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YAKIMA/KLICKITAT FISHERIES PROJECT MONITORING AND EVALUATION

PROJECT NUMBER 1995-063-25
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THE CONFEDERATED TRIBES AND BANDS OF THE YAKAMA NATION

FINAL REPORT
For the Performance Period May 1, 2004 through April 30, 2005

Submitted: June 27, 2005

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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 by far the largest and most complex fisheries management project in the Yakima Subbasin in terms of data collection and management, physical facilities, habitat enhancement and management, and experimental design and research on the basin's fisheries resources. Using principles of adaptive management, the YKFP is attempting to evaluate all stocks historically present in the 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 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. In these first few years of CESRF operation, the CESRF has demonstrably increased the number of spring Chinook returning to lower Columbia mainstem and Yakima Basin fisheries and increased both the number and spatial distribution of fish returning to spawning grounds in the Upper Yakima Basin. Most demographic variables are similar between natural and hatchery origin fish. However, preliminary results indicate that hatchery origin fish are returning at smaller size-at-age and may be less successful at producing progeny in the wild than their wild/natural counterparts. Long-term fitness of the target population is being evaluated by a large-scale test of domestication. Semi-natural rearing and predator avoidance training have not resulted in significant increases in survival of hatchery fish, however growth manipulations in the hatchery may be reducing the number of precocious males produced by the CESRF and increasing the number of migrants. Ecological impacts to valued non-target taxa from supplementation activities have remained within containment objectives. Research estimates indicate that some fish and bird predators consume large numbers of juvenile salmonids in the Yakima Basin.

Fall Chinook

The YKFP is presently releasing 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 banner returns of fall Chinook in recent years and enhanced fisheries from Alaska to Prosser Dam. The YKFP is exploring 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 releasing over 1.0 million coho smolts annually from acclimation sites in the Naches and Upper Yakima subbasins. These fish are also a combination of in-basin production from brood stock collected in the vicinity of Prosser Dam plus out-of-basin stock generally reared at Eagle Creek National Fish Hatchery and moved to the Yakima Subbasin for final rearing and release. Monitoring of these YKFP efforts to re-introduce a sustainable, naturally spawning coho population in the Yakima Basin have indicated that adult coho returns averaged nearly 3,000 fish from 1997-2003 (an order of magnitude greater than the prior 10-year average) including an estimated return of over 1,500 wild/natural coho to the Yakima River Basin in 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 over 900 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 60 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.

Introduction

The monitoring and evaluation program for the YKFP was organized into four categories- Natural Production (tasks 1.a - 1.y), Harvest (task 2.b), 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 2004. 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.f, 1.g, and 1.h are included in full as appendices to this report.

Contributing authors from the Yakama Nation YKFP in alphabetical order are: Michael Berger, Bill Bosch, Melinda Davis, Chris Frederiksen, David Lind, Todd Newsome, and Ann Stephenson. Doug Neeley of Intstats Consulting and Bruce Watson of Mobrand Biometrics 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.

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) model. A brief description of the EDT model can be found on the Mobrand Biometrics Incorporated website at www.mobrand.com.

Progress: EDT model outputs and interpretation were constructed for the Yakima Subbasin planning "fix it loop" process to provide additional support and clarification that was requested by the Independent Scientific Review Panel (ISRP) after the Yakima Subbasin Plan had been presented to them in late June, 2004. Other work under the modeling task included reconciling the variance between the EDT predicted equilibrium abundance for the upper Yakima steelhead population and the observed adult counts at Roza dam due to interactions with resident rainbow trout, and finally, conduction of field work for physical attribute data collection in tributaries of the Yakima River.

Yakima Subbasin Planning "fix it loop" process:

Additional EDT model interpretation in the form of outputs and summaries were constructed to assist the Yakima Subbasin planning efforts. The written summaries provide an overview of the biotic and abiotic limiting factors impacting survival at various life stages for anadromous salmonid populations derived from geographic area summary tables. Geographic areas generally represent morphologically homogonous reaches of the mainstem Yakima River or individual tributaries of a watershed and are ranked accordingly for restoration and preservation potential for individual populations by the EDT model. For our purpose, the geographic areas prioritized for restoration and preservation were consolidated across populations and species for ranking geographic areas for all anadromous salmonid species. By doing so, restoration and preservation actions could be prioritized for areas that would theoretically improve production or protect vital habitat for multiple species.

The EDT protocol and results are presented in Tables 17 and 30, Appendix M, EDT_Product_Interpretation, of the final version of the Yakima Subbasin Plan dated November 26th, 2004. This document and associated EDT products produced for the Subbasin Plan are too large to incorporate here. To review the Yakima Subbasin Plan, please refer to the Northwest Power Planning Council's website at http://www.nwppc.org/fw/subbasinplanning/Yakima or visit the Yakima Subbasin Fish and Wildlife Planning Board's web site at http://www.co.yakima.wa.us/yaksubbasin/ for additional information and to obtain a CD copy of the final Yakima Subbasin Plan including all appendices.

Upper Yakima Steelhead equilibrium abundance adjustments:

The ecosystem diagnostic and treatment model is a scientifically based model that uses the Beverton-Holt stock recruitment function to estimate life stage specific survival as a function of habitat quality and quantity. Although there are attributes characterizing the environment with respect to the biological community and intra-specific competition between species, the EDT model was not designed to partition the quantity of habitat between ecotypes of the same species (in this case, steelhead and rainbow trout) among other dynamics that impact the productivity and abundance of each. These specifically include the genetic and environmental determinants of anadromy or residency where an interbreeding, sympatric population exists.

The inherited predisposition for smoltification (steelhead) and maturation (resident rainbow trout) in an interbreeding population has proven to be a complex phenomena and there is very little science available that would allow one to predict the likely production stemming from a steelhead and rainbow trout spawning pair. To complicate matters even further, environmental conditions encountered during critical growth periods (e.g. temperature profiles and food abundance) of juvenile rearing lifestages may also inhibit or support their inherited genetic predisposition. The existence of a sympatric population in the Upper Yakima watershed that possesses these vary complicated biological interactions creates a substantial variation between the predicted equilibrium abundance by the EDT model and the observed adults passing over Roza dam into the Upper Yakima. Currently, EDT predicts equilibrium abundance for the Upper Yakima steelhead population of 1,100 returning adults. The mean observed adults for the last 10 years passing over Roza dam into the Upper Yakima has been approximately 95 adults.

For the fiscal year of 2004, Mobrand Biometrics was contracted to assist with development of methodologies to account for these biotic and abiotic interactions and adjust the predicted abundance of the steelhead population generated by the EDT model. It should be noted that this work does not entail a resolution of the biological dynamics associated with an interbreeding population but to simply take matters into consideration and use existing knowledge to construct a scientifically sound hypothesis to account for these interactions and apply them to the adjusted abundance. This work will prove to be of value for the salmon recovery process and the YKFP steelhead master plan currently being constructed. For a detailed description of this work and results, please see Appendix A.

2004 field work:
Habitat surveys were conducted to collect data and ground truth existing attribute rankings for a number of tributaries that previously had little to no empirical data to support the current rankings in the EDT model. In the past, extensive field work and literature review was used to populate the EDT model for the Yakima River mainstem but due to the size of the Yakima watershed, empirical data to support attribute rankings in the tributaries have been sparse. The field surveys in 2004 were primarily done in tributaries of the Naches watershed, and the Naches mainstem itself. These tributaries included the Rattlesnake, Little Rattlesnake, North Fork of the Rattlesnake, Nile, Little Naches, Quartz Creek and Bear Creek. Surveys were conducted in twelve-hundred foot transects and depending on the size of the tributary, two to five transects were surveyed for a sampling percentage of roughly twenty to twenty-five percent of the total length of tributary or stream reach. Although the EDT model has forty-six attributes, field data collection focused on the abiotic attributes that characterize the physical environment of the watershed. Among those included in the surveys were: habitat composition, natural confinement, hydro confinement, maximum and minimum channel widths, wood counts and the condition of the riparian corridor. Raw field data was then transferred into an electronic format and converted into EDT attribute index values.

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, 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.

Progress: Growth profiles of naturally rearing fall Chinook juveniles in the lower Yakima River were monitored via beach seining efforts from April 1st through June 1st, 2004. 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 at Union Gap (RM 107.1-111.6). Seining was conducted using a 30 foot beach seine. All Fall Chinook greater than or equal to 55 mm were targeted for PIT tagging operation. Those fish less than 55 mm captured in the Granger reach received a Lower Caudal (LC) clip and those in the Union Gap reach received an Upper Caudal (UC) clip. Fork lengths were taken on all PIT tagged fish and a proportion of caudal-clipped fish. Marked fish were monitored at the Chandler Juvenile Monitoring Facility (CJMF). Caudal-clipped (UC or LC) fish observed at CJMF that met the size criteria (>=55mm) but did not present with a PIT tag were PIT tagged as part of the CJMF sampling operation. Fish below Prosser Dam were not clipped. PIT tag detections were monitored at the CJMF, and at McNary and Bonneville Dams.

The average fork lengths for April and May at Van Giessen, Granger and Union Gap were: 50mm and 57mm, 41mm and 53mm, and 41mm and 48mm, respectively (Figure 1). The larger sizes at Van Giessen are likely related to warmer temperatures as fish move downstream. Temperature stowaways are located in each of the three reaches to evaluate this relationship. Average temperatures were monitored for April and May (Table 1). The temperature logger at Granger was lost for May.

Table 1. Average Temperature (◦F) for April and May, 2004.

	April	May
Union Gap	**49.6**	**54.2**
Granger	**53.3**	**----**
Van Giessen	**55.9**	**64.1**

Fish were captured and PIT tagged in the Richland area (Van Giessen) April 14th. Fish at the Granger and Union Gap locations were not PIT tagged until May 6th and May 17th, respectively. The number of fish PIT tagged at

VanGiessen, Granger and Union Gap were 181, 125 and 118, respectively (Figure 2). However, fish were not PIT tagged in the Union Gap reach until after May 17th, 2004. Unknown to our crew, a "pulse" of water was released from Roza Dam on May 16th, 2004. This may have resulted in the presence of some age-0 spring Chinook during the tagging operation in Union Gap, and some of these fish may have been mistakenly identified and tagged as wild fall Chinook, since they were similar in length at that time. We only recaptured 2 upper caudal clipped fish at the CJMF. Due to poor recapture recovery at the CJMF, we may choose to discontinue caudal clipping of fish in 2005.

Figure 1. Average fork lengths of wild fall Chinook captured by beach seine at all sites for April and May, 2004.

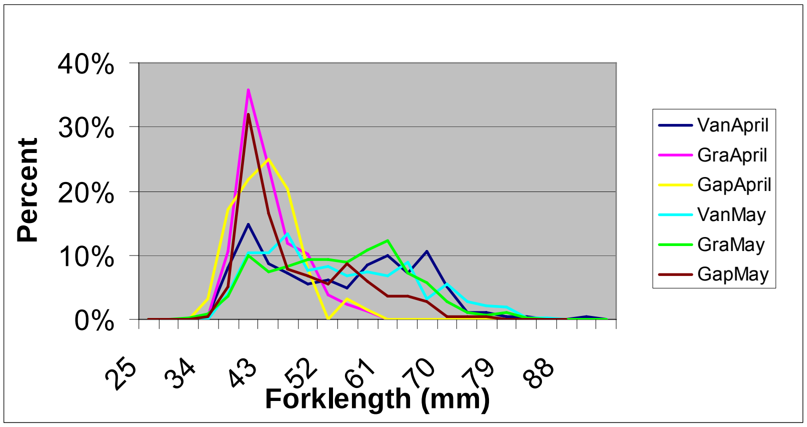


Figure 2. Percentage of fall Chinook PIT tagged in the Yakima River that were subsequently detected at the CJMF, and at McNary, JohnDay and Bonneville Dams, 2004.

Site	PIT Tags	%CJMF	%McNary	%JohnDay	%Bonneville
VanG	**181**	**----**	**6**	**4**	**1**
GRA	**125**	**14**	**2**	**1**	**ND**
GAP	**118**	**ND**	**ND**	**ND**	**ND**

*ND = No Detections

Although fish were PIT tagged as early as April 14th, the first detections at McNary Dam did not occur until May 11th, 2004. Over 80% of the fall Chinook PIT tagged above and below Prosser Dam moved out of the Yakima River and passed through McNary Dam by May 31st.

Personnel Acknowledgements: Melinda Davis is the project biologist for this task. Technicians Andrew Lewis, Ernie Reynolds and Jason Allen 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. 2005. Spring Chinook Salmon Interactions Indices and Residual/Precocial Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report. Annual Report 2004. DOE/BP-00017478.

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 year of the OCT/SNT treatment cycle. Beginning with brood year 2002, 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) without a reduction in post-release survival. The two growth regimes to be 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. To estimate smolt-to-smolt survival by rearing treatment (HI/LO), 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 groups for both smolt-to-smolt and smolt-to-adult survival and report on these data annually.

Progress: Tagging of brood year 2003 fish began at the Cle Elum hatchery on October 18, 2004 and was completed on December 9, 2004. Marking results are summarized in Table 2. Appendix B contains mark summary data for all brood years to date. As in prior years, all fish were adipose fin-clipped. Approximately 2,200 fish (4.6% to 5.1% of the fish) in each of 18 raceways were CWT tagged in the snout and then PIT tagged. The remainder of the fish (792,770) had a CWT placed in their body (i.e. left/right cheek, anterior/posterior dorsal fin, anal fin and adipose fin) and a colored elastomer dye placed into the adipose eyelid. The three colors of elastomer dye in the adipose eyelid corresponded to the three acclimation sites (red = Clark Flat, green = Easton and orange = Jack Creek). Fish with the elastomer dye in the left eyelid corresponded to the HI treatment and the right eyelid to the LO treatment. The six different CWT body tags corresponded to the rearing raceway (numbers 1-6, 7-12 and 13-18) at the Cle Elum Hatchery. Two raceways containing approximately 89,000 fish were hatchery control fish. These fish were differentially marked with a CWT in the snout. A final quality control check by YN staff took place December 20-22, 2004.

Juvenile smolt-to-smolt survival data and analyses for brood years 1997-2001 OCT/SNT treatments are being finalized and prepared for peer-reviewed publication. Appendix C contains an analysis of HI and LO smolt-to-smolt survival for brood year 2002. Appendix D contains an analysis of OCT/SNT smolt-to-adult survival for brood years 1997-2001 (for all adults which returned in or prior to 2004). Additional survival data across years are given in Appendix B.

Table 2. Summary of 2003 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	HI	CFJ02	WW	Left	Red	Anal Fin	43712	2222	45934	10/24/2004	11/2/2004
CLE02	LO	CFJ01	WW	Right	Red	Adipose Fin	42730	2222	44952	11/3/2004	11/8/2004
CLE03	LO	ESJ04	WW	Right	Green	Left Cheek	41555	2222	43777	11/8/2004	11/15/2004
CLE04	HI	ESJ03	WW	Left	Green	Right Cheek	43159	2222	45381	11/15/2004	11/18/2004
CLE05	LO	JCJ02	WW	Right	Orange	Anal Fin	45401	2222	47623	11/18/2004	11/23/2004
CLE06	HI	JCJ01	WW	Left	Orange	Adipose Fin	46079	2222	48301	11/23/2004	12/1/2004
CLE07	LO	ESJ02	WW	Right	Green	Anal Fin	43418	2222	45640	12/1/2004	12/6/2004
CLE08	HI	ESJ01	WW	Left	Green	Adipose Fin	43261	2222	45483	12/6/2004	12/9/2004
CLE09	LO	ESJ06	WW	Right	Green	Posterior Dorsal	43410	2222	45632	12/1/2004	12/7/2004
CLE10	HI	ESJ05	WW	Left	Green	Anterior Dorsal	44255	2222	46477	11/23/2004	12/1/2004
CLE11	LO	CFJ04	HH	Right	Red	Anterior Dorsal	41017	2222	43239	11/18/2004	11/23/2004
CLE12	HI	CFJ03	HH	Left	Red	Anterior Dorsal	43680	2222	45902	11/15/2004	11/18/2004
CLE13	LO	JCJ04	WW	Right	Orange	Left Cheek	44569	2222	46791	11/9/2004	11/15/2004
CLE14	HI	JCJ03	WW	Left	Orange	Right Cheek	45218	2222	47440	11/3/2004	11/9/2004
CLE15	LO	CFJ06	WW	Right	Red	Posterior Dorsal	45697	2222	47919	10/29/2004	11/4/2004
CLE16	HI	CFJ05	WW	Left	Red	Anterior Dorsal	44815	2222	47037	10/26/2004	11/1/2004
CLE17	LO	JCJ06	WW	Right	Orange	Posterior Dorsal	45375	2222	47597	10/21/2004	10/28/2004
CLE18	HI	JCJ05	WW	Left	Orange	Anterior Dorsal	45420	2222	47642	10/18/2004	10/21/2004

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 14, 2003 through April 28, 2004. 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 6,132 (3,931 wild and 2,201 hatchery) juvenile spring Chinook were PIT tagged from fish collected at the Roza juvenile fish bypass trap. Wild fish were tagged from December 15, 2003 through April 22, 2004; and hatchery fish March 17 through April 27, 2004.

Appendix E contains a detailed analysis of wild/natural and CESRF (hatchery) smolt-to-smolt survival for Roza-tagged releases for brood year 2002 (migration year 2004) and summarizes these data for prior brood years 1997-2001 (migration years 1999-2003). Additional data on this task are provided in Appendix B.

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.

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 2004 smolt passage estimates were as follows: wild spring Chinook–141,194; LO spring Chinook– 166,431 (Easton: 60,727; Jack Creek: 50,387; Clark Flat: 55,317); HI spring Chinook– 175,942 (Easton: 61,445; Jack Creek: 58,010; Clark Flat: 56,487); wild fall Chinook– 218,717; Marion Drain hatchery fall Chinook– 7,702; wild coho– 18,787; hatchery coho– 164,135; and wild steelhead– 34,337. These estimates are provisional and subject to change as better entrainment estimates are developed. Appendix F contains a detailed analysis of data obtained from these studies. Additional data on this task are also provided in Appendix B.

Personnel Acknowledgements: Biologist Mark Johnston; and Fisheries Technician Leroy Senator are, respectively, the project supervisors and on-site supervisor of CJMF operations. Other Technicians that assisted are Sy Billy, Wayne Smartlowit, Morales Ganuelas, Pharamond Johnson, Steve Salinas, Shiela Decoteau, 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

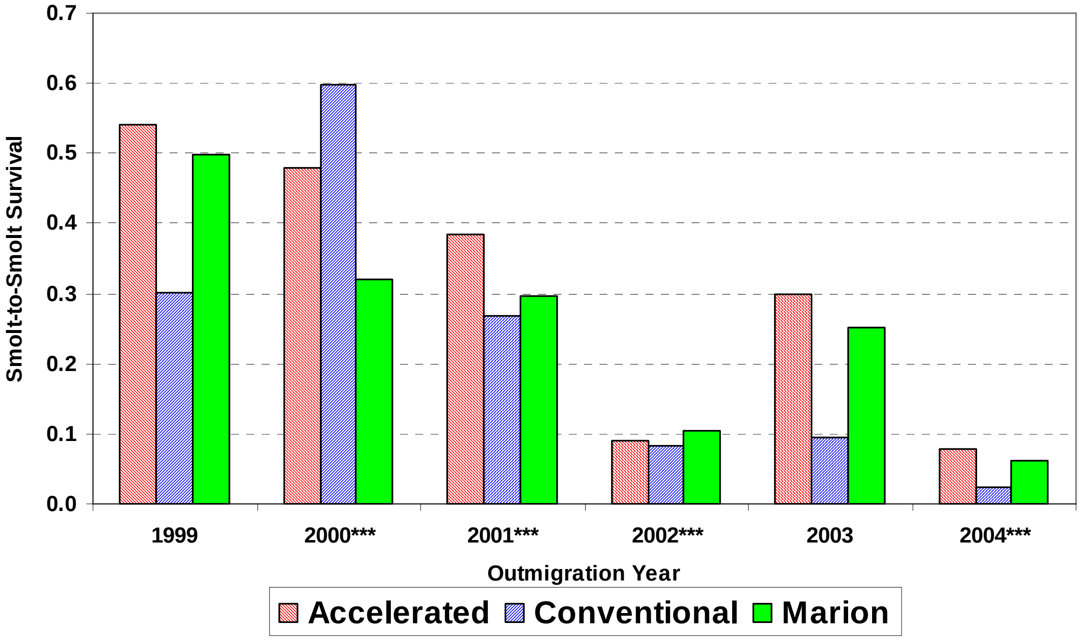
Rationale: To determine the optimal release timing (April vs. May) to increase overall smolt and smolt-to-adult survival.

Method: Approximately 329,000 fall Chinook smolts were produced from adult fall Chinook spawned during the fall of 2003. These smolts were divided into two equal groups. One group (control) was reared using conventional rearing methods with ambient river water during incubation and rearing. The other group (experimental treatment) was incubated and reared using warmer well water to accelerate emergence, growth, and ultimately smoltification. Both groups of fish were spawned, incubated, and reared at the Prosser Hatchery.

Progress: The Yakama Nation collected a total of 230 fall Chinook broodstock from the Prosser Dam Denil ladder and from fish taken from Chandler canal at Prosser in 2004. This resulted in production of 329,000 smolts that were split into two groups: approximately 165,000 smolts received accelerated incubation and rearing treatment, and about 164,000 smolts were incubated and reared on ambient river water (conventional group). All fish were ventral clipped, either left (conventional group) or right (accelerated group), to distinguish treatment groups as returning adults at Prosser Dam (video monitoring) and from carcasses recovered by WDFW during their fall Chinook redd surveys conducted downstream of Prosser Dam. Fish from both groups were 50% marked using ventral fin clips, and approximately 4,000 fish from each group were PIT tagged to evaluate smolt-to-smolt survival and migration timing to the lower Columbia River. The Prosser accelerated rearing had a higher survival index (0.08, Appendix G) than the conventionally reared fish (0.02, Appendix G).

Approximately, 2,000 PIT tagged Marion Drain hatchery fall Chinook juveniles were released to estimate survival from Marion Drain Hatchery to CJMF and McNary Dam. The survival index for the Marion Drain conventional group was higher (0.06, Appendix G) than the Prosser reared conventional fish (0.02, Appendix G) and just under the Prosser accelerated release group (0.08). Six years of combined survival indices to McNary Dam releases are given below in Figure 3. See Appendix G for a detailed report and analysis of fall Chinook smolt-to-smolt survival.

Figure 3. Weighted Tagging-to-McNary-Passage Smolt-to-Smolt Survival Indices for 1999-2004* Outmigrants of three Groups of Fall Chinook (weights are release numbers)**



* Brood-years 1998-2003, respectively.

** Main-Stem-Yakima Stock under Accelerated Rearing, Main-Stem-Yakima Stock under Conventional Rearing, and Marion Drain Stock

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

Rationale: To determine the optimal location, date, and stock of release to maximize the feasibility of coho re-introduction into the Yakima Basin, and to determine the spawning distribution of returning adults.

Method: ***Phase I (1999-2003)*** The design of the phase I coho optimal stock consisted of a nested factorial experiment intended to test for survival differences between: out-of-basin and Prosser hatchery stocks; release location (upper Yakima and Naches sub-basins); and early versus late release date (May 7 and May 31). Phase I has been completed and results have been submitted for publication to the American Fisheries Society (AFS) North American Journal of Fisheries Management in an article titled “Evaluating the Feasibility of Reestablishing a Coho Salmon Population in the Yakima River, Washington”. The abstract from this paper follows.

> Historical returns of coho salmon (*Oncorhynchus kisutch*) to the Yakima River Basin have been estimated to range from 45,000 to 100,000 fish annually. Due to many causes, coho salmon became extinct in the Yakima River by the early 1980s. In 1996 a project was initiated "to determine the feasibility of reestablishing a naturally spawning coho population … within the Yakima River Basin …". The Yakima coho project explored whether successful adaptation and recolonization occurred when multi-generation hatchery fish were reintroduced to native habitats. The project also evaluated smolt survival for coho releases with different broodstock origins, and temporal and spatial distributions. The 2001-2003 releases from Yakima-return broodstock parents had significantly higher smolt-to-smolt survival indices than releases from out-of-basin broodstock parents. We found no significant difference between the smolt-to-smolt survival indices of smolts released in early versus late May. During 2000-2003, releases from the Naches subbasin (lower in the watershed) had higher smolt-to-smolt survival indices than releases from the Upper Yakima River. We also compared relative smolt-to-adult survival between Yakima River coho and spring Chinook (*O. tshawytscha*) since both are stream-type (yearling migrant) salmon. For seven juvenile migration years from 1997-2003, the mean smolt-to-adult survival index for returns from hatchery-derived coho production was estimated to be 3.7%, approximately 70% of the estimated mean survival index for wild/natural spring Chinook (5.3%) in the Yakima Basin over the same period. Finally, we documented that substantial natural production of coho is occurring, and smolt-to-adult survival for naturally produced coho appears to be at least 3.5 times the survival for returns from known hatchery releases. While the project demonstrated some success in reestablishing a natural spawning population of coho from an out-of-basin hatchery population, further development of locally adapted natural broodstock and establishing naturally producing populations in tributaries are likely necessary to sustain long-term, natural production.

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 and Woodward 2003). The design of the coho optimal stock has evolved toward testing survival from specific acclimation sites (including the current four), and trying to keep in-basin stock (Yakima Stock) acclimating in Lost Creek (Naches) and Boone Pond (Upper Yakima) in the upper portions of both watersheds. In this design, acclimation sites can only be compared geographically across sub-basins (Yakima and Naches). Out-of-basin coho will be acclimated at downstream acclimation sites in both sub-basins. Approximately 2,500 pit tags will represent each acclimation site during the normal acclimation period of February through May. Releases will continue to be volitional beginning the first Monday of April. An additional 3,000 PIT-tagged coho will be planted into each acclimation site during late summer to assess and monitor over-winter acclimation and survival. Acclimation sites will have PIT tag detectors to evaluate fish movement during the late winter and early spring.

Progress:

As the program awaits approval of the Coho Master Plan, the coho program maintains interim goals.

1. Increase juvenile smolt passage out of the Yakima sub-basin
2. Increase natural production and redd counts
3. Continue to increase and maintain a true in-basin coho brood stock
4. Increase smolt to adult percentages in both wild and hatchery adults

Currently, nearly all the goals are being met or surpassed. Hatchery and wild coho smolt passage increased in 2004, redd counts have increased dramatically, our 100% in-basin coho brood stock continues to be developed and our adult SAR's are slowly improving. Radio telemetry is showing more adults using tributaries and venturing into new, unseeded areas, and adult coho are returning to areas that are completely unexpected (for example, the Lost Creek Acclimation Site 2004 and the Easton Acclimation Site in 2003). As noted above, phase I has been completed and the results and recommendations are currently in review pursuant to publication.

2004 Results:

Coho releases in 2003 marked the beginning of Phase II of the feasibility study. The 2004 releases replicated the 2003 releases, with one exception. All out-of-basin coho were acclimated in the two lower acclimation sites, Holmes and Stiles, in-basin coho were acclimated in the furthermost upriver locations, Boone and Lost Creek. The out-migrating coho suffered significant mortality in the Yakima River in the 2001 drought year due to the late releases called for in the experimental designs. In an effort to improve out-migration survival, volitional releases were implemented beginning with the 2003 release to allow smolts every opportunity to take advantage of natural freshets and water releases from upstream dams. Pursuant to master plan specifications, coho smolt releases are to begin the first of each April, except in extreme drought years. In the event that extreme drought conditions are expected (to be determined in-season annually), out-of-basin coho will be brought in much earlier and forced out into the rivers in March. We will monitor out-migration from the acclimation sites annually with PIT tag detectors.

Detection efficiency at the outlets to acclimation ponds was poor again in 2004. The variable water flows, natural pond outlets and general lack of integrity at the release points (lack of concrete infrastructure and appropriate detection equipment) make high detection efficiency nearly impossible. However, each year brings new ideas on how to increase our detection efficiencies using portable tag readers. There will be some modifications done at each site for the 2005 out-migration, and the hope is for better data collection.

Site comparisons were analyzed and, based on the Willard stock, survival indices to McNary for releases in the Naches sub-basin exceeded those in the Upper Yakima River (Table 3). Analysis done within each sub-basin showed that in the Upper Yakima, the Holmes (acclimation site) survival index was higher than that of Boone. While in the Naches, the Stiles survival index was higher than that of Lost Creek.

Overall passage of coho from acclimation site release to Prosser Dam was much higher than that observed in previous years (i.e. 164,000 in 2004 compared to 14,500 in 2003 and 30,000 in 2002). We believe this occurred because the more abundant out-of-basin fish were released from the Stiles and Holmes acclimation sites which are located further down river thereby increasing their survival since a shorter travel distance means less exposure to predation and other mortality factors. The in-basin smolts acclimated in the upper basin sites (Boone and Lost Creek) had extremely similar survival rates between two completely different sub-basins, approximately 17%, however, survival for in-basin smolts was reduced somewhat from past years. This reduction in survival from the upper sites is generally attributed to longer migration, harsher conditions (colder water), and higher predation, not necessarily the brood used.

It is hoped that upward trends in overall smolt passage should ultimately increase the returns of in-basin brood-source adults in 2005. With an expected increase in adult returns in 2005, we hope to implement provisions of Phase II of the Coho Feasibility Study which calls for placing spawning adult coho into select tributaries to study stream seeding and interactions with resident fish.

See Appendix H for a detailed report and analysis of coho smolt-to-smolt survival indices for 2004 releases.

Table 3. Summary of 2004 release-to-McNary survival index by stock, timing and location (see Appendix H for details).

Upper Yakima Subbasin				Naches Subbasin			
Acc. Site	Stock	Release Number	Survival	Acclimation Site	Stock	Release Number	Survival
Holmes	Willard	2522	.1067	Stiles	Willard	2457	.1903
Boone	Yakima	2488	.1705	Lost Creek	Yakima	2445	.1793
Pooled over sub-basins					Willard	4979	.1479
					Yakima	4933	.1749
Pooled over sub-basins and Stock						9912	.1613

Other highlights from 2004 include:

- We estimated that the smolt-to-adult survival rate for 9,260 wild/natural origin coho smolts (counted at CJMF in 2003) was 19.21%. This is considerably higher than the survival of hatchery smolts and all prior years wild/natural SAR's (next bullet).

- The estimated smolt-to-adult survival rate for 14,500 hatchery coho smolts (counted at CJMF in 2003) from releases in the Upper Yakima and Naches Rivers was 3.4%. This is a marked improvement in survival over the past 3 years.

- The 2004 adult coho run was comprised of 1,779 wild/natural (78%) and 501 (22%) hatchery adult coho. This was the fourth year this distinction could be made. The entire hatchery release group was 100% CWT marked allowing for identification.

- During the 2004 upstream migration, approximately 90 radio tags were inserted into adult coho salmon passing the right bank Alaskan Steep Pass Denil. Final radio tag locations used in this analysis represent areas of resting or spawning before the fish (or carcasses) moved back down stream. Radio tags entering the Naches River have ranged from a low of 3% in 2000 to a high of 29% in 2003 (Table 4). In 2004, only 5.6% of the radio tagged adult coho entered the Naches River (Table 4). However, the vast majority of coho redds surveyed in 2004 in both sub-basins were found in the Naches River (Task 1.n).

Table 4. Results of 1999-2004 Radio Telemetry Studies for Yakima Basin Coho

	1999	2000	2001	2002	2003	2004	Average
Number Radio Tagged	86	102	105	48	71	90	
Never Seen	3.5%	5.9%	5.7%	4.0%	4.0%	6.7%	5.0%
Mortality/Regurgitated Tag	3.5%	2.0%	7.6%	6.0%	6.0%	2.2%	4.6%
Fell Back at Prosser	4.7%	7.8%	5.7%	4.0%	4.0%	12.2%	6.4%
Prosser Dam to Granger	4.7%	1.0%	6.7%	13.0%	9.0%	14.4%	8.1%
Granger to Sunnyside Dam	61.6%	41.1%	37.1%	19.0%	28%	30%	36.1%
Sunnyside Dam to Naches conf.	12.8%	16.6%	5.7%	6.0%	9.0%	6.7%	9.5%
Lower Naches	4.7%	2.0%	3.8%	6.0%	0%	0%	2.8%
Naches above Cowiche Dam	3.5%	1.0%	13.3%	3.0%	29%	5.6%	9.2%
Naches conf. to above Roza Dam		7.9%	9.5%	11.0%	9.0%	9.9%	9.5%
Mid-Yakima Tributaries	1.2%	14.6%	4.8%	1.0%	11%	12.2%	7.5%
Total above Naches confluence	8.2%	10.9%	26.6%	20.0%	38%	15.5%	19.9%
Total Coho into Naches River	8.2%	3.0%	17.1%	9.0%	29%	5.6%	12.0%

- 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 the Yakima River downstream of the Naches River confluence. However, in 2004 the land owners at Lost Creek reported observing salmon entering the outlet of the acclimation facility and Yakama Nation Fisheries technicians located 3 adult coho redds immediately downstream of the acclimation site. This could represent some evidence that some fish may be adapting to longer migrations. However the data generally show that a large percentage of coho in the Yakima River lack fidelity to their natal 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 main stem water for acclimation), 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, the percentage of adult coho spawning above the Yakima River's confluence with the Naches River is generally showing an increasing trend.

- Using radio tagged coho, we estimated that approximately 4% of the entire coho run spent various amounts of time in Sulfur Drain in 2003.

This percentage increased to 6.6% percent in 2004. This is similar to 2001 when approximately 7% of the coho run entered this irrigation return drain where eventual de-watering prevents any successful production from spawning. In 2004 we successfully captured and moved 150 adult coho salmon (4.5% of the overall coho run), 6 fall Chinook, and 4 steelhead from Sulfur Drain.

- 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 2004 and we found no incidence of age-0 precocials. There were significant numbers of subyearling coho observed in the lower Naches River 2004 residual surveys, indicating that natural production is occurring.

Personnel Acknowledgements: Special thanks to all the people involved in the coho monitoring and evaluation activities which also include redd surveys. These people include but are not limited to Joe Jay Pinkham III, Linda Lamebull, Jason Allen, Conan Northwind, and Quincy Wallahee Andrew Lewis, and Ernest Reynolds. Also, thanks to the Prosser Fish Culturing facility, for their excellent fish culturing skills and year round cooperation, Ida Sohappy YKFP book keeper, and David Byrnes, the contracting officer's technical representative for BPA for this project.

Task 1.j Yakima Spring Chinook Juvenile Morphometric/Coloration

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

Knudsen, C. M. (editor). 2005. Reproductive Ecology of Yakima River Hatchery and Wild Spring Chinook. Annual Report 2004, Project Number 1995-064-24. BPA Report DOE/BP-00017478.

And

Busack, C., A. Frye, T. Kassler, T. Pearsons, S. R. Phelps, S. L. Schroder, J. B. Shaklee, J. Von Bargen, S. F. Young, C. M. Knudsen, and G. Hart. 2005. Yakima Fisheries Project Genetic Studies, Yakima/Klickitat Fisheries Project Monitoring and Evaluation, Annual Report 2004. Project No. 1995-064-24; BPA Report DOE/BP-00017478.

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:

Spring Chinook (2004 run)

An estimated 15,154 spring chinook passed upstream of Prosser Dam in 2004. The total adult count was 14,413 (95.1%) fish, while the jack count was 741 (4.9%) fish. Of the adult count, 4,195 were identified as hatchery origin. Returning hatchery adults this year comprised 4 and 5 year olds (brood years 1999 and 2000). The ratios of wild to hatchery fish were 71:29 and 77:23, for adults and jacks respectively.

The 25%, 50% and 75% dates of cumulative passage were April 30, May 9 and May 17, respectively.

The estimated mean fork length for adults (wild and hatchery) and jacks (wild and hatchery) measured from video observations at Prosser Dam was 70.3 cm and 49.8 cm, respectively. These estimated video fork lengths for adults were 0.2 cm and 0.8 cm larger for adults and jacks respectively, than those measured "hands-on" at Roza during trapping and broodstock collection activities. Historical video data suggests that video based fork lengths at Prosser are not a reliable measurement to estimate true fork length. It is believed this is a result of a "mismatch" in the applied multiplier value (video length x multiplier value = true length) relative to the horizontal passage trajectory of the fish as it passes by the viewing window.

Fall Run (coho and fall chinook)

Coho (2004)

The estimated coho run was 2,389 fish. It should be mentioned that an undetermined number of fish "dropped out" below Prosser Dam and are not reflected in this count. Some fish were harvested while others were falsely attracted into tributaries such as Spring Creek. Adults comprised 97.3% and jacks 2.7% of the run. Of the estimated run, 47.7% were processed at the Denil and mark sampling there indicated the run was comprised of approximately 76.5% wild/natural and 23.5% hatchery coho.

The 25%, 50% and 75% dates of cumulative passage were September 22, September 29, and October 11, respectively.

The estimated mean adult and jack fork lengths as measured from video observations at Prosser Dam were 71.6 cm and 40.6 cm, respectively, compared to 68.4 cm and 38.6 cm for fish sampled at the Denil trap. This indicates a possible size bias of the true fork length for fish measured from the videotapes. This bias has been observed in past years for all salmonid species at Prosser Dam.

Fall Chinook (2004 run)

Estimated fall chinook passage at Prosser Dam was 2,947 fish. Adults comprised 97.1% of the run, and jacks 2.9%. Of the total number of fish, 250 were adipose clipped, 240 fish were adults and 10 fish were jacks. The median passage date was October 4, while the 25% and 75% dates of cumulative passage were September 18 and October 17, respectively. Of the total fish estimate, 423 (14.4%) were counted at the Denil.

The mean estimated adult and jack fork lengths as measured from video observations at Prosser Dam were 83.6 cm and 50.2 cm, respectively, compared to 78.0 cm and 52.4 cm for fish sampled at the Denil trap.

Steelhead (2003-04 run)

The estimated steelhead run was 2,755 fish. Of the total, 16 (0.6%) were adipose clipped fish, which were all out-of-basin strays since no hatchery returns were expected to the Yakima River. The median passage date was October 27th, 2003, while the 25% and 75% cumulative dates of passage were October 11th, 2003 and November 30th, 2003 respectively.

The mean fork length was 64.1 cm, and fish ranged in size from 14.8 cm to 114.5 cm.

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 210 steelhead were counted past Roza Dam for the 2003-04 run. As shown in Figure 4, most steelhead migrated past Roza Dam from February through early May of 2004.

Spring Chinook
At Roza Dam 11,005 (91.6% adults and 8.4% jacks) spring Chinook were counted at the adult facility between April 26 and September 10, 2004. The

adult return was comprised of natural- (70.4%) and CESRF-origin (29.6%) fish. The jack return was comprised of natural- (76.7%) and CESRF-origin (23.3%) fish. Figure 5 shows spring Chinook passage timing at Roza in 2004.

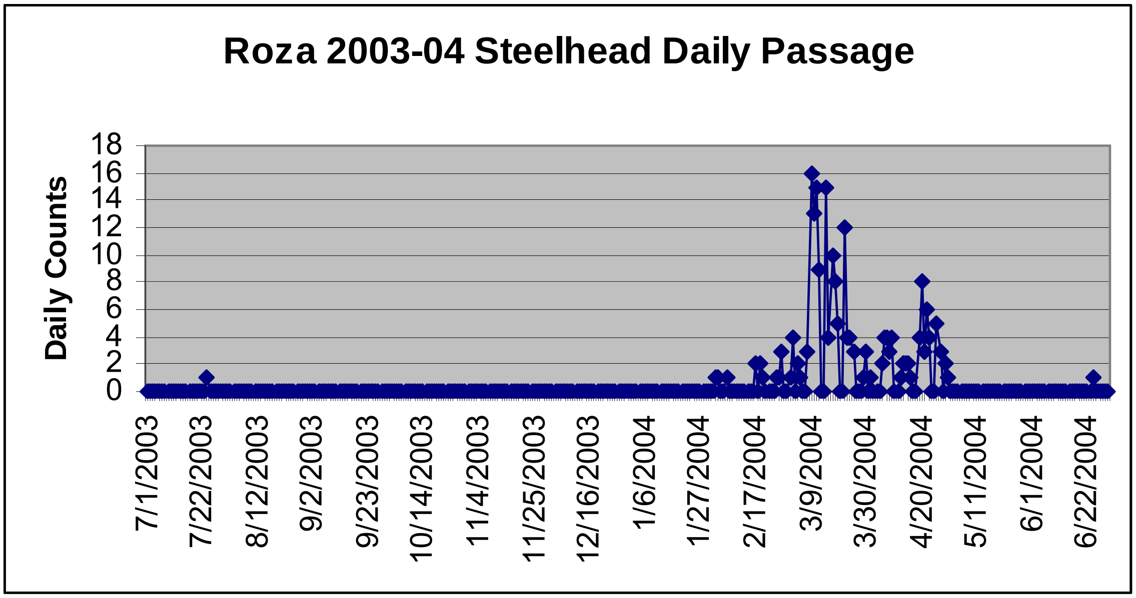


Figure 4. Daily steelhead passage at Roza Dam, 2003-04.

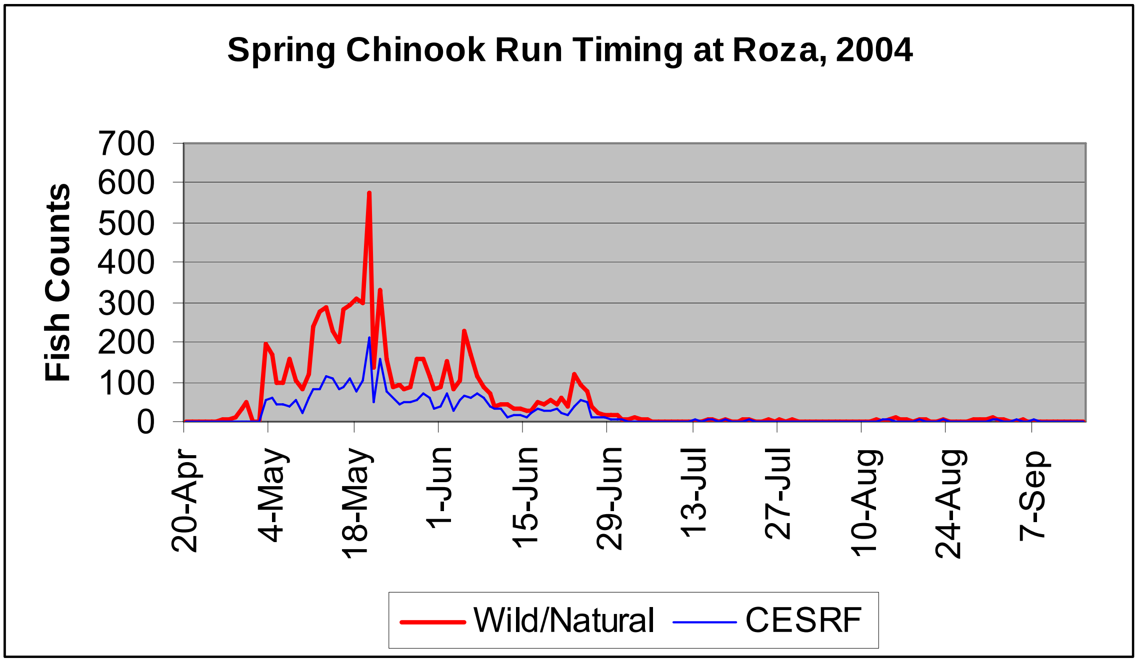


Figure 5. Daily passage counts for natural- and CESRF-origin spring Chinook at Roza Dam, 2004.

Coho

A total of 37 adult and no jack coho were observed passing Roza Dam from September 22, 2004 through January 21, 2005. Of the total, no adults were observed to have a CWT in the snout (hatchery-origin).

Cowiche Dam

Coho

A total of 83 adult and 7 jack coho were observed passing Cowiche Dam from October 27, 2004 through March 15, 2005. Of the total, no adults were observed to have a CWT in the snout (hatchery-origin).

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: Steelhead surveys in Satus and Toppenish basins and Ahtanum Creek began in mid-March and ended in late May. Total redd counts by subbasin were as follows: Satus basin- 108, Toppenish basin- 99, and Ahtanum Creek- 16. For all three basins a total of 223 redds were counted. Steelhead spawning in the Satus watershed was impacted significantly by water conditions due to the very low snowpack in the winter of 2004-05: low flows precluded passage into the upper portions of Dry Creek; Shinando, Kusshi and Wilson Charley creeks also had low flows; and Mule Dry creek never watered up.

Steelhead redd surveys in the Naches River system were conducted jointly by the U.S. Forest Service and the Washington Dept. of Fish and Wildlife. These surveys counted 140 total redds in the Naches system between March 25 and May 20, 2005 (G. Torretta, USFS, personal communication).

Spring Chinook: Redd counts began in late July in the American River and ended in early October in the upper Yakima River. Total counts for the American, Bumping, Little Naches, Naches, and Rattlesnake rivers were respectively: 91, 205, 75, 303, and 44 redds. Redd counts in the upper Yakima, Teanaway and the Cle Elum rivers were: 2,985, 129, and 330, respectively. The entire Yakima basin had a total of 4,163 redds (Naches- 719 redds, upper Yakima- 3,440). Historical spring Chinook redd count data are provided in Appendix B.

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

Yakima R.: 550 redds. 90.2% of the redds were located between RM 70 and RM 93. Redds were found as high as RM 116.3.

Naches R.: 2 redds. Three surveys were conducted from the end of October to mid-November from Wapatox Dam to Cowiche Dam.

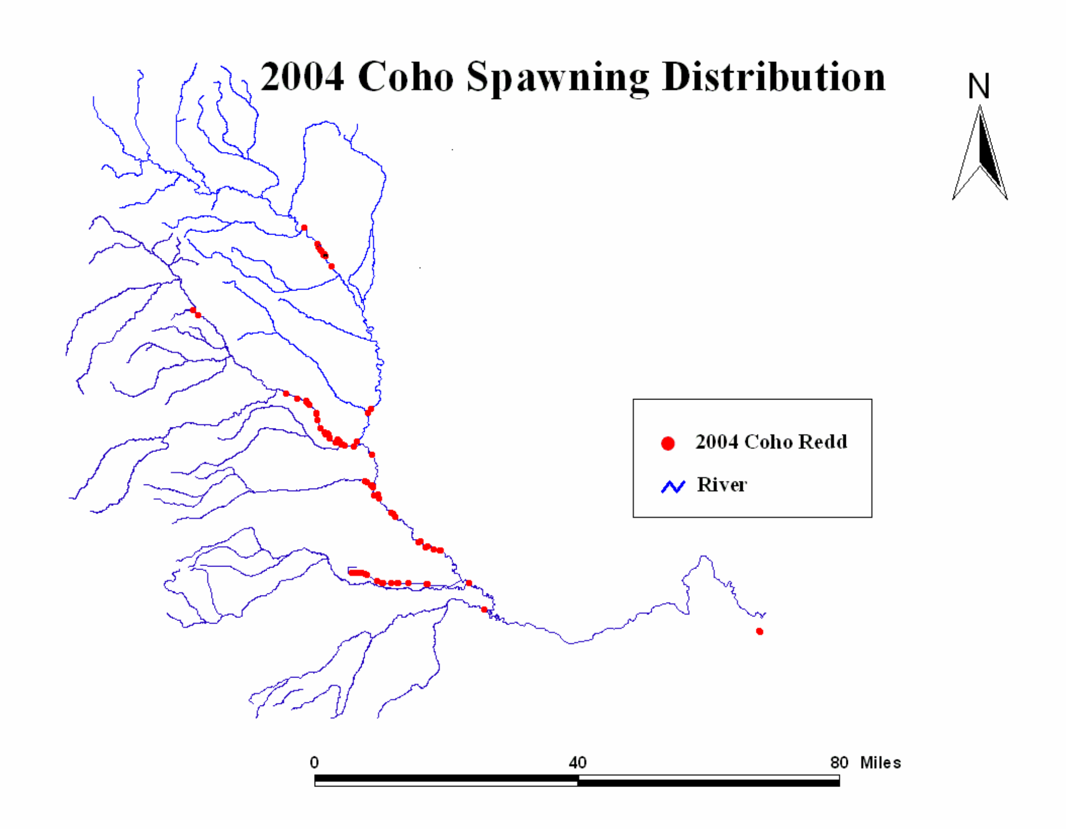
Marion Drain: 100 redds. 71% of the redds were located below HWY 97.

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 divided into sections that are checked via boat or foot daily. Winter freshets and weather did not hinder the spawning surveys in 2004, thus, the coho redd count was the second highest the YN has recorded and there seemed to be excellent production. The shift of increasing numbers of coho spawning in the Naches River continued in 2004, with the 2004 redd count being the third highest recorded since 1998. Many redds were located intermixed with fall chinook redds, tucked under cut banks, and/or were found in many side channels. Tributary redd enumeration and identification was much more accurate in 2004 due to the low water and relatively good weather. The consistency of surveyors and the discoveries of new spawning areas may result in increased coho redd counts in the future.

Table 5. Yakima Basin Coho Redd Counts, 1998-2004.

River	1998	1999	2000	2001	2002	2003	2004
Yakima River	53	104	142	27	4	32	78
Naches River	6	NA	137	95	23	56	87
Tributaries	193	62	67	29	16	21	92
Total	252	166	346	154	43	109	257

Figure 6. Distribution of coho redds in the Yakima River Basin in 2004.



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. 2005. Spring Chinook Salmon Interactions Indices and Residual/Precocial Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report. Annual Report 2004. DOE/BP-00017478.

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, B. Watson, T. Pearsons, D. Fast, S. Young and J. Rau. 2005. Comparing the reproductive success of Yakima River hatchery-and wild-origin spring Chinook. Annual Report 2004, Project Number 1995-063-25. BPA Report DOE/BP-00017478.

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). 2005. Reproductive Ecology of Yakima River hatchery and wild spring Chinook. Annual Report 2004, Project Number 1995-064-24. BPA Report DOE/BP-00017478.

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 are summarized in Table 6 by species and sampling method. Historical data from age and length sampling activities of spring Chinook in the Yakima Basin are presented in Appendix B.

Table 6. The 2004 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	83	15.5	49	40.4	451	59.5	2	71.0
Upper Yakima Wild/Natural			41	43.4	515	59.8	3	69.3
Spawner Survey Samples								
Upper Yakima Supplementation			2	52.0	69	58.7	1	68.0
Upper Yakima Wild/Natural			7	47.3	300	59.1	1	67.0
American River Wild/Natural					4	56.5	4	77.5
Naches River Wild/Natural			3	46.0	119	61.0	11	75.2
Yakima R. Fall Chinook								
Hatchery	5	45.2	32	56.5	20	66.2	9	77.3
Wild/Natural	38	43.4	142	56.0	82	69.3	63	77.2
Yakima R. Coho								
Hatchery	31	31.4	224	53.6				
Wild/Natural	17	32.4	784	55.9				

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.u Habitat Monitoring Flights and Ground Truthing

Rationale: To record an aerial video record of a particular subbasin that can be used to aid in the EDT Level 2 data input to the model.

Methods:

Progress: Ground survey work accomplished pursuant to this task in fiscal year 2004 was discussed under Task 1.a, Modeling.

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 the upper Little Naches and South Fork Tieton Rivers in the fall of 2004. Each sample was analyzed to estimate the percentage of fine or small particles present (<0.85 mm). The Washington State TFW program guidelines on sediments were used to specify the impacts that estimated sedimentation levels have had on salmonid egg-to-smolt survival. These impacts will be incorporated in analyses of impacts of “extrinsic” factors on natural production.

Progress:

Little Naches Monitoring

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 20 years for the two historical reaches, and 13 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 is very similar to the previous year (cumulative average of 11.77 % for 2004 compared to 11.62 % for 2003). These results were not significantly different from each other (Figure 7). The unchanged conditions between years may be due to fairly low flows (little bedload movement or flushing) and relatively stable watershed conditions. The lower levels of fine sediment are encouraging and should minimize mortality on eggs and alevins. This marks three years (2002-2004) that overall average fine sediment in the basin has been under 13%. A note of caution is needed though. Three years of improving conditions is a short time span. Further monitoring is needed to see if this trend will continue or not.

The reason for the recently improved conditions is not fully understood. In the earlier years of sampling, overall average fine sediment levels in the Little Naches were quite high and reached a peak in 1993 of 19.7% fines (Figure 7). Due to the high rate of fine sediment at that time, considerable road improvement, abandonment, and drainage work was completed by landowners in 1994 and 1995. In addition, more protective measures were enacted 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 (Figure 7). 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 regrowth in previously harvested areas. These factors and others need to be compiled and analyzed to determine the degree to which they are affecting the in-channel fine sediment levels. Until a more thorough analysis is conducted on sediment sources in the Little Naches, their contribution and affect will be difficult to quantify.

An analysis of the monitoring results at individual reaches can sometimes help identify site-specific conditions and factors influencing localized fine sediment rates. This past year, the highest average fine sediment was again found at Little Naches Reach 3. This particular reach has bank erosion in the near vicinity, but also has jeep and dirt bike disturbance along the river above this area. In addition, the old dirt bike trail upstream crosses an unstable hillside that is delivering material to the river. Some fine sediment may also be coming from Bear Creek which enters immediately above this sampling reach. These probable sediment sources need to be evaluated and corrected. Conversely, the cleanest reach sampled this past year was Little Naches Reach 2 (9.5% reach average fines). The USFS did some bank stabilization work near the bridge. Beaver have also been quite active above this reach and their dams may be trapping and collecting fine sediment before it enters this reach.

A review of the results 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 subwatersheds. 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 two years the average percentage of fine sediment has declined. This year the average fine sediment levels in these two reaches were similar with 12.6% at Little Naches Reach 1 and 11.1% at North Fork Reach 1. The latest fine sediment results at these reaches has improved, but is still somewhat greater than found in the earliest years of monitoring in 1985 and 1986.

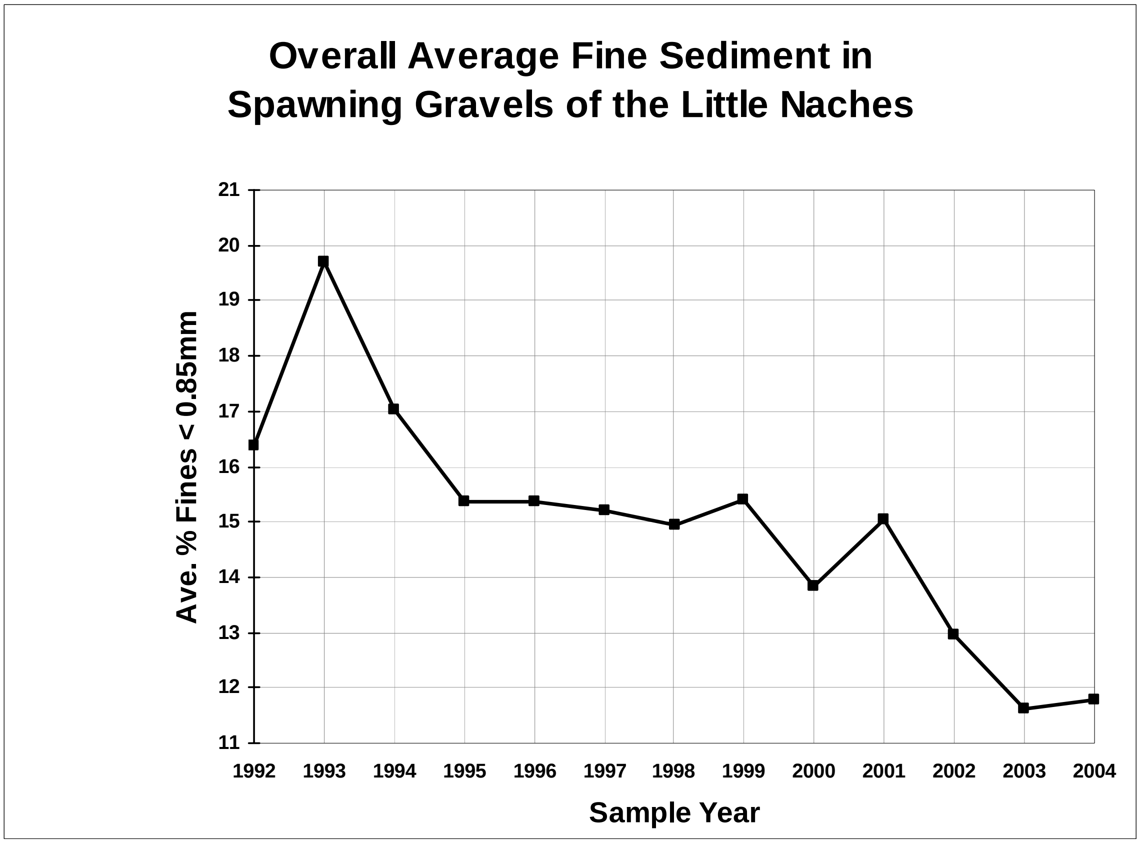


Figure 7. Overall Fine Sediment (<0.85mm) Trends in the Little Naches River Drainage, 1992-2004.

South Fork Tieton Monitoring

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 six consecutive years (see Figure 8). This year the reach average fine sediment, less than 0.85mm in size, is slightly lower than 2003 and substantially lower than the peak found in 2002 (8.9% in 1999, 12.9% in 2000, 12.9% in 2001, 17.3% in 2002, 13.3% in 2003, 12.4% in 2004). This year's results are similar to those found in 2000 and 2001. The latest conditions are encouraging, but further identification and correction of upstream sediment sources would be valuable to ensure that favorable bull trout spawning conditions are maintained.

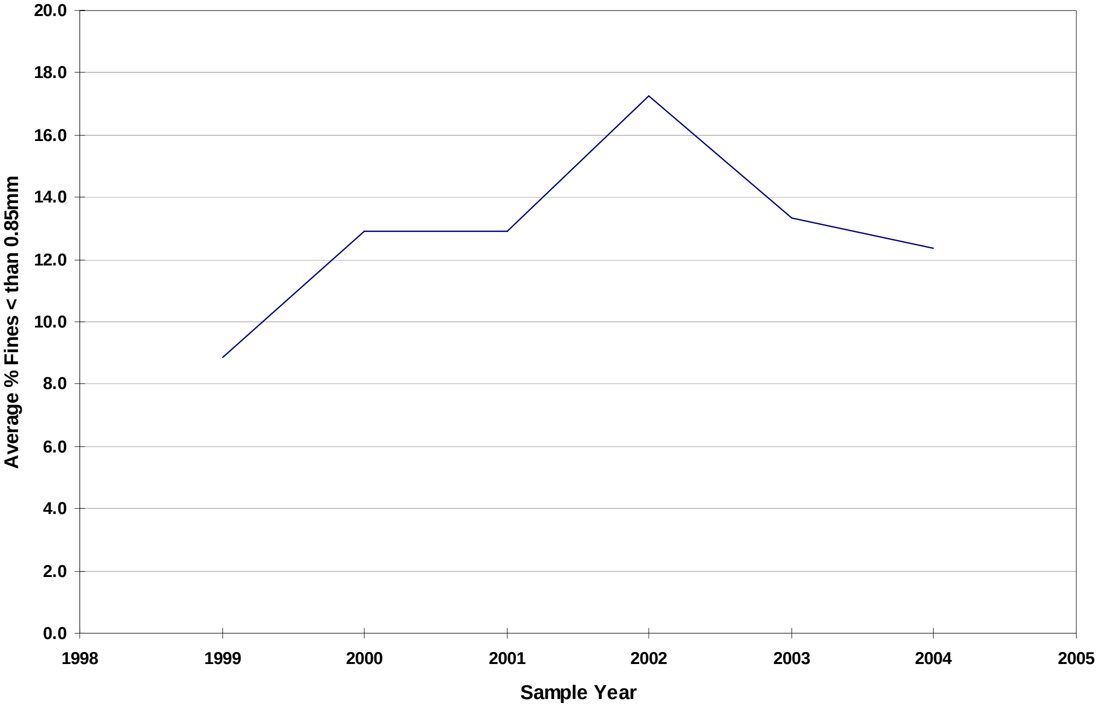


Figure 8. Fine Sediment Trends in the South Fork Tieton River (1999-2004).

Summary

The overall average fine sediment levels in the Little Naches this past year (2004) was very similar to 2003. This marks three years of improving spawning conditions as measured by overall average fine sediment levels. The recent downward movement in fine sediment should reduce impacts on egg and alevin survival. However, the latest conditions only cover a short time frame of three years. The current fine sediment conditions are also still somewhat higher than those found in the earliest years of monitoring. Further monitoring is needed to see if the latest conditions are a continuing trend or just a short term change. 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 and isolated unstable areas should be evaluated for their delivery capability and effect on spawning conditions.

Sampling in the South Fork Tieton River by the USFS showed a slight decrease in average fine sediment levels this past year compared to 2003. The results from this season are similar to fine sediment conditions observed in years 2000 and 2001. Similar to the Little Naches, fine sediment sources and their causes should be investigated, quantified and addressed.

For all of the monitoring project watersheds (Little Naches, American, Tieton, Rattlesnake), a better understanding of fine sediment delivery sources and their relative contribution to the stream system is needed. The monitoring work has been extremely valuable for assessing conditions and trends directly in the spawning habitat. However, the sources of the fine sediment, scale of contribution, and factors that cause the delivery have not been quantified to any great degree. The past watershed analyses provided some insight into sediment delivery sources, but this information is becoming dated and only provided a coarse picture. Further investigations into sediment sources and contributions could greatly enhance the understanding of spawning habitat conditions in the watershed.

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. Plum Creek provided some funding for field staff wages. Finally, technicians from the Yakama Nation Fisheries did another great job coring the samples from the Little Naches and processing all the samples this winter.

Task 1.x Predator Avoidance Training

Details on this work were presented in the 2003 annual report: (http://www.efw.bpa.gov/Publications/P00013769-1.pdf). No additional work was done pursuant to this task in fiscal year 2004.

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:

- 2004 Annual Report HI-LO smolt-to-smolt Survival (See Appendix C)

- 2004 Annual Report OCT-SNT smolt-to-adult Survival (See Appendix D)
- 2004 Annual Report, Wild and Hatchery Smolt Survival of Roza Spring Chinook Releases (See Appendix E)
- Chandler entrainment and canal survival rate estimates (See Appendix F)
- Annual Report: Smolt Survival to McNary of Year-2004 Fall Chinook (Appendix G) and Coho (Appendix H) 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 and Klickitat 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 both the Klickitat and Yakima rivers. 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 and Klickitat River in-basin Tribal harvest for salmon and steelhead are presented in Table 7.

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

Table 7. A summary of Yakama Nation tributary estimated harvest in the Yakima and Klickitat subbasins, 2004.

River	Dates	Weekly Schedule	Notes	Chinook	Jacks	Steelhead	Coho
Klickitat River	4/6-7/31	Noon Tuesday to 6 p.m. Saturday	1	571	5	341	
Klickitat River	8/3-8/21	Noon Tuesday to 6 p.m. Saturday	2	283	0	245	
Klickitat River	10/19-11/27	Noon Tuesday to 6 p.m. Saturday	3	63	0	16	3,868
Klickitat Total				917	5	602	3,868
Yakima River	4/6-6/26	Noon Tues to 6 PM Saturday		963	38	0	0
Yakima River	9/21-11/27	Noon Tues to 6 PM Saturday		0	0	0	0

1. Commercial Sale opened from: May 4 to May 9; May 11 to May 31; and June 17 to July 31.
2. Commercial Sale opened August 20 to October 31.
3. Commercial Sale opened from November 2 to December 25.

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. Frye, T. Kassler, T. Pearsons, S. R. Phelps, S. L. Schroder, J. B. Shaklee, J. Von Bargen, S. F. Young, C. M. Knudsen, and G. Hart. 2005. Yakima Fisheries Project Genetic Studies, Yakima/Klickitat Fisheries Project Monitoring and Evaluation, Annual Report 2004. Project No. 1995-064-24; BPA Report DOE/BP-00017478.

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 2004 were consistent with the techniques used in 2003, with the addition of aerial surveys and American White Pelican carcass analysis.

Hotspot Surveys—Spring

The hotspot survey design for 2004 followed the methods used in 2001 through 2003, designed by the Washington Cooperative Fish and Wildlife Research Unit. Details of these methods can be found in their annual reports.

In 2004, hotspot surveys were conducted on Mondays, Wednesdays, and Fridays at Horn Rapids Dam (Horn Rapids) and the outlet pipe at the Chandler Juvenile Fish Facility (Chandler) in Prosser. Thirty-seven surveys were conducted at Chandler between April 5th and July 12th and thirty surveys were conducted at Horn Rapids between April 6th and June 30th. The continued presence of American White Pelicans at Prosser warranted the additional surveys at that site. Surveys were generally conducted at both sites on the same day by different individuals. Observations began on the nearest 15-minute interval after sunrise and ran for eights 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. The number of survey windows within a day varied depending on the length of the day.

River Reach Surveys—Spring and Summer

Spring river surveys included all six of the river reaches surveyed in previous years. Each reach was surveyed approximately once every 2 weeks between

April 8 and June 28. The reaches included the Benton, Vangie, Zillah, Canyon, Cle Elum and Easton reaches, which account for approximately 37% of the Yakima River. During the summer river surveys included the upper three reaches, the Canyon, Cle Elum and Easton. Each reach was surveyed once a week from June 29th through August 28th.

North Fork Teanaway River Surveys—Spring and Summer

The section of the North Fork of the Teanaway, a tributary of the Yakima River, from the Jack Creek acclimation sites downstream for 3.5 km was again surveyed in 2004. The time, species, and total number of piscivorous birds were noted as the surveyors walked downstream. This area was surveyed eight times between April 22nd and July 29th 2004.

Acclimation Site Surveys—Winter/Spring

Spring chinook acclimation sites associated with the Cle Elum Supplementation and Research Facility were again monitored by hatchery personnel in 2004. All surveys were conducted approximately three times a day between January 20 and May 10. Acclimation sites surveyed included Easton, Clark Flat, and Jack Creek.

In 2004, four coho acclimation sites were monitored as well: Boone Pond and Holmes on the Yakima River, and Lost Creek and Stiles on the Naches River. All observations were made between March 1st and May 9th. Sites were generally surveyed twice a day when personnel visited these sites, once in the morning and once in the afternoon.

Progress: The predation of birds on fish continues to contribute to the loss of some out-migrating juvenile salmonids in the Yakima River Basin, constraining natural and artificial production to some level.

In 2004, piscivorous birds were counted from river banks at hotspots and from a boat along river reaches. Consumption by gulls at hotspots was based on direct observations of gull foraging success and modeled abundance while consumption by all other piscivorous birds was estimated using published dietary requirements and modeled abundance. Seasonal patterns of avian piscivore abundance were identified, diurnal patterns of gull abundance at hotspots were identified, and predation indices were calculated for hotspots and river reaches for the spring and summer.

Hotspot Surveys—Spring

Avian Piscivore Abundance

The average daily number of gulls at Chandler remained low throughout the 2004 survey season. Gull numbers peaked on April 21st at 7.5 gulls on average per day and then again on July 2 at 7.3 gulls per day. Gull numbers at Horn Rapids were consistently higher than at Chandler and peaked at 43.3 gulls per day on May 24th.

Consumption by Gulls

During the 2004 hotspot survey season 11,977 individual fish, assuming 100% salmonid smolts based on direct observation, were consumed by gulls at Chandler and 100,873 smolts at Horn Rapids for a total of 112,850 smolts. This accounted for 3.5% of all juvenile salmonids, both hatchery and wild, passing through or being released from Chandler.

American White Pelicans

Historically, American White Pelicans were known to occur in Washington State (Dawson and Bowles, 1909). They are currently listed as a State Endangered species in Washington. The only currently known breeding site in Washington is on Badger Island on the Columbia River, below the confluence of the Snake and Columbia Rivers, downstream from the mouth of the Yakima. 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). Bands that were recovered from three pelicans on the lower Yakima River in recent years were found to have come from British Columbia, eastern Montana, and the Klamath National Wildlife Refuge (Tracy Hames, personal communication). In 2004, pelicans returned in greater numbers and earlier in the year then in 2003. The average number of pelicans per day peaked on May 24 at 291 birds.

Aerial Surveys

Four aerial surveys were conducted over the Yakima River between March and September of 2004. All surveys included the mouth of the Yakima River in Richland upstream to the town of Yakima. One survey extended into the lower reaches of the Yakima Canyon and the September survey included Badger Island on the Columbia River, a 10 minute flight from the mouth of the Yakima. Aerial surveys of the Yakima River were divided into 12 geographic reaches extending from the mouth of the Yakima to Easton. These reaches were based on aerial surveys conducted on the Yakima River in the past. Surveys usually began around 8:30 am and lasted approximately three hours.

Aerial surveys were conducted mainly to look at the abundance and distribution of American White Pelicans along the Yakima River from its mouth to the town of Yakima. Other piscivorous birds besides pelicans that were observed included: Bald Eagle, Belted Kingfish, Common Merganser, Double-crested Cormorant, Great Blue Heron, Great Egret, Gulls and Osprey. Ninety-one percent of the birds observed were American White Pelicans and five percent were gulls. The majority of the pelicans observed, 88%, were in reach 5 between Mabton bridge and Union Gap, 6% in reach 4 and 2% in reaches 3 and 1. Pelicans were often observed in backwaters and ponds off the main-stem river. Aerial surveys allowed for a one hundred percentage of the lower Yakima River to be surveyed.

American White Pelican Carcasses

In 2004, a total of five pelican carcasses were recovered by Yakama Nation Fisheries personnel from the Yakima River between the end of April and the end of June. One carcass was found on May 5th at Chandler. The other four were found in or near the lower Yakima River. Of the five birds, only two had fish contents in their digestive systems. One contained a nearly intact chiselmouth, and the other contained a sucker with a mostly digested head.

River Reach Surveys

Avian Piscivore Abundance—Spring

In the spring of 2004, from April through June, after combining the two gulls species into a single group, 13 different piscivorous bird species were observed on the Yakima River. These included: American White Pelican, Bald Eagle, Black-crowned Night Heron, Belted Kingfisher, Caspian Tern, Common Merganser, Double-crested Cormorant, Forster's Tern, Great Egret, Great Blue Heron, Gull species, Hooded Merganser, and Osprey. These are the same 13 species observed in previous years.

The Canyon drift exhibited the lowest concentration of piscivorous birds with only 1.39 birds per kilometer (km), while the Zillah drift had the highest concentration of birds, with 7.89 birds per km on average. The day that the most birds per kilometer were observed was on the Zillah reach, 17.2 birds per km, on May 25th. When gulls are excluded from these counts, the only reaches that are largely affected are the Benton and Vangie reaches, the two lowest reaches on the river. Osprey, Great Blue Heron, and Belted Kingfisher were the only species found on all six reaches in the spring, and Common Mergansers were again seen on all reaches except the Vangie reach. Common Mergansers were most abundant in the upper most reaches of the river on the

Easton and Cle Elum reaches as has been the case in all previous years surveyed.

Common Mergansers are of particular importance because of their known utilization of salmon smolts as forage (White 1957; Wood 1985) and their relatively high abundance within the upper reaches of the Yakima River. In 2004, Mergansers were again encountered most frequently on the Easton and Cle Elum reaches, 2.55 birds per km and 1.81 birds per km respectively. They represented 90% of all piscivorous birds counted within the Easton reach, 86% within the Cle Elum reach during spring and 50% in the Canyon. In the lower three reaches, Common Mergansers accounted for only 17% of all avian piscivores observed on the Zillah reach, 2% on the Benton reach, and were not observed on the Vangie reach at all.

The distribution of bird species over all six reaches during the spring was highly variable. The lower sections of the river had a greater diversity of species with ten species occurring in the Vangie reach, nine in Benton, and eight in Zillah. Six species were found in Easton and Cle Elum, and five species were seen in the Canyon. The Vangie reach had the greatest diversity of birds observed on any reach, with ten of the 13 species, occurring at some point during the spring survey season. American White Pelicans and gulls were most prevalent in the lower three reaches of the river and Common Mergansers were most prevalent in the upper three reaches of the river.

Avian Piscivore Consumption—Spring

For the purposes of these surveys, the Yakima River was divided into three main strata based on geographic differences with one or more of the river reaches used to calculate the kilograms of fish consumed by birds in that strata. Stratum one is made up of the upper most reaches of the Yakima, including the Easton and Cle Elum reaches, Stratum two consists of the Yakima Canyon, and Stratum three is made up of the area downstream of the Yakima Canyon to its confluence with the Columbia, represented by the Zillah, Benton, and Vangie reaches. Mean biomass of all fish species consumed in Stratum I in the spring of 2004 was 86.9 kg/km, 38.6 kg/km in Stratum 2, and 411.2 kg/km in Stratum 3. In the spring, Common Mergansers accounted for 67% of the consumption in Stratum 1, 69% of Stratum 2, and 6% of Stratum 3. Due to their high daily dietary requirements, 1.34 kg per day, American White Pelicans accounted for 78% of the total consumption in Stratum 3 in the spring, up from 68% of the consumption in 2003

Avian Piscivore Consumption—Summer

The mean biomass of all fish species consumed by avian piscivores in the summer was 57.4kg/km in Stratum one, and 24.4 kg/km in Stratum two. Common mergansers accounted for 90% of the total consumption in the summer in Stratum 1, and 69% in Stratum 2.

North Fork Teanaway River Surveys—Spring and Summer

Bird species seen along the North Fork of the Teanaway during surveys in 2004 included 13 Belted Kingfisher, 26 Common Merganser, and one Great Blue Heron. A minimal amount of fish was consumed on this section of the Teanaway, 2.7 kg of fish in the spring and 5.4 kg in the summer. The difference in consumption between the two seasons can be accounted for by the presence of one large brood of Common Mergansers, 21 juveniles and one female, seen during the summer. Only 40 individual piscivorous birds total were seen during these surveys, confirming that the Jack Creek Acclimation Site has not become a major attractant for fish eating birds either during the release of smolts or during the breeding season.

Acclimation Site Surveys—Winter/Spring

Again in 2004 only a minimal number of birds were seen at the spring Chinook Acclimation Sites. A total of 92 Belted Kingfisher were seen at Clark Flat and Jack Creek, accounting for 65% of the birds seen at these two sites. Other birds observed were Bald Eagles, Great Blue Heron, Common Mergansers, Golden Eagles (possibly juvenile Bald Eagles), and three American White Pelicans at Clark Flat, the furthest upstream sighting of this species. The spring Chinook acclimation sites have not become a major attractant for piscivorous birds.

At the coho acclimation sites, the majority of the birds observed were Common Mergansers, accounting for 92% of the observations, with the remainder of the birds being Belted Kingfisher, Great Blue Heron, Bald Eagle, Golden Eagle Hooded Merganser, and one Osprey. One coho acclimation site, Boone Pond in the upper Yakima, attracted an exceptionally large number of Common Mergansers, 1406 individuals.

Summary

In 2004, Common Mergansers continued to be the major avian predator in the upper Yakima River. In the lower Yakima River the number of American White Pelicans continued to increase and this species was the major avian consumer along the lower three river reaches. There was also another dramatic increase in the number of pelicans seen at Chandler in 2004, where they have displaced gulls as the main predator at that site, as in 2003. Gulls remained the major avian predator at Horn Rapids Dam, though pelicans were observed at this site in 2004 as well. The spring Chinook acclimation sites have not been a major attractant for piscivorous birds, but one coho acclimation site, Boone Pond on the upper Yakima, attracted a large number of Common Mergansers. Aerial surveys show the prevalence of pelicans in the lower Yakima River, often in backwater areas just off the mainstem Yakima River.

Personnel Acknowledgements: Ann Stephenson is the project biologist for this task. Technicians Sara Sohappy and Ted Martin assisted with the field activities.

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 1-3), Parker Dam to Toppenish (Sections 4-6), and Toppenish to Granger (Sections 7-9). In the past, valid estimates have not been successful for Granger and Sunnyside, thus population estimates are currently on hold until sufficient PIT tags are deployed, allowing for valid estimates to be obtained. In addition to work associated with population estimates, stomach samples are collected from every fifth NPM that is 200+ cm in fork length, and these are collected within the population estimate sites. Northern pikeminnow stomachs with fish present are further analyzed to determine the number and type(s) of species consumed. This analysis is performed using diagnostic bones which allows determination of species (though for salmonids this is more difficult) and approximate body length. All new NPM over 200+ cm are tagged with a PIT tag and subsequently all fish are scanned for the presence of a PIT tag. If a PIT tag is found the tag code and fork length are recorded along with the fish's location (GPS). In addition to GPS tracking of recaptured NPM, radio tags have also been attached to 20 fish in order to determine site fidelity of PIT tagged NPM. This information will be used to determine if PIT tagged fish are remaining in the sample areas that will be used to estimate NPM populations.

Progress:
Currently, the predation crew has marked out the major pool complexes within the river reach from Yakima to Granger (Table 8). These sites are the places where PIT tags are placed in fish and movement patterns are being established for NPM. In addition to PIT tags, radio tagging and tracking are also being conducted for further study of NPM movement. In the meantime, catch per unit effort (CPUE) is recorded for study locations to allow some idea of the current population trends in the middle Yakima River sections. Based on sampling done April 19-20, 2004 most NPM are presently found in the Toppenish 3 and 4 reaches (Figure 9).

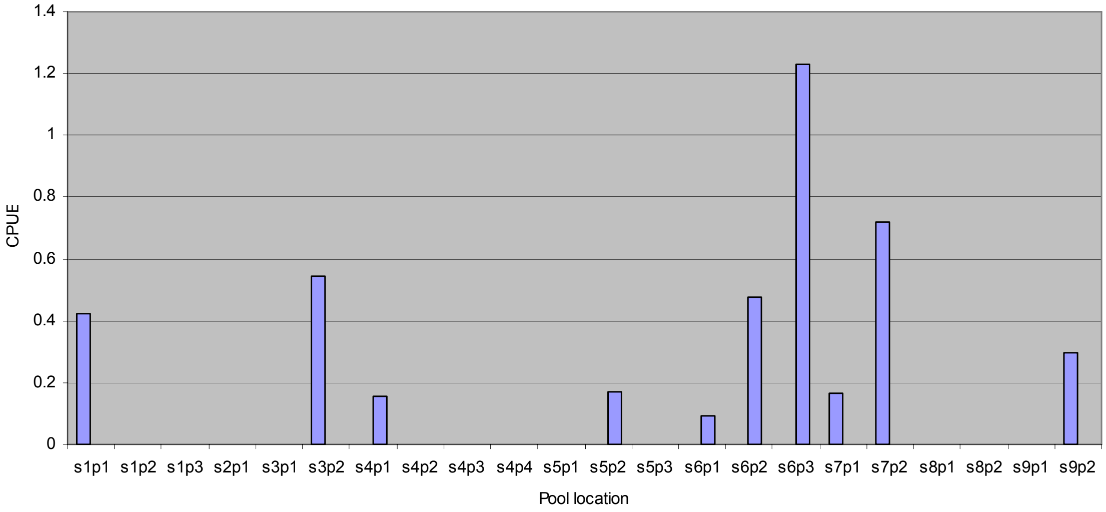


Figure 9. Catch per unit effort (CPUE) of Northern pikeminnow recaptured in the Yakima River on April 19-20, 2004 by location code.

Table 8. Current location of Northern pikeminnow sample sites.

Site[a]	Start & End of Site	Number of Pools	Way Point #	North GPS #	West GPS #	Approx. Length of Pool
Gap - Gap 1	Start 1			N46-37.862	W120-30.884	
Gap - Gap 1		1	S1P1	N46-37.844	W120-30.703	400 Meters
Gap - Gap 1		2	S1P2	N46-37.822	W120-30.648	200 Meters
Gap - Gap 1		3	S1P3	N46-37.576	W120-30.126	100 Meters
Gap - Gap 1	End 1			N46-37.498	W120-29.729	
Gap - Gap 2	Start 2			N46-36.185	W120-28.239	
Gap - Gap 2		4	S2P1	N46-36.168	W120-28.227	300 meters
Gap - Gap 2	End 2			N46-35.292	W120-28.003	
Gap - Gap 3	Start 3			N46-33.543	W120-28.012	
Gap - Gap 3		5	S3P1	N46-33.541	W120-27.973	150 Meters
Gap - Gap 3		6	S3P2	N46-33.142	W120-28.152	300 Meters
Gap - Gap 3	End 3			N46-32.678	W120-28.177	

Site[a]	Start & End of Site	Number of Pools	Way Point #	North GPS #	West GPS #	Approx. Length of Pool
Toppenish 1	Start 4			N46-29.425	W120-25.389	
Toppenish 1		7	S4P1	N46-29.354	W120-25.768	100 Meters
Toppenish 1		8	S4P2	N46-29.104	W120-25.871	250 Meters
Toppenish 1		9	S4P3	N46-28.876	W120-25.306	100 Meters
Toppenish 1		10	S4P4	N46-28.780	W120-25.172	200 Meters
Toppenish 1	End 4			N46-28.942	W120-24.754	
Toppenish 2	Start 5			N46-27.551	W120-23.155	
Toppenish 2		11	S5P1	N46-27.548	W120-23.159	200 Meters
Toppenish 2		12	S5P2	N46-27.343	W120-22.588	400 Meters
Toppenish 2		13	S5P3	N46-27.263	W120-21.973	200 Meters
Toppenish 2	End 5			N46-27.283	W120-21.998	
Toppenish 3	Start 6			N46-25.611	W120-21.167	
Toppenish 3		14	S6P1	N46-25.514	W120-21.117	500 Meters
Toppenish 3		15	S6P2	N46-25.267	W120-21.836	200 Meters
Toppenish 3		16	S6P3	N46-25.196	W120-20.451	100 Meters
Toppenish 3	End 6			N46-25.205	W120-20.052	
Toppenish 4	Start 7			N46-24.167	W120-18.001	
Toppenish 4		17	S7P1	N46-24.354	W120-17.752	300 Meters
Toppenish 4		18	S7P2	N46-24.178	W120-17.208	250 Meters
Toppenish 4	End 7			N46-23.926	W120-16.786	
Toppenish 5	Start 8			N46-23.019	W120-14.631	
Toppenish 5		19	S8P1	N46-23.011	W120-14.203	100 Meters
Toppenish 5		20	S8P2	N46-22.893	W120-13.718	400 Meters
Toppenish 5	End 8			N46-22.616	W120-13.507	
Granger 1	Start 9			N46-20.934	W120-12.882	
Granger 1		21	S9P1	N46-20.851	W120-12.780	400 Meters
Granger 1		22	S9P2	N46-20.820	W120-12.445	1/2 Mile both sides
Granger 1	End 9			N46-20.242	W120-11.889	
2 miles below Granger 1 end point				N46-19.461	W120-10.090	
Toppenish Cr.				N46-	W120-	

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

A summary of NPM stomach contents collected at Sections 1-9 is presented in Table 9. A total of 93 stomachs were collected during the spring 2004 field season (14 at Sec 1-3, 50 at Sec 4-6, and 29 at Sec 7-9). The actual number of NPM caught at Sections 1-3, Sections 4-6, and Sections 7-9 sites was 91, 281, and 163, respectively. These data are still preliminary. All stomachs with fish present were further analyzed to determine the species using diagnostic bones to identify them.

Table 9. Summary of species found in Northern pikeminnow stomachs sampled in the Yakima Basin in 2004.

Species	**Count found in NPM stomachs**
Chiselmouth	4
Sculpin	10
Dace	5
Mountain White Fish	1
Northern Pikeminnow	8
Pumpkin Seed	0
Red Side Shiner	8
Salmon (unknown species)	10
Steelhead	5
Sucker	4
Unknown Species	0
Total All Species	**55**

Task 4.c Indirect Predation (and environmental analysis)

Rationale: The release of hatchery salmonids may enhance or decrease the survival of randomly commingled wild salmonid smolts by altering the functional or numerical response of predators. For example, predators may increase consumption of wild fish by switching prey preferences from invertebrates to fish, or may be attracted to areas where hatchery fish are released. Conversely, large numbers of hatchery fish may confuse or satiate predators, resulting in enhanced survival of wild fish.

Methods:

Progress: No work was budgeted for this task in fiscal year 2003.

See Appendix F in 2002 Annual Report (http://www.efw.bpa.gov/Publications/P00005881-2.pdf) for the latest information on this study.

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. 2005. Spring Chinook Salmon Interactions Indices and Residual/Precocial Monitoring in the Upper Yakima Basin; Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report. Annual Report 2004. DOE/BP-00017478.

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

Temple, G. M., T. N. Pearsons, C. L. Johnson, T. D. Webster, and N. H. Pitts. 2005. Results of non-target taxa monitoring after the sixth release of hatchery salmon smolts in the upper Yakima Basin. Pages 6-34 in Pearsons, T. N., G. M. Temple, A. L. Fritts, C. L. Johnson, T. D. Webster, and N. H. Pitts. 2005. Yakima River Species Interactions Studies; Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report. Annual Report 2004 submitted to Bonneville Power Administration, Portland, Oregon. DOE/BP-00017478.

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. 2005. Pathogen Screening of Naturally Produced Yakima River Spring Chinook Smolts; Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report. Annual Report 2004. DOE/BP-00017478.

Literature Cited

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

Hubble J. and J. Woodward, (editors). 2003. Yakima Coho Master Plan. Prepared by Yakama Nation in cooperation with Washington State Department of Fish and Wildlife. September 2003. Yakima Klickitat Fisheries Project, Toppenish, WA. See www.ykfp.org Technical Reports and Publications to obtain an electronic copy of this report.

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

APPENDICES A through J

	Task	
A.	1.a.	Determinants of Anadromy and Residency in Rainbow / Steelhead (Mobrand Biometrics Inc. subcontract)
B.		Yakima River / CESRF Spring Chinook Salmon – Yakama Nation Data Summary
C.	1.d.	IntStats, Inc. Annual Report: Survival of Upper Yakima Spring Chinook from 2004 Release to McNary Dam Smolt Passage for Releases Subjected to Low and High Early-Rearing Nutritional Regimes
D.	1.d.	IntStats, Inc. Annual Report: Brood Years 1997-2000 OCT-SNT Smolt-to-Adult Survival from Release to Roza Dam Recovery
E.	1.e.	IntStats, Inc. Annual Report: Smolt Survival to McNary Dam of Year-2004 Spring Chinook Releases at Roza Dam
F.	1.f.	IntStats, Inc. Annual Report: Chandler Certification
G.	1.g.	IntStats, Inc. Annual Report: Smolt-to-Smolt Survival of Main-Stem-Yakima Fall Chinook reared under Accelerated- and Conventional-Rearing Conditions (and Smolt-to-Smolt Survival of Marion Drain Fall Chinook)
H.	1.h.	IntStats, Inc. Annual Report: Smolt Survival to McNary of Year-2004 Coho Releases into the Yakima Basin
I.		M&E Financial Report
J.		M&E Equipment Inventory List

Appendix A

Determinants of Anadromy and Residency in Rainbow / Steelhead (*Oncorhynchus Mykiss*), and Implications for Enhancing Steelhead Production in the Yakima River Subbasin

Completion Report

June 2005

Prepared for:
The Yakama Nation

Submitted by:
Mobrand – Jones & Stokes

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INTRODUCTION

The purpose of this paper is to describe the determinants of anadromy and residency in rainbow trout/steelhead (O. mykiss), and to describe and document an EDT-based procedure that estimates the partitioning of production between anadromous and resident life history types in a sympatric and interbreeding population. It is hoped that the EDT tool that will be described will prove useful in at least the initial planning of steelhead restoration projects in the Yakima River, and that the summary of the determinants of O. mykiss life histories will be useful in monitoring such restoration projects and in developing Yakima-specific research.

THEORETICAL RELATIONSHIP BETWEEN RESIDENCY AND ANADROMY

Mart Gross (1987) described the conditions that must obtain for an anadromous life history to evolve. As will become apparent, this evolutionary analysis can, with a number of significant caveats, also be used to estimate the resolution of a competition between anadromous and resident life history types in an interbreeding population. The essential points of Gross's analysis are presented here both because of the light they shed on fundamental ecological relationships, and because the EDT-based approach to partitioning production between resident and anadromous O. mykiss is based similar considerations. Gross begins with the obvious truth that anadromy cannot be selected unless it confers greater fitness than residency. He then defines fitness (W) for a semelparous species maturing at age x as the mean number of progeny per female, which can be expressed as:

$$W = \Sigma \ (l_x b_x) \qquad \text{Equation 1}$$

where l_x is the survivorship to age x, and b_x is the mean number of progeny produced per age-x female.

Gross then defines the freshwater environment as H_1, the marine environment as H_2, the smolt outmigration as $M_{1,}$ and the spawning run as M_2. He makes the simplifying but reasonable assumption that the number of progeny per female is proportional to mean fecundity which, in turn, is proportional to growth rate. The freshwater growth rate is defined as g_1, the marine growth rate as $g_{2,}$ and the migratory growth rate as g_m. In order to use growth *rate* as an index of fecundity, an appropriate time period must be specified. Gross uses a temporal scale in which 1 = the entire life span, and t_1 is the fraction anadromous fish spend in freshwater, t_2 is the fraction spent in the ocean, and t_m is total the fraction spent in the smolt and adult migrations. Thus fecundity, the index of relative progeny produced, is the product of g_i and t_i.

The core of the analysis consists of a description of the fitness costs and benefits of a life history that either remains continuously in freshwater or moves between environments in an anadromous fashion.

Under these conditions, anadromy (A) will be favored over residency (R) if:

$$W(A) > W(R), \text{ or}$$

$$W(H_1 + H_2 + M_T)_A > W(H_1)_R \qquad \text{Equation 2}$$

where $W(M_T)$ is the total fitness cost of migration ($M_T = M_1 + M_2$).
The standard of comparison is the fitness of the resident life history. Thus, it is stipulated that $W(H_1)_R = 1$, and therefore that $g_1 = 1$, and $s_1 = 1$. For an anadromous individual, then, $W(H_1)_A = t_1 W(H_1)_R = t_1$. The fitness benefit of marine maturation, $W(H_2)$, would then be $t_2(g_2{*}\ s_2)$, and the fitness cost of migration, $W(M_T)$, would be $t_m(g_m{*}s_m)$. It then follows from expression 2 that anadromy will be selected for only if:

$$t_2(g_2{*}s_2) + t_m(g_m{*}s_m) + t_1 > 1 \qquad \text{Equation 3}$$

Expression 3 can be re-arranged as:

$$(s_m s_2) * (s_2 t_2 g_2/s_m s_2 + s_m t_m g_m/s_m s_2 + t_1/s_m s_2) > 1 \qquad \text{Equation 4}$$

Given that s_1 is 1, the product of s_m and s_2 would be roughly equal to the *productivity* of an anadromous population. Then, the expression $s_2 t_2 g_2/s_m s_2$ would be the fecundity ($t_2 g_2$) contributed by marine rearing weighted by the relative survival ($s_2/s_2 s_m$) in the ocean. Similarly, $s_m t_m g_m/s_m s_2$ would be the *fecundity cost* of migration weighted by the relative survival during migration. Thus, the expression ($s_2 t_2 g_2/s_m s_2 + s_m t_m g_m/s_m s_2 + t_1/s_m s_2$) is roughly equivalent to the survival-weighted mean fecundity of an anadromous life history relative to a resident life history. If one substitutes P_A, the productivity of an anadromous life history for ($s_m s_2$), and $Fec_{A \text{ relative to } R}$ for the survival-weighted mean fecundity of an anadromous life history relative to a resident life history, one gets:

$$P_A * Fec_{A \text{ relative to } R} > 1 \qquad \text{Equation 5}$$

Expression 5, as will be seen, is a close approximation to the method by which EDT output is used to estimate the partitioning of production between resident and anadromous life history types in an interbreeding population of rainbow trout and steelhead.

Several general points should be made regarding expression 3. It is a commonplace that marine growth rates are much greater than freshwater growth rates. What is not, however, appreciated so frequently is the fact that either the survival cost of migration *or* the growth rate cost of migration can easily swamp the growth benefits of marine maturation. In systems like the Yakima, the relative survival of outmigrating smolts (s_m) is affected by high water temperatures, heavy predation inside and outside the Yakima, and losses associated with up to seven diversions inside the subbasin (Easton, Town Ditch, Roza, Wapato, Sunnyside, Prosser and Horn Rapids) in addition to the losses incurred in the four mainstem Columbia hydroelectric dams. The length of the “gauntlet” Yakima steelhead must run before even reaching the Columbia must therefore have a strong bearing on the relative fitness of an anadromous O. mykiss life history.

Similarly, the growth rate cost of migration can depress the relative production of steelhead. In a controlled system like the Yakima, late spring freshets are much less common now than they were historically. Because outmigration speed is partly a function of discharge and water velocity (Zabel et al. 1998), it is reasonable to expect the bioenergetic cost of outmigration to increase as flows decrease. To the degree that it can be expected that steelhead smolts from the upper Yakima and Naches drainages must exhaust bioenergetic reserves to reach the ocean, it can be expected that the relative growth/fecundity advantage of steelhead will be diminished, the survival cost will be increased, and the life history equilibrium will be shifted in favor of resident fish.

DETERMINANTS OF ANADROMY AND RESIDENCY IN RAINBOW / STEELHEAD

There are at least four factors that affect the proportion of an O. mykiss population that completes its life cycle entirely in fresh water as rainbow trout, or migrates to the sea and returns to the natal stream as steelhead. These factors are:

1. The degree of sympatry and interbreeding between anadromous and resident life history types.
2. Environmental conditions, especially as they affect size and/or growth rates during critical periods.
3. The relative productivity of the anadromous and resident life history types, in terms of the probability of survival to adulthood, fecundity and potential egg deposition.
4. Genetic factors including population-specific tendencies of one life history form to produce the other, threshold growth rates for subsequent smolting and sexual maturation, and genetic linkage between growth rate, smolting and maturation.

At present, no method integrates all of these factors into a quantitative tool capable of predicting the average abundance and productivity of interbreeding rainbow trout and steelhead populations. Cramer (2003) has developed a decision tree based on environmental conditions that has some utility in identifying streams that are likely to produce primarily one form or the other. Lestelle (2000) developed a process utilizing EDT output that attempts to estimate productivity and equilibrium abundance of trout and steelhead primarily on the basis of relative productivity and fecundity. Neither Cramer nor Lestelle, however, fully utilize the emerging body of information regarding the genetics of anadromy and residency in O mykiss, although the EDT-based approach does include a factor intended to reflect a genetic “bias” in favor of anadromy.

Degree of Interbreeding Between Anadromous and Resident Life History Types

The important question in designing a steelhead (or rainbow trout) restoration project is not so much whether trout and steelhead are sympatric as whether the two life history forms interbreed to an appreciable degree. As Kostow (2003) documented, the presence of one form almost always implies the existence of the other. Kostow found that sympatry between rainbow trout and steelhead was very nearly universal within the Columbia Basin in the absence of complete barriers to anadromous migration. The few exceptions to this rule usually occurred in drainages supporting abundant cutthroat trout populations (coastal or Westslope), which are thought to displace resident rainbow trout.

Knowledge of the degree of interbreeding is essential because sympatric but reproductively isolated populations must be modeled and analyzed differently from interbreeding populations. In the former case, rainbow and steelhead would be conceived and modeled essentially as different species. Depending on spawning distributions and juvenile migration patterns, some intra-specific competition would have to be reflected in any quantitative analysis, but the general analytical situation would not be qualitatively different from modeling steelhead and spring Chinook in the same subbasin. If, however, interbreeding is common, new genetic considerations arise, as well as issues of relative (trout/steelhead) survival to maturity, relative fecundity, and how these combined factors affect a competition to produce offspring.

Unambiguous evidence of substantial interbreeding between rainbow and steelhead did not exist until recently, and even now can be obtained only with some difficulty (see below). Perhaps this difficulty in obtaining clear evidence of interbreeding is responsible for the common belief that reproductive isolation is the norm. Robert Behnke (2002), in responding to a paper (Pascual et al. 2001) describing the “evolution” of a population of steelhead from a long-established population of resident rainbow trout in the Rio Santa Cruz in Argentina, said the following:

> “Pascual et al. (2001) concluded that resident and anadromous O. mykiss of the Rio Santa Cruz are not genetically differentiated and, thus, not reproductively isolated. But this question is not yet resolved. Where steelhead and resident rainbow trout populations coexist in sympatry, some hybridization will probably occur. Steelhead populations typically contain a small proportion of residual males that mature sexually before smolting, and they might then mate with resident females. Resident males can act as ‘sneakers’ and fertilize some eggs during steelhead spawning. A slight amount of genetic interchange between resident and anadromous populations will make it difficult, perhaps impossible, to establish unambiguous genetic differentiation between the two. The basic question in need of resolution is: does like give rise to like? Do steelhead produce steelhead and do resident rainbows produce resident rainbows, at least in the overwhelming majority of cases?”

In subsequent remarks, Behnke made it clear that he believed rainbow trout and steelhead interbreed infrequently and that, in the vast majority of cases, like does indeed give rise to like.

Kostow (2003) was of a similar opinion. She contends that, despite some evidence for interbreeding, it is likely that sympatric trout and steelhead usually form demographically independent populations within ESUs, similar to those formed by sympatric summer and winter steelhead. Much of the evidence for interbreeding to which both Kostow and Behnke were responding consists of similarity at molecular genetic markers between trout and steelhead. In all molecular surveys of O mykiss with adequately wide geographic coverage, the genetic differences between fish from different drainages were larger than the differences between the trout and steelhead in the same drainage. Such results demonstrate a “genetic affinity” between sympatric trout and steelhead, and thus either occasional interbreeding or evolutionary kinship. They do not, however, imply that interbreeding is common, or that “like does not give rise to like” except under the most unusual of conditions.

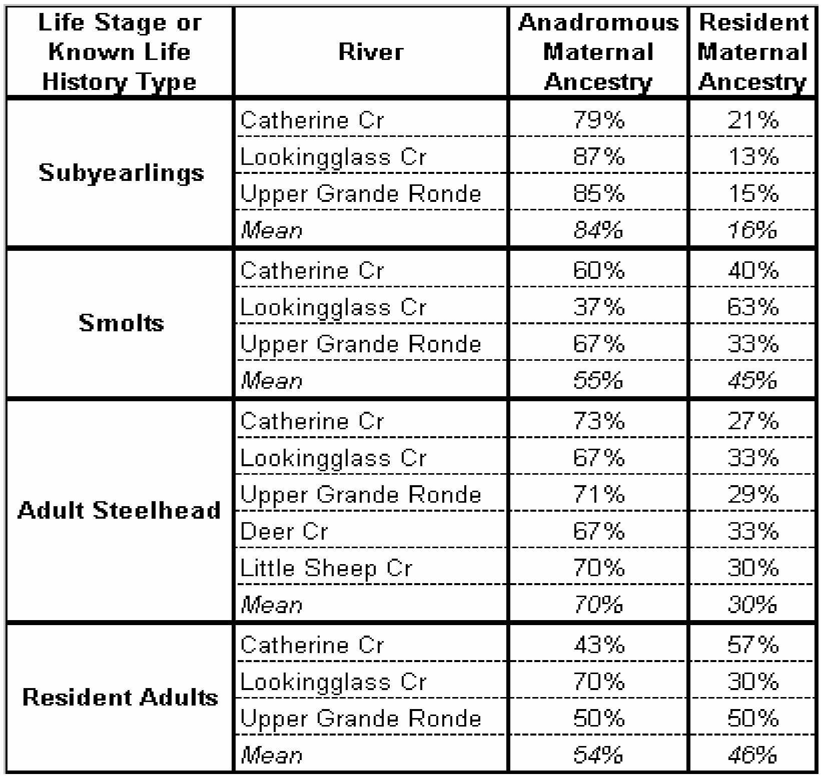
Studies of Sr/Ca ratios in otolith primordia of O mykiss are beginning to erode this conservative opinion. Because Sr concentrations are generally higher in the ocean than in freshwater, the eggs of anadromous females contain higher concentrations of Sr than the eggs of freshwater females. Consequently, the portion of the otolith that is formed initially (the “otolith primordium”) in the progeny of anadromous females also contains higher high Sr/Ca ratios than otolith primordia in the progeny of freshwater females.

In a study of Sr/Ca ratios in otolith primordia of known trout and steelhead in the Deschutes River, Zimmerman and Reeves (2002) found complete reproductive isolation, although the number of fish examined was relatively small (20 adult steelhead and 38 adult trout), and a handful of resident males were observed spawning with anadromous females in earlier studies (Zimmerman and Reeves 1996). In subsequent work, Zimmerman and Reeves (2002) speculate that reproductive isolation is nearly complete in the Deschutes because steelhead spawn considerably later, in deeper and faster water, and in smaller and/or intermittent tributaries. These authors also examined otolith primordia in O. mykiss from the Babine River in British Columbia. Here the Sr/Ca ratios indicated two of nine resident trout had steelhead mothers and one of 24 adult steelhead had resident mothers. It should be noted that all otolith studies suffer from the fact that paternal origin cannot be determined, and Zimmerman and Reeves point out that an unknown percentage of the trout they examined might have had a precocial (or residualized) steelhead for a father.

Two current studies, which indicate relatively higher levels of interbreeding, bear specifically on the last point. Genetic pedigree studies of O. mykiss populations using DNA microsatellite markers are currently underway in the Hood River (Lower Columbia ESU) and in Little Sheep Creek (Imnaha River tributary in the Snake ESU). Both of these studies entail passing DNA-typed adult steelhead above weirs and conducting a pedigree analysis on the resulting progeny. Preliminary results in the Hood River study indicate that a fairly large number of adult steelhead had a non-anadromous parent, and particularly a non-anadromous male parent. In the Hood River, researchers were able to assign 84% of the adult steelhead returning to the trap (Powerdale Dam) to a steelhead parent that was known to have spawned in the basin. About 40% of the fish, however, could only be assigned to a female parent, while about 10% could only be assigned to a male parent (Blouin 2003, Ardren 2003). The other parent in these cases was apparently a non-anadromous fish. In the Little Sheep Creek study, 100% of the adult steelhead entering the creek were DNA-typed, as were several hundred resident trout residing in the upper drainage. When *O. mykiss* parr above the weir were compared with the adults passed over the weir, most could not be matched to an anadromous parent-pair. By 2003, 1,211 juveniles had been pedigreed. Of this number, 361 could be assigned to anadromous parents and six to resident male by anadromous female crosses. These data suggest that the resident *O. mykiss* population in Little Sheep Creek is much larger than previously thought, that their juvenile offspring intermingle with the progeny of anadromous fish, and that resident and anadromous fish are interbreeding (P. Moran, NMFS, personal communication, 2005).

Perhaps the most definitive study of interbreeding resident and anadromous O. mykiss yet conducted occurred in the Grande Ronde River (Ruzycki 2003 and presented in a February, 2005 workshop by Rich Carmichael, ODFW). Part of the Grande Ronde work entailed the establishment of anadromous or resident maternal origin for subyearlings, known smolts, steelhead adults and resident adults in three or four Grande Ronde tributaries and in Little Sheep Creek. The results of this analysis are summarized in Table 1.

Table 1. Anadromous/resident maternal ancestry in Grande Ronde and Little Sheep Creek *O. mykiss* as revealed by Sr/Ca ratios in otolith primordia (R. Carmichael, ODFW, personal communication, February, 2005)



Life Stage or Known Life History Type	River	Anadromous Maternal Ancestry	Resident Maternal Ancestry
Subyearlings	Catherine Cr	79%	21%
	Lookingglass Cr	87%	13%
	Upper Grande Ronde	85%	15%
	Mean	*84%*	*16%*
Smolts	Catherine Cr	60%	40%
	Lookingglass Cr	37%	63%
	Upper Grande Ronde	67%	33%
	Mean	*55%*	*45%*
Adult Steelhead	Catherine Cr	73%	27%
	Lookingglass Cr	67%	33%
	Upper Grande Ronde	71%	29%
	Deer Cr	67%	33%
	Little Sheep Cr	70%	30%
	Mean	*70%*	*30%*
Resident Adults	Catherine Cr	43%	57%
	Lookingglass Cr	70%	30%
	Upper Grande Ronde	50%	50%
	Mean	*54%*	*46%*

Although Table 1 clearly shows that the anadromous maternity is dominant for Grande Ronde O mykiss, it also shows a much higher level of interbreeding between life history types than has been seen in any other Columbia River subbasin yet investigated. It is particularly striking that the maternal pedigree of both smolts and resident adults was nearly identical and nearly equally divided between resident adults and steelhead.

This study may have particular relevance to the Yakima Subbasin because eight Snake and Columbia hydroloelectric dams lie between the ocean and the mouth of the Grande Ronde River. Although only four Columbia River hydroelectric dams lie below the mouth of the Yakima, five diversion dams must be passed by upper Yakima smolts before they reach the Columbia. Smolt-to-adult survival clearly impacts the relative abundance of steelhead in an interbreeding population, and dams clearly affect smolt-to-adult survival (SAR). It is not implausible that the cumulative effect of nine dam bypasses and a shorter migration path have approximately the same impact on SAR for Yakima steelhead as eight dams and a longer migratory path has on Grande Ronde steelhead. Indeed, the EDT-based estimates of the survival of steelhead smolts from Roza Dam to returning adults at Roza Dam is 2.1%, while mean smolt-to-adult survival for several populations of Grande Ronde River steelhead is 1.9%.

Although otolith studies have never been conducted on Yakima O mykiss, Pearsons et al. (1998) demonstrated that there was enough overlap in the spawning timing and spatial distributions of trout and steelhead in the upper Yakima watershed (the drainage above

Roza Dam) to provide opportunities for interbreeding. The steelhead distributions were generally nested within the trout distributions. Pearsons et al. also noted that sympatric trout and steelhead in Teanaway River, a tributary of the upper Yakima watershed, were genetically indistinguishable based on the allozyme loci they analyzed. They were able, however, to identify four genetically distinct Yakima steelhead populations using their markers (Upper Yakima, Naches River, Satus Creek and Toppenish Creek). They also used admixture analysis to argue that there was evidence of crosses between trout and steelhead, perhaps partly facilitated by hatchery programs for both species. However, other explanations are available that may explain the apparent hatchery influence that they noted and the markers they attributed to hatchery sources may be natural variation in the Yakima (Utter 2001).

In light of Pearsons et al., it is reasonable to assume that interbreeding is quite common in the upper Yakima, although the relative scarcity of steelhead there precludes the degree of common maternity between forms seen in the Grande Ronde. Much less is known about the Naches, Toppenish Creek and Satus Creek populations. Both steelhead and rainbow trout are moderately abundant in the Naches drainage, and there is no evidence that spawning timing and locations for trout and steelhead do not overlap. Steelhead are quite abundant in Satus and Toppenish Creeks and, based on the scarcity of O mykiss three or more years old, resident rainbow are apparently very scarce. Again, however, there is no evidence that the few trout in Satus and Toppenish Creek do not share spawning locations and times with steelhead. In light of these observations as well as those in Hood River, Sheep Creek and the Grande Ronde River, the most reasonable assumption for the entire Yakima Subbasin is that interbreeding occurs fairly freely, with the frequency of rainbow/steelhead matings occurring roughly in proportion to the relative equilibrium abundances adult trout and steelhead.

Critical Windows and Environmental Conditions

A substantial number of studies have shown that growth rates above some threshold occurring during a relatively brief period early in life cause juvenile salmonids to embark on one of two developmental paths: smoltification or sexual maturation. In Atlantic salmon (Salmo salar), the first such critical window occurs in mid-summer (~July) of the first year. If, as Metcalfe (1998) states, July growth rates are high enough that attainment of minimal size for smolting is likely by late spring of the following year, individual fish begin the process of smoltification. The second critical period for Atlantic salmon occurs in fall (~November), and determines whether or not the fish begins the process of sexual maturation. Here again, if November growth rate is high enough that minimum adult size can be attained by the following fall, the maturation process begins. Target size for maturation is clearly gender-specific, because males are capable of becoming precocially mature at much smaller sizes than the smallest mature females. The maturation "decision", however, is not irrevocable, as low growth rates the following spring can arrest the process, and the fish remains in fresh water for an additional year as a resident. According to this theory, then, each annual cycle includes an initial growth-rate-related decision of whether or not to smolt the following spring, followed by a second, provisional decision regarding maturation. Applying this theory to O mykiss, resident trout are fish that attain critical growth rates for maturation first – either because they have a much higher growth rate threshold than the fish that smolt, or because their mid-summer environment rarely supports such rapid growth in early summer.

Unfortunately, most of the work on “critical windows” addresses Atlantic salmon, Chinook salmon and brown trout; systematic study of critical developmental periods and threshold growth rates in steelhead could not be found during the research for this paper. If indeed this kind of research has not been conducted on O. mykiss, it is a serious hole in our understanding that must be addressed as soon as possible.

A comparable process may well exist in spring Chinook salmon although the existence of the first smoltification decision is not apparent because, at the latitudes of Washington and Oregon, threshold growth rates are virtually always attained. Recent work in the Yakima Subbasin (Larson et al. 2004), however, suggests that a second late-fall/winter window for precocial maturation of males does exist. Thus, it is possible that a critical window for initiating sexual maturation (at least of males) may occur during the late fall or winter for all salmonids. Indeed, it may be possible that both the “spring/smolting” and the “fall-winter/maturation” windows exist for all salmonids.

Cramer (2005) proposes a similar theory for steelhead, but emphasizes the environmental conditions necessary to support threshold growth rates at critical times. Although Cramer did not organize his observations according to the Atlantic salmon developmental model, they are reasonably compatible with it. Assuming, then, that the July/smoltification and November/maturation windows described for Atlantic salmon also apply to O mykiss, Cramer’s theory can be re-stated as follows. If summertime temperatures in the natal stream do not exceed 15^{o}C, and the stream is relatively large (base flows 500 – 1,000 cfs), July growth rates are unlikely to exceed threshold values before the November threshold for maturation is attained. Such streams are likely to support O mykiss populations dominated by resident trout. Because juvenile O mykiss are universally observed migrating downstream into larger streams as they grow, even tributaries warmer than 15^{o}C or substantially smaller than 500 cfs at baseflow will support primarily resident fish if they flow into such a larger, cooler stream. Conversely, because of the larger proportion of preferred “edge habitat” provided by smaller streams, it is likely that smaller streams will support rapid growth rates in July and predominantly anadromous fish, especially if maximum summer temperatures exceed 15^{o}C. Coastal streams, on the other hand, almost always produce mainly the anadromous form, because the normal spring-time movements of juveniles results in ocean entry.

While Cramer’s theory, however explained, is consistent with a great many observations, there are also numerous counter-examples, possible confounds with the after-effects of impassible or partially passable dams and, perhaps most importantly, an inability to explain the growing number of systems that are known to support populations of *both* steelhead and resident rainbow trout.

The issue of environmental conditions favoring threshold growth rates for steelhead smoltification is clearly important. If the critical periods for steelhead smoltification and “precocialization” can be determined, it would be wise to target streams that provide optimal growth conditions during these periods for steelhead supplementation. Similarly, streams that currently support predominantly trout populations could be enhanced for steelhead if growth conditions could be improved during critical periods. It is important to realize that increasing growth rates does not necessarily mean increasing maximum water temperatures. Although higher temperatures do increase growth rates in the late spring and early summer, they also have many undesirable effects. It is at least possible that increasing primary productivity and prey availability, decreasing energy expenditure by reducing mid-summer flows or adding velocity cover – indeed, modifying the environment in any way that minimizes foraging effort and maximizes daily calorie intake – would produce the same effect. Moreover, it may not be an entirely bad thing if enriching the accessibility of food for juvenile steelhead also increases the proportion of precocial males. As will be seen, precocial males may represent a critical genetic hedge against losing the anadromous trait.

A final consideration of developmental windows and threshold growth rates relates specifically to upper Yakima O mykiss. Instream flows in the upper Yakima during early summer are typically quite high because of irrigation demand. It is not unreasonable that the growth rates of O. mykiss fry, many of which emerge in late June and early July, are adversely affected by sustained, non-normative high flows. It thus is at least possible that the current river and reservoir management scheme is at least partly responsible for the relative abundance of trout and the relative scarcity of steelhead in the upper Yakima. Simply put, relatively few juveniles are able to find foraging stations of sufficient quality to enable them to exceed threshold growth rates in early summer.

Reproductive Competition Waged in Terms of Relative Productivity and Fecundity: The EDT-Based Approach

Overview and Derivation

The process for estimating equilibrium abundances of trout and steelhead from EDT output entails estimating the outcome of a competition between life history forms to produce juveniles. If the product of the productivity and *relative* potential egg deposition (mean abundance times mean fecundity) of one form is greater than 1.0, then that particular form wins the competition and is not affected by the other form – that is to say, its sympatric productivity is the same as it productivity in allopatry. The loser in this competition does not necessarily become extirpated. Rather, its productivity is reduced by a factor equal to its relative potential egg deposition. The loser does become extirpated, however, when it sympatric productivity (the product of allopatric productivity and relative egg deposition), becomes less than 1.0. Finally, it is also possible, that neither form wins the competition outright. In such a case, the productivities of both forms are reduced by a multiple equal to their relative potential egg depositions.

This approach makes few assumptions about the genetic factors involved in O. mykiss life histories. For the most part, it assumes that the population produces smolts and residents in large enough numbers that an increase in egg-to-adult survival for either form will be converted, eventually, into additional spawners and juvenile progeny. The outcome of this competition turns on the relative fecundity of rainbow and steelhead and the relative egg-to-adult survival of the two forms. Relative survival, in turn, is a function of habitat quality – from the spawning grounds to the North Pacific, for steelhead, and entirely within the subbasin, for trout.

With this general overview, consider the derivation of the method in detail. Performance measures for both forms are productivity (*P*), capacity (*C*), and equilibrium abundance (*Neq*). The purpose of this application is to estimate these measures for steelhead when resident rainbow compete for food and space resources.

Equilibrium abundance of first-time spawning resident rainbow trout when modeled independent of steelhead (as in allopatry) is computed as

$$Neq_{RI} = C_{RI}(1 - \frac{1}{P_{RI}})$$

Where C_{RI} is the estimated capacity for the resident life form modeled independent of steelhead, P_{RI} is the estimated productivity for the resident life form modeled independent of steelhead, and Neq_{RI} is the equilibrium abundance of the resident life form modeled independent of steelhead.

Similarly, equilibrium abundance of first-time spawning anadromous steelhead when modeled independent of rainbow is computed as

$$Neq_{AI} = C_{AI}(1 - \frac{1}{P_{AI}})$$

Where C_{AI} is the estimated capacity for the anadromous life form modeled independent of rainbow, P_{AI} is the estimated productivity for the anadromous life form modeled independent of rainbow, and Neq_{AI} is the equilibrium abundance of the anadromous life form modeled independent of rainbow.

Potential egg deposition (PED_{RI}) for the resident life form modeled independent of steelhead is estimated as

$$PED_{RI} = Neq_{RI} * \overline{F_R}$$

Where $\overline{F}_R$ is the average number of eggs per spawner (as the weighted average of age-specific fecundities) for the resident form.

Similarly, potential egg deposition (PED_{AI}) for the resident life form modeled independent of steelhead is estimated as

$$PED_{AI} = Neq_{AI} * \overline{F_A}$$

Where $\overline{F}_A$ is the average number of eggs per spawner (as the weighted average of age-specific fecundities) for the anadromous form.

It is assumed that O. mykiss are generally predisposed in the Pacific Northwest to be anadromous, unless mortality pressures cause residency to be more successful (produce more juveniles). This assumed predisposition is modeled by assigning additional weight to PED_{AI} (anadromous form modeled independent of rainbow) as shown below

$$WPED_{AI} = W_A * PED_{AI}$$

Where $WPED_{AI}$ is PED_{AI} weighted a constant W_A. For the current analysis, W_A was determined on the basis of production observed in Satus and Toppenish creeks. Specifically, it was set at the mean of the W_A.values which resulted in all production in these streams being steelhead.

Before proceeding to the final calculations, it is essential to describe the biological mechanism the equations describe. Fundamentally, the relative abundance of trout and steelhead in an interbreeding population id viewed as the outcome of a competition. This competition is waged in terms of the relative numbers of juveniles produced. Assuming rainbow and steelhead juveniles are identical, and that density-dependent competition between ecotypes occurs exclusively during juvenile life stages, then ecotype abundance will reflect the sheer relative numerical abundance of juveniles at equilibrium.

Assuming homogenous spawning distribution and identical spawn timing between ecotypes, relative juvenile abundance should be a function of survival to reproductive maturity and the relative potential egg deposition at equilibrium. The best measure of survival to reproductive maturity is productivity (the Beverton-Holt parameter); the best measure of potential egg deposition is the product of equilibrium adult abundance, mean fecundity, and the "anadromous bias" of West Coast O. mykiss represented by the weighting factor W_A. Therefore, relative steelhead potential egg deposition would be:

$$WPED_{AI} / (WPED_{AI} + PED_{RI})$$

For resident rainbow, then, productivity in sympatry P_{RS} is estimated as follows:

$$\text{If } P_{AI} * \left(\frac{WPED_{AI}}{PED_{RI} + WPED_{AI}} \right) \leq 1 \text{ then} \qquad \text{Equation 6}$$

$$P_{RS} = P_{RI}$$

else

$$P_{RS} = P_{RI} * \left(\frac{PED_{RI}}{PED_{RI} + WPED_{AI}} \right)$$

Sympatric rainbow productivity should be the same as allopatric rainbow productivity when eq. 1 is less than 1 because the steelhead competitors simply produce fewer juveniles – either because their productivity is too low, or their relative potential egg deposition is too low, or both.

If eq. 1 is *not* true, then some of the juveniles produced at equilibrium will be steelhead, and the two ecotypes will produce progeny in direct proportion to their relative weighted potential egg deposition.

Rainbow capacity in sympatry C_{RS} remains unchanged from capacity modeled independent of the anadromous form as shown below

$$C_{RS} = C_{RI}$$

Equilibrium abundance of the resident form in sympatry is then estimated using the equation described for residency modeled independently, though the terms are replaced with those given for allopatry.

Similarly, for the anadromous form, productivity in sympatry P_{AS} is estimated as follows

$$\text{If } P_{RI} * \left(\frac{PED_{RI}}{PED_{RI} + WPED_{AI}} \right) \leq 1 \text{ then} \qquad \text{Equation 7}$$

$$P_{AS} = P_{AI}$$

else

$$P_{AS} = P_{AI} * \left(\frac{WPED_{AI}}{PED_{RI} + WPED_{AI}} \right)$$

and steelhead capacity in sympatry C_{AS} remains unchanged from capacity modeled independent of the resident form as shown below

$$C_{AS} = C_{AI}$$

Equilibrium abundance of the anadromous form in sympatry is then estimated using the equation described for anadromy modeled independently, though the terms are replaced with those given for allopatry.

Application: Estimation of Rainbow and Steelhead Abundance in Naches and Upper Yakima Watersheds

Applying the method described above to O mykiss populations in the Yakima entailed the following steps:

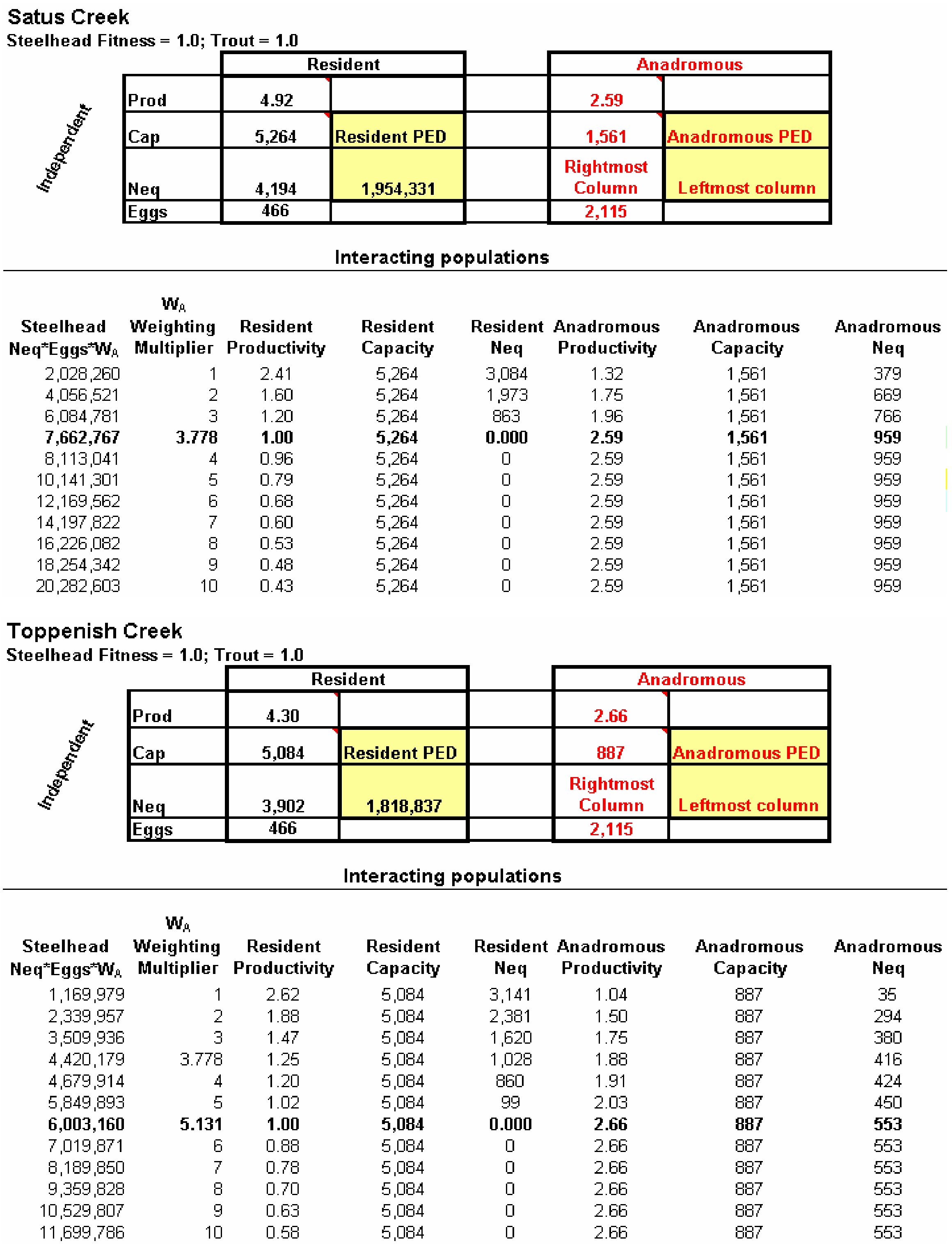
1. Baseline production for allopatric steelhead populations in the upper Yakima, the Naches drainage, Satus Creek and Toppenish Creek were first simulated with EDT in order to generate allopatric estimates of steelhead productivity and carrying capacity for each area. Based on the age structure, age-length relationships, length fecundity relationships and sex ratios of upper Yakima rainbow trout (Yakama Nation, unpublished data; Geoff McMichaels, WDFW, personal communication, 2000), mean steelhead fecundity *per spawner* was estimated at 2,115 eggs.

2. Baseline production for allopatric rainbow trout populations in the upper Yakima, the Naches drainage, Satus Creek and Toppenish Creek were simulated with EDT in order to generate allopatric estimates of trout productivity and carrying capacity for each area. Based on the age structure, age-length relationships, length fecundity relationships and sex ratios WDFW observed in the course of monitoring the upper Yakima trout population, (Geoff McMichaels, personal communication, 2000), the mean rainbow trout fecundity *per spawner* was estimated at 466 eggs. In the absence of information for other trout populations, this mean fecundity figure was assumed for all Yakima rainbow trout.

3. Trout and steelhead parameters were then substituted into the equations for sympatric productivity described above, and various values of W_A were applied to estimate equilibrium abundance of trout and steelhead. The minimum possible W_A value for Satus and Toppenish creek steelhead was assumed to be the value that reduced trout Neq in each drainage to zero.

4. Importantly, the W_A value for O mykiss populations in the upper Yakima and Naches watersheds was assumed to be best approximated by the mean of the values ascribed to the Satus and Toppenish creek populations.

The results of these calculations, in spreadsheet form, are shown in Figures 1 and 2. The accuracy of the estimates of steelhead production in the upper Yakima and Naches watersheds might be indexed by the degree of congruence between the EDT-based estimates and, respectively, the mean steelhead passage numbers at Roza Dam and mean escapement estimates for the Naches watershed. From 1995 to 2003, the mean steelhead count at Roza Dam has been 92 adults (Bill Bosch, Yakama Nation, personal communication 2004), a figure that agrees quite well with the EDT estimate of 94. Over



Satus Creek

Steelhead Fitness = 1.0; Trout = 1.0

Independent

	Resident			Anadromous	
Prod	4.92			2.59	
Cap	5,264	Resident PED		1,561	Anadromous PED
Neq	4,194	1,954,331		Rightmost Column	Leftmost column
Eggs	466			2,115	

Interacting populations

Steelhead Neq*Eggs*W_A	W_A Weighting Multiplier	Resident Productivity	Resident Capacity	Resident Neq	Anadromous Productivity	Anadromous Capacity	Anadromous Neq
2,028,260	1	2.41	5,264	3,084	1.32	1,561	379
4,056,521	2	1.60	5,264	1,973	1.75	1,561	669
6,084,781	3	1.20	5,264	863	1.96	1,561	766
7,662,767	**3.778**	**1.00**	**5,264**	**0.000**	**2.59**	**1,561**	**959**
8,113,041	4	0.96	5,264	0	2.59	1,561	959
10,141,301	5	0.79	5,264	0	2.59	1,561	959
12,169,562	6	0.68	5,264	0	2.59	1,561	959
14,197,822	7	0.60	5,264	0	2.59	1,561	959
16,226,082	8	0.53	5,264	0	2.59	1,561	959
18,254,342	9	0.48	5,264	0	2.59	1,561	959
20,282,603	10	0.43	5,264	0	2.59	1,561	959

Toppenish Creek

Steelhead Fitness = 1.0; Trout = 1.0

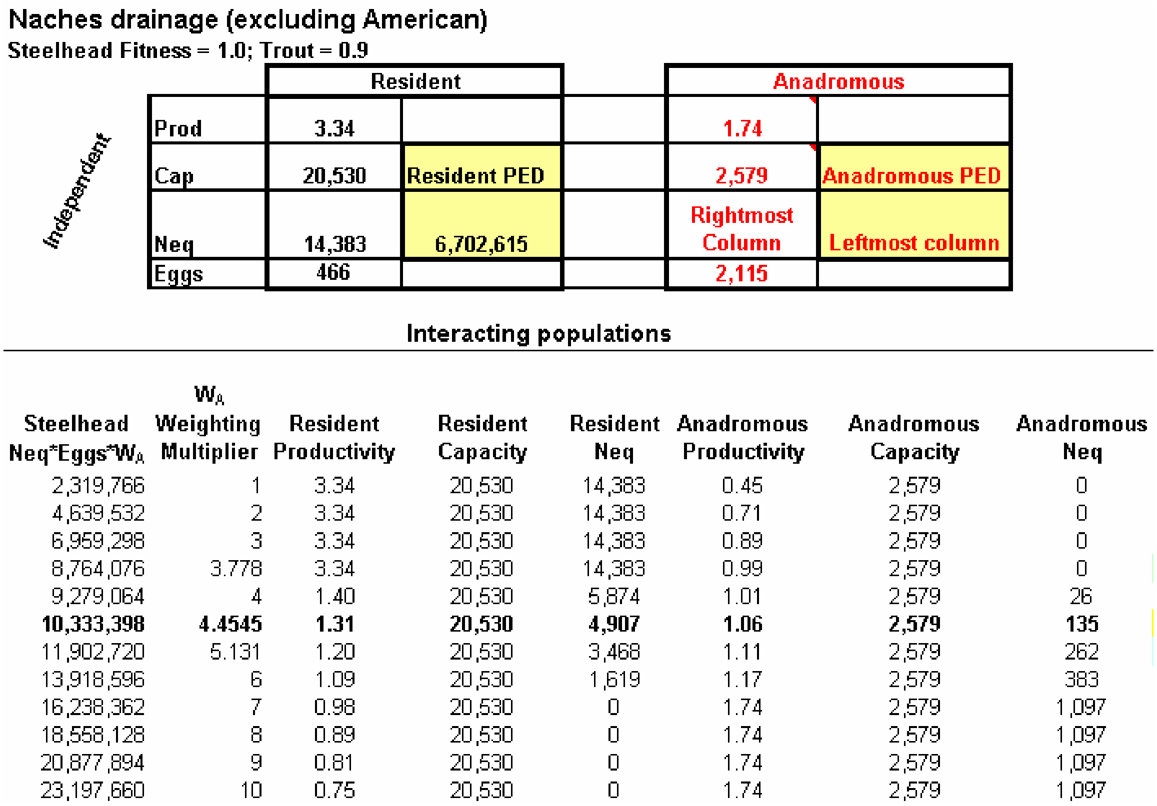
Independent

	Resident			Anadromous	
Prod	4.30			2.66	
Cap	5,084	Resident PED		887	Anadromous PED
Neq	3,902	1,818,837		Rightmost Column	Leftmost column
Eggs	466			2,115	

Interacting populations

Steelhead Neq*Eggs*W_A	W_A Weighting Multiplier	Resident Productivity	Resident Capacity	Resident Neq	Anadromous Productivity	Anadromous Capacity	Anadromous Neq
1,169,979	1	2.62	5,084	3,141	1.04	887	35
2,339,957	2	1.88	5,084	2,381	1.50	887	294
3,509,936	3	1.47	5,084	1,620	1.75	887	380
4,420,179	3.778	1.25	5,084	1,028	1.88	887	416
4,679,914	4	1.20	5,084	860	1.91	887	424
5,849,893	5	1.02	5,084	99	2.03	887	450
6,003,160	**5.131**	**1.00**	**5,084**	**0.000**	**2.66**	**887**	**553**
7,019,871	6	0.88	5,084	0	2.66	887	553
8,189,850	7	0.78	5,084	0	2.66	887	553
9,359,828	8	0.70	5,084	0	2.66	887	553
10,529,807	9	0.63	5,084	0	2.66	887	553
11,699,786	10	0.58	5,084	0	2.66	887	553

Figure 1. Spreadsheets showing procedure for estimating W_A for Satus and Toppenish creek steelhead. The minimum W_A value for each population was assumed to be the value that reduced trout Neq to zero. As indicated by the bold row in the tables of figures for each population, W_A for Satus steelhead was estimated at 3.778 while W_A for Toppenish steelhead was estimated at 5.131.



Naches drainage (excluding American)

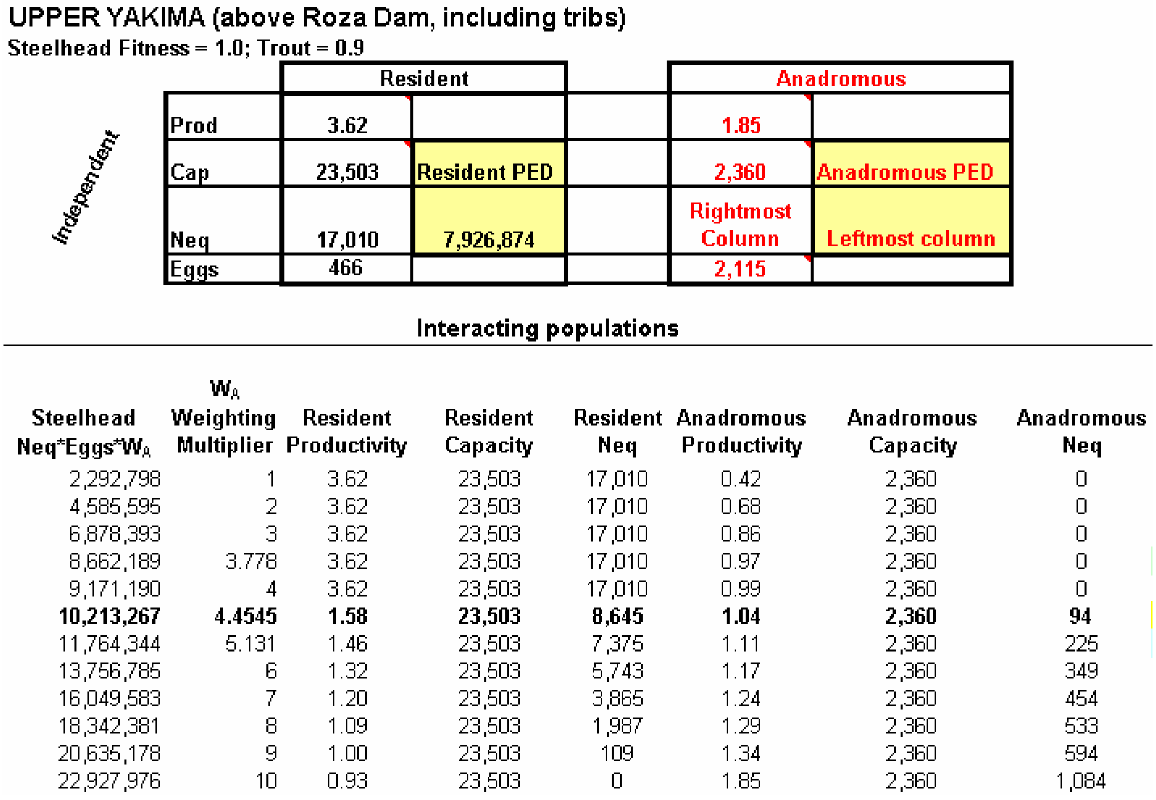
Steelhead Fitness = 1.0; Trout = 0.9

independent

	Resident			Anadromous	
Prod	3.34			1.74	
Cap	20,530	Resident PED		2,579	Anadromous PED
Neq	14,383	6,702,615		Rightmost Column	Leftmost column
Eggs	466			2,115	

Interacting populations

Steelhead Neq*Eggs*W_A	W_A Weighting Multiplier	Resident Productivity	Resident Capacity	Resident Neq	Anadromous Productivity	Anadromous Capacity	Anadromous Neq
2,319,766	1	3.34	20,530	14,383	0.45	2,579	0
4,639,532	2	3.34	20,530	14,383	0.71	2,579	0
6,959,298	3	3.34	20,530	14,383	0.89	2,579	0
8,764,076	3.778	3.34	20,530	14,383	0.99	2,579	0
9,279,064	4	1.40	20,530	5,874	1.01	2,579	26
10,333,398	**4.4545**	**1.31**	**20,530**	**4,907**	**1.06**	**2,579**	**135**
11,902,720	5.131	1.20	20,530	3,468	1.11	2,579	262
13,918,596	6	1.09	20,530	1,619	1.17	2,579	383
16,238,362	7	0.98	20,530	0	1.74	2,579	1,097
18,558,128	8	0.89	20,530	0	1.74	2,579	1,097
20,877,894	9	0.81	20,530	0	1.74	2,579	1,097
23,197,660	10	0.75	20,530	0	1.74	2,579	1,097



UPPER YAKIMA (above Roza Dam, including tribs)

Steelhead Fitness = 1.0; Trout = 0.9

independent

	Resident			Anadromous	
Prod	3.62			1.85	
Cap	23,503	Resident PED		2,360	Anadromous PED
Neq	17,010	7,926,874		Rightmost Column	Leftmost column
Eggs	466			2,115	

Interacting populations

Steelhead Neq*Eggs*W_A	W_A Weighting Multiplier	Resident Productivity	Resident Capacity	Resident Neq	Anadromous Productivity	Anadromous Capacity	Anadromous Neq
2,292,798	1	3.62	23,503	17,010	0.42	2,360	0
4,585,595	2	3.62	23,503	17,010	0.68	2,360	0
6,878,393	3	3.62	23,503	17,010	0.86	2,360	0
8,662,189	3.778	3.62	23,503	17,010	0.97	2,360	0
9,171,190	4	3.62	23,503	17,010	0.99	2,360	0
10,213,267	**4.4545**	**1.58**	**23,503**	**8,645**	**1.04**	**2,360**	**94**
11,764,344	5.131	1.46	23,503	7,375	1.11	2,360	225
13,756,785	6	1.32	23,503	5,743	1.17	2,360	349
16,049,583	7	1.20	23,503	3,865	1.24	2,360	454
18,342,381	8	1.09	23,503	1,987	1.29	2,360	533
20,635,178	9	1.00	23,503	109	1.34	2,360	594
22,927,976	10	0.93	23,503	0	1.85	2,360	1,084

Figure 2. Estimation of equilibrium trout and steelhead populations in the upper Yakima and Naches River watersheds based on the mean W_A ascribed to Satus and Toppenish Creek steelhead. The bold line represents the mean weighting multiplier and predicted trout and steelhead production for each watershed.

this same period, the mean steelhead return to the entire Yakima Subbasin, based on Prosser Dam counts, has been 1,813. If, as estimated by steelhead radiotagging studies conducted from 1989 – 1993 (Hockersmith et al. 1995), the mean Naches escapement is 32% of the total return, the mean return of steelhead to the Naches over the years 1995 – 2003 has been 580, considerably more than the EDT-based estimate of 135. On the other hand, the 32% figure for the proportion of total steelhead production attributable to the Naches is based on escapements occurring in the mid-1980s. Steelhead passage into upper Toppenish Creek has improved considerably since the mid-1980s, because the Toppenish Lateral Canal Diversion Dam, which formerly restricted passage, was washed out by a series of floods. It is thus possible that relative steelhead escapement into Toppenish Creek has increased in recent years, and that the current proportion of steelhead escaping to the Naches watershed is less than 32%. Indeed, if Naches production is estimated by the number of steelhead redds counted there in 2004, the EDT-based estimate agrees quite well with empirical observation. A total of 94 steelhead redds were counted in the Naches in 2004 (Chris Frederickson, Yakama Nation, personal communication 2005). Assuming each female digs an average of 1.2 redds, and that 60% of Naches steelhead are female, the escapement of steelhead to the Naches in 2004 was 131 fish. Nevertheless, in light of the difficulty of detecting steelhead redds during spring run-off, it is likely that the 2004 redd count was itself an underestimate, and that current steelhead production in the Naches is closer to 580 than 131.

Application: Implications of Mortality at Diversion Dams Inside the Yakima River

As mentioned, SAR affects the productivity of steelhead relative to resident trout in an interbreeding population, and therefore the relative equilibrium abundance of steelhead. The diversion dams on the Yakima and Naches mainstem reduce steelhead SAR primarily because of predation occurring inside and immediately below the bypass structures (Fast et al. 1991). It is therefore of some interest to compute the equilibrium steelhead population for portions of the upper Yakima and Naches watersheds under a scenario in which all smolt losses associated with Yakima Subbasin diversion dams are eliminated.

Figure 3 shows the equilibrium steelhead populations predicted for Rattlesnake Creek, the Little Naches River, the Bumping River, the North, Middle and West Forks of the Teanaway River, Big Creek, Manastash Creek and Taneum Creek. Steelhead production is estimated both with current smolt losses ascribed to diversion dams (red bars) and without such losses (blue bars). In addition, production in Manastash, Big and Taneum creeks assumes diversion-related passage problems inside each tributary have been eliminated. In almost all cases, elimination of smolt losses at mainstem Yakima and Naches diversion dams greatly increases steelhead production. With current estimated mainstem diversion dam impacts, the total steelhead production estimated for all of the targeted tributaries is 349. With impacts removed, total steelhead production increases almost five-fold, to 1,637. This relationship is significant in terms of any future plan to increase Yakima steelhead production by supplementing selected tributaries in the upper watershed.

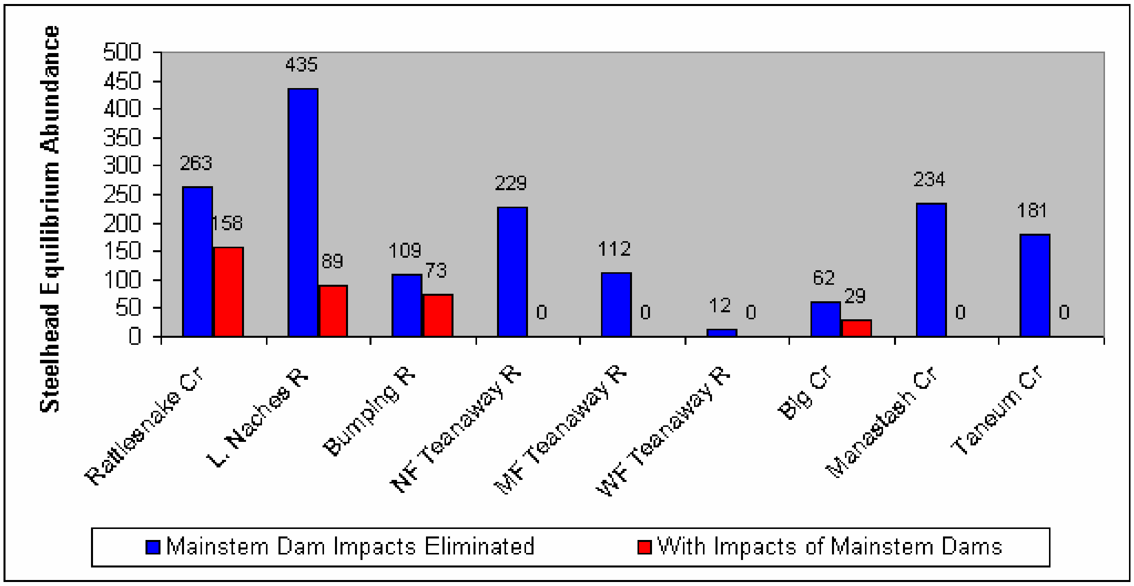


Figure 3. Estimated equilibrium steelhead production in selected Yakima Subbasin tributaries with and without smolt mortalities associated with mainstem Yakima and Naches diversion dams. Production estimates based on EDT analysis.

Genetics

Introduction

In an interbreeding population of steelhead and rainbow trout, the fate of an individual in terms of becoming a smolt, a precocial male or a resident trout depends on a combination of genetic factors and threshold growth rates occurring during critical time periods. The genetic factors appear to determine the particular threshold values needed to trigger one developmental path or another, as well as the expression or suppression of genetically linked traits.

Two studies provide a wealth of information on these topics. The first to be discussed (Thrower et al. 2004) is a study of the "genetic architecture" of growth, smolting, precocialism and residency in a population of Alaskan O. mykiss. The second (Carmichael 2005) is a similar study of the genetic determinants of smolting and "non-smolting" among various populations of trout and steelhead in the Grande Ronde Subbasin.

Genetic Architecture of Anadromy, Residency and Precocial Maturation (Thower et. al 2004)

Background

Perhaps the best study of the genetic determinants of life history in O. mykiss is that of Thrower et al.(2004). This study suggested that growth patterns, the incidence of precocial males ("precocialism") and smolting are genetically linked traits, and that the heritabilities of smolting, precocialism and growth were moderate to high, implying the possibility for rapid selection. Perhaps more importantly, the study indicated that smolting and precocialism are alternative phenotypic expressions of the same group of genes. More precisely, Thrower et al. showed that smolting and precocialism are negatively correlated genetically, probably because of antagonistic pleiotropy.

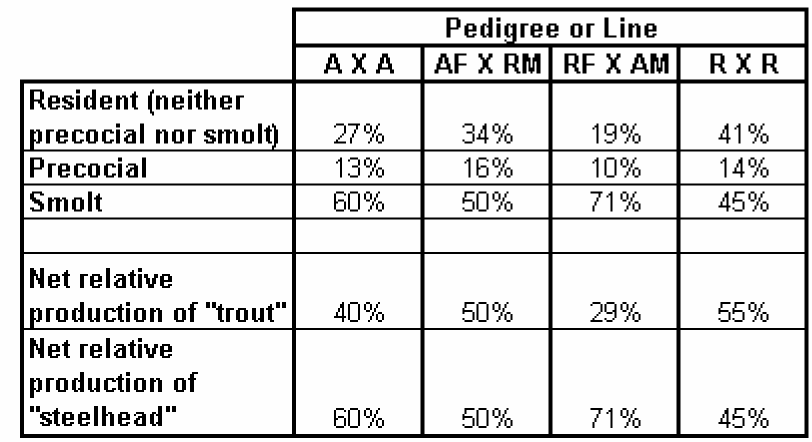
The experimental subjects for this study were intriguing as they may well be quite similar to O mykiss populations in the Yakima. Specifically, Thrower et al. examined the developmental fate of the progeny of crosses between Sashin Creek steelhead and Sashin Lake rainbow trout. Sashin Lake occurs above two impassible waterfalls, and contained no fish prior to a release of small numbers of juvenile steelhead from the creek in 1926. Habitat in the lake and its tributaries was excellent, and a large resident O mykiss population established itself. The lake and creek populations thus may be comparable to Yakima O mykiss populations in the 1940s and 1950s, in that the upper population (Sashin Lake or Yakima above Roza Dam) were entirely or nearly entirely resident, because outmigrating smolts were entirely or nearly entirely unable to return to their natal areas, while the lower populations (Sashin Creek or the Yakima subbasin below Roza Dam) supported a substantial steelhead population. In addition, in both situations the resident and anadromous populations were genetically identical initially.

In the Thrower study, the fate of 75 families of reciprocal crosses between males and females were followed through their second year. The families included progeny from resident by resident crosses (R X R), anadromous by anadromous crosses (A X A), and crosses of anadromous females with resident males (AF X RM) and resident females with anadromous males (RF X AM). The response variables tracked among families included length and weight the June after hatching, the October after hatching and June of the second year; growth rate from the first June to the first October (age-1 growth); growth rate from the first October to the second June (age1-2 growth); proportion smolting; proportion maturing (proportion precocial males); and proportion that failed either to smolt or become sexually mature (proportion adopting the resident trout life history or “proportion resident”). Each family was reared independently during the first year but, after being marked to indicate pedigree, all families were combined in a single vessel and maintained under identical conditions.

Results

Because of larger egg size, A X A and AF X RM progeny were initially larger than any of the lines not including an anadromous mother. Growth rates among the R X R and hybrid progeny were, however, greater than AXA progeny, and there was no significant difference in size between any of the populations by June of the second year.
The developmental fate of the progeny of the various crosses is summarized in Table 2. The difference in smolt production between pure anadromous and pure resident lines was not great – 60% for pure anadromous progeny vs. 45% for pure resident progeny – nor were pure anadromous progeny the most likely to become smolts. When normalized relative to the line producing the greatest proportion of smolts (RF X AM), pure anadromous progeny produced 15% fewer smolts than the RF X AM line and 22% more than the pure resident line. If the study were replicated sufficiently, it is possible that the pure anadromous line would produce the greatest mean proportion of smolts, as was the

Table 2. Proportion of progeny of anadromous-resident crosses that became precocial males, smolts or undifferentiated fish ("trout") after two years. "A X A" = progeny of anadromous by anadromous crosses; "AF X RM" = progeny of anadromous females & resident males; "RF X AM" = progeny of resident females and anadromous males; "R X R" = progeny of resident by resident crosses. Data from Thrower et al. 2004.



	Pedigree or Line			
	A X A	AF X RM	RF X AM	R X R
Resident (neither precocial nor smolt)	27%	34%	19%	41%
Precocial	13%	16%	10%	14%
Smolt	60%	50%	71%	45%
Net relative production of "trout"	40%	50%	29%	55%
Net relative production of "steelhead"	60%	50%	71%	45%

case in the Carmichael study of Grande Ronde steelhead (see below). Moreover, smolt production was estimated purely in terms of silvery appearance. If relative smolt production were expressed in terms of downstream survival, as in the Carmichael study, the relative differences among lines would probably be more extreme and perhaps differently ordered. Indeed, although Thrower et al. do not provide specifics, they allude to a subsequent phase of the study, which indicated that the marine survival of pure resident smolts was lower than that of pure anadromous smolts. Therefore it is not unreasonable to assume that the anadromous trait is actually more closely associated with anadromous lineage than is evident in Table 2.

Unlike the Grande Ronde study, in which the pure resident line produced 3- to 8-times as many precocial males as any other line, the proportion of precocial males was relatively constant among crosses for all of the Sashin lines. The pure resident line did, however, produce the greatest number of undifferentiated resident trout after two years, a developmental fate that was not monitored in the Carmichael study.

Table 2 is expressed in terms of means and thus does not indicate the very large variability in developmental fate among all families. Incidence of smolting ranged from 2% to 99% across all families. Similarly, the range of precocialism and residency across all families was 0 – 50% (0 – 100% for males) and 1 – 92%, respectively. Such results suggest that the incidence of the genetically correlated traits of smolting, precocialism and residency is probably highly stock-specific.

Thrower et al. noted some intriguing relationships between growth during specific periods and ultimate developmental fate. Across all lines, incidence of smolting was weakly (r^2 = 0.12) but positively correlated with October-June growth. Conversely, across all lines, precocialism was weakly (r^2 = 0.103) but *negatively* correlated with October-June growth. These findings are intriguing because they suggest the existence of a growth window that determined the mutually exclusive paths of precocity or smoltification. Unfortunately, the width of the period over which growth rates were estimated was too broad to provide direction for hatchery managers attempting to maximize smolt production by controlling growth rates, or for designers of a steelhead enhancement program attempting to assess the suitability of candidate streams for steelhead supplementation.

As mentioned, heritability for growth, smolting and precocialism was moderate to high. Heritability of final length and weight was 0.5 and 0.7, respectively, while heritability for June – October and October – June growth rates was 0.75 and 0.2, respectively. Heritability for smolting and precocialism was nearly identical, being estimated at 0.45 and 0.44, respectively.

Perhaps the most significant finding of the study was that smolting and precocialism were strongly negatively correlated, both phenotypically (-0.47) and genetically (-0.45). Thrower et al. state that "The negative genetic correlation between the proportion smolting and the proportion maturing at age 2 indicates the likely presence of antagonistic pleiotropy (or possibly linkage) between these traits (pleiotropy, or multiple gene effects, and linkage between loci are the most common causes of genetic correlation; Lynch and Walsh 1998)". The negative genetic correlation between smoltification and precocialism indicates that the two traits are antagonistically related, and that selection for one will result in a selection against the other.

Several additional genetic correlations were observed. While there was no genetic correlation between smoltification and weight at age 1 (October), the genetic relationship between weight at age 1 and precocialism was strongly negative.

Thrower et al interpreted their data as indicating that the relationship between size and growth rate thresholds and smoltification vs. precocialism varies by line. They also noted that the large heritabilities for growth rate, size, smoltification, precocialism and "residency" imply all are capable of responding rapidly to selection. They reasoned that continued selection against smoltification in the lake population would increase precocialism, thereby lowering October-June growth rate and thus posing possible demographic threats to a population comprised of individuals decreasing in size and therefore fecundity.

Precocial steelhead males are apparently incapable of smolting in subsequent years (Schmidt and House 1979). Therefore, such individuals are conserved and are capable of passing on the smoltification/precocialism gene complex to their progeny.
Because of it is concise and comprehensive, the concluding paragraphs of the discussion section of the Thrower et al. study are presented in their entirety:

> *"One would expect the selection coefficient for smolting in this population to be very large and negative because the phenotypic expression of this physiological process includes downstream migration, which in this case, results in a loss of those genotypes from the population. Because high variation for this trait remains, this suggests some form of balancing selection is occurring in the lake population, one that maintains a selective advantage for fish possessing the genes associated with smolting (e.g. high spring growth rates) while the phenotypic expression of smolting and the associated downstream migration is rarely manifested.*

> *The results of this study indicate that after 70 years of freshwater residency, a formerly anadromous, wild, freely breeding population of O. mykiss has retained large amounts of genetic variability associated with growth, precocious maturation and smolting despite complete selection against the phenotypic expression of at least one of the fitness related characters (smolting migration) critical for the reestablishment of an anadromous population. Contrary to expectations, it appears that the dynamic interactions of season specific growth rates, early maturation, and smolting have maintained substantial genetic variation in these critical life history traits. The results of Thrower et al. (in press), however, indicated that the marine survival of the smolts of the lake-derived fish is poor relative to the smolts derived from anadromous parents. Consequently, key genetic factors associated with marine survival do not appear to be closely linked to freshwater growth, precocious maturation, or smolting in the lake population. Thrower et al. (2004), speculated that the poorer marine survival could be due to the lower overall genetic variability of this population associated with a founder effect at stocking. However, selection in the marine environment has been operative over the last 70 years (approximately 12-14 generations) in the anadromous population, which has maintained a connection with changing marine conditions which the resident population in the lake has not had. Genes associated with marine survival may have been "archived" in the lake population (perhaps through linkage with selectively positive traits) without access to adaptive marine selection. It is possible, therefore, that both genetic impoverishment (in terms of alleles influencing marine survival) and lack of reinforcing selection on migratory behavior could be responsible for the reduced marine performance. However, in formerly anadromous populations maintained in freshwater habitats for extended periods, if sufficient genetic variability has been maintained for migratory behavior and other factors contributing to marine survival, selection upon return to marine environments should improve marine survival rates."*

Carmichael's Grande Ronde Study

Background

The Grande Ronde study was not so much intended to reveal the genetic architecture underlying growth and smolting as to determine the degree to which either life history form could give rise to the other, and the degree to which such life history switching was actually occurring in the subbasin.

A portion of this study has already been discussed. To reiterate, a study of Sr/Ca ratios in otolith primordia of subyearlings, smolts, adult steelhead and adult resident trout indicated that maternal pedigree of known smolts and steelhead adults included a surprisingly large proportion of resident trout, and conversely, that the maternal pedigree of known resident adults included a surprisingly large proportion of steelhead.

The remainder of the study examined the developmental and physiological characteristics and the survival to Lower Granite Dam of the yearling progeny of A X A, R X R, AF X RM and RF X AM crosses. The progeny of all crosses were reared under identical conditions and released during the spring of their second year after being PIT-tagged. Six releases of PIT-tagged juveniles were made in the years 1998 through 2003. Fish were monitored for the following attributes:

- Seasonal ATP-ase activity profiles by line.
- Length, weight and condition factor of all lines at release, and the length, weight and condition by line of fish that were subsequently detected at Lower Granite Dam.
- Migration rates to Lower Granite Dam by line.
- The proportion of precocial males in each line after one year.
- Survival to Lower Granite Dam by line.

Results

As shown in Figure 4, although the ATP-ase activities of all lines increased in the spring of their second year, the relative timing differed by line. Pure anadromous and hybrid progeny showed maximal ATP-ase activities in mid-March and early April, whereas pure resident progeny peaked in late April. Figure 5 shows that pure steelhead progeny, just before release in the spring of their second year, were larger and had a lower condition factor than the progeny of either resident trout or hybrids. Figure 6 shows the relative migration timing of juveniles as they passed Lower Granite Dam for brood years 1999 and 2000. Pure steelhead progeny tended to reach Lower Granite Dam sooner than the progeny of the other lines, although the AF x RM line from the 1999 brood year moved nearly as rapidly.

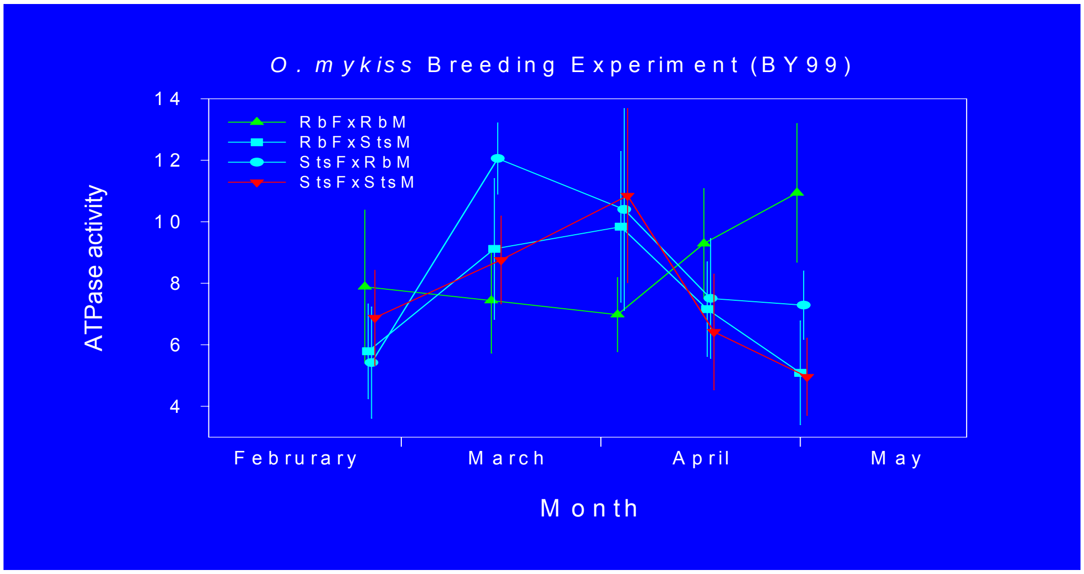


Figure 4. ATP-ase activities of Grande Ronde O. mykiss juveniles in the late winter and early spring of their second year. Juveniles were crosses of resident males and females, anadromous males and females, resident females and anadromous males and anadromous females and resident males. Vertical lines are confidence intervals. Data from Carmichael (2005).

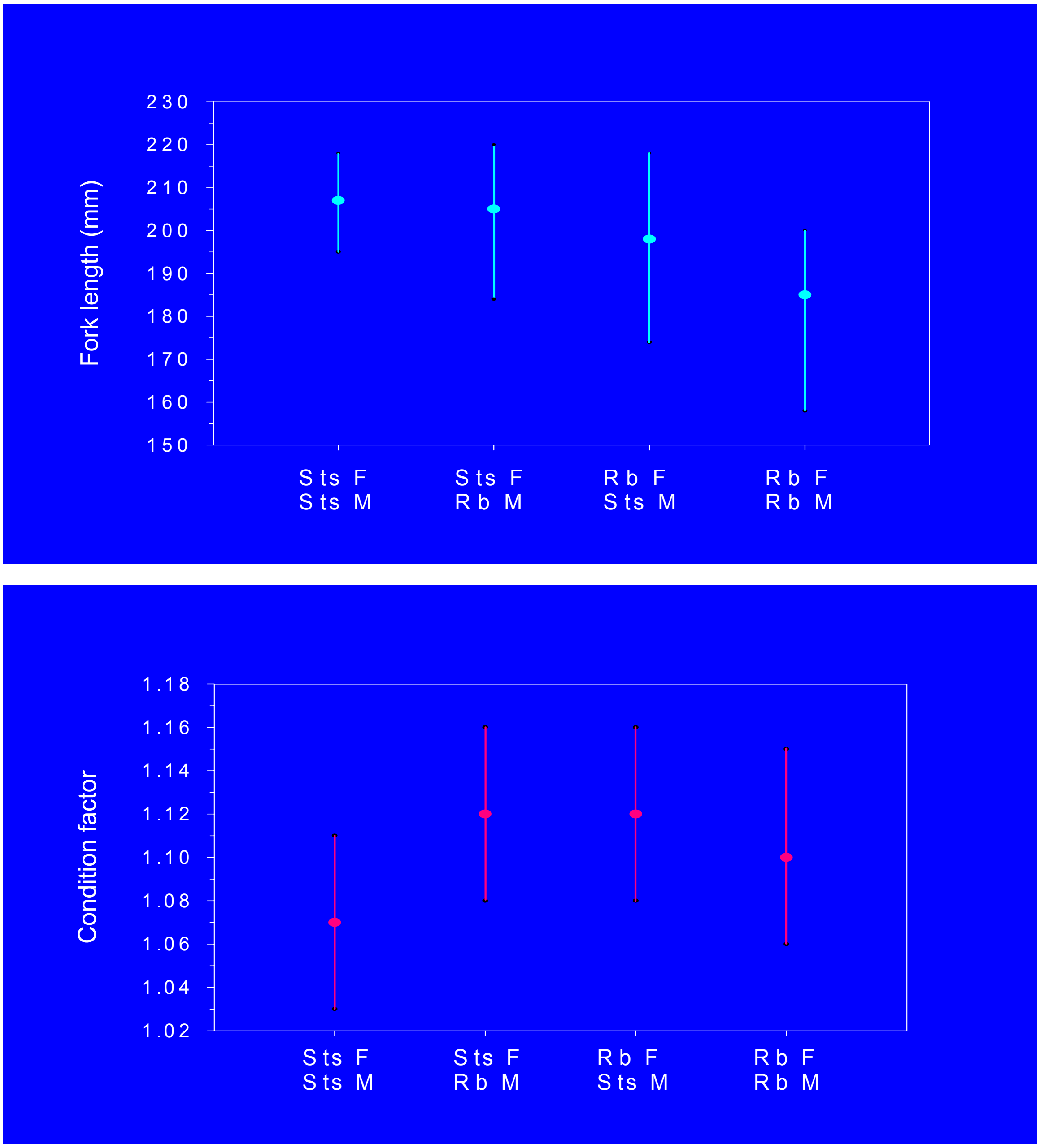


Figure 5. Length and condition factor of juvenile Grande Ronde O. mykiss at release. Juveniles were crosses of resident males and females, anadromous males and females, resident females and anadromous males and anadromous females and resident males. Vertical lines are confidence intervals. Data from Carmichael (2005).

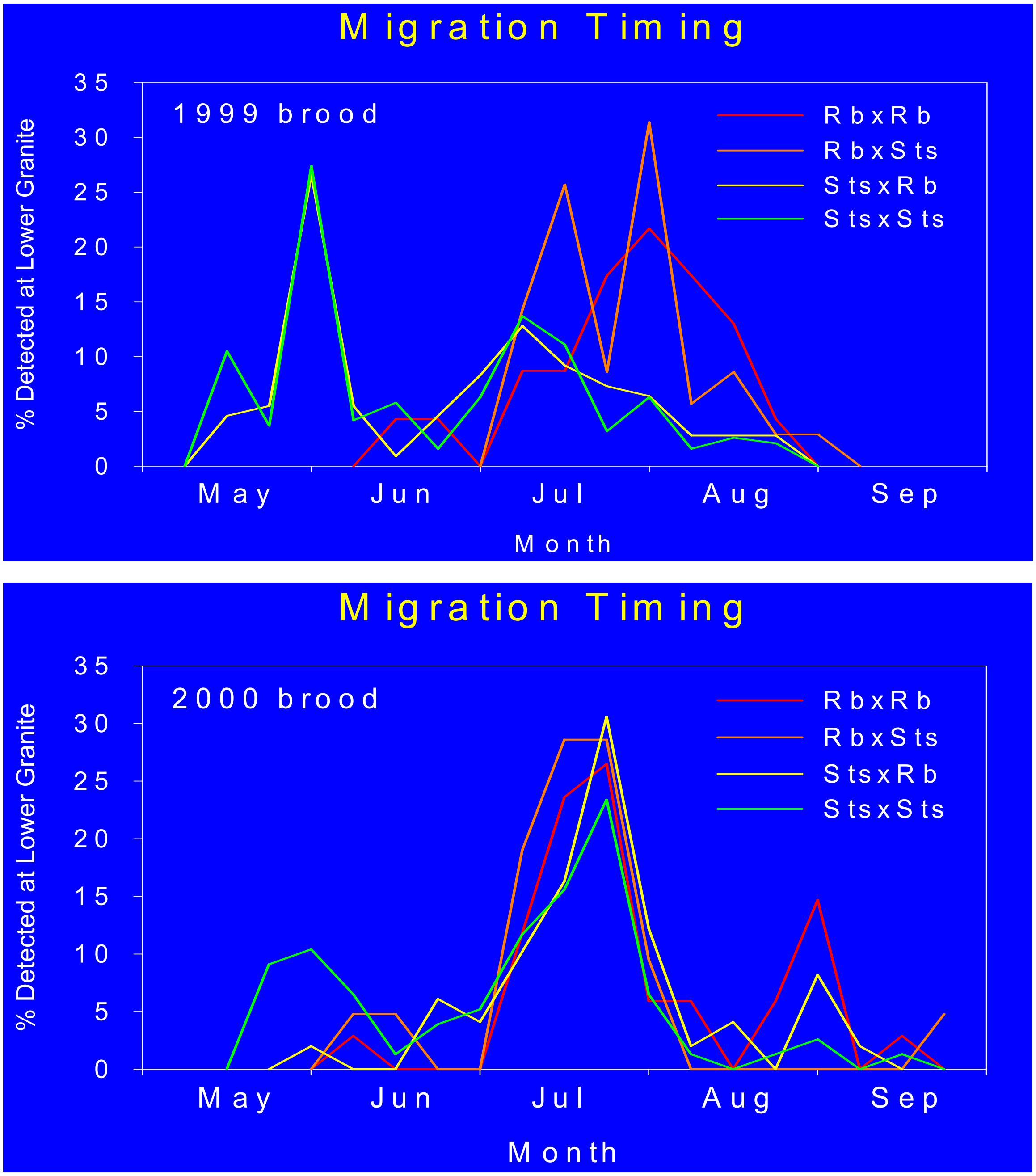
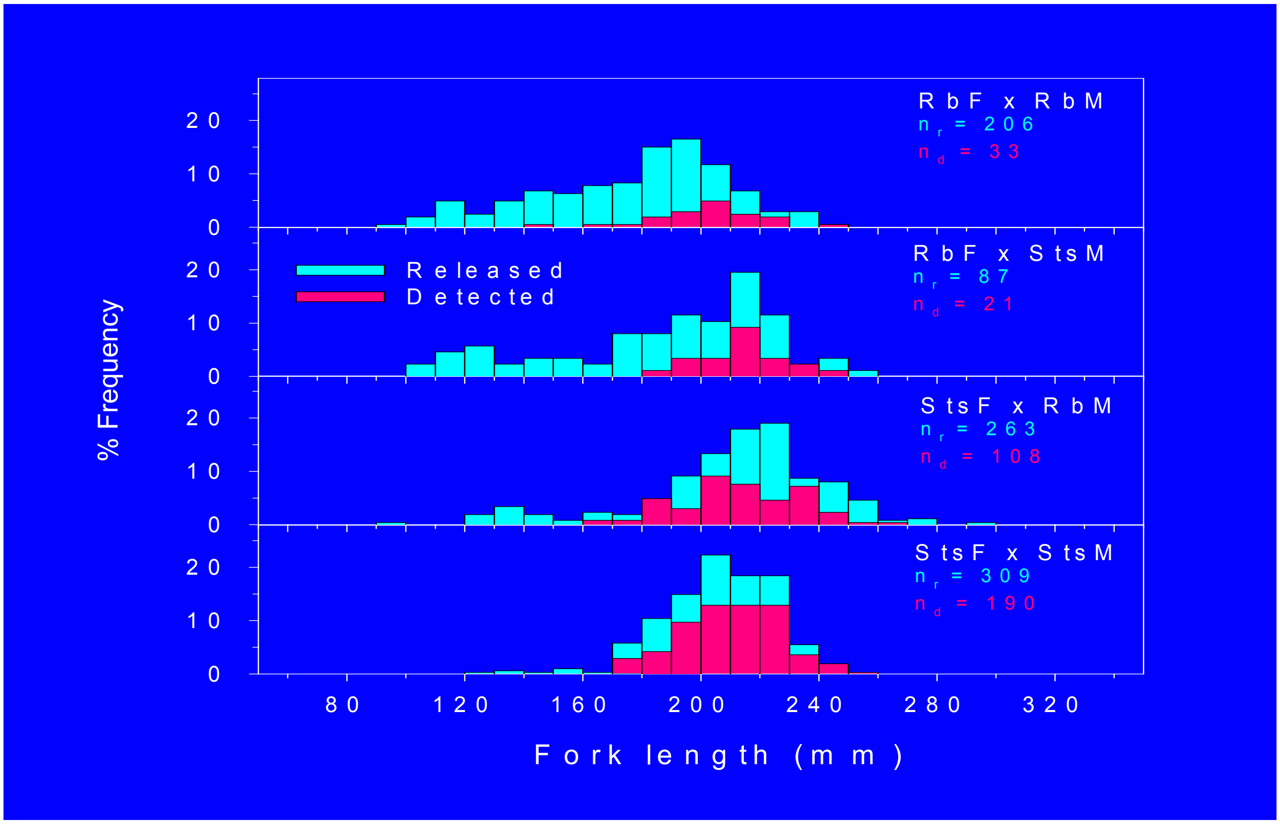


Figure 6. Migration timing of yearling Grande Ronde O. mykiss released in the Wallowa River and detected at Lower Granite Dam. Juveniles were crosses of resident males and females, anadromous males and females, resident females and anadromous males and anadromous females and resident males. Data from Carmichael (2005).

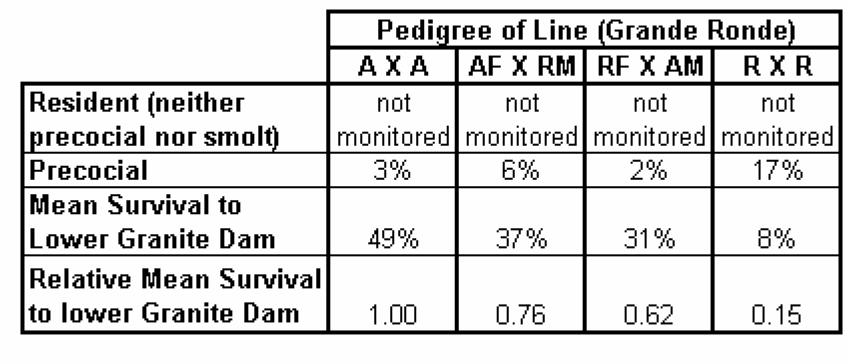
Figure 7 shows the length distribution of all fish at release, as well as the length distribution at release of only those individuals detected at Lower Granite Dam. This figure once more shows that the mean size of pure anadromous progeny was larger and less variable than fish in other lines, as well as the fact that detection at Lower Granite was very low for fish smaller than about 180mm at release, regardless of line. It should be noted that the precise fate of the smaller fish, or of any fish not detected at Lower Granite Dam, is not known. It is possible that some of these fish died during outmigration, that some reared an additional year and smolted the following spring, and that some never smolted but instead adopted a totally resident life history. At a presentation in February of 2005, Carmichael stated that the number of tagged fish detected at Lower Granite the year after release was “very small”, suggesting that most of the undetected fish either died during migration or an extra year of rearing, or became truly resident.

Figure 7. Mean length distribution of all juvenile Grande Ronde O. mykiss at release (blue bars) versus length distribution (at release) of individuals detected at Lower Granite Dam (red bars). Juveniles were crosses of resident males and females, anadromous males and females, resident females and anadromous males and anadromous females and resident males. Data from Carmichael (2005).



Finally, Table 3 summarizes the results of the controlled breeding and outmigration portion of the study in terms of developmental fate (insofar as it could be determined) and survival by line. Because Carmichael et al. did not estimate the proportion of fish in each line that neither smolted nor matured, the results cannot be directly compared with Thrower et al. The results do show that precocial males were produced at substantially lower rates that were observed in the Sashin lines, and that the pure resident line produced three to eight times as many precocial makes as the other lines. It is clear that the survival of the pure anadromous line to Lower Granite Dam was higher than any other line, being about 24% higher than the AF X RM line, 28% higher than the RF X AM line and 85% higher than the pure resident line. The data also suggests a maternal effect on smolting and survival as the survival of the AF X RM hybrid was greater than the RF X AM line.

Table 3. Developmental fate and survival to Lower Granite Dam of juvenile Grande Ronde O. mykiss PIT-tagged and released in the spring of their second year. Juveniles were crosses of resident males and females, anadromous males and females, resident females and anadromous males and anadromous females and resident males. Data from Carmichael (2005).



	Pedigree of Line (Grande Ronde)			
	A X A	AF X RM	RF X AM	R X R
Resident (neither precocial nor smolt)	not monitored	not monitored	not monitored	not monitored
Precocial	3%	6%	2%	17%
Mean Survival to Lower Granite Dam	49%	37%	31%	8%
Relative Mean Survival to lower Granite Dam	1.00	0.76	0.62	0.15

RECOMMENDATIONS FOR INCREASING YAKIMA STEELHEAD PRODUCTION

Based on the discussion of our current understanding of the environmental and genetic determinants and anadromy and residency in O. mykiss, it is reasonable to make the following recommendations for increasing steelhead production in the Yakima Subbasin.

1. Concentrate on appropriate tributaries in the upper Yakima and Naches watersheds. The upper Yakima and Naches watersheds, as opposed to the Satus and Toppenish creek watersheds, are the proper general focus for a steelhead enhancement program inside the Yakima Subbasin. This is so because, unlike Satus and Toppenish Creek, there is no evidence of density-dependent steelhead production there, suggesting production already is near capacity. Within these two drainages, the warmer tributaries would be better enhancement candidates because they provide better habitat for fry and early parr, and might support threshold growth rates for smoltification during the critical early developmental window.

   Habitat conditions in candidate tributaries might be altered to favor high growth rates in late spring and early summer – and thus the developmental decision to smolt – by increasing prey availability and decreasing the energetic cost of foraging. Prey availability could be improved by increasing primary production, by stream fertilization or by the addition of salmon carcasses or carcass analogs. Foraging could be made easier for juveniles by adding large woody debris or boulders to the stream margins and, wherever possible, by reconnecting cut-off side channels to the main channel.

2. Consider adult supplementation based on reconditioned upper Yakima kelts. One of the most significant findings of the Thrower et al. study is that the genetic basis for anadromy is not easily lost in steelhead populations. In light of the historical similarities between the upper Yakima and Sashin Lake populations, it is reasonable to assume that upper Yakima O. mykiss still retain the necessary genotype for smoltification.

   If one assumes the trait has been preserved, then it is clear that the most appropriate door stock for an upper Yakima steelhead supplementation program is the existing upper Yakima O. mykiss population. A potentially effective form of supplementation for the population could be the outplanting of reconditioned kelts. Adult steelhead could be tagged when intercepted on their spawning run at Roza Dam and then recaptured after spawning at the Chandler smolt trap and restored to health in the tribal kelt reconditioning program. Surviving adults, rather than their artificially reared progeny, could then be released into selected upper Yakima tributaries. This type of adult supplementation would eliminate most of the potential for domestication selection, would eliminate the potential for "mining" wild adults to support a hatchery and, because kelts are disproportionately female, would entail the production AF X RM hybrids, which Carmichael et al. found to produce nearly as many smolts as pure anadromous crosses.

3. Use the EDT-based procedure for the initial estimate of steelhead productivity and capacity, using lower values of W_A where impacts on the resident form are a high priority. Until an analytical tool is developed that adequately integrates habitat assessment, threshold growth rates for smolting and selection pressure for and against anadromy, the existing EDT-based method could be used in the initial design of a supplementation program for upper Yakima and Naches steelhead. As seen earlier, the mean of the W_A values – 4.45 -- that produced completely anadromous populations in Satus and Toppenish creeks could be used to estimate the potential equilibrium abundance of steelhead in selected tributaries under defined conditions, and this abundance estimate could be used to size an adult outplanting program. Smaller values for W_A could be used if suppression of resident trout production were a major concern, because smaller W_A values assume an equilibrium population composed of relatively more trout and fewer steelhead.

4. Improve survival of outmigrating steelhead smolts and returning adults. A relatively large equilibrium abundance of the anadromous life history type presupposes a reasonably large productivity value for steelhead. One of the most effective ways of increasing steelhead productivity relative to resident trout is to increase the survival of outmigrating smolts and the pre-spawning survival of returning adults.

   Smolt survival could be increased substantially if the causes of mortality at irrigation dams were reduced or eliminated. Currently, based on the recoveries of PIT-tagged smolts (Neeley 2000), steelhead smolt mortality rates at the major lower river diversions dams (Wapato, Sunnyside, Prosser) are estimated at approximately 7, 15 and 30% for the months of April, May and June, respectively. Although losses at other diversion dams are assumed to be somewhat less, the cumulative impact on smolts beginning migration from a point high in the watershed can be severe. As was seen earlier, the elimination of just the mortality associated with diversion dams might provide the advantage steelhead need to increase their relative abundance in the upper Yakima and Naches watersheds.

   One of the most reasonable explanations for the loss of smolts at diversion dams is predation by birds and fish at the bypass outfalls (Fast et al. 1991). Therefore a reasonable approach to increasing the productivity of all anadromous fish in the Yakima Subbasin would be to reduce the numbers of predators congregating in the vicinity of diversion dams and bypass outfalls, and/or to rebuild the outfall structures themselves, such that bypassed juveniles are returned to the river more slowly and gently and over a greater area.

   Clearly, steelhead production would also be increased if pre-spawning mortality of adults were reduced. It is, however, unclear how pre-spawning mortality could be reduced, unless smolts from targeted streams were externally marked so that returning adults could be recognized and collected at Prosser Dam. If a smolt-based steelhead supplementation program is ever implemented in the upper Yakima or Naches watersheds, hatchery smolts could be marked with injected elastomer implants indicating their stock and tributary of release. Such fish could then be recognized at Prosser Dam and transported directly to the appropriate tributary.

5. Conduct appropriate research on Yakima steelhead. All of the various types of study described in this report should be conducted on Yakima O mykiss populations. A thorough Sr/Ca otolith study throughout the watershed is needed to determine with certainty that interbreeding occurs freely or only in certain areas. Carmichael et al, have provided an excellent blueprint for a Yakima study of this type. Controlled mating studies like those of Carmichael et al. and Thrower et al. are also clearly necessary. If the outcome of supplementation or environmental manipulation on an interbreeding trout and steelhead population is to be predicted with any degree o certainty, the tendency of local fish of different sex and pedigree to produce smolts, precocial males or resident trout must be determined. The timing and magnitude of threshold growth rates for smoltification is another issue that must be resolved before ideal outplanting streams can be recognized or sub-optimal streams can be appropriately modified. Last but certainly not least, the relative abundance of resident adults, steelhead and their progeny must be regularly monitored in the upper Yakima and Naches watersheds, perhaps especially in tributaries or other areas that appear compatible with steelhead spawning and rapid early growth. Only by monitoring relative abundance of trout and steelhead and their reproductive success (with otolith analysis) can the truth of future theories of the determinants of the relative abundance of trout and steelhead be determined.

   Fortunately, the Yakima Subbasin already has most of the infrastructure necessary to conduct a comprehensive study of rainbow/steelhead ecology. The Cle Elum hatchery already contains rearing facilities necessary for family-based studies like that of thrower et al, and the Co-Managers of the Yakima/Klickitat Fisheries Project already possess the equipment and expertise to PIT-tag and monitor the movements and survival of juveniles as was done in the Carmichael study. Moreover, the opportunities for monitoring the movements of tagged or untagged fish in the Yakima Subbasin far surpass anything that was available to either Carmichael or Thrower.

   Increasing the abundance of steelhead in the upper Yakima would seem to be a superb opportunity for true adaptive management. Easily monitored, promising candidate tributaries are abundant (Taneum, Swauk, Umtanum and Manastash creeks, the forks of the Teanaway River, etc.), adult and juvenile monitoring and capture facilities are present at multiple sites, a state-of-the-art hatchery research complex exists at Cle Elum, and the Co-managers has developed a large staff of expert researchers. It is therefore suggested that an adult steelhead supplementation project be implemented on one or more upper Yakima tributaries, that coordinated research on developmental windows and the genetic architecture of anadromy and residency be conducted at the Cle Elum hatchery, and that the targeted tributaries be intensively monitored for changes in adult rainbow and steelhead abundance and their relative reproductive success in situ.

References

Ardren, W. 2003. Genetic analyses of steelhead in the Hood River, Oregon: statistical analyses of natural reproductive success of hatchery and natural-origin adults passed upstream of Powerdale Dam. Report to the Bonneville Power Administration, Portland, OR.

Behnke, R. 2002. Comment: First Documented Case of Anadromy in a Population of Introduced Rainbow Trout in Patagonia, Argentina. Transactions of the American Fisheries Society 131:582–585, 2002.

Blouin, M. 2003. Relative reproductive success of hatchery and wild steelhead in the Hood River. Report to Oregon Department of Fish and Wildlife, Portland, OR.

Cramer, S.P., D.B. Lister, P.A. Monk, K.L. Witty. 2003. A review of abundance trends, hatchery and wild fish interactions, and habitat features for the Middle Columbia Steelhead ESU. Prepared for: Mid Columbia Stakeholders, March 2003. S.P. Cramer & Associates, Inc. 39330 Proctor Blvd Sandy, OR 97055

Fast, D., J. Hubble, M. Kohn, and B. Watson. 1991. Yakima River spring chinook enhancement study. Final report submitted to Bonneville Power Administration, Portland, Oregon. DOE/BP-39461-9.

Gross, M.R. 1987. Evolution of Diadromy in fishes. American Fisheries Society Symposium 1: 14-25, 1987.

Hockersmith, E., J. Vella, L. Stuehrenberg, R.N. Iwamoto, and G. Swan. 1995. Yakima river radio-telemetry study: Steelhead, 1989-93. National Marine Fisheries Service, report to Bonneville Power Administration, contract DE-AI79-BP00276, Portland, Oregon, 94 pp.

Kostow, K. 2003. Factors that Influence Evolutionarily Significant Unit boundaries and status Assessment in a highly polymorphic species, Oncorhynchus mykiss, in the Columbia Basin. Oregon Department of Fish and Wildlife Information Report #2003-04, October 15, 2003. Prepared under an Interagency Personnel Agreement (IPA) between Oregon Department of Fish and Wildlife, Fish Division, Portland OR. and NOAA Fisheries, NW Fisheries Science Center, Seattle WA.

Larson, D.A., B.R. Beckman, K.A. Cooper, D. Barrett, M. Johnson, P. Swanson and W. Dickhoff. 2003. Assessment of high rates of precocious male maturation in a spring Chinook salmon supplementation hatchery program. Transactions of the American Fisheries Society: Vol. 133, No. 1, pp. 98–120.

Lestelle, L. 2000 Equations to partition performance of O. mykiss between resident (rainbow) and anadromous (steelhead) life history forms. Unpublished paper prepared for the Yakama Indian Nation.

Lynch, M..and B. Walsh.1998. Genetics and Analysis of Quantitative Traits. Sunderland, MA: Sinauer Associates, Inc.

Metcalfe, N.B. 1998. The interaction between behavior and physiology in determining life history patterns in Atlantic salmon (*Salmo salar).* Can. J. Fish. Aquat. Sci. 55(Suppl. 1): pp 93-103

Neeley, D. 2001. Annual report: Outmigration year 2000. Part 2. Chandler Certification and Calibration (Spring Chinook and Coho). Report to Bonneville Power Administration and the Yakima/Klickitat Fisheries Project. April 12, 2001.

Pascual, M, P. Bentzen, C. Rossi, G. Mackey, M. Kinnison and R. Walker. 2001. First Documented case of anadromy in a population of introduced rainbow trout in Patagonia, Argentina. Transactions of the American Fisheries Society 130:53–67, 2001

Pearsons, T.N., S.R. Phelps, S.W. Martin, E.L. Bartrand and G.A. McMichael. 1998. Gene flow between resident and anadromous rainbow trout in the Yakima Basin: ecological and genetic evidence. Project No. 89-105. Bonneville Power Administration, Portland, OR.

Ruzycki, J.R., M.W. Flesher, R.W. Carmichael, and D.L. Eddy. 2003. Oregon Evaluation Studies, Lower Snake Compensation Plan. Oregon Department of Fish and Wildlife. Portland, OR.

Schmidt, S. P. and House, E. W. 1979. Precocious sexual development in hatchery-reared and laboratory maintained male steelhead trout (Salmo gairdneri). Journal of the Fisheries Research Board of Canada 36, 90.93.

Thrower, J, J. Hard and J.E. Joyce. 2004. Genetic architecture of growth and early life-history transitions in anadromous and derived freshwater populations of steelhead Journal of Fish Biology (2004) 65 (Supplement A), pp 286 –307.

Utter, F. 2001. Patterns of subspecific anthropogenic introgression in two salmon generations. Reviews in Fish Biology and Fisheries. 10: 265-279.

Zabel, R.W., J.J.Anderson, P.A. Shaw. A multiple-reach model describing the migratory behavior of Snake River yearling chinook salmon (Oncorhynchus tshawytscha). Can. J. Fish. Aquat. Sci. 55: 658:667 (1998)

Zimmerman, C.E. and G.H. Reeves. 1996. Steelhead and rainbow trout early life history and habitat use in the Deschutes River, Oregon. 1995 Annual Report. Prepared for Portland General Electric Co. Portland, OR.

Zimmerman, C.E. and G.H. Reeves. 2002. Identification of steelhead and resident rainbow trout progeny in the Deschutes River, Oregon, revealed with otolith microchemistry. Transactions of the American Fisheries Society 131:986–993, 2002.

Appendix B

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

2004 Annual Report

June 27, 2005

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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.

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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 2004. 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 survival
- 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.

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 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).

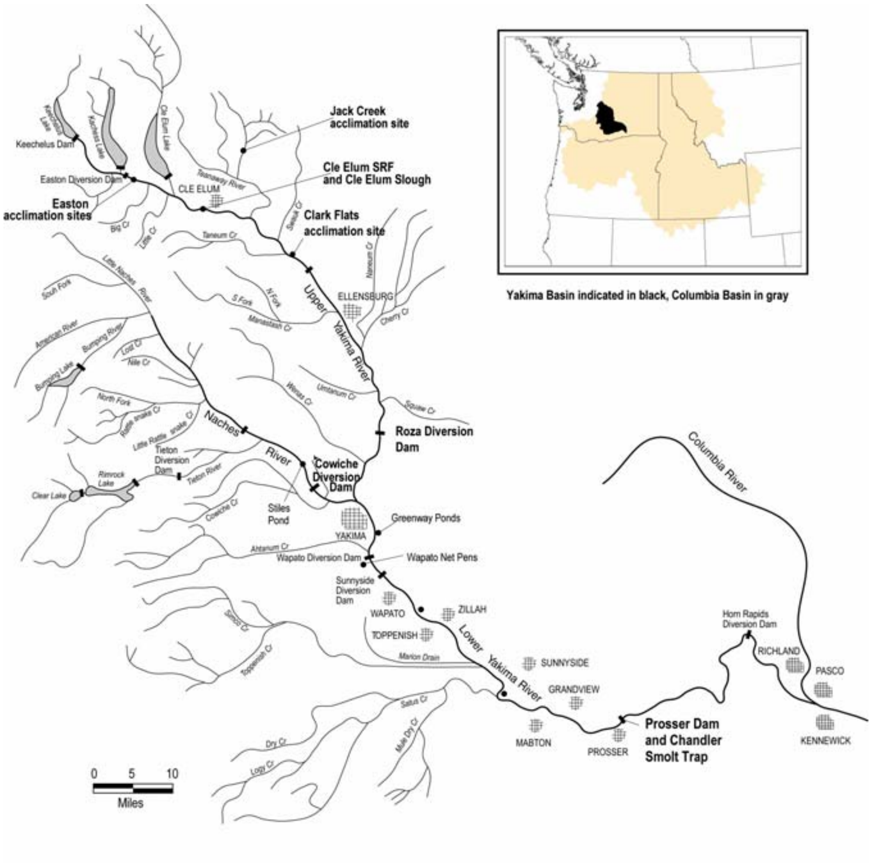

Figure 1. Yakima River Basin.

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).

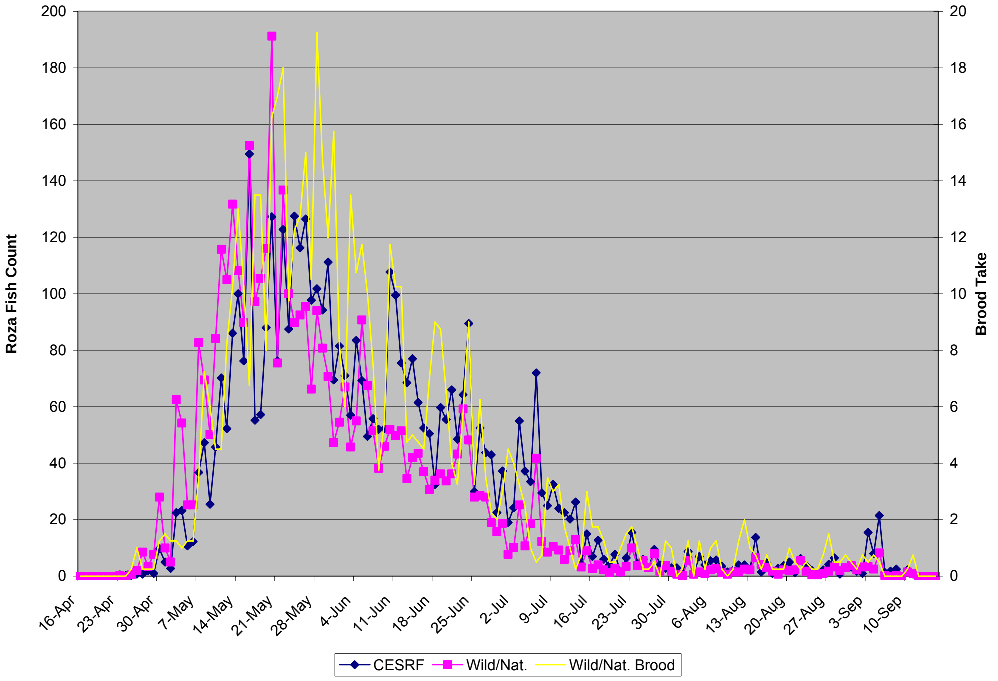

Figure 2. Mean spring Chinook run timing and broodstock collection at Roza Dam, 2001-2004.

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

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

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

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 "passively" 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
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*[1]							
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%
2002	1,820	89	1,909	6,064	71	6,135	7,884	160	8,044	76.3%
2003	394	723	1,117	1,036	1,105	2,141	1,430	1,828	3,258	65.7%
2004	6,536	671	7,207	2,876	204	3,080	9,412	875	10,287	29.9%
Mean[2]	3,213	349	3,562	4,010	591	4,601	7,311	1,036	8,347	57.9%

1. This is a rough estimate since Roza counts are not available for 1991.
2. For NoR columns, mean of 1997-present values. For all other columns, mean of 2001-present values.

Adult-to-adult Survival

The overall status of Yakima Basin spring Chinook is summarized in Table 3. Adult-to-adult survival 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 Below Prosser	Prosser Count	Harvest Above Prosser	Spawners Below Roza[2]	Roza Count	Roza Removals[3]	Est. Escapement		Redd Counts	
Year	Adults	Jacks	Total							Upper Y.R.[4]	Naches[5]	Upper Y.R.	Naches
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
Mean[6]	8,218	923	9,141	251	8,890	1,172	80	5,454	497	4,957	2,183	1,582	582

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 (1995-2004).

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		8,649	0.73
2001	12,084	784				
2002	8,073					
2003	3,341[1]					
2004	10,377					
Mean	3,753	315	3,160	126	3,556	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 Year	Estimated Spawners	Estimated Yakima R. Mouth Returns					Returns/ Spawner
		Age-3	Age-4	Age-5	Age-6	Total	
1982	86	85	1,275	324	0	1,683	19.57
1983	131	123	928	757	10	1,818	13.83
1984	383	110	706	564	0	1,381	3.60
1985	683	132	574	396	0	1,102	1.61
1986	2,666	68	712	499	15	1,294	0.49
1987	1,162	27	183	197	0	407	0.35
1988	1,340	32	682	828	0	1,542	1.15
1989	992	28	331	306	0	665	0.67
1990	954	24	170	74	0	269	0.28
1991	706	7	37	121	57	222	0.31
1992	852	29	877	285	0	1,191	1.40
1993	1,145	45	593	372	0	1,010	0.88
1994	474	14	164	164	0	343	0.72
1995	124	40	164	251	0	455	3.67
1996	887	179	3,987	1,620	0	5,787	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		633	1.77
2000	3,866	72	2,084			2,157	0.56
2001	3,914	127					
2002	1,861						
2003	1,400						
2004	2,197						
Mean	1,314	83	1,074	506	5	1,625	1.24

1. Approximately 48% of these fish were jacks.

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

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns Age-3	Age-4	Age-5	Age-6	Total	Returns/ Spawner
1982	22	42	223	248	0	513	23.32
1983	101	67	359	602	0	1,028	10.21
1984	187	54	301	458	0	813	4.36
1985	337	81	149	360	0	590	1.75
1986	1,457	36	134	329	11	509	0.35
1987	567	12	71	134	0	216	0.38
1988	827	19	208	661	5	892	1.08
1989	524	11	69	113	0	193	0.37
1990	425	15	113	84	0	213	0.50
1991	414	3	5	22	0	30	0.07
1992	335	23	157	237	0	417	1.24
1993	721	8	218	405	8	639	0.89
1994	230	7	36	16	0	59	0.26
1995	98	33	32	96	0	161	1.63
1996	159	30	173	760	0	964	6.05
1997	371	13	1,544	610	0	2,166	5.84
1998	414	120	766	1,153	0	2,039	4.92
1999	61	72	100	165		337	5.55
2000	246	62	165			227	0.92
2001	1,918	18					
2002	1,180						
2003	1,192						
2004	318						
Mean	555	31	276	360	1	641	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		843	2.02
2000	4,112	134	2,323			2,457	0.60
2001	5,832	146					
2002	3,041						
2003	2,592						
2004	2,515						
Mean	1,869	114	1,309	896	14	2,260	1.21

1. Approximately 48% of these fish were jacks.

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

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

Brood Year	Estimated Spawners	Estimated Yakima R. Mouth Returns Age-3	Age-4	Age-5	Total	Returns/ Spawner
1997	261	741	7,753	176	8,670	33.22
1998	408	1,242	7,939	584	9,765	23.93
1999	738[1]	134	693	16	843	1.14
2000	567	1,071	3,528		4,599	8.11
2001	595	383				
2002	629					
2003	441					
2004	597					
Mean	530	714	4,978	259	5,969	16.60

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 2004, age composition of American River spring Chinook has averaged 0, 38, 60, and 2 percent age-3, -4, –5, and -6, respectively (Table 9). Naches system spring Chinook averaged 2, 54, 43 and 1 percent age-3, -4, –5 and -6, respectively (Table 10). The upper Yakima River natural origin fish averaged 7, 87, 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	
Mean	1.2	46.0	52.3	0.5			35.4	62.4	2.2		0.4	37.8	59.9	1.9

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	
Mean	3.4	62.5	33.0	1.1		0.9	48.1	50.4	0.5		1.9	54.3	43.1	0.7

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	5.8	94.2		52		99.1	0.9	112	1.8	97.6	0.6
Mean	12.4	82.7	4.9		1.5	91.7	6.8		6.6	87.3	6.1

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 16, 81, and 3 percent age-3, -4, and –5, respectively (Table 12) from 2001-2004 compared to 12, 78, and 10 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. Furthermore, carcass recovery sample data for 2003 are incomplete as data collected by NOAA fisheries samplers has not been integrated into this data set. 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 Year	Males				Females				Total		
	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	10.0	90.0		20		98.0	2.0	51	2.8	95.8	1.4
Mean	35.4	62.0	2.7		0.2	96.4	3.3		15.5	81.4	3.1

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

Return Year	Males				Females				Total		
	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
Mean	23.4	71.7	4.9		0.2	93.1	6.6		12.5	81.8	5.7

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 Year	Males				Females				Total		
	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	
Mean	20.7	71.6	7.7			89.9	10.1		9.4	81.7	8.9

Sex Composition

In the American River, the mean proportion of males to females in wild/natural carcasses sampled on the spawning grounds from 1986-2004 was 48:52 for age-4 and 32:68 for age-5 spring Chinook (Table 15). In the Naches River, the mean proportion of males to females was 45.5:54.5 for age-4 and 25:75 for age-5 fish (Table 16). In the upper Yakima River, the mean proportion of males to females was 32:68 for age-4 and 25:75 for age-5 fish (Table 17).

For upper Yakima fish collected at Roza Dam for brood stock or research purposes from 1997-2004, the mean proportion of males to females was 38:62 and 35:65 for age-4 fish from the wild/natural and CESRF populations, respectively (Tables 19 and 20). For these same samples, the mean proportion of males to females was 36:64 and 39:61 for age-5 fish from the wild/natural and CESRF populations, 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 Year	Age-3		Age-4		Age-5		Age-6	
	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		
mean			48.0	52.0	32.2	67.8		

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

Return	Age-3		Age-4		Age-5		Age-6	
Year	M	F	M	F	M	F	M	F
1986	100.0		46.2	53.8	18.2	81.8	50.0	50.0
1987	100.0		31.0	69.0	13.3	86.7	100.0	
1988		100.0	36.4	63.6	28.6	71.4		
1989			60.0	40.0	25.9	74.1		100.0
1990	50.0	50.0	55.6	44.4	52.6	47.4		
1991	100.0		66.7	33.3	20.4	79.6		
1992	100.0		45.5	54.5	23.1	76.9	100.0	
1993			57.9	42.1	30.0	70.0		
1994			40.0	60.0	22.2	77.8		
1995			33.3	66.7	37.5	62.5		
1996			58.6	41.4		100.0		
1997	100.0		46.2	53.8	28.0	72.0	40.0	60.0
1998			29.4	70.6	27.9	72.1		
1999	100.0		62.5	37.5	25.0	75.0		
2000	100.0		44.1	55.9	25.0	75.0		
2001	100.0		37.4	62.6	24.6	75.4		
2002	100.0		37.4	62.6	20.0	80.0		
2003	83.3	16.7	47.1	52.9	36.1	63.9		
2004	100.0		29.4	70.6	20.0	80.0		
mean			45.5	54.5	25.2	74.8		

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		30.6	69.4		100.0
mean	82.4	17.6	31.9	68.1	24.8	75.2

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		26.5	73.5		100.0
mean	97.2	2.8	19.6	80.4	33.3	41.7

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
mean	97.8	2.2	38.3	61.7	35.8	64.2

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		
mean	100.0	0.0	35.3	64.7	39.0	61.0

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 1996-2004 (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 42, 60, and 71 cm for age-3, -4, and -5 males, and averaged 60 and 69 cm for age-4 and -5 females, respectively (Table 23). From 2001-2004, 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		
Mean[2]		40.0		59.2		76.6				62.3		72.9		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 1996-2004 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		
Mean[2]		40.9		60.2		76.0		78.0		41.0		60.9		72.8		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 1996-2004 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	3	44.0	49	58.8					111	58.4	1	67.0
Mean[1]		41.8		59.6		71.1		44.7		59.5		68.6

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[1] Mean of mean values for 1996-2004 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	18	60.9					50	57.9	1	68
Mean		45.5		60.4		69.2				61.6		69.6

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
Mean		42.0		59.4		71.3				60.1		68.5

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

	Males						Females					
Return	Age 3		Age 4		Age 5		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2001			4	61.3					33	60.4		
2002	2	40.2	25	59.6					63	59.4	2	66.1
2003	17	42.6	16	57.8	15	74.0			31	59.7	19	70.4
2004	6	39.4	9	57.1					42	59.3		
Mean		40.7		58.9		74.0				59.7		68.3

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
Mean				42.1		60.5		70.6

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

Return	Age 2		Age 3		Age 4		Age 5	
Year	Count	POHP	Count	POHP	Count	POHP	Count	POHP
2000	66	15.9	633	38.3				
2001	893	15.2	474	40.0	2343	59.3		
2002	475	15.2	26	38.7	1535	59.2	34	67.0
2003	137	15.7	394	41.8	255	60.6	215	71.4
2004	83	15.5	49	40.4	451	59.5	2	71.0
Mean		15.5		39.8		59.6		69.8

Migration Timing

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

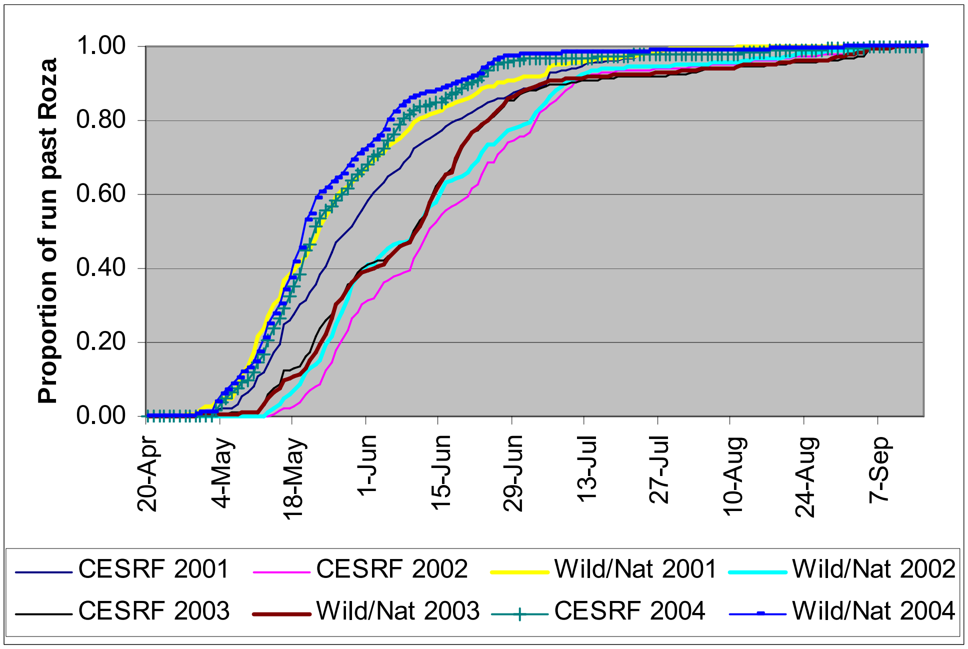

Figure 3. Proportionate passage timing at Roza Dam of wild/natural and CESRF adult spring Chinook (including jacks), 2001-2004.

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

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
Mean	13-Aug	11-Sep	25-Sep	21-Sep

1. Approximately one-half of the redds in the system were counted before this date and one-half were counted after this date. For the CESRF, approximately one-half of the total broodstock were spawned before 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
Mean	986	121	14	1,121	159	185	107	47	499

[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 December 17, 2004 to determine the number of CESRF releases not returning to the Yakima River Basin. For 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 Roza Dam. For coded-wire tagged fish, a stray is 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.

Table 32. Number of PIT- and CWT-tagged CESRF fish not returning to the Yakima River Basin (strays) per number of tagged fish released, brood years 1997-present.

Brood Year	PITs Released	PIT Strays	Stray Rate	CWTs Released	CWT Strays	Stray Rate
1997	39,892	2	0.01%	348,444	1	0.00%
1998	38,466	1	0.00%	575,451		
1999	39,799	0	0.00%	725,736		
2000	40,057	2	0.00%	802,039		
2001	40,029	7	0.02%	334,358		

Marked (adipose fin clipped) fish are occasionally found during carcass surveys in the Naches River system. Prior to 2004, all of those found have been determined to be out-of-basin strays based on analysis of recovered CWTs. Four adipose-fin-clipped fish were found during carcass surveys in the Naches system in 2004; it is presently unknown whether these fish were strays from the CESRF.

Table 33. Individual CESRF PIT-tagged fish detected outside of the Yakima River Basin by brood year, age class, and PIT tag code.

Brood Year	Age Class	PIT Code	Release Date	Observation Site[1]	Observation Date	Roza Date
1997	4	5216065700	4/1/1999	GRA	5/14/2001	
1997	4	52165D6560	4/1/1999	GRA	5/29/2001	
1998	5	3D9.1BF0EAE1D9	3/15/2000	PRA	4/26/2003	5/19/2003
1998	5	3D9.1BF0F63B24	4/22/2000	IHA	5/14/2003	
1999	4	3D9.1BF0EAFC98	4/1/2001	RIA	5/24/2003	6/15/2003
1999	4	3D9.1BF0EAFC98	4/1/2001	PRA	5/20/2003	6/15/2003
1999	4	3D9.1BF0EE3667	4/1/2001	IHA	5/26/2003	6/11/2003
2000	3	3D9.1BF10DA75F	4/1/2002	IHA	6/30/2003	
2000	3	3D9.1BF12FB9C1	4/1/2002	RIA	8/3/2003	
2000	3	3D9.1BF12FB9C1	4/1/2002	IHA	6/29/2003	
2001	2	3D9.1BF139D4DF	4/1/2003	IHA	7/24/2003	
2001	2	3D9.1BF139DD0A	4/1/2003	IHA	7/8/2003	
2001	2	3D9.1BF13ADA45	4/1/2003	RIA	8/2/2003	
2001	2	3D9.1BF13ADA45	4/1/2003	PRA	7/27/2003	
2001	2	3D9.1BF1560C65	4/1/2003	IHA	7/28/2003	
2001	2	3D9.1BF1562B78	4/1/2003	PRA	7/30/2003	
2001	2	3D9.1BF156311E	4/1/2003	PRA	6/9/2003	
2001	2	3D9.1BF166ABA2	4/1/2003	PRA	7/17/2003	

1. GRA=Lower Granite; IHA=Ice Harbor; PRA=Priest Rapids; RIA=Rock Island; WEA=Wells

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. 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 34 and 35.

Table 34. 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[8]	Fry Ponded[3]	Live-Egg-Fry Survival	Smolts Released[4]	Fry-Smolt Survival	Live-Egg-Smolt Survival
1997	261	23	91.2%	106	132	2.6%	482,287	451,458	6.4%	451,644	100.0%	386,048	85.5%	85.5%
1998	408	70	82.8%	140	198	1.4%	725,682	655,229	9.7%	646,353	98.6%	589,683	91.2%	90.0%
1999	738[5]	24	96.7%	213	222	2.7%	832,397	762,607	8.4%	759,412	99.6%	758,789	99.9%	99.5%
2000	567	61	89.2%	170	278	9.2%	937,516	878,534	6.3%	855,461	97.4%	834,285	97.5%	95.0%
2001	595	171	71.3%	145	223	53.2%	408,485	380,169	6.9%	367,564	96.7%	370,236	100.7%	97.4%
2002	629	89	85.9%	125	261	10.0%	892,239	791,266	11.3%	773,619	97.8%	749,067	96.8%	94.7%
2003	441	54	87.8%	115	200	0.0%	820,933	761,902	7.2%	739,988	97.1%	735,959	99.5%	96.6%
2004	592	70	88.2%	125	245	0.4%	830,108	762,349	8.2%	751,370	98.6%			
Mean	529	70	86.6%	142	220	9.9%	741,206	680,439	8.0%	668,176	98.2%	632,010	95.9%	94.1%

Table 35. Cle Elum Supplementation and Research Facility spawning and survival statistics (HoR brood only), 2001 - present.

Brood Year	Total Collected	Total Morts.	PreSpawn Survival	No. Fish Spawned[1] Males[2]	Females	% BKD Loss	Total Egg Take[6]	Live Eggs[7]	% Egg Loss[8]	Fry Ponded[3]	Live-Egg-Fry Survival	Smolts Released[4]	Fry-Smolt Survival	Live-Egg-Smolt Survival
2001	123	40	67.5%	4	30	40.1%	70,366	66,826	5.0%	These crosses for sampling purposes only; no fish ponded.				
2002	201	22	89.1%	26	72	4.2%	232,316	93,115	9.2%	91,398	98.2%	87,837	96.1%	94.3%
2003	143	12	91.6%	30	51	0.0%	201,690	87,966	8.2%	86,859	98.7%	88,733	102.2%	100.9%
2004	126	19	84.9%	22	49	0.0%	166,043	100,168	6.7%	98,469	98.3%			
Mean	148	23	83.3%	21	51	11.1%	167,604	87,019	7.3%	92,242	98.4%	88,285	99.1%	97.6%

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. May be greater than live egg count due to error associated with counting methods and mechanisms.
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. 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.
7. For only those HxH fish which were actually ponded.
8. All documented egg loss at spawn time plus dead eggs counted at shock divided by the estimated total egg take.

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.

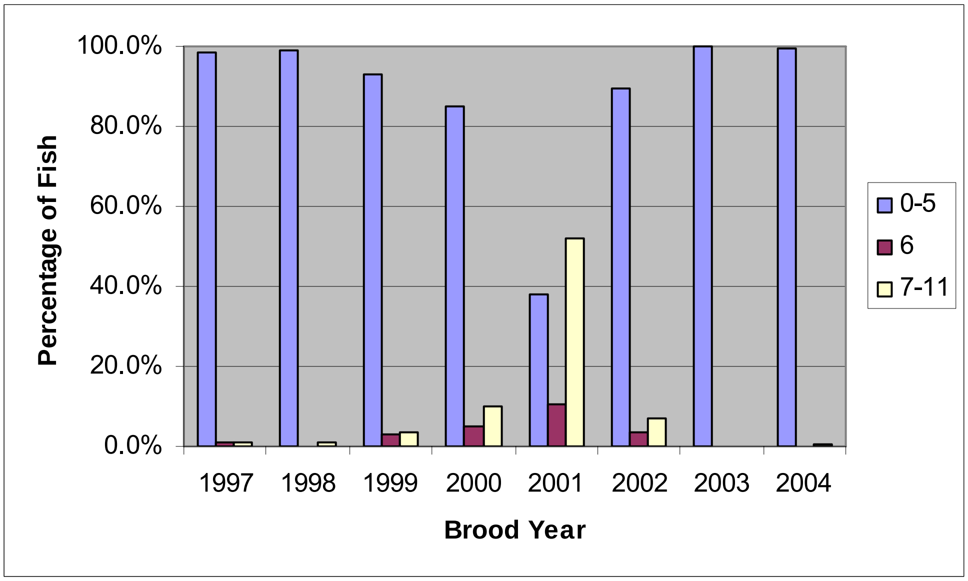

Figure 4. Proportion of wild/natural females spawned at CESRF by BKD rank, 1997 – present.

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. Average fecundity in the following table is calculated as the sum of the number of live eggs (machine count), dead eggs, and all documented egg loss for all females divided by the number of females (N) in the sample.

Table 36. 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	3,723.8	4	3,968.8						
1998			161	3,710.6	15	4,320.1						
1999			183	3,804.5	14	4,286.0						
2000			224	3,760.3	2	5,567.0						
2001			72	3,816.2	9	4,823.9			18	3,909.2		
2002	1	1,038.0	205	3,767.6	7	4,152.0			60	3,436.4	1	4,449.0
2003			163	4,013.6	31	4,994.8			30	3,302.1	19	4,989.5
2004			224	3,359.8	2	4,267.0			42	3,393.4		
Mean				3,744.5		4,547.4				3,510.3		4,719.2

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 37. Mean food conversion (lbs fed/lbs gained) of CESRF juveniles by brood year and growth month, 1997 – 2003.

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	
Mean	1.1	1.0	1.3	1.1	1.2	1.1	2.2	1.5	2.2	0.6	1.9	1.4	0.7

Length and Weight Growth Profiles

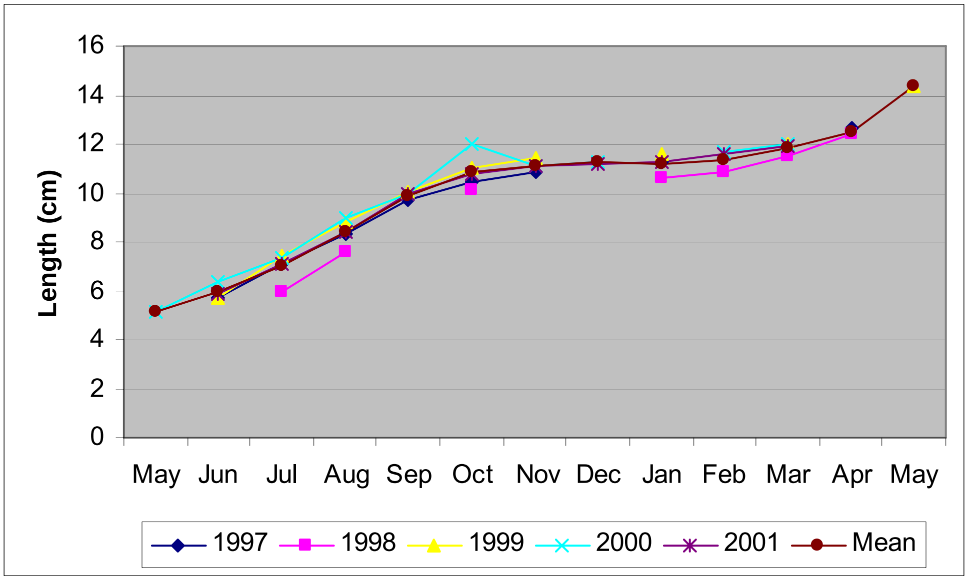

Figure 5a. Mean length (cm) of CESRF juveniles by brood year and growth month, 1997 - 2001.

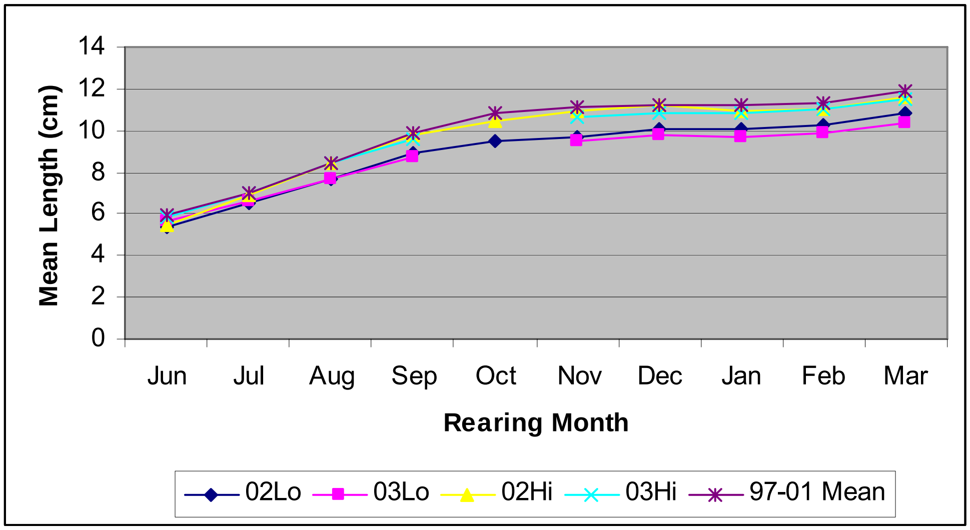

Figure 5b. Mean length (cm) of CESRF juveniles by brood year, treatment and growth month, 2002-2003.

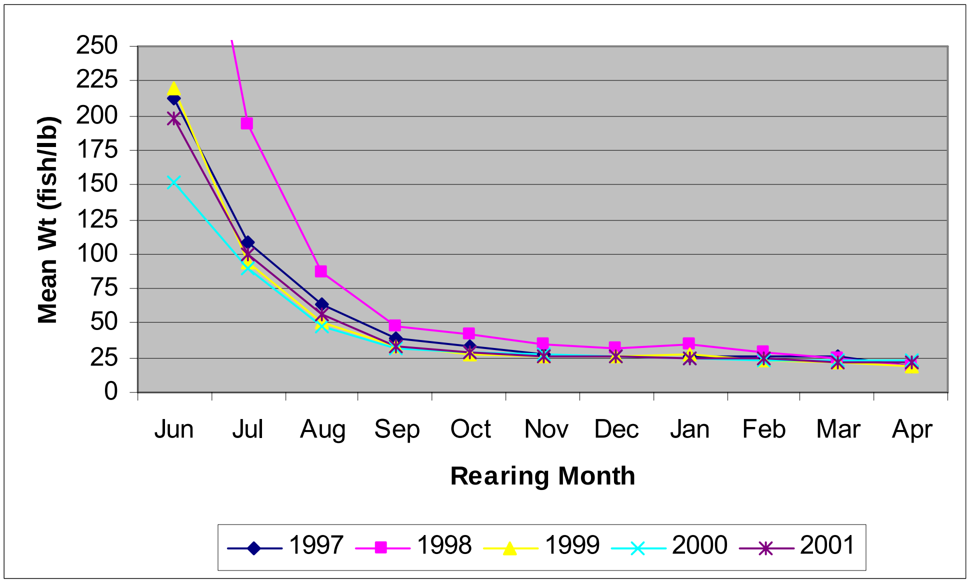

Figure 6a. Mean Weight (fish/lb) of CESRF juveniles by brood year and growth month, 1997 - 2001.

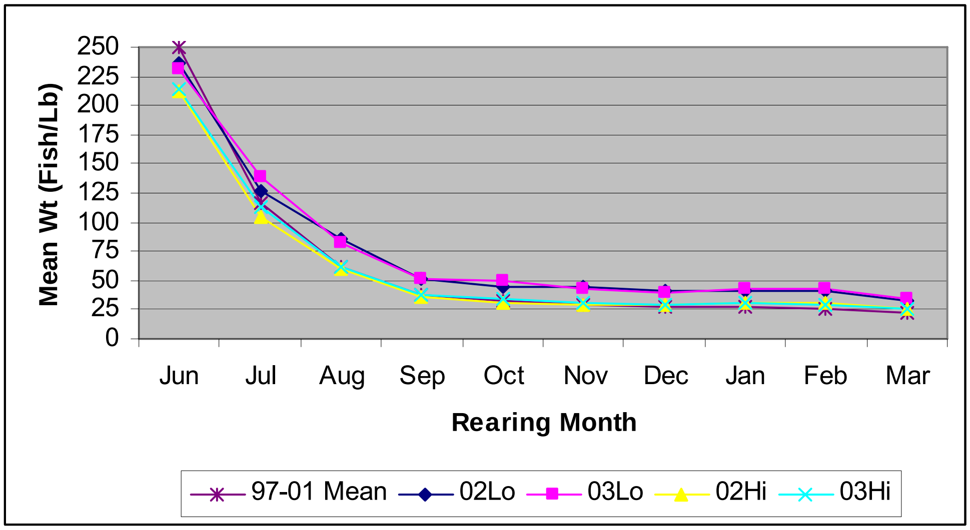

Figure 6b. Mean Weight (fish/lb) of CESRF juveniles by brood year, treatment and growth month, 2002-2003.

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

	Brood Year							
Raceway	1997	1998	1999[1]	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 brood.
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).

Predator Avoidance

A predator avoidance training experiment was conducted upon a population of hatchery Yakima spring Chinook juvenile salmon reared at the CERSF, in a pilot test that evaluates this type of behavioral conditioning as a fish culture methodology to improve hatchery juvenile smolt survival. This study was designed to test the hypothesis that predator-avoidance-trained (PAT) fish would survive in proportionally higher numbers than a comparable sized population of untrained (control or CNT) juvenile salmon. This study also employed a grid matrix to measure salmonids' behavioral response to avian predator activity. Avian predators were employed as training agents to three experimental raceways stocked with hatchery spring Chinook juveniles, and three raceways, also stocked with Chinook juveniles, were designated as experimental controls. Approximately 40,000 spring Chinook from brood year 2001 were used in this tri-replicate experimental design conducted during their rearing at the CESRF in 2002 and eventual release from the Easton acclimation site in the spring of 2003.

The critical measure in this study, the survival index, was derived from PIT-tag interrogations from out-migrating Chinook smolts passing through John Day and McNary Dams. The estimation method took John Day daily expansions, adjusted for passage timing rates based upon Bonneville detections, and the total number quantified was divided by the total number of PAT and control fish PIT-tagged, with tag shedding rates held at less than 1%. All fish at Easton were "forced out" of the acclimation ponds in late March of 2003 and this reduced the tag detection efficiency of the PIT-tag detection system at that site, though the effect on the total PIT-tagged denominator was determined to be minimal. No significant difference in survival was detected between PAT and control fish at John Day and McNary Dams (Table 39).

Table 39. Estimated survival indices of control (CNT) and predator-avoidance-trained (PAT) fish from PIT-tagging to passage at McNary and John Day Dams for 40,000 spring Chinook released from the Easton acclimation facility in migration year 2003.

	McNary		John Day	
	CNT	PAT	CNT	PAT
Detections	617	582	246	260
Expanded Detections	1238.8	1180.5	919.3	936.1
Number PIT-Tagged	4007	4000	4007	4000
Survival Index	0.3092	0.2951	0.2294	0.2340

Incidence of Precocialism

Since the start of hatchery production operations for spring Chinook salmon at the CESRF a team from NOAA Fisheries has conducted research to characterize the physiology and development of wild and hatchery-reared spring Chinook salmon in the Yakima River Basin. These studies have revealed that approximately 35-50% of the hatchery-reared males from this program undergo precocious maturation at 1+ years of age (Table 40). Recent data collected from fish at Roza Dam during mid-winter re-distribution indicates that only 5-10% of the wild spring Chinook precociously mature at 1+ years of age (Table 40). 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. The current research has four central objectives: 1) continue monitoring the maturation rate of the Cle Elum hatchery population, 2) monitor the rate of precocious male maturation in the wild Yakima spring Chinook population, 3) conduct pilot growth rate modulation studies at CESRF to control the precocious male maturation rate while ensuring the health and fitness of the smolts, and 4) assist tribal and state biologists with production scale growth modulation studies. Ultimately, these studies will help direct rearing strategies at the CESRF to allow production of hatchery fish with physiological and life-history attributes that are similar to their wild cohorts.

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.

Table 40. Upper Yakima Basin spring Chinook size and gender summary.

Sample Type	Brood Year	Sample Date	Number	Fork Length (mm)	Weight (g)	Female	Male	Prec. Male
CESRF	1997	3/2/1999	48	115.5	17.2	52.1%	47.9%	[1]
CESRF	1998[2]	3/14/2000	56	114.5	17.3	32.1%	32.1%	35.8%
CESRF	1999[3]	3/12/2001	1078	118.6	18.5	49.0%	26.0%	25.0%
CESRF	2000[3]	3/18/2002	1079	121.7	20.1	48.3%	33.3%	18.4%
CESRF	2001[3]	3/11/2003	660	118.9	18.9	52.5%	21.7%	25.8%
RozaWild	2001[4]	1/23/2003	283	107.8	13.0	50.5%	44.5%	4.9%
RozaWild	2001[4]	2/13/2003	317	97.0	9.2	51.4%	42.9%	5.7%

1. Precocious maturation was not determined in these fish from the first brood year sampled during physiological monitoring.
2. Samples collected during routine physiological monitoring just prior to volitional release.
3. Samples collected during pathology screening just prior to volitional release.
4. Samples collected at Roza Dam during winter re-distribution.

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 41. 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	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[3]	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
Mean	331,447	325,787	227,141	216,793	248,850	657,234

1. Brood years 1997-2001: Optimum Conventional Treatment (OCT). Brood Years 2002- : Normal (High) growth.
2. Brood years 1997-2001: Semi-natural Treatment (SNT). Brood Years 2002- : Slowed (Low) growth.
3. 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.

Table 42. CESRF average pond densities at release by brood year, treatment, and acclimation site.

Brood Year	Treatment Control[1]	Treatment[2]	Acclimation Site CFJ	ESJ	JCJ
1997	41,487	35,722	38,215	39,190	
1998	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[3]	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
Mean	42,980	42,068	41,704	43,245	43,383

1. Brood years 1997-2001: Optimum Conventional Treatment (OCT). Brood Years 2002- : Normal (High) growth.
2. Brood years 1997-2001: Semi-natural Treatment (SNT). Brood Years 2002- : Slowed (Low) growth.
3. 2001 Easton release was a predator-avoidance training sub-experiment. These releases are excluded from mean pond density calculations.

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.

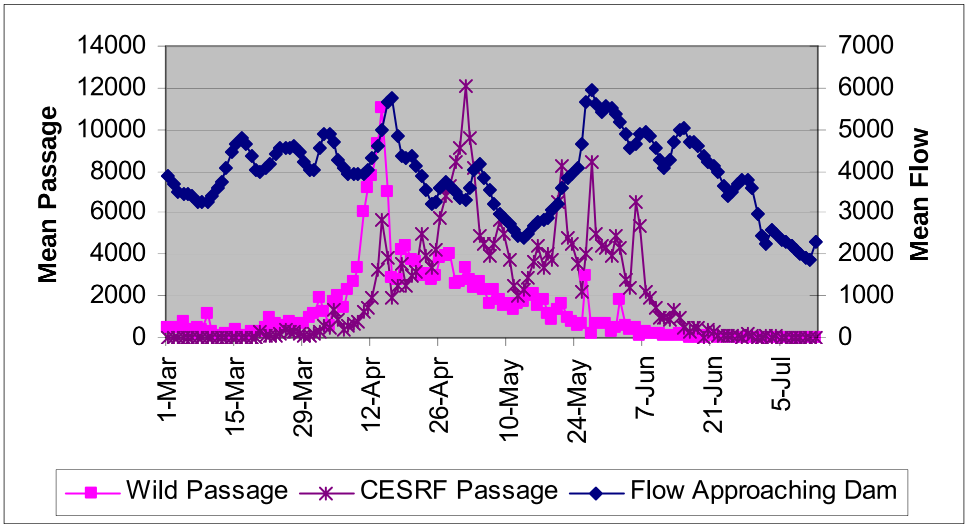

Figure 7. Mean flow approaching Prosser Dam versus mean estimated smolt passage at Prosser of aggregate wild/natural and CESRF spring Chinook for outmigration years 1999-2004.

Smolt-to-Smolt Survival

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

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

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[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.

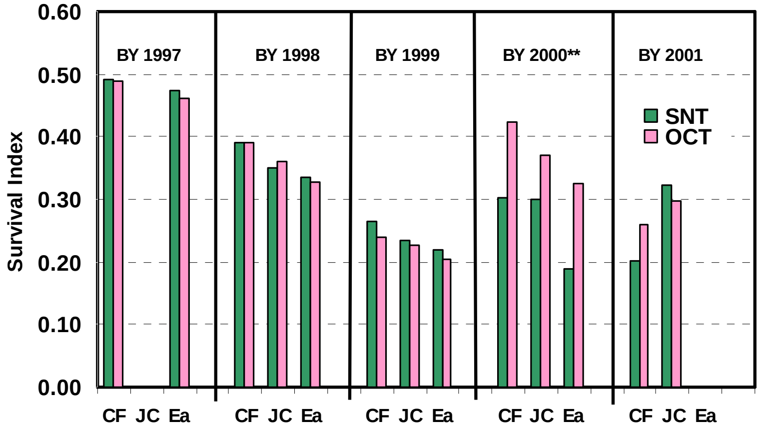
statistical tests did not result in the same level of significance. For the fourth brood, there was an elevated level of BKD infestation. The SNT-treated smolts had a significantly higher mean BKD index than did the OCT and also had a lower smolt-to-smolt survival index. When the survival index was adjusted 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 43. 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	**0.2401**	**0.2264**	**0.2035**	**0.4239**	**0.3716**	**0.3249**	**0.2600**	**0.2984**
SNT	Volitional Release Number	6454	6410	6455	5858	6466	5924	3372	11555
	Survival Index	**0.2646**	**0.2346**	**0.2194**	**0.3030**	**0.3001**	**0.1899**	**0.2005**	**0.3230**

1. See textual footnote 1 above.



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

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

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

** Unadjusted for BKD index

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)].

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) Detection of upstream-migrating PIT-tagged adult spring Chinook at Prosser Dam will not be possible for all returning fish until at least the spring of 2006. Adult PIT detection equipment was installed at the left-bank ladder at Prosser Dam in the fall of 2004. Installation of adult PIT detection equipment at the other two Prosser adult ladders is planned for the future as funding becomes available.

4) Detection of upstream-migrating PIT-tagged adult spring Chinook at Roza Dam presently occurs at an approximate 100% rate only for marked CESRF fish and wild/natural fish taken for broodstock. The majority of wild/natural fish are 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.

Given these complicating factors, Tables 44-47 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 44. Estimated smolt passage at Chandler and smolt-to-adult survival rates (Chandler smolt to Yakima R. mouth adult).

			Estimated Smolt Passage at Chandler				CESRF smolt-	Yakima R. Mouth Adult Returns[6]		Smolt-to-Adult Survival[6]	
Brood Year	Migr. Year	Mean Flow[1]	Wild/ Natural[2]	Control[3]	Treatment[4]	CESRF Total	to-smolt survival[5]	Wild/ Natural[2]	CESRF Total	Wild/ Natural[2]	CESRF Total
1982	1984	4134	381,857					6,753		1.8%	
1983	1985	3421	146,952					5,198		3.5%	
1984	1986	3887	227,932					3,932		1.7%	
1985	1987	3050	261,819					4,776		1.8%	
1986	1988	2454	271,316					4,518		1.7%	
1987	1989	4265	76,362					2,402		3.1%	
1988	1990	4141	140,218					5,746		4.1%	
1989	1991		109,002					2,597		2.4%	
1990	1992	1960	128,457					1,178		0.9%	
1991	1993	3397	92,912					544		0.6%	
1992	1994	1926	167,477					3,790		2.3%	
1993	1995	4882	172,375					3,202		1.9%	
1994	1996	6231	218,578					1,238		0.6%	
1995	1997	12608	52,028					1,995		3.8%	
1996	1998	5466	291,557					21,151		7.3%	
1997	1999	5925	274,436	45,469	56,042	101,511	26.3%	12,855	8,670	4.7%	8.5%
1998	2000	4946	74,054	109,087	116,020	225,107	38.2%	8,265	9,765	11.2%	4.3%
1999	2001	1321	116,422	235,316	216,433	451,749	59.5%	1,786	843	1.5%	0.2%
2000	2002	5015	441,712	193,515	132,228	325,743	39.0%	11,106[7]	4,599[7]	2.5%[7]	1.4%[7]
2001	2003	3504	249,559	48,082	59,819	107,901	29.1%				
2002	2004	2439	160,724	175,933	166,430	342,363	40.9%				

1. Mean Flow approaching Prosser Dam March 29-July 4. No data available for migration year 1991.
2. Aggregate of Upper Yakima, Naches, and American wild/natural populations. For migration years 1984-1999 includes estimates of juvenile migration during winter months (generally Nov – Feb). Winter migrant estimates for migration years 2000-2004 are interpolated using prior years' data.
3. Brood years 1997-2001: Optimum Conventional Treatment (OCT). Brood Years 2002- : Normal (High) growth.
4. Brood years 1997-2001: Semi-natural Treatment (SNT). Brood Years 2002- : 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; does not include age-5 adult returns.

Table 45. Estimated wild/natural smolt-to-adult return rates (SAR) based on adult detections of PIT tagged fish. Roza tagged smolts to Bonneville Dam adult returns.

		Wild/Natural smolts tagged at Roza				
		Adult Returns at Age[1]				
Brood Year	Number Tagged	Age 3	Age 4	Age 5	Total	SAR[1]
1997	310	0	1	0	1	0.32%[2]
1998	6,209	15	171	14	200	3.22%
1999	2,179	2	8	0	10	0.46%
2000	8,718	1	51		52	0.60%
2001	7,804	9			9	

Table 46. Estimated CESRF smolt-to-adult return rates (SAR) based on adult detections of PIT tagged fish. Roza tagged smolts to Bonneville Dam adult returns.

		CESRF smolts tagged at Roza				
		Adult Returns at Age[1]				
Brood Year	Number Tagged	Age 3	Age 4	Age 5	Total	SAR[1]
1997	407	0	2	0	2	0.49%[2]
1998	2,999	5	42	2	49	1.63%
1999	1,744	1	0	0	1	0.06%
2000	1,503	0	1		1	0.07%
2001	2,146	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 47. Estimated release-to-adult survival of PIT-tagged CESRF fish (CESRF tagged smolts to Bonneville and Roza Dam adult returns).

		Adult Detections at Bonn. Dam					Adult Detections at Roza Dam				
Brood Year	Number Tagged	Age3	Age4	Age5	Total	SAR	Age3	Age4	Age5	Total	SAR
1997[1]	39,892	18	182	4	204	0.51%	65	517	16	598	1.50%
1998	38,466	49	478	48	575	1.49%	54	310	34	398	1.03%
1999	39,799	1	25	1	27	0.07%	1	22	0	23	0.06%
2000	40,057	42	159		201	0.50%	37	110		147	0.37%
2001	40,029	32					20				

1. 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.

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 48. 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%
Mean	444	635	578	203	907	679	876	12.5%

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

Year	Columbia R. Mouth Run Size	Col. R. Mouth to BON Harvest	BON to McNary Harvest	Yakima R. Mouth Run Size	Yakima River Harvest	Columbia Basin Harvest Summary			Col. Basin Harvest Rate	
						Total	Wild	CESRF	Total	Wild
1982	3,709	65	276	1,822	434	775	775	0	20.9%	
1983	2,370	120	104	1,441	84	308	308	0	13.0%	
1984	3,830	141	274	2,658	289	704	704	0	18.4%	
1985	5,342	205	192	4,560	865	1,262	1,262	0	23.6%	
1986	13,378	282	824	9,439	1,340	2,447	2,447	0	18.3%	
1987	6,111	97	408	4,443	517	1,022	1,022	0	16.7%	
1988	5,967	411	430	4,246	444	1,285	1,285	0	21.5%	
1989	8,538	219	689	4,914	747	1,654	1,654	0	19.4%	
1990	6,099	327	425	4,372	663	1,414	1,414	0	23.2%	
1991	4,172	177	270	2,906	32	479	479	0	11.5%	
1992	5,684	98	363	4,599	345	806	806	0	14.2%	
1993	4,328	36	281	3,919	129	446	446	0	10.3%	
1994	1,910	82	102	1,302	25	209	209	0	10.9%	
1995	1,221	0	74	666	79	153	153	0	12.6%	
1996	5,409	4	293	3,179	475	772	772	0	14.3%	
1997	5,148	2	373	3,173	575	951	951	0	18.5%	
1998	2,638	2	150	1,903	188	341	341	0	12.9%	
1999	3,832	3	194	2,781	604	801	801	0	20.9%	
2000	26,722	53	1,684	19,100	2,458	4,195	4,075	120	15.7%	
2001	29,618	992	3,880	23,265	4,630	9,503	5,462	4,041	32.1%	30.7%
2002	21,858	1,328	2,456	15,099	3,108	6,891	2,542	4,350	31.5%	26.9%
2003	10,157	347	883	6,957	440	1,670	1,062	608	16.4%	16.1%
2004[1]	21,875	1,110	1,943	15,289	1,679	4,731	2,725	2,006	21.6%	17.3%
Mean	8,692	265	720	6,175	876	1,862	1,378	2,751	18.2%	17.7%

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 50 gives the results of a query of the RMIS database run on December 17, 2004 for CESRF spring Chinook CWTs released in brood years 1997-2000. 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 50. Marine and freshwater recoveries of CWTs from brood year 1997-2000 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) Dec. 17, 2004.

Brood	Observed CWT Recoveries			Expanded CWT Recoveries		
Year	Marine	Fresh	Marine %	Marine	Fresh	Marine %
1997	3	56	5.1%	6	320	1.8%
1998		52	0.0%		234	0.0%
1999[1]		2			10	
2000[1]		1			5	

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 1999-2000 are considered incomplete.

Literature Cited

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

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

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

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

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

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

Olla, B.L., M.W. Davis, and C.H. Ryer. 1994. Behavioural deficits in hatchery-reared fish: potential effects on survival following release. Aquaculture and Fisheries Management 25 (Suppl. 1):19-34.

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

Appendix A. *Tag and Release Information by Cle Elum Pond Id, Brood Years 1997-2003.*

Brood Year	C.E. Pond	Accl. Pond	Treatment /Avg BKD[1]		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; HI = normal growth or LO = slowed growth for brood years 2002 – present. 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 1997-2003.*

Brood Year	C.E. Pond	Accl. Pond	Treatment /Avg BKD[1]		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; HI = normal growth or LO = slowed growth for brood years 2002 – present. 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 1997-2003.*

Brood Year	C.E. Pond	Accl. Pond	Treatment /Avg BKD[1]		Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
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; HI = normal growth or LO = slowed growth for brood years 2002 – present. All fish are progeny of wild/natural parents unless denoted as HH which designates the hatchery control line beginning with brood year 2002. "Avg BKD" denotes the average BKD ELISA ranking of the female parents whose progeny were in these ponds.

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Brood Year	C.E. Pond	Accl. Pond	Treatment /Avg BKD[1]		Tag Information			First Release	Last Release	CWT Code	No. PIT	No. CWT	Est. Tot. Release[2]
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; HI = normal growth or LO = slowed growth for brood years 2002 – present. 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 1997-2003.*

Brood Year	C.E. Pond	Accl. Pond	Treatment /Avg BKD[1]			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] Optimum Conventional (OCT) or Semi-Natural (SNT) for brood years 1997-2001; HI = normal growth or LO = slowed growth for brood years 2002 – present. 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 1997-2003.*

Brood Year	**C.E. Pond**	**Accl. Pond**	**Treatment /Avg BKD**[1]			**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	Anterior Dorsal	3/9/2005	4/27/2005	610136	2,222	41,017	43,021
2003	CLE12	CFJ03	HI	HH	0.1	Left	Red	Anterior Dorsal	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] Optimum Conventional (OCT) or Semi-Natural (SNT) for brood years 1997-2001; HI = normal growth or LO = slowed growth for brood years 2002 – present. 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 C

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Annual Report: Survival of Upper Yakima Spring Chinook from 2004 Release to McNary Dam Smolt Passage for Releases Subjected to Low and High Early-Rearing Nutritional Regimes

Doug Neeley, Consultant to Yakama Nation

Introduction

Two early-rearing nutritional regimes were tested for brood-year 2002 hatchery-reared Yakima Upper spring chinook. A lower feeding rate (low treatment) was administered at the Cle Elum Hatchery through early rearing to determine whether that treatment would reduce the proportion of precocials produced compared to conventional nutritional early rearing, which served as a control treatment (high treatment). The goal was to have 10 grams/fish for the lower treatment and 15 grams/fish for the high treatment by mid-October 2003, 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. Early in 2004, 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. Screens at the acclimation site were pulled on March 15, after which the smolt could volitionally exit the ponds until late May when all smolt remaining in the ponds were forced out.

This report does not directly evaluate the effect of the two treatments on the precocial rate; instead, its major focus is evaluating their effects on smolt-to-smolt survival from release to McNary Dam passage.

Summary

The lower early-rearing feeding-rate treatment had a significantly lower smolt-survival index than the conventional feeding-rate treatment. The mean release size of the low treatment was significantly less than the high treatment, but when the smolt-survival index was adjusted for the mean pre-release size as a covariate, there was no significant difference between the adjusted treatment means. The volitional mean release date of the low treatment was significantly earlier than the high treatment, but the low-treatment mean[1] McNary-passage date was significantly later than the high treatment.

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[1] Mean passage date was statistically analyzed instead of median passage date because statistical tests for means are generally more powerful than those for means; however median passage dates are also presented.

Analysis

Methods of estimating the survival index are discussed in Appendix A along with the individual ponds' survival-index estimates. Mean survival indices are presented in Table 1.a. for each treatment within each site and are also presented graphically in Figure 1. A logistic analysis of variation of the survival indices is presented in Table 1.b. The low treatment has a significantly lower survival index than does the high treatment (P = 0.004, Table 1.b). The consistency of the low treatment's performance over sites is evident in Figure 1. Further, the low treatment had the lower survival index for 8 of the 9 paired-ponds blocks.

I also assessed the effect of the treatment on the pre-release size of the smolt, measured as grams/fish[2]. The mean fish size is given for each treatment within each site in Table 2.a and in Figure 2 with an associated analysis of variance in Table 2.b. The low treatment consistently had the lowest pre-release smolt size (9 of the 9 paired-pond blocks), the main effect treatment difference being highly significant (P < 0.001, Table 2.b.). A logistic analysis of covariation of survival on fish size resulted in the difference in treatment survival means adjusted for pre-release size being non-significant (P = 0.740, Table 3.b.), the adjusted low and high means being more similar than the unadjusted means (Table 3.a. and Figure 3 respectively compared to Table 1.a. and Figure 1).

It is interesting to note that the mean date of volitional release was significantly earlier for the low treatment (P = 0.026, Table 4.b), but the mean date of McNary passage was significant later (P < 0.001, Table 5.b) than that for the high treatment. The mean release dates for the two treatments for each site are given in Table 4.a and Figure 4 with the associated analysis of variance given in Table 4.b.[3]. Although the mean release date for the low treatment release date is slightly later than the high treatment for Jack Creek (Figure 4), for two of the three blocks at that site the low treatment had an earlier release date, as was the case for Easton: however, the low treatment had the earliest release date for all three pairs of ponds for Clark Flat[4]. The mean and median McNary passage dates for the two treatments for each site are given in Table 5.a. with the associated analysis of variance give in Table 5.b. It should be noted that the median and mean passage dates are almost identical; therefore only the mean passage dates are given in Figure 5 and subsequent passage date summaries. Even though the differences in the mean passage dates are not great, the low treatment had the latest mean and median passage date for each of 9 blocks.

If there were no true treatment differences in over-all smolt survival, then a decrease in precocialism due the low treatment should result in more smolts passing McNary Dam in their outmigration to the ocean resulting in a higher estimated survival to McNary, but the opposite is the case. However, the reduced low-treatment survival may be due to a possibly later smolting resulting from the smaller pre-release size, which may have also contributed to the later McNary passage time associated with the low treatment. The decision was made to partition the release period as nearly as possible into ten-day periods and to investigate the smolt-to-smolt survival and the mean McNary passage date within these release periods.

Preliminary estimates[5] were made of survival of low and high fish that exited the acclimation ponds within the 1st, 2nd, 3rd, and 4th ten-day periods after the screens were pulled at the acclimation site permitting volitional release (the respective periods beginning March 15, March 25, April 4, and April 14). Survival estimates were also made for all fish exiting April 24 or thereafter, since there were an insufficient number of fish remaining to

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[2] Converted from fish/pound measure used at Cle Elum hatchery

[3] In the analysis of variance, the block source F-ratio was nearly 1 or less; therefore it was pooled with the error source to provide a pooled error with a larger degrees of freedom, providing more powerful statistical tests.

[4] The possible relative differences among the acclimation sites are reflected in the magnitude of the Site x Treatment interaction, which was significant at the 10% level (P = 0.092, Table 4.b.).

[5] These are preliminary because no attempt was made to adjust these estimates for fish that were removed at McNary and transported or possibly sacrificed. Such fish only comprised 2% of the total low- and high-treated fish that were PIT-tagged in the hatchery and detected at McNary. However, survival-index estimates based on total passage presented in Tables 1.a, 1.b., 3.a., and 3.b., and in Figures 1 through 3 as well as passage-time summaries in Table 5., 5.b., and Figure 5 were adjusted for fish removed at McNary.

permit a further ten-day partitioning. The estimates are graphically presented in Figure 6. As illustrated in the figures, the survival rates for the High exceeded those for the Low at the 5% significance level in each of the first three periods (p = 0.000, 0.008, and 0.018, respectively). The survival rates do not differ significantly for the last two periods (p = 0.757 and 0.717, respectively). Of the total fish released, 67.5% of the low and 62.2% of the high had exited the ponds during the first three periods when the high survival was greater than the low. As can be seen from Figure 7 the McNary mean passage date is later for the low fish in all periods, significantly so in the first four periods (p = 0.000, 0.002, 0.000, 0.041, and 0.319 for the 1st through 5th periods, respectively). Apparently the McNary passage date is later than the high through much, if not all, of the period of volitional release. If McNary passage date was due to a later smolting, then the effect is manifest throughout the release period.

Table 1.a. Weighted Smolt-to-Smolt Survival Proportions for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (Weights are volitional release numbers) (Note: Estimates adjusted for blocks and sites since blocks and sites are significant)

Treatment		Clark Flat	Easton	Jack Creek	Over Sites
Low	Volitional Release Number	6479	6508	6532	19519
	Survival Index	**0.2083**	**0.1646**	**0.1568**	**0.1765**
High	Volitional Release Number	6514	6453	6515	19482
	Survival Index	**0.2317**	**0.1778**	**0.1967**	**0.2021**
Over Treatments	Volitional Release Number	12993	12961	13047	39001
	Survival Index	**0.2200**	**0.1712**	**0.1767**	**0.1893**
	P for Site differences	**0.0460**	**Sign at 5% level**		
	P for Treatment differences	**0.0044**	**Sign at 1% level**		
	P for Site x Treatment Interactions	0.2121			

Table 1.b. Weighted Logistic Analysis of Variation of Smolt-to-Smolt Survival Proportions for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (Weights are volitional release numbers)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 Error P
Site[1]	117.14	2	58.57	5.37	**0.0460**
Block within Site[2]	65.40	6	10.90	5.18	0.0327
Treatment (Low vs High)[2]	41.54	1	41.54	19.75	**0.0044**
Site x Treatment[2]	8.54	2	4.27	2.03	0.2121
Error(1)	12.62	6	2.10		

[1] Site is tested against Block

[2] Block, Treatment, Interaction tested against Error(1)

Figure 1. Smolt-to-Smolt Survival Proportions for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (Refer to Table 1.a.)

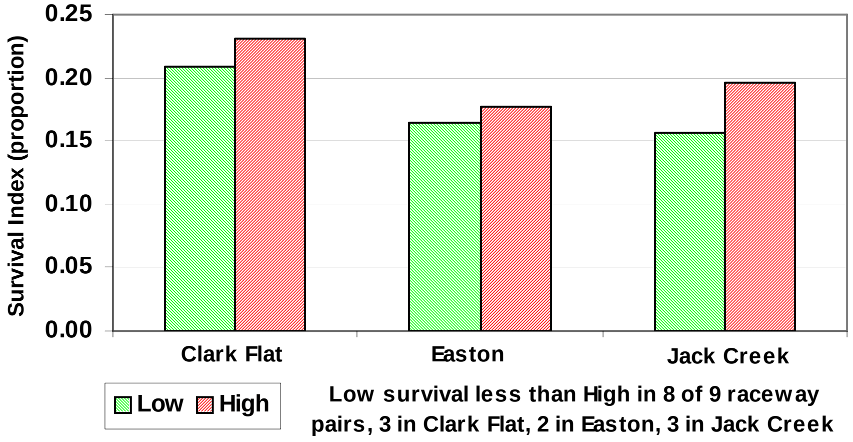


Table 2.a. Pre-Release-Size Means (Grams/Fish) for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish

Treatment	Clark Flat	Easton	Jack Creek	Over Sites
Low	**13.6**	**14.3**	**13.2**	**13.7**
High	**18.1**	**17.9**	**17.6**	**17.9**
Over Treatments	**15.8**	**16.1**	**15.4**	**15.8**

P for Site differences	0.6899	
P for Treatment differences	**0.0001**	**Sign at 1% level**
P for Site x Treatment Interactions	0.7082	

Table 2.b. Analysis of Variance of Pre-Release Size (Grams/Fish) for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish

Source	Sums of Squares (SS)	Degrees of Freedom (DF)	Mean Square (SS/DF)	F-Ratio	P
Site[1]	1.50	2	0.75	0.40	0.6899
Block within Site[2]	11.39	6	1.90	1.90	0.2269
Treatment (Low vs High)[2]	78.76	1	78.76	78.89	**0.0001**
Site x Treatment[2]	0.73	2	0.37	0.37	0.7082
Error(1)	5.99	6	1.00		

[1] Site is tested against Block

[2] Block, Treatment, Interaction tested against Error(1)

Figure 2. **Pre-Release Mean Size (Grams/Fish) for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (refer to Table 2.a.)**

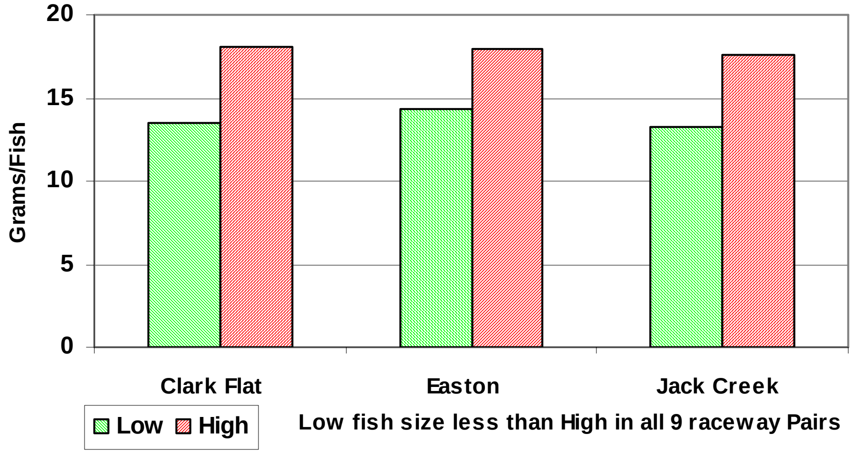


Table 3.a. **Weighted Smolt-to-Smolt Survival Proportions <u>adjusted for Size at Release</u> for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (Weights are volitional release numbers)**

Treatment		Clark Flat	Easton	Jack Creek	Over Sites
Low	Volitional Release Number	6479	6508	6532	19519
	Survival Index	**0.2084**	**0.1648**	**0.1567**	**0.1765**
High	Volitional Release Number	6514	6453	6515	19482
	Survival Index	**0.2317**	**0.1776**	**0.1967**	**0.2021**
Over Treatments	Volitional Release Number	12993	12961	13047	39001
	Survival Index	**0.2200**	**0.1712**	**0.1767**	**0.1893**
	P for Site differences	**0.0166**	**Sign at 5% level**		
	P for Treatment differences	0.7405			
	P for Site x Treatment Interactions	0.2816			

Table 3.b. **Weighted Logistic Analysis of Covariation of Smolt-to-Smolt Survival Proportions on pre-Release Size for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (Weights are volitional release numbers)**

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P
Pre-Release Size^2	67.57	1	67.57	10.08	**0.0247**
Site^1	117.51	2	58.76	8.76	**0.0166**
Block within Site^2	40.23	6	6.71	2.83	0.1365
Treatment (Low vs High)^2	0.29	1	0.29	0.12	0.7405
Site x Treatment^2	7.81	2	3.91	1.65	0.2816
Error(1)	11.83	5	2.37		

[1] Site tested against Block
[2] Size, Block, Treatment, Interaction initially tested against Error(1)

Figure 3. **Mean Smolt-to-Smolt Survival Proportions adjusted for Size at Release for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (refer to Table 3.a.)**

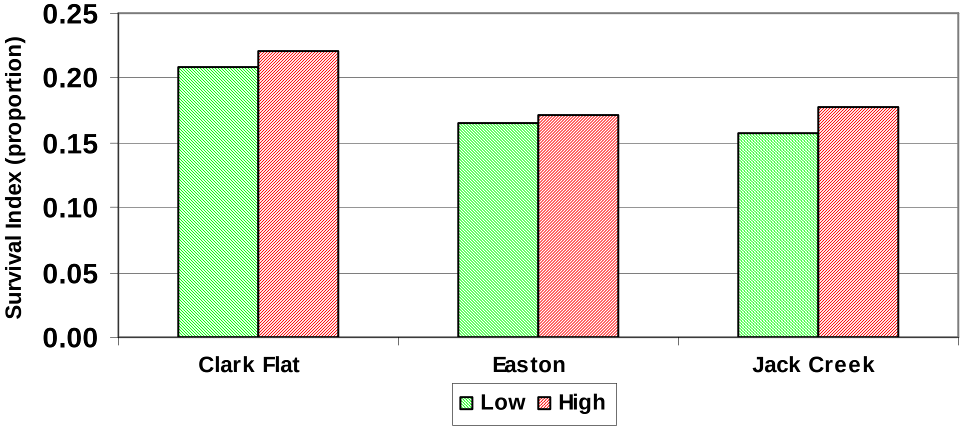


Table 4.a. **Release-Date Means for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish**

Treatment		Clark Flat	Easton	Jack Creek	Over Sites
Low	Volitional Release Detections	6479	6508	6532	19519
	Julian Release Date	**95.5**	**97.8**	**99.3**	**97.5**
High	Volitional Release Detections	6514	6453	6515	19482
	Julian Release Date	**100.5**	**101.0**	**98.6**	**100.0**
Over Treatments	Volitional Release Detections	12993	12961	13047	39001
	Julian Release Date	**98.0**	**99.4**	**99.0**	**98.8**

P for Site differences	0.5229	
P for Treatment differences	**0.0255**	Sign at 5% level
P for Site x Treatment Interactions	**0.0919**	Sign at 10% level

Table 4.b. **Analysis of Variance of Mean Release Dates for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish**

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P
Site[1]	12645	2	6322.5	0.84	0.4782
Block within Site[2]	45363	6	7560.5	0.69	0.6663
Treatment Low vs High)[2]	60000	1	60000.0	5.50	0.0574
Site x Treatment[2]	54160	2	27079.9	2.48	0.1639
Error(1)	65461	6	10910.2		
Site[3]	12645	2	6322.5	0.68	0.5229
Treatment[3]	60000	1	60000.0	6.50	**0.0255**
Site x Treatment[3]	54160	2	27079.9	2.93	**0.0919**
Error(2)[4]	110824	12	9235.4		

[1] Site is initially tested against Block

[2] Block, Treatment, Interaction initially tested against Error(1)

[3] Block, Treatment, Interaction finally tested against Error(2)

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

Table 5.a. **Weighted Mean and Median McNary-Passage Dates of Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (Weights are expanded McNary passage numbers)**

Treatment		Clark Flat	Easton	Jack Creek	Over Sites
Low	Expanded McNary Detections	1352	1077	1026	3455
	Mean Julian Detection Date	**123.7**	**128.3**	**128.3**	**126.5**
	Median Julian Detection Date	122.8	128.9	129.1	126.6
High	Expanded McNary Detections	1511	1153	1283	3948
	Julian Detection Date	**121.3**	**123.7**	**123.9**	**122.9**
	Median Julian Detection Date	120.1	123.0	122.5	121.7
Over Treatments	Expanded McNary Detections	2863	2231	2309	7403
	Julian Detection Date	**122.4**	**125.9**	**125.8**	**124.6**
	Median Julian Detection Date	121.4	125.9	125.4	124.0
	P for Site differences	**0.0030**	Sign at 1% level		
	P for Treatment differences	**0.0004**	Sign at 0.1% level		
	P for Site x Treatment Interactions	0.4036			

Table 5.b. **Weighted Analysis of Variance of Mean McNary-Passage-Date Release-Dates for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (Weights are expanded McNary passage numbers)**

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P
Site[1]	20976.10	2	10488.05	8.98	0.0157
Block within Site[2]	7007.60	6	1167.93	1.19	0.4175
Treatment Low vs High)[2]	25005.65	1	25005.65	25.56	0.0023
Site x Treatment[2]	2102.32	2	1051.16	1.07	0.3991
Error(1)	5868.73	6	978.1217		
Site[3]	20976.10	2	10488.05	9.77	**0.0030**
Treatment[3]	25005.65	1	25005.65	23.30	**0.0004**
Site x Treatment[3]	2102.32	2	1051.16	0.98	0.4036
Error(2)[4]	12876.33	12	1073.03		

[1] Site is initially tested against Block

[2] Block, Treatment, Interaction initially tested against Error(1)

[3] Block, Treatment, Interaction finally tested against Error(2)

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

Figure 4. **Mean Release Date for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (refer to Table 4.a.)**

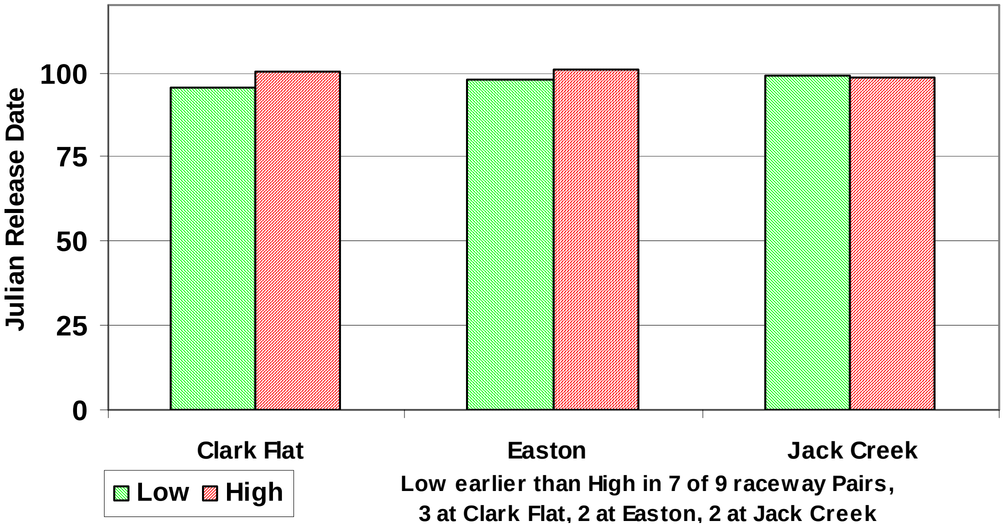


Figure 5. **Weighted Mean McNary Passages Date of Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish (refer to Table 5.a.)**

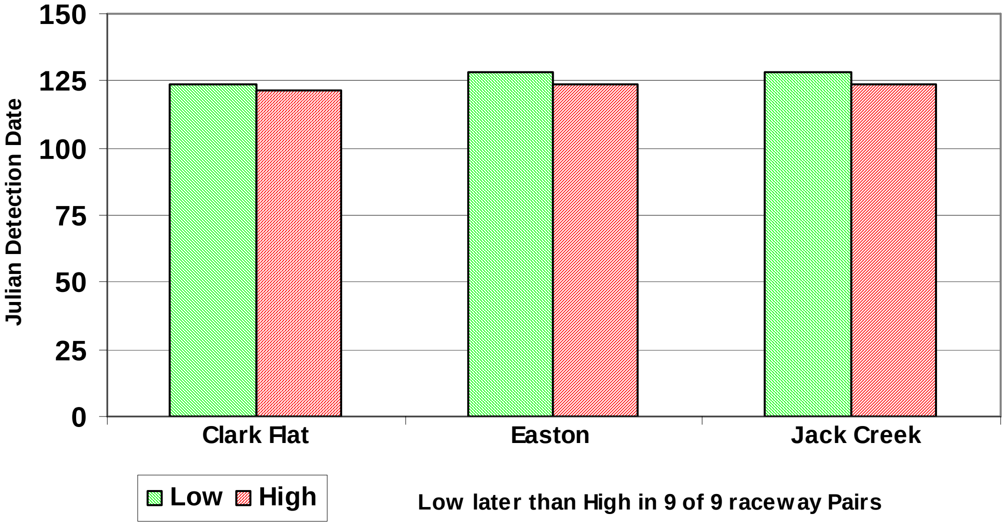
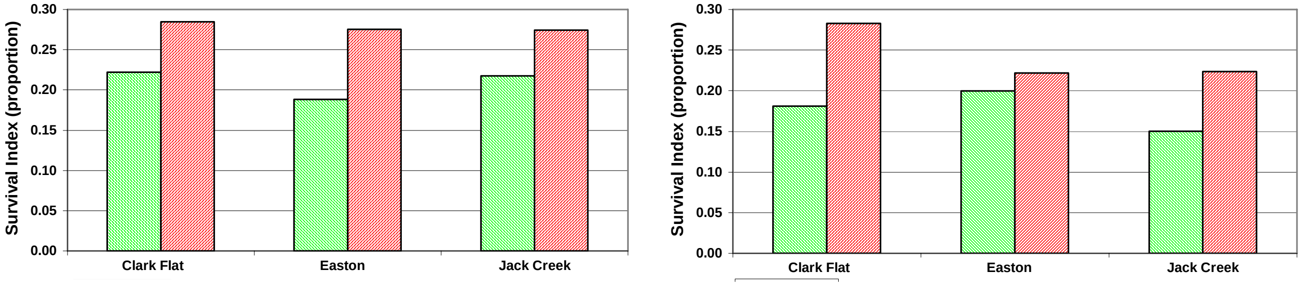


Figure 6. **Smolt-to-Smolt Survival for Brood-Year 2004 (Release-Year 2004) Low- and High-Treated Fish from Five Release Periods.**

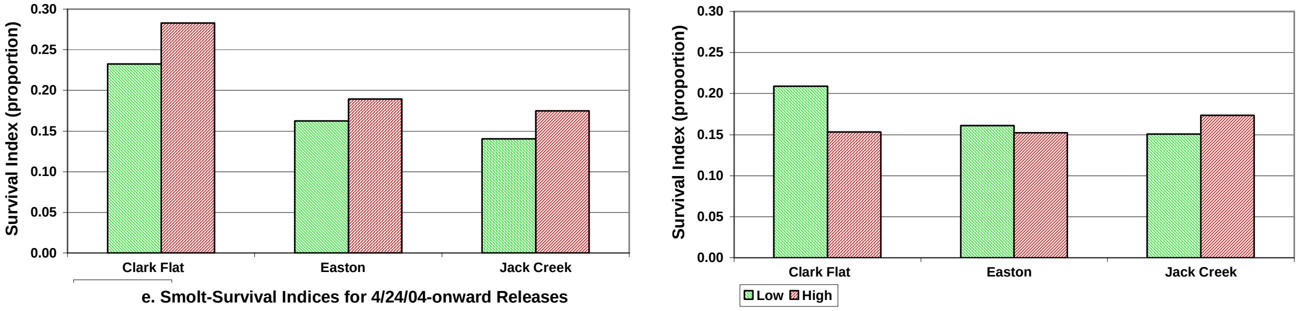
a. Smolt-Survival Indices for 3/15/04-3/24/04 Releases

b. Smolt-Survival Indices for 3/25/04-4/03/04 Releases



c. Smolt-Survival Indices for 4/04/04-4/13/04 Releases

d. Smolt-Survival Indices for 4/14/04-4/23/04 Releases



e. Smolt-Survival Indices for 4/24/04-onward Releases

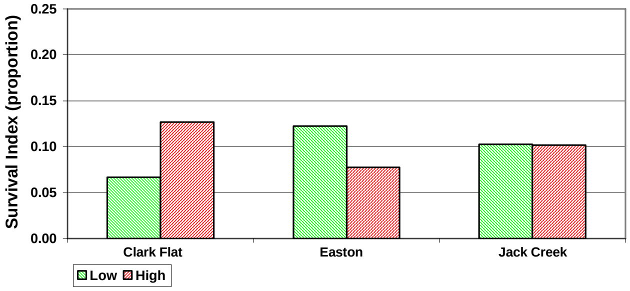
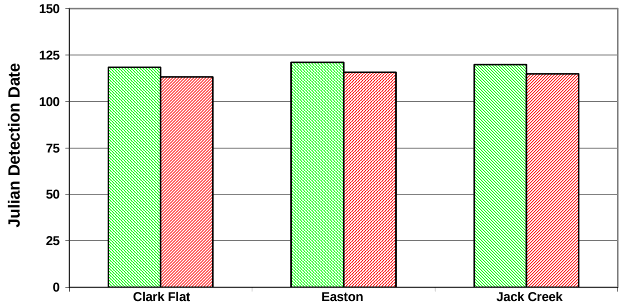
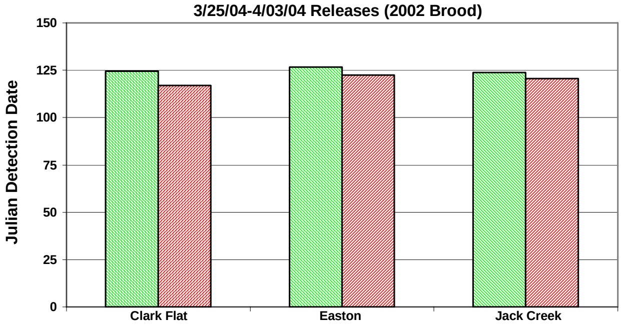


Figure 7 Mean McNary Passage Date for Brood-Year 2002 (Release-Year 2004) Low- and High-Treated Fish from Five Release Periods.

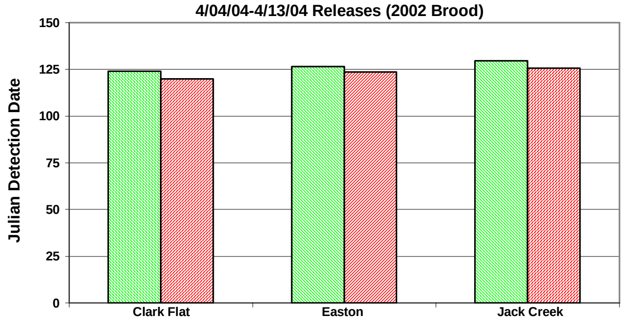
a. Smolt Mean McNary Detection Julian Date for 3/15/04-3/24/04 Releases (2002 Brood)



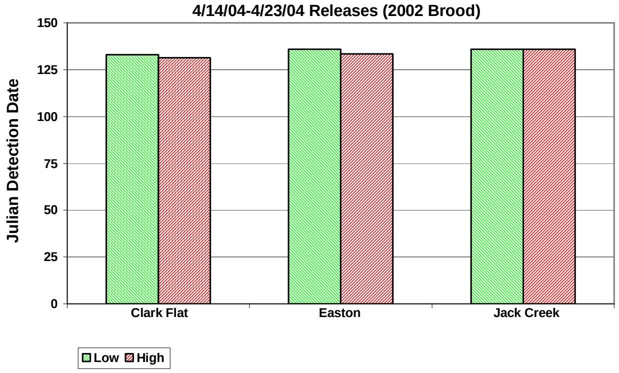
b. Smolt Mean McNary Detection Julian Date for 3/25/04-4/03/04 Releases (2002 Brood)



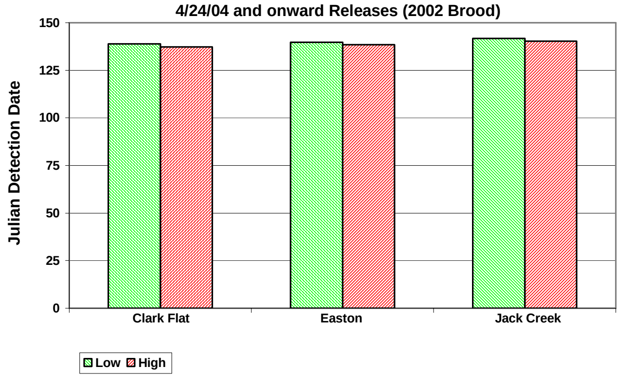
c. Smolt Mean McNary Detection Julian Date for 4/04/04-4/13/04 Releases (2002 Brood)



d. Smolt Chinook Mean McNary Detection Julian Date for 4/14/04-4/23/04 Releases (2002 Brood)



e. Smolt Mean McNary Detection Julian Date for 4/24/04 and onward Releases (2002 Brood)



Appendix A. Estimated Survival Index

Estimation of Survival Index

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

Equation A.1.

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

wherein

1) “Stratum” is a group of contiguous McNary detection dates among which the daily detection efficiencies[6] were sufficiently homogeneous to permit the use of a pooled estimate of the detection efficiency for that stratum;

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 Efficiency” is the estimated proportion of <u>all</u>[7] those Yakima PIT-tagged Spring Chinook passing McNary Dam during the stratum that were detected at McNary (discussed in next session).

Table A.1 presents the estimated stratum detections and detection efficiencies going into Equation A.1 along with the survival index estimates for each release.

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[6] 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.

[7] 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.1. Stratum Detection Numbers and Detection Efficiencies and Resulting Survival Indices for Each Spring Chinook Acclimation Site for Brood Year 2002 (Outmigration-year 2004) with High (HI) and Low (LO) Feeding-Treatment Levels

a) Clark Flat (C.F.) Acclimation Ponds

Detection Efficiency Strata		McNary Detections	C.F. 1 LO	C.F. 2 HI	C.F. 3 HI	C.F. 4 LO	C.F. 5 LO	C.F. 6 HI
Sratum	1	Total (T)	1	0	3	0	0	0
First Date		Removed (R)	0	0	0	0	0	0
Last Date	4/12/2004	T-R	1	0	3	0	0	0
tion Efficiency	0.6661	Expanded	1.5	0.0	4.5	0.0	0.0	0.0
Sratum	2	Total (T)	84	151	188	122	87	116
First Date	4/13/2004	Removed (R)	2	4	2	2	2	7
Last Date	4/30/2004	T-R	82	147	186	120	85	109
tion Efficiency	0.5742	Expanded	144.8	260.0	325.9	211.0	150.0	196.8
Sratum	3	Total (T)	41	37	40	48	42	32
First Date	5/1/2004	Removed (R)	1	1	1	1	0	0
Last Date	5/3/2004	T-R	40	36	39	47	42	32
tion Efficiency	0.5029	Expanded	80.5	72.6	78.5	94.5	83.5	63.6
Sratum	4	Total (T)	20	14	13	25	33	24
First Date	5/4/2004	Removed (R)	0	1	0	0	1	0
Last Date	5/6/2004	T-R	20	13	13	25	32	24
tion Efficiency	0.4400	Expanded	45.5	30.5	29.5	56.8	73.7	54.5
Sratum	5	Total (T)	29	32	20	20	22	28
First Date	5/7/2004	Removed (R)	0	1	1	0	1	0
Last Date	5/10/2004	T-R	29	31	19	20	21	28
tion Efficiency	0.3997	Expanded	72.6	78.6	48.5	50.0	53.5	70.0
Sratum	6	Total (T)	27	26	20	24	26	19
First Date	5/11/2004	Removed (R)	0	0	0	0	1	1
Last Date	6/3/2004	T-R	27	26	20	24	25	18
tion Efficiency	0.3260	Expanded	82.8	79.7	61.3	73.6	77.7	56.2
		Total (T)	202	260	284	239	210	219
		Removed (R)	3	7	4	3	5	8
		T-R	199	253	280	236	205	211
		Expanded	427.7	521.4	548.4	485.9	438.5	441.3
		Volitional Release Number	2124	2162	2171	2177	2178	2181
		Survival Index	**0.2013**	**0.2412**	**0.2526**	**0.2232**	**0.2013**	**0.2023**

Table A.2. Brood-year 2002 (Outmigration-year 2004) (continued)

b) Easton (Ea.) Acclimation Ponds

		McNary	East. 1	East. 2	East. 3	East. 4	East. 5	East. 6
Detection Efficiency Strata		Detections	HI	LO	HI	LO	LO	HI
Sratum	1	Total (T)	2	0	0	0	0	0
First Date	1/0/1900	Removed (R)	0	0	0	0	0	0
Last Date	4/12/2004	T-R	2	0	0	0	0	0
tion Efficiency	0.6661	Expanded	3.0	0.0	0.0	0.0	0.0	0.0
Sratum	2	Total (T)	119	46	76	39	65	82
First Date	4/13/2004	Removed (R)	1	2	2	0	2	4
Last Date	4/30/2004	T-R	118	44	74	39	63	78
tion Efficiency	0.5742	Expanded	206.5	78.6	130.9	67.9	111.7	139.8
Sratum	3	Total (T)	25	27	19	19	22	18
First Date	5/1/2004	Removed (R)	0	0	1	0	1	0
Last Date	5/3/2004	T-R	25	27	18	19	21	18
tion Efficiency	0.5029	Expanded	49.7	53.7	36.8	37.8	42.8	35.8
Sratum	4	Total (T)	16	19	16	13	10	9
First Date	5/4/2004	Removed (R)	1	0	0	1	1	1
Last Date	5/6/2004	T-R	15	19	16	12	9	8
tion Efficiency	0.4400	Expanded	35.1	43.2	36.4	28.3	21.5	19.2
Sratum	5	Total (T)	24	26	21	19	30	17
First Date	5/7/2004	Removed (R)	0	0	1	1	0	0
Last Date	5/10/2004	T-R	24	26	20	18	30	17
tion Efficiency	0.3997	Expanded	60.0	65.0	51.0	46.0	75.1	42.5
Sratum	6	Total (T)	34	58	35	40	37	33
First Date	5/11/2004	Removed (R)	3	1	0	2	1	0
Last Date	6/3/2004	T-R	31	57	35	38	36	33
tion Efficiency	0.3260	Expanded	98.1	175.8	107.3	118.5	111.4	101.2
		Total (T)	220	176	167	130	164	159
		Removed (R)	5	3	4	4	5	5
		T-R	215	173	163	126	159	154
		Expanded	452.4	416.4	362.4	298.6	362.4	338.6
		Volitional Release Number	2157	2176	2182	2171	2161	2114
		Survival Index	**0.2098**	**0.1913**	**0.1661**	**0.1375**	**0.1677**	**0.1602**

Table A.2. Brood-year 2002 (Outmigration-year 2004) (continued)

c) Jack Creek (J.C.) Acclimation Ponds

		McNary	J.C. 1	J.C. 2	J.C. 3	J.C. 4	J.C. 5	J.C. 6
Detection Efficiency Strata		Detections	HI	LO	LO	HI	LO	HI
Sratum	1	Total (T)	0	0	3	0	0	2
First Date	1/0/1900	Removed (R)	0	0	0	0	0	0
Last Date	4/12/2004	T-R	0	0	3	0	0	2
tion Efficiency	0.6661	Expanded	0.0	0.0	4.5	0.0	0.0	3.0
Sratum	2	Total (T)	87	46	58	124	36	110
First Date	4/13/2004	Removed (R)	0	1	0	1	2	5
Last Date	4/30/2004	T-R	87	45	58	123	34	105
tion Efficiency	0.5742	Expanded	151.5	79.4	101.0	215.2	61.2	187.9
Sratum	3	Total (T)	25	22	27	24	10	28
First Date	5/1/2004	Removed (R)	0	0	1	1	0	0
Last Date	5/3/2004	T-R	25	22	26	23	10	28
tion Efficiency	0.5029	Expanded	49.7	43.7	52.7	46.7	19.9	55.7
Sratum	4	Total (T)	9	14	12	16	10	13
First Date	5/4/2004	Removed (R)	0	1	0	0	0	0
Last Date	5/6/2004	T-R	9	13	12	16	10	13
tion Efficiency	0.4400	Expanded	20.5	30.5	27.3	36.4	22.7	29.5
Sratum	5	Total (T)	25	33	27	21	21	21
First Date	5/7/2004	Removed (R)	1	0	0	2	0	0
Last Date	5/10/2004	T-R	24	33	27	19	21	21
tion Efficiency	0.3997	Expanded	61.0	82.6	67.5	49.5	52.5	52.5
Sratum	6	Total (T)	37	32	40	38	52	32
First Date	5/11/2004	Removed (R)	0	0	0	1	0	1
Last Date	6/3/2004	T-R	37	32	40	37	52	31
tion Efficiency	0.3260	Expanded	113.5	98.1	122.7	114.5	159.5	96.1
		Total (T)	183	147	167	223	129	206
		Removed (R)	1	2	1	5	2	6
		T-R	182	145	166	218	127	200
		Expanded	396.2	334.4	375.7	462.3	315.9	424.7
		Volitional Release Number	2175	2165	2184	2177	2183	2163
		Survival Index	**0.1822**	**0.1544**	**0.1720**	**0.2124**	**0.1447**	**0.1964**

Estimation Of Detection Rates

Conceptual Computation

Detection Efficiency is estimated as follows:

Equation A.2

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

The downstream-dam counts actually represents a pooling of counts from John Day and Bonneville dams[8].

The methods used were similar to those developed by Sandford and Smith[9]. 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.2.a)].

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

Step 3. The resulting relative distribution frequencies from Table B.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.2.c)].

Step 4. There were cases where there were downstream detections for a given date but there were no joint downstream and McNary detections for that downstream date. In such cases there was no direct way of allocating the downstream detections to a given McNary date. What was done was to obtain a pseudo-distribution for McNary detection dates by offsetting the six previous downstream dates' and the six following downstream-dates' McNary-date distributions, and applying their pooled offset distributions to the downstream-dam detection date having no joint McNary distribution. (This step probably differs

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[8] 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. I understand that, 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 rate. 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").

[9] 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.

from Smith and Sanford's, their generated daily detection efficiencies 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.2.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.2.a), far-right column] were then divided by the downstream-dam total from step 4 above [Table A.2.c), far-right column], giving an estimated McNary-detection efficiency associated with the McNary date [Table A.2.d), far-right-hand column].

Actually, before the last step, Table A.2.a)'s and Table A.2.b)'s numbers were pooled over John Day and Bonneville Dams.

Daily detection efficiencies were then stratified into contiguous days of relatively homogeneous detection efficiencies, and the daily detection efficiencies 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 efficiencies 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 efficiencies within strata was selected. With that partitioning fixed, establishing two 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 efficiencies within the strata was selected. This second partitioning was then fixed and, along with the first fixed partitioning, established three strata. A third partitioning was similarly developed within the three established strata to form a fourth 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-efficiency estimates were inconsistent in sign. For example, if the combined Bonneville-based McNary detection efficiency in one of the created strata was greater than that in an adjacent stratum, but the John Day-based McNary detection efficiency in the one was less than that in the adjacent, then the partitioning was not accepted.

3. When the logistic variation[10] of daily detection efficiencies 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 efficiencies were adjusted accordingly.

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

Table A.2. **Conceptual method of estimating detection efficiencies**

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

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

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

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

Table A.2. Conceptual method of estimating detection efficiencies (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,.)**

Efficiency Estimates

The Bonneville Dam-based and John Day Dam-based McNary detection-efficiency estimates are given in Table A.3 along with the estimates pooled over those two downstream dams, which were the estimates used.

Table A.3. Estimated McNary (McN) Detection Rates based on Bonneville (Bonn) and (John Day) Detections and their Pooled Detections with McNary and Based on the Pooling of the Detections of those two dams Downstream (DS) of McNary

Applicable Passage Dates		**Bonneville-Based Estimates**			**John Day-Based Estimates**			**Pooled Estimates**		
Beginning	Ending	Detections		Detection	Detections		Detection	Detections		Detection
Date	Date	Bonn	Bonn, McN	Rate	JD	JD, McN	Rate	DS	DS,McN	Rate
	04/12/04	28.7	19	0.6631	71.9	48	0.6673	100.6	67	0.6661
04/13/04	04/30/04	408.5	247	0.6046	904.7	507	0.5604	1313.2	754	0.5742
05/01/04	05/03/04	111.8	58	0.5186	246.1	122	0.4958	357.9	180	0.5029
05/04/04	05/06/04	71.7	32	0.4463	141.9	62	0.4369	213.6	94	0.4400
05/07/04	05/10/04	83.2	35	0.4207	312.1	123	0.3941	395.3	158	0.3997
05/11/04		184.1	57	0.3096	337.3	113	0.3350	521.4	170	0.3260

The assumptions behind the detection efficiency 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 efficiencies 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 efficiencies are probably biased, but the bias would be less than assuming a single detection-efficiency 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.

Appendix D

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Annual Report: Brood Years 1997-2000 OCT-SNT Smolt-to-Adult Survival from Release to Roza Dam Recovery

Doug Neeley, Consultant to Yakama Nation

1. Data Base and Methods

Age 2, 3, 4, and 5 PIT-tagged adult returns to Roza from respective brood years 2001, 2000, 1999, 1998, and 1997 of Optimum Conventional Treatment (OCT) and Semi-Natural Treatment (SNT) spring chinook experimental releases were included with previous year's Roza returns to assess survival from smolt release to adult return survival (SAR). For each brood year, the numbers of PIT-tagged adults were combined over age-3 and older returns, these combined return numbers were then divided by the respective numbers of smolt released as adult survival estimates. Estimates were computed for each raceway and were subject to a weighted1 logistic analysis of variation to determine the effects of treatment and treatment x site interaction, there being a total of up to three acclimation release sites with up to three paired raceways (blocks) per site within which the OCT and SNT treatments were assigned.

Age-2 returns were regarded as male precocials returns. The decision was made to analyze those returns that would have likely spent a portion of their life in the ocean; therefore age-2 returns were not included in the analysis. Historically, a majority of adult fish were age-4 fish. Therefore, the decision was made to exclude brood-year 2001 from this analysis because only age-3 fish would be used in estimating adult survival. Brood-year 2001 smolt-to-adult survival estimates will be included in next year's annual report. In the analyses presented here, brood years 1997 through 1999 adult survival estimates are based on age-3 through age-5 returns; brood year 2000 estimates are based on age-3 to age-4 fish and should be regarded underestimates. There has been no evidence of age-6 or greater PIT-tagged adult returns to date.

PIT tag detectors were installed at all acclimation sites. With the exception of brood-year 1997, the OCT-SNT survival estimates are based only on PIT-tagged fish detected leaving the ponds; i.e., the release numbers were the number of fish detected as volitionally leaving the pond, and the adult returns were based on adult PIT tag detections at Roza that were previously detected leaving the ponds as smolt. The PIT-tag detectors used for brood-year 1997 proved to have low detection efficiencies; therefore, the release numbers used were the numbers of fish PIT-tagged adjusted for estimated pre-release mortalities of PIT-tagged fish, and adult return numbers were based on all adult PIT-tagged detections at Roza.

2. Analysis

Table 1 presents mean SAR estimates along with release numbers for each treatment within each release site and brood year. A logistic analysis of variation for the first three brood years (1997 though 1999, Table 2.a.)

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[1] The weighting variable was the release number.

indicated no significant main effect differences between the SNT and OCT treatments (P = 0.415) and no treatment x year, treatment x site, or treatment x site x year interactions (P = 0.972, 0.342, and 0.304, respectively). In other words, there were no significant differences between the SNT and OCT treatments within any of the sites or years for these three brood years.

This was not the case for brood year 2000, in which the difference between the SNT and OCT survivals was significant at the 10% level (P = 0.094, Table 2.b.), the SNT having a lower mean survival index than the OCT for every release site and a lower survival index than in seven of the nine blocked raceway pairs. One possible reason for the poorer SNT performance is that there were greater levels of the causative agent of Bacterial Kidney Disease (BKD) present in the SNT smolts for that brood year than in the previous three brood years (BKD almost absent for those brood years). It turns out that the SNT smolt had a significantly higher BKD-presence index than did the OCT fish (p = 0.001, analysis of variance on mean BKD-presence index[2], Table 3). A logistic analysis of covariation was run, adjusting the survival index for the BKD index as the covariate. When survival indices were adjusted for the BKD index, there was no longer a significant difference between the treatments' mean survival indices (p = 0.572, logistic analysis of variation, Table 4).

Table 1. Semi-Natural Treatment (SNT) and Optimal Conventional Treatment (OCT) Mean Survival for PIT-tagged Volitional Releases in the Upper Yakima to Roza Dam Adult Return for brood-years 1997 through 2001 (respective release years 1999-2003) from three Acclimation Sites on the Upper Yakima

Brood Year	Treatment	Measure	Clark Flat CF	Jack Creek JC	Easton ET
1997*	SNT	Release Number	11,974		7,961
		Survival	**1.70%**		**1.42%**
	OCT	Release Number	11,978		7,979
		Survival	**1.39%**		**1.44%**
1998	SNT	Release Number	7,196	4,693	7,261
		Survival	**1.25%**	**0.77%**	**1.03%**
	OCT	Release Number	7,194	3,732	7,309
		Survival	**1.20%**	**1.23%**	**0.88%**
1999	SNT	Release Number	6,454	6,410	6,455
		Survival	**0.05%**	**0.09%**	**0.03%**
	OCT	Release Number	6,519	6,473	6,480
		Survival	**0.08%**	**0.05%**	**0.06%**
2000	SNT	Release Number	5,858	6,466	5,924
		Survival	**0.34%**	**0.36%**	**0.20%**
	OCT	Release Number	6,340	6,480	6,512
		Survival	0.43%	0.57%	0.46%
2001	SNT	Release Number	3,372	11,555	
		Survival	**0.03%**	**0.07%**	
	OCT	Release Number	3,559	11,601	
		Survival	**0.08%**	**0.05%**	

* 1997 based on all PIT-tagged fish, release numbers being adjusted for pre-release mortaliltes, other years based on only fish detected as volitionally leaving the detection ponds;

** 2001 brood year excluded from analysis because it is based on only age 3 returns.

---

[2] Ray Brunson (United States Fish and Wildlife Service, Olympia, Washington) provided disease data. Between 59 and 61 fish were sampled for ELISA levels per raceway.

Table 2.a. Weighted Logistic Analysis of Variation of Semi-Natural Treatment (SNT) and Optimal Conventional Treatment (OCT) Adult Survivals to Roza Dam for brood years 1997-1999 (weights being release numbers)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	Using Block or Error (1)		Using Error (2)	
				F-Ratio	Type 1 Error P	F-Ratio	Type 1 Error P
Year[1]	673.27	2	336.64	233.77	0.0000	235.00	0.0000
Year (adj for Site)[1]	594.28	2	297.14	206.35	0.0000	207.43	0.0000
Site[1]	83.96	2	41.98	29.15	0.0000	29.31	0.0000
Site (adj for Year)[1]	4.97	2	2.49	1.73	0.2138	1.73	0.1949
Site x Year[1]	2.23	3	0.74	0.52	0.6778	0.52	0.6727
Block (within Site and Year)[2]	20.16	14	1.44	1.01	0.4923		
Treatment (Trt: SNT versus OCT)[2,3]	0.98	1	0.98	0.69	0.4209	0.68	0.4152
Trt x Year[2,3]	1.06	2	0.53	0.37	0.6960	0.37	0.6941
Trt x Year (adj)[2,3]	0.08	2	0.04	0.03	0.9724	0.03	0.9725
Trt x Site[2,3]	4.17	2	2.09	1.46	0.2648	1.46	0.2504
Trt x Site (adj)[2,3]	3.19	2	1.60	1.12	0.3540	1.11	0.3425
Trt x Site x Year[2,3]	5.45	3	1.82	1.27	0.3213	1.27	0.3044
Error(1)	19.95	14	1.43				
Error(2)[4]	40.11	28	1.43				

[1] Initially tested against block

[2] Initially tested against Error (1)

[3] All adjusted for Year, Site, Site x Year interaction, and Block: Trt x Year (adj) also adjusted for Trt x Site, Trt x Site (adj) also adjusted for Trt x Year, Trt x Site x Year also adjusted for all two-factor interactions

[4] Error(2) represents the pooling of Block and Error(1), justified because the block mean deviance was nearly equal to the Error(1) mean deviance. Because of the larger degrees of freedom associated with Error(2), testing all sources against Error(2) results in more powerful statistical tests.

Table 2.b. Weighted Logistic Analysis of Variation of Semi-Natural Treatment (SNT) and Optimal Conventional Treatment (OCT) Adult Survivals to Roza Dam for brood year 2000 (weights being release numbers)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	F-Ratio	Type 1 Error P
Site[1]	2.58	2	1.29	0.19	0.3420
Block within Site[2]	41.14	6	6.86	2.96	0.1059
Treatment	9.17	1	9.17	3.96	0.0936
(SNT versus OCT)[2]	9.17	1	9.17	3.96	0.0936
Site x Treatment[2]	1.69	2	0.85	0.37	0.7084
Error	13.88	6	2.31		

[1] F-ratio tested against Block

[2] F-ratio tested against Error

Table 3. Least Squares Analysis of Variance of Semi-Natural Treatment (SNT) and Optimal Conventional Treatment (OCT) Mean Bacterial Kidney Disease (BKD) Indices for Brood Year 2000 PIT-tagged fish

				Using Block or Error (1)		Using Error (2)	
Source	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Square = SS/DF	F-Ratio	Type 1 Error P	F-Ratio	Type 1 Error P
Site[1]	0.8232	2	0.4116	2.80	0.1385	3.56	0.0612
Block within Site[2]	0.8826	6	0.1471	1.75	0.2576		
Treatment[2]	1.9734	1	1.9734	23.42	0.0029	17.06	0.0014
Site x Treatment[2]	0.7804	2	0.3902	4.63	0.0608	3.37	0.0688
Error(1)	0.5056	6	0.0843			0.73	0.6358
Error(2)[3]	1.3882	12	0.1157				

[1] Site is initially tested against Block

[2] Block, Treatment, Ineraction initially tested against Error(1)

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

Table 4. Weighted Logistic Analysis of Covariation of Semi-Natural Treatment (SNT) and Optimal Conventional Treatment (OCT) Adult Survivals to Roza Dam for brood years 1997-1999 on Mean Bacterial Kidney Disease Index as Covariate (weights being release numbers)

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	F-Ratio	Type 1 Error P
BKD[2]	11.08	1	11.08	5.82	0.0607
Site[1]	8	2	4.00	2.10	0.2036
Block within Site[2]	34.17	6	5.70	2.68	0.1493
Treatment[2]	0.78	1	0.78	0.37	0.5710
Site x Treatment[2]	3.81	2	1.91	0.90	0.4647
Error	10.62	5	2.12		

[1] F-ratio tested against Block

[2] F-ratio tested against Error

Figure 1.a presents the percentage smolt-to-adult survival to Roza Dam estimates in graphical form; Figure 1.b. presents the percentage smolt-to-smolt survival to McNary Dam survival for the same brood years. Both figures have common features. For both survival measures, the highest survival rates are associated with brood-year 1997 which were released in 1999, the year with among the highest record high flows in the Yakima basin and the highest for the five-year study. The lowest overall survival rates are associated with brood year 1999 which were released in 2001, the year with among the lowest record flows and the lowest for the five-year study. For brood year 2000, for which the BKD index was high compared to previous years and was highest for the SNT fish, the survival rate of the SNT as a proportion of the OCT is comparable for both the smolt-to-smolt and the smolt-to-adult measures (ranging over sites from 0.58 to 0.71 for the smolt-to-smolt and from 0.43 to 0.80 for the smolt-to-adult survivals).

There are notable differences in the relative adult and smolt survival measures. The low adult survivals for brood year 1999 when compared to other years are relatively much lower than that of smolt survivals. Recall the low survivals were associated with low-flow outmigration year 2001. A majority of Yakima-origin spring chinook normally returns as age-4 fish. The return year for age-4 fish was 2003. Returns of Bonneville Dam released Spring

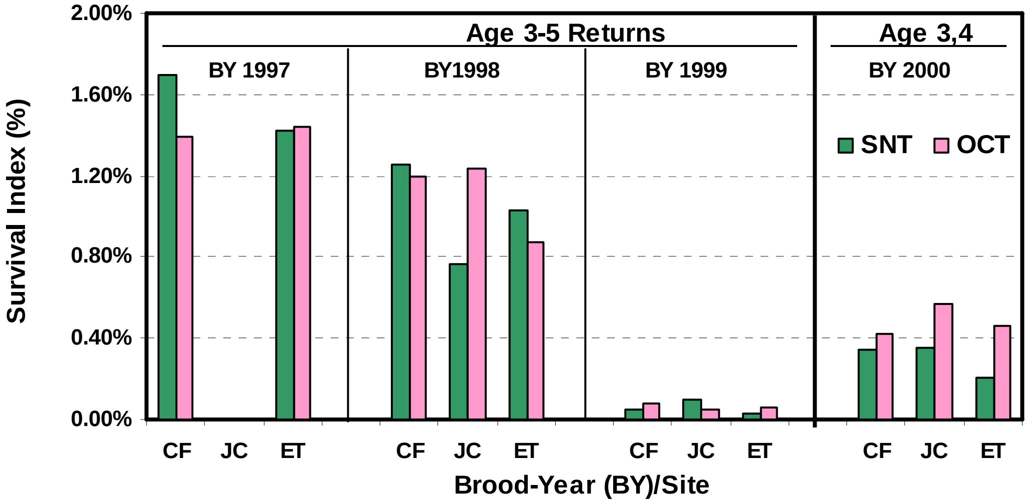
Chinook were among the highest on record, suggesting excellent ocean conditions. However, age 4 returns for the Yakima releases that year were the lowest for the four brood years. Assuming that the adult survival and smolt survival estimates are accurate, the fact that the relative survival rates of the Yakima adults were even lower than the brood year's smolt survival to McNary Dam and that ocean conditions were excellent suggest high mortalities within the lower Columbia below McNary Dam associated with the low flows.

Another notable difference between relative adult and juvenile survivals is that the SNT smolt survival may have had a marginally higher smolt survival than the OCT (Figure 1.b.) for the 1997 through 1999 brood years. No such inference can be made from the adult survival estimates (Figure 1.a).

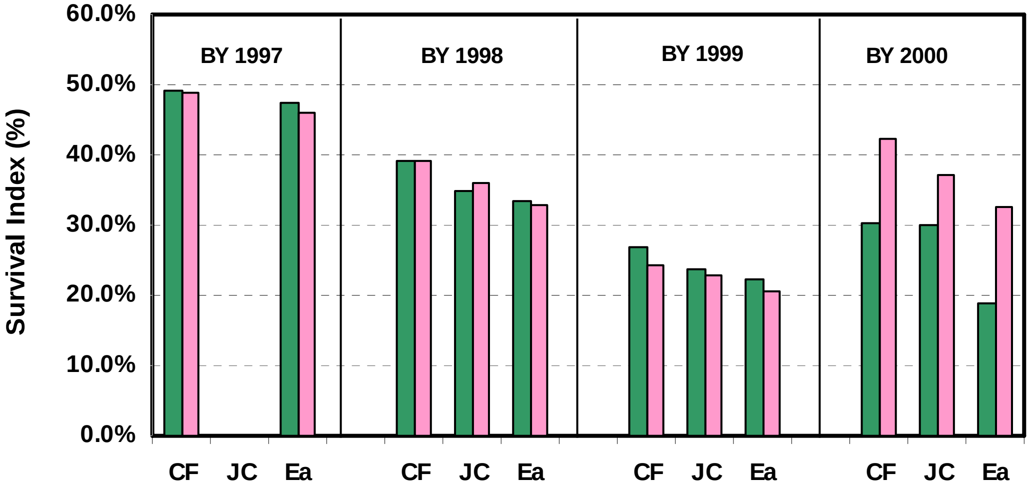
It should also be noted that the smolt-to-smolt survivals presented in Figure 1.b. differ somewhat from those presented in the 2003 Annual Report. This is because errors of estimation were discovered in two of the brood years. Smolt-to-smolt survival data for brood years 1997-2001 are being finalized and prepared for peer-reviewed publication.

Figure 1. Brood Years 1997 through 2000 Smolt-to-Smolt Survival and Smolt-to-Adult Survival Estimates from Volitional Releases in the Upper Yakima of PIT-tagged Semi-Natural Treated (SNT) and Optimal Conventional Treated (OCT) (Release Years 1999 through 2002, respectively)

a. Smolt-to-Adult Survival to Roza Dam on the Upper Yakima River



b. Smolt-to-Smolt Survival to McNary Dam on the Mid-Columbia River



CF-Clack Flat; JC-Jack Creek; ET-Easton
SNT-Semi-Natural Treatment, OCT-Optimum Conventional Treatment
1997 BY: Release based on adjusted tagged Fish. Other BYs: Based on Volitional Release
1999 BY: 2001 Outmigration Year, Year of Record Lowest Flow)
2000 BY - SNT: Juveniles had higher BKD Index than OCT

Appendix E

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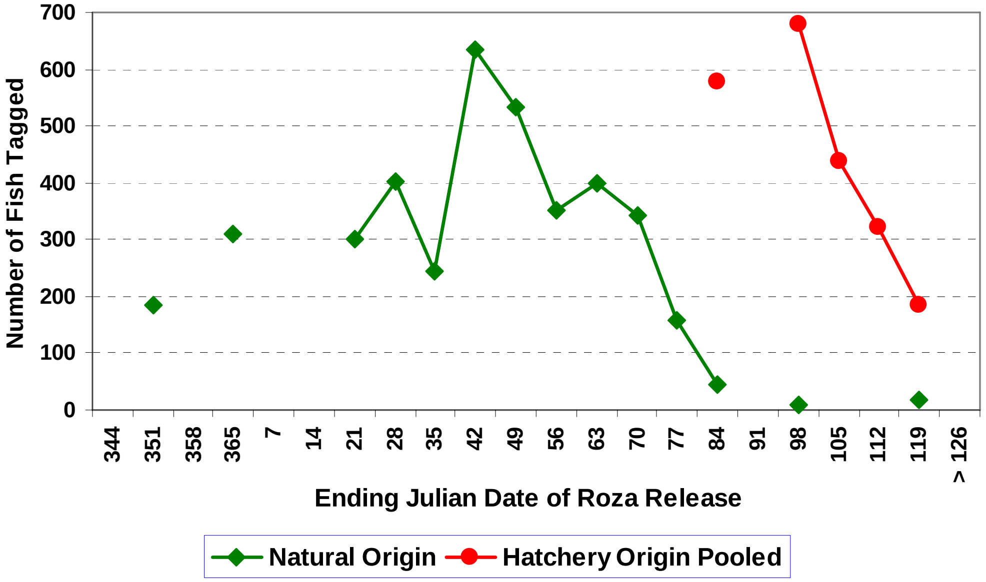
Annual Report: Smolt Survival to McNary Dam of Year-2004 Spring Chinook Releases at Roza Dam

Doug Neeley, Consultant to Yakama Nation

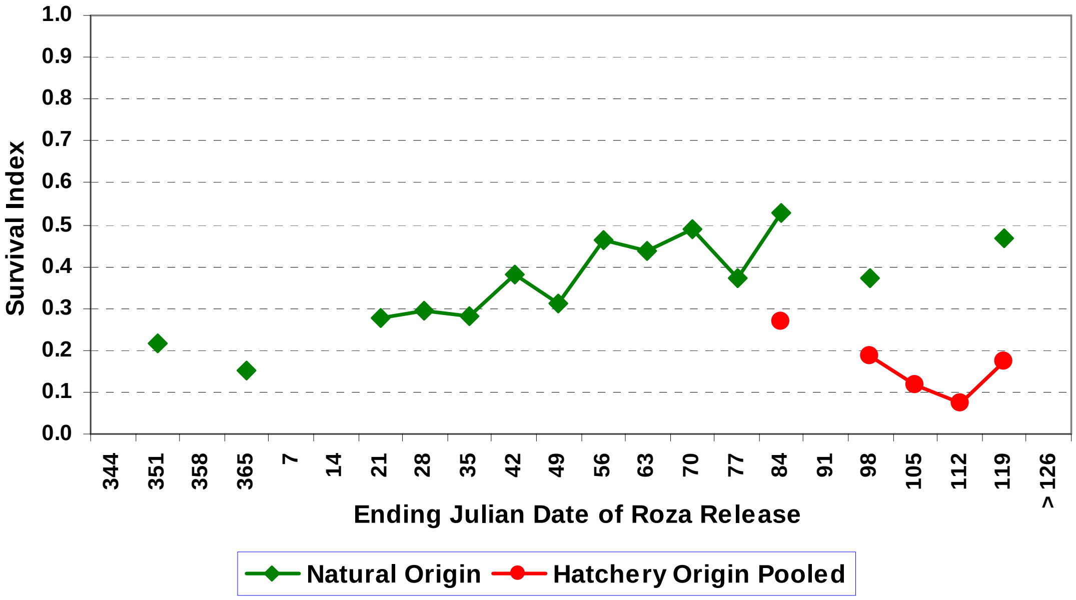
For the 2004 Roza Dam smolt releases, there were few natural-origin smolt trapped at Roza Dam that were passing the dam contemporaneously with hatchery smolt. This is illustrated in Figure 1, which presents the numbers of natural- and hatchery-origin smolt that were released at Roza within a given Julian week, the first hatchery smolt being trapped, tagged, and released during the week ending Julian date 84. The number of natural-origin smolt that were trapped and tagged contemporaneously with hatchery-origin smolt was only 74; whereas, 2201 hatchery smolt were trapped and tagged, the contemporaneous tagged natural smolt being only 3% of the hatchery. In all previous release years (1999-2003), the contemporaneous natural-origin number ranged from 20% to 140% of the hatchery number.

Figure 1. 2004 Spring Chinook Number of Natural and Hatchery Smolt Trapped and Released with PIT-Tags at Roza Dam (2002 Brood)



As indicated in Figure 2 and Table 1, in spite of the low number of contemporaneous natural smolt tagged, the release-to-McNary survival of contemporaneous natural smolt was significantly higher than that of hatchery smolt[1] for Julian weeks ending 84 and later (P = 0.024, 1-sided test for natural survival greater than hatchery, derived from logistic analysis of variation, Table 2). This is consistent with the previous release years in which the contemporaneous natural survival index exceeded that of the hatchery at the 10% significance level in 4 of those 5 years [in the exceptional release year of 2001 (1999 brood), the natural-origin survival did not exceed that of the hatchery (P = 0.738, 2003 Annual Report: Yakima/Klickitat Fisheries Project Monitoring and Evaluation)].

Figure 2. 2004 Spring Chinook Roza-Release-to-McNary-Dam Smolt-to-Smolt Survival Index (2002 Brood)



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[1] The hatchery estimate was based on a pooling of estimates from hatchery smolt that were previously PIT-tagged in the hatchery and those for untagged hatchery smolt that were tagged at Roza prior to release there. There was a significant difference (P = 0.048 based on a 2-sided test, Table 2) between the survivals of these two groups in 2004, with the survival-index proportion (0.209, Table 1) of the previously tagged smolt exceeding that of the previously untagged (0.173, Table 1). However, since their survival indices were relatively close compared to their difference from the contemporaneous natural survival-index proportion (0.494, Table 1), the decision was made to pool the previously tagged and untagged smolt survival indices. It should be noted that in all previous years, there were no significant differences between the previously tagged and previously untagged hatchery-smolt survival indices (estimated P values ranging from 0.346 to 0.761 for the five previous release years, 2003 Annual Report: Yakima/Klickitat Fisheries Project Monitoring and Evaluation).

Table 1. 2004 Release Numbers and Release-to-McNary Smolt-to-Smolt Survival Indices for Natural- and Hatchery-Origin Pit-Tagged Fish Released at Roza Dam on the Upper Yakima River (2002 Brood)

		Before Hatchery Detections at Roza										
	Weekly Beginning Release Date	12/11/03	12/25/03	1/15/04	1/22/04	1/29/04	2/5/04	2/12/04	2/19/04	2/26/04	3/4/04	3/11/04
	Beginning Release Julian Date	351	365	21	28	35	42	49	56	63	70	77
Natural Origin	Number Released	184	309	301	402	244	633	532	352	398	344	158
	Expanded McNary Passage Number	39.6	47.3	83.2	119.1	68.5	241.1	165.0	163.4	173.3	168.6	58.7
	Survival-Index Estimate	0.2151	0.1532	0.2764	0.2963	0.2806	0.3809	0.3101	0.4641	0.4354	0.4901	0.3717

		During Hatchery Detections at Roza					Weighted* Means	
	Weekly Beginning Release Date	3/18/04	4/1/04	4/8/04	4/15/04	4/22/04	Pre-	During
	Beginning Release Julian Date	84	98	105	112	119	Hatchery	Hatchery
Natural Origin	Number Released	46	10			18	3857	74
	Expanded McNary Passage Number	24.4	3.7			8.4	1327.7	36.5
	Survival-Index Estimate	0.5301	0.3730			0.4670	0.3442	0.4935
Hatchery Untagged	Number Released	500	601	400	298	175		1974
	Expanded McNary Passage Number	137.0	99.4	49.7	23.7	31.9		341.7
	Survival-Index Estimate	0.2739	0.1655	0.1243	0.0795	0.1824		0.1731
Hatchery Tagged	Number Released	78	77	39	24	9		227
	Expanded McNary Passage Number	19.0	26.2	2.3	0.0	0.0		47.5
	Survival-Index Estimate	0.2434	0.3404	0.0583	0.0000	0.0000		0.2091
Hatchery Origin Pooled	Number Released	578	678	439	322	184		2201
	Expanded McNary Passage Number	155.9	125.7	52.0	23.7	31.9		389.2
	Survival-Index Estimate	0.2698	0.1853	0.1185	0.0736	0.1734		0.1768

Table 2. Weighted Logistic Analysis of Variation of Indices of Smolt-to-Smolt Survival-to-McNary for Contemporaneously Outmigrating Natural- and Hatchery-Origin Smolt Released at Roza in 2004 (2002 Brood) (Weights are Release Number)

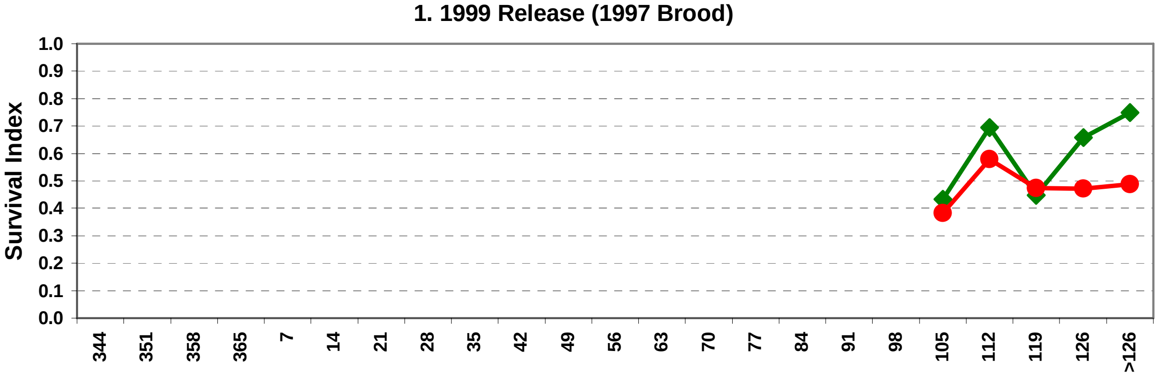
Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	P	1-sided Type 1 p**
Block	87.14	4	21.79	6.15	0.0257	
Natural versus Hatchery	21.55	1	21.55	6.08	0.0487	0.0243
Tagged vs Untagged Hatchery (see footnote 1 in text)	21.85	1	21.85	6.17	0.0476	
Error	21.25	6	3.54167			

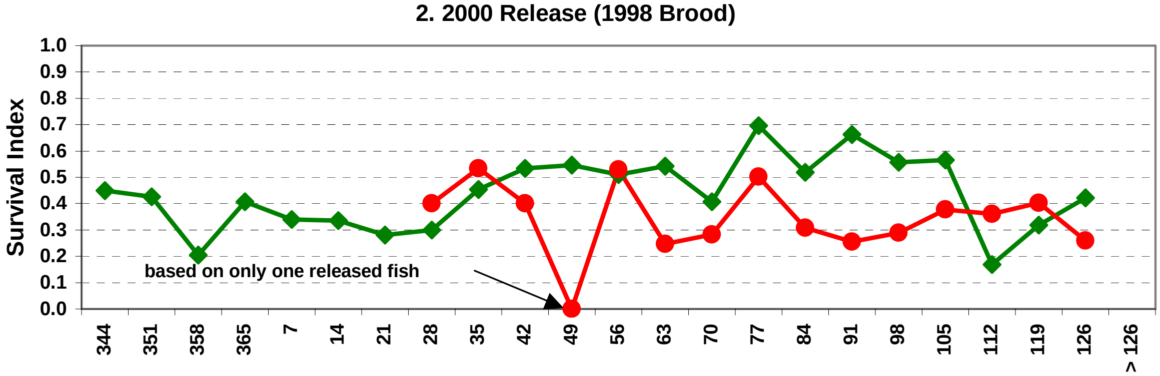
As in previous years, survival-index comparisons were made between natural smolt that passed Roza prior to Roza passage of hatchery smolt (early) to natural smolt passing contemporaneously with hatchery smolt (late). In 2004, the survival of the earlier-passing natural smolt did not significantly differ from that of the later passing smolt (P = 0.490, Table 3). The findings from previous years varied (2003 Annual Report: Yakima/Klickitat Fisheries Project Monitoring and Evaluation), with early outmigrating natural smolt having a significantly higher survival index in 2001 (P < 0.001), significantly lower survival indices in 2000 and 2002 (P < 0.001), and, as in 2004, no significant difference in 2003 (P = 0.823). 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's bypass system is watered up and, therefore, not detected at McNary. Consequently, survival estimates of early Roza-passing smolt may be underestimated. Further, the division of the natural outmigrants into "earlier" and "late" groups based on the beginning passage of hatchery fish is artificial. Appendix A contains a set of figures for the survival indices for all six of the release years.

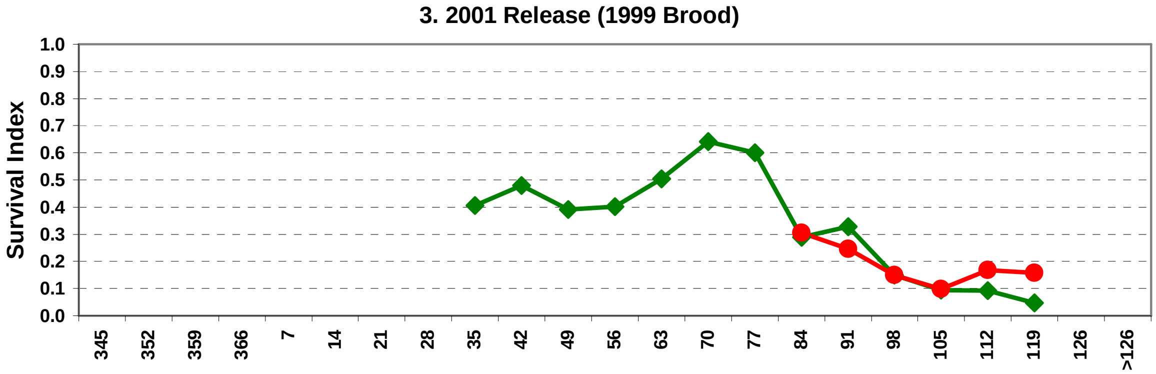
Table 3. Weighted Logistic Analysis of Variation of Indices of Survival Indices of Natural-Origin Smolt Released at Roza in 2004 at the same as Hatchery-Origin Smolt and those Released prior to Hatchery-Origin Smolt (2002 Brood) (Weights are Release Numbers)

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

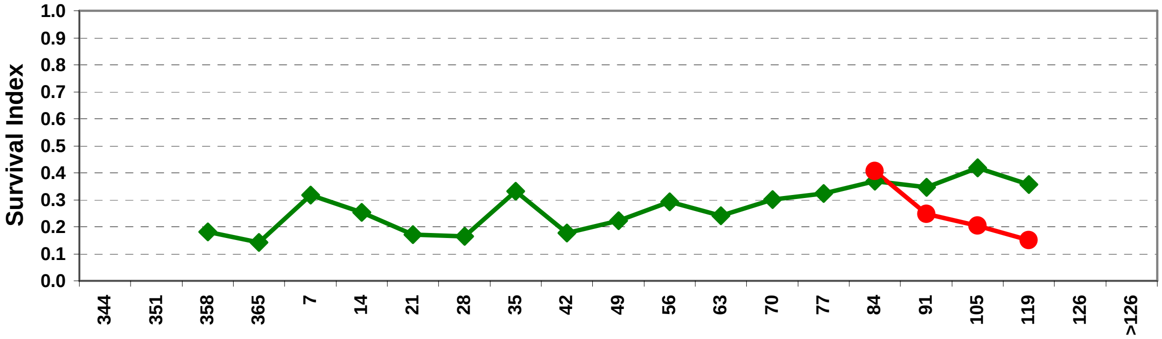
Appendix A. Figures of Survival Indices from Roza Dam Release to McNary Passage in 1999 through 2004 of Natural and Hatchery Origin Smolt



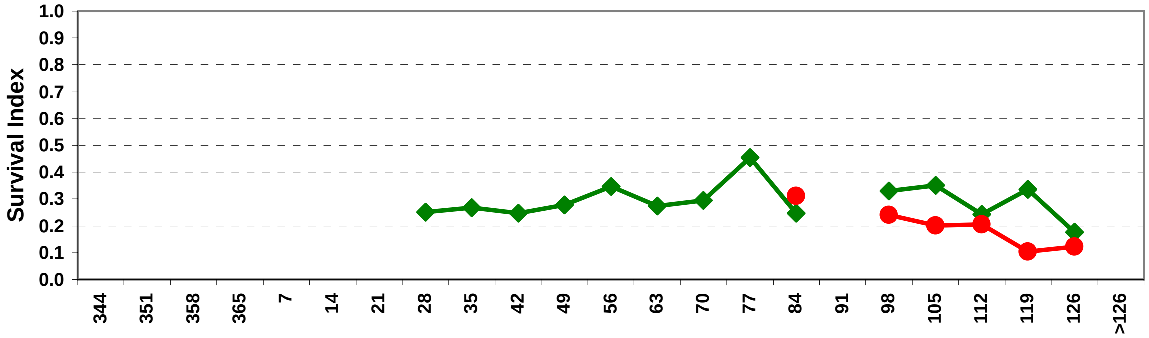




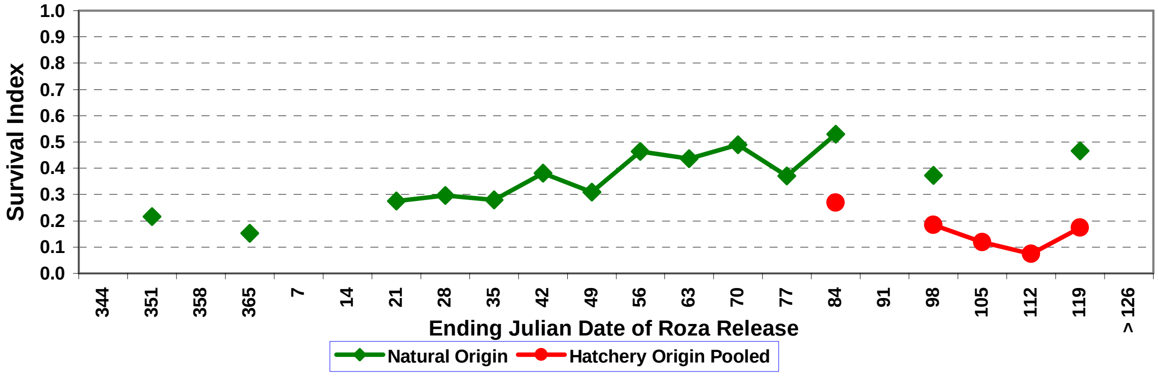
4. 2002 Release (2000 Brood)



5. 2003 Release (2001 Brood)



6. 2004 Release (2002 Brood)



Appendix F

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Annual Report: Chandler Certification for Yearling Outmigrating Smolt

Doug Neeley, Consultant to Yakama Nation

1. Introduction

Those fish passing Prosser Diversion Dam (dam) on the Yakima River that are entrained into Chandler Canal (canal) and then survive the canal into the bypass leading back to the river are sampled at the Chandler Juvenile Monitoring Facility (facility). These sampled fish are anesthetized, enumerated, and then directed to a recovery tank. Once recovered, these sampled fish are then returned to the river downstream of the dam.

The sampling involves a gate in the bypass that diverts bypass flow into a live-box from which the fish are taken and enumerated. The gate is opened to the live-box a certain proportion of time (this proportion is referred to as the timer-gate rate, TR); the rest of the time the bypass flow carries the fish directly to the river. The timer-gate rate is electronically set by the enumeration team and is varied over the passage season depending on the number[1] of fish entering the facility.

To estimate the total passage for a given species at Prosser, the species' sampled daily count is expanded by dividing the count by the proportion of Prosser passage that is enumerated on that day. This enumerated proportion used for the expansion is actually a product of three proportions: 1) entrainment rate, 2) canal-survival rate (canal survival), and 3) sample rate which are defined below:

1. Entrainment rate is the proportion of those fish passing Prosser dam that enter (are entrained into) Chandler Canal;
2. Canal survival is the proportion of those entrained fish that survive the canal to the facility; and
3. Sample rate is the proportion of those fish surviving the canal that are sampled, anesthetized, and enumerated.

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[1] When the number of fish approaches a value that exceeds the ability of the enumeration team to handle and count them, then the timer-gate rate is reduced. Alternatively, if there are few fish being enumerated, the timer-gate rate is increased.

Therefore, the expanded daily count is that given in equation Eq.1.

Eq.1.
$$\text{Daily Expanded Count} = \frac{\text{Daily Count of Fish in Sample}}{(\text{Daily Entrainment Rate}) * (\text{Daily Canal Survival}) * (\text{Daily Sample Rate})}$$

Estimates of the proportions in Eq.1, which are based on PIT-tagged fish detections, are discussed below:

Entrainment Rate: Estimates of daily entrainment rates are derived from the proportions of paired releases of PIT-tagged fish that are detected by the bypass PIT-tag detector (bypass detector) located upstream of the sample gate but downstream of the separator[2]. One of the paired releases is made into the dam's forebay on the right bank approximately ½ mile upstream of the dam, and the other release is made into Chandler Canal just below the headgates. The ratio of the bypass-detected proportion of the forebay release to the bypass-detected proportion of the canal release serves as an estimate of the entrainment rate unless the ratio exceeds 1, in which case the entrainment rate is equated to 1 (100%).

One major assumption behind this estimate being an unbiased estimate of the true entrainment rate is that the forebay survival (proportion of forebay-released fish surviving to the dam) is 1.0 (100%).

Canal Survival: The estimate of this parameter is the bypass-detected proportion of those fish that are released into the canal below the headgates.

Sample Rate: With the exception of mortalities (including sacrificed fish), all fish, once enumerated, are passed through a second PIT-tag detector (sample detector) and on to a recovery tank. For a given day of bypass detection, the proportion of those fish detected by the bypass detector that are subsequently detected by the sample detector serves as an estimate of the sample rate. Beginning in outmigration year 2003, mortalities (with the exception of sacrifice fish) are also passed through the sample detector.

It is not possible to make releases on each day, and a truly random sampling of days is not possible. During certain periods when flows are high, many fish may be passing the dam, but very few may be entrained into the canal. When few fish are entrained, there often is an insufficient number for PIT-tagging and release. To overcome this problem of sampling under conditions that are not always representative of the flow distribution, the decision was made to develop predictive models, relating estimates from the release days to predictor variables that are available on a daily basis. By doing so, the predictor equations can be used to obtain predicted entrainment estimates for all days, whether or not releases were made. One assumption is that the estimates of the parameters in the predictor equations can be accurately applied to predictor variable values that fall outside the domain of values from the sampled days.

The proportions of forebay-released and canal-released fish detected by the bypass detector were actually corrected for an estimate of the bypass detector's detection efficiency. The detection efficiency, as defined here, is the proportion of fish passing through the bypass detector that are actually detected. The detection efficiency is estimated for a given release by taking the number of released fish jointly detected by both the bypass and sample detectors and dividing that number by the total number of released fish detected by the sample detector. That estimate is usually 1 (100% of the fish passing through the bypass detector are usually detected by the bypass detector). Any corrected proportion estimates that exceed 1 are equated 1.

Issues have arisen regarding the estimation procedures used in the past.

---

[2] The separator separates by-passed smaller fish from larger fish and debris that made it past the trash racks.

Pre-release mortalities: In past reports there have been inconsistencies as to the releases to be used in developing the predictive model. Some releases were omitted because of “high pre-release” mortality. However, there did not appear to be consistency from year to year in defining “high pre-release mortality”. The decision was made toward the end of 2003 to review all data sets, and omit every forebay and canal release that had a post-tagging mortality rate of greater than 5% prior to release. The reason for omitting these releases was the concern that the tagging process may have overly stressed these fish, and the subsequent survival after release may have been affected by this stress. There was not sufficient time to screen and reanalyze these data for the 2003 report. The data have now been screened and reanalyzed for releases made before 2004.

Biases resulting from PIT-tagging fish that have already entrained into the canal for subsequent release into the forebay to estimate their subsequent entrainment: Since the fish that are released to estimate entrainment have already been entrained, these fish may be more predisposed to being entrained again than fish that have not previously been entrained. These two groups of fish are respectively referred to as experienced and naïve fish. There is evidence that this is the case, and this is discussed later in the report.

2. Entrainment Rate

The predictor canal-diversion-rate model used is a logistic regression model relating the entrainment rate (er) to the canal diversion rate (cdr), which is the estimated proportion of flow approaching Prosser Dam that is diverted into the canal. The estimator for canal-diversion rate is given in Equation 2. (Eq. 2).

Eq.2.

$$\mathrm{cdr} = \frac{(\text{below - screen canal flow}) + 132}{(\text{I - 82 river flow}) + (\text{below - screen canal flow})}$$

In the equation, the below-screen canal flow is the daily canal flow in cubic feet per second (cfs) measured just downstream of the bypass system that diverts fish entrained into the canal back into to the river. The number 132 in the equation is the designed flow (in cfs) of water bypassed from the canal to the river, and I-82 flow is the below-dam river flow at the Interstate Highway 82’s bridge crossing the Yakima River downstream of the dam and the bypass outfall.

Analyses of the screened data focused initially on early releases (Julian date ≤ 140) because of concerns that higher estimates of “canal survival” later in the season (Julian date > 140) may indicate that there were also forebay mortalities during this period. (Canal survival is covered in the next section wherein the basis of selecting Julian date 140 to separate the early and late releases is discussed.) The Spring Chinook model selected for releases using the screened data took a different form than the model fit in the past using an inconsistent screening of the data. The new model form selected is that given Eq. 3.a., the higher order term in the equation involves cdr raised to the 2nd power

Eq.3.a. Model 1:

$$\mathrm{er} = \frac{1}{1 + \exp\{-[\mathrm{b}(0) + \mathrm{b}(1) * \mathrm{cdr} + \mathrm{b}(2) * \mathrm{cdr}^2]\}} \text{ for cdr} \le -\frac{\mathrm{b}(1)}{2 * \mathrm{b}(2)}$$

In past fits, the higher-order term in the model involved cdr raised to the 3rd power (Eq. 3.b.).

Eq.3.b. Model 2:

$$\mathrm{er} = \frac{1}{1 + \exp\{-[\mathrm{b}(0) + \mathrm{b}(1) * \mathrm{cdr} + \mathrm{b}(3) * \mathrm{cdr}^3]\}} \text{ for cdr} \le \sqrt{-\frac{\mathrm{b}(1)}{3 * \mathrm{b}(3)}}$$

.

In the case of Coho, Model 2 gave a better fit than Model 1, as was the case in the past. Model selection was based on stepwise polynomial fits; but, the difference in the predictive capability of the two models is small.

The Model 1 fit for early Spring Chinook is given in Figure 1.a, along with the individual estimates for each year. There was evidence from past analyses that there were differences in the Coho and Spring Chinook entrainment predictors. This was tested using Model 1 for both species[3]. The early release fits of the early and late releases for both species are given in Figure 1.b. along with combined fit over the two species. The coefficients are given in Table 1.a. There were no significant differences between early release Coho and Spring Chinook coefficients (Table 1.b.). The graphical predicted entrainment rate for early Spring Chinook is lower than that of Coho in Figure 1.b., but given the lack of significant differences between the coefficients, I decided to combine the Coho and Spring Chinook early release-date data.

I also combined the Coho and Spring Chinook late release data[4] for the purpose of comparing early and late release entrainment-rate fits. There was a significant difference between the early and late fitted b(0) coefficients, but not the b(1) and b(2) coefficients. The early and late entrainment predictors are presented in Figure 1.c. along with the combined fit over early and late releases. Table 2.a. presents the estimated late- and early-release and combined release entrainment-model coefficients and Table 2.b. presents the comparisons between early and late release coefficients.

The final decision has not been made as to whether to use individual entrainment fits for the Spring Chinook and Coho or for the early and late releases. The combined coefficient estimates from Table 2.a. are substituted into Eq. 2. and are given in Eq. 4.

Eq.4. Model 1: $$\mathrm{er} = \frac{1}{1 + \exp\{-[-5.655 + 22.807 * \mathrm{cdr} - 15.073 * \mathrm{cdr}^2]\}} \text{ for cdr} \leq 0.7565$$

It should be noted that there were no significant differences among the yearly entrainment fits for either the Spring Chinook, the Coho, or the combined data sets (Table 3.), justifying the use of a common entrainment fit over years, whether that fit is made separately for the two species or is made for the combined species. It should also be noted that releases were made in years 1991, 1992, and 1997 through 2003 (as well as in 2004 and 2005 for which analyses have not been performed); however releases from 2000 were omitted because there was evidence that the forebay and canal releases were sometimes inadvertently switched.

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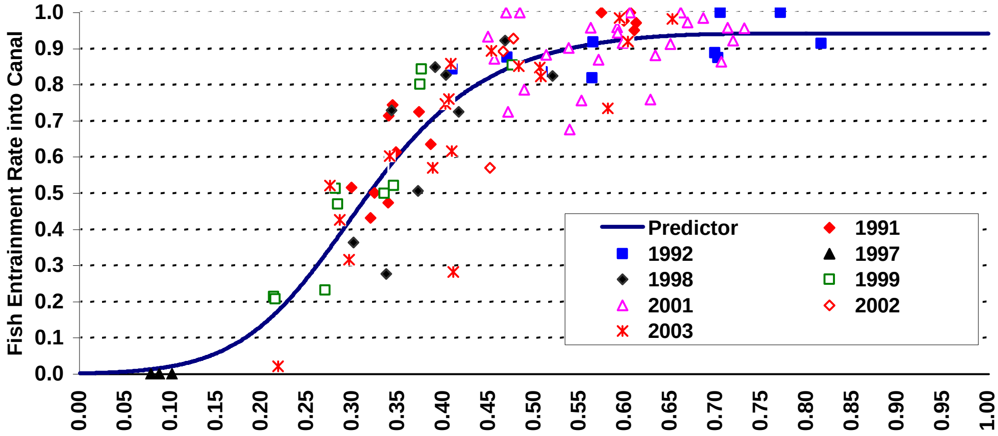
[3] Although Model 2 gave a slightly better fit for Coho than did Model 1, Coho's fits for early releases were based on only 21 data points; whereas, Spring Chinook's early-release fits were based on 94 data points. Since Model 1 was selected for Spring Chinook, Coho's Model 1 was also used for comparison purposes.

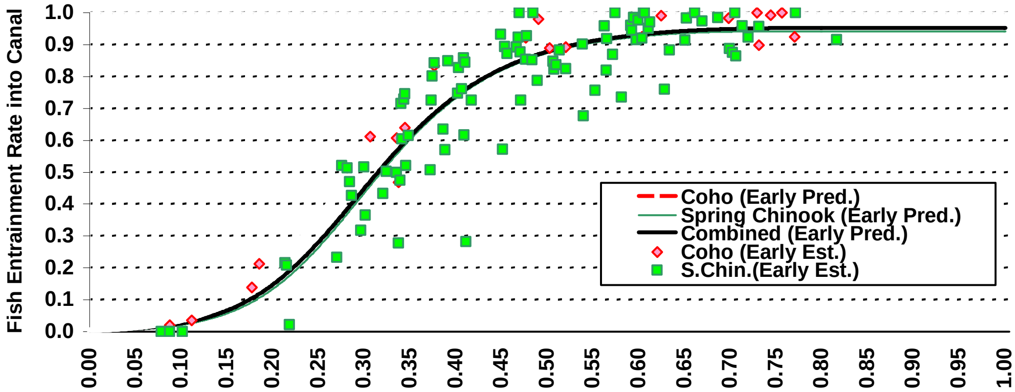
[4] There were only 5-screened late release pairs of Spring Chinook and only 21 of Coho. No formal comparison between the species' late release fits is presented.

Figure 1. Predicted entrainment rate resulting from logistically regressing estimated Entrainment Rate on Canal Diversion Rate

a. Spring Chinook Early Entrainment-Rate Predictor



b. Early Entrainment Rate Predictor



c. Early and Late Entrainment Rate Predictor

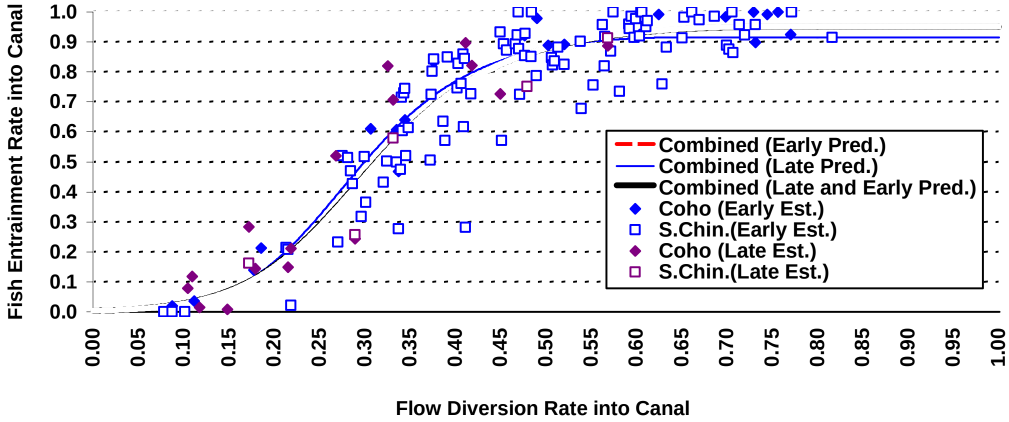


Table 1.a. **Logistic Early Release Entrainment Predictor Coefficients relating Entrainment Rate (er) to Canal Diversion Rate (cdr) [refer to Eq. 3.a.]**

	Early Release Spring Chinook		**Early Release Coho**		**Early Release Both Species**	
Coefficient	Estimate	Standard Error	Estimate	Standard Error	Estimate	Standard Error
b(0)	-6.0990	0.4603	-5.4861	0.6626	-5.7674	0.3927
b(1)	24.5898	2.0773	23.3580	3.0994	23.1603	1.7755
b(2)	-17.0437	2.2168	-14.9599	3.3480	-15.3324	1.8952

Table 1.b. **Logistic Analysis of Variation comparing differences in the three pairs of estimated partial logistic coefficients between early Spring Chinook and Coho Logistic Entrainment Predictors [i.e., comparing b(0)s, b(1)s, and b(2)s of Eq. 3.a.]**

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev = Dev/DF	F-Ratio	Type 1 P
Comparing B(0)s	1.33	1	1.33	0.15	0.6975
Comparing B(1)s	0.26	1	0.26	0.03	0.8635
Comparing B(2)s	0.63	1	0.63	0.07	0.7890
Error	954.15	109	8.75		

Table 2.a. **Logistic Early and Late Release Entrainment Predictor Coefficients relating Entrainment Rate (er) to Canal Diversion Rate (cdr) [refer to Eq. 3.a.]**

	Early Release Both Species		**Late Release Both Species**		**Combined Releases Both Species**	
Coefficient	Estimate	Standard Error	Estimate	Standard Error	Estimate	Standard Error
b(0)	-5.7674	0.3927	-6.0643	0.7523	-5.6549	0.3209
b(1)	23.1603	1.7755	26.4898	4.4793	22.8067	2.5546
b(2)	-15.3324	1.8952	-20.7983	6.2707	-15.0729	2.8069

Table 2.b. **Logistic Analysis of Variation comparing differences in the three pairs of estimated partial logistic coefficients between early and late Yearling Entrainment Predictors [i.e., comparing b(0)s, b(1)s, and b(2)s of Eq. 3.a.]**

Source	Deviance (Dev)	Degrees of reedom (DI	Mean Dev = Dev/DF	F-Ratio	Type 1 P
Combine Intercepts	64.37	1	64.37	7.76	0.0061
Combine B(1)s	0.25	1	0.25	0.03	0.8624
Combine B(2)s	0.02	1	0.02	0.00	0.9609
Error	1078.11	130	8.29		

Table 3. Logistic Analysis of Variation comparing yearly Entrainment Fits.

a. Spring Chinook (Early and Late Combined)

	Deviance	D.F.	Mean Deviance	F-Ratio	Type 1 P
Among Years	117.65	15	7.84	0.84	0.6258
Within Years	696.17	75	9.28		

b. Coho (Early and Late Combined)

	Deviance	D.F.	Mean Deviance	F-Ratio	Type 1 P
Among Years	71.57	12	5.96	1.05	0.4485
Within Years	102.09	18	5.67		

c. Coho and Spring Chinook Combined (Early and Late Combined)

	Deviance	D.F.	Mean Deviance	F-Ratio	Type 1 P
Among Years	197.71	18	10.98	1.41	0.1425
Within Years	875.09	112	7.81		

3. Canal Survival

Over the years, estimates of canal survival have generally tended to remain relatively constant toward the beginning of the outmigration season. Later in the season, there has tended to be a drop-off in survival as the season progressed. The drop off in survival has primarily been characterized by using a logistic spline fit that partitions the predictions into two parts, one predictor that is constant over the early part of the outmigration and the other predictor for the later part during which the survival decreases with respect to Julian date. The method of identifying the demarcation point between the earlier and later part is to shift the partitioning date at one-day intervals and then to choose the Julian date partitioning that results in the smallest residual variation around the predicted canal- survival response. For combined releases made prior to 2002 the partitioning was Julian date 140, after which the drop was estimated. There were no significant differences among the predicted drop off rates in survival among those years. The 2003 partitioning date was also 140, but the drop off rate for the 2003 releases was greater than the releases made prior to 2002. There were only three canal releases of yearling smolt in 2002; therefore, that data were excluded from the fit. Further, all year 2000 releases were excluded because of evidence that canal and forebay releases were inadvertently switched.

It should be noted that Spring Chinook tend to outmigrate earlier than Coho. There are Spring Chinook outmigrating later in the season, but the daily numbers are usually insufficient for making releases to estimate canal survival with any reasonable degree of precision. For this reason, estimates from Spring Chinook and Coho releases have been combined so that a late season canal-survival predictor derived primarily from Coho releases could also serve as a surrogate for Spring Chinook. The underlying assumption behind including both species' estimates in the regression is that the decrease in canal survival with respect to increasing Julian date subsequent to Julian Date 140 are the same for both Coho and Spring Chinook. Even though the coefficients associated with the drop off in survival predictor variables are common for the two species, the early outmigrant survivals were fitted separately for each species within each year. The fit is conditioned in such a way to produce different intercepts or base survivals for each species for the post-Julian-date-140 fits; therefore the survival estimates for given late-outmigrant Julian Date will not be the same for the two species even though the estimated rate of canal-survival decline is the same for both Spring Chinook and Coho. It should be noted that river temperature[5] and canal flow were also evaluated as predictor variables; however using Julian date as the predictor variable produced by far the best fit. There was no improvement in the predictive capability of the model by including river temperature in addition to Julian date.

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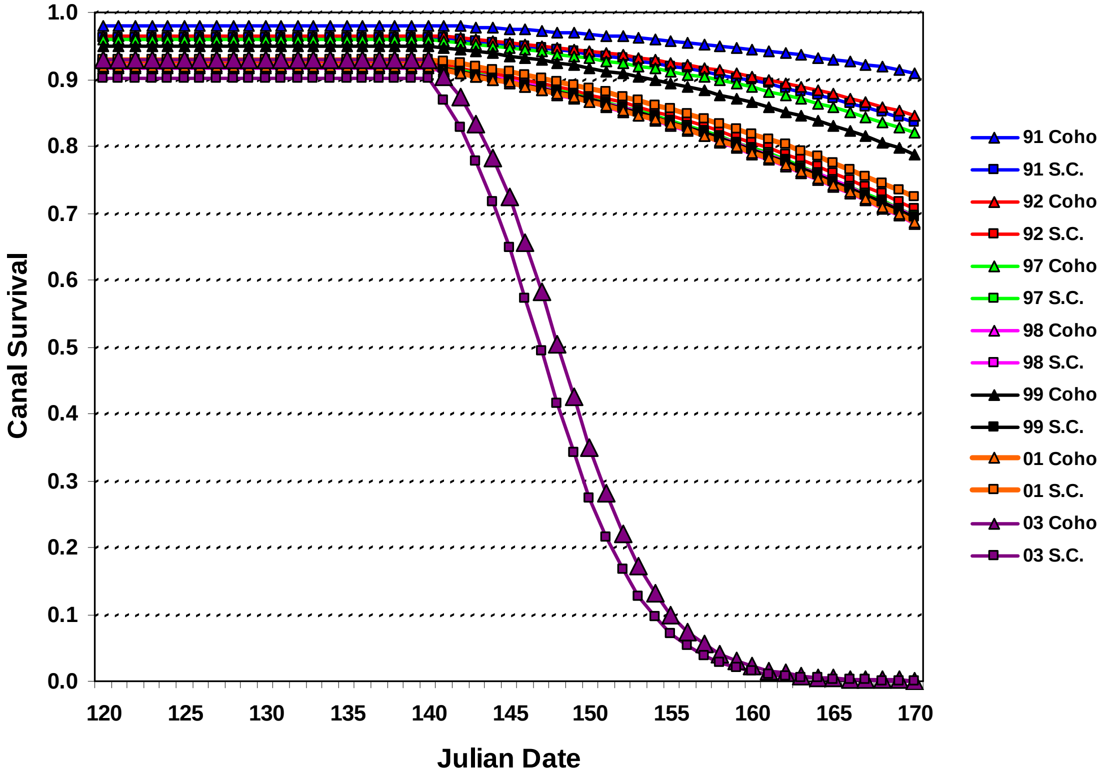
[5] There are no measures of canal temperatures.

There was an improvement in the predictive capability of the model when canal flow was included in addition to Julian date, with a slight drop off in survival with decreasing flow; however the marginal decreases did not differ significantly between the early and late outmigrants once the effect of Julian date for the late outmigrants was adjusted for. Fitted responses are presented in Figure 2 for the Julian Date fit.

Again there has been uncertainty as to whether the smolt trapped, tagged, and released toward the end of the season were more stressed and were subject to greater mortality because of the more unfavorable outmigration conditions (usually higher river temperatures and lower flows). Two treatments were evaluated during the 2004 outmigration to indirectly address this issue. One treatment was the release of fish the day after PIT-tagging, which is the standard procedure, and the other treatment was the release of fish for two or three days after PIT-tagging. The tagging schedule was set so that there would be paired releases on the same days for both 1-day and more-than-1-day holdings. The intent was to separately compare the estimated canal survivals between pairs of holding times for both early and late releases and to determine whether or not there was a greater drop in survival associated with the longer holding for the later releases than the for the earlier releases. Unfortunately, I must not have adequately articulated the purpose of the trial to the tagging crew, because there were paired holding-day releases of early yearling outmigrants but none for later yearling outmigrants. The only finding from the trial was that that there was no substantial or significant difference between the survivals of the two treatments for the earlier outmigrants.

Figure 2. Plot of Logistic Canal Survival Response on Julian Date



4. Daily Sample Rate

Yearly estimates of sample rates were developed based on bypass and sample-room detections of all PIT-tagged fish released upstream of the facility. Sample rates are changed by varying the proportion of the time that a timer gate is opened to the live box. The sample rate (sr) is estimated by dividing the number of fish that are detected by both the sample detector and the bypass detector by the number of fish detected by that bypass detector. The daily sample rate for a given timer-gate rate (TR) is based on all PIT-tagged fish of a given stock that pass the bypass detector on a given day pooled over days sharing the same TR setting (Eq. 5.).

Eq. 5.

$$\mathrm{sr} = \frac{\sum_{\mathrm{i}} \text{Joint Bypass and Sample - Room Detections (i)}}{\sum_{\mathrm{i}} \text{Bypass Detections (i)}}$$

$$\text{i being the bypass detection date}$$

Daily sample rates used for estimation purposes were only from dates that were bracketed by that same timer-gate-rate setting. Dates that were preceded or followed by a different timer-gate-rate setting were excluded from the sample-rate database because the day in question could have experienced one timer rate earlier in the day and another later in the day. Bypass detection days on which fish were trapped and hauled from the livebox to the McNary Dam pool were also excluded because these fish were usually not run through the sample-room detector. Beginning in 2003 a protocol was set in place under which trapped and hauled fish would also be run through the sample-room detector.

Tables 4.a. and 4.b.present the estimated sample rates within each timer-gate rate (TR) setting within each year respectively for Spring Chinook and Coho. Also given in the Tables are the total number of bypass detections used to estimate the sample rates (denominator in Eq.5.) and the numbers of bypass-detection days that the estimates were based on. The standard errors of sr, also given in the tables, are based on an estimate of the variance of the weighted[6] sample-rate estimate over detection days. The estimated sample rates are almost always less than the timer-gate rate; therefore, the tables also present the sr/TR ratios. Because of the limited number of detection dates for many of the TR settings, the estimates from the $TR < .33$ were pooled as were estimates for $.33 \leq TR \leq 0.5$ and for $TR > 0.5$; the SR/TR ratios from this pooling are presented in Tables 5.a. and 5.b. respectively for Spring Chinook and Coho. The first two groupings were themselves pooled, again because of the limited number of detection dates, and this pooling is also presented in the table.

If fish movements were purely random and livebox mortalities were taken into account, one would expect that the sample rate would equal the timer-gate rate. Research was conducted in 1998 to determine whether fish loss could explain why sr was usually less than TR. From this research, it was discovered that some PIT-tagged fish that were placed into the livebox escaped the livebox and swam upstream into the bypass and through the bypass detector; the sample-room detector never detected these fish. Such fish escape could be one source of fish loss. The sample detector would never detect fish that escape the live box; therefore escaping fish would not contribute to the sample-rate estimate. In 1999 a device was placed in the sampler to discourage the escape. This effort did not result in the sr/TR ratio becoming 1, and there is likely fish loss in the livebox in addition to that attributable to fish escaping back to the bypass.

It was discovered after the 2002 monitoring effort that dead fish from the live box were never scanned for PIT-tags. Undetected livebox mortalities of PIT-tagged fish could be another source of fish loss. Beginning with the 2003 outmigrants, livebox mortalities are also being run through the sample-room detector. The main issue that we

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[6] Weights are the daily number of bypass detections.

hope to address by passing mortalities through the sample-room detector is the failure for the sr/TR ratio to be constant over years. This is an issue because, for each species for the various TR settings within many of the years, sr estimates are based on only a few (sometimes none or one) bypass detection dates. The hope was that by including livebox mortalities it would be possible to stabilize the sr/TR ratios over years. As can be seen from Tables 5.a. and 5.b., this is unlikely to be the case. For TR rates ≤ 0.5, the sr/TR ratio for 2003 was among the lowest over years for both Spring Chinook and Coho. For those years for which there was more than one detection date involved in the estimate, only 2001 had a lower sr/TR ration for TR ≤ 0.5[7]. With mortalities being run through the sample detector in 2003, the sr/TR ratio would have been expected to increase, not to decrease.

It is clear that either the sample rate for a given TR setting is not constant over years or that the live box loss is not constant over years or both.

5. *Experienced versus Naïve releases (adjusting for bias)*

Of the three expansion predictors (entrainment, canal survival, and sampling rates), entrainment appears to be the least problematic from an estimation standpoint; however, there is evidence that the entrainment predictions based on forebay and canal releases of experienced fish is biased. In 1991, Dave Seiler (Fisheries Biologist, Washington Department of Fish and Wildlife) noted that the ratio of unbranded-to-branded fish from a screw trap located well downstream of Prosser Dam was far greater than those sampled from the Chandler bypass system. If these branded fish were captured, anesthetized, branded, and released from the bypass and then released into Prosser's forebay, then this would suggest that there may be a bias associated with bypass estimates of entrainment rates.

Efforts were made in 1997 and 1998 to assess the potential bias using experienced PIT-tagged fish. In 2001 fish were sample from both the Chandler bypass and the Sunnyside bypass located several miles upstream of Prosser Dam, and forebay releases were made for each group. The Chandler-tagged fish were taken as the experienced group and the Sunnyside-tagged fish were taken as the naïve. There was a major concern associated with the 1997 experiment; the Sunnyside fish were not actively passing Prosser and could not be considered representative sampling of naïve passage. There was a second issue. That year was a high flow year, and the entrainment rate was low; therefore, for several of the paired releases, there were no Chandler detections of either the naïve or experienced fish. There were only three paired releases (all Coho) from 1997 that could be compared. In 1998, attempts were made to sample naïve fish from the Yakima River in Prosser's forebay using a screw trap. Unfortunately almost no fish were captured in the screw trap, and only one paired release (Fall Chinook) was made that year. For all four comparable pairs, the proportion of experienced forebay-released fish detected in the Chandler bypass was greater than that for the naïve proportion; and for three of those pairs, the difference was substantial and highly significant (Table 6).

My recommendation is to estimate the ratio of McNary-detected PIT-tagged hatchery releases that were not detected at Prosser to those that were detected at Prosser. A comparable ratio can be developed using the expansion of those hatchery fish detected at Prosser using Eq. 1. It may be possible to then calibrate the expansion factors based on McNary estimates, and then to apply the calibrations to all wild and hatchery fish enumerated at Chandler.

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[7] For Spring Chinook in 1992, the sr/TR ratio was smaller than that in 2003 for TR < .5; however, the 1992 estimate was based on only 1 detection date.

Table 4.a. Estimated Spring Chinook Sample Rates (sr) for at Chandler Juvenile Monitoring Facility for Timer-Gate Rate (TR) Settings based on Chandler Detections of all Spring Chinook released in the Yakima Nation upstream of Prosser Dam

Year	Sample Rate (sr) Information*	Timer (TR) Rates						
		0.1	0.2	0.25	0.33	0.5	0.75	1.0
1991	Sample Rate Estimate**	0.1667			0.3239	0.4015	0.6718	
	Standard Error (SE)	0.23570			0.03733	0.00853	0.01367	
	sr**/TR ratio	1.6667			0.9815	0.8031	0.8958	
	Separator Detections**	6			565	1178	387	
	Number of Days**	2			6	6	4	
1992	Sample Rate Estimate		0.0000		0.2591			
	Standard Error (SE)		no estimate		0.01070			
	sr/TR ratio		0.0000		0.7850			
	Separator Detections		2		2208			
	Number of Days		1		25			
1997	Sample Rate Estimate				0.1250			0.7661
	Standard Error (SE)				no estimate			0.06046
	sr/TR ratio				0.3788			0.7661
	Separator Detections				72			124
	Number of Days				1			6
1998	Sample Rate Estimate				0.2575	0.3741		
	Standard Error (SE)				0.00948	0.04932		
	sr/TR ratio				0.7802	0.7482		
	Separator Detections				1845	139		
	Number of Days				29	8		
1999***	Sample Rate Estimate				0.2711	0.4221		
	Standard Error (SE)				0.01067	0.01073		
	sr/TR ratio				0.8215	0.8441		
	Separator Detections				2110	2303		
	Number of Days				35	41		
2000	Sample Rate Estimate			0.0667	0.2654	0.3924		0.8725
	Standard Error (SE)			0.07817	0.00967	0.01243		0.04796
	sr/TR ratio			0.2667	0.8041	0.7847		0.8725
	Separator Detections			15	4055	4427		604
	Number of Days			3	39	25		6
2001	Sample Rate Estimate	0.0585			0.1008	0.1197		0.9804
	Standard Error (SE)	0.00221			0.01029	0.01916		0.00354
	sr/TR ratio	0.5848			0.3055	0.2394		0.9804
	Separator Detections	1516			3789	2958		2139
	Number of Days	2			8	22		26
2002	Sample Rate Estimate		0.1472		0.2804	0.3333		0.9667
	Standard Error (SE)		0.00752		0.03417	0.16667		0.01390
	sr/TR ratio		0.7359		0.8496	0.6667		0.9667
	Separator Detections		10946		938	12		210
	Number of Days		27		36	5		35
2003	Sample Rate Estimate				0.2223	0.2600		0.9765
	Standard Error (SE)				0.00752	0.02500		0.01099
	sr/TR ratio				0.6737	0.5201		0.9765
	Separator Detections				16787	573		851
	Number of Days				53	24		27

* Estimated SR = (Pooled joint Separator and Sample Room Detections)/(Pooled Separator Detections). Pooled Separator Detections are given along with Number of Days (Adjacent Days) over which detections are pooled. Adjacent Days are the number of days for a given Timer Rate setting that are preceded and followed by days at that setting.

** Pooled estimates exclude data from 05/06/1991 for which date the sr estimate was 0 based on 248 separator detections.

*** In 1999,a device was installed to prevent escape from the livebox. Dates of installation and removal of device were not recorded in the event log for the Facility.

NOTE: Standard Error is based on n - 1 degrees of freedom where in n is "Number of Days"

Table 4.b. Estimated Coho Sample Rates (sr) for at Chandler Juvenile Monitoring Facility for Timer-Gate Rate (TR) Settings based on Chandler Detections of all Spring Chinook released in the Yakima Nation upstream of Prosser Dam

Year	Sample Rate (SR)	Timer (TR) Rates						
	Information*	0.1	0.2	0.25	0.33	0.5	0.75	1.0
1991	Sample Rate Estimate				0.2796			
	Standard Error (SE)				0.02704			
	SR/TR ratio				0.8474			
	Separator Detections				1788			
	Number of Days				9			
1992	Sample Rate Estimate		0.1481		0.2350			
	Standard Error (SE)		0.02905		0.01632			
	SR/TR ratio		0.7407		0.7122			
	Separator Detections		27		685			
	Number of Days		2		11			
1997	Sample Rate Estimate							0.9172
	Standard Error (SE)							0.03045
	SR/TR ratio							0.9172
	Separator Detections							157
	Number of Days							9
1998	Sample Rate Estimate				0.2251	0.3755		
	Standard Error (SE)				0.01750	0.02920		
	SR/TR ratio				0.6820	0.7511		
	Separator Detections				391	1414		
	Number of Days				10	40		
1999**	Sample Rate Estimate				0.2408	0.3119		
	Standard Error (SE)				0.01683	0.02132		
	SR/TR ratio				0.7296	0.6239		
	Separator Detections				947	561		
	Number of Days				23	26		
2000	Sample Rate Estimate			0.1298	0.2472	0.2939		
	Standard Error (SE)			0.04479	0.02462	0.03745		
	SR/TR ratio			0.5191	0.7490	0.5878		
	Separator Detections			131	619	245		
	Number of Days			3	9	18		
2001	Sample Rate Estimate				0.1144	0.1963		
	Standard Error (SE)				0.01100	0.03792		
	SR/TR ratio				0.3467	0.3925		
	Separator Detections				839	107		
	Number of Days				8	6		
2002	Sample Rate Estimate		0.1696		0.1883	0.6000		
	Standard Error (SE)		0.02249		0.02141	0.21602		
	SR/TR ratio		0.8478		0.5707	1.2000		
	Separator Detections		230		377	5		
	Number of Days		25		8	4		
2003	Sample Rate Estimate				0.1867	0.2695		
	Standard Error (SE)				0.01455	0.02275		
	SR/TR ratio				0.5656	0.5389		0.0000
	Separator Detections				1109	334.0000		1
	Number of Days				35	26		1

* Estimated SR = (Pooled joint Separator and Sample Room Detections)/(Pooled Separator Detections). Pooled Separator Detections are given along with Number of Days (Adjacent Days) over which detections are pooled. Adjacent Days are the number of days for a given Timer Rate setting that are preceded and followed by days at that setting.

** In 1999,a device was installed to prevent escape from the livebox. Dates of installation and removal of device were not recorded in the event log for the Facility.

NOTE: Standard Error is based on n - 1 degrees of freedom where in n is "Number of Days"

Table 5. Pooled Estimates of sr/TR ratios over Sets of Timer-Gate Rate Settings

a. Spring Chinook (pooled from summaries given in Table 4.a.)

Year	Sample Rate (sr)	Timer (TR) Rates				
	Information*	TR =.1-.25	TR=.33 -.5	TR=.75-1	TR <=.5	TR > .5
1991	sr**/TR ratio	1.6667	0.8609	0.8958	0.8637	0.8958
	Separator Detections**	6	1743	387	1749	387
	Number of Days**	2	12	4	14	4
1992	sr/TR ratio	0.0000	0.7850		0.7843	
	Separator Detections	2.0000	2208	0	2210	
	Number of Days	1	25	0	26	
1998	sr/TR ratio		0.77792033		0.7779	0.8549
	Separator Detections		1984	0	1984	
	Number of Days		37	0	37	
1999**	sr/TR ratio		0.83329557		0.8333	
	Separator Detections		4413	0	4413	
	Number of Days		76	0	76	
2000	sr/TR ratio	0.2667	0.7940	0.8725	0.7931	0.8725
	Separator Detections	15.0000	8482	604	8497	604
	Number of Days	3	64	6	67	6
2001	sr/TR ratio	0.5848	0.2765	0.9804	0.3331	0.9804
	Separator Detections	1516.0000	6747	2139	8263	2139
	Number of Days	2	30	26	32	26
2002	sr/TR ratio	0.7359	0.8473	0.9667	0.7448	0.9667
	Separator Detections	10946	950	210	11896	210
	Number of Days	27	41	35	68	35
2003	sr/TR ratio		0.6686	0.9765	0.6686	0.9765
	Separator Detections		17360	851	17360	851
	Number of Days		77	27	77	27

Table 5. (continued)

b. Coho (pooled from summaries given in Table 4.b)

Year	Sample Rate (SR) Information*	Timer (TR) Rates				
		TR =.1-.25	TR=.33 -.5	TR=.75-1	TR <=.5	TR > .5
1991	SR/TR ratio		0.8474		0.8474	
	Separator Detections		1788		1788	
	Number of Days		9		9	
1992	SR/TR ratio	0.7407	0.7122		0.7133	
	Separator Detections	27.0000	685		712	
	Number of Days	2	11		13	
1997	Sample Rate Estimate					
	Standard Error (SE)					
	Number of Days			9		9
1998	Sample Rate Estimate					
	Standard Error (SE)					
	Number of Days		50		50	
1999**	SR/TR ratio		0.69025802		0.6903	
	Separator Detections		1508		1508	
	Number of Days		49		49	
2000	SR/TR ratio	0.5191	0.7033		0.6790	
	Separator Detections	131.0000	864		995	
	Number of Days	3	27		30	
2001	SR/TR ratio		0.3519		0.3519	
	Separator Detections		946		946	
	Number of Days		14		14	
2002	SR/TR ratio	0.8478	0.5789		0.6800	
	Separator Detections	230	382		612	
	Number of Days	25	12		37	
2003	SR/TR ratio		0.5594	0.0000	0.5594	0.0000
	Separator Detections		1443	1	1443	1
	Number of Days		61	1	61	1

Table 6. **Paired comparison of proportions of experienced and naïve PIT-tagged releases into Prosser Diversion Dam's Forebay that were subsequently detected by the Chandler Bypass PIT-tag detector**

Species	Release Date		Experienced (E)	Naïve (N)	Z-Test	1 P for Q(E) > Q(N)
Coho	05/22/97	Number Released	282	61		
		Proportion Detected (Q)	0.0780	0.0656	0.33	0.1856
Coho	05/29/97	Number Released	278	459		
		Proportion Detected (Q)	0.1007	0.0109	3.93	0.0000
Coho	06/12/97	Number Released	192	227		
		Proportion Detected (Q)	0.0990	0.0220	2.63	0.0021
Fall_Chin	05/29/98	Number Released	197	100		
		Proportion Detected (Q)	0.2437	0.1800	1.21	0.0568

Appendix G

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2004 Annual Report: Smolt-to-Smolt Survival of Main-Stem-Yakima Fall Chinook reared under Accelerated- and Conventional-Rearing Conditions (and Smolt-to-Smolt Survival of Marion Drain Fall Chinook)

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1. Introduction

From 1999 through 2004, there have been releases from three groups of Fall Chinook. Two of the groups were of progeny from Main-Stem-Yakima Fall Chinook stock collected at Prosser: One of the two was assigned to a conventional-rearing treatment as a control, and the other was assigned to a rearing treatment designed to accelerate smolting, permitting an earlier release and outmigration during a period believed to be more optimal for survival. These two groups were released into the Yakima River downstream of the Prosser Diversion Dam on the lower Yakima.

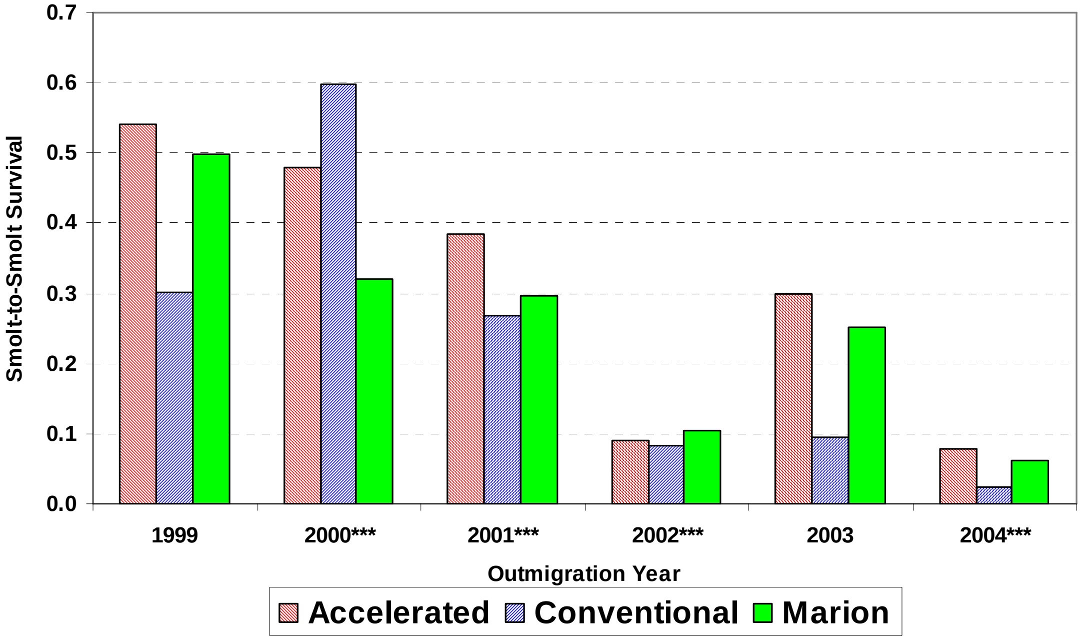
The third release group involved a different stock of hatchery-reared Fall Chinook, Marion Drain Fall Chinook, which are genetically distinct from the Main-Stem-Yakima stock. The Marion Drain releases are part of a supplementation program, which takes Marion Drain returns as broodstock and releases their hatchery-reared progeny back into Marion Drain.

A portion of each release is PIT-tagged, and the survivals of the PIT-tagged portion of each group from release to McNary Dam (McNary) passage are estimated using the PIT-tag detection tallies at McNary expanded by an estimate of McNary's detection efficiency. The expanded McNary tally for each group divided by the number originally PIT-tagged is the estimated survival index.   The daily-expanded passage estimates are also used to estimate mean passage date at McNary

2. Summary

The smolt-to-smolt survival indices of the Main-Stem-Yakima Fall Chinook assigned to the accelerated-rearing treatment exceeded those assigned to the conventional-rearing treatment in five of the six outmigration years, the exception being outmigration-year 2000 (Figure 1).

Figure 1. Weighted Tagging-to-McNary-Passage Smolt-to-Smolt Survival Indices for 1999-2004* Outmigrants of three Groups of Fall Chinook (weights are release numbers)**



* Brood-years 1998-2003, respectively.

** Main-Stem-Yakima Stock under Accelerated Rearing, Main-Stem-Yakima Stock under Conventional Rearing, and Marion Drain Stock

3. Analysis

In outmigration years 1999 and 2003 there were unreplicated releases of the three groups--accelerated, conventional, and Marion Drain. In outmigration-years 2000 through 2002, there were two replicated releases of each group, the second release made one day following the first. However, Melinda Davis and Todd Newsome[1] felt that most Fall Chinook do not immediately move out after their release and that it is likely that the fish from each group's two releases would tend to mix before outmigrating. If this were the case, the two releases would not be independent, thus a measure of error variation based on differences between each group's two releases' survival indices would be too small, leading to an inflated chance of concluding there were statistically significant differences among the groups' survival indices when there were not. Therefore, the databases from the two releases within each group were pooled within each year. In 2004, there again were two separate releases per group, but the releases were separated by three days instead of one, and the decision was made to treat the two releases within each group as independent replicated releases. For comparing survival rates among groups, the group x year interaction source of variation was used as a source of error. Group x year interactions are tested against the 2004 differences in survivals between replicates within groups as a source of error. Since this latter source of error is from only one year, how representative it is of other years is unknown as is the degree of bias associated with testing group x year interactions against this error.

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[1] Fisheries Biologist, Yakima Nation, personal communication

Survival indices were estimated by first estimating the number of PIT-tagged fish reaching McNary. The number of fish detected at McNary was expanded (divided) by McNary's PIT-tag detection efficiency (the estimated proportion of PIT-tagged fish passing McNary that were detected at McNary). The expanded passage, adjusted for removal of PIT-tagged fish at McNary, was then divided by the number of fish tagged, the result being an index of survival. These survival indices were then subjected to a logistic analysis of variation. The estimation for the 2004 releases are presented in Appendix A, as are the detection efficiencies used to estimate the survival indices and the index estimates

The logistic analysis of variation of the smolt-to-smolt survival indices is presented in Table 1. The groups assigned to the accelerated-rearing conditions had a higher mean survival over years compared to the conventionally reared group. The difference was significant at the 5% level (P = 0.033 based on a 1-sided test derived from the logistic analysis of variation, Table 1).

Table 1. Weighted Logistic Analysis of Variation of Tagging-to-McNary Smolt Survival for 1999-2004* Outmigrants of three Groups of Fall Chinook (weights are release numbers)**

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Deviance (Dev/DF)	F-Ratio	Type 1 P
Year	5956.74	5	1191.35	17.89	0.0001 ***
Marion vs Prosser	4.53	1	4.53	0.07	0.7995 ***
Accelerated vs Control	283.54	1	283.54	4.26	0.0660 ***
Interaction	666.03	10	66.60	13.16	0.0284 ****
Error (Among 2004 Replicates)	15.18	3	5.06		

* Brood years 1998 through 2003, respectively.

** Main-Stem-Yakima Stock under Accelerated Rearing, Main-Stem-Yakima Stock under Conventional Rearing, and Marion Drain Stock

*** Tested against "Interaction" source, one-sided test for Accelerated survival greater than Conventional is P = ½*0.0660 = 0.0330, 0.0660 from above table's Type 1 P.

**** Tested against "Error" source

The individual yearly survival-index estimates are given in Table 2 along with the travel time, mean date of McNary passage, and mean travel time from release to McNary passage. The survival-index estimates of the accelerated were greater than those of the conventional in 5 of the 6 years (the exception, outmigration 2000, contributed to the significant interaction observed in Table 1). The overall survival index in 2004 was lower than the survival indices for other five years. While the mean travel time, which is the mean passage date minus the release date, was greater for the accelerated group in 5 of the 6 years (the exception being 2004), the accelerated-rearing-group mean date of McNary passage was always earlier.

Table 2. **Tagging-to-McNary-Passage Smolt-to-Smolt Survival Indices and Passage Measures for 1999-2004* Outmigrants of three Groups** of Fall Chinook (weights are release numbers)**

Outmigration Year		Below Prosser Release		Marion Release	Over Treatments
		Accelerated	Conventional		
	Expanded McNary Passage	1081.5	593.5	514.1	2189.1
1999	Number Tagged	2000	1973	1032	5005
	Survival Index	**0.5407**	**0.3008**	**0.4981**	**0.4374**
	Release Date	04/25/99	05/25/99	05/22/99	
	Mean McNary Passage Date	05/22/99	06/17/99	06/21/99	
	Mean Release-to-McNary Travel Time	28	24	31	
	Expanded McNary Passage	972.1	1207.8	321.8	2501.7
2000* **	Number Tagged	2033	2018	1003	5054
	Survival Index	**0.4782**	**0.5985**	**0.3209**	**0.4950**
	Release Date	04/20/00	05/25/00	04/10/00	
	Mean McNary Passage Date	05/27/00	06/19/00	05/28/00	
	Mean Release-to-McNary Travel Time	36	25	48	
	Expanded McNary Passage	774.1	528.1	303.6	1605.8
2001* **	Number Tagged	2014	1965	1020	4999
	Survival Index	**0.3844**	**0.2687**	**0.2976**	**0.3212**
	Release Date	04/19/01	05/16/01	04/12/01	
	Mean McNary Passage Date	05/27/01	06/07/01	05/26/01	
	Mean Release-to-McNary Travel Time	38	22	44	
	Expanded McNary Passage	179.9	166.8	105.1	451.7
2002* **	Number Tagged	2001	2000	1000	5001
	Survival Index	**0.0899**	**0.0834**	**0.1051**	**0.0903**
	Release Date	04/15/02	05/15/02	04/01/02	
	Mean McNary Passage Date	06/08/02	06/21/02	06/15/02	
	Mean Release-to-McNary Travel Time	54	37	76	
	Expanded McNary Passage	596.6	183.5	249.1	1029.2
2003	Number Tagged	2000	1938	994	4932
	Survival Index	**0.2983**	**0.0947**	**0.2506**	**0.2087**
	Release Date	05/01/03	05/20/03	05/01/03	
	Mean McNary Passage Date	05/24/03	06/08/03	06/02/03	
	Mean Release-to-McNary Travel Time	23	19	32	
	Expanded McNary Passage	316.9	95.9	125.0	537.8
2004* **	Number Tagged	3999	4001	2001	10001
	Survival Index	**0.0792**	**0.0240**	**0.0625**	**0.0538**
	Release Date	05/04/04	05/19/04	04/20/04	
	Mean McNary Passage Date	06/01/04	06/17/04	05/25/04	
	Mean Release-to-McNary Travel Time	28	29	34	
	Expanded McNary Passage	3921.0	2775.6	1618.7	8315.3
Over	Number Tagged	14047	13895	7050	34992
Years	**Survival Index**	**0.2791**	**0.1998**	**0.2296**	**0.2376**

* Brood-years 1998-2003, respectively

** Main-Stem Yakima Stock under Accelerated Rearing, Main-Stem-Yakima Stock under Conventional Rearing, and Marion Drain Stock

*** Estimates are pooled over two replicates-per-treatment

The Marion group is not truly comparable to the two groups of the Main-Stem-Yakima stock because: 1) it is a different stock, 2) its release site (Marion Drain) is well upstream of that of the other two groups' release site (below Prosser Diversion Dam), and 3) its release time is usually different than those of the others. The Marion Drain stock was always released before the conventional-rearing-treatment group; and, in 5 of the 6 years, it was released earlier than or on the same day as the accelerated-rearing-treatment group. In the first release year, the Marion Drain stock was released on about the same date as the conventional-rearing group, much later than the accelerated-rearing group. In all years, the mean travel time from Marion Drain to McNary was greater than the travel time from Prosser to McNary for the other two groups, possibly partially due to the greater distance the Marion Drain stock had to travel. In all but the second year of release, the Marion Drain survival was greater than that of the conventional-rearing release of the Main Stem Yakima Stock.

4. Recommended Estimation Alterations

Only McNary-detected fish are expanded to estimate smolt survival to McNary; however, John Day detected fish not previously detected at McNary also survived to McNary. Estimation procedures will be explored in 2005 that will permit the expansion of such John Day detection by the product of the estimated detection efficiency of John Day dam based on detections at Bonneville and the estimated probability of fish not being detected at McNary[2]. The procedure developed should still permit the estimation of expanded daily McNary passage numbers.

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[2] This estimated probability would likely be 1 - McNary's detection-efficiency.

Appendix A. Estimated Survival Index and Logistic Analysis

Weighted logistic analyses of variation were performed on release-to-McNary survival-index estimates using release number as the weighting variable.

Smolt-to-smolt survival index: The release-to-McNary smolt-to-smolt survival index in this study is estimated as follows:

Equation A.1.

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

wherein

5) “Stratum” is a group of contiguous McNary detection dates among which the daily detection efficiencies[3] were sufficiently homogeneous to permit the use of a pooled estimate of the detection efficiency for that stratum;

6) “McNary Detections” is the release’s fish detected at McNary during the stratum;

7) “Detections Removed” is the number of the stratum’s “McNary Detections” that were removed for transportation or for sampling and not returned to the river (Fish detected at McNary’s Raceways A and B but not subsequently detected at McNary); and

8) “Detection Efficiency” is the estimated proportion of <u>all</u>[4] Yakima PIT-tagged Fall Chinook passing McNary Dam during the stratum that were detected at McNary (Equation A.2).

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[3] 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.

[4] All is all PIT-tagged Fall Chinook releases into the Yakima, not only those of the three release groups.

Equation A.2.

$$\text{Stratum's McNary detection efficiency} = \frac{\text{Stratum's number of joint detections at McNary and downstream dam}}{\text{Statum's total number of detections at downstream dam}}$$

The numbers of downstream-dam detections actually represent a pooling of number of detections from John Day and Bonneville dams. The method of estimating the detection efficiency and the pooling procedure is discussed in the 2003 Annual Report.

For the 2004 outmigration year, no strata were identified, and a single pooled detection efficiency over all dates was used to expand the total number of smolt detected passing McNary. The McNary detection efficiencies used are presented for each outmigration year in Table 1.A, the pooled estimates over downstream dams (Bonneville and John Day) were used for the expansions.

Table A.1. Estimated McNary (McN) Detection Efficiencies based 1) on Bonneville (Bonn) and John Day (JD) Detections and their Pooled Detections with McNary and 2) on the Pooling of the Detections of those two dams Downstream (DS) of McNary

Applicable Passage Dates		Bonneville-Based Estimates			John Day-Based Estimates			Pooled Estimates		
Beginning	Ending	Detections		Detection	Detections		Detection	Detections		Detection
Date	Date	Bonn	Bonn, McN	Efficiency	JD	JD, McN	Efficiency	DS	DS,McN	Efficiency
Outmigration Year 1999										
	05/24/99	47.1	15	0.3186	100.3	21	0.2095	147.3	36	0.2443
05/25/99	05/31/99	53.7	18	0.3352	167.6	50	0.2984	221.3	68	0.3073
06/01/99	06/26/99	286.8	61	0.2127	787.7	144	0.1828	1074.6	205	0.1908
06/27/99		55.4	17	0.3070	103.4	34	0.3287	158.8	51	0.3211
Outmigration Year 2000										
	05/28/00	42.9	6	0.1398	64.4	16	0.2485	107.3	22	0.2050
05/29/00	06/18/00	82.7	30	0.3629	157.5	43	0.2731	240.1	73	0.3040
06/19/00	06/28/00	4.4	2	0.4545	50.9	24	0.4712	55.3	26	0.4699
06/29/00		3.0	1	0.3333	33.2	22	0.6627	36.2	23	0.6354
Outmigration Year 2001										
		159.0	99	0.6226	551.0	353	0.6407	710.0	452	0.6366
Outmigration Year 2002										
05/03/02	06/25/02	125.0	39	0.3120	265.0	258	0.9736	390.0	297	0.7615
Outmigration Year 2003										
01/00/00	05/19/03	29.4	11	0.3744	31.1	12	0.3861	60.5	23	0.3804
05/20/03	05/29/03	46.7	11	0.2358	113.9	28	0.2458	160.6	39	0.2429
05/30/03	06/01/03	52.5	19	0.3620	188.1	56	0.2977	240.6	75	0.3117
06/02/03	06/15/03	129.0	53	0.4110	253.8	97	0.3822	382.8	150	0.3919
06/16/03	07/08/03	64.5	43	0.6664	52.1	36	0.6912	116.6	79	0.6775
Outmigration Year 2004										
05/13/04	06/19/04	79.0	30	0.3797	171.0	56	0.3275	250.0	86	0.3440

Table A.2 presents the stratum numbers used for each stratum for each year in Equation A.1 along with the estimated survival-rate estimates.

Table A.2. Stratum Detection Numbers and Detection Efficiencies and Resulting Survival Indices for Each Release

a) Brood-Year 1998 (Outmigration-Year 1999)

Detection Efficiency Strata		McNary Detections	Accelerated	Convetional	Marion Drain
Sratum	1	Total (T)	101	0	0
First Date	4/26/99	Removed (R)	0	0	0
Last Date	5/24/99	T-R	101	0	0
Detection Efficiency	0.2443	Expanded	413.4	0.0	0.0
Sratum	2	Total (T)	157	1	0
First Date	5/25/99	Removed (R)	0	0	0
Last Date	5/31/99	T-R	157	1	0
Detection Efficiency	0.3073	Expanded	510.9	3.3	0.0
Sratum	3	Total (T)	30	94	85
First Date	6/1/99	Removed (R)	0	0	0
Last Date	6/26/99	T-R	30	94	85
Detection Efficiency	0.1908	Expanded	157.3	492.7	445.6
Sratum	4	Total (T)	0	32	22
First Date	6/27/99	Removed (R)	0	1	0
Last Date	8/24/99	T-R	0	31	22
Detection Efficiency	0.3211	Expanded	0.0	97.5	68.5
		Total Expanded	1081.5	593.5	514.1
		Number Tagged	2000	1973	1032
		Survival Index	**0.5407**	**0.3008**	**0.4981**
		Release Date	04/25/99	05/25/99	05/22/99
		McNary Mean Detection Date	05/22/99	06/17/99	06/21/99
		Release to McNary Passage Days	28	24	31

Table A.2. (continued)

b) Brood-Year 1999 (Outmigration-Year 2000)

		McNary	Accelerated		Convetional		Marion Drain	
Detection Efficiency Strata		Detections	Release 1	Release 2	Release 1	Release 2	Release 1	Release 2
Sratum	1	Total (T)	50	51	0	1	5	34
First Date	4/20/00	Removed (R)	0	0	0	0	0	0
Last Date	5/28/00	T-R	50	51	0	1	5	34
Detection Efficiency	0.2050	Expanded	243.9	248.8	0.0	4.9	24.4	165.9
Sratum	2	Total (T)	76	74	82	113	12	28
First Date	5/29/00	Removed (R)	2	6	4	2	0	0
Last Date	6/18/00	T-R	74	68	78	111	12	28
Detection Efficiency	0.3040	Expanded	245.4	229.7	260.6	367.2	39.5	92.1
Sratum	3	Total (T)	0	2	117	117	0	0
First Date	6/19/00	Removed (R)	0	0	0	0	0	0
Last Date	6/28/00	T-R	0	2	117	117	0	0
Detection Efficiency	0.4699	Expanded	0.0	4.3	249.0	249.0	0.0	0.0
Sratum	4	Total (T)	0	0	34	15	0	0
First Date	6/29/00	Removed (R)	0	0	0	0	0	0
Last Date	7/30/00	T-R	0	0	34	15	0	0
Detection Efficiency	0.6354	Expanded	0.0	0.0	53.5	23.6	0.0	0.0
		Total Expanded	489.3	482.7	563.1	644.6	63.9	258.0
		Number Released	1000	1033	1008	1010	495	508
		Survival Index	**0.4893**	**0.4673**	**0.5586**	**0.6383**	**0.1290**	**0.5078**
		Release Date	04/20/00	04/21/00	05/25/00	05/26/00	04/11/00	04/10/00
		McNary Mean Detection Date	05/26/00	05/28/00	06/21/00	06/17/00	05/29/00	05/28/00
		Release to McNary Passage Days	36	37	27	23	48	48
		Pooled Treatment Expanded		972.1		1207.8		321.8
		Pooled Treatment Number Released		2033		2018		1003
		Survival Index		**0.4782**		**0.5985**		**0.3209**
		Pooled McNary Mean Detection Date		05/27/00		06/19/00		05/28/00
		Pooled Release to McNary Passage Days		36		25		48

c) Brood-Year 2000 (Outmigration-Year 2001)

		McNary	Accelerated		Convetional		Marion Drain	
Detection Efficiency Strata		Detections	Release 1	Release 2	Release 1	Release 2	Release 1	Release 2
Sratum	1	Total (T)	285	210	226	112	96	98
First Date		Removed (R)	3	3	2	3	1	1
Last Date		T-R	282	207	224	109	95	97
Detection Efficiency	0.6366	Expanded	446.0	328.2	353.9	174.2	150.2	153.4
		Number Released	1002	1012	1011	954	510	510
		Survival Index	**0.4451**	**0.3243**	**0.3500**	**0.1826**	**0.2946**	**0.3007**
		Release Date	04/19/01	04/20/01	05/16/01	05/17/01	04/13/01	04/12/01
		McNary Mean Detection Date	05/27/01	05/28/01	06/07/01	06/06/01	05/26/01	05/27/01
		Release to McNary Passage Days	38	38	22	21	43	45
		Pooled Treatment Expanded		774.1		528.1		303.6
		Pooled Treatment Number Released		2014		1965		1020
		Survival Index		**0.3844**		**0.2687**		**0.2976**
		Pooled McNary Mean Detection Date		05/27/01		06/07/01		05/26/01
		Pooled Release to McNary Passage Days		38		22		44

Table A.2. (continued)

d) Brood-Year 2001 (Outmigration-Year 2002)

Detection Efficiency Strata		McNary Detections	Accelerated		Convetional		Marion Drain	
			Release 1	Release 2	Release 1	Release 2	Release 1	Release 2
Sratum	1	Total (T)	68	69	76	51	43	37
First Date	5/3/02	Removed (R)	0	0	0	0	0	0
Last Date	6/25/02	T-R	68	69	76	51	43	37
Detection Efficiency	0.7615	Expanded	89.3	90.6	99.8	67.0	56.5	48.6
		Number Released	1001	1000	1000	1000	500	500
		Survival Index	**0.0892**	**0.0906**	**0.0998**	**0.0670**	**0.1129**	**0.0972**
		Release Date	04/15/02	04/16/02	05/15/02	05/16/02	04/01/02	04/01/02
		McNary Mean Detection Date	06/09/02	06/07/02	06/19/02	06/22/02	06/14/02	06/16/02
		Release to McNary Passage Days	55	52	36	38	75	77
		Pooled Treatment Expanded		179.9		166.8		105.1
		Pooled Treatment Number Released		2001		2000		1000
		Survival Index		**0.0899**		**0.0834**		**0.1051**
		Pooled McNary Mean Detection Date		06/08/02		06/21/02		06/15/02
		Pooled Release to McNary Passage Days		54		37		76

e) Brood-Year 2002 (Outmigration-Year 2003)

Detection Efficiency Strata		McNary Detections	Accelerated	Convetional	Marion Drain
Sratum	1	Total (T)	72	0	0
First Date	1/0/00	Removed (R)	1	0	0
Last Date	5/19/03	T-R	71	0	0
Detection Efficiency	0.3804	Expanded	187.6	0.0	0.0
Sratum	2	Total (T)	51	0	11
First Date	5/20/03	Removed (R)	1	0	0
Last Date	5/29/03	T-R	50	0	11
Detection Efficiency	0.2429	Expanded	206.8	0.0	45.3
Sratum	3	Total (T)	34	12	33
First Date	5/30/03	Removed (R)	1	0	0
Last Date	6/1/03	T-R	33	12	33
Detection Efficiency	0.3117	Expanded	106.9	38.5	105.9
Sratum	4	Total (T)	35	47	39
First Date	6/2/03	Removed (R)	0	0	1
Last Date	6/15/03	T-R	35	47	38
Detection Efficiency	0.3919	Expanded	89.3	119.9	98.0
Sratum	5	Total (T)	4	17	0
First Date	6/16/03	Removed (R)	0	0	0
Last Date	1/0/00	T-R	4	17	0
Detection Efficiency	0.6775	Expanded	5.9	25.1	0.0
Sratum	6	Total (T)	193	76	83
First Date	1/0/00	Removed (R)	596.5694068	183.5229936	249.1203575
Last Date	1/0/00	T-R	2000	1938	994
Detection Efficiency	0.0000	Expanded	0.3	0.1	0.3
		Total Expanded	596.6	183.5	249.1
		Number Tagged	2000	1938	994
		Survival Index	**0.2983**	**0.0947**	**0.2506**
		Release Date	05/01/03	05/20/03	05/01/03
		McNary Mean Detection Date	05/24/03	06/08/03	06/02/03
		Release to McNary Passage Days	23	19	32

Table A.2. (continued)

f) Brood-Year 2003 (Outmigration-Year 2004)

Detection Efficiency Strata		McNary Detections	Accelerated		Convetional		Marion Drain	
			Release 1*	Release 2*	Release 1*	Release 2*	Release 1*	Release 2*
Sratum	1	Total (T)	48	61	13	20	17	26
First Date	5/3/2002	Removed (R)	0	0	0	0	0	0
Last Date	6/25/2002	T-R	48	61	13	20	17	26
Detection Efficiency	0.7615	Expanded	139.5	177.3	37.8	58.1	49.4	75.6
		Number Released	1999	2000	2000	2001	1000	1001
		Survival Index	**0.0698**	**0.0887**	**0.0189**	**0.0291**	**0.0494**	**0.0755**
		Release Date	05/03/04	05/06/04	05/17/04	05/20/04	04/19/04	04/22/04
		McNary Mean Detection Date	05/31/04	06/01/04	06/16/04	06/17/04	05/22/04	05/26/04
		Release to McNary Passage Days	28	26	30	28	33	35
		Pooled Treatment Expanded		316.9		95.9		125.0
		Pooled Treatment Number Released		3999		4001		2001
		Survival Index		**0.0792**		**0.0240**		**0.0625**
		Pooled McNary Mean Detection Date		06/01/04		06/17/04		05/25/04
		Pooled Release to McNary Passage Days		27		29		34

* Individual releases within release groups treated like independent replicates only in 2004

Appendix H

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Annual Report: Smolt Survival to McNary of Year-2004 Coho Releases into the Yakima Basin

Doug Neeley, Consultant to Yakama Nation

2004 Outmigration Year

Unlike releases in 1999 through 2003, the 2004 releases did not represent any experimental design for the purpose of making statistical comparisons between treatments. For the 2002 brood released in 2004, the decision was made to assign the stock to different acclimation sites within each subbasin, and the assignment was not random. Progeny of Yakima-returns were assigned to the most upstream sites within subbasins, and progeny of hatchery-reared stock were assigned to the most downstream sites (personal communication with Todd Newsome, Fisheries Biologist, Yakama Nation). In previous years, fish from the different stock were assigned to each pond, permitting statistical comparisons between stocks.

For the 2004 releases, the acclimation sites used were Holmes and Boon on the Upper Yakima and Styles and Lost Creek on the Naches. Based on past survival estimates for comparable ponds, the assignments of Yakima stock were to ponds that historically had lower survival rates to McNary Dam and the hatchery stock (Willard Hatchery) assignments were to ponds with the highest survival rates. Table 1 demonstrates that, for the Naches subbasin, Lost Creek, to which the Yakima stock was assigned, historically had the lowest survival to McNary, and Stiles, to which the Naches stock was assigned, had the highest survival. The 2004-outmigration year was the first year that the Boon pond on the Upper Yakima was used, so there is no historical information on the relative survivals to McNary from the Boone and Holmes sites.

The failure to assign both stocks to the same sites or to randomly assign the treatments[1] to the different sites for the 2004 outmigrants means that smolt-to-smolt survival-estimate comparisons between stocks are completely confounded with site comparisons. In the past, Site x Stock Interaction was used as the error source for assessing whether there were significant subbasin x treatment interaction or significant subbasin and treatment main effect difference in survival differences. Because of the confounding of stock and site effects, such statistical comparisons are not possible. Survivals were estimated for each site and are presented in Table 2. Because of poor detection efficiencies at the acclimation sites, survival estimates are based on all tagged fish

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[1] In years 1999 and 2001 through 2003 two stocks were evaluated and in 1999 through 2002 there were two release dates evaluated, therefore treatments either involved stock, times of release, or stock and release-date treatment combinations.

from the Yakima basin rather than on fish detected at the acclimation sites. This is the same measure of survival used in all previous years. Estimation procedures are discussed in Appendix A.

Only McNary-detected fish are expanded to estimate smolt survival to McNary; however, John Day detected fish not previously detected at McNary also survived to McNary. Estimation procedures will be explored in 2005 that will permit the expansion of such John Day detection by the product of the estimated detection efficiency of John Day dam based on detections at Bonneville and the estimated probability of fish not being detected at McNary[2]. The procedure developed should still permit the estimation of expanded daily McNary passage numbers.

Table 1. Historical smolt-to-smolt[3] survival comparisons between Lost Creek and Stiles ponds where comparisons were available (in years of early and late releases, the survivals from those two releases were pooled)

		Naches Subbasin	
Outmigration Year	Stock	**Lost Creek*** (historically lowest survival pond)	**Styles**** (historically highest survival pond)
1999	Yakima	0.0789	0.3990
	Willard	0.2043	0.5537
2000	Willard	0.2351	0.3508
2001	Yakima	0.2170	0.4202
	Willard	0.0286	0.1837
2002	Yakima	0.3338	0.5207
	Willard	0.2129	0.3741
2003	Yakima	0.2098	0.2571
	Willard	0.0898	0.2367

* Assigned to Yakima Stock in 2004

** Assigned to Willard Stock in 2004

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[2] This estimated probability would likely be 1 - McNary's detection-efficiency.

[3] Tagging-to-McNary-Passage survival (summarized from Append A of "Annual Report: Smolt Survival to McNary of Year-2003 Coho Releases into the Yakima Basin"

Table 2. Release Numbers and Survival Indices for each Pond for 2004 Coho Releases into the Upper Yakima and Naches Subbasins

Upper Yakima Subbasin				**Naches Subbasin**			
Acclimation Site	**Stock**			**Acclimation Site**	**Stock**		
Holmes	**Willard**	Release Number	2522	**Styles**	**Willard**	Release Number	2457
		Survival Estimate	0.1067			Survival Estimate	0.1903
Boone	**Yakima**	Release Number	2488	**Lost Creek**	**Yakima**	Release Number	2445
		Survival Estimate	0.1705			Survival Estimate	0.1793
				Pooled over Subbasins	**Willard**	Release Number	4979
						Survival Estimate	0.1479
					Yakima	Release Number	4933
						Survival Estimate	0.1749
				Pooled over Subbasins and Stock		Release Number	9912
						Survival Estimate	0.1613

We note that, in general, survivals were poor relative to previous years. The fact that the Yakima stock releases' survival indices are somewhat lower than those of the Willard stock in the Naches Subbasin is not noteworthy because of the assignment of Yakima stock to historically lowest survival ponds and of Willard stock to highest survival ponds

Recommended Estimation Alterations: Only McNary-detected fish are expanded to estimate smolt survival to McNary; however, John Day detected fish not previously detected at McNary also survived to McNary. Estimation procedures will be explored in 2005 that will permit the expansion of such John Day detection by the product of the estimated detection efficiency of John Day dam based on detections at Bonneville and the estimated probability of fish not being detected at McNary[4]. The procedure developed should still permit the estimation of expanded daily McNary passage numbers.

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[4] This estimated probability would likely be 1 - McNary's detection-efficiency.

Smolt-to-smolt survival index: The release-to-McNary smolt-to-smolt survival index in for the 2004 releases is estimated by

Equation A.1.

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

wherein

9) “McNary Detections” is number the release’s fish detected at McNary Dam;

10) “Detections Removed” is the number of the release’s “McNary Detections” 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

11) “Detection Efficiency” is the estimated proportion of <u>all</u>[5] Yakima PIT-tagged Coho passing McNary Dam during the stratum that were detected at McNary (Equation A.4).

Equation A.4.

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

The downstream-dam counts actually represent a pooling of counts from John Day and Bonneville dams[6]. In previous years, the detection days were stratified into groups of days with relatively homogeneous detection

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

[6] 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

efficiencies, and equation A.1 were applied to separate strata, and the resulting estimates were added over strata. However, since there were fewer releases of Coho made in 2004 (no calibration releases of Coho were made in 2004) and since the survival rate of Coho releases into the Upper Yakima and Naches were low, there were an insufficient number of McNary detections to permit stratification. A single detection efficiency was use for the whole outmigration.

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 and estimates going into the estimates of 2005 survival indices are given in Table A.1.

Table A.1. **2004 Coho McNary Detection Efficiency, Coho Passage, and Smolt-to-Smolt Survival Estimates**

Detection	Subbasin >	Upper Yakima			
Efficiency (E)	Stock >	Willard Stock			Yakima Stock
0.1418	Pond >	Holmes			Boone
	Tag Group File Extender >	HWA	HWB	HWC	BYA
	McNary Detections (D)	12	14	13	61
	Removed (R)	0	0	1	1
	D - R	12	14	12	60
	(D-R)/E	84.6	98.8	84.6	423.2
	Passage P = (D-R)/E + R	84.6	98.8	85.6	424.2
	Number Tagged (N)	852	834	836	2488
	Survival Index = P/N	0.0994	0.1184	0.1025	0.1705
Pooled	Number Tagged (N)			2522	
	Survival Index = P/N			0.1067	

Detection	Subbasin >	Naches			
Efficiency (E)	Stock >	Willard			Yakima
0.1418	Pond >	Stiles			Lost Creek
	Tag Group File Extender >	SWA	SWB	SWC	LYA
	McNary Detections (D)	23	26	19	63
	Removed (R)	0	2	0	1
	D - R	23	24	19	62
	(D-R)/E	162.2	169.3	134.0	437.4
	Passage P = (D-R)/E + R	162.2	171.3	134.0	438.4
	Number Tagged (N)	832	830	795	2445
	Survival Index = P/N	0.1950	0.2064	0.1686	0.1793
Pooled	Number Tagged (N)			2457	2445
	Survival Index = P/N			0.1903	0.1793

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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").

Appendix I. Financial Report.

Confederated Tribes and Bands of the Yakama Nation
Yakama Nation Fisheries Program, PO Box 151, Toppenish, WA 98948

Project No. *1995-063-25*
Project Name: *YKFP Monitoring & Evaluation All*
Contract No. : *17635*
Prepared by/Contact Person: *Ida Sohappy-Ike (509) 865-5121 ext. 6345*

Invoice date: 6/17/05
Performance Period: 5/1/04-4/30/05
Invoice Period: 4/1/05-4/30/05
Invoice No: 07-FY05-17635

Schedule B

2345.ALL

Cost Code	Description	FY 04 Budget	FY 05 Budget	FY 04 & 05 Cum. Budget	FY 04 Expenditures	FY 05 Expenditures	FY 04 & 05 Cum. Exp.	Previously Reported	Claimed This Invoice	FY 04 & 05 Budget Balance
512111	WAGES	471,477	753,975	1,225,451	471,476.74	731,746.18	1,203,222.92	1,066,341.79	136,881.13	22,228.32
519111	Fringe	79,959	131,907	211,865	79,958.52	120,585.54	200,544.06	176,779.54	23,764.52	11,321.15
521131	Agreements	-	800	800		800.00	800.00	800.00	-	-
521161	Aerial Flights	2,163	7,040	9,203	2,163.30	3,981.30	6,144.60	4,635.00	1,509.60	3,058.70
541121	Sensitive Equipment	39,006	35,700	74,706	39,006.27	36,737.29	75,743.56	58,142.21	17,601.35	(1,037.30)
541151	Printiing & Binding	500	-	500	-	-	-	-	-	500.00
541161	Operation & Maintenance	1,876	8,804	10,680	1,875.87	1,411.66	3,287.53	2,307.14	980.39	7,392.19
551111	Operating Supplies	191,341	48,037	239,378	191,840.88	58,793.81	250,634.69	229,740.79	20,893.90	(11,256.66)
551161	Small tools	-	3,150	3,150		1,809.70	1,809.70	1,315.65	494.05	1,340.30
551291	GSA	48,298	68,959	117,257	48,297.99	75,418.79	123,716.78	98,286.66	25,430.12	(6,459.50)
561131	Waste Disposal	2,421	1,500	3,921	2,420.50	1,540.00	3,960.50	3,226.50	734.00	(40.00)
561171	Telephone	186	200	386	186.48	224.61	411.09	292.23	118.86	(24.61)
561175	Cell phone	5,939	8,250	14,189	5,939.02	7,718.33	13,657.35	11,452.23	2,205.12	532.01
571111	Insurance	-	14,631	14,631	-	14,902.00	14,902.00	14,902.00	-	(270.75)
581110	Travel Holding	-	-	-	-	-	-	887.25	(887.25)	-
581111	Commercial Air	-	-	-	-	-	-	-	-	-

581141	Per Diem	1,617	9,363	10,980	1,616.70	6,792.17	8,408.87	4,904.42	3,504.45	2,570.83
621251	Indirect Cost	164,733	208,946	373,678	164,732.56	200,730.04	365,462.60	321,374.33	44,088.27	8,215.70
521121	Sub Contracts	179,898	53,094	232,992	179,897.92	50,970.15	230,868.07	216,067.07	14,801.00	2,124.05
651171	Capital Equipment	35,415	48,000	83,415	35,415.25	80,048.00	115,463.25	41,415.25	74,048.00	(32,048.00)
	TOTAL:	**1,224,828**	**1,402,356**	**2,627,184**	**1,224,828**	**1,394,209.57**	**2,619,037.57**	**2,252,870.06**	**366,167.51**	**8,146.43**
Sub-Budget 1a	**Sub-Total**	48,798.09	54,986.44	103,784.53	48,798.09	49,561.83	98,359.92	88,035.30	10,324.62	5,424.61
Sub-Budget 1b	**Sub-Total**	59,729.72	93,066.91	152,796.63	59,729.72	92,137.24	151,866.96	131,517.04	20,349.92	929.67
Sub-Budget 1c	**Sub-Total**	13,430.49	43,337.64	56,768.13	13,430.49	41,284.97	54,715.46	42,642.32	12,073.14	2,052.67
Sub-Budget 1d	**Sub-Total**	312,904.95	139,427.06	452,332.01	312,904.95	169,002.04	481,906.99	375,147.50	106,759.49	(29,574.98)
Sub-Budget 2	**Sub-Total**	424,149.99	727,484.66	1,151,634.65	424,149.99	699,861.18	1,124,011.17	986,330.35	137,680.82	27,623.48
Sub-Budget 3	**Sub-Total**	118,964.74	15,178.00	134,142.74	118,964.74	14,553.15	133,517.89	129,341.89	4,176.00	624.85
Sub-Budget 4	**Sub-Total**	64,582.09	109,383.79	173,965.88	64,582.09	101,995.43	166,577.52	145,469.46	21,108.06	7,388.36
Sub-Budget 5	**Sub-Total**	64,490.30	82,797.92	147,288.22	64,490.30	88,286.61	152,776.91	131,138.52	21,638.39	(5,488.69)
Sub-Budget 6	**Sub-Total**	117,777.63	136,693.58	254,471.21	117,777.63	137,691.69	255,469.32	223,247.68	32,221.64	(998.11)
All Sub-Budgets GRAND TOTAL		**1,224,828**	**1,402,356**	**2,627,184**	**1,224,828**	**1,394,374.14**	**2,619,202.14**	**2,252,870.06**	**366,332.08**	**7,981.86**

I CERTIFY THIS IS TRUE AND ACCURATE

Jerry Meninick, Chairman
Yakama Tribal Council

Appendix J. Equipment Inventory.

2345 EQUIPMENT LIST
CONTRACT NUMBER: 17635
CONTRACT PERIOD: 05/01/04-04/30/05
CAPITALIZED EQUIPMENT LIST

NO.	ITEM DESCRIPTION	VENDOR	MAKE MODEL	SERIAL NUMBER	YEAR	FUND NUMBER	PROPERTY NUMBER	DOC NUMBER	ITEM COST	LOC COND
1	LASER RANGEFINDER IMPULSE	GEO SOLUTION	****PENDING**	109384	2004	23458101.541121.1	16264	156412	2,981.00	5/4
2	POCKET PC	GEO SOLUTION	H4155	TWC42317T	2004	23458101.541121.1	16263	156412	399.00	
							Sub-Total		**3,380.00**	
1	DIGITAL VIDEO CAMCORDER	FIRST CALL SOULUTIONS	ELURA 90	382032060364	2005	23458101.541121.2	16980	168713	699.00	
2	17" LCD FLAT PANEL DISPLAY W/CABLE	GATEWAY	**PENDING	**PENDING	2004	23458101.541121.2	**PENDING	169781	371.94	5/4
							Sub-Total		**1,070.94**	
1	SCALE: OHAUS SCOUT PRO	VWR SCIENTIFIC	SP4001	7123181011	2004	23458101.541121.3	16081	156240	369.50	5/4
							Sub-Total		**369.50**	
1	PUSH BUTTON COUNTERS	VWR SCIENTIFIC	**PENDING	**PENDING	2004	23458101.541121.4	NA	150607	247.10	2/4
2	PUSH BUTTON COUNTERS	VWR SCIENTIFIC	**PENDING	**PENDING	2004	23458101.541121.4	NA	150607	247.10	2/4
3	PUSH BUTTON COUNTERS	VWR SCIENTIFIC	**PENDING	**PENDING	2004	23458101.541121.4	NA	150607	247.10	2/4
4	PUSH BUTTON COUNTERS	VWR SCIENTIFIC	**PENDING	**PENDING	2004	23458101.541121.4	NA	150607	247.10	2/4
5	PENTIUM 4 PROCESSOR	GATEWAY CO	ATXAEGWSPE6100	33974106	2004	23458101.541121.4	15848	152876	2,435.00	1/4
6	PENTIUM 4 PROCESSOR	GATEWAY CO	ATXAEGWSPE6100	33974107	2004	23458101.541121.4	15849	152876	2,435.00	1/4
7	PENTIUM 4 PROCESSOR	GATEWAY CO	ATXAEGWSPE6100	33974108	2004	23458101.541121.4	15850	152876	2,435.00	1/4
8	PENTIUM 4 PROCESSOR NOTEBOOK	GATEWAY CO	450RGH	33971304	2004	23458101.541121.4	15851	152876	2,994.00	1/4

NO.	ITEM DESCRIPTION	VENDOR	MAKE MODEL	SERIAL NUMBER	YEAR	FUND NUMBER	PROPERTY NUMBER	DOC NUMBER	ITEM COST	LOC COND
9	PENTIUM LAPTOP COMPUTOR	GATEWAY CO	**PENDING	34022633	2004	23458101.541121.4	15889	153580	2,468.00	1/4
10	KVA TRANSFORMER	TRIAD SEVICE ELECTRIC	**PENDING	**PENDING	2004	23458101.541121.4	**PENDING	156205	1,500.00	8/4
11	VIEWSONIC 17" LCD FLAT PANNEL	CDW	VSI0047	PIQ042503226	2004	23458101.541121.4	16200	156872	447.88	1/4
12	SONY DIGITAL CAMERA	CDW	DSCF828	1382073	2004	23458101.541121.4	16203	156982	997.00	1/4
14	DIGITAL DOCK WORKCENTER DESK	OFFICE DEPOT	**PENDING	**PENDING	2004	23458101.541121.4	**PENDING	156961	131.66	1/4
15	DIGITAL DOCK WORKCENTER 2-DRWR	OFFICE DEPOT	**PENDING	**PENDING	2004	23458101.541121.4	**PENDING	156961	61.43	1/4
16	2-6' UTILITY FOLDING TABLES	OFFICE DEPOT	**PENDING	**PENDING	2004	23458101.541121.4	*NA	156961	73.72	1/4
17	12-FOLDING CHAIRS	OFFICE DEPOT	**PENDING	**PENDING	2004	23458101.541121.4	*NA	156961	263.88	1/4
18	WIRELESS DATA TRANSRECEIVER	FREEWAVE TECHNOLOGY	FGR-115 RC	916-9432	2004	23458101.541121.4	16283	157655	1,350.00	2/4
19	WIRELESS DATA TRANSRECEIVER	FREEWAVE TECHNOLOGY	FGR-115RC	916-9269	2004	23458101.541121.4	16284	157655	1,350.00	2/4
20	WIRELESS DATA TRANSRECEIVER	FREEWAVE TECHNOLOGY	FGR-115RC	916-9433	2004	23458101.541121.4	16285	157655	1,350.00	2/4
21	WIRELESS DATA TRANSRECEIVER	FREEWAVE TECHNOLOGY	FGR-115RC	916-9436	2004	23458101.541121.4	16286	157655	1,350.00	2/4
22	WIRELESS DATA TRANSRECEIVER	FREEWAVE TECHNOLOGY	FGR-115RC	916-9263	2004	23458101.541121.4	16287	157655	1,350.00	2/4
23	WIRELESS DATA TRANSRECEIVER	FREEWAVE TECHNOLOGY	FGR-115RC	916-9272	2004	23458101.541121.4	16288	157655	1,350.00	2/4
24	WIRELESS DATA TRANSRECEIVER	FREEWAVE TECHNOLOGY	FGR-115RC	916-9438	2004	23458101.541121.4	16289	157655	1,350.00	2/4
25	WIRELESS DATA TRANSRECEIVER	FREEWAVE TECHNOLOGY	FGR-115RC	916-9271	2004	23458101.541121.4	16290	157655	1,350.00	2/4
26	WIRELESS DATA TRANSRECEIVER	FREEWAVE TECHNOLOGY	FGR-115RC	916-9267	2004	23458101.541121.4	16291	157655	1,350.00	2/4
27	COLOR LASERJET	CDW	**PENDING	SJPFAB10616	2004	23458101.541121.4	**PENDING	157318	2,299.00	1/4
28	WATER RESNT KEYBOARD & MOUSE	INCOMMAND-PKG DEAL	**PENDING	**PENDING	2004	23458101.541121.4	**PENDING	157704	1,169.80	1/4

NO.	ITEM DESCRIPTION	VENDOR	MAKE MODEL	SERIAL NUMBER	YEAR	FUND NUMBER	PROPERTY NUMBER	DOC NUMBER	ITEM COST	LOC COND
29	WATER RESNT KEYBOARD & MOUSE	INCOMMAND			2004	23458101.541121.4		157704	0.00	1/4
30	WATER RESNT KEYBOARD & MOUSE	INCOMMAND			2004	23458101.541121.4		157704	0.00	1/4
31	WATER RESNT KEYBOARD & MOUSE	INCOMMAND			2004	23458101.541121.4		157704	0.00	1/4
32	RFID READER W/BATTERY	BIOMARK	FS200IF-ISO	5668	2005	23458101.541121.4	16695	165388	2,750.00	1/4
33	RFID READER W/BATTERY	BIOMARK	FS200IF-ISO	5675	2005	23458101.541121.4	16696	165388	2,750.00	1/4
34	RFID READER W/BATTERY	BIOMARK	FS200IF-ISO	5667	2005	23458101.541121.4	16697	165388	2,750.00	1/4
35	INTEL PENTIUM 405E NOTEBOOK	GATEWAY CO	M405	35046802	2005	23458101.541121.4	16908	166922	2,353.00	5/4
36	INTEL PENTIUM 405E NOTEBOOK	GATEWAY CO	M405	35046801	2005	23458101.541121.4	16909	166922	2,353.00	1/4
37	INTEL PENTIUM 4 PROCESSOR LAPTOP	GATEWAY CO	AK MBTXNIASL2E6300	35046393	2005	23458101.541121.4	16910	166922	3,341.00	1/4
38	INTEL PENTIUM 4 PROCESSOR	GATEWAY CO	M675PRR	35046803	2005	23458101.541121.4	16911	166922	3,520.00	5/4
39	XEROX PHASER 8400DX	CDW	PHASER 8400	RPCI48266H	2005	23458101.541121.4	16618	165386	2,499.99	1/4
40	SONY REAL ACTION TIME LAPSE RECORDER	CDW	SVT-RA168	0104037 F	2005	23458101.541121.4		165280	190.95	1/4
41	INVISIBLIND	CABELA'S	**PENDING	**PENDING	2005	23458101.541121.4	**PENDING	168946	339.99	5/4
42	14'ALUMINUM BOAT	A. J. MARINE	**PENDING	**PENDING	2005	23458101.541121.4	**PENDING	168941	2,310.44	1/4
43	ALUMINUM TABLE SCALE	RENEGADE METALCRAFT	**PENDING	**PENDING	2005	23458101.541121.4	**PENDING	170050	375.00	4/4
44	ALUMINUM TABLE	RENEGADE METALCRAFT	**PENDING	**PENDING	2005	23458101.541121.4	**PENDING	170050	830.00	4/4
45	ADULT SCALE CHUTE	RENEGADE METALCRAFT	**PENDING	**PENDING	2005	23458101.541121.4	**PENDING	170050	125.00	4/4
46	VERT/HORZ JET METAL BANDSAW	OXARC	**PENDING	**PENDING	2005	23458101.541121.4	**PENDING	169799	982.98	4/4
							Sub-Total		**60,321.12**	
1	COMPRESSOR	BI MART	CFBN125A-2	2361305577	2005	23458101.551111.4	**PENDING	161402	247.70	8/4
2	COMPRESSOR	BI MART	CFBN125A-2	2261105632	2005	23458101.551111.4	**PENDING	161402	247.70	8/4

NO.	ITEM DESCRIPTION	VENDOR	MAKE MODEL	SERIAL NUMBER	YEAR	FUND NUMBER	PROPERTY NUMBER	DOC NUMBER	ITEM COST	LOC COND
3	BLACK STORAGE CABINET	YAKIMA BINDERY	**PENDING	**PENDING	2004	23458101.551111.4	**PENDING	160137	605.42	1/4
4	BLACK STORAGE CABINET	YAKIMA BINDERY	**PENDING	**PENDING	2004	23458101.551111.4	**PENDING	160137	605.43	1/4
5	OHAUS DIGITAL SCALE	EAGAR	**PENDING	**PENDING	2004	23458101.551111.4	**PENDING	159277	124.91	1/4
6	OHAUS DIGITAL SCALE	EAGAR	**PENDING	**PENDING	2004	23458101.551111.4	**PENDING	159277	124.90	1/4
7	OHAUS DIGITAL SCALE	EAGAR	**PENDING	**PENDING	2004	23458101.551111.4	**PENDING	159277	124.90	1/4
							Sub-Total		**2,080.96**	
1	2-SONY 256 MEMOR STICK PRO	CDW	**PENDING	**PENDING	2004	23458102.551111	*NA	156982	239.20	1/4
							Sub-Total		**239.20**	
1	DEEPSEA MULTI SEALITE	MECCO	**PENDING	**PENDING	2005	23458104.541121	**PENDING	162066	435.00	1/4
2	JVC DVD RECORDER/VIDEO RECORDER	CDW		159UO920	2005	23458104.541121	16562	163737	358.00	1/4
3	SONY REAL ACTION TIME LAPSE RECORDER	CDW	SVT-RA168	0103913 E4	2005	23458104.541121	16612	165280	506.70	1/4
4	SONY REAL ACTION TIME LAPSE RECORDER	CDW	SVT-RA168	0104037 F	2005	23458104.541121	16613	165280	697.65	1/4
5	SONY REAL ACTION TIME LAPSE RECORDER	CDW	SVT-RA168	0104177G4	2005	23458104.541121	16620	165280	697.65	1/4
							Sub-Total		**2,695.00**	
1	STATIONARY TRANCEIVERS W/ANTENNA	DIGITAL ANGEL CORPORATION			2004	23458101.651171.4	**PENDING	154635	30,000.00	2/4
2	STATIONARY TRANCEIVERS W/ANTENNA	DIGITAL ANGEL CORPORATION			2004	23458101.651171.4	**PENDING	154635	0.00	2/4
3	FABRICATION OF TABLES, TROUGHS, PIT TAG TRAILER	RENEGADE METALCRAFT			2004	23458101.651171.4	**PENDING	154453	5,415.25	1/4
4	PIT TAG READER	BIOMARK	**PENDING	**PENDING	2005	23458101.651171.4	**PENDING	165388	6,000.00	1/4

NO.	ITEM DESCRIPTION	VENDOR	MAKE MODEL	SERIAL NUMBER	YEAR	FUND NUMBER	PROPERTY NUMBER	DOC NUMBER	ITEM COST	LOC COND
5	STATIONARY TRANCEIVERS	BIOMARK	**PENDING	**PENDING	2005	23458101.651171.4	**PENDING	165389	6,000.00	2/4
6	STATIONARY TRANCEIVERS	BIOMARK	**PENDING	**PENDING	2005	23458101.651171.4	**PENDING	165389	6,000.00	2/4
7	STATIONARY TRANCEIVERS	BIOMARK	**PENDING	**PENDING	2005	23458101.651171.4	**PENDING	165389	6,000.00	2/4
8	ANTENNA	BIOMARK	**PENDING	**PENDING	2005	23458101.651171.4	**PENDING	165389	8,000.00	2/4
9	ANTENNA	BIOMARK	**PENDING	**PENDING	2005	23458101.651171.4	**PENDING	165389	8,000.00	2/4
10	ANTENNA	BIOMARK	**PENDING	**PENDING	2005	23458101.651171.4	**PENDING	165389	8,000.00	2/4
11	DIESEL ENGINE	H & S GENERAL CONTRACTORS	**PENDING	**PENDING	2005	23458101.651171.4	**PENDING	168947	16,048.00	4/4
12	175 HP MERCURY JET PUMP BOAT MOTOR	DON'S DRY DOCK	**PENDING	**PENDING	2005	23458101.651171.4	**PENDING	168945	16,000.00	1/4
							Sub-Total		**115,463.25**	
1	PENTIUM 4 NOTEBOOK	GATEWAY	450RGH	33971305	2005	23458106.541121	15847	152875	2,407.00	1/4
2	RFID READER	BIOMARK	FS2001FR-ISO	5666	2005	23458106.541121	16698	165388	2,750.00	1/4
3	RFID READER	BIOMARK	FS2001FR-ISO	5645	2005	23458106.541121	16699	165388	2,750.00	1/4
							Sub-Total		**7,907.00**	

****PENDING-WORKING WITH ALICE ON GETTING TAG NUMBERS**

N/A-UNABLE TO TAG

Grand Total **193,526.97**

LOCATION: 1. HEADQUARTERS 2. CHANDLER 3. PROSSER 4. ROZA 5. NELSON SPRINGS 6. HATCHERY 7. KLICKITAT 8. CLE ELUM 9. WDFW 10. MISSING OR STOLEN

CONDITION: 4. GOOD 5. FAIR 6. POOR 7. SALVAGEABLE 8. MISSING OR STOLEN