT	3.4	Right	Orange	Posterior Dorsal	3/15/2001	5/31/2001	630487	2,224	39,952	41,826
1999	CLE05	JCJ05	SNT	3.7	Left	Orange	Adipose Fin	3/15/2001	5/31/2001	630482	2,225	41,894	43,408
1999	CLE06	JCJ06	OCT	3.7	Right	Orange	Caudal Fin	3/15/2001	5/31/2001	630483	2,225	43,407	45,275
1999	CLE07	CFJ05	SNT	2.7	Left	Green	Adipose Fin	3/15/2001	5/31/2001	630490	2,230	38,519	40,134
1999	CLE08	CFJ06	OCT	2.7	Right	Green	Caudal Fin	3/15/2001	5/31/2001	630491	2,226	42,534	44,334
1999	CLE09	CFJ01	SNT	3.8	Left	Green	Left Cheek	3/15/2001	5/31/2001	630494	2,225	39,682	41,552
1999	CLE10	CFJ02	OCT	3.8	Right	Green	Right Cheek	3/15/2001	5/31/2001	630495	2,225	39,538	41,537
1999	CLE11	ESJ05	SNT	4.3	Left	Red	Adipose Fin	3/15/2001	5/31/2001	630488	2,225	41,880	43,872
1999	CLE12	ESJ06	OCT	4.4	Right	Red	Caudal Fin	3/15/2001	5/31/2001	630489	2,225	41,567	43,575
1999	CLE13	JCJ01	SNT	4.7	Left	Orange	Left Cheek	3/15/2001	5/31/2001	630492	2,226	40,305	42,300
1999	CLE14	JCJ02	OCT	4.7	Right	Orange	Right Cheek	3/15/2001	5/31/2001	630493	2,225	39,538	41,489
1999	CLE15	CFJ03	SNT	2.9	Left	Green	Anterior Dorsal	3/15/2001	5/31/2001	630496	2,225	29,994	31,882
1999	CLE16	CFJ04	OCT	2.9	Right	Green	Posterior Dorsal	3/15/2001	5/31/2001	630497	2,225	31,205	33,124
1999	CLE17	ESJ01	SNT	2.8	Left	Red	Left Cheek	3/15/2001	5/31/2001	630484	2,225	42,963	44,707
1999	CLE18	ESJ02	OCT	2.8	Right	Red	Right Cheek	3/15/2001	5/31/2001	630485	2,226	46,702	48,621

[1] Optimum Conventional (OCT) or Semi-Natural (SNT) for brood years 1997-2001. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. "Avg BKD" denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

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

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2000	CLE01	JCJ02	OCT	3.8	Left	Green	Left Cheek	3/15/2002	5/31/2002	631296	2,225	46,752	48,200
2000	CLE02	JCJ01	SNT	3.8	Right	Green	Right Cheek	3/15/2002	5/31/2002	631297	2,225	45,239	46,980
2000	CLE03	JCJ03	SNT	2.2	Right	Green	Posterior Dorsal	3/15/2002	5/31/2002	631360	2,226	44,940	46,710
2000	CLE04	JCJ04	OCT	2.2	Left	Green	Anterior Dorsal	3/15/2002	5/31/2002	631363	2,225	45,758	47,569
2000	CLE05	ESJ01	SNT	3.4	Right	Orange	Right Cheek	3/15/2002	5/31/2002	631298	2,225	41,482	43,497
2000	CLE06	ESJ02	OCT	3.4	Left	Orange	Left Cheek	3/15/2002	5/31/2002	631299	2,226	43,243	45,210
2000	CLE07	CFJ03	SNT	2.3	Right	Red	Posterior Dorsal	3/15/2002	5/31/2002	631364	2,225	46,071	48,005
2000	CLE08	CFJ04	OCT	2.3	Left	Red	Anterior Dorsal	3/15/2002	5/31/2002	631365	2,225	47,337	48,747
2000	CLE09	ESJ05	SNT	3.0	Right	Orange	Caudal Fin	3/15/2002	5/31/2002	630978	2,225	39,500	40,478
2000	CLE10	ESJ06	OCT	3.0	Left	Orange	Adipose Fin	3/15/2002	5/31/2002	630979	2,226	44,246	46,253
2000	CLE11	CFJ05	SNT	3.0	Right	Red	Caudal Fin	3/15/2002	5/31/2002	630981	2,225	44,237	46,203
2000	CLE12	CFJ06	OCT	3.0	Left	Red	Adipose Fin	3/15/2002	5/31/2002	630980	2,226	45,395	47,353
2000	CLE13	ESJ03	SNT	2.3	Right	Orange	Posterior Dorsal	3/15/2002	5/31/2002	631176	2,225	41,287	43,129
2000	CLE14	ESJ04	OCT	2.3	Left	Orange	Anterior Dorsal	3/15/2002	5/31/2002	630974	2,225	42,553	44,494
2000	CLE15	JCJ05	SNT	2.9	Right	Green	Caudal Fin	3/15/2002	5/31/2002	630973	2,227	45,715	47,573
2000	CLE16	JCJ06	OCT	2.9	Left	Green	Adipose Fin	3/15/2002	5/31/2002	630972	2,225	46,340	48,238
2000	CLE17	CFJ01	SNT	2.3	Right	Red	Right Cheek	3/15/2002	5/31/2002	630582	2,225	45,331	47,156
2000	CLE18	CFJ02	OCT	2.3	Left	Red	Left Cheek	3/15/2002	5/31/2002	630583	2,226	46,613	48,490

[1] Optimum Conventional (OCT) or Semi-Natural (SNT) for brood years 1997-2001. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. "Avg BKD" denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

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2001	CLE01	JCJ04	OCT	6.0	Right	Red	Anterior Dorsal	3/15/2003	5/15/2003	210410	4,000	38,809	42,510
2001	CLE02	JCJ03	SNT	6.0	Left	Red	Posterior Dorsal	3/15/2003	5/15/2003	210411	4,000	38,496	42,042
2001	CLE05	CFJ01	SNT	3.6	Left	Green	Posterior Dorsal	3/15/2003	5/15/2003	210413	4,017	37,765	40,640
2001	CLE06	CFJ02	OCT	3.7	Right	Green	Anterior Dorsal	3/15/2003	5/15/2003	210417	4,000	36,700	40,142
2001	CLE07	JCJ01	SNT	3.9	Left	Red	Right Cheek	3/15/2003	5/15/2003	210416	4,000	39,081	42,655
2001	CLE08	JCJ02	OCT	3.7	Right	Red	Left Cheek	3/15/2003	5/15/2003	210415	4,000	39,048	42,771
2001	CLE09	JCJ05	SNT	4.0	Left	Red	Caudal Fin	3/15/2003	5/15/2003	210414	4,001	37,655	41,331
2001	CLE10	JCJ06	OCT	3.8	Right	Red	Adipose Fin	3/15/2003	5/15/2003	210412	4,000	35,321	39,039
2001	CLE13	ESJ01	CON	3.9	Left	Orange	Right Cheek	3/15/2003	3/28/2003	210422	1,333	5,455	6,729
2001	CLE14	ESJ02	PAT	3.9	Right	Orange	Left Cheek	3/15/2003	3/28/2003	210423	1,333	5,252	6,525
2001	CLE15	ESJ03	CON	3.9	Left	Orange	Posterior Dorsal	3/15/2003	3/28/2003	210419	1,336	4,978	6,259
2001	CLE16	ESJ04	CON	3.9	Left	Orange	Anterior Dorsal	3/15/2003	3/28/2003	210418	1,333	5,160	6,437
2001	CLE17	ESJ05	PAT	3.9	Right	Orange	Caudal Fin	3/15/2003	3/28/2003	210420	1,334	5,344	6,617
2001	CLE18	ESJ06	PAT	3.9	Right	Orange	Adipose Fin	3/15/2003	3/28/2003	210421	1,333	5,294	6,539

[1] Optimum Conventional (OCT) or Semi-Natural (SNT) for brood years 1997-2001; for Easton, control (CON) and predator avoidance trained (PAT). 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 1997-2005.

Brood Year	C.E. Pond	Accl. Pond	Treatment[1] /Avg BKD			Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
2002	CLE01	JCJ06	HI	WW	2.0	Right	Green	Anal Fin	3/15/2004	5/14/2004	613400	2,222	45,007	46,875
2002	CLE02	JCJ05	LO	WW	2.0	Left	Green	Adipose Fin	3/15/2004	5/14/2004	613401	2,222	46,273	46,588
2002	CLE03	ESJ03	HI	WW	1.6	Right	Orange	Anterior Dorsal	3/15/2004	5/14/2004	613402	2,222	49,027	50,924
2002	CLE04	ESJ04	LO	WW	1.6	Left	Orange	Posterior Dorsal	3/15/2004	5/14/2004	613403	2,222	50,347	52,115
2002	CLE05	CFJ05	LO	WW	2.2	Left	Red	Adipose Fin	3/15/2004	5/14/2004	613404	2,222	45,816	46,584
2002	CLE06	CFJ06	HI	WW	2.2	Right	Red	Anal Fin	3/15/2004	5/14/2004	613405	2,222	46,468	48,496
2002	CLE07	ESJ05	LO	WW	1.9	Left	Orange	Adipose Fin	3/15/2004	5/14/2004	613406	2,222	45,047	45,491
2002	CLE08	ESJ06	HI	WW	1.9	Right	Orange	Anal Fin	3/15/2004	5/14/2004	613407	2,222	48,293	50,316
2002	CLE09	JCJ03	LO	WW	1.8	Left	Green	Anterior Dorsal	3/15/2004	5/14/2004	613408	2,222	41,622	43,512
2002	CLE10	JCJ04	HI	WW	4.9	Right	Green	Posterior Dorsal	3/15/2004	5/14/2004	613409	2,222	46,346	48,279
2002	CLE11	ESJ02	LO	WW	1.9	Left	Orange	Right Cheek	3/15/2004	5/14/2004	613410	2,222	43,619	45,594
2002	CLE12	ESJ01	HI	WW	1.9	Right	Orange	Left Cheek	3/15/2004	5/14/2004	613411	2,222	44,091	46,112
2002	CLE13	JCJ01	HI	WW	1.8	Right	Green	Right Cheek	3/15/2004	5/14/2004	613412	2,222	44,379	46,327
2002	CLE14	JCJ02	LO	WW	1.8	Left	Green	Left Cheek	3/15/2004	5/14/2004	613413	2,222	46,241	48,208
2002	CLE15	CFJ01	LO	HH	1.3	Left	Red	Snout	3/15/2004	5/14/2004	613414	2,222	42,192	44,184
2002	CLE16	CFJ02	HI	HH	1.3	Right	Red	Snout	3/15/2004	5/14/2004	613415	2,222	41,702	43,653
2002	CLE17	CFJ03	HI	WW	1.6	Right	Red	Anterior Dorsal	3/15/2004	5/14/2004	613416	2,222	37,769	39,782
2002	CLE18	CFJ04	LO	WW	1.6	Left	Red	Posterior Dorsal	3/15/2004	5/14/2004	613417	2,222	42,066	43,864

[1] HI = normal growth or LO = slowed growth for brood years 2002 – 2004. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. "Avg BKD" denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

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

Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 1997-2005.

Brood Year	C.E. Pond	Accl. Pond	Treatment[1] /Avg BKD			Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
2003	CLE01	CFJ02	HI	WW	0.2	Left	Red	Anal Fin	3/9/2005	4/27/2005	610126	2,222	43,712	45,785
2003	CLE02	CFJ01	LO	WW	0.2	Right	Red	Adipose Fin	3/9/2005	4/27/2005	610127	2,222	42,730	44,551
2003	CLE03	ESJ04	LO	WW	0.1	Right	Green	Left Cheek	3/9/2005	4/27/2005	610128	2,222	41,555	43,544
2003	CLE04	ESJ03	HI	WW	0.1	Left	Green	Right Cheek	3/9/2005	4/27/2005	610129	2,222	43,159	45,215
2003	CLE05	JCJ02	LO	WW	0.2	Right	Orange	Anal Fin	3/9/2005	4/27/2005	610130	2,222	45,401	47,443
2003	CLE06	JCJ01	HI	WW	0.2	Left	Orange	Adipose Fin	3/9/2005	4/27/2005	610131	2,222	46,079	48,095
2003	CLE07	ESJ02	LO	WW	0.3	Right	Green	Anal Fin	3/9/2005	4/27/2005	610132	2,222	43,418	45,464
2003	CLE08	ESJ01	HI	WW	0.3	Left	Green	Adipose Fin	3/9/2005	4/27/2005	610133	2,222	43,261	45,310
2003	CLE09	ESJ06	LO	WW	0.2	Right	Green	Posterior Dorsal	3/9/2005	4/27/2005	610134	2,222	43,410	45,402
2003	CLE10	ESJ05	HI	WW	0.2	Left	Green	Anterior Dorsal	3/9/2005	4/27/2005	610135	2,222	44,255	42,776
2003	CLE11	CFJ04	LO	HH	0.1	Right	Red	Snout	3/9/2005	4/27/2005	610136	2,222	41,017	43,021
2003	CLE12	CFJ03	HI	HH	0.1	Left	Red	Snout	3/9/2005	4/27/2005	610137	2,222	43,680	45,712
2003	CLE13	JCJ04	LO	WW	0.2	Right	Orange	Left Cheek	3/9/2005	4/27/2005	610138	2,222	44,569	46,413
2003	CLE14	JCJ03	HI	WW	0.2	Left	Orange	Right Cheek	3/9/2005	4/27/2005	610139	2,222	45,218	47,079
2003	CLE15	CFJ06	LO	WW	0.1	Right	Red	Posterior Dorsal	3/9/2005	4/27/2005	610140	2,222	45,697	47,468
2003	CLE16	CFJ05	HI	WW	0.1	Left	Red	Anterior Dorsal	3/9/2005	4/27/2005	610141	2,222	44,815	46,840
2003	CLE17	JCJ06	LO	WW	0.1	Right	Orange	Posterior Dorsal	3/9/2005	4/27/2005	610142	2,222	45,375	47,211
2003	CLE18	JCJ05	HI	WW	0.1	Left	Orange	Anterior Dorsal	3/9/2005	4/27/2005	610143	2,222	45,420	47,363

[1] HI = normal growth or LO = slowed growth for brood years 2002 – 2004. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. “Avg BKD” denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

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

Appendix A. Tag and Release Information by Cle Elum Pond Id, Brood Years 1997-2005.

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 1997-2005.

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 B

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Annual Report: 2004 through 2006 Smolt-to-Smolt Survival of Upper Yakima Spring Chinook from Release to McNary Dam Smolt Passage for Brood-Years 2002-2004

Doug Neeley, Consultant to Yakama Nation

Introduction

Two early-rearing nutritional regimes were tested using hatchery-reared Upper Yakima 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 for each of the three years. Smolt were transferred from the hatchery to three different acclimation sites in the Upper Yakima River Basin (Clark Flat and Easton on the Upper Yakima River and Jack Creek on the North Fork Teanaway River), there being a total of three pond pairs within each of the three sites, corresponding to the nine pairs of raceways at the hatchery.

For these brood years there was also a domestication study, the treatments of which were superimposed on the low and high treatments at the Clark Flats acclimation site. Two of the pairs of Clark Flats raceways receiving the low and high treatments were stocked from crosses of naturally spawned parents from the supplementation program, the use of naturally spawned stock being the standard hatchery-production protocol from the beginning of production at the Cle Elum facility (starting with brood-year 1997). 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[2]. Statistical comparisons between the hatchery x hatchery and natural x natural production lines were confined to Clark Flat raceways so that potential acclimation site differences would not bias the comparisons.

Summary

The early low and high nutrition treatment fish were volitionally released. Low-treated fish were smaller fish at the time of release and had somewhat later McNary passage times than high-treated fish. When smolt-to-smolt survival was measured from release to McNary Dam based on all released fish, the low nutrition fish had a lower survival than the high nutrition fish. Further, the hatchery x hatchery crosses from Clark Flat had a higher survival than the natural x natural crosses. However, evaluations by Don Larsen (NOAA Fisheries) on gonad maturity indicate that hatchery x hatchery fish have lower proportion of precocials than do natural x natural fish. Adjustment of McNary survival using release numbers adjusted for proportion of precocial fish per raceway resulted in a higher survival rate for natural x natural fish fed at the high early nutrition level and more similar survival rates when both hatchery x hatchery and natural x natural fish were fed at the low nutrition level.

Analysis based on all released Fish

Methods of estimating the survival index are discussed in some detail in Appendix A along with the individual acclimation ponds' survival-index estimates. Mean smolt-to-smolt survival indices from volitional release to McNary Dam based on all released fish are presented in Table 1 for the brood years 2002 through 2004 releases (respectively release-years 2004 through 2006); respective bar graphs of these means are given Figure 1. As is clearly indicated, the mean low-treatment survival indices are less than those of the high-treatment at each acclimation site in each year. The difference is highly significant ($P < 0.0001$) based on a logistic analysis of variation given Appendix Table B.1. Although there was also evidence of treatment x site interaction ($P=0.053$), the interaction was related to the magnitude of the differences over sites and years, not to the direction of the difference.

The proportions released from the ponds were also subjected to an analysis to see if there was an indication of a Low versus High difference in pre-release survival. While there was a significant difference ($P = 0.028$, Appendix Table B.2), there was also some evidence of a site x treatment interaction ($P = 0.053$, Appendix Table B.2), and the means indicate no consistent difference: The yearly High proportions are uniformly higher at Clark Flat, are uniformly lower at Jack Creek, and are not consistent in terms of directional differences at Easton (Table 2.) when compared to the Low. A major contributor to the significance in Appendix Table B.2 is probably a single raceway's proportion, which is discussed in a note below Table 2.

As indicated in Table 3, there was no significant or substantial difference between volitional release times of the low- and high-treated fish ($P = 0.12$, Appendix Table B.3). However, the mean day of McNary passage (Table 4) was significantly later for the low-nutrition treated fish ($P < 0.0001$, Appendix Table B.4).

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[2] Any HxH adult returns not used for brood-stock are sacrificed so that they cannot escape to the spawning grounds.

Since the HxH crosses were only allocated to a Clark Flat raceway pair, HxH and NxN measures were only compared within Clark Flat since any HxH comparison to other acclimation NxN ponds would be confounded with site differences. Statistical comparisons are therefore far less powerful than those associated with the Low and High nutritional level comparisons which involves nine paired comparisons within a year. Comments regarding HxH and NxN differences are made when the estimated significant levels (P) are less than 0.1 (10% significance level).

In addition to survival to McNary, other comparisons included proportion of fish released, mean release time, and Mean McNary passage date.

Although none of the HxH versus NxN comparisons made were significant at the 5% level (from Appendix B: smolt-to-smolt survival-to-McNary P = 0.059 from Table B.1, proportion released P = 0.74 from Table B.2, Julian mean release date P = 0.60 from Table B.3, Julian mean McNary detection date P = 0.77 from Table B.4.), the mean smolt-to-smolt survival is very near significance at the 5% level. What is particularly notable and, on the surface, unexpected is that the Hatchery x Hatchery smolt-to-smolt survival estimate was greater than that of the Natural x Natural for 5 of the 6 comparisons (two nutrition levels within each of three years, Table 5).

Analysis of Variables measured prior to Release

In spite of the fact that sufficient feed was administered to both sets of treated fish to meet their feeding demands after mid-October, the weights of the Low treated fish were substantially and significantly less than that of the High treated fish (P < 0.0001, Appendix Table B.5). Table 6 presents the mean pre-release (March) weights (grams/fish) for each acclimation site within each year. The smaller size at release may have contributed to the reduced survival index and the later McNary passage time for Low-nutrition fish.

Information was also collected from a random sample of sixty fish from each raceway on their sexual maturity. The proportion of these fish with mature testes was taken as a measure of pre-release precocialism. A logistic analysis of variation revealed significant differences between the Low and High and between the Hatchery x Hatchery and Natural x Natural Lines (respective P = 0.0004 and P = 0.0005, Appendix Table B.5). Mean precocialism was uniformly lower for the Low treatment of hatchery x hatchery and natural x natural lines within each of the three years (Table 7). Interestingly, mean precocialism was also uniformly lower for the hatchery x hatchery fish than the natural x natural fish for the High and Low treatments within each year. It may be possible that a single generation of skipping a precocial-spawning contribution (as is the case in the HxH line) may reduce the proportion of precocial fish in the next generation.

Survival to McNary adjusted for Proportion Precocial Fish

If we assume that none of the fish that are precocial would swim downstream to McNary, then the estimate of survival to McNary, which is the expanded PIT-tagged passage number at McNary divided by the number of fish detected at the pond, would be an overestimate of survival. A preferred estimate would be dividing the expanded passage by the number of released fish that are not precocial. Such estimates were made by dividing the expanded

McNary passage by the product of the number detected leaving the pond and the estimated non-precocial proportion (1 – precocial proportion). The logistic analysis of variation of this adjusted measure of survival (Appendix Table B.7) reveals a significant HxH versus NxN line main effect difference at the 10% level and a significant Low vs High main effect difference and a significant interaction between the line and nutrition levels (respective $P = 0.078$, $P < 0.0001$, and $P = 0.039$; Appendix Table B.7).

As indicated in Table 8 and Figure 2, the HxH non-precocial fish had a lower survival than the NxN non-precocial fish in five of the six comparisons at Clark Flat; this is in stark contrast to the survival estimates unadjusted for precocialism where the HxH line had the highest smolt-to-smolt survival.

Table 1. Weighted* Volitional-Release-to-McNary Smolt-to-Smolt Survival Indices for Brood-Year 2002, 2003, 2004 Low- and High-nutrition treated Upper Yakima Spring Chinook Smolt in release-years 2004, 2005, and 2006

Aclimation Site	Nutritional Level	Measure	2002	2003	2004	Over Years
Clark Flat	**High**	**Survival**	**23.2%**	**16.9%**	**36.1%**	**25.4%**
		Number Releas	6514	6478	6491	19483
	Low	**Survival**	**20.9%**	**15.0%**	**28.7%**	**21.6%**
		Number Releas	6479	6428	6471	19378
Easton	**High**	**Survival**	**17.9%**	**14.2%**	**26.7%**	**19.6%**
		Number Releas	6453	6474	6462	19389
	Low	**Survival**	**16.6%**	**12.5%**	**24.9%**	**17.9%**
		Number Releas	6508	6499	6299	19306
Jack Creek	**High**	**Survival**	**19.8%**	**16.1%**	**27.8%**	**20.4%**
		Number Releas	6515	6514	4389	17418
	Low	**Survival**	**15.7%**	**12.8%**	**22.3%**	**16.9%**
		Number Releas	6532	6521	6296	19349
Over Sites	**High**	**Survival**	**20.3%**	**15.7%**	**30.5%**	**21.9%**
		Number Releas	19482	19466	17342	56290
	Low	**Survival**	**17.7%**	**13.4%**	**25.3%**	**18.8%**
		Number Releas	19519	19448	19066	58033

*** Weights are numbers of all detected releases.**

Figure 1. Volitional-Release-to-McNary Smolt-to-Smolt Survival Indices for Brood-Year 2002, 2003, 2004 Low- and High-Nutrition treated Upper Yakima Spring Chinook Smolt in release-year 2004, 2005, and 2006 (Low, downward slash; High, upward slash)

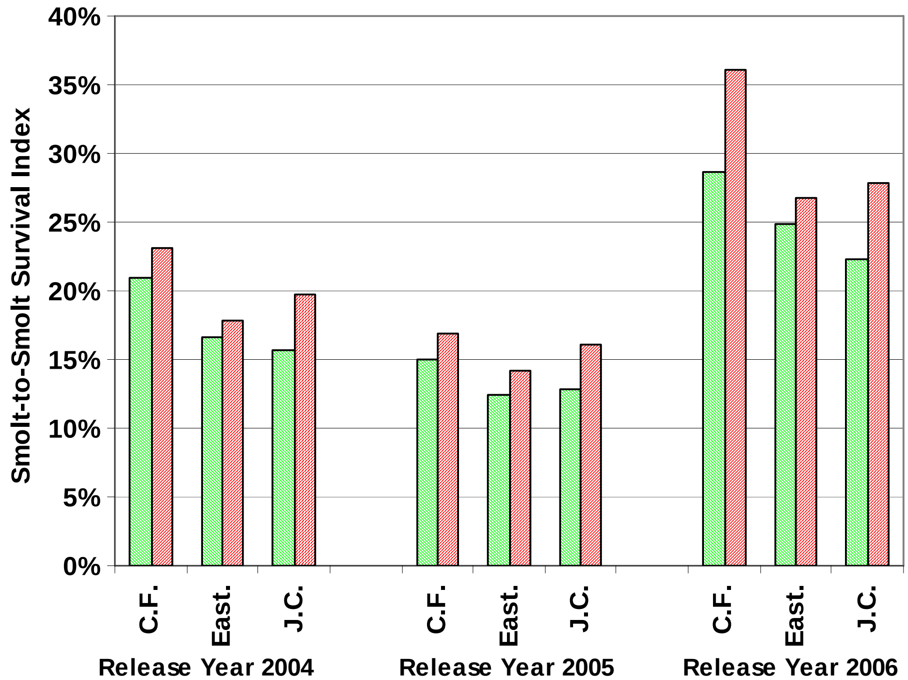


Table 2. Weighted* Proportion of PIT-Tagged fish Detected leaving Acclimation Sites for Brood-Year 2002, 2003, 2004 Low- and High-Nutrition treated Upper Yakima Spring Chinook Smolt in release-year 2004, 2005, and 2006

Aclimation Site	Nutritional Level	Measure	2002	2003	2004	Over Years
Clark Flat	**High**	**Proportion**	**97.7%**	**97.2%**	**97.4%**	**97.4%**
		Number Releas	6669	6666	6666	20001
	Low	**Proportion**	**97.2%**	**96.4%**	**97.0%**	**96.9%**
		Number Releas	6669	6667	6669	20005
Easton	**High**	**Proportion**	**96.7%**	**97.1%**	**96.9%**	**96.9%**
		Number Releas	6670	6668	6667	20005
	Low	**Proportion**	**97.6%**	**97.5%**	**94.5%**	**96.5%**
		Number Releas	6670	6665	6668	20003
Jack Creek	**High**	**Proportion**	**97.7%**	**97.7%**	**65.8%**	**87.1%**
		Number Releas	6668	6667	6668	20003
	Low	**Proportion**	**97.9%**	**97.8%**	**94.4%**	**96.7%**
		Number Releas	6669	6667	6666	20002
Over Sites	**High**	**Proportion**	**97.4%**	**97.3%**	**86.7%**	**93.8%**
		Number Releas	20007	20001	20001	60009
	Low	**Proportion**	**97.6%**	**97.2%**	**95.3%**	**96.7%**
		Number Releas	20008	19999	20003	60010

*** Weights are numbers of fish tagged**

NOTE: The low proportion, 65.8%, for the high nutrition treatment at Jack Creek for brood-year 2004 was because of a high pre-release mortality at one of the three ponds—a mortality due to pond-specific problems unrelated to the treatment. The estimate proportion at that pond was 3.8%, and the proportions at other the other two high-nutrition ponds were 96.3% and 97.4%.

Table 3. Mean Julian Volitional-Release Dates of Brood-Year 2002, 2003, 2004 Low- and High-Nutrition Upper Yakima Spring Chinook Smolt for respective 2004, 2005, and 2006 Volitional Releases

Aclimation Site	Nutritional Level	2002	2003	2004	Over Years
Clark Flat	High	100.5	78.3	103.7	94.2
	Low	95.5	74.9	101.4	90.6
Easton	High	101.0	87.4	100.2	96.2
	Low	97.8	86.1	99.6	94.5
Jack Creek	High	98.6	95.9	91.6	95.4
	Low	99.3	93.6	95.9	96.2
Over Sites	High	100.0	87.2	98.5	95.2
	Low	97.5	84.9	99.0	93.8

Table 4. Mean Julian McNary Passage Dates of Brood-Year 2002, 2003, 2004 Low- and High-Nutrition Upper Yakima Spring Chinook Smolt for respective 2004, 2005, and 2006 Volitional Releases

Aclimation Site	Nutritional Level	2002	2003	2004	Over Years
Clark Flat	High	121.4	122.8	124.7	123.0
	Low	123.7	124.2	127.5	125.2
Easton	High	123.8	124.2	127.1	125.0
	Low	128.1	126.2	129.0	127.8
Jack Creek	High	123.8	126.1	124.7	124.9
	Low	128.4	127.8	127.3	127.8
Over Sites	High	123.0	124.4	125.5	124.3
	Low	126.8	126.1	128.0	126.9

Table 5. Weighted* Volitional-Release-to-McNary Smolt-to-Smolt Survival for Hatchery x Hatchery and Natural x Natural crosses of 2002, 2003 and 2004 returns of Upper Yakima Spring Chinook (respective smolt-release years 2004, 2005, and 2006).

Nutrition Level	Cross	Measure	2002	2003	2004	Over Years
High	H X H	**Survival**	**24.12%**	**17.39%**	**39.69%**	**27.08%**
		Number Released	2162	2135	2147	6444
	N x N	**Survival**	**22.69%**	**16.61%**	**34.39%**	**24.56%**
		Number Released	4352	4343	4344	13039
Low	H X H	**Survival**	**20.22%**	**16.71%**	**33.13%**	**23.40%**
		Number Released	2124	2134	2164	6422
	N x N	**Survival**	**21.28%**	**14.16%**	**26.46%**	**20.64%**
		Number Released	4355	4294	4307	12956
Pooled over	H X H	**Survival**	**22.18%**	**17.05%**	**36.40%**	**25.24%**
Nutrition		Number Released	4286	4269	4311	12866
Treatments	N x N	**Survival**	**21.99%**	**15.39%**	**30.44%**	**22.61%**
		Number Released	8707	8637	8651	25995

Table 6. March Smolt Mean Weights (Grams/Fish) just prior to Release in 2004, 2005, and 2006 Low- and High-Nutrition-Treated Fish (respective Brood Years 2002, 2003, 2004)

Aclimation Site	Nutritional Level	2002	2003	2004	Over Years
Clark Flat	High	18.06	19.28	17.17	18.17
	Low	13.55	14.16	13.53	13.75
Easton	High	18.86	17.84	16.22	17.64
	Low	14.30	13.23	13.30	13.61
Jack Creek	High	17.62	16.23	14.17	16.00
	Low	13.22	11.98	14.54	13.24
Over Sites	High	18.18	17.78	15.85	17.27
	Low	13.69	13.12	13.79	13.53

Table 7. Percentage Precocial Proportion of Fish in 2004, 2005, and 2006 Low- and High-Nutrition-Treated Fish (respective Brood Years 2002, 2003, 2004)

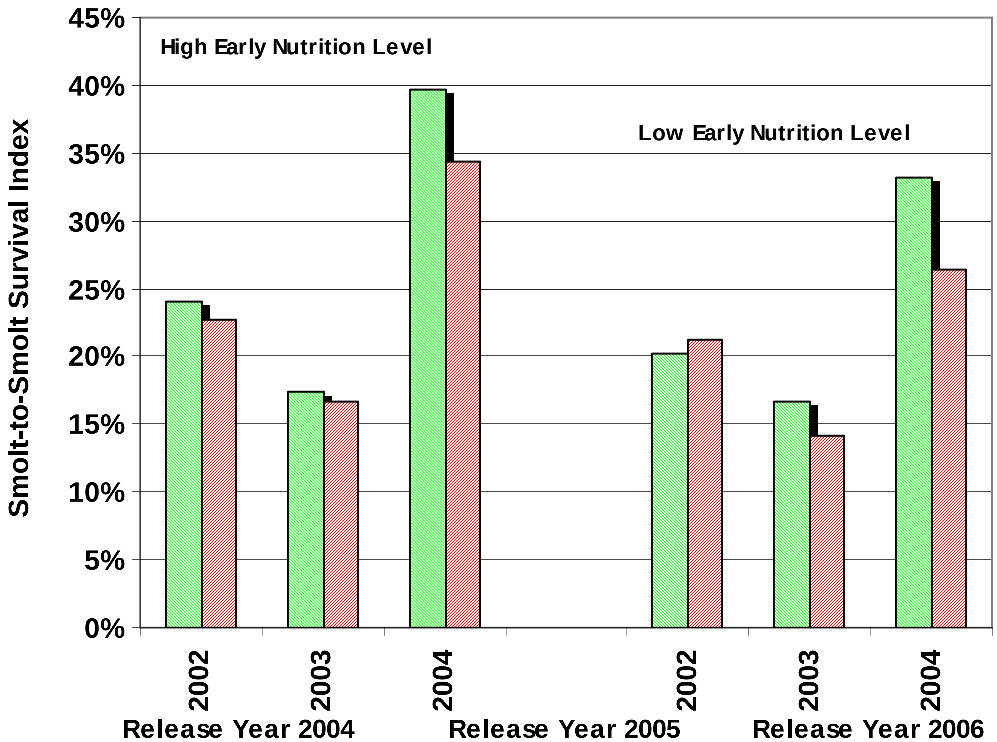
Nutritional Level	Stock	2002	2003	2004
High	H x H	14.3%	14.6%	14.1%
High	N x N	56.1%	30.1%	46.6%
Low	H x H	13.3%	7.1%	11.1%
Low	N x N	36.7%	15.5%	11.7%

Table 8. Weighted* Volitional-Release-to-McNary Smolt-to-Smolt Survival for non-Precocial Hatchery x Hatchery and Natural x Natural crosses of 2002, 2003 and 2004 returns of Upper Yakima Spring Chinook (respective smolt-release years 2004, 2005, and 2006).

Nutritional Level	Stock	2002	2003	2004	Over Years
High	**H x H**	**28.1%**	**20.4%**	**46.2%**	**31.61%**
	weight*	1852.8	1823.3	1844.3	5520.4
High	**N x N**	**51.7%**	**23.8%**	**64.4%**	**44.09%**
	weight*	1911.6	3033.6	2318.8	7264.0
Low	**H x H**	**23.3%**	**18.0%**	**37.3%**	**26.15%**
	weight*	1841.5	1982.5	1923.8	5747.8
Low	**N x N**	**33.6%**	**16.8%**	**30.0%**	**26.26%**
	weight*	2756.6	3628.6	3801.3	10186.6

*** Weight = Number detected leaving pond x (1 - pre-release precocial proportion)**

Figure 2. Volitional-Release-to-McNary Smolt-to-Smolt Survival Indices for <u>non-Precocial</u> Hatchery x Hatchery and Natural x Natural crosses of Brood-Year 2002, 2003, 2004 Low- and High-Nutrition treated Upper Yakima Spring Chinook Smolt in release-year 2004, 2005, and 2006 (Low, downward slash; High, upward slash)



Appendix A. Estimated Survival Index

A.1. Estimation Of Detection Rates

Conceptual Computation

Detection Rate is estimated as follows:

Equation A.1.

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

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

The methods used were similar to those developed by Sandford and Smith[3]. 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 detection [Table A.1.a)].

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

Step 3. The resulting relative distribution frequencies from Table A.1.b) were then multiplied by the total downstream dam's detections (whether or not previously detected at McNary) for the given downstream date to obtain estimates of the cross-tab number for the downstream dam's total detections [Table A.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

[3] 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.

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 probably differs from Smith and Sanford's, their generated daily detection rates being 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 A.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 A.1.a), far-right column] were then divided by the downstream-dam total from step 4 above [Table A.1.c), far-right column], giving an estimated McNary-detection efficiency associated with the McNary date [Table A.1.d), far-right-hand column].

Actually, before the last step, Table A.1.a)'s and Table A.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. The strata's beginning and ending dates were chosen in a manner that minimized the variation among daily detection rates within strata, thereby maximizing the detection-rate variation among strata. This was done using step-wise logistic regression. 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[4] 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.

Table A.1. Conceptual method of estimating detection rates

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)	…	

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

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 A.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 Date (Julian)	N'(McN,D.S.) = N(D.S.)*P(McN,D.S.)						McN Dam Total
	D.S. Date (Julian)						
	…	100	101	**102**	103	…	
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,.)**

A.2. Rate Estimates

Estimates for 2004, 2005, and 2005 detection rates are given Table A.2.

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

	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 Bonn.Det.	Joint Bonn. McN.Det.	McN. Det. Rate	Total Bonn.Det.	Joint Bonn. McN.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

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.

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.

A.3. Estimation of Survival Index

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

Equation A.2.

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

wherein

1) “Stratum” is a group of contiguous McNary detection dates among which the daily detection rates[5] were sufficiently homogeneous to permit the use of a pooled estimate of the detection rate for that stratum;

[5] 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 <u>all</u>[6] those Yakima PIT-tagged Spring Chinook passing McNary Dam during the stratum that were detected at McNary (discussed in next session).

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

[6] 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 A.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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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 A.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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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 A.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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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 A.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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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 A.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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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 A.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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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 A.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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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 A.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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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 A.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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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
	Epanded 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

Appendix B. Analysis of Variation

NOTE: **In all analyses, the "block" source referred to in the analyses refers to race-way pairs. Each raceway pair has smolt derived from the same diallele cross and are assumed to have less genetic variability between ponds within pairs than among ponds from different pairs.   The Low- and High-Nutrition Treatments are allocated to different ponds within each pair. On block at Clark Flat is allocated to the HxH (HH) cross, all other blocks are allocated to the NxN (NN) crosses.**

Table B.1. Weighted* Logistic Analyses of Variation of Volitional-Release-to-McNary Smolt-to-Smolt Survival Indices for Low- and High-Nutrition treated Upper Yakima Spring Chinook Smolt in 2004, 2005, and 2006 (weights are number of fish detected leaving the acclimation facilities).

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio[a]	Type 1 Error P[a]
Year	2026.72	2	1013.36	127.20	**0.0000**
Site	331.38	2	165.69	20.80	**0.0000**
Year x Site	37.63	4	9.41	1.18	0.3588
HH[b] vs NN[c]	33.17	1	33.17	4.16	**0.0593**
HH vs NN x Year	18.87	2	9.44	1.18	0.3330
Block	119.50	15	7.97	2.82	**0.0265**
Lo vs Hi	171.92	1	171.92	60.92	**0.0000**
Lo vs Hi x Year	4.59	2	2.30	0.81	0.4620
Lo vs Hi x Site	18.78	2	9.39	3.33	**0.0637**
Lo vs Hi x Year x Site	14.77	4	3.69	1.31	0.3115
Lo vs Hi x HH vs NN	0.31	1	0.31	0.11	0.7449
Lo vs Hi x HH vs NN x Year	5.56	2	2.78	0.99	0.3963
Error	42.33	15	2.82		

[a] The source of the denominator mean deviance used in the tests were: A) Block used for Year, Site, Year x Site Interaction, HH vs NN and HH vs NN x Year Interaction; and B) Error for all others.

[b] HH is Hatchery Spawned x Hatchery Spawned Cross

[c] NN is Naturally Spawned x Naturally Spawned Cross

***Weight is number volitionally released**

Table B.2. Weighted* Logistic Analysis of Variation of Proportion of PIT-Tagged fish Detected leaving Acclimation Sites for Low- and High-Nutrition treated Upper Yakima Spring Chinook Smolt in 2004, 2005, and 2006

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Year	2253.46	2	1126.73	4.22	**0.0352**
Site	1432.63	2	716.32	2.68	0.1010
Year x Site	1355.56	4	338.89	1.27	0.3255
HH[b] vs NN[c]	30.57	1	30.57	0.11	0.7398
HH vs NN x Year	7.90	2	3.95	0.01	0.9853
Block	4006.80	15	267.12	2.26	**0.0623**
Lo vs Hi	696.97	1	696.97	5.91	**0.0281**
Lo vs Hi x Year	153.22	2	76.61	0.65	0.5365
Lo vs Hi x Site	846.76	2	423.38	3.59	**0.0533**
Lo vs Hi x Year x Site	725.18	4	181.30	1.54	0.2420
Lo vs Hi x HH vs NN	1.69	1	1.69	0.01	0.9063
Lo vs Hi x HH vs NN x Year	14.65	2	7.32	0.06	0.9400
Error	1769.89	15	117.99		

[a] The source of the denominator mean deviance used in the tests were: A) Block used for Year, Site, Year x Site Interaction, HH vs NN and HH vs NN x Year Interaction; and B) Error for all others.

[b] HH is Hatchery Spawned x Hatchery Spawned Cross

[c] NN is Naturally Spawned x Naturally Spawned Cross

***Weight is number tagged**

Table B.3. Analysis of Variance of Mean Julian Volitional-Release Dates of Low- and High-Nutrition Upper Yakima Spring Chinook Smolt for 2004, 2005, and 2006 Releases of Low- and High-Nutrition-Treated Fish

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (MS = SS/DF)	F-Ratio	Type 1 Error P
Year	1946.99	2	973.50	148.05	**0.0000**
Site	124.41	2	62.20	9.46	**0.0022**
Year x Site	1116.44	4	279.11	42.45	**0.0000**
HH[b] vs NN[c]	1.94	1	1.94	0.30	0.5950
HH vs NN x Year	7.77	2	3.88	0.59	0.5662
Block	98.63	15	6.58	0.63	0.8122
Lo vs Hi	28.29	1	28.29	2.70	0.1214
Lo vs Hi x Year	25.10	2	12.55	1.20	0.3296
Lo vs Hi x Site	43.38	2	21.69	2.07	0.1611
Lo vs Hi x Year x Site	18.66	4	4.67	0.44	0.7746
Lo vs Hi x HH vs NN	7.67	1	7.67	0.73	0.4060
Lo vs Hi x HH vs NN x Year	29.95	2	14.98	1.43	0.2707
Error	157.38	15	10.49		

[a] The denominator mean deviance used in the tests were: A) Block used for Year, Site, Year x Site Interaction, HH vs NN and HH vs NN x Year Interaction; and B) Error for all others.

[b] HH is Hatchery Spawned x Hatchery Spawned Cross

[c] NN is Naturally Spawned x Naturally Spawned Cross

Table B.4. Analysis of Variance of Mean Julian Volitional-Release McNary Dam Passage Dates of Low- and High-Nutrition Upper Yakima Spring Chinook Smolt for 2004, 2005, and 2006 Releases of Low- and High-Nutrition-Treated Fish

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (MS = SS/DF)	F-Ratio	Type 1 Error P
Year	34.53	2	17.26	9.19	**0.0025**
Site	65.65	2	32.83	17.48	**0.0001**
Year x Site	34.86	4	8.71	4.64	**0.0123**
HH[b] vs NN[c]	0.17	1	0.17	0.09	0.7683
HH vs NN x Year	2.48	2	1.24	0.66	0.5310
Block	28.18	15	1.88	1.33	0.2948
Lo vs Hi	93.97	1	93.97	66.44	**0.0000**
Lo vs Hi x Year	9.86	2	4.93	3.49	**0.0571**
Lo vs Hi x Site	1.36	2	0.68	0.48	0.6269
Lo vs Hi x Year x Site	3.93	4	0.98	0.69	0.6077
Lo vs Hi x HH vs NN	0.39	1	0.39	0.28	0.6072
Lo vs Hi x HH vs NN x Year	0.44	2	0.22	0.16	0.8576
Error	21.22	15	1.41		

[a] The source of the denominator mean deviance used in the tests were: A) Block used for Year, Site, Year x Site Interaction, HH vs NN and HH vs NN x Year Interaction; and B) Error for all others.

[b] HH is Hatchery Spawned x Hatchery Spawned Cross

[c] NN is Naturally Spawned x Naturally Spawned Cross

*

Table B.5. Analysis of Variance of March Smolt Mean Weights (Grams/Fish) just prior to Release for 2004, 2005, and 2006 Releases of Low- and High-Nutrition-Treated Fish

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (MS = SS/DF)	F-Ratio	Type 1 Error P
Year	11.20	2	5.60	6.51	**0.0092**
Site	17.30	2	8.65	10.06	**0.0017**
Year x Site	10.50	4	2.63	3.05	**0.0502**
HH[b] vs NN[c]	0.20	1	0.20	0.23	0.6366
HH vs NN x Year	1.70	2	0.85	0.99	0.3952
Block	12.90	15	0.86	0.41	0.9518
Lo vs Hi	188.60	1	188.60	90.38	**0.0000**
Lo vs Hi x Year	19.10	2	9.55	4.58	**0.0281**
Lo vs Hi x Site	6.90	2	3.45	1.65	0.2244
Lo vs Hi x Year x Site	7.50	4	1.88	0.90	0.4892
Lo vs Hi x HH vs NN	2.10	1	2.10	1.01	0.3317
Lo vs Hi x HH vs NN x Year	0.90	2	0.45	0.22	0.8085
Error	31.30	15	2.09		

[a] The denominator mean deviance used in the tests were: A) Block used for Year, Site, Year x Site Interaction, HH vs NN and HH vs NN x Year Interaction; and B) Error for all others.

[b] HH is Hatchery Spawned x Hatchery Spawned Cross

[c] NN is Naturally Spawned x Naturally Spawned Cross

Table B.6. Logistic Analysis of Variation of Male Precocial[7] Proportion of Sampled Fish prior to Release for 2004, 2005, and 2006 Releases of Low- and High-Nutrition-Treated Fish*

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio[a]	Type 1 Error P[a]
Year	81.56	2	40.78	13.54	**0.0004**
Site	0.56	2	0.28	0.09	0.9117
Year x Site	11.05	4	2.76	0.92	0.4793
HH[b] vs NN[c]	58.06	1	58.06	19.28	**0.0005**
HH vs NN x Year	3.88	2	1.94	0.64	0.5390
Block	45.17	15	3.01	0.70	0.7477
Lo vs Hi	89.95	1	89.95	20.97	**0.0004**
Lo vs Hi x Year	2.58	2	1.29	0.30	0.7449
Lo vs Hi x Site	2.58	2	1.29	0.30	0.7449
Lo vs Hi x Year x Site	17.18	4	4.30	1.00	0.4394
Lo vs Hi x HH vs NN	4.75	1	4.75	1.11	0.3105
Lo vs Hi x HH vs NN x Year	3.01	2	1.51	0.35	0.7101
Error	60.05	14	4.29		

[a] The source of the denominator mean deviance used in the tests were: A) Block used for Year, Site, Year x Site Interaction, HH vs NN and HH vs NN x Year Interaction; and B) Error for all others.

[b] HH is Hatchery Spawned x Hatchery Spawned Cross

[c] NN is Naturally Spawned x Naturally Spawned Cross

[7] Proportion fish with mature testes prior the leaving raceways based on a sample of 60 fish per raceway

Table B.7. Weighted* Logistic Analyses of Variation of Volitional-Release-to-McNary Smolt-to-Smolt Survival Indices for Low- and High-Nutrition treated non-precocial Upper Yakima Spring Chinook Smolt in 2004, 2005, and 2006 (weights are number of fish detected leaving the acclimation facilities).

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio[a]	Type 1 Error P[a]
Year	2529.67	2	1264.84	47.12	**0.0000**
Site	332.93	2	166.47	6.20	**0.0109**
Year x Site	49.23	4	12.31	0.46	0.7650
HH[b] vs NN[c]	95.92	1	95.92	3.57	**0.0782**
HH vs NN x Year	123.72	2	61.86	2.30	0.1341
Block	402.67	15	26.84	0.84	**0.6326**
Lo vs Hi	1155.12	1	1155.12	36.02	**0.0000**
Lo vs Hi x Year	30.73	2	15.37	0.48	0.6291
Lo vs Hi x Site	84.65	2	42.33	1.32	0.2985
Lo vs Hi x Year x Site	151.36	4	37.84	1.18	0.3618
Lo vs Hi x HH vs NN	166.49	1	166.49	5.19	**0.0389**
Lo vs Hi x HH vs NN x Year	38.15	2	19.08	0.59	0.5650
Error[d]	448.97	14	32.07		

[a] The source of the denominator mean deviance used in the tests were: A) Block used for Year, Site, Year x Site Interaction, HH vs NN and HH vs NN x Year Interaction; and B) Error for all others.

[b] HH is Hatchery Spawned x Hatchery Spawned Cross

[c] NN is Naturally Spawned x Naturally Spawned Cross

[d] **Note:** Analysis of variation adjusted for one missing value:
2004 release year (by 2002), Jack Creek Raceway 3, High Treatment:
degrees of freeom for error reduced from 15 to 14.

***Weight is (number volitionally released)*(1 – precocial proportion)**

Appendix C

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Annual Report: Smolt Survival to McNary Dam of Year-2006
Spring Chinook Releases at Roza Dam

Doug Neeley, Consultant to Yakama Nation

As was the case for 2004 and 2005 Roza Dam (Roza) smolt releases, there were few natural-origin (natural) released smolt compared to hatchery-origin (hatchery) smolt in 2006 during the period when hatchery and natural smolt contemporaneously passed Roza. There were only 500 natural fish released contemporaneously with hatchery-origin fish compared to 3,802 hatchery fish in 2006, the contemporaneous natural/hatchery release proportion being 0.13, which was higher than in 2005 and 2004 when the natural/hatchery-release ratios were both 0.03. However, the natural/hatchery release ratios for these three years were all lower than those in release years 1999 through 2003, over which the contemporaneous natural/hatchery-release ratio ranged from 0.20 to 1.41.

Roza-to-McNary smolt-to-smolt survival indices of pre-contemporaneous natural smolt and of contemporaneous natural and hatchery smolt are summarized in Table 1 and graphically presented in Figure 1 for all release years. As in most previous years, the 2006 contemporaneous survival of the natural smolt was significantly greater than the hatchery. For the years for which the estimated survival of the hatchery was greater than the contemporaneous natural, the differences were not significant (2001 and 2005 release years). Logistic analyses of variation tables for Roza-to-McNary survival are given in Table A.1 of Appendix 1 for all release years.

In 2006, more natural fish were trapped and released prior to the period of natural-hatchery contemporaneous passage than during that period (1833 prior versus 500 during). This was true in several previous years and may reflect natural temporal passage. The reason there were not more early passage smolt in all years may reflect the difficulty in sampling throughout the whole of the early out-migration.

The 2006 survival of late-passage natural smolt was significantly greater than that of the early-passage (P = 0.001, Table A.2. in Appendix A.). This also was true of the 2000 and 2002 releases (P <0.0001 and P = 0.0004, respectively, Table A.2.). In 2001, the early-passage had a significantly higher survival (P = 0.0001, Table A.2.). As mentioned in earlier reports, these comparisons are not particularly meaningful because some of the earlier released smolt may have passed McNary Dam before McNary Dam's bypass system is watered up.

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

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

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

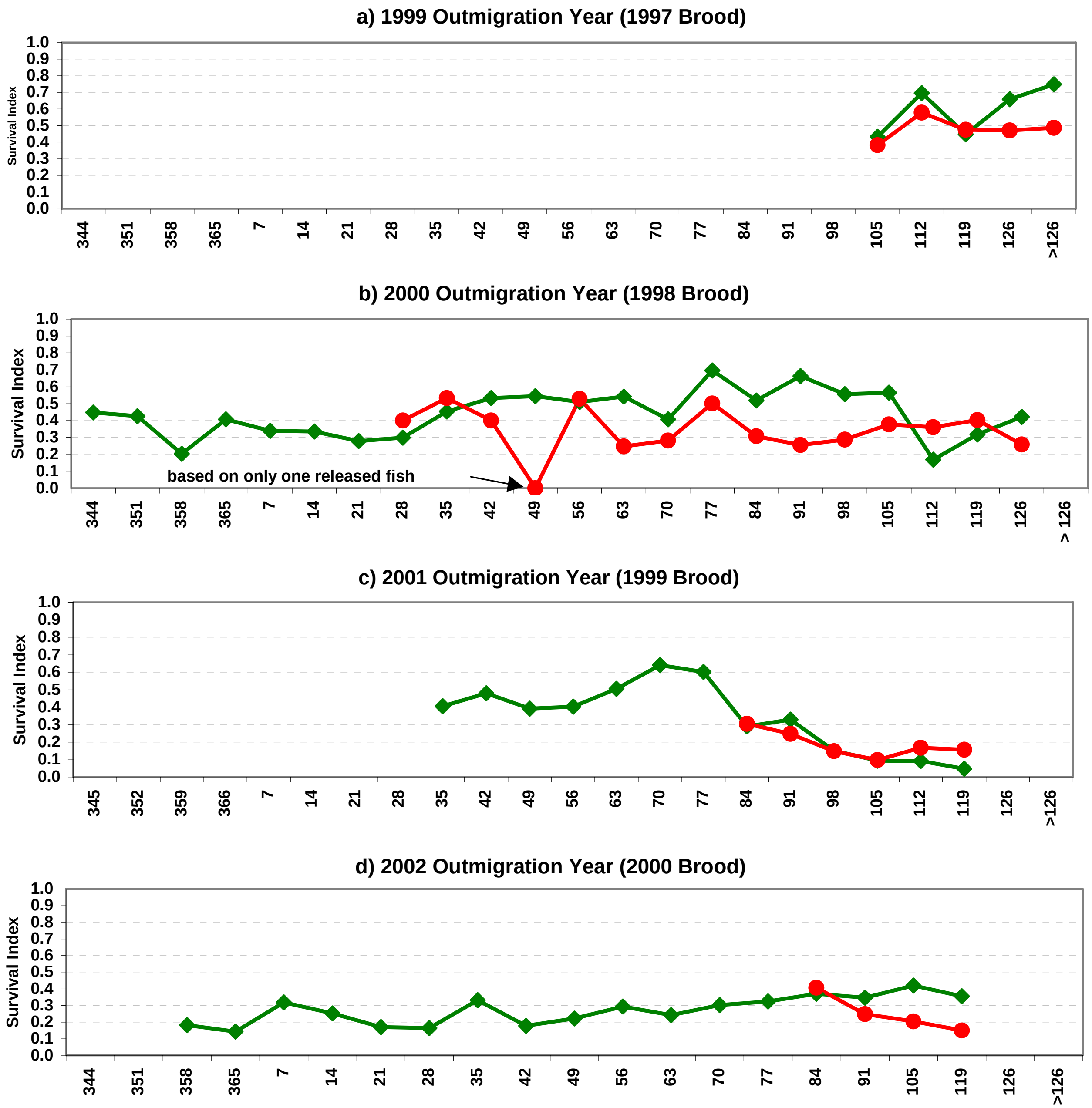
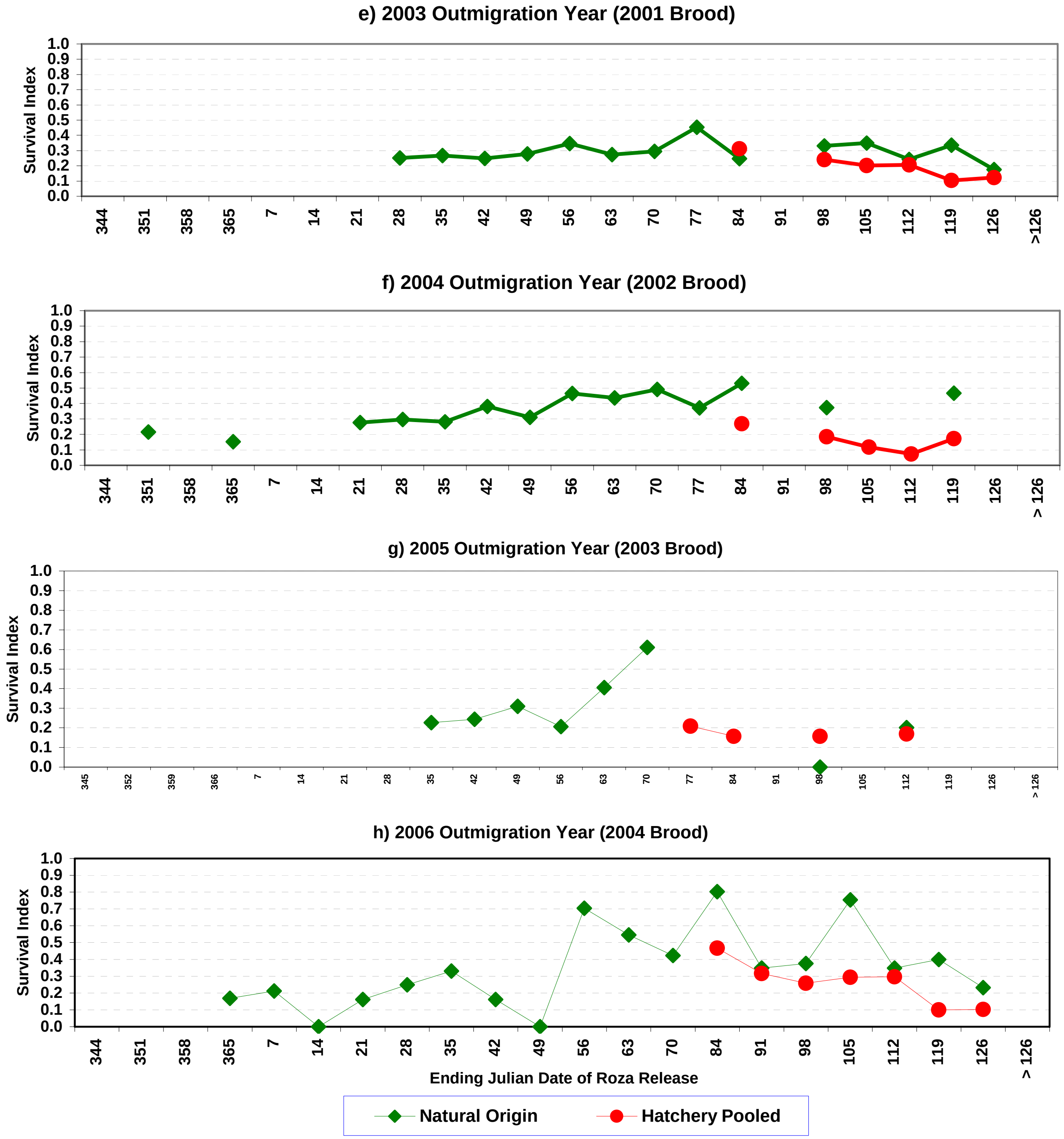


Figure 1. (continued)



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			

[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 < 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[2](Early) Natural versus Contemporaneous Natural Smolt (no 1999 early release)

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 (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	5.98	1	5.98	0.81	0.4035	Late
Error	44.43	6	7.41			

h) 2006 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	246.57	1	246.57	17.31	0.0010	Late
Error	199.40	14	14.24			

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

Appendix D

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2006 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 which may have some genetic differences from the Main-Stem-Yakima stock. 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. Hatchery-reared progeny from of crosses of Marion Drain brood-stock were part of a supplementation program and were released into Marion Drain.

Beginning with brood-year 2005 (release-year 2006), there was a shift in focus: The accelerated treatment was adopted as the procedure to follow at the Prosser supplementation site, 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 extirpated from the Yakima basin.

A portion of each 2006 release at Prosser and Stiles was PIT-tagged, and smolt-to-smolt survival indices of the PIT-tagged fish to McNary Dam (McNary) 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. Stratification estimates are given in Appendix A for these releases. Stratification procedures are discussed in my annual report for Spring Chinook, (the identified strata and stratum estimates for Fall Chinook, Spring Chinook, and Coho actually differ). There was no PIT-tagging of the Marion Drain stock released in 2006.

2. Analysis

A summary of estimated McNary passage times and estimated indices of smolt-to-smolt survival to McNary Dam based on all PIT-tagged fish are given in Table 1 for both Stiles- and Prosser-reared fish. There were no PIT-tag detectors available at Prosser for monitoring the number of released smolt as there were at Stiles ponds; therefore, survival to McNary based on the number of fish actually released was not possible. The mean travel time estimates based total tagged fish in Table 1 is simply the difference between the mean detection date at McNary and the date that the screens were pulled at the release site. Both pre-release and post-release mortality and PIT-tag shedding can affect the survival-to-McNary survival estimates based on all tagged fish in Table 1.

There were two distinct PIT-tagged releases (groups) at Prosser; one released four days after the other, and these estimates may be regarded as independent releases. While there were also two PIT-tag groups for Stiles, they were not independent releases. The two releases were reared together in the Upper Stiles Pond and were able to mix and volitionally leave the pond together. The Stiles and Prosser estimates from the two groups are presented separately in Table 1 along with pooled estimates over the two groups.

Table 1. Summary estimates of Stiles- and Prosser-Reared Fall Chinook based on all tagged Fish in 2006 (2005 brood-year) [Data summaries from Appendix A.]

	Stiles Release		
	PIT Tag Group 1	PIT Tag Group 2	Pooled Mean
Releases Date (Screens Pulled)	04/27/06	04/27/06	04/27/06
Mean McNary Detection Date	6/14/06	6/14/06	6/14/06
Mean Travel Time	**47.8**	**48.2**	**48.0**
Tagging-to-McNary Survival Percentage	**15.3%**	**14.8%**	**15.1%**

	Prosser Release		
	PIT Tag Group 1	PIT Tag Group 2	Pooled Mean
Releases Date (Screens Pulled)	04/24/06	04/28/06	04/28/06
Mean McNary Detection Date	5/26/06	5/26/06	5/26/06
Mean Travel Time	**32.0**	**28.1**	**28.0**
Tagging-to-McNary Survival Percentage	**31.4%**	**31.0%**	**31.2%**

Since there were PIT-tag detectors above the outfall from the Stiles ponds, the survival estimates could be parsed out into an index of pre-release survival and tag retention and an index of post-release survival to McNary. These estimates are given in Table 2 along with estimated mean volitional-release time and mean McNary passage time and related measures.

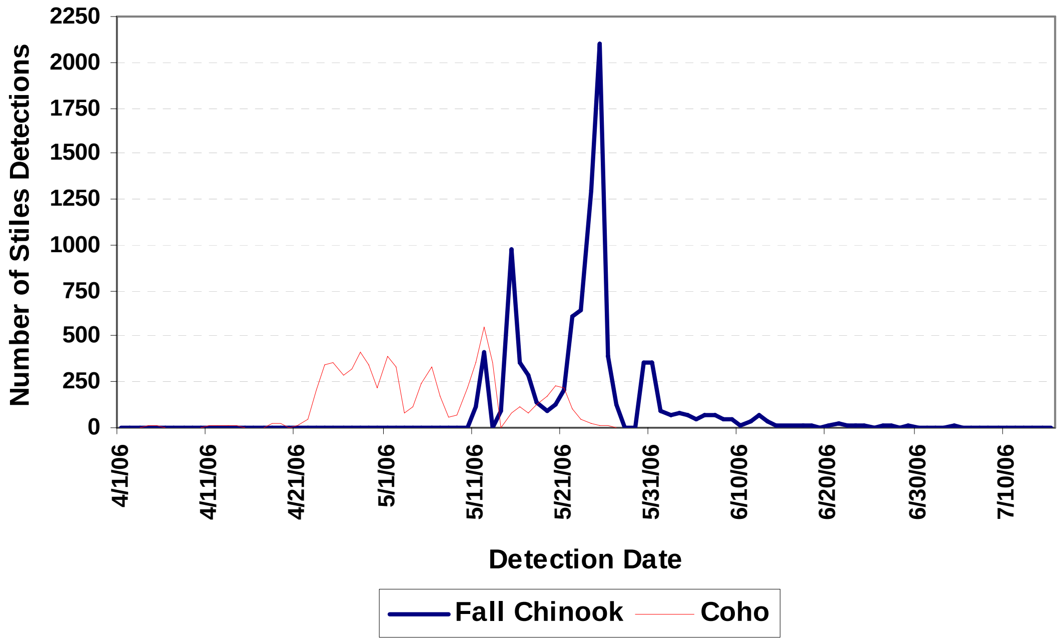
Table 2. Summary estimates of Upper-Stiles-Pond-Reared Fall Chinook Releases into the Naches River in 2006 (2005 brood-year) [Data summaries from Appendix A.]

	Stiles Release		
	PIT Tag Group 1	PIT Tag Group 2	Pooled Mean
Releases Date (Screens Pulled)	04/27/06	04/27/06	04/27/06
Mean Date of Volitional Release	5/24/06	5/23/06	05/23/06
Mean McNary Detection Date	6/15/06	6/16/06	06/15/06
Mean Travel Time			
From Date Screens Pulled	**48.8**	**49.8**	**49.3**
From Mean Volitional release Date	**22.2**	**23.9**	**23.0**
Percent Leaving Pond (Pre-release Survival and T	**87.4%**	**81.3%**	**84.3%**
Release-to-McNary Survival Percentage	**14.8%**	**15.5%**	**15.2%**

One concern about the use of the Upper Stiles Pond was that fall Chinook volitionally leaving this pond would have had to pass Lower Stiles Pond where larger Coho fish were being reared. This may have subjected the smaller Fall Chinook to a level of pre-release predation by larger Coho. However, since the release-site PIT tag detectors were located below the lower pond, and the pre-release survival estimates were near between 80% and 90% (Table 2) which is just a bit less than that observed for Coho reared in the lower pond (90.1% Coho pre-release survival), this concern may be unfounded. Although the Coho tend to leave the pond before Fall Chinook, there is a substantial overlap in their volitional release distributions (Figure 1). If predation by Coho were a serious problem, then there should be some pre-release mortality. If the high pre-release survival estimates apply to this period of distribution overlap, then there was probably very little pre-release predation by Coho in the Stiles rearing ponds in 2006.

It should be noted that, of the 874 fish detected at McNary from all Stiles-tagged fish, 224 or 25.6% were detected before June 12th; however of the 498 McNary-detected fish that were detected earlier at Stiles, only 7 or 1.4 percent were detected at McNary before June 12th. This suggests that the detector's efficiency may have been much lower for fish leaving the ponds earlier than those leaving the ponds later.

Figure 1. Daily volitional detection numbers of Coho and Fall Chinook at Stiles Pond



There were also small releases made at other sites, and their summaries are given in Table 3.

Table 3. Summary estimates of other Fall Chinook Releases into the Yakima River in 2006 (2005 brood-year)

Release Site >	Below Prosser*	Granger*	Horn Rapids**	Van Giesen*
Release Date	04/20/06 - 04/25/06	05/10/06	05/09/06	04/18/06 - 04/24/06
Mean McNary Detection Date			05/30/06	
Mean Travel Time for all Tagged Fish			**21.0**	
Number Tagged	54	21	191	40
Total McNary Detections	4	1	13	2
Expanded McNary Detections	17.8	2.9	56.7	9.9
Tagging-to-McNary Survival	**32.9%**	**13.7%**	**29.7%**	**24.8%**

* Too few McNary detections from multiple releases for meaningful estimates of survival or mean travel time to McNary from below-Prosser, Granger, and Van Giesen

** Single Release: Data for Horn Rapids summaries from Appendix A.

Appendix A. Stratified McNary Detection Rates and Estimate Summaries

				All Tagged Fish		
				Stiles releases		Pooled over Stiles
Stratum 1	Beginning Date					
	Ending Date	06/05/06	Subtotal	47	44	
	Detection Rate	0.2249	Expanded Total	208.9	195.6	
Stratum 2	Beginning Date	06/06/06				
	Ending Date	06/11/06	Subtotal	69	64	
	Detection Rate	0.1830	Expanded Total	377.0	349.7	
Stratum 3	Beginning Date	06/12/06				
	Ending Date	0.3480	Subtotal	330	320	
	Detection Rate		Expanded Total	948.4	919.6	
			a Total over Strata	446	428	874
			b Expanded Total over Strata	1534.3	1464.9	2999.3
			c Tagged	9999	9902	19901
			d Tagging-to-McNary Survival (b/c)	0.1534	0.1479	0.1507
			e McNary Detection Date	06/14/06	06/14/06	06/14/06
			f Date Screens Pulled	04/27/06	04/27/06	04/27/06

				All Tagged Fish			
				Prosser Releases		Pooled over Prosser	Horn Rapid Releases
Stratum 1	Beginning Date						
	Ending Date	06/05/06	Subtotal	309	298		9
	Detection Rate	0.2249	Expanded Total	1373.7	1324.8		40.0
Stratum 2	Beginning Date	06/06/06					
	Ending Date	06/11/06	Subtotal	28	31		2
	Detection Rate	0.1830	Expanded Total	153.0	169.4		10.9
Stratum 3	Beginning Date	06/12/06					
	Ending Date	0.3480	Subtotal	16	20		2
	Detection Rate		Expanded Total	46.0	57.5		5.7
			a Total over Strata	353	349	702	13
			b Expanded Total over Strata	1572.7	1551.6	3124.3	56.7
			c Tagged	5001	5000	10001	191
			d Tagging-to-McNary Survival (b/c)	0.3145	0.3103	0.3124	0.2968
			e McNary Detection Date	05/26/06	05/26/06	05/26/06	05/30/06
			f Date Screens Pulled	04/24/06	04/28/06	04/28/06	05/09/06

Volitional Release Date for Stiles Summarized on Next Page

Appendix A. Stratified McNary Detection Rates and Estimate Summaries (Continued)

				Volitional Release Only		
				Stiles releases		Pooled over Stiles
Stratum 1	Beginning Date					
	Ending Date	06/05/06	Subtotal	0	0	
	Detection Rate	0.2249	Expanded Total	0	0	
Stratum 2	Beginning Date	06/06/06				
	Ending Date	06/11/06	Subtotal	3	4	
	Detection Rate	0.1830	Expanded Total	16.4	21.9	
Stratum 3	Beginning Date	06/12/06				
	Ending Date	0.3480	Subtotal	247	244	
	Detection Rate		Expanded Total	709.8	701.2	
		a	Total over Strata (volitional)	250	248	498
		b	Expanded Total over Strata (Volition	726.2	723.1	1449.3
		c	Volitional Releases	4897	4662	9559
		d	Release-to-McNary Survival (b/c)	0.1483	0.1551	0.1516
		e	Total PIT-Tagged	9999	9902	19901
		f	Proportion Detected (c/e)	0.4897	0.4708	0.4803
		g	McNary Detection Date	6/15/06	6/16/06	6/15/06
		h	Mean Release Date	5/24/06	5/23/06	5/23/06
		I	Mean Travel Time (g-h)	22.18	23.92	23
		j	Total McNary Detections of all Tagg	446	428	874
		k	Total Expanded Detections of all Ta	1534.3	1464.9	2999.3
		l	Detection Rate at Release Site* (a/j)	0.5605	0.5794	0.5698
		m	Prerelease Survival (f/l)	0.8737	0.8125	0.8430

* Based on unexpanded counts at McNary

Appendix E

IntSTATS

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Annual Report: 2006 Smolt Survival Index to McNary

Coho Releases into the Yakima Basin

Doug Neeley, Consultant to Yakama Nation
March 13, 2007

Introduction

For brood-years 2002 and 2003 (respective outmigration years 2004 and 2005), out-of-basin stock and Yakima-return stock smolt were released at different sites; therefore, it was not possible to compare smolt-to-smolt survival indices among sites or among stock because stock and site effects were completely confounded. For brood-year 2004 (outmigration year 2006), Yakima stock and Eagle Creek Hatchery brood smolt were released from each of four sites: the Boone and Holmes ponds in the Upper Yakima sub-basin and Stiles and the Lost Creek in the Naches sub-basin. There were also small releases of Washougal Hatchery stock at all of these sites except Stiles. Same site releases of Yakima-origin and out-of-basin stocks were made for the 1997 and 1999 through 2001 broods (1999 and 2001-2003 outmigration years, respectively). Insufficient Yakima-return stock was available in brood-year 1998 for hatchery production.

In the earlier brood-years of paired stock release, there were either no PIT-tag detectors at the acclimation sites or the detection efficiencies of acclimation-site detectors were so low that any estimates of the in-river smolt-to-smolt survival index (release-to-McNary-Dam out-migrant survival index) based on those releases would have had extremely low precisions; therefore, for the purpose of comparing Yakima-Stock to out-of-basin stock over years, estimates of survival indices to McNary are based on number of fish tagged not on number of fish detected leaving the acclimation ponds.

Tagging-to-McNary Survival Index

In the earlier brood years, there were two different release dates being compared (early and late dates when fish were released into the river or early and late dates for the pulling of screens at the ponds for volitional release). The analyses of data for those early brood years clearly indicated that the smolt-to-smolt survival index was higher for the earlier releases (Sub-basin means in Table 1.a. and logistic analysis of variation in Table 1.b.) In subsequent years, earlier volitional releases became the standard practice, and no late releases were made.

For brood-year 1997, the out-of-basin stock used was Cascade; for brood-years 1998 through 2002, Willard stock was used; and for brood-years 2003 and 2004, Washougal and Eagle Creek stock were used. In brood-years 2003-2004, Eagle Creek stock was the out-of-basin stock of preference, and Washougal was used to infuse some late-run genes into the population and to meet overall release goals. For these later years, Eagle Creek stock has been the out-of-basin brood-stock used for comparison to Yakima-return stock.

Cascade stock had a significantly higher tagging-to-McNary smolt-to-smolt survival index than did Yakima-return stock in brood-year 1997 (Table 1.b.). For brood-years 1999 through 2001, Yakima-return stock had a significantly higher smolt-to-smolt survival index than Willard stock (Table 1.b.).

In brood-year 2004, there was no significant difference between the Yakima-return and the Eagle Creek brood-stock. The mean survival indices for the 2004 brood are given in Table 2.a by site within sub-basin as well as by sub-basin. Table 2.b. gives the associated logistic analysis of variation for Yakima-return and Eagle Creek brood-stock. Washougal stock, which was not included in the analysis of variation, had a uniformly poorer survival index than either the Yakima or Eagle-Creek stock (Table 2.a.).

The tagging-to-McNary "survival" indices presented in Table 2.a. would be affected by many losses from both mortality and non-mortality factors, including: pond and in-river mortality, pre-and post-release tag shedding, and the failure of the McNary detectors to detect fish that have passed through those detectors.

One of the reasons for analyzing the 2004 brood (Table 2.b.) separately from the previous years (Table 1.b.) is that the detection efficiency at the acclimation sites was much more precise than in previous years. For the 2004 brood as well as subsequent broods, survival-index estimates will likely be based on river survival (release-to-McNary instead of tagging-to-McNary). The 2004 brood-year release-to-McNary survival indices are presented in the next section.

Figure 1 presents the tagging-to-McNary early-release smolt-to-smolt survival indices for sub-basins based on only those sites where both the in-basin and out-of-basin stocks were both released.

Table 1.a. Brood-Year 1997-2001 Tagging-to-McNary Survival Indices [release year two years later than brood year][8]

Brood Year 1997 (Outmigration Year 1999)

Subbasin	Release Time> / Brood Stock	Mid-May 05/17/99		Late-May 05/27/99		Mean over Release Time	
		Yakima	Cascade	Yakima	Cascade	Yakima	Cascade
Upper Yakima	**Survival Index**	**0.4324**	**0.5839**	**0.3410**	**0.4564**	**0.3866**	**0.5200**
	Number Tagged	2401	2044	2410	2055	4811	4099
Naches	**Survival Index**	**0.2851**	**0.4496**	**0.2142**	**0.3194**	**0.2490**	**0.3841**
	Number Tagged	2291	2434	2384	2468	4675	4902
Mean/Total over Subbasins	**Survival Index**	**0.3605**	**0.5109**	**0.2780**	**0.3817**	**0.3188**	**0.4460**
	Number Tagged	4692	4478	4794	4523	9486	9001

Brood Year 1998 (Outmigration Year 2000)

Subbasin	Release Time> / Brood Stock	Early May 05/07/00		Late May 05/31/00		Mean over Release Time	
		Yakima	Willard	Yakima	Willard		Willard
Upper Yakima	**Survival Index**		**0.2361**		**0.1153**		**0.1758**
	Number Tagged		4963		4938		9901
Naches	**Survival Index**		**0.2993**		**0.2866**		**0.2930**
	Number Tagged		4977		4981		9958
Mean/Total over Subbasins	**Survival Index**		**0.2677**		**0.2013**		
	Number Tagged		9940		9919		

Brood Year 1999 (Outmigration Year 2001)

Subbasin	Release Time> / Brood Stock	Early May 05/07/01		Late May 05/25/01		Mean over Release Time	
		Yakima	Willard	Yakima	Willard	Yakima	Willard
Upper Yakima	**Survival Index**	**0.0694**	**0.0443**	**0.0333**	**0.0127**	**0.0512**	**0.0286**
	Number Tagged	2456	2453	2487	2431	4943	4884
Naches	**Survival Index**	**0.3199**	**0.0932**	**0.3172**	**0.1187**	**0.3185**	**0.1059**
	Number Tagged	2499	2482	2500	2476	4999	4958
Mean/Total over Subbasins	**Survival Index**	**0.1957**	**0.0689**	**0.1756**	**0.0662**	**0.1856**	**0.0675**
	Number Tagged	4955	4935	4987	4907	9942	9842

Brood Year 2000 (Outmigration Year 2002)

Subbasin	Release Time> / Brood Stock	Early May 05/06/02		Late May 05/25/02		Mean over Release Time	
		Yakima	Willard	Yakima	Willard	Yakima	Willard
Upper Yakima	**Survival Index**		**0.0634**	**0.1287**	**0.2153**	**0.1287**	**0.1647**
	Number Tagged		1248	2500	2497	2500	3745
Naches	**Survival Index**	**0.2504**	**0.2993**	**0.6021**	**0.2879**	**0.4283**	**0.2936**
	Number Tagged	2442	2498	2500	2498	4942	4996
Mean/Total over Subbasins	**Survival Index**	**0.2504**	**0.2207**	**0.3654**	**0.2516**	**0.3277**	**0.2383**
	Number Tagged	2442	3746	5000	4995	7442	8741

Brood Year 2001 (Outmigration Year 2003)

Subbasin	Release Time / Time> / Brood Stock	Volitional Release* 04/08/03				Mean over Release Time	
		Yakima	Willard			Yakima	Willard
Upper Yakima	**Survival Index**	**0.1155**	**0.0980**			**0.1155**	**0.0980**
	Number Tagged	3355	4960			3355	4960
Naches	**Survival Index**	**0.2334**	**0.1633**			**0.2334**	**0.1633**
	Number Tagged	6665	4998			6665	4998
Mean/Total over Subbasins	**Survival Index**	**0.1939**	**0.1308**			**0.1939**	**0.1308**
	Number Tagged	10020	9958			10020	9958

*** Beginning in Early April**

[8] Refer to 2003 Annual report.

Table 1.b. Weighted Logistic Analysis of Variation of Tagging-to-McNary Smolt Survival Index for 1997-2001 Brood Years' Releases of Coho into the Upper Yakima and Naches Sub-basins (weights are tagging numbers) [release year two years later than brood year]

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 p
Year	4430.82	4	1107.71	13.91	**0.0000**
Basin (adjusted for year)	917.12	1	917.12	11.52	**0.0011**
Basin x Year Interaction	2136.02	4	534.01	6.71	**0.0001**
Site	2728.44	3	909.48	11.42	**0.0000**
Site x Year Intearaction	398.2	5	79.64	base for above F-tests	
Stock	1189.87	2	594.94	10.42	**0.0004**
Willard vs Yakima	394.26	1	394.26	6.90	**0.0140**
Cascade vs Yakima	795.62	1	795.62	13.93	**0.0009**
Treatment (Trt--Early vs Late)	31.24	1	31.24	0.55	0.4659
Stock x Trt Interaction*	147.13	2	73.57	1.29	0.2922
Other Interactions**	1114.76	6	185.79	3.25	**0.0154**
Within-Year Error***	1542.12	27	57.12	base for stock, treatment F-tests	

* (Willard vs Yakima) x Trt; (Cascade vs Yakima) x Trt

** Iteractions not included within Error

*** Error interactions of Stock, Trt, and Stock x Trt with Basin within Year and site within Basin within Year

Table 2.a. Brood-Year 2004 Tagging-to-McNary Survival Indices [2006 release year][9]

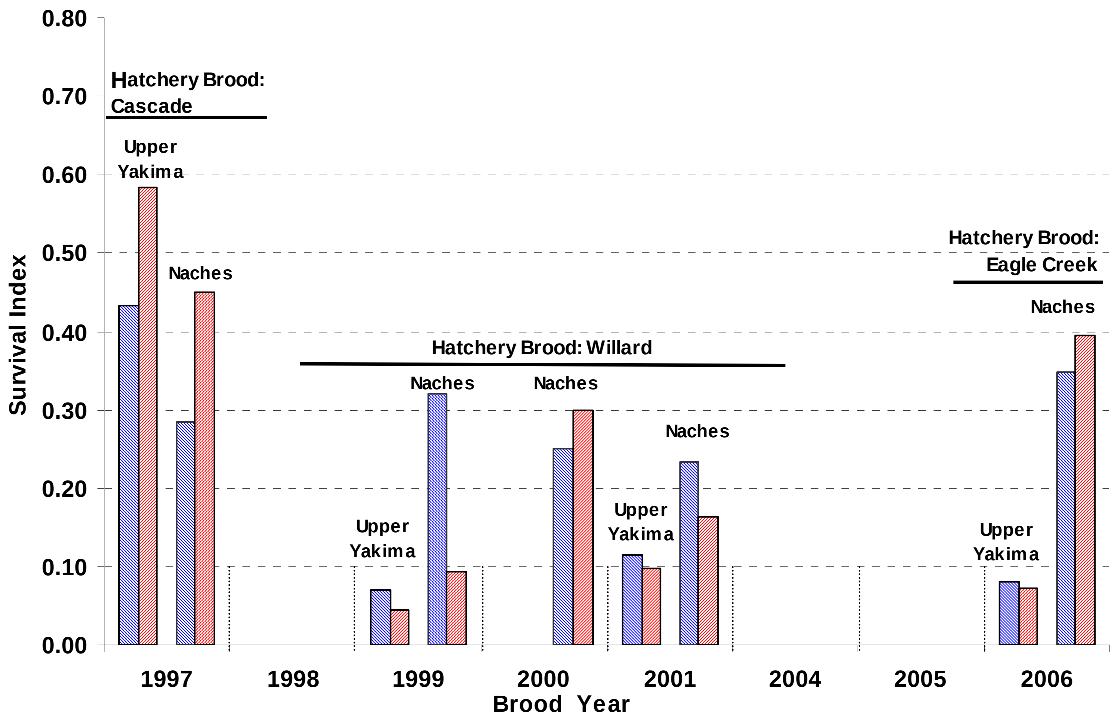
	Subbasin >	**Upper Yakima**		**Naches**		**Subbasin Means**	
Stock	**Measure**	**Holmes**	**Boone**	**Stiles**	**Lost Creek**	**Upper Yakima**	**Naches**
Eagle Creek	**Tagging-to-McN Survival**	**0.1182**	**0.0257**	**0.3505**	**0.4381**	**0.0721**	**0.3944**
	Number Tagged	2514	2500	2506	2515	5014	5021
Yakima	**Tagging-to-McN Survival**	**0.1248**	**0.0369**	**0.3499**	**0.3476**	**0.0810**	**0.3487**
	Number Tagged	2512	2501	2490	2491	5013	4981
Eagle Creek and Yakima Main Effect	**Tagging-to-McN Survival**	**0.1215**	**0.0313**	**0.3502**	**0.3931**	**0.0765**	**0.3717**
	Number Tagged	5026	5001	4996	5006	10027	10002
Washougal	**Tagging-to-McN Survival**	**0.0312**	**0.0170**		**0.2817**	**0.0241**	**0.2817**
	Number Tagged	1024	1026		1022	2050	1022

[9] Estimation methods discussed in greater detail in **Appendix A**.

Table 2.b. **Weighted Logistic Analysis of Variation of Tagging-to-McNary Smolt Survival Index for 2004 Brood Year's [2006 Release Year's] Releases of Coho into the Upper Yakima and Naches Sub-basins (weights are tagging numbers)**

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Site Adjusted for Stock	3012.35	3	1004.12	80.03	0.0023
Stock (Upper Yakima versus Eagle Creek) Adjusted for Site	11.17	1	11.17	0.89	0.4150
Site x Stock	37.64	3	12.55		

Figure 1. **Tagging-to-McNary Survival Indices for early Release Coho from Yakima (downward slash) and Hatchery (upward slash) Brood [release year two years later than brood year]**



Release-to-McNary Survival Index

Table 3.a. gives the release-to-McNary survival indices for the 2004 brood and Table 3.b. gives the associated logistic analysis of variation. There was no PIT-tag detector installed at the Boone site; therefore no estimates are available for that site. Again, there is no significant difference between the Yakima-return and Eagle Creek brood stocks. The numbers of detections of Washougal stock were only 7 from Holmes, 0 from Stiles, and 248 from Lost Creek, and the estimates for that stock should be regarded as very imprecise. The survival indices for all stocks from Lost Creek are the highest experienced to date. They are so high, that they are somewhat suspect; however, up to the time of this report, there has been nothing discovered about the estimation procedures at that site that should have impacted the estimates any more than at any other site.

Table 3.a. Brood-Year 2004 Release-to-McNary Survival Indices [2006 Release Year][10]

	Subbasin >	Upper Yakima		Naches		Subbasin Means	
Stock	**Measure**	**Holmes**	**Boone**	**Stiles**	**Lost Creek**	**Upper Yakima**	**Naches**
Eagle Creek	**Release-to-McN Survival**	**0.1862**		**0.3881**	**0.6266**	**0.1862**	**0.4972**
	Pond Detections	636		1974	1663	636	3637
Yakima	**Release-to-McN Survival**	**0.2501**		**0.3915**	**0.6802**	**0.2501**	**0.5064**
	Pond Detections	781		1598	1057	781	2655
Eagle Creek and Yakima Main Effect	**Release-to-McN Survival**	**0.2214**		**0.3896**	**0.6474**	**0.2214**	**0.5011**
	Pond Detections	1417		3572	2720	1417	6292
Washougal	**Release-to-McN Survival**	**0.0000**			**0.8130**	**0.0000**	**0.8130**
	Pond Detections	7			248	7	248

[10] Estimation methods discussed in greater detail in **Appendix A**.

Table 3.b. Weighted Logistic Analysis of Variation of Release-to-McNary Smolt Survival Index for 2004 Brood Year's [2006 Release Year's] Releases of Coho into the Upper Yakima and Naches Sub-Basins (weights are volitional release detections numbers)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Site Adjusted for Stock	811.74	2	405.87	101.59	0.0097
Stock (Upper Yakima versus Eagle Creek) Adjusted for Site	8.62	1	8.62	2.16	0.2796
Site x Stock	7.99	2	4.00		

Pre-release Survival Index

The proportion of tagged fish detected leaving the acclimation ponds divided by an estimate of the detection efficiency at the ponds will give an estimate of survival index that is only affected by pre-release mortality and tag-shedding. Estimates of detection efficiency for each tag group were obtained by dividing the number of tags jointly detected at the acclimation pond and McNary Dam by the total number detected at McNary. Table 4.a. gives the estimates[11].

[11] Estimation methods discussed in greater detail in **Appendix A**.

Table 4.a. Proportion of PIT-tagged fish detected at Acclimation Ponds and pre-Release Survival Index for Brood-Year 2004 Coho (2006 outmigration Year)[12]

	Subbasin >	**Upper Yakima**		**Naches**		**Subbasin Means**	
Stock	**Measure**	**Holmes**	**Boone**	**Stiles**	**Lost Creek**	**Upper Yakima**	**Naches**
Eagle Creek	Proportion Detected at Pond	0.2530		0.7877	0.6612	0.2530	0.7244
	Pond Survival*	**0.6050**		**0.8855**	**0.6956**	**0.6050**	**0.7904**
	Number Tagged	2514		2506	2515	2514	5021
Yakima	Proportion Detected at Pond	0.3109		0.6418	0.4243	0.3109	0.5330
	Pond Survival*	**0.4869**		**0.9175**	**0.5384**	**0.4869**	**0.7279**
	Number Tagged	2512		2490	2491	2512	4981
Eagle Creek and Yakima Main Effect	Proportion Detected at Pond	0.2819		0.7150	0.5433	0.2819	0.6291
	Pond Survival*	**0.5460**		**0.9014**	**0.6174**	**0.5460**	**0.7593**
	Number Tagged	5026		4996	5006	5026	10002
Washougal	Proportion Detected at Pond	0.2530			0.2427	0.2530	0.2427
	Pond Survival*	**0.0068**			**0.3431**	**0.0068**	**0.3431**
	Number Tagged	1024			1022	1024	1022

* Pond Survival (Combined Pond and Tag Retention) Rate
= Proportion (Detected at Pond)/(Detection Rate), wherein
Detection Rate
= (Number jointly detected at McNary and Pond)/(Total Number Detected at Pond)
** Under Estimate because Pond Detection Rate Estimate = 0 and treated as 1

[12] Estimation methods discussed in greater detail in **Appendix A**.

Appendix A. Estimation Methods

Smolt-to-smolt survival index: Release-to-McNary smolt-to-smolt survival index for the 2006 releases (2004 brood) is generally estimated by

Equation A.1.

$$\text{McNary Survival Index} = \frac{\displaystyle\sum_{\text{Strata}} \frac{\text{McNary Detections}}{\text{Stratum's McNary Detection Efficiency}}}{\text{Number of PIT-Tagged Fish}}$$

wherein

1) “McNary Detections” is number the release’s fish detected at McNary Dam (for **Tagging**-to-McNary survival index, the number of tagged fish detected at McNary; for **Release**-to-McNary survival, the number of fish previously detected at acclimation pond)

2) “Stratum’s Detection Efficiency” is the estimated proportion of all[13] Yakima PIT-tagged Coho passing McNary Dam during a stratum that were detected at McNary (Equation A.4).

3) “Number of PIT-tagged fish: for **tagging**-to-McNary survival index, the total number of tagged fish; for **release**-to-McNary survival, the number of fish detected at acclimation pond.

Equation A.4.

$$\text{Stratum's McNary detection efficiency} = \text{within-stratum} \frac{\text{number of joint detections at McNary and downstream dams}}{\text{estimated total number of detections at downstream dams}}$$

[13] All PIT-tagged Coho releases into the Yakima, upper Yakima, and Naches, not only those of this study’s release groups.

In Equation A.4., the downstream-dam count actually represents a pooling of counts from John Day and Bonneville dams[14]. The detection days were stratified into groups of days with relatively homogeneous detection efficiencies.

In previous years, there were adjustments in Equation A.4. for PIT-tags removed at McNary (e.g., due to transportation from McNary). In 2006, no such adjustments were made because there was no or little evidence of such removal of Yakima-origin PIT-tagged fish in 2006.

A major reason for referring to the survival measure as a survival index instead of survival is that there are known biases associated with the detection efficiency which were discussed in the 2003 Annual Report.

Data summaries used to estimate the brood-year 2006 (outmigration year 2006) survival-index estimates are given in Tables A.1.a. and A.1.b. for tagging-to-McNary and release-to-McNary estimates. Table A.2 gives proportion detected at ponds.

[14] In recent years experiments were conducted at John Day and Bonneville that varied the proportion of flow spilled in the daytime relative to the proportion spilled at night. To offset the electric power lost at one dam during a given period, contravening action was often taken at the other dam (Personal Communication, Rock Peters, U.S. Army Corps of Engineers, Portland, Oregon.) Given this situation, it was deemed more appropriate to pool John Day and Bonneville Dam-based estimates of the McNary Detection Efficiency. This means that some of the fish detected at both John Day and Bonneville dams were used twice to estimate the McNary detection efficiency (an effective “sampling with replacement”). This method of estimation is now being reconsidered because of possible bias that would result if some fish were more inclined to be entrained into the bypass systems where the detectors are located than other fish.

Table A.1. 2006 Coho McNary Smolt-to-Smolt Survival Index Estimates (2004 brood)

a. Tagging-to-McNary Survival Index

Stock: Washougal

Stratum Dates/ Detection Rates		Counts	Holmes	Lost Creek	Boone
	05/12/06	Unexpanded =	0	0	0
Detection Rate =	0.2964	Expanded =	0.0	0.0	0.0
05/13/06	05/22/06	Unexpanded =	0	2	0
Detection Rate =	0.1105	Expanded =	0.0	18.1	0.0
05/23/06	05/28/06	Unexpanded =	1	3	1
Detection Rate =	0.3454	Expanded =	2.9	8.7	2.9
05/29/06		Unexpanded =	4	36	2
Detection Rate =	0.1379	Expanded =	29.0	261.1	14.5
Stratum Totals		Unexpanded =	5	41	3
		Expanded =	31.9	287.9	17.4
		Number Tagged =	1024	1022	1026
		Tagging-to-McNary Survival Index =	0.0312	0.2817	0.0170

Stock: Yakima

Stratum Dates/ Detection Rates		Counts	Holmes	Lost Creek	Boone	Stiles
	05/12/06	Unexpanded =	76	29	16	126
Detection Rate =	0.2964	Expanded =	256.4	97.8	54.0	425.1
05/13/06	05/22/06	Unexpanded =	6	32	2	45
Detection Rate =	0.1105	Expanded =	54.3	289.5	18.1	407.1
05/23/06	05/28/06	Unexpanded =	1	40	2	11
Detection Rate =	0.3454	Expanded =	2.9	115.8	5.8	31.8
05/29/06		Unexpanded =	0	50	2	1
Detection Rate =	0.1379	Expanded =	0.0	362.7	14.5	7.3
Stratum Totals		Unexpanded =	83	151	22	183
		Expanded =	313.6	865.8	92.4	871.3
		Number Tagged =	2512	2491	2501	2490
		Tagging-to-McNary Survival Index =	0.1248	0.3476	0.0369	0.3499

Stock: Eagle Creek

Stratum Dates/ Detection Rates		Counts	Holmes	Lost Creek	Boone	Stiles
	05/12/06	Unexpanded =	28	1	2	45
Detection Rate =	0.2964	Expanded =	94.5	3.4	6.7	151.8
05/13/06	05/22/06	Unexpanded =	16	19	3	64
Detection Rate =	0.1105	Expanded =	144.7	171.9	27.1	578.9
05/23/06	05/28/06	Unexpanded =	5	57	3	41
Detection Rate =	0.3454	Expanded =	14.5	165.0	8.7	118.7
05/29/06		Unexpanded =	6	105	3	4
Detection Rate =	0.1379	Expanded =	43.5	761.6	21.8	29.0
Stratum Totals		Unexpanded =	55	182	11	154
		Expanded =	297.2	1101.9	64.3	878.5
		Number Tagged =	2514	2515	2500	2506
		Tagging-to-McNary Survival Index =	0.1182	0.4381	0.0257	0.3505

Table A.1. (continued)

b. Release-to-McNary Survival Index

Stratum Dates/ Detection Rates		Counts	Stock: Washougal Site		
				Lost Creek	
	05/12/06	Unexpanded =		0	
Detection Rate =	0.2964	Expanded =		0.0	
05/13/06	05/22/06	Unexpanded =		0	
Detection Rate =	0.1105	Expanded =		0.0	
05/23/06	05/28/06	Unexpanded =		2	
Detection Rate =	0.3454	Expanded =		5.8	
05/29/06		Unexpanded =		27	
	0.1379	Expanded =		195.8	
		a. Total Unexpanded =	0.0	29.0	0.0
		b. Total Expanded =	0.0	201.6	0.0
		c. Volitional Release =		248	
d. Release-to-McNary Survival Index (b./c.) =				0.8130	

Stratum Dates/ Detection Rates		Counts	Stock: Yakima Site		
			Holmes	Lost Creek	Stiles
	05/12/06	Unexpanded =	49	9	83
Detection Rate =	0.2964	Expanded =	165.3	30.4	280.0
05/13/06	05/22/06	Unexpanded =	3	29	35
Detection Rate =	0.1105	Expanded =	27.1	262.3	316.6
05/23/06	05/28/06	Unexpanded =	1	37	10
Detection Rate =	0.3454	Expanded =	2.9	107.1	28.9
05/29/06		Unexpanded =	0	44	0
	0.1379	Expanded =	0.0	319.1	0.0
		a. Total Unexpanded =	53	119	128
		b. Total Expanded =	195.3	719.0	625.6
		c. Volitional Release =	781	1057	1598
d. Release-to-McNary Survival Index (b./c.) =			0.2501	0.6802	0.3915

Stratum Dates/ Detection Rates		Counts	Stock: Eagle Creek Site		
			Holmes	Lost Creek	Stiles
	05/12/06	Unexpanded =	13	0	38
Detection Rate =	0.2964	Expanded =	43.9	0.0	128.2
05/13/06	05/22/06	Unexpanded =	6	15	55
Detection Rate =	0.1105	Expanded =	54.3	135.7	497.5
05/23/06	05/28/06	Unexpanded =	2	55	41
Detection Rate =	0.3454	Expanded =	5.8	159.2	118.7
05/29/06		Unexpanded =	2	103	3
	0.1379	Expanded =	14.5	747.1	21.8
		a. Total Unexpanded =	23	173	137
		b. Total Expanded =	118.4	1042.0	766.2
		c. Volitional Release =	636	1663	1974
d. Release-to-McNary Survival Index (b./c.) =			0.1862	0.6266	0.3881

Appendix Table A.2 gives estimates for proportion of PIT-tagged fish detected at acclimation ponds and pre-release survival index for Brood-Year 2004.

Table A.2. Estimation of Tagged Proportion that were detected at Acclimation Ponds and of Pre-Release Survival Index

	Stiles		
	Yakima Stock	Eagle Creek Stock	Washougal Stock
a. Number Tagged	2490	2506	
b. Number Detected Leaving Site	1598	1974	
c. Proportion Detected Leaving Site (a./b.)	**0.6418**	**0.7877**	
d. Number Detected leaving Site and at McNary	128	137	
e. Number Detected at McNary	183	154	
f. Pond Detection Efficiency (d./e.)	0.6995	0.8896	
g. Expanded Number Detected Leaving Site (b./f. or b. if f. = 0)	2284.6	2218.9	
h. Proportion Leaving Pond (g./a., Pre-release Survival and Pond Retention)	**0.9175**	**0.8855**	

	Lost Creek		
	Yakima Stock	Eagle Creek Stock	Washougal Stock
a. Number Tagged	2491	2515	1022
b. Number Detected Leaving Site	1057	1663	248
c. Proportion Detected Leaving Site (a./b.)	0.4243	0.6612	0.2427
d. Number Detected leaving Site and at McNary	119	173	29
e. Number Detected at McNary	151	182	41
f. Pond Detection Efficiency (d./e.)	0.7881	0.9505	0.7073
g. Expanded Number Detected Leaving Site (b./f. or b. if f. = 0)	1341.2	1749.5	350.6
h. Proportion Leaving Pond (g./a., Pre-release Survival and Pond Retention)	**0.5384**	**0.6956**	**0.3431**

	Holmes		
	Yakima Stock	Eagle Creek Stock	Washougal Stock
a. Number Tagged	2512	2514	1024
b. Number Detected Leaving Site	781	636	7
c. Proportion Detected Leaving Site (a./b.)	0.3109	0.2530	0.0068
d. Number Detected leaving Site and at McNary	53	23	0
e. Number Detected at McNary	83	55	5
f. Pond Detection Efficiency (d./e.)	0.6386	0.4182	0.0000
g. Expanded Number Detected Leaving Site (b./f. or b. if f. = 0)	1223.1	1520.9	7.0
h. Proportion Leaving Pond (g./a., Pre-release Survival and Pond Retention)	**0.4869**	**0.6050**	**0.0068**

Appendix F

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

Annual Report 2006

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EXECUTIVE SUMMARY

- Merganser, pelican and heron populations slightly declined from 2004-2005 levels. Gulls remain common in only one lower river reach.

- Cormorant populations are increasing in the middle and lower river, consuming 13.5% of the small fish biomass (all species) taken by birds in spring 2006, up from 3.5% in 2004-2005.

- Pelicans dominate fish consumption in spring, taking 64% of the small fish biomass (all species) eaten by birds. Mergansers consumed 12% of the small fish biomass taken by birds in spring.

- Pelicans could potentially consume the entire hatchery production of fall chinook smolts and yet only supply 26% of their diet. Mergansers could potentially consume 35% of the hatchery spring chinook biomass.

- Pelican numbers at Chandler were far reduced in 2006 compared to 2004-2005, with moderate numbers only after smolt passage had ceased.

- Based on energetics alone, Chandler pelicans could consume up to 286,000 smolts, predominately fall chinook. Based on a behavioral model, Horn Rapids gulls consumed 93,000 smolts, also predominately fall chinook. These totals give an extreme upper limit of smolt consumption of about 10% of the total hatchery smolt production. The actual total is far lower, with field observations of pelicans indicating they often feed on fish at Chandler and Selah Ponds far larger than salmon smolts, including suckers, pikeminnow and bullhead.

- Analysis of 2004-2006 data suggests that abundance of pelicans at Chandler and gulls at Horn Rapids correlates well with coho passage but not as strongly with spring chinook, fall chinook, or steelhead passage.

- The higher the river volume during peak smolt out-migration the lower the predation rate by birds. Chandler Bypass pipe orientation makes fish vulnerable to predation at low water. At high water, Chandler smolts are largely invulnerable from bird predation.

- PIT tags found at 6 predatory bird sites in the Yakima River indicate that cormorants and pelicans are expanding in the mid-Yakima River area, feeding on more hatchery coho and spring chinook smolts than hatchery fall chinook and steelhead. 559 tags were found representing 11,771 smolts consumed between the years 2000-2006, 41.5% by cormorants, 30% by pelicans and 26% by herons. The growth of cormorant numbers in the Yakima River follows increases in their populations in the Mid-Columbia River and Columbia River Estuary.

- PIT tag detections from a lower river heron colony suggest that under low water conditions, coho smolts may be vulnerable to predation in river sloughs. Cormorants may have begun displacing herons in the Selah nesting colony.

- PIT tag detections in Selah and Roza indicate that pelicans on the Yakima River are part of the larger Mid-Columbia River pelican population, moving between the two rivers, and also moving up and down the Yakima River.

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 2006, American White Pelicans appeared to have expanded their range in the Yakima Basin, becoming more common in the Yakima River Canyon, Selah, Toppenish Creek, and the Naches River, possibly searching for new island nesting sites. Because of their growing presence throughout the Basin, we directed greater efforts to monitoring pelicans in the middle Yakima River in Selah and the Yakima River Canyon, and in lower river reaches below Parker.

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, suckers and wild fall chinook exiting from the fish bypass pipe. Gull numbers at Horn Rapids were also consistently low at high water.

In 2006, as in the previous 6 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, while consumption estimates of American White Pelicans were based on abundance estimates and daily food requirements. 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 and cormorants appear to be the only significant predators on salmon smolts in the lower river and mergansers in the upper river during normal conditions at present.

As in all the previous years, Common Mergansers were the most significant fish predator in the upper river, consuming 92% of the fish biomass consumed by birds in these reaches, potentially consuming 35% of the hatchery spring chinook and 32% of the hatchery coho smolts present. However, an earlier 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.

As in the previous three years, American White Pelicans were the dominant bird consumer of fish in the lower river in spring, consuming over 64% of the fish consumed by birds in the lower river and 64% of the fish biomass consumed by birds on the entire river. Pelicans inhabiting the lower river could potentially consume the entire hatchery production of fall chinook smolts released in the lower river (2.1 million smolts) and yet only supply 26% 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 17.5 birds per day at Chandler, down from 57 birds per day in 2005, but this was based on a smaller data set with less systematic surveys. 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 an estimated 247,000 to 286,000 (over 90% fall chinook) in 2006, down from an estimated 826,000 smolts in 2005. However a number of lines of evidence including correlation analysis and anecdotal observations clearly call these assumptions into question, making these huge smolt consumption estimates for pelicans in 2005-2006 highly doubtful.

Correlation analysis suggests pelicans are not primarily tracking fall chinook at Chandler, but instead may be tracking coho smolts. Pelican numbers at Chandler showed the highest, moderate correlations with the coho smolt runs in 2004-2006, and the weakest correlations with fall chinook, spring chinook and steelhead smolt runs. The size of smolts may be an important factor in the bioenergetics of pelican consumption. Coho smolts averaged 31 g, while fall chinook smolts averaged about 6 g. The fall chinook smolts may be far too small to be an efficient food source for pelicans. Anecdotal observations at Chandler bypass pipe and Selah Pond suggest pelicans are also consuming significant numbers of other fish species of size classes larger than salmon smolts, including sucker, chiselmouth, northern pikeminnow and bullhead.

Gulls numbers at Horn Rapids in 2006 remained similar to the levels in 2005, declining from about 6 birds per day to about 5 birds per day. Gulls were estimated to have consumed 93,000 fish this past year at Horn Rapids, an increase of 400% from the totals in 2005. Like in 2005, gull presence and predation at Chandler was minimal. The increase in predation at Horn Rapids alters the declining trend in gull consumption at the hotspots between 2002-2005. The total gull consumption in 2006 represents about 2.7% of the more than 3.4 million smolts that passed Chandler. In a pattern similar to the pelicans at Chandler, gull numbers at Horn Rapids in 2004-2006 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 2006, as it was in 2004-2005.

Pelicans were captured with padded leg-hold traps to facilitate monitoring their movements and diet in the Yakima River in Selah and at Chandler Fish Bypass. A total of four immature pelicans were wing-tagged and leg banded at Chandler and Selah; 3 were fitted with radio-transmitters. Radio-tagged animals were relocated during river reach surveys in the lower river, at Chandler, and during aerial surveys of the lower Yakima Basin. No stomach samples could be obtained from captured pelicans.

Pelican, Double-crested Cormorant, Great Blue Heron and Common Merganser roosting and nesting sites were examined for the presence of salmon PIT tags in August and September. Sites surveyed included the Yakima River Canyon above Roza Dam, areas near the Selah gravel ponds (both pond islands and a gravel bar in the Yakima River itself) and cormorant and heron rookeries along the Yakima River near Selah and at Satus Wildlife Management Area on the Yakama Reservation.

A total of 559 PIT tags from smolts marked between 2000-2006 were recovered at the 6 sites including: 276 spring chinook, 171 coho, 95 fall chinook, and 6 steelhead. Most of the tags were from the last three years. These 559 tags represent at least 11,771 smolts consumed by birds, 39% by cormorants, 28% by pelicans and 24% by herons. The Selah Rookery, a cormorant and heron site, had nearly 46% of the tags collected, with the Chandler Fish Bypass, a pelican site, yielding another 21%. The 171 coho tags represent 6,240 fish or 53%, predominately taken by cormorants and herons. The 276 spring chinook tags represent 4,388 fish or 37%, predominately taken by cormorants and pelicans. The 95 fall chinook tags represent 1,100 fish, with pelicans surprisingly taking 70%.

The high number of tags recovered from heron colonies is surprising, given the fish consumption estimates developed for herons using the river reach model are relatively low (5-8% of small fish biomass eaten by birds per year 2005-2006). Herons consumed an estimated 36% of the coho smolts, 15% of the spring chinook and 8% of the fall chinook smolts sampled by PIT tag returns. Coho smolts may be vulnerable to heron predation in river sloughs during low water. The tag recoveries from the Selah Rookery, dominated by cormorants in 2006, contribute to the findings of the river reach survey that suggest that cormorants are increasingly becoming a major factor in fish predation and more specifically smolt predation in the middle and lower Yakima River between Roza and Zillah. Based on tag returns, cormorants took an estimated 39% of the smolts eaten by birds, while the data from the river reach survey suggests that in 2006 they took 13.5% of the small fish consumed by birds in the entire river, up from 3.5% in 2005. The PIT tags collected from Roza and Selah Bars indicate the expansion of pelicans in the Canyon and in the lower river between Roza and Parker. They also show movements of pelicans and cormorants between the Columbia and Yakima Rivers as well as broad movement of pelicans within the Yakima River Basin.

Plans for the 2007 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 4 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 1997-2006. 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
Bald Eagle (*Haliaeetus leucocephalus*) BAEA
Osprey (*Pandion haliaetus*) OSPR
Caspian Tern (*Sterna caspia*) CATE
Forster's Tern (*Sterna forsteri*) FOTE
Great Egret (*Ardea alba*) GREG

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

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 State endangered species. At present, the only known 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 those 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 near the California – 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.

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 2006, Yakama Nation salmon hatcheries alone released over 3.44 million salmon smolts (between 6-31 g) to the Yakima Basin, including fall chinook, spring chinook and coho. This represents an estimated introduction of 203.9 kg/km of fish biomass in the form of spring chinook smolts in the upper river, 118.2 kg/km of coho smolts in the middle river, and 140.5 kg/km in the form of fall chinook and coho smolts in the lower river. In 2005, salmon hatcheries contributed over 3.8 million salmon smolts with similar biomass totals.

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 2004, 4,163 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) then spring chinook spawned a cumulative total of nearly 17.5 million eggs. The literature suggests those eggs have a 59.6% chance of surviving to become 0.3 gram fry the next year, representing 10.4 million fish. In the upper Yakima River alone, an estimated 13.7 million spring chinook eggs were deposited in 3,444 redds in 2004, leading to the production of an estimated 8.16 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. However, spring chinook, coho, and steelhead smolts are of the appropriate size (>20g) to be consumed by these birds. Fall chinook smolts weighing 7 grams or less may be near the lower limit of prey size for these piscivores. Survivors from the 2005 cohort of fry make up the wild smolts enumerated at Chandler Bypass in 2006.

It is important to note that the Chandler Bypass facility was closed due to flooding in 2006 during peak freshets on April 12 (6,500 cfs), May 1 (10,285 cfs) and May 20 (12,898 cfs). Chandler was closed for total of 20 days in 2006: 4/10-12, 4/29-5/3, and 5/19-30, which were very likely peak migration periods for smolts moving down from the upper Yakima and Naches sub-basins. Thus the very low total Chandler count of 92,175 wild spring chinook, and the counts of 159,352 hatchery spring chinook, 49,103 wild and Marion Drain fall chinook, 49,558 hatchery and wild coho, and 18,838 steelhead are all likely underestimated. The absence of data from Chandler during these key periods undermines the analysis of the impacts of bird predation along river reaches and at hotspots. In particular it makes it difficult to correlate the numbers of pelicans and gulls with the passage of specific runs of smolts at Chandler Bypass and Horn Rapids Dam.

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. The WDFW data indicate 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 1 and 2). The terrain and habitat varies greatly along its length, which begins at 2,440 meters in elevation at the headwaters and ends at 104 meters elevation at its mouth on the Columbia River near the City of Richland, WA.

The upper reaches of the Yakima River, above the town of Cle Elum, are high gradient areas dominated by mixed hardwood-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 conifer and hardwoods 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, 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.

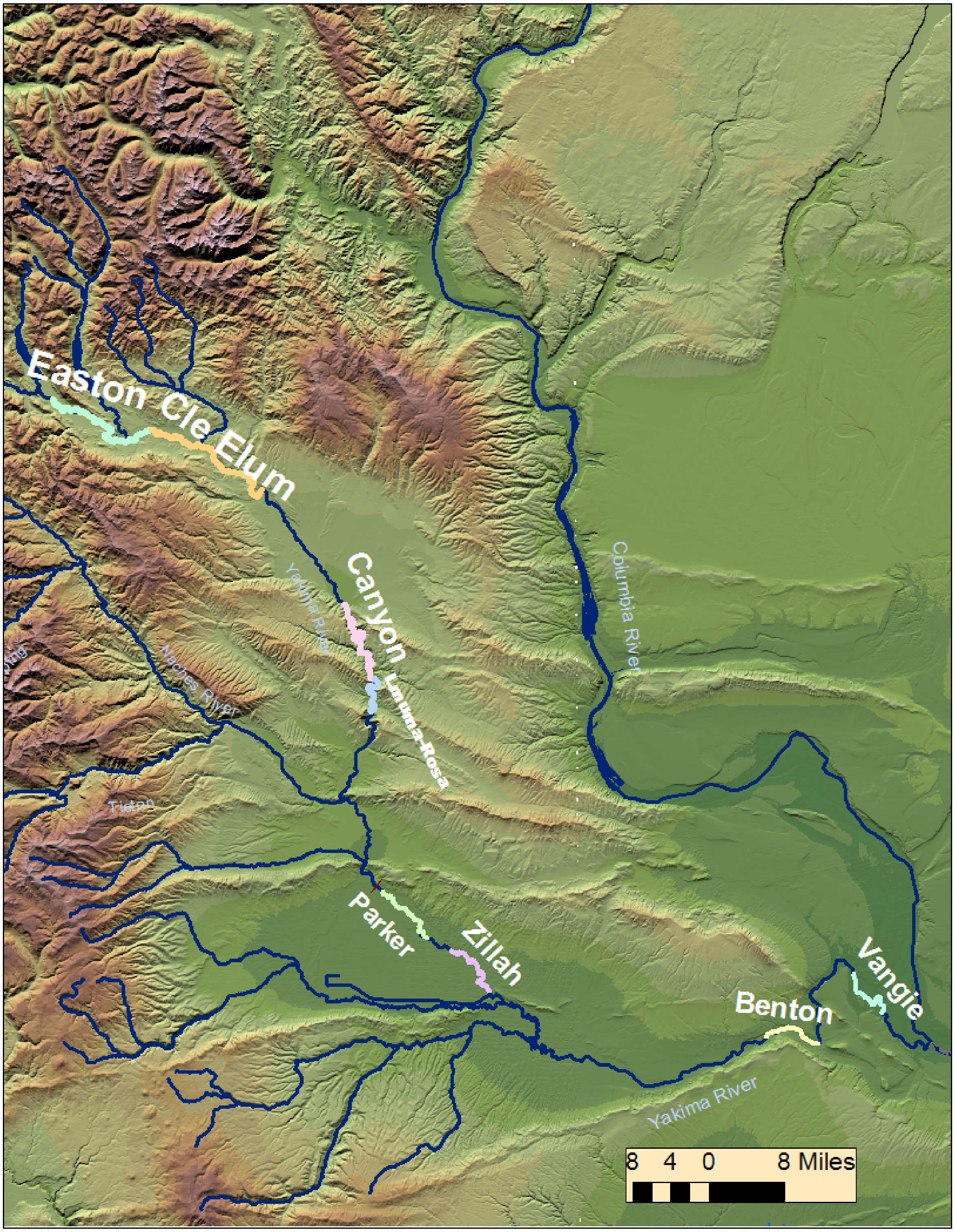

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Figure 10. Yakima River Basin with locations of surveyed reaches.

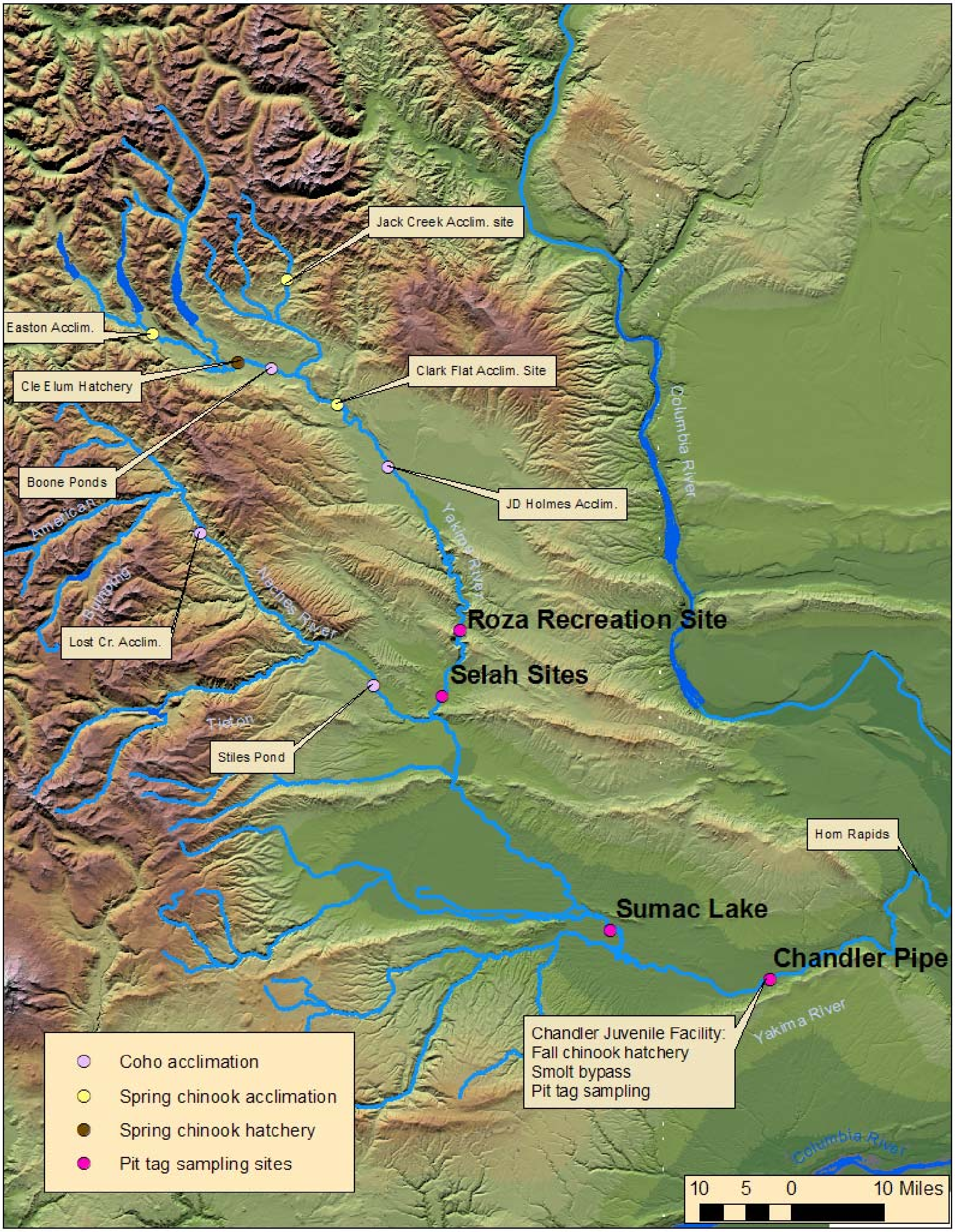

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Figure 11. Yakima River Basin with locations of hotspots (Chandler & Horn Rapids), acclimation sites and PIT tag sampling sites.

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 4 to June 27, "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 June 28 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

<u>Hotspot Surveys</u>

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 2006, 11 hotspot surveys were conducted at Chandler Bypass and 12 at Horn Rapids between April 3 and June 16. 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 2006 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 3 and June 16, pelican counts in the 15 minute survey blocks were used to calculate an average number of pelicans per day. In addition another 17 spot surveys were conducted for pelicans at Chandler June 22 to July 24 at random times during the days. These data were 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 1, Table 3). All reaches surveyed in both the spring and summer 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. 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 Parker reach was added in the lower river this year to encompass new areas of pelican concentration. 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 3 weeks in spring. However high water, windy conditions and pelican live-trapping in May and June often meant some reaches were only surveyed once every 4-5 weeks. Easton and Cle Elum, the upper river reaches, were each surveyed once a month in April and May. The Canyon was surveyed twice in April and once in May. The lower river reaches include Parker, Zillah, Benton, and Vangie. Parker was surveyed once in April and twice in June, primarily to track large numbers of pelicans observed by Yakama Fisheries staff in June. Zillah was surveyed once a month April to June. Benton was surveyed once in April, twice in May and once in June, again tracking pelicans observed by Yakama Fisheries staff. Vangie was surveyed once in April and twice in May.

During the summer from June 28 through August 31, river surveys included only the upper and middle reaches. Easton was surveyed once in July and 3 times in August, with Cle Elum surveyed twice in July and three times in August. The Canyon was surveyed once at the end of June, twice in July and twice in August.

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.

In 2006, American White Pelicans appeared to have expanded their range in the Yakima Basin, becoming more common in the Yakima River Canyon, Selah, Toppenish Creek, and the Naches River, possibly searching for new island nesting sites. Because of their growing presence throughout the Basin, we directed greater efforts to monitoring pelicans in the middle Yakima River in Selah and the Yakima River Canyon, and in lower river reaches below Parker. Three pelicans were outfitted with radio transmitters at Chandler Fish Bypass in Prosser and in Selah.

Acclimation Site Surveys

Three spring chinook acclimation sites in upper Yakima River (Clark Flat, Jack Creek, and Easton) and two coho sites (Boone and Holmes) were surveyed for piscivorous birds in 2006 (Figure 2). Surveys were conducted between January 21 and May 6, 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. Coho sites were 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 22 to August 24. In addition one aerial survey was conducted by pilot Clif Dwyer to locate radio-collared pelicans on July 30. 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

Radio-collaring is frequently used to study the behavioral ecology of large waterbirds. Live-trapped birds can often be induced to regurgitate stomach contents and radio-collared birds can be followed to feeding hotspots and nesting sites. In this study we hoped to use radio locations of pelicans to understand the relationship of the Yakima Basin birds to breeding birds on Badger Island and to locate areas where pelicans feed on juvenile salmonids and other species.

Padded leg-hold traps were set for 3,114 trap hours over 21 days, May 17 to July 18 (3 days in the Yakima Canyon, 10 in Selah and 8 at Chandler). The trap array consisted of traps set either in shallow water on a gravel bar (up to 6 inches deep) or upon rocks in the Yakima River, or on or around small islands in Selah Pond. The trap array consisted of 20-27 traps opened for an average of 6 hours a day, occasionally set over night to catch pelicans coming into roost in the evening or early morning. Night sets were attempted because setting up the traps in the morning often disturbed the birds for the entire day. Birds appeared to avoid areas where they could observe traps being set. 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. Two birds were intubated to try to induce regurgitation of stomach contents.

Salmon PIT Tag Surveys at Nesting and Roosting Sites

A PIT tag reader attached to an extension pole was used to survey for tags deposited in various Yakima River nesting colonies and gravel bar roosts in late summer and early fall. Areas surveyed included: Chandler Fish Bypass and its rock and gravel islands; 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); Roza Recreation Area site gravel bar in the Yakima River used by roosting pelicans and mergansers (Roza Bar); and a Great Blue Heron colony in Satus Wildlife Area (Sumac Heronry), and an area of the Yakama Reservation off the Yakima River near Toppenish. A more extensive survey was conducted on smaller pelican roosts in gravel bars and islands in the Yakima River Canyon between Ellensburg and the Lmuma Recreation Site. Based on the percentage of salmon tags found at these sites, consumption estimates 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 was formerly a Great Blue Heron colony (occupied between 2000-2003) and in 2006 was dominated by cormorants (apparently occupied between 2004-2006).

RESULTS & DISCUSSION

River Reach Surveys

In 2006, 13 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 (4) 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 new Parker reach appears to have the highest density of avian predators supporting the higher numbers of pelicans, Double-crested Cormorants, 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 8 previous years surveyed, followed by Belted Kingfishers (Figure 3 & 4). In the middle reach, Pelicans were the most common bird in the spring with Common

Mergansers the most common species in summer (Figure 5 & 6). The species distribution along the lower reaches were more variable: pelicans were the most abundant bird at Parker and Zillah followed by cormorants; cormorants were the most abundant at Benton followed by Great Blue Heron, and gulls were the most abundant at Vangie followed by pelicans and Great Blue Heron (Figure 7). Great Blue Herons were the third most common species at Zillah and Vangie, with Common Mergansers the third most common species at Parker and Benton. The number of pelicans counted during the river reach surveys was significantly reduced from the counts in 2005, although pelicans appeared to be as abundant as last year in aerial surveys and in less systematic observations from Satus and Toppenish Creeks and in the Yakima Canyon.

Double-crested Cormorants, a major fish predator on the Lower Columbia River, were found in moderate numbers in the lower river and occasionally in the middle river. Caspian Terns, another major fish predator on the Lower Columbia River, were found in moderate numbers at Benton and Vangie and low numbers at Zillah. They were occasionally seen in Selah on the Yakima River below the Yakima Canyon.

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 8 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 growing populations in the middle and lower river and their high daily dietary requirements (Table 4). Cormorants, although only common in the river below the Yakima Canyon are the third 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. Lastly, Great Blue Heron, although the fourth most common piscivore in the Yakima Basin, are 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.

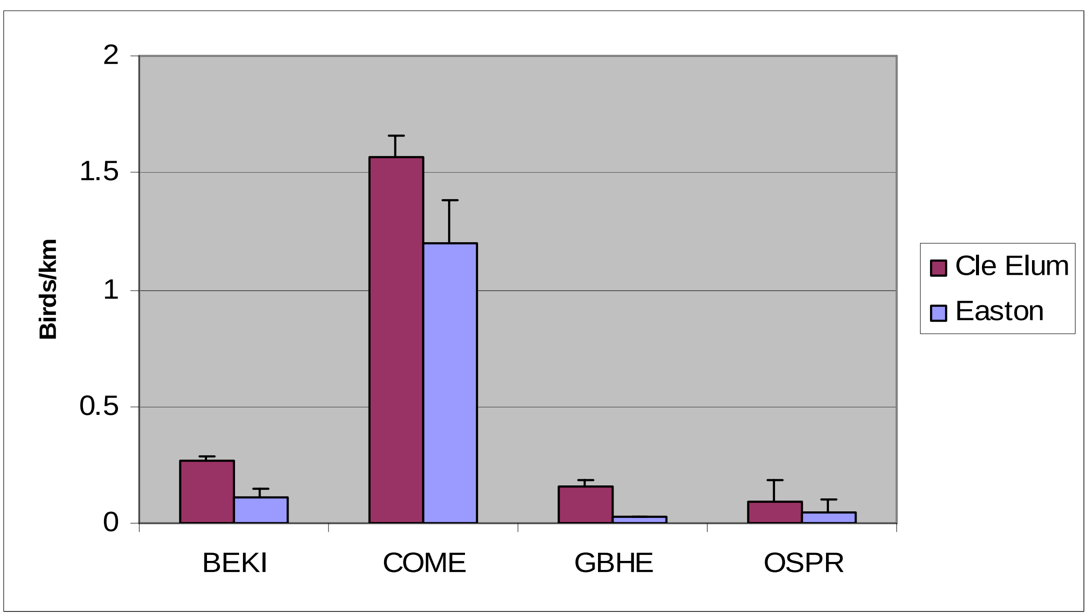


Figure 12. Average spring bird abundance on the Upper Yakima River. Bars indicate standard error.

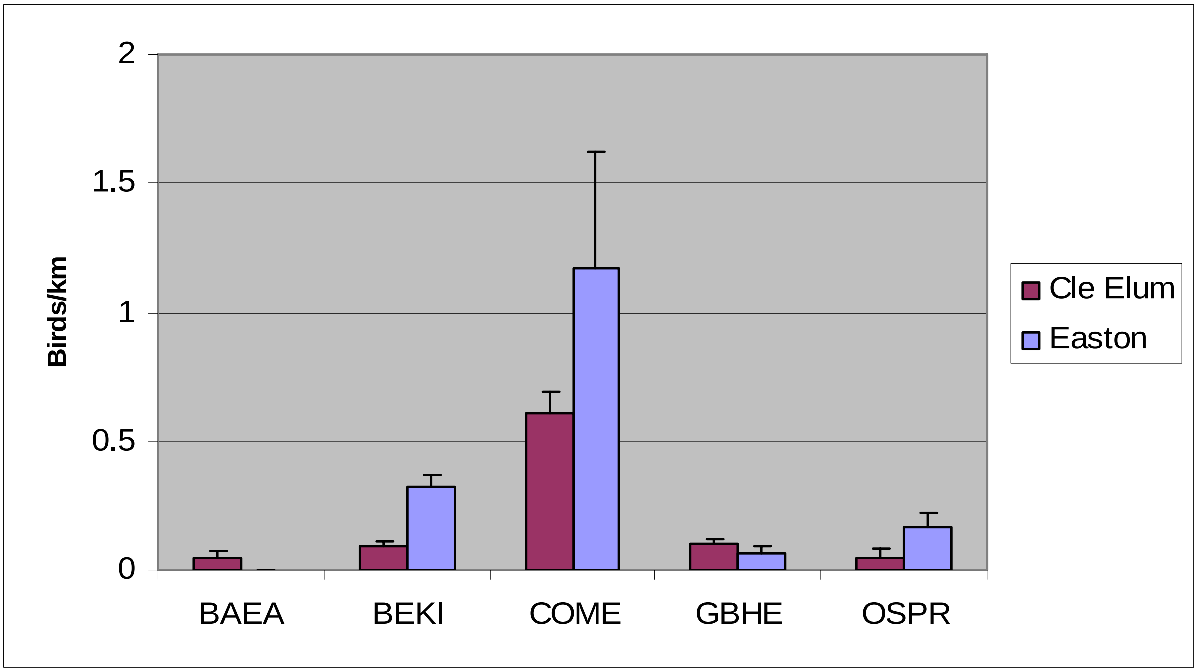


Figure 13. Average summer bird abundance on the Upper Yakima River. Bars indicate standard error.

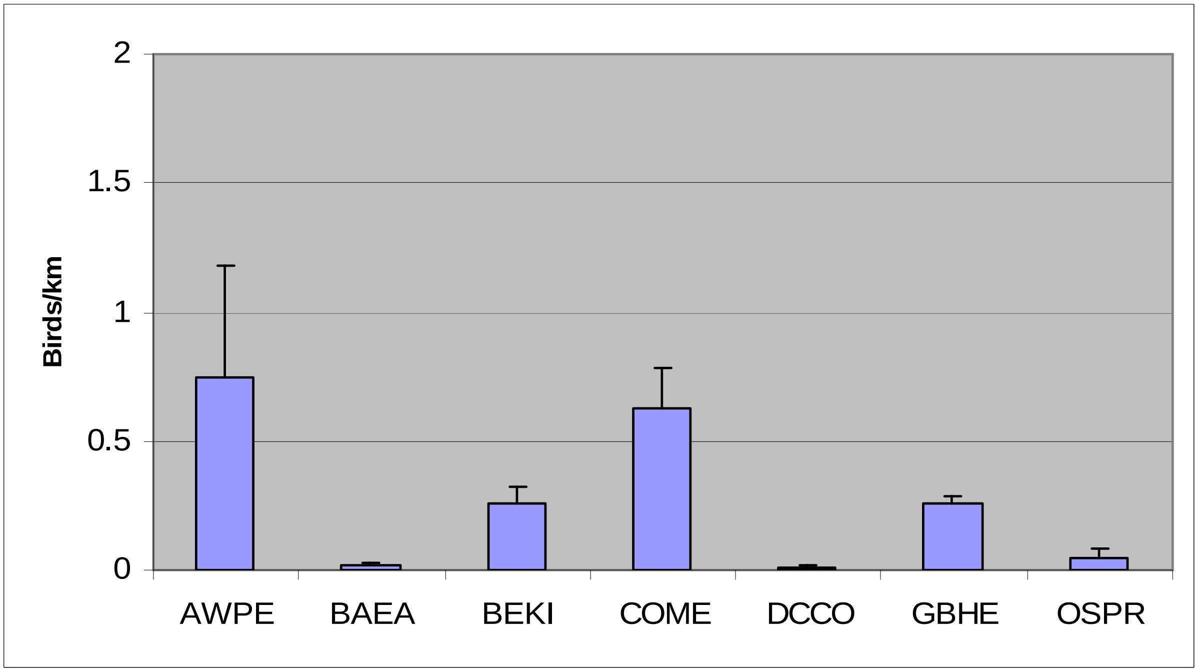


Figure 14. Average spring bird abundance on the Middle Yakima River. Bars indicate standard error.

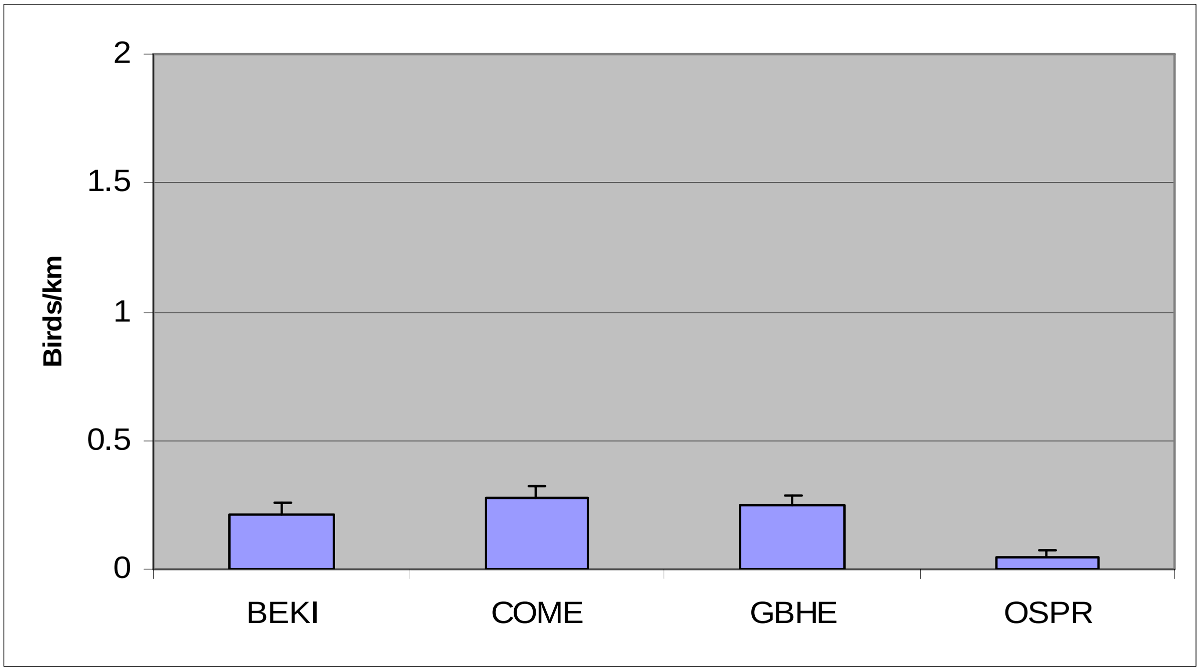


Figure 15. Average summer bird abundance on the Middle Yakima River. Bars indicate standard error.

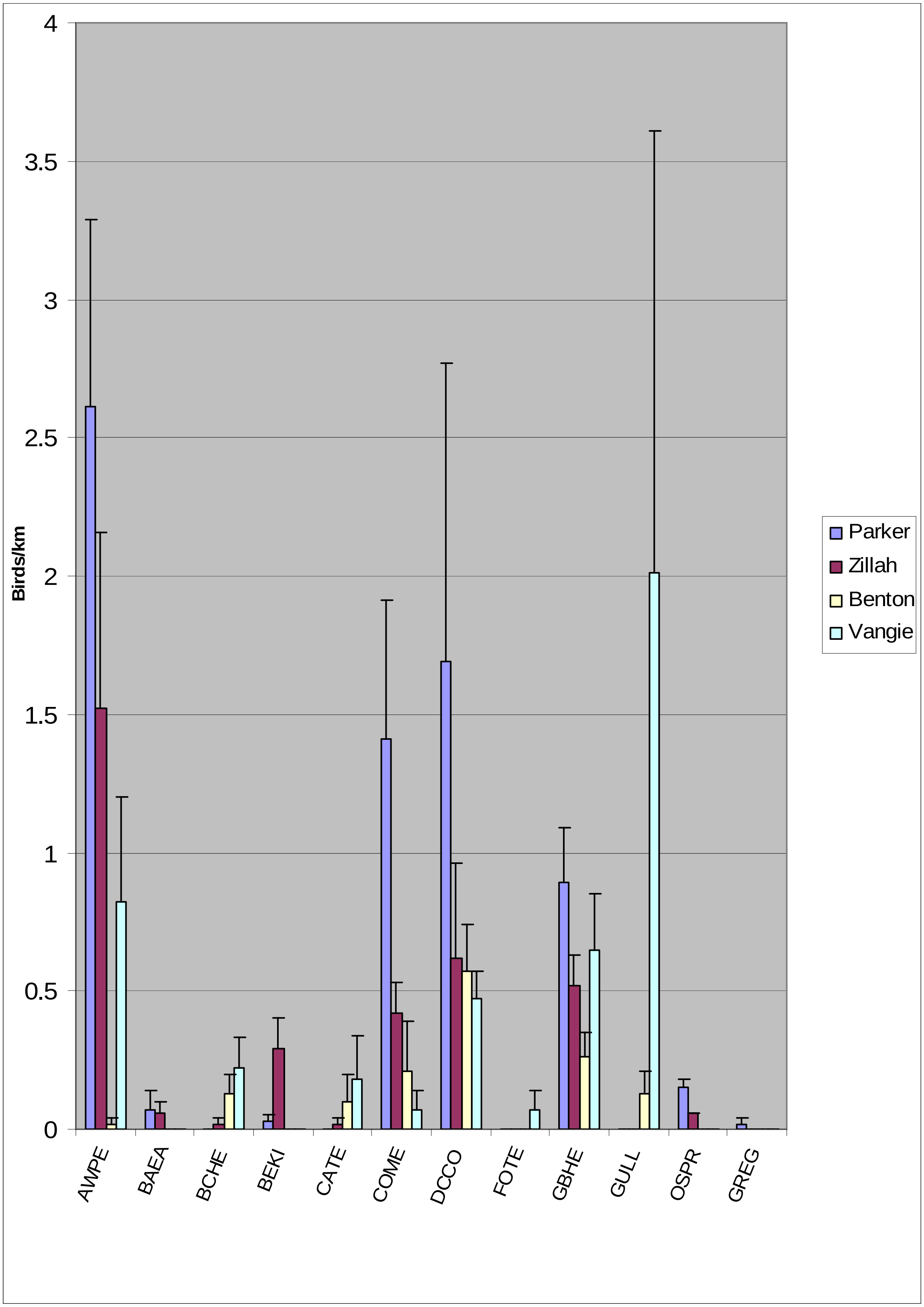


Figure 16. Average spring bird abundance on the Lower Yakima River. Bars indicate standard error.

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

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

Common Mergansers along River Reaches

In the upper river in spring, Common Mergansers averaged 1.4 birds/km, while on the middle river they averaged 0.6 birds/km. In the lower river in spring, they averaged 1.4 birds/km in Parker, 0.4 birds/km in Zillah, 0.2 birds/km at Benton and 0.1 birds/km at Vangie. In summer, Mergansers averaged 0.9 birds/km on the upper river, and 0.3 birds/km on the middle river. These spring and summer counts are lower than counts in 2005, although the sampling effort was lower this year and a new lower reach was added making direct year to year comparisons difficult. In spring 2005, Mergansers averaged 2.3 birds/km in the upper river and 1.1 birds/km in the middle river. In the lower river in spring 2005, mergansers averaged 1.0 birds/km in Zillah, 0.1 birds/km at Benton and were absent from Vangie. The Parker reach was not surveyed in 2005. In the summer 2005 mergansers averaged 1.3 birds/km in the upper river and 0.5 birds/km in the middle river. Overall, merganser counts in 2005 were fairly similar to counts in 2004.

A breeding pair of Common Mergansers

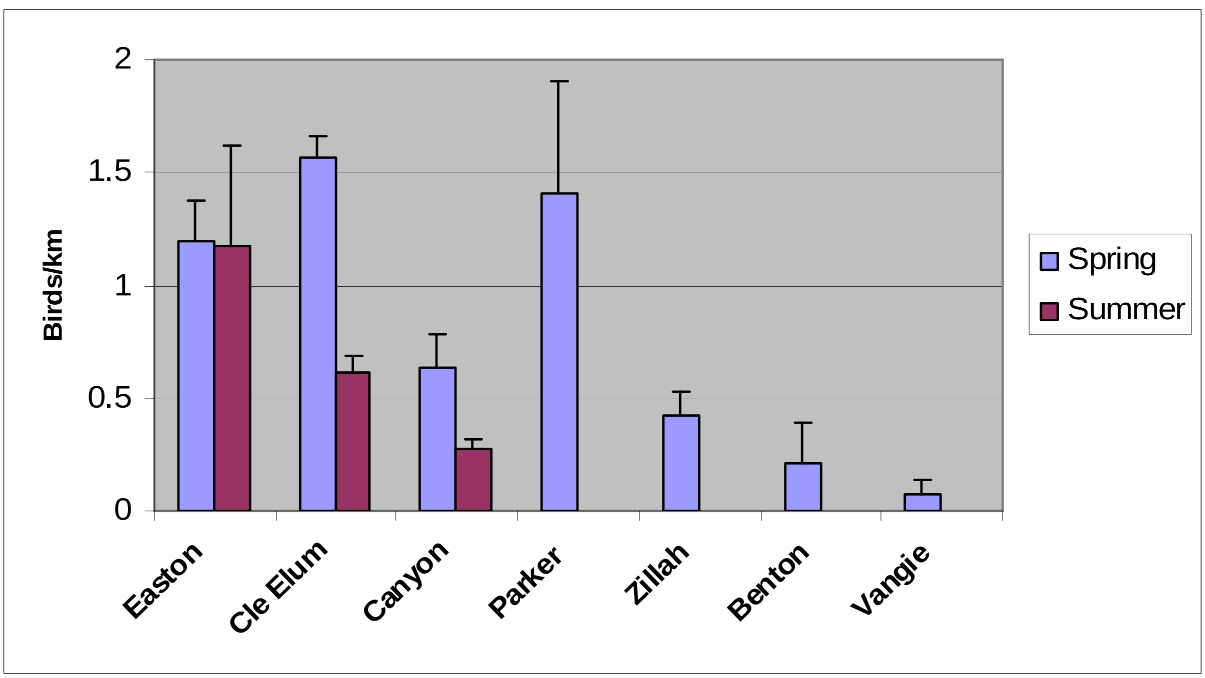
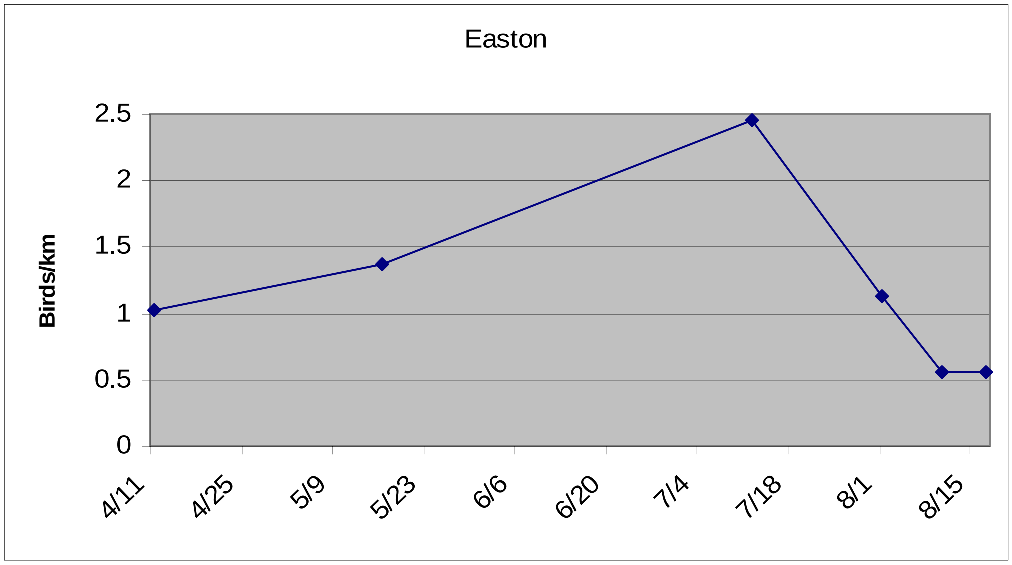
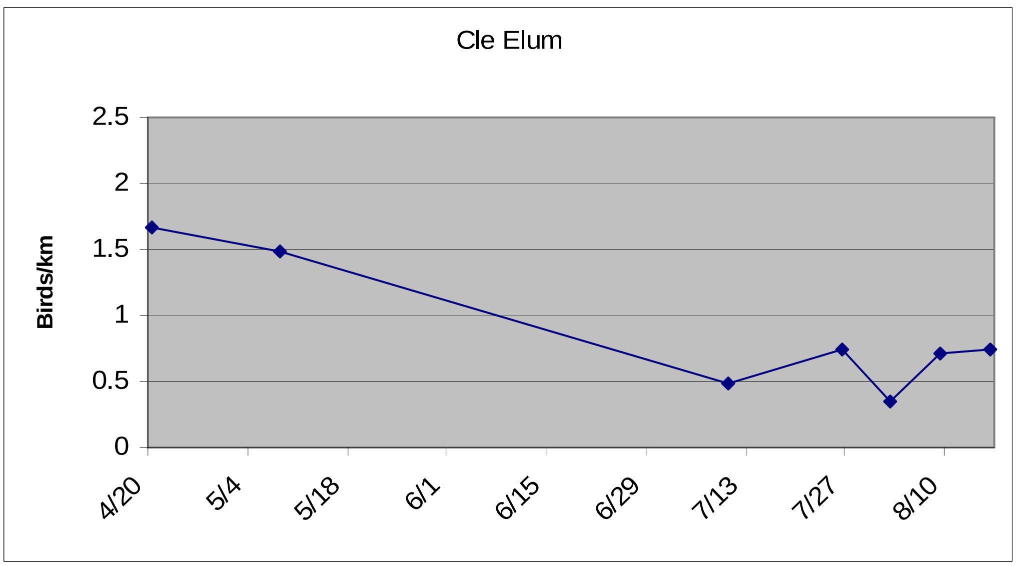
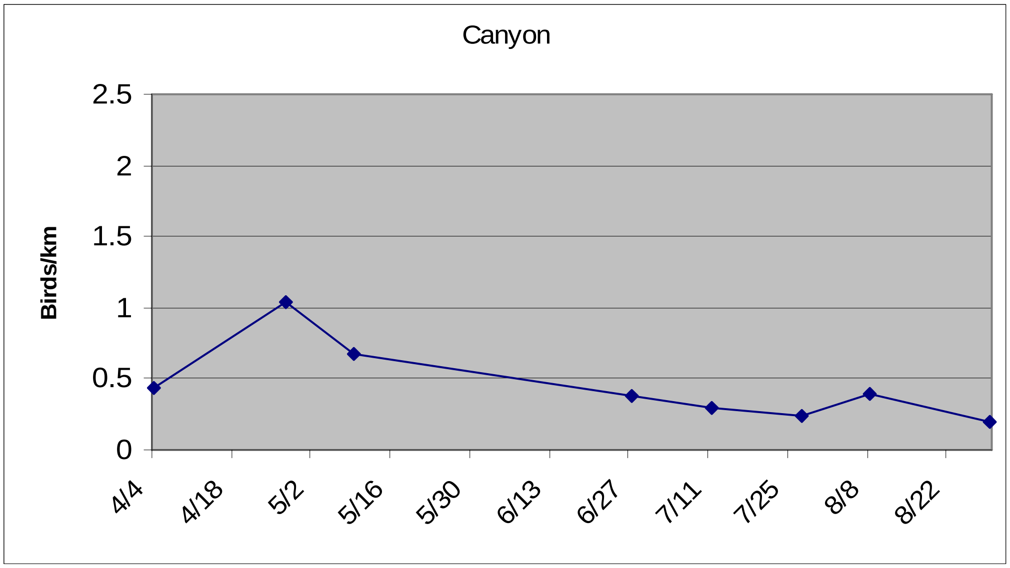


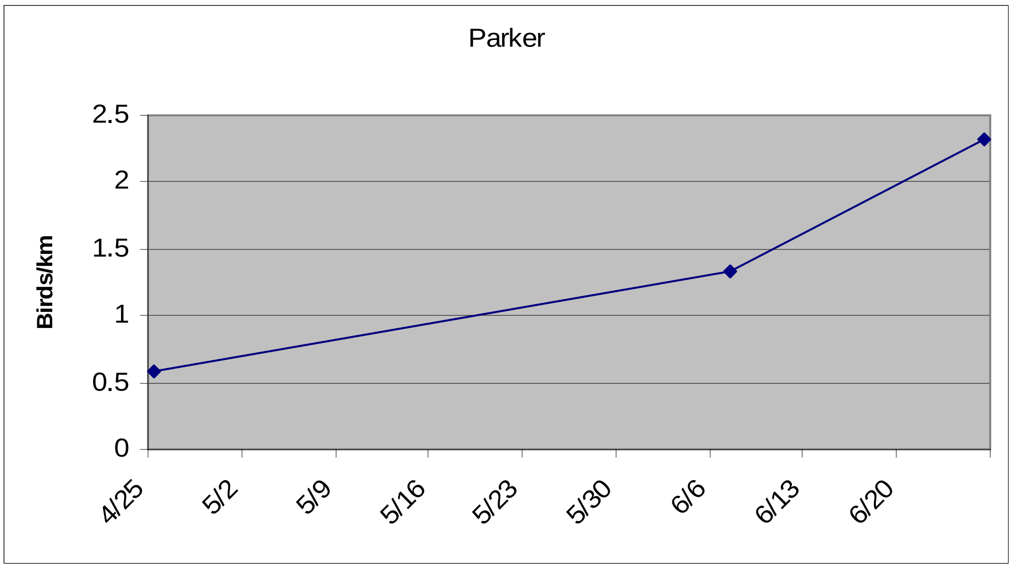
Figure 17. Average abundance of Common Mergansers on the Yakima River. Bars indicate standard error.

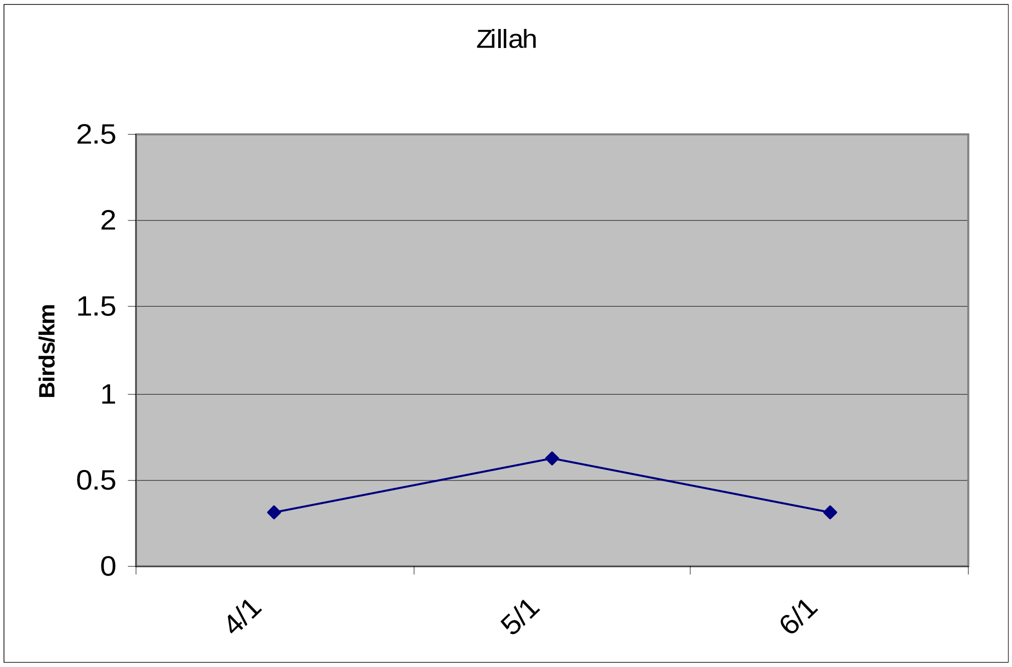
Figure 18. (7 graphs) Average abundance of Common Mergansers per kilometer in Easton, Cle Elum, Canyon, Parker, Zillah, & Benton reaches of the Yakima River. Easton is the uppermost and Vangie the lowest reach.

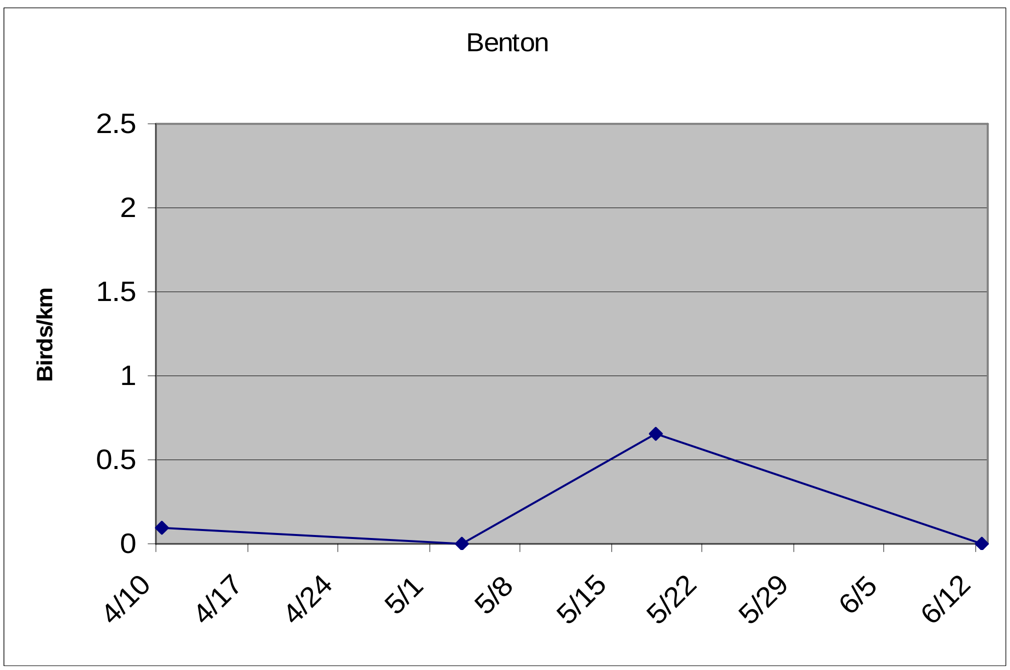





Canyon
Birds/km
2.5
2
1.5
1
0.5
0
4/4
4/18
5/2
5/16
5/30
6/13
6/27
7/11
7/25
8/8
8/22


Parker
Birds/km
2.5
2
1.5
1
0.5
0
4/25
5/2
5/9
5/16
5/23
5/30
6/6
6/13
6/20


Zillah
Birds/km
2.5
2
1.5
1
0.5
0
4/1
5/1
6/1


Benton
Birds/km
2.5
2
1.5
1
0.5
0
4/10
4/17
4/24
5/1
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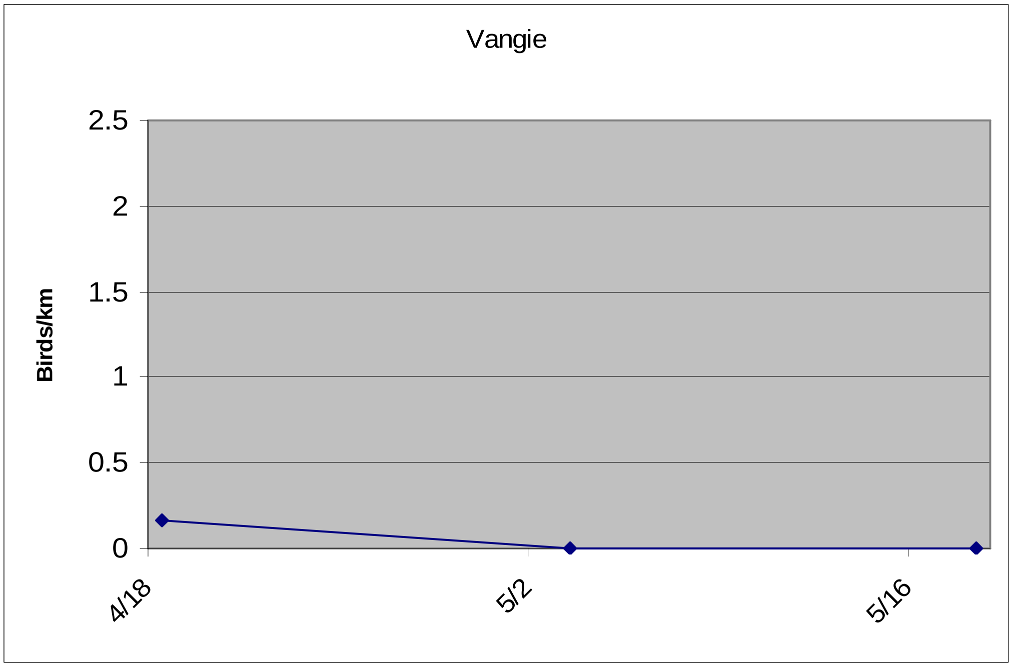


One of the original concerns of YKFP managers focused on whether mergansers and other avian predators are becoming more abundant in response to increases in Yakama Nation hatchery releases of chinook and coho salmon in the Yakima River over time. Data from 2004-2006 appear to indicate that mergansers are not showing a numeric response to increases in the numbers of salmon smolts in the Yakima River.

The 2006 estimated consumption of fish biomass by Common Mergansers was 72.1 kg/km in the upper river, 37.2 kg/km in middle river, and 35.4 kg/km in the lower river (spring only for the lower strata). This represented 92.8% 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, Common Mergansers consumed 11.1% of the fish biomass taken by birds in the spring (this small percentage is entirely due to high pelican presence in April and May) and 53.1% of the fish biomass taken during the summer period. In the lower river, Mergansers consumed 8.8% of the fish biomass taken by birds in spring.

These consumption estimates are generally less than those in 2004 and in 2005, which had very similar totals. 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 make direct comparisons to 2005 or 2004 problematic. However with the exception of pelicans in the middle river in 2006, the percentages of biomass consumed by mergansers from 2005 to 2006 are very similar. In spring 2005, Common Mergansers accounted for 93.3% of the consumption in the upper river, 86.6% in the middle river and 4.8% kg/km in the lower river. In the summer 2005, they accounted for 90% of the total consumption in the upper river and 69% in the middle river. With the exception of the pelicans in the middle river, the overall trends in merganser abundance and estimated consumption in 2004-2005 continued in 2006.

Based on our estimates, a minimum of 203.9 kg/km of hatchery spring chinook smolt biomass were present in the upper river and 118.2 kg/km of hatchery coho smolt biomass in the middle river in spring and summer 2006. If upper river Common Mergansers fed entirely on hatchery spring chinook in spring and summer, their consumption of an average of 72.1 kg/km would represent removal of 34.9% 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 37.2 kg/km would represent removal of 31.5% of the of the hatchery coho biomass present in middle strata. This worst 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 smolts at the 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 12% of the fish biomass consumed by birds in the entire Yakima River during the spring 2006 period. This appears similar to the 11.3 % estimated consumption by mergansers during spring 2005. 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 underestimated (WDFW 1997-2001). These two statistics suggest that mergansers consume salmonids and other fish taxa of the appropriate prey size at a proportion that is less than their availability in the Yakima River, indicating some degree of prey selection, either by species or size.

A conclusion that could be drawn from these varied data sources is that Common 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 Common 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 2006, as in 2003-2005, because they were both relatively abundant and have high daily dietary requirements. Pelicans were common in the lower and middle river in spring. Their significant presence (0.7 birds/km) in the middle river in spring allowed them to statistically dominate fish consumption in this strata as well. A flock of 210 pelicans were observed roosting in the Yakima Canyon in April and over 70 roosted in Selah Ponds in May, behavior suggesting these birds were expanding their range seeking their first nesting islands in the Yakima River Basin. 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. By mid-June the adults were replaced by immature animals without bill knobs or adult plumage characteristics.

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 (Figure 10). These are lower than pelican counts in 2004-2005, when Pelicans averaged 6.4 birds/km at Zillah and 0.9 birds/km and 0.4 birds/km at Benton and Vangie, respectively. However the sampling effort decreased in Zillah, Benton and Vangie compared to 2005, while being augmented by additional pelican surveys in the Yakima Canyon and the Parker reach, where pelicans were far more abundant than in previous years.

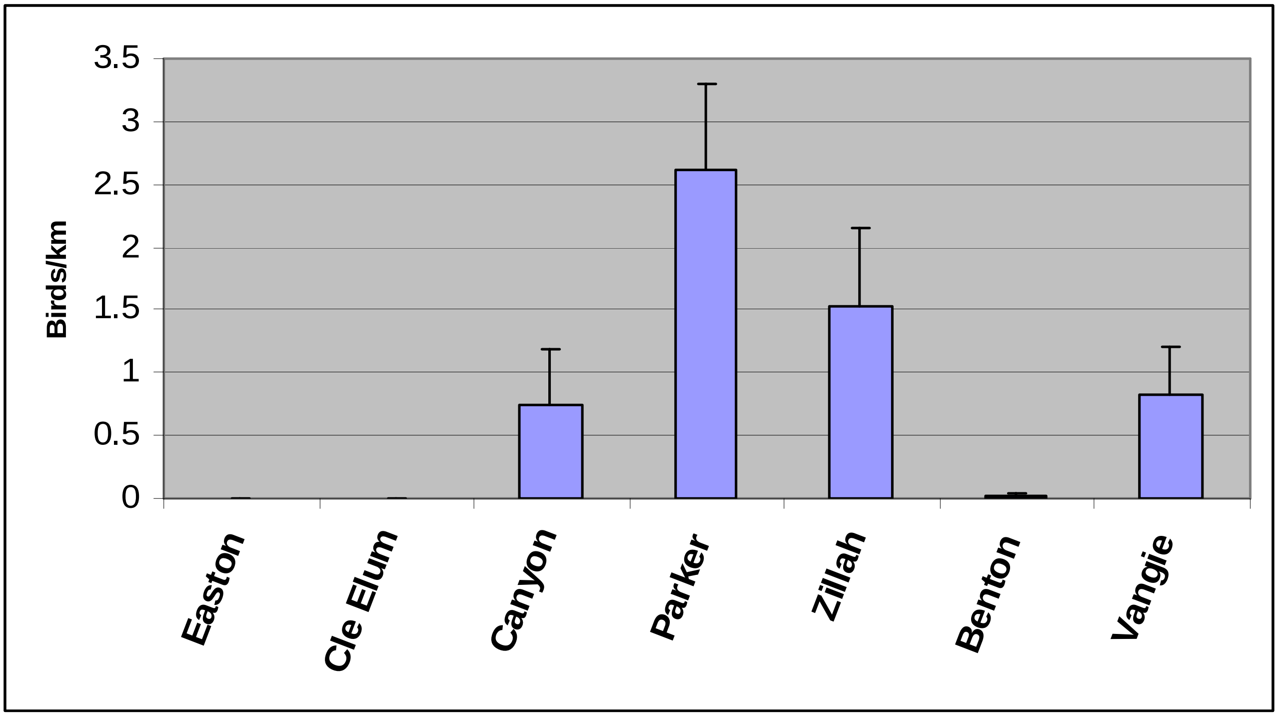


Figure 19. Average spring abundance of American White Pelicans along the Yakima River. Bars indicate standard error.

Three aerial survey counts of pelicans between Ellensburg and the Yakima River mouth on the Columbia River were conducted on May 22 (556 birds counted), July 7 (442 birds) and August 24 (34 birds). A survey in June was postponed due to inclement weather. In addition, one aerial flight to search for radio-collared birds was conducted on July 30, locating two radioed birds in the Toppenish Creek Delta and on the Sunnyside Canal near Prosser. 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 (*Cyprinus carpio*) and sucker. In 2005, a high of 660 pelicans were counted on May 17.

Based on the river reach predation model, the total estimated fish consumption by pelicans during the spring 2006 was 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 was so predominant that their total from the lower and middle rivers represented 63.7% of the total estimated fish biomass consumed by birds in the entire river in the spring. Again because of less sampling effort in 2006, comparisons to 2004-2005 are difficult. However, there was a decrease from 2004 and 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.

If the pelicans inhabiting the Yakima Canyon in spring consumed all the coho smolts released from Holmes Pond in Ellensburg representing 156,000 smolts with a biomass of 118.2 kg/km, that would satisfy only 64.9% of their dietary requirements, clearly a worst case scenario. Similarly, if pelicans inhabiting the lower river reaches consumed the entire 2006 hatchery production of hatchery fall chinook smolts released in the lower river, representing nearly 2.1 million smolts, a biomass of 65.9 kg/km, that would equate to only 25.5 % of the estimated fish biomass consumed by pelicans in the lower river. However, the small size of fall chinook smolts (<7 g) appears to preclude them from being a major component of the pelican diet.

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 4 years, it is known that Yakima River pelicans frequently consume other fish species of size classes larger than salmon smolts, including chiselmouth, sucker, northern pikeminnow and carp. Estimates of salmon and other fish taken by pelicans at Chandler Bypass, 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 common in the lower river while Great Blue Herons are common throughout the Yakima Basin. Cormorants were the most common bird at Benton, averaging 0.6 birds/km. Cormorants were the second most common bird at Parker, averaging 1.7 birds/km. The decreased sampling effort and addition of the Parker reach make year to year comparisons difficult. However, they increased in abundance at Zillah from 0.03 birds/km in 2005 to 0.6 birds/km in 2006. The numbers of cormorants at Benton and Vangie declined from an average of 0.9 birds/km in 2005 to 0.5 birds/km in 2006. 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 a huge increase in the estimated cormorant consumption from spring 2005, when they consumed only 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. However the addition of the Parker reach where cormorants were so abundant may skew the totals.

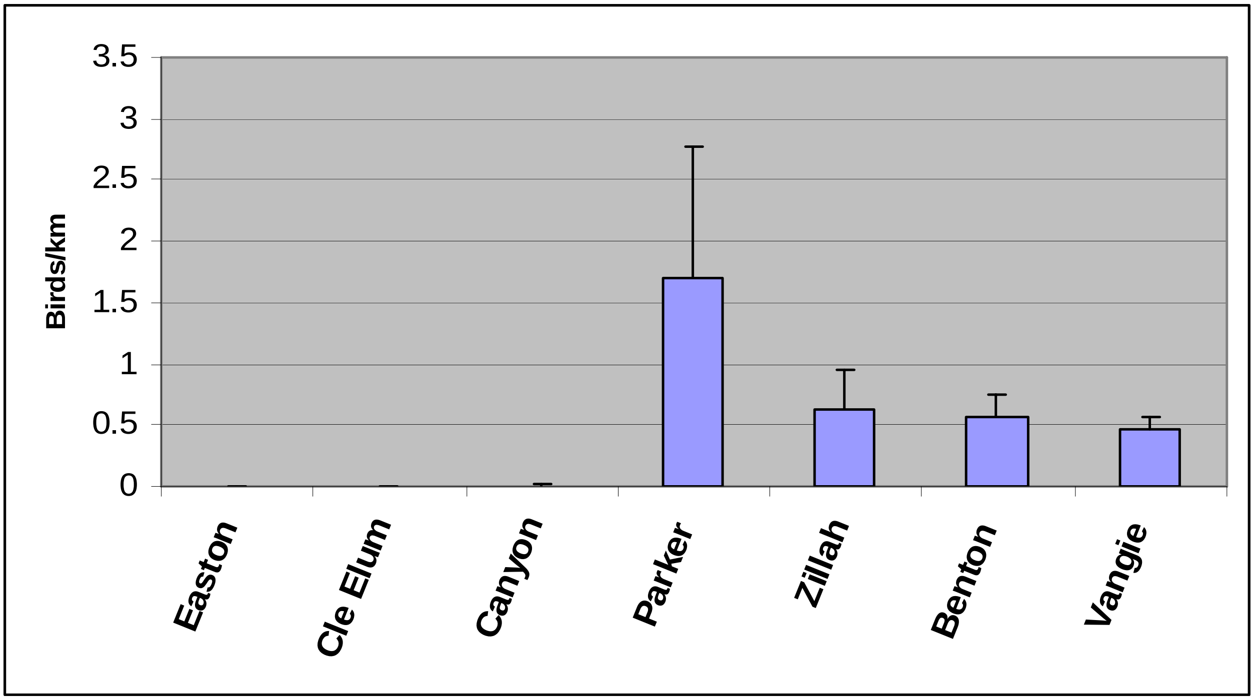


Figure 20. Average spring abundance of Double-crested Cormorants along the Yakima River. Bars indicate standard error.

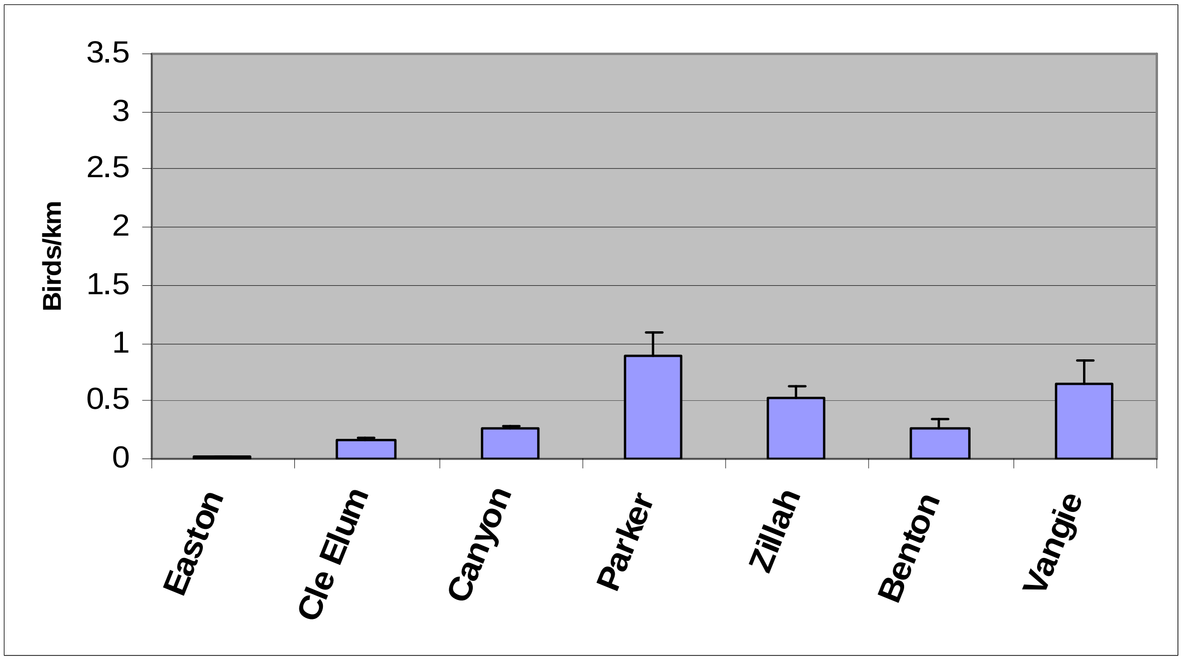


Figure 21. Average spring abundance of Great Blue Herons along the Yakima River. Bars indicate standard error.

On average, the numbers of Great Blue Herons declined from 2005 to 2006 most notably in the lower river going from an average of 0.8 birds/km to 0.5 birds/km. Declines were also observed in the middle and upper river where the average declined from 0.3 birds/km in 2005 to 0.2 birds/km in 2006. This is despite the addition of the Parker reach which held the greatest number of herons averaging 0.9 birds/km. Herons consumed an estimated 34.7 kg/km in the lower river in spring, representing 8.6% of the fish consumed in that reach. In the middle river they consumed a total of 16.4 kg/km during spring and summer, representing an average of 6.9% of the fish consumed by birds. In the upper river, herons consumed a total of 4.6 kg/km during spring and summer, representing 5.8% of the fish consumed. All told, Great Blue Herons consumed an estimated 8.0% of the small fish consumed in the entire river in the spring 2006. These figures are similar to estimates in 2005 when Great Blue Herons consumed an estimated 31.7 kg/km in the lower river in spring, 10.8 kg/km in the middle river in spring and summer, and 6.0 kg/km in the upper river in the spring and summer. In total in spring 2005, herons consumed an estimated 5.3% of the fish biomass consumed by birds in the entire river.

Hotspot Surveys

Chandler

Over the last 3 years, pelicans have completely displaced gulls as the dominant predatory bird at Chandler, changing the hotspot consumption equation significantly. The estimated consumption of smolts by gulls at Chandler continued to decrease from previous years, declining by 89% from 2005, but sampling effort, upon which this estimate is based, decreased from 31 days in 2005 to 11 days in 2006. Pelican numbers dropped to an average of 17.5 birds/day (high of 66) from 56.5 birds/day (high of 256) in 2005, but this is based on 28 days of random spot surveys rather than the 31 days of more intensive ½ day surveys in 2005. Birds were not counted on days when the river flooded, leaving pelicans and gulls with no rocks or gravel bars to roost on and deep muddy water impossible to feed in. Thus pelican and gull daily average numbers would be even lower if counts had been conducted on the 20 days when the Chandler Bypass was closed due to flooding and birds were absent. Gull numbers remained low, averaging 0.5 birds/day (high of 1.6), as compared to 1.4 birds/day (high of 4.2) in 2005. Other piscivorous bird species observed at Chandler included Great Blue Heron, Caspian Tern, Black-crown Night-Heron, Double-crested Cormorant, and Common Merganser. These 7 species as well as Great Egret and Osprey were observed at Horn Rapids.

Pelicans at Chandler

The year 2006 was characterized by frequent days of high water in the spring at Chandler, with peak freshets on May 1 (10,285 cfs) and May 20 (12,898 cfs), giving pelicans few places to roost and feed for long periods during the spring smolt run. When Chandler water levels finally declined in late June exposing perching sites, pelicans would often roost and preen for long periods without attempting to feed, a pattern similar to that in 2004-2005. Foraging pelicans attempted to grab 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 northern 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 were being bypassed. However, correlations between counts of chiselmouths and pelican numbers were low (.230). Gaylord Mink has observed pelicans unsuccessfully attempting to eat adult salmon at Chandler, the fish being too large for them to handle. Pelicans are capable of consuming their entire food requirements by eating a few large fish in a fairly short time (~1/2 hr) and then remaining inactive for very long periods (up to 14 hrs) (Tommy King, USDA APHIS, personal communication).

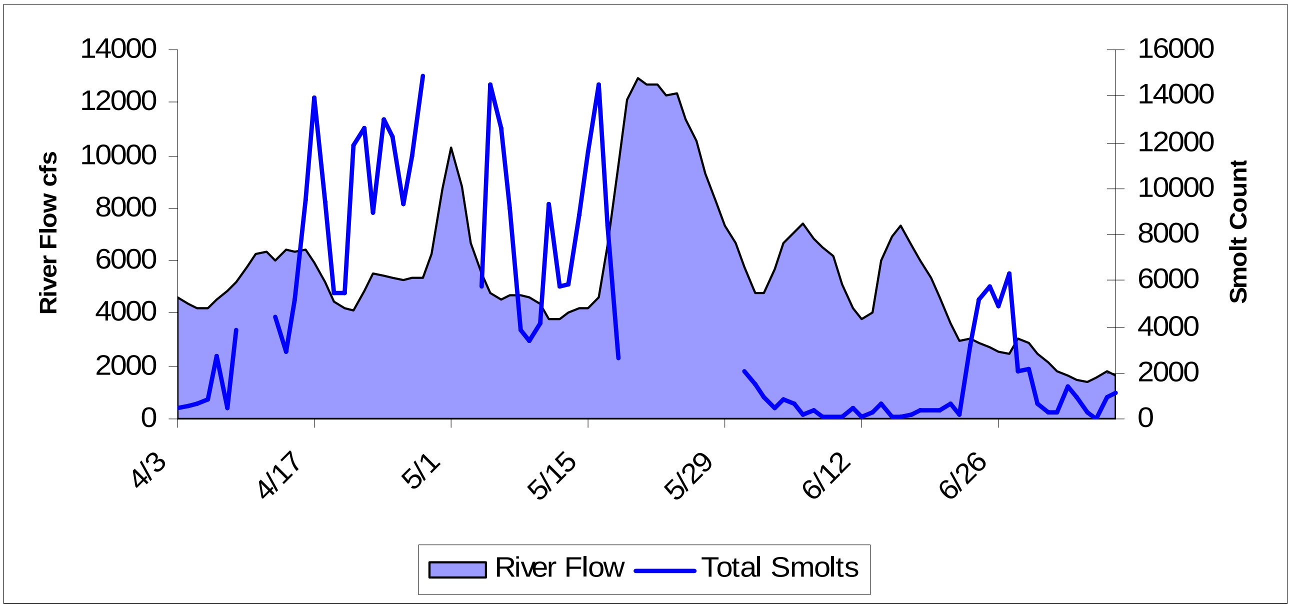


Figure 22. Total salmon smolt passage estimated at Chandler fish bypass. This data does not include fish released from Prosser Acclimation Ponds, predominately fall chinook. Gaps in the smolt line are due to missing passage data.

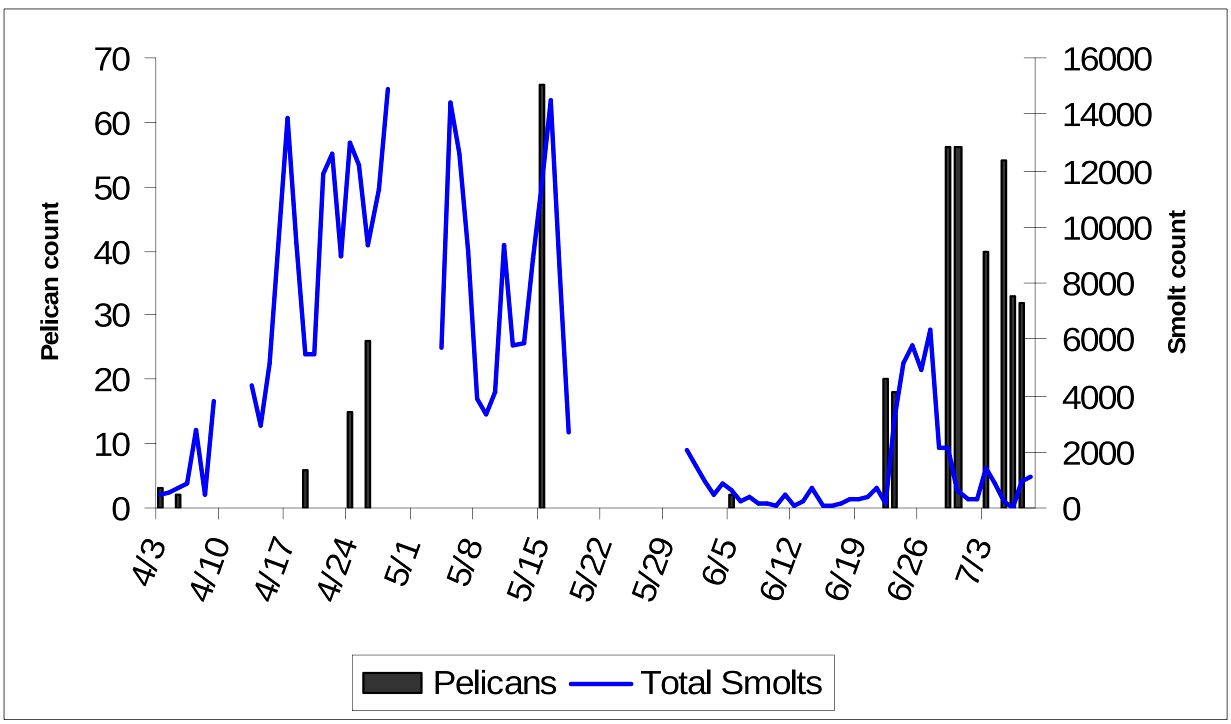


Figure 23. Comparison of pelican numbers and total smolt passage estimates at Chandler. This data does not include fish released from Prosser Acclimation Ponds, predominately fall chinook. Gaps in the smolt line are due to missing passage data.

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 1,968 kg of fish at Chandler in 2006, down from 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.

The 20 spring days that the Chandler bypass was closed due to flooding makes it difficult to assign estimates of pelican consumption to specific smolt runs. The smolt biomass consumption estimate of 1,968 kg would represent only 15.1% of the biomass of nearly 2.1 million fall chinook smolts released at Chandler from the Prosser Acclimation Ponds, just upstream from the bypass.

In 2004, based on the same worst case assumptions as above, pelicans at Chandler would have consumed 29.5% of the total smolt passage biomass. That passage includes over 900,000 bypassed fish as well as 2.3 million hatchery fish released at Chandler from Prosser Acclimation Ponds. If pelicans consumed salmon in proportion to their availability, the 29.5% of fish biomass consumed would represent nearly 1.4 million smolts consumed, including 63,082 spring chinook, 1.3 million fall chinook (56.8% of the hatchery production), 16,696 coho and 1,721 steelhead.

In 2005, based on the assumptions above, pelicans were estimated to have consumed 18.5% of the smolt passage biomass at Chandler between April 1 and July 1, 2005. The 2005 passage included both an estimated 860,000 bypassed smolts and nearly 2.2 million hatchery smolts released at Chandler from the Prosser Acclimation Ponds. In 2005, if pelicans actually consumed salmon smolts of all species in the proportion to their availability, the 18.5% would represent consumption of 826,178 smolts, including 29,794 spring chinook, nearly 800,000 fall chinook (35.4% of the hatchery production), 16,015 coho and 1,339 steelhead.

If estimated pelican predation per pelican at Chandler in 2006 was proportional to that in 2004-2005, pelicans consumed between approximately 247,000 and 286,000 smolts this year. Gaps in smolt data at Chandler preclude assigning these smolt estimates to run, but fall chinook would represent over 90% of the smolts consumed, based on the 2.1 million smolts released from Prosser Acclimation ponds in 2006.

However correlation analysis for 2004-2006 brings into question these 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 2006, only 16 pelican counts out of 28 total counts could be correlated with fish passage because of closure of the fish bypass. However the small sample showed moderate correlations between coho smolt passage and pelican numbers, suggesting that about 1/5 of the pelican count variability could be explained by coho passage. 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. 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 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).

The correlation analysis gives credence to rejecting any assumption that pelicans are responding indiscriminately to peak runs of any or all salmon species and presumably consuming large numbers of them (Table 5). The correlations do suggest that pelicans may be responding 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, Figure 15).

Table 53. Smolt – Bird Correlations 2004- 2006. 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
Hatchery Spring Chinook		
2004	0.241	0.235
2005	0.345	0.582
2006	-0.016	0.222
Total Spring Chinook		
2004	0.058	0.132
2005	0.337	0.538
2006	-0.016	0.185
Total Fall Chinook		
2004	0.447	0.442
2005	0.360	0.453
2006	0.276	0.699
Wild Coho		
2004	0.492	0.716
2005	**0.486 ***	**0.663 ***
2006	0.417	0.684
Hatchery Coho		
2004	**0.564 ***	**0.792 ***
2005	0.466	0.609
2006	**0.455 ***	**0.835 ***
Total Coho		
2004	**0.564 ***	0.790
2005	0.470	0.617
2006	0.453	0.832
Steelhead		
2004	0.232	0.322
2005	0.306	0.496
2006	-0.087	0.364
Total Salmonids		
2004	0.482	0.493
2005	0.425	0.650
2006	0.148	0.476

Gulls at Chandler and Horn Rapids

Based on observed successful foraging by gulls over 8 days of observation at Chandler, the birds are estimated to have consumed only 77 smolts this 2006 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 of 5.1 birds/day (high of 25.0), similar to the average of 5.8 birds/day (high of 36.3) in 2005. However, gulls were only sampled for 13 days at Horn Rapids versus 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 93,000 fish, an increase of over 400% from the estimate of 18,526 fish in 2005, but the decreased sampling effort makes year to year comparisons difficult. The 2006 estimate of 93,000 smolts is the same order of magnitude to that of 2004, when 112,850 smolts were counted. 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 2006 represents 2.7% of the more than 3.4 million hatchery smolts released in the Yakima River in 2006. In 2005, gulls were estimated to have consumed only 0.5% of the nearly 3.8 million hatchery smolts released.

In 2006, the only highly significant correlation between fish passage and gull numbers at Horn Rapids was for the hatchery coho run and total coho run (Table 5). The lowest was for the wild spring chinook, total spring chinook and hatchery spring chinook runs. The high correlations suggest that about 70% of the variability in gull numbers at Horn Rapids can be explained by differences in the coho run counted at Chandler.

Although the 2006 correlation analysis is based on a very 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. These correlations 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).

Smolts Consumed at Acclimation Sites

As in the years 2004-2005, smolt consumption in 2006 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 Belted Kingfisher, Common Merganser and Great Blue Heron. 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 3 month period, daily energy requirements of birds, and the average size of smolts, it was estimated that these three bird species together consumed 169-635 smolts per site (average 418). Common Mergansers and Great Blue Herons consumed between 79-86% of the spring Chinook smolts eaten by birds at Clark

Flat and Easton with Belted Kingfishers consuming 68% of the fish eaten by birds at Jack Creek. However, these avian predation rates represent only 0.07-0.23% of the approximately 786,000 smolts present in the ponds in 2006. In 2005 it was estimated that these same three bird species together consumed 703-832 smolts per site (average 757), with Common Mergansers and Great Blue Herons consuming between 84-94% of the spring Chinook smolts eaten by birds. These consumption rates represented only 0.25-0.30% of the smolts present in these ponds in 2005.

The four coho acclimation sites were not systematically surveyed for birds in 2006, with Holmes observed for a total of 13 days and Boone for 8, about a fourth of the survey effort in 2005. Stiles and Lost Creek were not surveyed. In 2006 Common Mergansers and Great Blue Herons were the most common bird seen at Holmes and Boone, as in 2005. Common Mergansers were abundant at Boone averaging 28 birds per day, similar to the 31 birds observed per day in 2005 when the site was more frequently surveyed. About 166,000 coho smolts were released in Boone in 2006. In 2005, mergansers were estimated to have consumed 64% of the 38,000 coho smolts released in Boone. Very few avian predators were observed at Holmes in 2005, taking an estimated 0.02% of the smolts present. With the notable exception of Boone which attracts high numbers of Common Mergansers, smolts reared in the other six spring chinook and coho acclimation sites are largely secure from predation by birds. With the exception of Boone, only limited bird monitoring appears warranted at the other six spring chinook and coho acclimation sites.

Pelican Radiotelemetry

No birds were caught in the first trapping array located at the gravel bar at Roza Recreation Site in the Yakima Canyon (May 17, 22 & 23). The animals using the Roza area were predominately adult birds. Pelicans apparently stopped visiting the Canyon as recreational use by the public increased during the late spring. Deploying the traps was also disruptive. By June most of the adults formerly seen at Selah, Chandler and other sites along the entire Yakima River were replaced by immature birds.

The first pelican, an immature female, was caught on June 19 at Selah in the Yakima River, with no birds caught on island traps set in Selah Pond. Three immature birds were captured at Chandler on July 6, 13 and 14, two females and one male. The last of the three birds captured at Chandler, a female, was caught during an overnight set. All four captured birds received yellow numbered patagial wing markers and metal FWS bands. The first 3 birds captured received radio-transmitter backpacks.

The bird captured in Selah on June 19, was subsequently re-sighted by boat in the lower river near Parker in the company of other pelicans on June 26. It was never visually or aerially relocated again in July or August. The second bird, captured at Chandler on July 6, was subsequently re-sighted at Chandler on July 7 and 18 and in the Toppenish Creek Delta area on July 30 (during an aerial survey by Clif Dyer). It was not relocated by aerial survey in August. The third, a male captured at Chandler on July 13 was relocated at the Sunnyside Canal area between Sunnyside and Prosser on July 30 (aerial survey by Clif Dyer). The apparent GPS location on dry land suggested mortality. However, a ground search in the area did not locate the bird and it was not relocated in August by aerial survey. The last bird, a female captured on July 14, did not receive a radio-transmitter and was never re-sighted again. Radio transmitters were not detectable at ground level even when the bird was known to be about 1 mile away. Aerial surveys may be the only efficient way of monitoring radio-collared pelicans.

The literature indicates that pelicans often regurgitate their stomach contents when captured. However, none of the four pelicans captured regurgitated stomach contents. Birds may have been in the traps too long to still contain food items when released. The last two birds were intubated with physiological saline into their stomach to try to induce vomiting to no effect.

Notable Pelican Observations

Pelicans observed in the Yakima Canyon during trapping in May roosted on gravel bars and did not appear to actively forage nearby. These animals were adult birds. Adult pelicans used the Selah Pond islands in April, May and June for roosting and foraged for fish on the northern side of the pond. On June 1, about 70 adult pelicans in the Selah Pond were observed cooperatively driving and feeding on what appeared to be bullheads into the shallows in a classical White Pelican feeding maneuver.

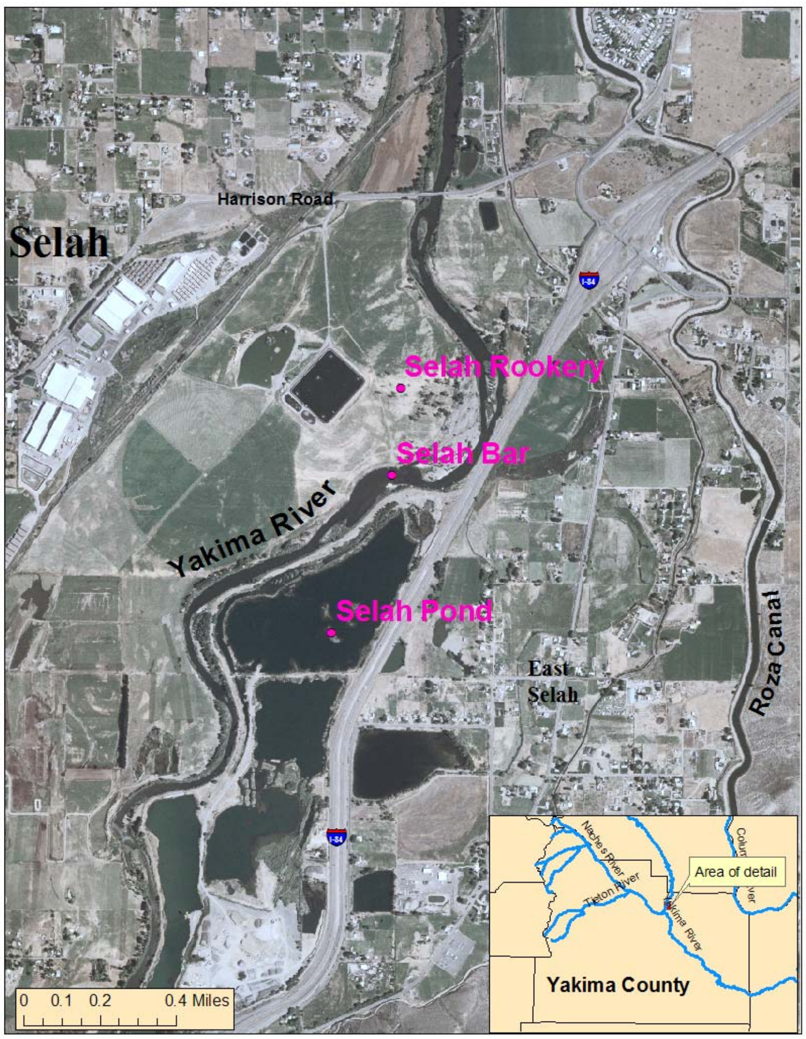
On June 1, approximately 40 abandoned large ground nests made of tules were found with large white eggs on the Selah Pond islands, most with 1-2 eggs, although a few nests had up to 6 eggs. Some nests had some down lining, but most did not. Eggs were intact, although some eggs had been displaced and were sitting on bare earth or in the water. We cracked open 2 eggs and found them filled with rotten yolk with no discernable embryo. Various water bird biologists who viewed the nests either in person or in photographs were split on whether they are goose or pelican. On July 30, I brought 31 eggs from 23 of the remaining nests to Chris Wood, collections manager of the ornithology unit at the Burke Museum, University of Washington in Seattle. He identified all of the eggs as Canada Goose based on microscopic views of the egg surface.

The design of the Chandler Bypass Pipe causes fish to exit disoriented and at right angles to the current making them vulnerable to birds. 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 larger chiselmouths and suckers were dying on the separator and exiting the pipe, presumably consumed by pelicans waiting at the other end. Other immature pelicans at Chandler appeared to only roost at the site and feed elsewhere at locations unknown.

Analysis of Smolt PIT Tags

A total of 559 PIT tags were found at 6 sites: Roza Bar, Selah Rookery, Selah Bar, Selah Pond, Chandler Bypass and Sumac Heronry (See Figures 2, 15, 16, & 17). Tags were found dating back to the year 2000, although 2005-2006 tags predominated, representing 69% of all recovered PIT tags. Twelve tags could not be completely traced to a specific hatchery or research activity and belonged to the Yakama Klickitat Fisheries Project. They may represent reused tags. Based on the ratio of tagged fish found at all sampling sites, coho are estimated to have dominated the bird catch. The 171 coho tags recorded represent an estimated 6,240 fish or 53%. About 75% of the estimated coho consumption was fish released from between 2004-2006. A total of 276 spring chinook tags were recorded representing an estimated 4,388 fish consumed or 37%. About 73% of the estimated spring chinook consumption were fish released from 2005-

2006. Fall chinook tags totaled 95, representing another 1100 fish or 9% of the total, with over 93% released from hatcheries in 2004-2006. Notably 2 tags collected at Roza Bar were fall chinook released in the Umatilla River in 2006. Only 6 steelhead tags were found, 5 at the Chandler fish bypass area. Three of the steelhead were released in 2005, two in 2006 and one in 2002. Steelhead represented a wide range of wild and hatchery populations including Toppenish Creek, Ahtanum Creek, Chelan Hatchery (released into the Snake River) and Wells Hatchery (released in the Methow River). One tag represented a reconditioned kelt that may have died in the Chandler tanks and was discarded at the bypass. These 6 fish represent an estimated 31 steelhead predated total, representing less than 1% of the total consumption by birds derived from this analysis using expansion of recovered PIT tags.



c:\avdata\birdpred\selahpoints.mxd Paul Huffman 4/10/2007

Figure 24. PIT Tag Sampling Locations in Selah.

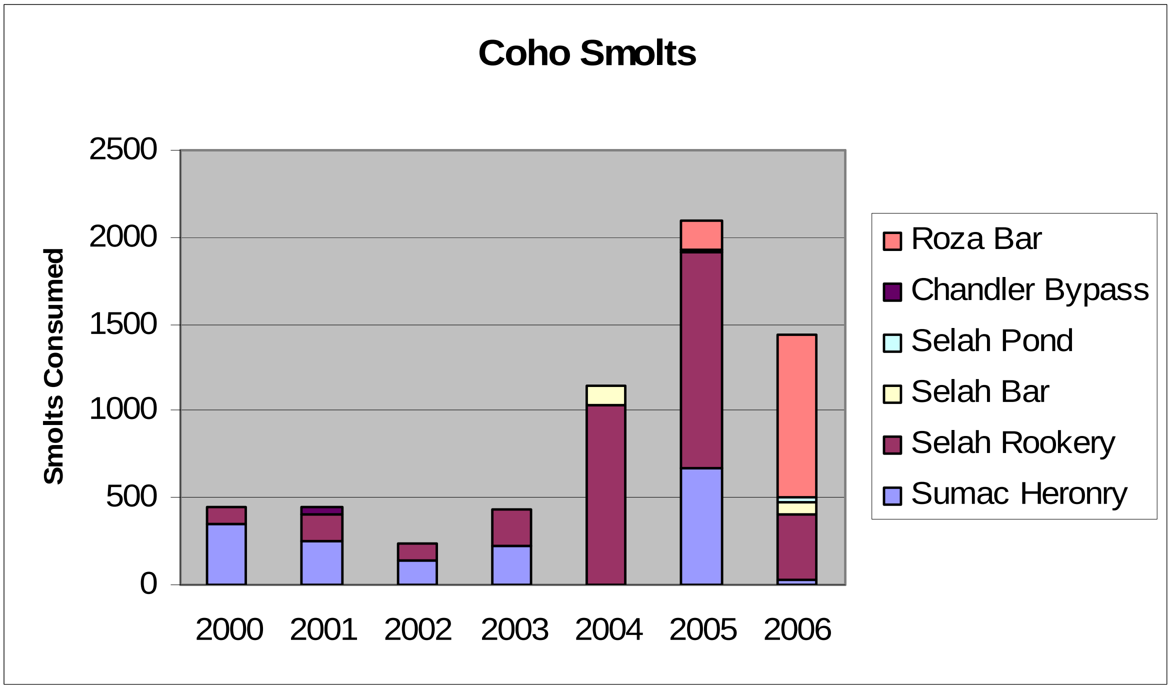


Figure 25. Estimated coho smolt consumption based on PIT tag returns from various roosting and nesting sites.

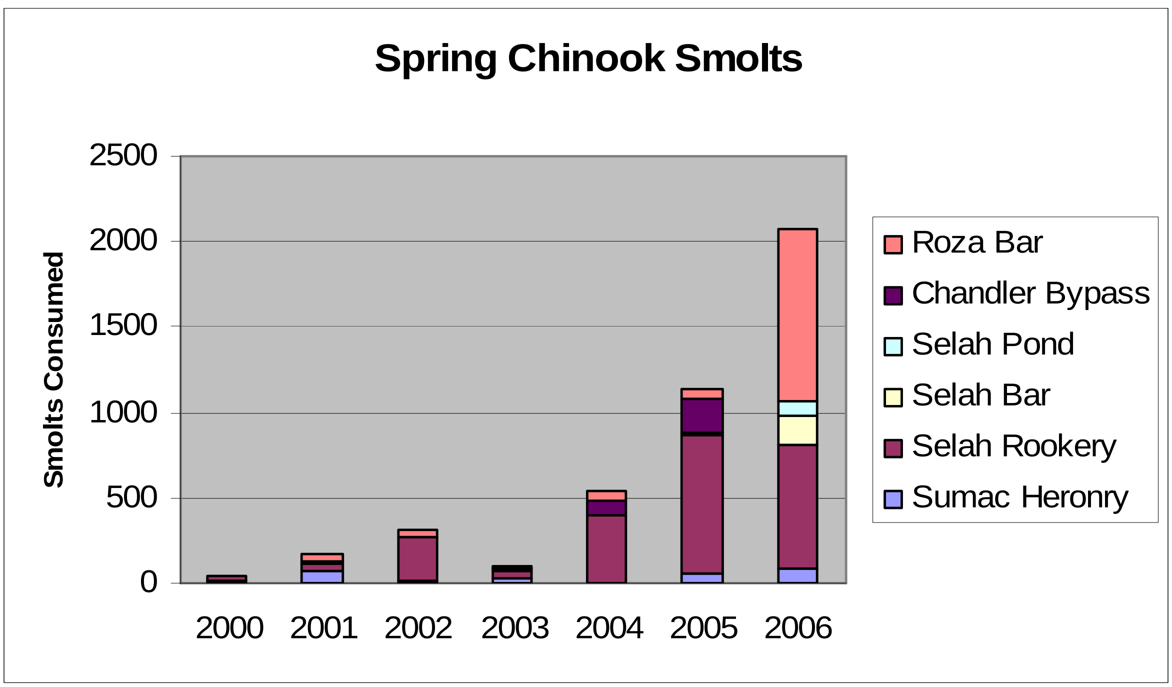


Figure 26. Estimated spring chinook smolt consumption based on PIT tag returns from various roosting and nesting sites.

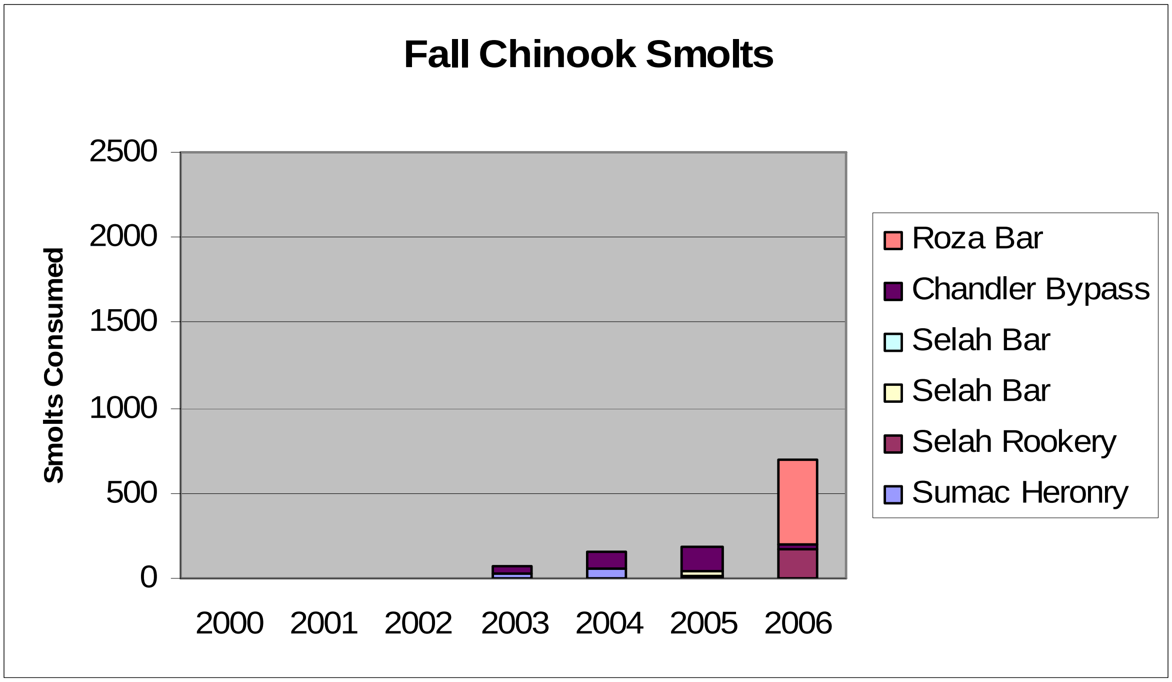


Figure 27. Estimated fall chinook smolt consumption based on PIT tag returns from various roosting and nesting sites.

The Selah Rookery (a heron and cormorant site) had the greatest number of tags found with 252 tags (46%), including 127 spring chinook, 96 coho, 29 fall chinook and 4 unknown. The Chandler Bypass outfall area (a pelican and formerly a gull site) had the second highest total of 116 tags (21%), including 56 fall chinook, 40 spring chinook, 7 coho, 5 steelhead and 8 unknown.

Based on the 6 different locations sampling 6 years of PIT tags, it can be concluded that fish predation has changed on the Yakima River over time, increasing in intensity with changes in the avian predators populations. However this predation pattern is confounded by unknown tag deposition and recovery rates from the wide range of geographic locations where tags were found. For example in-river gravel bars commonly frequented by pelicans and mergansers are far less stable substrates for tag deposition than groves of mature trees on floodplain benches such as in the Selah and Satus heron and cormorant nesting colonies. The bird species vary in their fidelity to particular sites to roost and excrete tags, and these sites vary in our ability to sample them. Water birds may excrete tags as they fly, sit or swim, although nesting and roosting sites are often places were food is carried to, digested and readily excreted, creating a reliable sample of the bird's diet. Tags deposited in deep water, on logs or on random river bank locations may never be recorded for sampling.

Another confounding variable is that the various bird species vary in the distances they fly each day between feeding and roosting or nesting sites and the length of time they may hold tags before excreting them. For example pelicans are well known to fly long distances (~50 mile radius or more) from feeding sites and roosts or nests, while mergansers might be assumed to occupy fairly small territorial ranges (~2 mile radius) during their spring nesting season. Proof of this significant factor is that pit tags from a few fall chinook and steelhead smolts released into the Umatilla River, Methow River, Snake River and Priest Rapids on the Columbia River were found at Roza and Chandler, suggesting their deposition by pelicans that moved between the Columbia River, possibly near McNary and Priest Rapids Dams, and the Yakima River. PIT tags from fall chinook released at Chandler were found in the Selah area, about 100 miles upstream, likely deposited by pelicans and cormorants.

A total of 106 coho and 224 spring chinook tags were recovered at all 6 sampling sites from smolts released from acclimation ponds from 2000-2006. Based on that sample, 3 of the current coho sites contributed relatively equal average numbers of smolts per year (Lost Creek – 145/year, Boone – 162/year, Stiles – 182/year (Stiles high of 833 in 2005)). Holmes had the highest average, 567 smolts/year, with the 2004-2006 period averaging 728 smolts/year. Holmes fish consumption was dominated by Roza roosting pelicans and Selah cormorants, but the fish were apparently eaten downstream and not at Holmes Pond itself located north of Ellensburg. Based on the sample, the 3 spring chinook acclimation ponds contributed relatively equal numbers of predated smolts per year (Clark Flat – 161/year, Jack Creek – 203/year, Easton – 190/year), most apparently consumed by Selah herons in 2000-2003 and cormorants and pelicans in 2004-2006. However based on tags collected, 2006 was the highest predation year at all 3 sites (Clark Flat – 380, Jack Creek – 900, Easton – 780), with the fish consumed by Roza pelicans and Selah cormorants. Sixty-nine tags were recovered (12.3%) from wild smolts tagged at Roza Dam, including 50 coho and 19 spring chinook, most apparently eaten by Selah cormorants. According to this tag sample, it appears the Roza Dam tagged chinook and coho and acclimation pond released chinook and coho have similar rates of tag recovery (David Lind, personal communication). Fall chinook tags found at Selah indicate that herons, cormorants and pelicans are feeding on fish originating from Stiles Pond on the Naches River.

Of the 559 tags recovered, 78 (14%) came from smolts that had been used to evaluate the monitoring efficiencies in the Chandler Canal and Forebay. It appears that almost invariably these smolts were either consumed by predatory birds after being rendered vulnerable to predation because of disorientation or had simply died in the canal or forebay and then the fish or loose tags were discharged from the fish bypass.

For heuristic purposes it was assumed that tag recovery deposition and recovery rates were unbiased at all 6 sites and during all 6 years. If that assumption is correct, coho appear to have been the predominant smolt prey from 2000-2006, followed by spring Chinook. However, the primary bird predator consuming these fish over time has changed. Based on the assumptions above using the data from these 6 sampling areas, Great Blue Herons appear to have been the dominant coho and spring chinook predator from 2000 to 2003, with double-crested cormorants becoming a greater factor during the 2004-2006 period. Based on data from the 3 Selah sampling sites (Selah Rookery, Selah Bar, and Selah Pond), cormorants shared predation dominance with Roza and Selah pelicans in 2006. While the Selah Rookery has been a consistent indicator of smolt consumption by herons and later cormorants from 2000 to 2006, estimates from 2006 smolts found at the Roza Bar (highs of 937 coho and 1004 spring chinook) and Selah Bar sites indicate the growing significance of pelicans in spring above and below Roza Dam as consumers of spring chinook and coho, although this is confounded by possible merganser smolt consumption in winter and early spring in the Canyon at Roza. The increases in smolt predation between 2000-2006 point to the rise of pelicans and cormorants below Roza in the last few years, both large species with high daily fish biomass requirements. Smolt predation appears to be additive, so with the addition of pelicans, together the two birds take more smolts than cormorants or herons did alone.

The Selah Rookery appeared to have approximately 20 active cormorant nests and smaller number of active heron nests in 2006. Unfortunately the colony was visited at the very end of nesting season making active nest estimates unreliable. The tag recoveries from Selah Heronry in 2004-2006 contribute to findings from the river reach survey that suggest that cormorants are increasingly a factor in overall fish predation and specifically smolt predation in the middle Yakima River and parts of the lower Yakima River between Roza and Zillah. Based on the river reach survey, cormorants are estimated to have taken 13.5% of the small fish biomass consumed by birds in the entire river in spring 2006, up from 3.5% in 2005. The growing presence of cormorants in the Yakima River mirrors the rapid increase of cormorant populations in the Columbia River estuary and in the Mid-Columbia area. However the small number of cormorant nests found (likely less than 100) in the Yakima River is orders of magnitude less than numbers found in the Columbia River (~20,000).

The high number of tags recovered from Great Blue Heron nesting colonies (Sumac Heronry from 2000-2006, Selah Heronry from 2000 – 2003) is surprising, given that fish consumption estimates developed from the river reach surveys suggest that herons are a relatively minor factor in smolt predation, consuming an estimated 5 - 8% of the small fish consumed by birds in the entire river in spring 2005-2006. In comparing the 2005-2006 year river reach surveys, Yakama River heron populations appear to be remaining stable or slightly declining. The heronry in Selah is long standing but has not been closely monitored year to year. At Sumac Lake, approximately 28-50 Great Blue Heron nests were counted each year at two sites between 1989-2002. A January 30, 2007 nest count mapped the existence of a number of heron and cormorant nests between Prosser and Selah on the Yakima River, but the nests were difficult to count without a light snow cover to bring them into contrast.

The tag recoveries from the Sumac and Selah Heronries indicate that, at least under some conditions such as low water, herons are efficient smolt predators. Based on tag recoveries in the years 2000-2006, Sumac and Selah herons consumed an estimated 36% of the 6,240 coho smolts, 15% of the 4,388 spring chinook smolts and 8% of the 1100 fall chinook that were estimated to have been consumed by birds from these sites. Herons may specialize on smolts that seek river sloughs and backwaters which would explain the high consumption rates for coho which are the species most likely to occupy such habitats as they move down the lower Yakima River during outmigration.

When the Sumac and Selah Heronries tag recoveries are examined in some detail (Figures 16, 17, and 18) we see that in the years 2000-2003 the number of estimated fish consumed was relatively low, averaging a total of 379 coho, 126 spring chinook and 6 fall chinook per year. But tag recoveries from 2004-2006 jumped to an average estimated 1,119 coho, 690 spring chinook and 75 fall chinook per year, primarily caused by the huge increases in fish consumed at Selah during that 3 year period. One could argue that the 2000-2003 tags were simply lost but the estimates derived from Sumac tag returns for coho and spring chinook remained relatively consistent each year: totaling 350, 250, 136.5 and 226 coho per year and totaling 21, 76, 21, and 22 spring chinook each year during the 4 year period. At Selah Heronry consumption estimates were also consistent, totaling 102, 150, 101 and 200 coho each year and 21, 35, 255, and 51 spring chinook each year during the same period. Only the 255 spring chinook consumed at Selah in 2002 appears out of the typical range for those 4 years.

The big jump in 2004-2006 fish consumption estimates in the Selah colony for coho (up to 1,039, 1246 and 370 per year) and spring chinook (up to 401, 804 and 722 per year) suggests a changing of the guard in the colony from herons to an even more efficient smolt predator, cormorants. The 4 spring chinook and 1 coho tag collected in the Selah Pond in 2006 just east of their nesting colony of 20 nests, also mark the recent arrival of cormorants to the pond, although they are very abundant there today with up to 70 cormorants observed feeding together and numerous birds using rocks and logs in the pond for roosting.

If our observations and tag recoveries at the Selah colony and other locations are accurate indices of smolt consumption, it appears that at these 6 tag recovery sites during the period 2000-2006 the top predators (cormorants, pelicans and herons) consumed an estimated 11,191 smolts or 1,599 smolts per year. Based on the tag samples, a total of at least 11,771 smolts were taken by all avian predators at these sites, 95% by cormorants, pelicans and herons and the other 5% by gulls and mergansers. However we would expect that tags deposited by these latter smaller birds are more likely to be randomly distributed along the river and its floodplain and are difficult to account for by our sampling approach.

Based on the tag returns assigned to salmon species, it is estimated that cormorants consumed the most smolts, 5,016 (43% - 2796 coho, 2029 spring chinook, 190 fall chinook, and 1 steelhead). Pelicans consumed the second most, 3,357 smolts (28.5% - 1475 spring chinook 1037 coho, 816 fall chinook and 29 steelhead) with Great Blue Heron consuming a similar number, 2,872 smolts (24.4% - 2,218 coho, 645 spring chinook, and 91 fall chinook). Based on tag recoveries, coho appear to be the preferred prey of cormorants and herons. All three birds prefer coho and spring chinook over fall chinook, likely because of the larger size of the coho and spring chinook smolts.

The 70 cormorants observed in 2006 at Selah Pond may represent the 40 or so adult birds and their offspring from the Selah Rookery. If 70 birds consumed 5,016 smolts (predominately coho and spring chinook) between 2004-2006, that would represent each cormorant consuming about 24 smolts during breeding season. This could serve as a rough index to breeding cormorant consumption per bird in the area. Similarly, if we can count the number of heron nests at Sumac Lake and elsewhere on the Yakima River, and apply consumption estimates from Sumac PIT tag returns, it can provide a rough index to the smolt consumption of breeding herons in the entire Yakima River riparian corridor. Roza Bar and Selah Bar PIT tags found in 2006 can serve as a very rough index of what approximately 100 pelicans consumed during the month of May, 2006: an estimated 2,691 smolts, 44% spring chinook, 37% coho and 19% fall chinook. Up to 210 pelicans were observed in the Yakima Canyon and Selah area during May. Based on the Roza PIT tag returns, it was estimated that Yakima River pelicans consumed almost 15,000 smolts in May 2006.

The presence of steelhead and fall chinook PIT tags originating from various Columbia River and Snake River sites, likely carried to the Yakima River by pelicans, indicates that smolts originating in the Yakima River are not only exposed to a suite of avian predators as they move down the Yakima, but continue to be vulnerable when they reach Columbia River obstructions such as McNary Dam or Priest Rapids Dam where numerous pelicans, cormorants and gulls await them. The five to six hundred pelicans in the Yakima Basin move between the Columbia and Yakima Rivers, interacting with over 1,000 Columbia Basin pelicans.

CONCLUSIONS

The 2006 river reach survey indicates that merganser, pelican and heron populations are declining slightly from 2004-2005 levels. Gulls were only common in one reach in the lower river. Cormorant populations in 2006 appear to have increased significantly from 2004-2005 levels, with concomitant increases in fish biomass consumed from 3.5% of the fish biomass consumed by birds in spring in 2005 to 13.5% in 2006. The 2006 increases in cormorant numbers makes this species the second most important avian piscivore in the Yakima River behind pelicans, moving slightly ahead of mergansers who continue to dominate the upper and middle river, as they have for the entire 10 years of this study. Mergansers have not shown a numeric response to hatchery supplementation of spring chinook and coho salmon smolts on their breeding grounds in the upper and middle Yakima River during this period.

If we compare consumption estimates to hatchery releases we can get a very rough estimate of the maximum number of smolts birds can possibly consume. For example, in the upper and middle river, based on biomass consumption estimates, if mergansers consumed smolts alone they could potentially consume 35% of the 2006 hatchery spring chinook biomass in the upper river and about 32% of the 2006 hatchery coho smolt biomass in the middle river. Pelicans inhabiting the lower river could potentially consume the entire 2006 hatchery production of fall chinook released in the lower river (2.1 million smolts) yet only satisfy 25.5% of their dietary requirements.

Actual smolt consumption by pelicans, cormorants, mergansers and other birds is actually far less, with all piscivorous species feeding on a diversity of fish appropriate to their size, including chiselmouth, sculpin, dace, sucker, northern pikeminnow, bullhead and carp. Some species don't subsist on fish alone. For example herons and gulls feed on crayfish, insects, amphibians and mice, with gulls also eating human refuse.

Observations of pelican feeding at Chandler, Selah Pond and elsewhere challenge popular perceptions of them as key predators of salmon smolts under normal conditions. Pelican numbers at Chandler were only consistently high after smolt passage was largely complete. Selah Pond pelicans were observed readily taking bullhead. Estimated pelican biomass consumption at Chandler declined significantly in 2006 compared to 2004-2005 because of a steep decline in the number of pelicans using the site because of high water in spring and early summer. However, 2006 smolt data gaps at the Chandler facility preclude assigning those pelican biomass consumption estimates to specific smolt runs as was done in 2004-2005.

If we assume that pelican consumption estimates based on bird abundances and daily energy requirements are accurate, that birds consume juvenile salmonids in proportion to their availability at hotspots, consumption in 2006 was proportional to that of 2004-2005, and that all fish eaten at Chandler were salmon smolts (a worst case scenario) the total number of smolts consumed by Chandler pelicans was between 247,000 and 286,000 smolts, over 90% fall chinook. This is about 30% of the estimated predation rate in 2005 and about 20% of the predation rate in 2004. Gulls at Horn Rapids and Chandler in 2006 consumed an estimated 93,000 smolts total, and if predation is proportional to the actual smolt run, they were predominately fall chinook. This is 400% higher the gull predation rate in 2005. The only caveat in terms of the gull consumption model is that it is based on a small number of samples.

Taken together Chandler pelicans and Horn Rapids gulls may have consumed up to 379,000 smolts in 2006, over 90% fall chinook, far less than consumption estimates in 2004-2005. This number can serve as an upper bound of smolt predation on the Yakima River, equaling about 10% of the total hatchery production of smolts in the Yakima River in 2006.

However, a number of lines of evidence strongly challenge the assumptions embedded in theses hotspot consumption estimates. Many pelicans appear to use hotspots primarily for roosting and may not be consuming many fish at the sites. When observed feeding at Chandler, pelicans have frequently consumed non-salmonid species, including chiselmouth, sucker and northern pikeminnow exiting the pipe. Most of these non-salmonid fish taken were significantly larger than the average size of salmon smolts.

Even if it is assumed the birds are targeting smolt runs, the correlation analysis from 2004-2006 suggests that pelican and gull predation on different smolt runs at hotspots is selective by run and not simply proportionate to the availability of smolts (ranging in size from 4-77 g), making the high smolt consumption estimates for pelicans, particularly of fall and spring chinook which are the smallest smolts in the Yakima River (averaging 7-21 g), extremely doubtful.

The correlations with the coho smolt run were the highest for gulls at Horn Rapids and pelicans at Chandler for 2004-2006, suggesting selection for coho and avoidance of fall or spring chinook. The only limitation comparing 2006 to the previous two years is a decrease in the number of bird counts on which the 2006 correlations are based. Despite differences in sampling, the correlative pattern in 2006 followed that of 2004-2005.

Both pelicans and gulls at Chandler and Horn Rapids appear to be more closely tracking the coho smolt run than any other smolt run, increasing in numbers at these sites (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 pelicans and gulls. The design of the Chandler pipe makes smolts and other exiting fish vulnerable to predation by birds.

PIT tags found at nesting and roosting sites of pelicans, cormorants and herons also suggest that the dominant avian smolt predators are selecting coho smolts out of proportion to their availability in the entire population of hatchery smolts and are avoiding hatchery fall chinook despite it being the most abundant run. The 559 pit tags collected from smolts marked between 2000-2006 represent the consumption of nearly 12,000 smolts: 53% coho, 38% spring chinook, 9% fall chinook and a tiny fraction steelhead.

PIT tag returns indicate that smolts consumed by cormorants, pelicans and herons were predominately coho and spring chinook. Relatively high tag returns from Sumac Heronry in the lower Yakima suggest that herons are able to target coho smolts in backwater sloughs under certain conditions, such as during low water years. During high water, smolt predation by birds will be less than in years of low flow, primarily because the high volume of water moves the smolts quickly through the system, with increased turbidity and choppy water making the fish harder to be seen and captured. 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.

Tag returns support the river reach data showing a growing cormorant population below Roza Dam which may impact smolt numbers in the future. Cormorants in the Mid-Columbia River and Columbia River Estuary are important consumers of salmon smolts. The growth of the cormorant population in the Yakima Basin is alarming because it comes at the same time that a large population of pelicans is already expanding their range in the Yakima Basin.

PIT tag returns indicate that the Yakima pelican population of approximately 600 birds is part of the larger Columbia River population of about 2000 birds. From aerial surveys of pelicans and PIT tag estimates from Roza Bar, it can be roughly estimated that Yakima River pelicans consumed about 15,000 smolts in May 2006 alone, a period of peak smolt passage.

In the Selah area, nesting cormorants may be displacing herons, replacing a less efficient smolt predator with a more efficient one. Based on PIT tag returns from the 6 sampling sites, cormorants consumed 41.5% of the sampled smolts eaten by birds with pelicans consuming 30%, and herons 26%. According to the tag returns from 2000-2006, pelicans and cormorants are the primary drivers of increasing smolt predation by birds with no other birds appearing to be of any real significance as predators in the Yakima Basin at the present time.

Plans for the 2007 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 4 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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