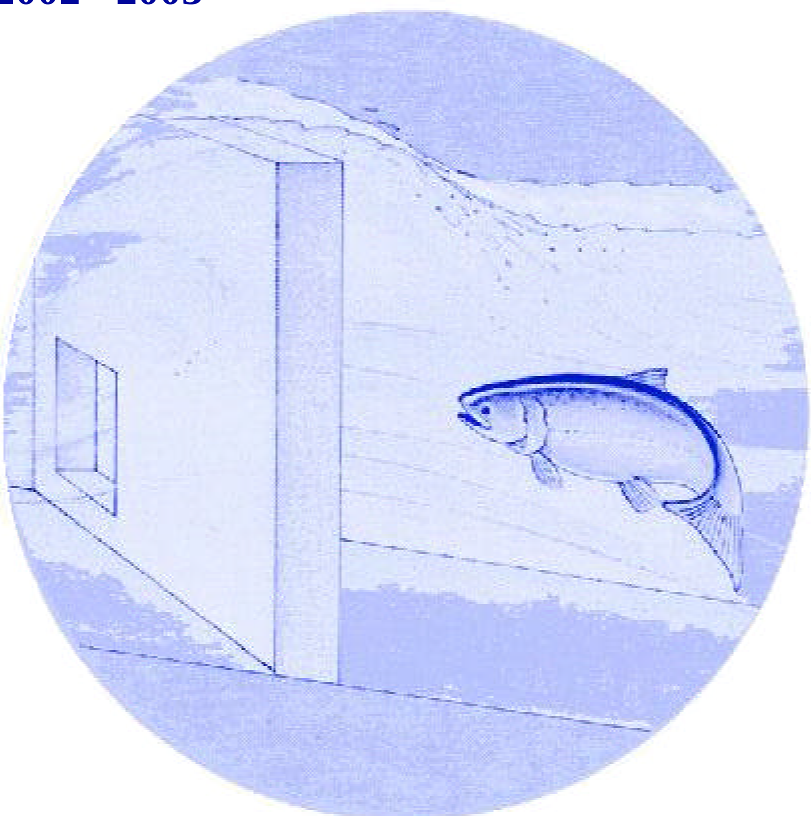
Yakima/Klickitat Fisheries Project

Washington Department of Fish and Wildlife Policy/Technical Involvement and Planning

Annual Report
2002 - 2003



DOE/BP-00006215-2

September 2003

This Document should be cited as follows:

Pearsons, Todd, John Easterbrooks, ''Yakima/Klickitat Fisheries Project'', Project No. 1995-06425, 23 electronic pages, (BPA Report DOE/BP-00006215-2)

Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

WDFW POLICY/TECHNICAL INVOLVEMENT AND PLANNING IN THE YAKIMA/KLICKITAT FISHERIES PROJECT

Annual Report 2002-2003

Prepared by:

Todd N. Pearsons

And

John A. Easterbrooks

Washington Department of Fish and Wildlife
600 Capitol Way North
Olympia, Washington 98501-1091

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, Oregon 97283-3621

Project Number 1995-064-25

September 2003

Introduction

The Yakima/Klickitat Fisheries Project (YKFP) is a supplementation project sponsored by the Northwest Power Planning Council and funded by the Bonneville Power Administration. The YKFP has adopted the definition of supplementation described by Regional Assessment of Supplementation Program (1992), which is "the use of artificial propagation in an attempt to maintain or increase natural production while maintaining the long-term fitness of the target population, and keeping the ecological and genetic impacts on nontarget populations within specified biological limits." Recent scientific reviews of hatchery supplementation continue to highlight the experimental nature and risk of supplementation (Independent Scientific Group 1996; National Research Council 1996; Lichatowich 1999; Independent Multidisciplinary Science Team 2000; Independent Scientific Advisory Board 2003; Hatchery Scientific Review Group 2003). In addition, many of these reviews included recommendations about the best ways to operate a supplementation program. Most of these recommendations were already being done or have been incorporated into the YKFP.

The objectives of the YKFP are: 1 - to test the hypothesis that new supplementation techniques can be used in the Yakima River Basin to increase natural production and to improve harvest opportunities while maintaining the long-term genetic fitness of the wild and native salmonid populations and keeping adverse ecological interactions within acceptable limits (Yakima Fisheries Project Final Environment Impact Statement, 1996); 2 - provide knowledge about the use of supplementation, so that it may be used to mitigate effects on anadromous fisheries throughout the Columbia River Basin; 3 - to maintain and improve the quantity and productivity of salmon and steelhead habitat, including those areas made accessible by habitat improvements; 4 - to ensure that Project implementation remains consistent with the Council's Fish and Wildlife Program; and 5 - to implement the Project in a prudent and environmentally sound manner. Current YKFP operations have been designed to test the principles of supplementation (Busack et al. 1997). The Project's experimental design has focused on the following critical uncertainties affecting supplementation:

1. The survival and reproductive success of hatchery fish after release from the hatchery;
2. The impacts of hatchery fish as they interact with non-target species and stocks; and,
3. The effects of supplementation on the long-term genetic fitness of fish stocks.

The YKFP endorses an adaptive management policy applied through a project management framework as described in the Yakima/Klickitat Fisheries Project Planning Status Report (1995), Fast and Craig (1997), and Clune and Dauble 1991. The project is managed by a Policy Group consisting of a representative of the Yakama Nation (YN, lead agency) and a representative of the Washington Department of Fish and Wildlife (WDFW). The functions of the parties are described in an MOU between the YN and the WDFW. A Scientific and Technical Advisory Committee (STAC) consisting of one representative from each management entity reports to the Policy Group and provides technical input on policy and other issues. Additional committee's, such as the Monitoring Implementation and Planning Team (MIPT), serve at the discretion of STAC. The Policy Group and STAC meet periodically (usually monthly) to conduct the business of the YKFP.

Although the YKFP is an all stocks initiative (BPA 1996), most effort to date has been directed at spring chinook salmon and coho salmon. This report is a compilation of the year's activities between August 1, 2002 and July 31, 2003. The Yakama Nation's portion of the YKFP is presented in another report. All findings should be considered preliminary until data collection is completed or the information is published in a peer-reviewed journal. Pearsons and Easterbrooks (2003) described last year's activities.

Progress

Policy

The policy level activities that John Easterbrooks (WDFW, Policy Representative) attended to during the past year included:

1) Participated in monthly YKFP Policy Group meetings (8/12/02, 9/25/02, 11/13/02, 12/9/02, 1/15/03, 2/25/03, 4/2/03, 5/7/03, 6/11/03, 7/9/03) and attended the 2003 Project Annual Review (PAR) and combined Yakima Basin Fishery Research Symposium at Central Washington University (CWU) sponsored by the Yakima/Klickitat Fisheries Project, CWU, and U.S. Bureau of Reclamation, March 25-26, 2003. Participated in a tour of the Klickitat Basin with NW Power Planning Council and YKFP Policy Group members on 8/27/02 to visit: 1) the Castille Falls fishway reconstruction project, 2) Klickitat Hatchery tour, 3) Synder Creek habitat restoration project at the former Champion Mill in Klickitat, etc.

2) Continued working on the Cle Elum Hatchery interpretive display with other "I.D." committee members representing BPA, the Yakama Nation and BPA's graphic design consultant. Participated in a design/review meeting at Cle Elum on 1/10/03 to finalize panel graphics and text and a final conference call with the consultant on 2/12/03 to approve production of the interpretive panels. Also spent several hours working on the phone directly with the graphics consultant on display text and graphics selection/acquisition.

3) Worked with STAC and MIPT members and theYakama Nation policy lead to continue development of the "hatchery domestication selection" research proposal and implementation plan for brood year 2002 fish that was approved in concept during the prior report period in response to M&E project criticism from the Independent Science Review Panal (ISRP). Participated in preparatory conference calls with WDFW staff on 12/4/02 prior to attending meetings with WDFW and YN MIPT members on 12/6/02 and 1/8/03 to discuss the plan of study and, specifically, how to minimize genetic risks to supplementation-line (S-line) associated with the presence of precocial hatchery x hatchery (H-line) smolts on the spawning grounds. WDFW and YN agreed to proceed with Hatchery-line at a MIPT/STAC meeting on 5/14/03 based on risk analysis that shows precocial Hatchery-line fish are not a significant genetic threat to natural-origin supplementation fish.

4) WDFW representative on the Nelson Springs M&E building replacement design committee. Attended meetings with the architectural and engineering consultants on 8/5/02, 12/9/02,

1/15/03, and 5/20/03 to review the design process, provide feedback on preliminary site plans/floor plans and approve the final designs.

5) Participated in a Yakima Basin Coho Master Plan meeting with WDFW and YN MIPT staff on 4/24/03.

6) Secured approval in April from Naches-Selah Irrigation District for YN MIPT staff to install a steelhead smolt trap in the irrigation canal or on the outlet of the fish screen bypass outfall in order to collect baseline genetic samples.

7) Documented (written) policy decisions approved in 2003:

   - Approved the disposition of spring chinook fry used for predation and behavioral dominance experiments. Fry produced from natural-origin adults (unmarked and adipose clipped fish) were approved for release into Cle Elum (Hatchery) Slough. Hatchery-line fry cannot be released into the river environment anywhere in the Yakima Basin because of the risk that surviving H-line adults could stray and spawn with wild, Naches-American River fish or upper Yakima River natural-origin or supplementation line (S-line) adults, which would compromise the YKFP experimental design. H-line fry were approved for release into a landlocked (no surface outlet) gravel pit pond above the normal floodplain.

Technical

Technical recommendations were provided to the policy group concerning a variety of issues such as: disease risk and management, domestication experimental design, mixed stock fisheries issues, genetic risks, quantitative objectives, and study recommendations (e.g., precocialism, physiology). Technical information about the Klickitat Basin was also provided to the YN as part of the Master Planning Process.

- Continued planning, refinement, risk/benefit assessments, and implementation of test of domestication selection
- Replaced smallmouth bass predation monitoring with new domestication selection work to accommodate no increase in spending
- Assessed the risk of precocially mature hatchery salmon to the integrity of the naturally produced upper Yakima spring chinook stock
- Developed an alternative approach to egg incubation that would allow pathogen screening of adults prior to transfer of eggs to the Cle Elum Supplementation and Research Facility
- Transitioned bird predation work from the University of Washington Cooperative Fish and Wildlife Unit to the Yakama Nation
- Refined monitoring plan for the coho Master Plan
- Assessed risk of coho reintroduction program
- Monitoring and evaluation results for 2002 were presented at a Project Annual Review (PAR) in March 25, 26, 2003 at Central Washington University as part of the Yakima

Basin Aquatic Science and Management Conference. Abstracts of the talks are available at www.ykfp.org

Yakima/Klickitat Fisheries Project Performance

Current information indicates that the YKFP is progressing well (Table 1). There appears to be constraints to natural production including, but not limited to, predation by fish and birds, intra- and interspecific competition for food and space, and habitat quality and quantity.

Table 1. Performance of the Yakima/Klickitat Fisheries Project: August 1, 2002 through July 31, 2003.

Performance Measure	Goal	Performance	Comments
Natural Production	Increase	Unknown	Too early to tell, but the hatchery has increased the number of adult spawners on the spawning grounds in 2001 and 2002, relative to previous years. The low number of fish returning in 2003 was likely due to drought conditions and poor smolt survival during emigration in 2001.
Harvest	Increase	Marginal	Significant, but reduced (relative to previous years), tribal subsistence fisheries occurred on both hatchery and naturally produced fish. No sport fishery occurred in the Yakima River during 2003 due to low run size of hatchery fish.
Genetics	Minimize genetic impacts	Unknown	Too early to tell, but risk minimization guidelines are in place and a large-scale test of domestication is underway.
Ecological Impacts	Within containment objectives	Achieved	Impacts are within containment objectives or are currently not attributable to supplementation. Strong interactors (e.g. predators, food) may be limiting natural production objectives.
Habitat	Protect existing high-quality habitat and increase productivity/capacity of freshwater environment	Progress	BPA's temporary hold on habitat purchases has delayed protection efforts. Tributary passage efforts and habitat restoration are ongoing.
Science	Disseminate important findings for use throughout the Columbia Basin	Achieved	Numerous annual reports were submitted to BPA, all tasks were reported on at a Conference, and 1 manuscript was published. Domestication experiment was initiated.

Two tables describe the performance of each science task by quarter. The first table is a list of all of the tasks included in the WDFW/YKFP Supplementation Monitoring Activities (1995-064-24) contract that began on April 1, 2002. The second table is the degree of progress that occurred during the quarter. The degree of progress is represented as the percent of the annualized task that is completed during a quarter. For instance, if a task required uniform effort throughout the year and the task was completed, then each quarter would receive “25%”. However, if a task did not require uniform effort, then it could be completed in one quarter and receive a score of 100%. Any shortfalls or significant comments are also described.

Table 2. List of tasks and subtasks for WDFW/YKFP supplementation monitoring activities (1995-064-24) during contract beginning April 1, 2002.

Task #	Task Title
OBJECTIVE 1	**Natural Production Monitoring**
TASK 1.c	Juvenile Spring Chinook Microhabitat Utilization and Redd Microhabitat Characterization
TASK 1.d	Juvenile Spring Chinook Marking
TASK 1.p	Spring Chinook Residualism/Precocialism
TASK 1.q	Spring Chinook Relative Hatchery/Wild Reproductive Success
TASK 1.r	Gamete Quality and Adult Spawner Characterization
TASK 1.s	Scale Analysis
OBJECTIVE 3	**Genetic Monitoring**
TASK 3.a	Spring Chinook Allozyme/DNA Data Colleciton and Analysis
TASK 3.c	Spring Chinook Domestication Selection
OBJECTIVE 4	**Ecological Interactions (Species Interaction Studies)**
TASK 4.a	Development and Monitoring of a Bird Predation Index
TASK 4.b	Estimate a Fish Predation Index in the Spring Chinook Salmon Migration Corridor
TASK 4.d	Spring Chinook Competition/Prey Index
TASK 4.e	Implement Monitoring Prescriptions to Detect and Contain Impacts to NTTOC
TASK 4.f	Spring Chinook Smolt Pathogen Sampling

Table 3. Percent of the annual completion of WDFW/YKFP supplementation monitoring activities (1995-064-24) during contract beginning April 1, 2002. Shortfalls and comments are footnoted. F=field or lab work, O=Office work.

Task	1st Quarter April-June		2nd Quarter July-September		3rd Quarter October-December		4th Quarter January-March	
	% F.	% O.	% F.	% O.	% F.	% O.	% F.	% O.
Natural Produc-tion								
1.c	0	0	100	25	0	35	0	40
1.d	0	50[a]	N/A	50[a]	N/A	0	N/A	0
1.p	0	0	80	0	20	60	0	40
1.q	50	50[a]	30	0[a]	20	20	0	30
1.r	0	40[a]	75	50[a]	20	5	5	5
1.s	0	0	N/A	50	N/A	50	N/A	0
Genetics								
3.a	N/A	25	N/A	15	N/A	15	N/A	45
3.c	N/A	40	N/A	30	N/A	20	N/A	10
Ecology								
4.a	50	10	50	20	0	20	0	50
4.b	100	5	0	30	0	25	0	40
4.d	0	0	90	10	10	70	0	20
4.e	0	25	90	25	10	25	0	25
4.f	30[b]	10[b]	5[c]	0[c]	25	5	40	50

Shortfalls and comments

[a] While significant progress was made on annual reports addressing Reproductive Success (1.q), Mark Evaluation (1.d), and Gamete Quality and Adult Spawner Characterization (1.r), significant effort during 2002 has been directed toward a completely unanticipated task: Developing a Domestication Study Design and Monitoring Program and responding to the ISRP's reviews and comments of that same study design. That process appears to be nearly complete now. It is anticipated that the annual reports for 1.q and 1.d will be completed in the second and third quarters, respectively. The annual report for 1.r will be completed in the fourth quarter.

[b] The Fish Health component of the 2001-2002 report was not completed due to vacancies in both laboratory and administrative staff. Report is still pending.

[c] During the 2002 smolt outmigration only 130 spring chinook smolts were sampled for pathogen testing instead of the target of 200. As I understand it, high water prevented collection of fish after the May 29 sample and when water levels subsided the smolt outmigration was over.

Summaries of each WDFW topical 2002 annual report, that has been produced under the Yakima/Klickitat Fisheries Project Monitoring and Evaluation Contract (Project 1995-064-24), have been reproduced below. All findings in this report should be considered preliminary and subject to further revision unless they have been published in a peer-reviewed technical journal.

Demographics

Knudsen, C. M. 2003. Reproductive ecology of Yakima River hatchery and spring chinook. Annual Report FY 2001-2002 submitted to Bonneville Power Administration, Portland, Oregon. DOE/BP-00004666-16.

This is the second in a series of annual and progress reports that address reproductive ecological research and comparisons of hatchery and wild origin spring chinook in the Yakima River basin. Data have been collected prior to supplementation to characterize the baseline reproductive ecology, demographics and phenotypic traits of the unsupplemented upper Yakima population, however this report focuses on data collected on hatchery and wild spring chinook returning in 2002; the second year of hatchery adult returns. This report is organized into three chapters, with a general introduction preceding the first chapter and summarizes data collected between April 1, 2002 and March 31, 2003 in the Yakima basin. Summaries of each of the chapters in this report are included below.

Adult traits: Size-at-Age - Naturally spawning age-3 and age-4 hatchery fish were significantly smaller than wild fish of the same age: approximately 3 cm smaller in 3-year olds and 2 cm smaller in 4-year olds. Three- and 4-year old hatchery origin fish weighed 0.2-0.3 kg less than wild fish of the same age. In general, American River fish were larger than Naches, which were larger than upper Yakima fish. These populational differences in size-at-age are likely local adaptations developed in response to selection pressures such as migration difficulty, spawn timing, and intra-sexual competition. There was no significant Treatment effect (OCT vs SNT) on body size. Sex Ratio - The female:male (F:M) ratios of upper Yakima River wild and hatchery origin fish collected at either Roza Adult Monitoring Facility (RAMF) or on the spawning grounds as carcass samples were not significantly different. The F:M ratios of American (2.0) and Naches (2.0) spawning ground carcass samples were significantly different from the upper Yakima population (3.7) and may partially reflect between population differences in rates of nonanadromous precocial male development. Age Composition - As in previous years, the overwhelming majority of upper Yakima River wild fish returned as 4-year olds (86%) with 5% returning at age-5. Age-4 and –5 fish made up 83 and 15% of the hatchery origin returns, respectively. Age-3 jacks made up 9 and 2% of the total wild and hatchery populations, respectively. Using linear discriminant function analysis, we classified wild fish into 3-, 4- and 5-year-old ages with 98, 92, and 94% classification accuracy, respectively. Hatchery fish were classified with a separate discriminant function with 100, 100, 87, and 87% classification accuracy for 2-, 3-, 4- and 5-year olds, respectively. Based on scale sampled carcass recoveries, age composition of the American River was 1, 55 and 44% age-3, -4 and –5, respectively.

Naches system fish were 1, 68 and 31% age-3, -4 and –5, respectively. In general, American River fish were older than Naches fish, and both were older than upper Yakima fish. Sexual Dimorphism – There were no significant Sex (Male vs. Female) effects detected in body size of wild or hatchery age-4 carcass recoveries in the American, Naches and upper Yakima River populations. American River and Naches age-5 fish did demonstrate significant sexual dimorphism in body size, with males larger than females. In paired length and weight samples collected from the same fish, first at RAMF and later at CESRF, fork length increased 5-6% in males and 4% in females on average, while male and female body weights decreased by 18-22% and 15-16%, respectively. POHP lengths did not differ significantly over time. Run/Spawn Timing - Mean and median passage timing of hatchery and wild fish at RAMF differed by 4 and 7 days, respectively, with wild fish passing significantly earlier than hatchery fish. Age-5's passed RAMF earliest on average (Julian date=158), followed by age-4's (Julian date=164) and age-3's (Julian date=182). Mean and median passage timing at RAMF and mean spawn timing (Sept. 25) of both upper Yakima River hatchery and wild fish was not significantly different. Mean and median spawn timing was August 17 and 20, respectively, for the American River and September 14 and 19, respectively, for the Naches population based on carcass recoveries. The earlier American River and Naches, to a lesser degree, spawn timing is a local adaptation to cooler incubation water temperatures experienced by the higher elevation populations that require more time to accumulate sufficient temperature units to fry emergence, which is generally synchronized across all Yakima basin spring chinook populations. Carcass Recovery Bias - The F:M ratio at RAMF was significantly different from the F:M ratio of spawning ground carcass recoveries, indicating that sex ratios estimated from carcass recoveries are biased. This is because female carcasses are recovered at higher rates than male carcasses. In addition, a comparison of the proportion of age-3, -4 and –5 old fish in the RAMF sample and the carcasses recovery sample indicated that older, larger fish were recovered as carcasses at significantly higher rates than younger, smaller fish. Within age classes, the mean POHP of wild origin age-4 and age-5 carcass recoveries did not differ significantly from fish sampled at RAMF. Thus, carcass recovery length distributions do appear to accurately represent size-at-age.

Gametic traits: Age-4 hatchery females (3,984 eggs) were slightly less fecund than wild origin females (4,067 eggs) based on fish collected at RAMF and spawned at CESRF. Age-5 wild origin females (4,729 eggs) were significantly more fecund on average than age-4 wild females. There was significant positive correlation between fecundity and female body size in both hatchery and wild origin age-4 females, but not age-5 females. The fecundity/length and fecundity/weight slopes of age-4 hatchery and wild origin females were not significantly different (common slopes = 942 eggs•[kg body weight]$^{-1}$ and 145 eggs•[cm POHP]$^{-1}$). Wild age-5 females produced approximately half as many eggs per unit increase in body weight (531 eggs•[kg body weight]$^{-1}$ and 77 eggs•[cm POHP]$^{-1}$). Including body weight, mean egg weight and POHP in a multi-variate fecundity regression equation significantly increased the amount of variation explained and improved the precision of fecundity estimates. There was a significant difference between age-4 hatchery (0.180 g) and wild (0.188 g) origin mean egg weights. Age-5 wild origin females had significantly heavier eggs (0.223 g) than age-4 females. There were weak positive correlations between egg weight and female POHP and body weight, but only the wild age-4 female's was significant explaining just 2% of the total variation. The relationship between egg size and fecundity was negative, weak and significant only in wild age-4's, explaining only 13%

on the total variation. Female Reproductive Effort (RE), the ratio of the weight of gametes to total body weight, of age-4 hatchery females (mean=0.198) was not significantly different than age-4 (mean=0.197) and age-5 (mean=0.179) wild females. There was no significant difference in viability of eggs of hatchery (mean viability =0.91) and wild (mean viability =0.91) origin fish. Hatchery age-4 females had Relative Fecundity (RF) values that were lower, but not significantly different from wild females (Wild RF= 1049 eggs•(kg body weight)$^{-1}$; Hatchery RF= 1089 eggs•(kg body weight)$^{-1}$), but wild age-5 female's (mean RF 807 eggs•(kg body weight)$^{-1}$) were significantly lower than both age-4 females. Both hatchery (mean=0.003) and wild (mean=0.004) origin females had very low proportions of abnormally developing fry, and the proportions were not significantly different. There was no significant difference between wild and hatchery origin fry fork lengths or body weights at the "button up" stage. There were strong positive relationships between fry size and egg weight for both wild and hatchery origin females.

In-river Redd Characteristics: We monitored the in-river redd characteristics of naturally spawning upper Yakima River hatchery and wild females. Redds were sampled by snorkeling 3 to 4 days per week between September 9 and October 2 and were associated with a female of known origin identified by the presence (wild) or absence (hatchery) of the female's adipose fin. After spawning was completed, a suite of redd width, length, depth, velocity and substrate parameters were collected from each known-origin redd. A total of 76 hatchery- and 43 wild-origin females and associated redds were monitored. Naturally spawning hatchery females were significantly smaller (p=0.01) than wild females by 1.7 cm on average. In our preliminary analyses of redd parameter data there were no significant differences in either redd width or length dimensions, water depth, velocities or substrate characteristics between hatchery- and wild-origin females (p>0.45). Redd characteristics were generally not correlated with female length and in the 8 significant correlations out of 44, female length only explained between 6 and 20% of the total variation. We will use this data to examine sample size needs and sampling effort for next year's work.

Reproductive Success

Schroder, S. L., C.M. Knudsen, B. D. Watson, T. N. Pearsons, S. F. Young, and J. A. Rau. 2003. Comparing the reproductive success of Yakima River hatchery- and wild-origin Spring Chinook. Annual Report FY 2001-2002. DOE/BP-00004666-15.

In 2001 hatchery- and wild-origin spring chinook were placed into an observation stream located at the Cle Elum Supplementation Research Facility to compare their reproductive success. Two groups containing both wild- and hatchery fish of both sexes were brought into the stream and allowed to spawn. Their longevity, spawning participation, and reproductive success were assessed. In addition, wild- and hatchery-origin precocious males were also introduced into one of the sections and allowed to spawn. We found that hatchery and wild males generally lived longer than females. In one group hatchery and wild females lived for similar periods of time while in the other wild females lived longer than hatchery females. Wild females were also more successful at burying their eggs and the eggs they buried had higher survival rates. This result occurred in both groups of fish. Spawning participation in males was estimated by using two statistics referred to as percent gonad depletion (PGD) and percent testes retention (PRT). Both of these measures assumed that loss of testes weight in males would reflect their spawning participation and therefore could be used to estimate reproductive success. Hatchery and wild males had similar PGD and PRT values. One of these measures, PRT, was negatively associated with male reproductive success, confirming the idea that reduction in testes weight can be used as a surrogate measure of a male's ability to produce offspring

Fry from the observation stream were collected throughout the emergence period that ran from January through May. Proportionate sub-samples of these fish were removed and microsatellite DNA was extracted from them. Pedigree analyses were performed to ascertain which adult fish had produced them. These analyses disclosed that wild males were more successful at producing progeny in one of the groups. No difference occurred in the other group. Precocial males and jacks fathered fewer progeny than did fish maturing at ages 4 and 5. In addition, male reproductive success was more than twice as variable as that seen in females. Some males apparently never spawned and others produced more than 7,000 offspring an amount that was more than double the quantity generated by the most successful female. Behavioral observations showed that a number of factors besides male origin influenced their reproductive success. One was relative body size; larger males tended to dominate smaller opponents and therefore had greater access to females. However, male dominance was not always related to relative size. The ability to attack and chase opponents was, however, positively related to reproductive success. We also discovered that the reproductive status of females and the social status of males were often reflected by their nuptial coloration. Territorial females typically had a single broad purple black stripe, light green or brown backs and white or gray ventral surfaces. Dominate males on the other hand, were generally a uniform dark brown or black color. The percentage of time that a male possessed a dark color pattern was positively linked to his reproductive success, as was the percentage of time he was observed courting or defending a female. The number of times a male was chased or attacked by a female also affected his reproductive success, in this situation the greater the frequency of such attacks the lower the reproductive success of the male. The pedigree analyses also disclosed that both hatchery and wild precocious males were able to fertilize eggs and produce offspring under natural spawning conditions.

In conclusion we found differences in the reproductive competency of hatchery- and wild origin spring chinook. Wild females were better at depositing their eggs and having those eggs produce fry. In one study group wild males were more successful at producing offspring than hatchery males. Additional replications of such evaluations are being carried out to determine if the differences seen can be replicated. A repeat of the work done in 2001, for example, was performed in 2002 and additional studies will take place this coming year.

Genetics

Busack, C. S., S. F. Young, A. L. Fritts, J. Loxterman, J. B. Shaklee, S. L. Schroder, C. M. Knudsen, and J. A. Rau. 2003. Genetic Studies in the Yakima River Basin. Annual Report FY 2001-2002 submitted to Bonneville Power Administration, Portland, Oregon. DOE/BP-00004666-13.

Genetic work for 2002 was quite diverse.

- In chapter 1 we report on studies of the population genetic structure, using DNA microsatellites, of steelhead collected from different locations in the Yakima River basin (Roza Dam, Ahtanum Creek, Toppenish Creek, and Satus Creek) in 2000 and 2001. Of 28 pairwise tests of genotypic differentiation, only the 2000 and 2001 Roza Dam collections and the 2000 and 2001 Satus Creek collections did not exhibit significant differences. Similarly, pairwise tests of genetic differentiation (FST) were significant for all comparisons except the between-years comparisons of Roza Dam, Toppenish Creek, and Satus Creek collections. All tests between populations sampled from different localities were significant, indicating that these collections represent genetically differentiated stocks.
- In chapter 2 we report on genetic comparisons, again using microsatellites, of the three spring chinook populations in the Yakima basin (Upper Yakima, Naches, and American) with respect to our ability to be able to estimate the proportions of the three populations in mixed smolt samples collected at Chandler. We evaluated this both in terms of mixed fishery analysis, where proportions are estimated, but the likely provenance of any particular fish is unknown, and classification, where an attempt is made to assign individual fish to their population of origin. Simulations were done over the entire ranged of stock proportions observed in the Yakima basin in the last 20+ years. Stock proportions can be estimated very accurately by either method.
- Chapter 3 reports on our ongoing effort at cryopreserving semen from wild Upper Yakima spring chinook. In 2002, semen from 91 males, more than 50% of those spawned, was cryopreserved. Representation over the spawning season was excellent.
- Chapters 4,5, and 6 all relate to the continuing development of the domestication study design. Chapter 4 details the ISRP consultations and evolution of the design from last year's preferred alternative to the current plan of using the Naches population as a wild control, and maintaining a hatchery-only control line alongside the supplemented line. During discussions this year a major issue was the possible impact to the research and to the supplementation effort, of gene flow from precocious males from the hatchery control line into the supplemented line. At the end of the contracting period, this issue still had not been resolved. Along with the discussion of development of the domestication research design, chapter 4 presents the current monitoring plan document, with discussion of the approach to the various traits to be analyzed.
- Chapters 5 and 6 deal with experimental power of the domestication monitoring design. There is still much work to be done on power, but in chapter 5 we explore our power to detect differences among the three lines for traits measured on individual adults. Power was found to be quite good for effects of 5% per generation over three generations for traits having a coefficient of variation (CV) of 10-20%, but low if the CV was 50%. Power is higher for comparisons between the hatchery control line and supplemented line than between the supplemented line and the wild control, a consequence of trying to avoid heavy impacts to the Naches population. Power could be improved considerably improved by sampling more Naches fish in years of high abundance.
- Chapter 6 presents the same power analysis, but attempts to explore the effect of precocious males from the hatchery control line spawning in the wild. It is clear that if gene flow from precocious males is more than one or two percent that the between-line comparisons will be

biased, making the supplemented line appear to be more similar to the hatchery control line than it should and more different from the wild control line than it should. However, it was also clear that more analysis is desirable, as the heightened or diminished power is really just an enhancement or reduction of a real difference. A more straightforward analysis of the proportion of observed differences that can be attributed to precocious gene flow needs to be done.

Ecological Interactions

Non-target Taxa of Concern

Pearsons, T. N., A. L. Fritts, G. M. Temple, C. L. Johnson, and M. R. Schmuck. 2003. Yakima River Species Interactions Studies. Annual Report FY 2002 submitted to Bonneville Power Administration, Portland, Oregon. DOE/BP-00004666-10.

Species interactions research and monitoring was initiated in 1989 to investigate ecological interactions among fish in response to proposed supplementation of salmon and steelhead in the upper Yakima River basin. This is the eleventh of a series of progress reports that address species interactions research and supplementation monitoring of fishes in the Yakima River basin associated with the Yakima/Klickitat Fisheries Project. Data have been collected before and during supplementation to characterize the ecology and demographics of non-target taxa (NTT) and target taxon, and to monitor interactions and supplementation success. Major topics of this report are associated with implementing NTT monitoring prescriptions for detecting potential impacts of hatchery supplementation, and monitoring fish predation indices. This report is organized into two chapters, with a general introduction preceding the first chapter. This annual report summarizes data collected primarily by the Washington Department of Fish and Wildlife (WDFW) between January 1, 2002 and December 31, 2002 in the Yakima basin, however these data were compared to data from previous years to identify preliminary trends and patterns. Summaries of each of the chapters included in this report are described below.

- Release of large numbers of hatchery origin salmon has the potential to negatively impact other fish taxa (non-target taxa). To determine changes in the status of non-target taxa that could be related to hatchery smolt releases, we compared the abundance, size structure, and distribution of 16 non-target taxa before and four years after annual spring releases of about 1 million yearling salmon smolts (coho and chinook) in the Yakima River, Washington. We compared any observed changes in status to predetermined containment objectives that were judged to reflect acceptable levels of impact. We utilized detection strategies that would balance our ability to detect changes and the chances of falsely associating a change with supplementation. With the exception of steelhead and cutthroat trout size, all of the changes we observed were within the containment objectives established for the project. The mainstem Yakima River steelhead size index has significantly decreased through the post-supplementation period (-1%, $P<0.049$). The decreased size of cutthroat trout (-1%) was not significant ($P>0.37$), however, the power of our statistical test was low (Power=16% with alpha set at 0.10). Our analysis suggests that the depressed sizes of steelhead and cutthroat trout were not related to supplementation activities. For instance, tributary cutthroat trout and spring chinook salmon exhibited minimal overlap in distribution and had limited opportunity for interactions. In contrast, high overlap occurred between rainbow trout (an analog for steelhead) and spring chinook salmon in the upper Yakima River. However, we could not detect any differences in the sizes of rainbow trout between areas of high and low target taxa abundance. These results suggest that any impacts that might have been caused by releasing hatchery smolts into areas containing non-target taxa were balanced or exceeded by the benefits (e.g., ecological release) of reducing the progeny of naturally produced fish or by the increase in nutrients provided by the hatchery and returning adults. The reduction of naturally produced fish in the river was the result of removing fish that would have spawned in the river and culturing them in a hatchery. The interactions of non-target taxa monitored with a predation index, including fall chinook salmon, and Pacific lamprey, will be monitored with secondary impact detection strategies in the future and leopard dace and sandroller interactions will no longer be evaluated.

- We estimated the number of salmonids that smallmouth bass ate during the spring of 2002 in the Yakima River. Predator surveys were conducted during the weeks of March 14 and March 28 and weekly from April 11 through June 21 in two sections of the lower Yakima River. Abundance was estimated using the relationship between catch per unit effort and population estimates that were calculated using maximum likelihood estimators of mark-recapture data from 1998 to 2000 and 2002. Diet was determined by lavaging smallmouth bass and identifying consumed fish in the lab by examining diagnostic bones. Daily consumption was calculated by estimating the average number of salmonids that a bass ate per day and extrapolating that number to the number of bass in the lower 68 kilometers of the Yakima River. Daily estimates were then summed to yield total consumption during the spring. Abundance of bass >150 mm increased during the spring from a low of 2,942 on March 16 to a high of 36,463 on June 21. The increase in abundance was primarily due to immigration of fish from the Columbia River and partially from recruitment of smaller fish into the 150 mm and larger size range. Daily consumption of salmonids was relatively low until late April and sharply increased in early May. Consumption of salmonids sharply decreased in early June despite the fact that bass numbers remained high and water temperature increased. Smallmouth bass ate an estimated 175,712 salmonids during the spring. Only 2,570 of these were estimated to be spring chinook. The remainder was mostly fall chinook salmon. Salmonid consumption estimates for 2002 were most similar to estimates for 1999 with 171,031 salmonids of which 3,795 were spring chinook. We found a positive relationship between our estimates of fall chinook salmon consumption and estimates of fall chinook production. Sampling of smallmouth bass will not continue in 2003.

Spring Chinook Interactions Indices and Residual/Precocial monitoring

Pearsons, T. N., B. James, C. L. Johnson, A. L. Fritts, and G. M. Temple. 2003. Spring chinook salmon interactions indices and residual/precocial monitoring in the upper Yakima River. Annual Report FY 2001-2002 submitted to Bonneville Power Administration, Portland, Oregon. DOE/BP-00004666-14.

Select ecological interactions and spring chinook salmon residual/precocial abundance were monitored in 2002 as part of the Yakima/Klickitat Fisheries Project's supplementation monitoring program. Monitoring these variables is part of an effort to help evaluate the factors that contribute to, or limit supplementation success. The ecological interactions that were monitored were prey consumption, competition for food, and competition for space. Spring chinook salmon life-history forms that have the potential to be influenced by supplementation and that pose ecological and genetic risks were monitored (residuals and precocials). Residual spring chinook salmon do not migrate to the ocean during the normal emigration period and continue to rear in freshwater. Precocials are those salmon that precocially mature in freshwater. The purpose of sampling during 2002 was to continue monitoring interactions indices and residual/precocial distribution and abundance. All sampling that we report on here was conducted in the upper Yakima River during summer and fall.

- Studying an indirect interaction such as competition is very challenging and yet extremely important because of the impact that competition can have in structuring fish communities. We developed and monitored space and competition indices for fish that have the potential to compete with juvenile spring chinook salmon during the summer and fall, 1998-2002. The space competition index was highest for spring chinook salmon, but the population food competition index was highest for mountain whitefish. Preliminary analyses revealed that competition indices for spring chinook salmon were the only indices that correlated well with spring chinook growth or survival. We suspect that our index of resource overlap may be too coarse to accurately reflect food competition and recommend identifying prey items to finer taxonomic levels in the future.

- We measured the core microhabitat values for age-0 spring chinook salmon and other species and life-stages of fishes that occupy similar habitats in four areas in the upper Yakima River Basin. We measured spring chinook salmon microhabitat variables during the summers of 1998 to 2002 in an effort to index the carrying capacity of rearing space. If supplementation activities succeed in increasing the density of age-0 spring chinook salmon and the resulting population exceeds the carrying capacity of the habitat, we expected to see an increase in the proportion of fish using suboptimal microhabitats. Contrary to our expectations, the proportion of spring chinook salmon in sub optimal habitats decreased with increasing abundance of spring chinook. We will continue to measure microhabitat use and, along with the food and space competition indices, monitor any changes that may be associated with supplementation activities.

- We examined the hypothesis that the Cle Elum Supplementation Hatchery alters the assemblage of spring chinook salmon that precocially mature in freshwater. We counted the number of precocials on the spawning grounds between 1998 and 2002 while snorkeling. The release of hatchery fish in the spring affected the natural distribution, abundance, and age structure of precocials observed on redds the following fall. The estimated number of age 0+, age 1+ and hatchery precocials observed on the spawning grounds during the peak of spawning ranged from 4 to 554, 16 to 42, and 11 to 52 respectively. During the peak of spawning, between 38% and 52% of all hatchery precocials observed on the spawning grounds within a year were in the Thorp section, whereas only 0% to 4% of all age 0+ precocials and 0% to 15% of all wild age 1+ precocials were observed in this section. In the spawning areas, we observed more hatchery precocials per female taken for hatchery broodstock (HP/F) than naturally produced age 0+ and 1+ precocials per female spawner (NP/F) in the wild combined during 1999. Except for year 2000, age 1+ HP/F was higher than age 1+ NP/F. The hatchery does not release age 0+ precocials, so it decreased production of this age of precocial. It appears that hatchery precocials experience high mortality after they are released into the river and pose ecological and genetic risks to wild fish.

Bird Predation

Major, W. III., J. M. Grassley, K. Ryding, C. E. Grue, T. N. Pearsons, and A. Stephenson. 2003. Abundance, distribution and estimated consumption (kg fish) of piscivorous birds along the Yakima River, Washington State. Annual Report FY 2002 submitted to Bonneville Power Administration, Portland, Oregon. DOE/BP-00004666-11.

The bird predation work was arraged into two chapters.

- Understanding of the abundance and spatial and temporal distributions of piscivorous birds and their potential consumption of fish is an increasingly important aspect of fisheries management. During 1999-2002, we determined the abundance and distribution and estimated the maximum consumption (kg biomass) of fish-eating birds along the length of the Yakima River in Washington State. Sixteen different species were observed during the 4-yr study, but only half of those were observed during all years. Abundance and estimated consumption of fish within the upper and middle sections of the river were dominated by common mergansers (M*ergus merganser)* which are known to breed in those reaches. Common mergansers accounted for 78 to 94% of the estimated total fish take for the upper river or approximately 28,383 ±1,041 kg over the 4 yrs. A greater diversity of avian piscivores occurred in the lower river and potential impacts to fish populations was more evenly distributed among the species. In 1999-2000, great blue herons potentially accounted for 29 and 36% of the fish consumed, whereas in 2001-2002 American white pelicans accounted for 53 and 55%. We estimated that approximately 75,878 ±6,616 kg of fish were consumed by piscivorous birds in the lower sections of the river during the study. Bird assemblages differed spatially along the river with a greater abundance of colonial nesting species within the lower sections of the river, especially during spring and the nesting season.

The abundance of avian piscivores and consumption estimates are discussed within the context of salmonid supplementation efforts on the river and juvenile out-migration**.**

- Consumption of fish by piscivorous birds may be a significant constraint on efforts to enhance salmonid populations within tributaries to the Columbia River in Washington State. During 1999-2002, we determined the abundance of fish-eating birds, primarily ring-billed (*Larus delawarensis*) and California (*L. californicus*) gulls and monitored their behavior at two man-made structures within the Yakima River in eastern Washington: Horn Rapids Dam, a low-head irrigation dam, and the return pipe for the Chandler Juvenile Fish Handling Facility. Earlier observations of congregations of gulls at these structures suggested an increased likelihood of predation of out-migrating juvenile salmonids. We estimated the number of fish consumed and examined the relationship between river flow and gull numbers and fish taken. Numbers of gulls at the structures varied daily between their arrival in Late March-early April and departure in late June (mean (±SE) - Horn Rapids: 11.7 (±2.0), Chandler: 20.1 (±1.5)). During the 4-yr study, numbers at Horn Rapids peaked dramatically during the last 2 weeks in May (between 132.9 (±4.2) to 36.6 (±2.2) gulls/day) and appeared to be associated with the release of > 1-mil hatchery juvenile fall chinook (*Oncorhynchus tshawytscha*) above the 2 study sites. A comparable peak in gull abundance was not observed at Chandler. Diurnal patterns of gull abundance also varied among years and sites. The relationship between foraging efficiency and gull numbers was not consistent among years or sites. Gull numbers were not correlated with river flow when year was considered. However, variations in flow among years appeared to be associated with average gull numbers at each site, but trends were not consistent between sites. Low seasonal flows were associated with increased predation at Chandler, whereas high seasonal flows were associated with increased predation at Horn Rapids. Assuming all fish taken were salmonids, we estimate gulls consumed between 0.1 – 10.3 % of the juvenile salmonids passing or being released from the Chandler Juvenile Fish Monitoring Facility located above the two structures. Staggered releases of hatchery fish, nocturnal releases of fish entrained in the Chandler facility, changes in the orientation of the outflow from the facility, and physical deterrents (e.g., sprinklers or overhead wires) may significantly reduce take by gulls at these sites.

Pathogens

Thomas, J. B. 2003. Pathogen screening of naturally produced Yakima River spring chinook smolts. Annual Report FY 2002 submitted to Bonneville Power Administration, Portland, Oregon. DOE/BP-00004666-12.

In 1999 the Cle Elem Hatchery began releasing spring chinook smolts into the upper Yakima River for restoration and supplementation. This project was designed to evaluate whether introduction of intensively reared hatchery produced smolts would impact the prevalence of specific pathogens in the naturally produced spring chinook smolts. Increases in prevalence of any of these pathogens could negatively impact the survival of these fish. Approximately 200 smolts were collected at the Chandler smolt collection facility on the lower Yakima River during

1998, 2000 and 2001 and 130 smolts were collected in 2002 for monitoring for specific pathogens. The pathogens monitored were infectious hematopoeitic necrosis virus, infectious pancreatic necrosis virus, viral hemorrhagic septicemia, *Flavobacterium psychrophilum*, *Flavobacterium columnare*, *Aeromonas salmonicida*, *Yersinia ruckeri*, *Edwardsiella ictaluri*, *Renibacterium salmoninarum* and *Myxobolus cerebralis*. In addition, the fish were tested for *Ceratomyxa shasta* spores in 2000 and 2001 (a correction from the 2001 report). To date, the only changes have been in the levels of the bacterial pathogens in the naturally produced smolts and they have been minimal. These changes are attributed to normal fluctuation of prevalence.

Acknowledgments

We would like to thank Bonneville Power Administration for financially supporting this work. In addition, we could not have completed this work without the help and support of many individuals from the Bonneville Power Administration (especially David Byrnes and Patti Smith), Yakama Nation (especially Melvin Sampson and David Fast), and Washington Department of Fish and Wildlife (especially Craig Busack, Curt Knudsen, Steve Schroder, Anthony Fritts, Gabriel Temple, and Christopher Johnson). Charity Davidson provided much office support throughout the year, which facilitated the scientific effort of the YKFP.

References

Bonneville Power Administration, Washington Department of Fish and Wildlife and Yakama Indian Nation. 1996. Yakima Fisheries Project - Final Environmental Impact Statement. Bonneville Power Administration, Portland, Oregon. DOE/BP-2784.

Busack, C., B. Watson, T. Pearsons, C. Knudsen, S. Phelps, and M. Johnston. 1997. Yakima Fisheries Project Spring Chinook Supplementation Monitoring Plan. Bonneville Power Administration, Portland, Oregon. DOE/BP-64878-1.

Clune, T., and D. Dauble. 1991. The Yakima/Klickitat fisheries project: a strategy for supplementation of anadromous salmonids. Fisheries 16(5):28-34.

Fast, D. E., and C. Craig. 1997. Innovative hatchery project working to rebuild wild salmon populations. Hydro Review XVI:30-3.

Hatchery Scientific Review Group. 2003. Hatchery Reform Recommendations.

Independent Multidisciplinary Science Team. 2000. Conservation Hatcheries and Supplementation Strategies for Recovery of Wild Stocks of Salmonids: Report of a

Workshop. Technical Report 2000-1 to the Oregon Plan for Salmon and Watersheds. Oregon Watershed Enhancement Board. Salem, Oregon.

Independent Scientific Advisory Board. 2003. Review of Salmon and Steelhead Supplementation. Northwest Power Planning Council. Portland, Oregon.

Independent Scientific Group. 1996. Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem. Northwest Power Planning Council. Portland, OR.

Lichatowich, J. 1999. Salmon Without Rivers: A History of the Pacific Salmon Crisis. Island Press. Washington D.C.

National Research Council. 1996. Upstream: Salmon and Society in the Pacific Northwest. National Academy Press. Washington D. C.

Pearsons, T. N., and J. A. Easterbrooks. 2003. WDFW Policy/Technical Involvement and Planning in the Yakima/Klickitat Fisheries Project. Annual Report FY 2001 submitted to Bonneville Power Administration, Portland, Oregon. DOE/BP-00006215-1.