Appendix J
Yakima/Klickitat Fisheries Project

Part A.

YKFP M&E Project description

Project ID: 199506325

Title: Yakima/Klickitat Fisheries Project Monitoring And Evaluation

a. Abstract

The YKFP is an effort to increase natural production and harvest opportunity of salmon and steelhead in the Yakima and Klickitat Subbasins using supplementation and habitat improvements. The project includes all stocks historically present in both basins. Currently, stock-specific plans are at widely differing levels of development: Yakima coho and fall chinook programs are in feasibility stages, while Yakima steelhead programs involve only habitat/life history inventory, kelt reconditioning, passage improvements and stock-status monitoring. The most complete program is the upper Yakima spring chinook supplementation program (Busack et al. 1997).
We will monitor each program in terms of natural production, harvest, genetics and ecological interactions. Studies of defined statistical power in these areas will guide project adaptive management and provide critical information for regional enhancement efforts. Expected outcomes include evaluations of:

- Impacts on natural production of targeted stocks;
- Ecological impacts on nontarget stocks;
- Identification of factors determining success or failure for each program.
- Relative survival between different experimental groups of hatchery fish and between hatchery fish and wild conspecifics.

Project success is defined as a significant increase in natural production with limited adverse impacts on non-target stocks. Natural production is monitored in terms of natural origin recruits and its components (adult reproductive performance and survival from egg to fry, fry to smolt, and smolt to adult). Genetic impacts will be monitored in terms of domestication and within- and between-population variability. Ecological impacts on nontarget stocks will be monitored by comparing abundance, size structure, geographic distribution and interaction indices before and after supplementation. Impacts of nontarget species on project fish will be assessed by indices of predation, competition, prey abundance, mutualism and disease.

b. Technical and/or scientific background

Prior to 1850, spring chinook, as well as other stocks of anadromous fish, were much more abundant in the Yakima Subbasin than they are now. Before the ocean and lower

Columbia exploitation of salmon and steelhead in the late l9th century and early 20th century, and before the valley was developed, the Yakima supported large runs of spring, summer and fall chinook, summer steelhead, coho and sockeye. Sockeye and summer chinook are now extinct in the subbasin. Currently, due to efforts of the YKFP the number of naturally produced coho is increasing in the subbasin. Historic spring chinook runs to the Yakima may range from a high of approximately 250,000 fish (Smoker 1956) to 202,500 (Mullan 1983). Historic adult fall and summer chinook production in the Yakima Subbasin may have ranged from 250,000 (Smoker 1956) to 202,500 (Mullan 1983). Estimates of historic steelhead run range from 100,000 fish (Smoker 1956) to 81,000 (Mullan 1983). Estimation of the historic magnitude of the sockeye run is difficult, as the run was eliminated before counting stations were established. However, Mullan (1986) presented statistics from which we estimated the historic sockeye run size to be between 103,000 – 211,100 adult sockeye salmon.

Meaningful restoration of salmon and steelhead runs in the Columbia Basin ultimately requires a return to "normative" conditions throughout the basin (Williams et al., 1996), or at least to a much more normative state. Because of the enormous societal obstacles and economic costs that constrain it, such an effort will take decades to implement and additional decades to take effect. Therefore interim measures, such as supplementation, are required to maintain fish runs for the foreseeable future.

The YKFP is in the process of planning and implementing habitat restoration and preservation projects that are prioritized through the Ecosystem, Diagnosis and Treatment Model (EDT). A preliminary limiting factors analysis for Yakima Subbasin salmon and steelhead has been summarized in the Yakima Subbasin Summary, and will be refined by an ongoing EDT analysis. EDT analysis has already identified high priority reaches and tributaries for preservation and restoration. A number of restoration projects have recently been initiated based on this prioritization. Ultimately the YKFP will comprise a series of complimentary habitat restoration and supplementation/reintroduction projects targeting all species historically present in the subbasin.

Supplementation is a cornerstone of efforts to rebuild salmon and steelhead runs throughout the Columbia Basin (RASP 1992; NPPC 1994; CRITFC 1995; ISAB, 1998). In the Yakima Subbasin, supplementation seems particularly promising because it has been shown theoretically (Busack and Knudsen, in press) that populations of low productivity (viz., subjected to high levels of density-independent mortality) are optimal candidates for supplementation, as are populations subject to high levels of predation (Peterman 1987; McIntyre et al., 1988). Such conditions characterize salmon and steelhead populations in the Yakima Subbasin (Dunnigan and Lamebull 2000; McMichael et al. 1998; Fast et al. 1991, Anonymous 1990). There are, however, concerns that supplementation might fail because of the following factors: poor smolt-adult survival (Miller et al. 1990; Steward and Bjornn 1990), poor reproductive success (Fleming and Gross 1992; Chilcote et al. 1986), adverse genetic change (Busack and Currens 1995; Reisenbichler 1997; Waples et al. 1990; Hindar et al. 1991; Waples 1991), adverse ecological impacts on target and nontarget species (Shoals and Hillock 1979; Collis et al. 1995; Shively et al. 1996; Hillman and Mullan 1989; Peery and Bjornn 1996;

Nickelson et al. 1986; Hillman 1989; Reeves et al. 1987; Mullan et al. 1992; Swain and Riddell 1990; Tabor et al. 1993; Ward et al. 1995; Wood 1987) and diminished primary and secondary productivity attributable to the removal of salmon carcasses from streams (Johnston and Ringler 1979; Michael 1995; Bilby et al. 1996; Levy 1997).

Table 1 summarizes the scope of ongoing and future YKFP monitoring activities, as well as current monitoring readiness and the significance of findings to date (summarized in Section e). A comprehensive monitoring plan addressing all of the preceding considerations has been developed for upper Yakima spring chinook (Busack et al. 1997). Stock-specific monitoring plans based on the spring chinook template will be developed for all other stocks, and plans for Yakima coho and fall chinook are in progress. Because it was the first, the Yakima spring chinook plan is self-sufficient and exhaustive in scope. Funding limitations may preclude explicit evaluation of every potential issue for other Yakima stocks. Monitoring plans for other stocks will entail extrapolation from spring chinook findings. Where appropriate, facility sharing (e.g., smolt and adult counting facilities) and an emphasis on performance, and risk monitoring will occur.

The YKFP monitoring program is a descendant of a number of earlier projects. The general elements of a monitoring plan were first outlined in the YKFP's 1993 Project Status Report (BPA 1993). These ideas were transformed into specific measures in the Yakima Fisheries Project Spring Chinook Supplementation Monitoring Plan (Busack et al. 1997). The completion of Planning Status Reports for Yakima coho and fall chinook (YN, unpublished documents) represents initial steps in the development of comprehensive monitoring plans for these stocks. Other efforts that have contributed to the evolution of the monitoring program include: the Yakima Spring Chinook Enhancement Study (Fast et al. 1991); genetic stock identification and genetic risk issues (Busack 1990; Busack et al. 1991; Busack and Currens 1995; Currens and Busack 1995; Kapuscinski and Miller 1993); power analysis for OCT/SNT comparisons (Hoffmann et al. 1994); semi-natural rearing treatment development (Maynard 1995); baseline hatchery/wild interaction studies (Pearsons et al. 1993 and 1996); Chandler smolt trap passage studies (Neeley 1992; Sanford and Ruehle 1996; Neeley 2001); reproductive success (Berejikian et al. 1997); spring chinook natural production objectives/strategies (Watson 1993); Yakima flow/survival studies (Yakama Nation, unpublished data); and project-specific marking methods (Schroder and Knudsen 1996).

Table 1. Potential scope of YKFP Monitoring Effort. The first letter (I or i) in each cell indicates how much information has been acquired in the area, and the second (M or m) indicates the readiness level of monitoring procedures. Regarding information, a capital "I" indicates monitoring has been occurring for some time and significant findings have been obtained. A lower-case "i" indicates newly-initiated monitoring activities, and/or activities which have yet to generate significant findings. Regarding monitoring readiness, a capital "M" indicates ongoing monitoring activity or one for which facilities and procedures are in hand to begin monitoring immediately. A lower-case "m" indicates a complete monitoring procedure can be described at the conceptual level, but cannot currently be implemented because certain key elements (e.g., facilities) are missing. A minus sign (-) indicates either a total lack of information or monitoring readiness, respectively, depending on whether it occurs in the first or second position.

		Yakima Spring Chinook	Yakima Fall Chinook	Yakima Coho (naturalized)	Yakima Steelhead
Natural Production	Smolts per spawner	IM	im	iM	IM
	Smolt/adult survival	IM	Im	-M	IM
	Relative hatch/wild survival	-M	-m	-M	-m
	Optimal Spawning Distribution	IM	im	-m	IM
	Relative Hatch/Wild Spawning Behavior	-M	-m	-m	-m
	Relative Hatch/Wild progeny per parent	-M	-m	-m	-m
	Hatchery rearing regime defined	IM	im	im	--
	Impact of environmental factors	im	im	-m	im
Harvest	In basin	IM	iM	iM	IM
	Out of basin	-m	im	iM	im
Genetics	Extinction Risk	im	im	-m	im
	Within population variability	IM	IM	iM	IM
	Between population variability	IM	IM	-m	IM
	Domestication	-m	-m	-m	-m
Ecological Interactions (re. hatchery fish)	Interactions with nontarget taxa	IM	Im	IM	Im
	Interactions with strong interactors	IM	Im	Im	Im

c. Rationale and significance to Regional Programs

From its inception, monitoring has been a critical element of the YKFP. The Yakima/Klickitat Fisheries Project was identified in the 1982 Columbia River Basin Fish and Wildlife Program (Measure 704(i)(3) and 904(e)(1). A draft Master Plan was presented to the Northwest Power Planning Council in 1987 and the Preliminary Design Report was completed in 1990. In both cases the NPPC instructed the managers (YN and WDFW) to carry out planning functions that addressed uncertainties in regard to the efficacy of supplementation in the areas of meeting production objectives and limiting adverse ecological and genetic impacts. At the same time, the Council underscored the importance of adaptive management in project implementation. The 1994 FWP again reiterated the importance to proceed with the YKFP because of the added production and learning potential the project would provide. In 1997, a comprehensive conceptual monitoring plan for the Yakima spring chinook portion of the project was developed (Busack et al. 1997), which addresses most of the objectives and tasks for all YKFP target stocks. The YKFP is unique in having been designed to rigorously test the efficacy of 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. Consequently, the project is developing a website and other tools for rapid and efficient dispersal of project results.

Another unique aspect of the YKFP is the fact that EDT analysis is being used to design and improve enhancement programs for all species and stocks. Particular emphasis is placed on reconstructing the structure and function of the historic ecosystem (the "Template"). The Template represents the definition of normative habitat conditions for the Yakima Subbasin. Project scientists are in the process of prioritizing portions of the subbasin of greatest preservation value and restoration potential. The EDT model will also be used to identify reach-specific habitat actions with the greatest potential to compliment supplementation.

As stated in the Yakima Subbasin Summary, the fundamental need for the Yakima Subbasin is to restore normative structure and function to aquatic and terrestrial habitat to the greatest degree practicable. This overall need includes the following seven components: 1) Restore/preserve floodplain connectivity, 2) Restore normative flows, 3) Restore access to historical production areas to all life stages of resident and anadromous salmonids, 4) Restore normative water quality to basin streams, 5) Restore and preserve riparian communities and normative watershed function, 6) Restore normative ecological interactions among target species and aquatic communities in all portions of the basin, and 7) Protect and restore native fish and wildlife populations by increasing or maintaining productivity.

The YKFP will implement enhancement and restoration activities addressing issues in components 1-5 that are identified by the EDT process. The YKFP has implemented monitoring and evaluation programs to evaluate ecological interactions and productivity described in components 6 and 7. Specifically, component 6 (ecological interactions) entails monitoring in the following areas:

1) Predation on juvenile salmonids and exacerbating conditions, e.g. high temperatures, non-normative flows, introduction of exotic species and instream structures (dams and bypass outfalls) that increase the vulnerability of juveniles.
2) Possible constraints on fish and wildlife production attributable to limited availability or accessibility of habitat and/or food.
3) Impaired production of fish and wildlife attributable to the scarcity or elimination of mutualists and/or keystone species.
4) Possible constraints on fish and wildlife production associated with pathogens.

Component 7 identifies the need to increase productivity of native fish and wildlife populations, and therefore implies monitoring the abundance and survival rates of targeted populations. The restoration of normative habitat conditions will substantially improve the productive capacity of the Yakima Subbasin, but will likely take many years to accomplish. Therefore there is an interim need for artificial production to increase the productivity of existing fish populations. Artificial production is also essential to restore extirpated species to the Yakima Subbasin.

d. Relationships to other projects

This project, "Yakima/Klickitat Monitoring and Evaluation", and the following four projects comprise the entirety of the YKFP: "YKFP Management, Data and Habitat", Project 198812025, "YKFP Operations and Maintenance" Project 199701325, "YKFP Design and Construction", Project 198811525 and "WDF&W Policy/Technical involvement and planning in YKFP", Project 199506425.

Except for one element, this project completely covers YKFP monitoring activities. The exception, smolt physiology monitoring, is provided by Dr. Walt Dickhoff and colleagues under Fish and Wildlife Program (FWP) project 9200200, "Physiological Assessment of Wild and Hatchery Juvenile Salmonids".

FWP habitat improvement projects (both YKFP and others) in the Yakima Subbasin relate to this project, as they will influence the quality of the aquatic environment. Project 199705100, "Yakima River Side Channel Survey" and "Yakima River Side Channel Restoration", are intended to correct one of the most serious environmental problems in the upper Yakima: the lack of fry rearing habitat provided by side channels. A series of riparian and instream flow enhancement projects targeting streams in or bordering the Yakama Nation Reservation – and therefore primarily benefiting steelhead – include project 199803400: "Re-establish Safe Access into Tributaries of the Yakima Subbasin", project 199803300 "Restore Upper Toppenish Creek Watershed", project 199705300 "Toppenish /Simcoe instream flow restoration and assessment", project 199901300 "Ahtanum Creek Watershed Assessment", and project 199603501 "Satus Creek Watershed Restoration". Projects, ("Upper Yakima Tributary Irrigation Improvement") and 5510900 ("Teanaway River Instream Flow Restoration") both attempt to restore adult and juvenile passage to upper Yakima tributaries dewatered or blocked by irrigation diversions. The Teanaway project is especially important because an acclimation site will be located on the North Fork of the Teanaway River. Finally, projects 9105700 and 9200900 provide funds for the WDFW Yakima screen shop and the Yakima Project Office of the Bureau of Reclamation (BOR) to build and maintain screens on irrigation diversions and to maintain fisheries monitoring and enhancement facilities (fish ladders, the Chandler and Roza smolt traps, the Roza adult trap, etc.) owned by the BOR.

e. Project history (for ongoing projects)

YKFP M&E is now a consolidation of nine earlier YKFP monitoring projects. The old project numbers and titles are listed below. All objectives and tasks in the current YKFP M&E Project are covered in the summary below. For the sake of clarity, we have included the current objective and task number along with the previous project number and title. The project history and accomplishments are summarized for each of the current objectives and tasks.

f. Proposal objectives, tasks and methods

Although the project entails only four fundamental objectives, there are 37 sub-objectives which we have termed tasks to accommodate the structure of this document. These 37 sub-objectives and associated hypotheses/assumptions are summarized in the table below. Every sub-objective will result in one or more of the following: a BPA report, a paper in a refereed journal, a complete monitoring procedure including functional facilities and analytical techniques.	
OBJ.	**Task, Hypothesis/Assumption, and Method**
1.	**Objective: Natural Production**: 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.
1.a	**Task:** Modeling: Design complementary supplementation/habitat enhancement programs for coho, spring & fall chinook & steelhead in the Yakima and Klickitat Subbasins. **Hypothesis:** Ecosystem Diagnosis and Treatment computer modeling accurately integrates habitat quantity, quality, and life history data to evaluate alternative enhancement strategies. Modeling can continue to be used throughout the Project to model the statistical power of reproductive success study designs, domestication study designs, treatment/control experimental designs, etc. **Rationale:** To design complementary supplementation/habitat enhancement programs for targeted stocks. **Methods:** To diagnose the fundamental environmental factors limiting natural production, and to estimate relative improvements in production attributable to alternative enhancement strategies, by using the "Ecosystem Diagnosis and Treatment" (EDT) model. Continue to model statistical power associated with proposed monitoring plans such as reproductive success, genetic risk assessment, adult sub-sampling frequency, etc.
1.b	**Task:** Fall chinook survival study: Determine optimal locations within the lower Yakima Basin for increasing natural production of fall chinook, and to guide location of future acclimation/release sites. **Hypothesis:** The relative survival of PIT tagged wild juvenile fall chinook from candidate supplementation areas to the lower Yakima accurately reflects natural production potential of the candidate areas. **Rationale:** Determine areas in the lower Yakima where potential for increased natural production of fall chinook is greatest (future acclimation/release sites). **Methods:** Determine the feasibility of collecting naturally produced fall chinook juveniles to mark with PIT tags to estimate relative survival between groups. Relative productivity among reaches is indexed by relative fry-to-smolt survival.

1.c	**Task:** Juvenile spring chinook micro-habitat utilization: Monitor microhabitat utilization of juvenile spring chinook salmon. Future deviations in use will suggest carrying capacity problems. **Hypothesis:** Changes in patterns of microhabitat utilization with supplementation will reflect spring chinook seeding in the upper Yakima. **Rationale:** Estimate the baseline microhabitat utilization patterns of juvenile spring chinook salmon. Even if supplementation were perfect, producing smolts and adults identical to wild fish in every way, the project could fail if existing production actually represented the carrying capacity of the Yakima Subbasin. A post-supplementation change in patterns of microhabitat use is one of the indices that will be used to monitor "carrying capacity constraints". **Methods:** Under excessive densities, a significant proportion of early spring chinook parr might be displaced into sub-optimal microhabitats. Accordingly, we will monitor the relative incidence of parr in "typical" (baseline) and "atypical" microhabitats as a function of estimated egg deposition and spawning escapement. Snorkelers will mark the location of spring chinook focal positions and measure associated physical parameters.
1.d	**Task:** Hatchery spring chinook juvenile marking: Estimate hatchery spring chinook smolt survival to Chandler & mainstem dams using PIT-tags, and smolt-to-adult survival (release to Yakima mouth) using CWTs. **Hypothesis:** H_0: Survival of SNT-reared fish does not exceed survival of OCT-reared fish. Current release numbers of juvenile spring chinook assumes that OCT smolt-to-adult survival rates will be 0.2% or higher. Under these circumstances it will be possible to detect a 50% effect size with 90% probability, alpha = 10%. **Rationale:** To evaluate hatchery treatments in terms of relative smolt survival to Chandler, McNary and John Day using PIT tags, and relative smolt-to-adult survival (to Roza Dam) using multiple body-implanted CWT's, and colored elastomer in multiple body locations denoting treatment replicates.. **Methods:** To estimate differences in smolt survival by treatment (OCT/SNT), acclimation site, and raceway, we will PIT-tag, ad-clip & CWT (snout) 40,000 parr, enough to detect survival differences at John Day with specified power (α=.05 β=.1, effect size=50%). 400,000 fish will be ad-clipped and CWT'ed in multiple body areas to uniquely code treatment, acclimation site, and raceway. Returning adults will be interrogated at Roza using hand-held CWT detectors to determine smolt-to-adult survival by group, and will then be released to spawn. Power for smolt-to-adult survival estimates is the same as for smolt survival. CWT'ed fish will also be recovered in spawning ground surveys (see task 1.q). Statistical analysis by ANOVA.
1.e	**Task:** Roza juvenile wild/hatchery smolt PIT tagging: Capture, PIT-tag and release wild and hatchery spring chinook to estimate relative wild/hatchery smolt survival to Chandler and the McNary Dam. **Hypothesis:** Survival of hatchery fish is high enough to result in an increase in natural origin recruits. **Rationale:** Relative hatchery/wild smolt survival to Chandler and McNary is a critical mechanistic element of project evaluation. **Methods:** Roza Canal fish bypass will be used to capture wild and hatchery spring chinook smolts, which will be PIT-tagged and released on site. Analysis by binomial techniques.

1.f	**Task:** Wild/hatchery survival and enumeration (Chandler Juvenile Monitoring Facility):Refine operational and analytical procedures used in estimating hatchery and wild smolt passage at Chandler smolt trap. **Hypothesis:** A stable relationship exists between smolt entrainment and hydraulic variables at Prosser Dam, and stock-specific proportions of smolt outmigrants can accurately be estimated by electrophoretic and/or micro satellite DNA techniques. **Rationale: 1.)** As referenced in the Spring Chinook Monitoring Plan, (Busack et al. 1997), Chandler is an essential element of M&E for Yakima stocks. Information wholly or partly collected at Chandler includes annual smolt production and outmigration timing, egg-to-smolt and smolt-to-adult survival rates, and relative smolt survival rates (to Chandler) between hatchery treatment groups (e.g., OCT v SNT) and between hatchery groups and marked groups of wild smolts. This information is used to determine whether post-supplementation changes in production and survival rates are consistent with a population for which natural production is increasing. This data can be gathered for all anadromous salmonids within the basin and is stock-specific for spring chinook (electrophoretic mixed stock analysis). **2.)** To refine smolt passage estimates (future and historical) by increasing the precision of passage estimators and correcting for any bias associated with the estimators. **Methods: 1.)** Chandler is operated continuously except for brief periods of canal maintenance. Species-specific relationships between canal diversion and smolt entrainment rates have been developed, and daily passage is estimated as the ratio of raw catch to entrainment (total production is the sum over the season). A subsample of smolts are bio-sampled each day and all PIT-tagged fish are interrogated as they enter the facility. Smolt–to-adult survival for wild fish is estimated as the ratio of brood year returns to brood year smolt production. Brood year returns are estimated (for example) for spring chinook as the sum of the number of jacks the year after outmigration, the number of age 4 fish two years after outmigration, and so on. Annual age composition is estimated by analyzing scales from spawning ground carcasses and adults sampled at the Roza adult trap, and total returns are estimated as the sum of Prosser counts and below-Prosser harvest. **2.)** Replicated releases of PIT-tagged smolts are used to make a series of entrainment rate estimates. Logistic regression is then used to express entrainment as a function of one or more hydraulic variables (e.g., percent discharge diverted into the canal) characterizing flow conditions at Prosser Dam at the time of release. These flow/entrainment relationships will be used to estimate future smolt production, to revise historical estimates of smolt production, and to generate confidence intervals for both.
1.g	**Task:** Fall chinook optimal rearing treatment: Develop an accelerated rearing treatment to enable early out migration and increase overall smolt survival. **Hypothesis:** The survival of hatchery fall chinook can be increased to levels consistent with an increase in natural production. **Rationale:** Determine if hatchery fall chinook smolt survival can be increased by accelerated incubation and rearing. **Methods:** Incubate and rear control and accelerated groups at the Prosser Hatchery on river water and warmer well water, respectively. PIT-tag fish to evaluate relative survival McNary Dam; differentially pelvic-clip fish to estimate relative smolt-to-adult survival. Analysis by logistic analysis of variance.
1.h	**Task:** Yakima coho stock and date of release study: Determine optimal location, date, and

	stock of release for Yakima coho re-introduction efforts. **Hypothesis:** The survival of a suitable stock of hatchery coho can be increased to levels sufficient to establish a naturalized population. **Rationale:** To determine the optimal date and place of release for Yakima coho re-introduction feasibility tests. **Methods:** A replicated factorial design is used to test for survival differences between release location (upper Yakima and Naches Subbasins) & release date (May 7 and May 31). Release date will have two replicates per drainage. Release groups will be PIT tagged to evaluate smolt survival to Chandler and McNary. Beginning in 2000, coho smolts will also be CWT'ed to monitor smolt-to-adult survival. CWTs will be recovered during broodstock collection. Statistical analysis by logistic analysis of variance.
1.i	**Task:** Yakima spring chinook juvenile behavior: Determine differences in hatchery & wild spring chinook smolt behavior closely related to survival. **Hypothesis:** Analysis of relative behavior in hatchery and wild fish at release will indicate which behaviors are correlated to survival. **Rationale:** To quantify behavioral differences between wild, OCT & SNT smolts, and to correlate those behaviors with smolt survival. **Methods:** Observe (direct and video) hatchery (OCT and SNT) and wild spring chinook collected at Roza and Prosser dams in a controlled environment. Response variables will include: water column position, position to overhead cover and substrate, use of different cover types, latency to normalized behavior and feeding, time required to adopt wild behavior. Analysis by principal component analysis and ANOVA.
1.j	**Task:** Yakima hatchery spring chinook juvenile morphometric and coloration studies: Determine whether significant differences in body shape and coloration exist between hatchery spring chinook at release. **Hypothesis:** Analysis of differences in coloration and morphology between OCT, SNT, and wild smolts at release will indicate which characteristics are correlated to survival. **Rationale:** One of the fundamental hypotheses of employing a SNT rearing treatment is to produce hatchery fish that resemble wild fish in color and body shape. This task estimates morphometric/coloration differences between OCT & SNT spring chinook juveniles. **Methods:** OCT and SNT fish will be photographed and truss measurements taken from the photographs will be used to characterize body shape. Color differences will be estimated from photographs taken just at release. Statistics: linear discriminant and principle component analysis.
1.k	**Task:** Yakima hatchery/wild spring chinook smolt physiology studies: Determine whether significant physiological differences exist among wild, OCT and SNT Yakima spring chinook smolts during rearing, at release, and at Chandler and at John Day Dam. **Hypothesis:** Analysis of physiological differences (lipid content, ILGF-1, gill-ATPase, thyroxin, condition factor) between OCT, SNT, and wild smolts at release and after a substantial outmigration period will indicate which characteristics are tightly linked to survival. **Rationale:** To compare OCT, SNT and wild spring chinook in terms of physiological smolt quality. **Methods:** Monitor plasma concentrations of thyroxin & insulin-like growth hormone, % body lipid, gill ATP-ase, growth rate and condition factor for OCT, SNT and wild fish as

	pre-smolts and as (PIT-tagged) outmigrants collected at Roza, Chandler & McNary. Statistical analysis by ANOVA.
1.l	**Task:** Adult salmonid enumeration at Prosser Dam: Estimate the total number of adult salmonids returning to the Yakima Basin by species (spring and fall chinook, coho and steelhead), including return of externally marked fish. **Hypothesis:** Water clarity will allow videographic species-specific passage estimates of specified precision. **Rationale:** To estimate passage of jacks and adults at Prosser, Roza and Cowiche Dams (spring and fall chinook, coho and steelhead), including passage of externally marked fish, and to collect biotic and abiotic data for each run. **Methods:** Use time-lapse video recorders (VHS) and cameras in viewing windows in all ladders at Prosser Roza & Cowiche Dams. Extract data from tapes. Monitor passage at Prosser and Roza year-round (for all species); monitor passage at Cowiche only Sept. 15 – Dec. 31 (for coho).
1.m	**Task:** Adult salmonid enumeration and broodstock collection at Roza and Cowiche dams: Estimate the total number of adult salmonids returning to the upper Yakima (Roza), and the total number of adult coho returning to the Naches (Cowiche). **Hypothesis:** Water clarity will allow videographic species-specific passage estimates of specified precision at Cowiche (coho only) and Roza (coho and steelhead). Additionally, flows at Cowiche Dam force all coho to use the ladder. It will be economically possible to modify the Cowiche Dam ladder to collect coho broodstock. **Rationale:** To estimate the upper Yakima spawning escapement at Roza Dam for spring chinook, steelhead and coho; to estimate spawning escapement of hatchery spring chinook by experimental group (treatment\acc site\raceway) at Roza; and to estimate passage of externally marked fish at Roza. **Methods:** From September 15 to March 31 monitor passage videographically. From April 1 to September 14, estimate passage of steelhead and spring chinook, and collect spring chinook broodstock, by operating the adult trap. All CWT'ed spring chinook will be electronically diverted to a holding tank and interrogated with a hand-held CWT detector and a PIT-tag detector.
1.n	**Task:** Spawning ground surveys (redd counts): Monitor spatial and temporal redd distribution in the Yakima Subbasin (spring chinook, Marion Drain fall chinook, coho, Satus/Toppenish steelhead), and collect carcass data. **Hypothesis:** Redd counts accurately reflect potential egg deposition and age distribution from carcass recovery can be used to estimate age structure. **Rationale:** To describe spatial and temporal redd distribution for Yakima spring chinook, coho, fall chinook (Marion Drain), and steelhead (Satus/Toppenish), and to collect demographic data from carcasses. **Methods:** Periodic foot and/or boat surveys are conducted within the geographic range for each species (increasing for Yakima coho as acclimation sites are relocated upriver and returns increase). Redds are individually marked during each survey and carcasses are sampled for marks and to collect data on egg retention, age (analysis of scale samples), sex, and length.
1.o	**Task:** Natural Spawning Observations: Characterize wild spring chinook reproductive behavior (adults and precocials) to serve as a baseline for future comparisons between hatchery & wild reproductive behavior.

	Hypothesis: Deviations from overall baseline behavioral patterns will indicate phenotypic and genotypic impacts from supplementation. **Rationale:** Detailed observations will allow scientists to characterize typical wild spring chinook reproductive behavior to serve as a baseline for evaluations of hatchery fish behavior. **Methods:** Before returns of hatchery adults in began in 2001, field activities will focus on observation and description of naturally spawning spring chinook in the upper Yakima and Naches Rivers. Knowledge of natural variation (within-year and between-year) in behavioral repertoires and the frequency of individual behaviors provide the basis for a power analysis of future studies to detect hatchery/wild differences in reproductive behavior. The presence and behavior of precocial males associated with spawning females is also recorded. Beginning with 2001 returns and continuing for at least two cycles, first-generation hatchery adults will be observed in the natural environment. Behavior, micro-habitat preferences, spawn timing, etc. of hatchery and wild spawners will be compared in the upper Yakima River. Observations will be recorded on audiotape and underwater video recordings.
1.p	**Task:** Yakima spring chinook residuals/precocials studies: Monitor abundance and distribution of wild and hatchery residual and precocial spring chinook salmon. **Hypothesis:** Supplementation does not significantly change the abundance and distribution of residual/precocial spring chinook. **Rationale:** Estimate the baseline abundance of residual and precocial spring chinook and determine the sampling effort needed to detect post-supplementation changes. **Methods: 1)** <u>Residuals</u> **–** Direct counts of juvenile chinook that did not migrate as 1+ smolts will be made by snorkeling index areas. Selected individuals will be captured and examined for sexual maturity (examination of gonads) and age (scale samples). **2)** <u>Precocials</u> - Snorkelers will count precocial spring chinook on active redds within index areas to assess supplementation-induced abundance changes. Sampling effort for monitoring abundance precocial abundance after supplementation will be based on 1998 observations.
1.q	**Task:** Relative hatchery/wild reproductive success: Determine whether spawning behavioral and reproductive success of wild and hatchery-origin spring chinook are comparable, and estimate reproductive success of hatchery coho in a natural stream. **Hypothesis: Spring Chinook:** Ho: Wild- and hatchery-origin spring chinook adult reproductive competency are equivalent when compared in a controlled-flow spawning channel. It is assumed that the artificial spawning channel will not cause deviant reproductive behavior, and can therefore be used to assess relative hatchery/wild reproductive success for spring chinook throughout the Yakima Subbasin. **Coho:** Ho: Reproductive success of hatchery coho spawning in certain areas of the Yakima Subbasin is high enough to support a naturalized population. **Rationale:** The reproductive competence of hatchery-reared adults is a major uncertainty surrounding supplementation. This task addresses that question directly for Yakima spring chinook and coho. Hatchery- and wild-origin spring chinook will be compared in a controlled-flow spawning channel to determine whether their behavior and reproductive effectiveness differs significantly. **Methods:** **1) Spring chinook:** DNA-typed wild and hatchery spring chinook adults and jacks

	collected at Roza Dam and precocial males will be tagged with individually numbered disk-tags and placed into Cle Elum spawning channel. Eleven pairs of size-matched wild- and hatchery-origin females (22 total females) will be placed in each of two 45m channel sections. A similar number of size-matched pairs of males will be introduced. In addition, five pairs of size-matched jacks will be included. Phenotypic and morphological traits will be collected and ethological characterizations of the reproductive behavior of individual fish will be made. The number of progeny produced by each male and female will be estimated by trapping post-emergent fry and identifying their parentage via DNA analysis. Reproductive efficiency will be determined for discrete WxW, HxW and HxH matings. Visual observations will be recorded on audio tape and, where possible, underwater video recordings will also be made. Statistical analysis will be by ANOVA. **2) Coho:** We will identify optimal reaches and tributaries for natural coho production, and for future acclimation/release sites, by comparing existing, tributary- and reach-specific substrate composition data with coho reproductive performance under controlled conditions. Controlled matings will be conducted in a semi-natural channel not subject to extreme flow fluctuations. This channel will be sub-divided into segments with substrate composed of various proportions of fine particles. Groups of hatchery coho will be allowed to spawn in each segment. Weirs will be installed between segments in order to capture emergent fry, and mean egg-to-fry survival will be estimated for each segment. Observed egg-to-fry survival rates will be compared to expected rates for wild coho in order to assess the bias attributable to hatchery ancestry of the donor stock. Bias adjusted relationships between percent fines and egg-to-fry survival will then be applied to the existing data for potential coho spawning areas throughout the basin. Estimated egg-to-fry survival values for potential spawning areas will be incorporated into the EDT model to identify the most promising areas for coho re-introduction, and for locating future acclimation/release facilities.
1.r	**Task:** Yakima spring chinook gamete quality monitoring: Estimate sex-specific fertility, in-hatchery mortality, incidence of monstrosities and fry emergence timing for upper Yakima spring chinook from a subsample of eggs. **Hypothesis:** H_0: Supplementation will not change gamete quality. **Rationale:** The following demographic variables for the upper Yakima spring chinook population will be monitored: age-specific mean fecundity, the length- and weight-fecundity relationship, egg size, total reproductive effort, female size (weight and length), fertility, in-hatchery egg-to-fry survival, occurrence of monstrosities, emergence patterns, and fry size vs. female size relationship. **Methods**: Adult female traits and egg size will be measured at the time of spawning. Fertility, in-hatchery mortality and monstrosities will be measured on a subsample of eggs collected from individual females and incubated in separate isolettes. Emergence timing of fry from individual females will be measured by placing eyed eggs into incubation containers with substrate and an outlet with a catch basin. Fry will be counted as they volitionally exit the rearing containers on a daily basis. Hatchery returns will be sampled in the same manner in 2002 and beyond and compared to their wild counterparts. Statistical analysis will include ANOVA, ANCOVA and linear regression.
1.s	**Task:** Scale analysis: Determine age and stock composition of juvenile and adult salmonid stocks and predator species in the Yakima basin. **Hypothesis:** H_0: Supplementation activities will not change the age structure of YKFP

	target stocks. Naturalized coho can reliably be distinguished from hatchery coho using scale analysis. **Rationale: 1. Spring chinook.** To determine age and stock composition of juvenile and adult salmonid stocks in the Yakima Subbasin. Age structure of naturally produced upper Yakima spring chinook will be monitored to ensure that the age structure does not change as the result of supplementation. **2. Coho**. So long as it is feasible to mark 100% of the hatchery coho, scale analysis to determine origin type will be unnecessary. During the period 2000-2003, we expect to mark 100% of all hatchery coho released in the Yakima. However, the prospects for marking all hatchery coho beyond 2003 are not known. It is therefore prudent to develop techniques using scale analysis to differentiate between hatchery and wild origin coho. **3. Yakima River Predators.** Potential predator fish control projects are likely to be more feasible when most of the predatory impact is confined to several older age classes. We are collecting this information against the possibility of a need to implement a predator control program in the future. **Methods: 1. Spring Chinook:** We will determine age distribution by scale analysis. Genetic data needs to be analyzed on a brood year basis, and the age structure of the population is itself an important genetic characteristic. Thus, aging the broodstock scales samples collected at the time of trapping will provide a baseline and be used to augment the biochemical genetic data. **2. Coho:** We will use scale analysis to determine the proportion of hatchery vs. wild smolt and adult Yakima coho production. Juvenile coho scales will be randomly collected at Chandler. Estimates of the proportion of hatchery and wild smolts will be applied to the estimated smolt out migration. Adult coho scales will be collected at the broodstock collection facilities to estimate the proportion of hatchery/wild escapement. Estimates of the proportion of hatchery and wild adults will be applied to estimated adult returns. **3. Yakima River Predators:** Collect scale samples from piscivorous fishes collected while performing task 4b (See below).
1.t	**Task:** Fish health monitoring: Monitor the disease status of Yakima Basin hatchery juveniles and broodstock, and determine pre-supplementation incidence of pathogens in wild Yakima spring chinook. **Hypothesis:** Disease related mortalities at the Cle Elum Hatchery can be kept at negligible levels. **Rationale:** There are two objectives to this element: to monitor the physiological health and disease status of hatchery fish in the Yakima basin (both juveniles and adult broodstock), and to establish a baseline data set describing existing levels of pathogens in wild spring chinook prior to introduction of hatchery fish. **Methods:** Approximately 200 hatchery juveniles will be sacrificed at regular intervals and examined for disease and incidence of pathogens. All adult broodstock will also be examined for pathogens upon spawning at the hatchery. The work will follow USFWS protocols and laboratory analyses will be conducted at a USFWS fish health laboratory. In addition, approximately 200 wild spring chinook smolts will be fully screened according to standard USFWS protocols at a USFWS fish health lab. This work will utilize fish already collected for ongoing Chandler Smolt Trap calibration work (electrophoretic stock identification).
1.u	**Task:** Habitat inventory, aerial videos and ground truthing: Measure critical environmental variables by analyzing data extracted from aerial videos and verified by

	ground observations. **Hypothesis:** A significant proportion of the inter-annual variability in salmon and steelhead productivity is attributable to fluctuations in key environmental factors inside the subbasin that can be measured by aerial videography and hydrological data. **Rationale:** To measure a number of environmental variables by analyzing data extracted from periodic aerial videos. **Methods:** Aerial videos of the Yakima Subbasin will be conducted and analyzed. The habitat conditions (e.g. area of "watered" side channels, LWD, pool/riffle ratio, etc.) from the videos will be checked by dispatching technicians to specific areas to verify that conditions are in fact as they appear on video.
1.v	**Task:** Out-of-basin environmental monitoring: Obtain and utilize information regarding mainstem and marine environmental and harvest-related impacts on all Yakima anadromous salmonids. **Hypothesis:** A significant proportion of the inter-annual variability in salmon and steelhead productivity is attributable to fluctuations in key environmental factors in the mainstem Columbia and ocean. **Rationale:** To obtain and utilize information from outside sources, regarding environmental and harvest-related impacts on all anadromous salmonids occurring outside the Yakima Subbasin. **Methods:** The method entails communicating (telephone, E-mail and occasional face-to-face meetings) with various state and federal agencies, other research programs, hatcheries, and university researchers and collecting information regarding out of basin environmental and harvest-related impacts on anadromous stocks.
1.w	**Task:** Sediment impacts on habitat: Monitor stream sediment loads associated with the operation of dams and other anthropogenic factors (e.g., logging, agriculture and road building) affecting streams in the Yakima Subbasin. **Hypothesis:** Salmon and steelhead production can be limited by anthropogenic sediment loading. **Rationale:** To monitor stream sediment loads associated with the operation of dams and other anthropogenic factors (e.g., logging, agriculture and road building) that can increase sediment loads in streams utilized by all salmonids in the Yakima Subbasin. **Methods:** Excessive sediment loads can play a critical role in egg-to-fry survival, and can depress survival and productivity of many other life stages of salmonids. Representative gravel samples will be collected from throughout an impacted reach. Each sample will be analyzed to estimate the percentage of fines or small particles present. The state TFW program guidelines on sediments will then be used to specify the impacts estimated sedimentation levels have had on salmonid egg-to-smolt survival. These impacts would be incorporated in analyses of impacts of "extrinsic" factors on natural production.
1.x	**Task:** Yakima hatchery spring chinook predator avoidance training: Determine efficacy of exposing Yakima hatchery spring chinook to predators prior to release in terms of increasing survival to Chandler Juvenile Monitoring Facility. **Hypothesis:** H_0: Predator avoidance training will have no impact on smolt survival. **Rationale:** Hatchery fish have been shown to be more susceptible to predation than wild counterparts, and it has been suggested that hatchery fish lack skills required to avoid predators (Wiley et al. 1993; Maynard et al. 1995). **Method:** Predator avoidance training will consist of introducing a hungry predator into a

	cage submerged in a raceway 3 times per week for 3 weeks prior to release. The predator will be allowed to feed for a predetermined interval. The design will entail dividing PIT-tagged SNT fish randomly into control and treatment groups. Survival for both groups will be estimated at Chandler and McNary.
1.y	**Task:** Biometrical support: Provide the services of a half- time PH.D. level biometrician for the project.
2.	**Objective: Harvest**: Develop methods to detect increases in harvest of YKFP targeted stocks.
2.a	**Task:** Out-of-basin harvest monitoring: Estimate group- and stock-specific harvest of hatchery and wild anadromous salmonids outside of the Yakima Subbasin. **Hypothesis:** H_0: Supplementation will not increase out-of-basin harvest. **Rationale:** To develop a database to track the contribution of target stocks to out-of-basin fisheries. **Methods:** Coordinate with agencies responsible for harvest management (WDFW, ODFW, USFWS, CRITFIC, etc.) to estimate the harvest of target stocks.
2.b	**Task:** In-basin harvest: Estimate group- and stock-specific harvest of hatchery and wild anadromous salmonids within the Yakima Subbasin. **Hypothesis:** H_0: Supplementation will not increase harvest in the Yakima Subbasin. **Rationale:** To develop a database to track the contribution of target stocks to in-basin fisheries. **Methods:** Monitor tribal subsistence and sport fisheries on the Yakima rivers at designated locations. Fish will be interrogated for various marks. This information will be used along with other adult contribution data (i.e. broodstock, dam counts, spawner ground surveys) to determine overall project success.
3.	**Objective: Genetics**: Develop methods of detecting significant pre- & post-supplementation genetic changes in targeted stocks as reflected by changes in extinction risk, within-stock genetic variability, between-stock genetic variability, and domestication.
3.a	**Task:** DNA data collection and analysis: Augment DNA microsatellite baselines of all Yakima chinook stocks for monitoring within- and between population genetic variability. **Hypothesis:** Continued DNA screening of known populations within the Yakima Basin will allow detection of changes in within- and between-population genetic variability with specified precision. **Rationale:** Continued genetic monitoring via DNA microsatellites is needed for genetic monitoring, reproductive success monitoring, and possibly other monitoring areas as well such a domestication selection analysis. **Methods:** Tissues from chinook salmon will be analyzed according to protocols being refined at the WDFW Genetics Lab. Approximately 12 variable loci will be analyzed from all adult broodstock collected for Cle Elum Hatchery, from fry exiting the controlled-flow spawning channel, and from adults sampled at Roza Dam prior to being released for natural spawning. The work will be done at the WDFW Genetics Lab. We plan to do this annually at least through the first cycle of adult returns from the hatchery. This will give us a mating-by-mating measure of reproductive success, and allow very precise estimation of effective size of the population. DNA analysis has supplanted allozyme work for adult spring chinook, and may well provide a non-lethal approach for sampling juveniles at Chandler smolt collection facility. DNA use is in lace for steelhead and will be included in

	steelhead monitoring plans as they are developed.
3.b	**Task:** Stray recovery on Naches and American spawning grounds: Determine the extent of gene flow from the supplemented Upper Yakima stock into the Naches and American River stocks. **Hypothesis:** Spawning ground recovery of strays will be complete enough to support estimation of maximum levels of gene flow with specified precision using DNA microsattelite analysis. **Rationale:** To determine the extent of gene flow from the supplemented Upper Yakima stock into the Naches and American River stocks. **Methods:** Upper Yakima fish on the American and Naches spawning grounds will be counted during normal spawning ground surveys and compared to the total run to estimate the maximum rate of gene flow. DNA baselines for American River and Naches spring chinook will be developed by analysis of tissue collected during spawning surveys. DNA analysis will then be incorporated to monitor possible impacts on population diversity resulting from straying.
3.c	**Task:** Yakima spring chinook domestication: develop a domestication selection study for Upper Yakima spring chinook involving HxH and WxW matings that is sufficiently powerful to detect significant effects. **Hypothesis:** A domestication monitoring plan can be designed and carried out that will detect domestication selection impacts at several traits of interest with specified precision. **Rationale:** To develop a domestication selection study for upper Yakima spring chinook that is sufficiently powerful to detect effects but also does not violate broodstock composition rules. **Methods:** Just prior to the time of this writing, a meeting of peer scientists with expertise in genetics and reproductive ecology was convened to begin problem definition and attempt to identify research approaches. Two major threads of thought were identified. Several scientists supported an approach that would maintain lines of pure wild and pure hatchery fish to afford the opportunity to observe and measure traits diverging under presumed domestication selection. A second dominant approach would measure comparative performance of a suite of fitness traits in a controlled population made up of hatchery- and wild-origin adults. Parentage would be tracked using DNA markers. During 2001, project scientists with collaboration from peer scientists will develop a menu of feasible domestication selection monitoring plans. The approach taken will probably involve measurement of a suite of traits in the progeny of hatchery and wild matings, focusing initially on first generation effects. Ideally these test groups will be compared in wild and hatchery environments. Size of study will be determined by power analysis and by modeling the genetic effects of modifying broodstock rules to allow hatchery fish to be used as broodstock. This work will be augmented by pre- and post-supplementation comparisons of various traits.
4.	**Objective: Ecological Interactions**: Develop methods to assess ecological impacts of supplementation on non-target taxa, and impacts of strong interactor taxa on productivity of targeted stocks.
4.a	**Task:** Avian predation index: Develop methods to index impact of avian predation on annual smolt production of Yakima Subbasin salmon and steelhead. **Hypothesis:** Avian predators are capable of significantly depressing smolt production and

	accurate methods of indexing avian predation across years can be developed. **Rationale:** The loss of wild spring chinook salmon juveniles to various types of avian predators has long been suspected as a significant constraint on production and could limit the success of supplementation. The index will consist of two main components; 1) an index of bird abundance and 2) an index of consumption. **Methods:** An index will be calculated for each major bird predator. Methods to determine the feasibility of accomplishing these two components will be tested. Piscivorous birds will be counted from either an inflatable raft, driftboat, or jetsled depending upon water conditions. Shortly after or during bird censuses a consumption index will be developed. Observational and direct methods will be attempted to determine which methods are most appropriate for each bird species. Birds that swallow their prey above water (e.g., heron) might be evaluated using behavioral observations and those that swallow their prey underwater (e.g., merganser) might be evaluated using direct methods such as stomach content examination.
4.b	**Task:** Fish predation index: Develop methods to index impact of piscivorous fish on annual smolt production of Yakima Subbasin salmon and steelhead. **Hypothesis:** Fish predators are capable of significantly depressing smolt production and simple and accurate methods of indexing fish predation across years can be developed. **Rationale:** Develop an index of the mortality rate of upper Yakima spring chinook attributable to piscivorous fish in the lower Yakima River. 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:** The abundance of all major piscivorous fish species will be estimated during the smolt outmigration in representative reaches of the lower Yakima, and predator-specific smolt consumption data will be gathered in the same reaches. From this data, reach-specific Predation Indices will be calculated. Estimates of salmonids consumption take into account water temperature, mean weight of predator, mean number of salmonids in each predator□s gut, and mean weight of prey items at ingestion in the gut contents. These variables are used in the following equation (Ward et al. 1995) to estimate the predation index. Results from representative study reaches will be extrapolated from the Yakima Confluence to Roza Dam.
4.c	**Task:** Indirect predation: Determine the impact of the abundance of hatchery smolts on the survival of commingled smolts (wild and hatchery) via alterations in the behavior of non-salmonid predators. **Hypothesis:** H_0: Survival does not differ for groups of outmigrants that are or are not commingled with hatchery smolts. **Rationale:** The release of hatchery salmonids may enhance or decrease the survival of 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:** To investigate this interaction, a series of release-specific environmental variables will be regressed on the Chandler to McNary survival rates of a large number of groups of PIT tagged smolts. These smolts will have been released well above Chandler, and the test groups will "define themselves": *viz.*, be defined after the fact, as they are

	detected at Chandler. A test group will consist of the minimum number of fish estimated to estimate survival to McNary with specified power. One of the independent environmental parameters will be the weighted mean number of hatchery smolts passing Chandler while test group was passing; others will include discharge, temperature and turbidity in the lower Yakima and McNary pool, and the weighted mean smolt passage index at McNary. A significant correlation coefficient for the "hatchery smolt abundance" variable will be taken as evidence consistent with indirect predation. Corroborating evidence will be sought in observations of predator congregations at Chandler, Horn Rapids Dam, and other lower Yakima predation "hot spots", and in consumption rates observed in predatory fish and birds.
4.d	**Task:** Yakima River spring chinook competition/prey index: Determine whether space competition or limited prey abundance restricts production of upper Yakima spring chinook smolts. **Hypothesis:** Space and food competition can limit upper Yakima spring chinook production. Supplementation can increase spring chinook fry abundance enough to deplete prey & diminish spring chinook productivity **Rationale:** The abundance of prey may limit the number of spring chinook salmon juveniles that can be produced in the upper Yakima basin. For example, spring chinook salmon may compete with one another for a limited amount of food, which may increase in density-dependent mortality rates. **Methods:** We will monitor stomach fullness of spring chinook salmon parr during the summer and fall in three index areas over time. Stomach fullness will be calculated by dividing the dry weight of the stomach contents by the total body weight or other relevant denominator. Full stomachs will suggest that adequate food is available and that food is not limiting spring chinook production.
4.e	**Task:** Non-Target Taxa of Concern (NTTOC) monitoring: Determine the impact of spring chinook supplementation on the abundance, distribution or size structure of 16 NTTOC in the Yakima basin. **Hypothesis:** H_0: Spring chinook supplementation will not depress the stock status of NTTOC below specified levels. **Rationale:** To determine if the spring chinook supplementation program is impacting the abundance, distribution, or size structure of non-target taxa of concern (NTTOC). **Method:** We will compare pre- and post-supplementation data to determine potential impacts. Field efforts will include backpack and drift boat electrofishing, smolt counts at CJMF, and snorkeling. We will use NTTOC stock status (abundance, size structure, and distribution) monitoring, interactions index monitoring, and interactions experiments to evaluate changes for 16 NTTOC.
4.f	**Task:** Pathogen sampling: Determine the impacts of pathogens on supplementation success and supplementation impacts on the incidence of pathogens in wild Yakima spring chinook smolts. **Hypothesis:** H_0: Spring chinook supplementation will not increase the incidence of pathogens in wild smolts and inriver pathogens will not limit the success of the supplementation project. **Rationale:** In order to determine if supplementation increases the incidence of pathogens, we will monitor levels of pathogens compared to a baseline data set describing existing levels of pathogens in wild spring chinook prior to introduction of hatchery fish.

	Method: We will collect approximately 200 wild spring chinook smolts at CJMF throughout the migration period and later examine for fish pathogens using standard fish health screening protocols at a the WDFW fish health laboratory to calculate a fish pathogen index.

g. Facilities and equipment

Anadromous salmonids in the Yakima Subbasin can probably be monitored more thoroughly than in any other river in the Pacific Northwest. Full implementation of this project will increase monitoring power even further. All adults and jacks are enumerated via video monitoring at Prosser Dam in the lower Yakima, as well as Roza Dam on the middle Yakima, where the entire upper Yakima spring chinook run passes up a ladder and down a flume in an adult collection facility. Therefore, "intrusive" (hands-on) monitoring of all upper Yakima hatchery and wild adults can be conducted at Roza, allowing the detection of marked fish that cannot be identified on video. The right-bank ladder/denil/trap complex at Prosser Dam confers a similar capability. Stock-specific counts of migrating smolts can be made at the Chandler Juvenile Monitoring Facility (also located at Prosser Dam), which is equipped with two PIT-tag detectors. The project has four mobile PIT-tagging stations and trained tagging crews. Smolts can be collected at Roza Dam (and at two other dams between Roza and Prosser), so that survival and outmigration timing data can be estimated from tagged fish released above Prosser. The project also has a number of portable PIT-tag detectors, allowing the enumeration of tagged or untagged smolts and juveniles in virtually any portion of the basin. Undeveloped but potential adult and smolt monitoring facilities also exist at Horn Rapids Dam (Wanawish) on the extreme lower Yakima, at Easton Dam on the extreme upper Yakima, and Cowiche Dam on the lower Naches.

The state-of-the-art hatchery at Cle Elum and associated acclimation sites have a capacity to produce 810,000 spring chinook smolts that can be segregated into experimental rearing treatments from the eyed egg stage through release. An addition to the hatchery has an experimental spawning channel for evaluating differences in reproductive success and associated behaviors of hatchery and wild fish. The hatchery and Chandler juvenile monitoring facility also includes facilities for juvenile behavior studies. The project has hatcheries at Prosser Dam and Marion Drain capable of rearing multiple treatment groups of fall chinook and coho. The Prosser Dam adult trap and the Prosser hatchery are currently being used to collect returning adults in an effort to develop locally adapted fall chinook and coho broodstocks.

The project has within itself (WDFW genetics lab) or through the auspices of collaborating entities (UW genetics lab) the facilities and personnel to conduct state-of-the-art allozyme and microsatellite DNA analyses. Similarly, the project has made arrangements with other entities (NMFS, USFWS) to conduct comprehensive physiological and pathological analyses of hatchery and wild fish.

h. References

Anonymous. 1990. Yakima Subbasin Plan.

Berejikian, B.A., E.P. Tezak, S.L. Schroder, C.M. Knudsen, and J.J. Hard. 1997. Reproductive behavioral interactions between wild and captively reared coho salmon (Oncorhynchus kisutch). ICES Journal of Marine Science 54:1040-1050.

Bilby, R. E., B. K. Fransen, and P. A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: Evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164-173.

BPA (Bonneville Power Administration). 1993. Yakima /Klickitat Fisheries Project Planning Status Report.

Busack, C. 1990. Yakima/Klickitat Production Project genetic risk assessment. In Yakima/Klickitat Production Project preliminary design report, Appendix A. Report, DOE/BP-00245-2. Bonneville Power Administration, Portland, OR.

Busack, C.A., and K.P. Currens. 1995. Genetic risks and hazards in hatchery operations: Fundamental concepts and issues. American Fisheries Society Symposium 15: 71-80.

Busack, C., and C. Knudsen. A production-function based model of supplementation. Transactions of the American Fisheries Society (in press).

Busack, C, C. Knudsen, A. Marshall, S. Phelps, and D. Seiler. 1991.Yakima Hatchery Experimental Design. Progress Report, DOE/BP-00102. Bonneville Power Administration, Portland, OR.

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

Chilcote, M.W., S.A. Leider, and J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Transactions of the American Fisheries Society 115: 726-735.

Collis, K., R.E. Beaty, and B.R. Crain. 1995. Changes in catch rate and diet of northern squawfish associated with the release of hatchery-reared juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 15: 346-35

CRITFC (Columbia River Intertribal Fish Commission). 1995. Wy-Kan-Ush-Mi Wa-Ksih-Wit (Spirit of the Salmon). Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs and Yakama Tribes.

Currens, K.P., and C. Busack. 1995. A framework for assessing genetic vulnerability. Fisheries 20:24-31.

Dunnigan J.L., and L.L. Lamebull. 2000. Lower Yakima River Predatory Fish Monitoring: 1999 Annual Report. Bonneville Power Administration, Portland, Oregon.

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

Fleming, I.A., and M.R. Gross. 1992. Reproductive behavior of hatchery and wild coho salmon (Oncorhynchus kisutch): Does it differ? Aquaculture 103:101-121.

Hillman, T.W. 1989. Spatial interaction of juvenile chinook salmon and the redside shiner. Pages 209-247 in Don Chapman Consultants Inc., Summer and winter ecology of juvenile chinook salmon and steelhead trout in the Wenatchee River, Washington.

Hillman, T. W. and J. W. Mullan. 1989. Effect of hatchery releases on the abundance and behavior of wild juvenile salmonids. Pages 265-285 in Don Chapman Consultants Inc., Summer and winter ecology of juvenile chinook salmon and steelhead trout.

Hindar, K., N. Ryman, and F. Utter. 1991. Genetic effects of cultured fish on natural fish populations. Canadian Journal of Fisheries and Aquatic Sciences 48:945-957.

Hoffmann, A., C. Busack, and C. Knudsen. 1994. Experimental designs for testing differences in survival among salmonid populations. Report, DOE/BP-00029-3. Bonneville Power Administration, Portland OR.

ISAB (Independent Scientific Advisory Board). 1998. Review of salmonid artificial production in the Columbia River Basin as a scientific basis for Columbia River production programs. Northwest Power Planning Council, November, 1998.

Johnston, J. H., and N. H. Ringler. 1979. The occurrence of blow fly larvae (Diptera: Calliphoridae) on salmon carcasses and their utilization as food by juvenile salmon and trout. The Great Lakes Entomologist 12:137-140.

Kapuscinski, A.R., and L.M. Miller. 1993. Genetic hatchery guidelines for the Yakima/Klickitat fisheries project. Public review draft. Unpublished report to Yakima/Klickitat Fisheries Project.

Levy, S. 1997. Pacific salmon bring it all back home. BioScience 47:657-660.

Maynard, D.J., T.A. Flagg, and C.V.W. Mahnken. 1995. A review of seminatural culture strategies for enhancing the postrelease survival of anadromous salmonids. American Fisheries Society Symposium 15: 307-316.

McIntyre, J.D., R.R. Reisenbichler, J. Emlen, R.L. Wilmot, and J.E. Finn.1988. Predation of Karluk River sockeye salmon by coho salmon and char. Fishery Bulletin 86:611-616.

McMichael, G.A., A. Fritts, and J.L. Dunnigan. 1998. Lower Yakima River predatory fish census: feasibility study 1997. Bonneville Power Administration annual project report. Portland OR.

Michael, J. H. 1995. Enhancement effects of spawning pink salmon on stream rearing juvenile coho salmon: managing one resource to benefit another. Northwest Science 69:228-233.

Miller, W.H., T.C. Coley, H.L. Burge, and T.T. Kisanuki. 1990. Analysis of salmon and steelhead supplementation: emphasis on unpublished reports & present programs. Project 88-100, U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

Mullan, J.W. 1983. Overview of Artificial and Natural Propagation of Coho Salmon (*Onchorhynchus kisutch*) on the Mid-Columbia River. Fisheries Assistance Office, U.S. Fish and Wildlife Service, Leavenworth, Washington. December 1983.

Mullan, J.W. 1986. Determinants of sockeye salmon abundance in the Columbia River, 1880s-1982: a review and synthesis. Biological Report 86(12), September 1986, U.S. Fish and Wildlife Service, Fisheries Assistance Office, Leavenworth, Washington.

Mullan, J. W., A. Rockhold, and C. R. Chrisman. 1992. Life histories and precocity of chinook salmon in the mid-Columbia River. The Progressive Fish-Culturist 54:25-28.

Neeley, D. 1992. Compiled analyses of 1991-92 entrainment/survival studies at Chandler smolt trap. Unpublished reports to the Post Release Survival Task Team of the Yakima Fisheries Project.

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.

Nickelson, T.E., M.F. Solazzi, and S.L. Johnson. 1986. Use of hatchery coho salmon (Oncorhynchus kisutch) presmolts to rebuild wild populations in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 43:2443-2449.

NPPC (Northwest Power Planning Council). 1994. Columbia River Basin Fish and Wildlife Program. Adopted Nov. 15, 1982, amended Dec. 14, 1994. Northwest Power Planning Council, Portland, OR.

Pearsons, T. N., G. A. McMichael, E. L. Bartrand, M. Fischer, J. T. Monahan, and S. A. Leider. 1993. Yakima Species Interactions Study. Annual Report, DOE/BP-01483-3. Bonneville Power Administration, Portland, OR.

Pearsons, T. N., G. A. McMichael, S. W. Martin, E. L. Bartrand, J. A. Long, and S. A. Leider. 1996. Yakima River Species Interactions Studies. Annual Report, DOE/BP-99852-3. Bonneville Power Administration, Portland, OR.

Peery, C. A., and T. C. Bjornn. 1996. Small-scale investigations into chinook salmon supplementation strategies and techniques: 1992-1994. Idaho Cooperative Fish and Wildlife Unit, Technical Report 96-3.

Peterman, R.M. 1987. Review of the components of recruitment of Pacific salmon. Pages 417-429 in M.J. Dadswell, R.J. Klauda, C.M. Moffitt, R.L. Saunders, R.A. Rulifson and J.E. Cooper, eds. Common strategies of anadromous and catadromous fishes.

RASP (Regional Assessment of Supplementation Planning). 1992. Supplementation in the Columbia River Basin, Parts 1-5. Report, Bonneville Power Administration.

Reeves, G.H., F.H. Everest, and J.D. Hall. 1987. Interactions between the redside shiner (*Richardsonius balteatus*) and the steelhead trout (Salmo gairdneri) in western Oregon: the influence of water temperature. Canadian Journal of Fisheries and Aquatic Sciences 44(9): 1603-1613.

Reisenbichler, R.R.. 1997. Genetic factors contributing to declines of anadromous salmonids in the Pacific Northwest. Pages 223-244 in D.J. Stouder, P.A. Bisson, and R.J. Naiman, eds. Pacific Salmon & their Ecosystems: Status and Future Options. Chapman.

Sandford, B.P., and T.E. Ruehle. 1996. Juvenile salmonid PIT-tag studies at Prosser dam and Chandler canal fish collection facility, Yakima River, 1991 and 1992. Final Report. DOE/BP-07099-2. Bonneville Power Administration, Portland, OR.

Schroder, S.L. and C.M. Knudsen. 1996. Review of fish marking and tagging procedures suitable for the NATURES program. Pages 128-166 in D.J. Maynard, T.A. Flagg and C.V.W. Mahnken, eds. Development of a Natural Rearing System to Improve Supplemental Fish

Shively, R.S., P.P. Poe, and S.T. Saunter. 1996. Feeding response by northern squawfish to a hatchery release of juvenile salmonids in the Clearwater River, Idaho. Transactions of the American Fisheries Society 125: 230-236.

Shoals, W.H., and R.J. Hillock. 1979. An evaluation of rearing fall-run chinook salmon, Oncorhynchus tshawytscha, to yearlings at Feather River Hatchery, with a comparison of returns from hatchery and downstream releases. California Fish and Game 64: 239.

Smoker, W.A. 1956. Evaluation to the potential salmon and steelhead production of the Yakima River to the commercial and recreational fisheries. Washington Department of Fisheries. Report Number 01, 136.

Steward, C.R. and T.C. Bjornn. 1990. Supplementation of salmon and steelhead stocks with hatchery supplementation: A synthesis of published literature. U.S. Department of Energy, Bonneville Power Administration, Project 88-100. Portland, OR.

Swain, D.P., and B.E. Riddell. 1990. Variation in agonistic behavior between newly emerged juveniles from hatchery and wild populations of coho salmon, Oncorhynchus kisutch. Canadian Journal of Fisheries and Aquatic Sciences 47: 566-571.

Tabor, R. A., R. S. Shively, and T. P. Poe. 1993. Predation on juvenile salmonids by smallmouth bass and northern squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management 13:831-838.

Waples, R.S. 1991. Genetic interactions of hatchery and wild salmonids: lessons from the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 48(Supplement 1): 124-133.

Waples, R.S., G.A. Winans, F.M. Utter, and C. Mahnken. 1990. Genetic monitoring of Pacific salmon hatcheries. NOAA Technical Report NMFS 92.

Ward, D. L., J. H. Petersen, and J. J. Loch. 1995. Index of predation on juvenile salmonids by northern squawfish in the lower and middle Columbia River and in the lower Snake River. Transactions of the American Fisheries Society 124:321-334.

Watson, B.D. 1993. Proposed natural production objectives for upper Yakima spring chinook under the Yakima/Klickitat Fisheries Project. Internal YFP report.

Williams et al. 1996. Return to the river: restoration of salmonid fishes in the Columbia River ecosystem. Idependent Scientific Review Group, Northwest Power Planning Council, 10 September, 1996.

Wood, C. C. 1987. Predation of juvenile Pacific salmon by the common merganser (*Mergus merganser*) on eastern Vancouver Island. I: Predation during the seaward migration. Canadian Journal of Fisheries and Aquatic Sciences 44:941-949.

Appendix X Part B.

Design for Domestication Monitoring of the Yakima Spring Chinook Supplementation Program

Yakima/Klickitat Fisheries Project Monitoring Implementation Planning Team

Revised February 7, 2004

Introduction

We propose to evaluate to evaluate the domesticating effects of supplementation, and compare the intensity of domestication incurred under supplementation as practiced in the YKFP spring chinook program at the Cle Elum Supplementation Research Facility (CESRF) to that incurred under a more conventional regime of continuous hatchery culture. The primary design consists of comparing three lines- a wild control line, a supplemented line, and a hatchery control line- for 13 adult and 17 juvenile traits. Traits vary in frequency of evaluation from annually to once per generation. Details on the traits are presented in the Trait, Protocol and Analysis Overview section. The YKFP spring chinook supplementation program began with broodstock collection in 1997. The first adult (4-year olds) return was in 2001. The formal domestication research effort began in the fall of 2002, although data for evaluation of many of the traits began in 1997.

Experimental Lines and General Hypotheses

A. *Supplementation line (S):* the Upper Yakima spring chinook population, supplemented annually by production from 16 raceways at CESRF and associated acclimation sites at Jack Creek, Easton, and Clark Flat. Broodstock collection is at the Roza Adult Monitoring Facility (RAMF) at Roza Dam (Fig. 1). In contrast to most hatchery programs, broodstock are collected randomly throughout run, and consist of 100% natural origin fish. Other aspects of the program are as already described in numerous project documents.

B. *Wild control line (WC):* Naches River spring chinook. The Naches River spring chinook occur in the Naches arm of the Yakima basin (Fig. 1). Because they will not be supplemented during the study, they are available as wild control lines. We have determined that Naches fish can be used for 10 of 13 adult traits and 9 of 15 juvenile traits in our design, provided we can adequately sample fish on the spawning grounds, and collect gametes from a minimum of 10 pairs per year for research. Spawning ground surveys are already routinely done. We anticipate that in the future we may also be able to sample fish can be sampled and collected at a trap at the Cowiche Dam on the lower Naches River (Fig. 1). This trap is designed to collect coho salmon, so some modifications to the trap or the dam itself may have to be made to facilitate the efficient capture of chinook.

To minimize impacts to the control population, collection of gametes from the Naches population will be minimal, semen and partial egg lots from 10-30 pairs per year, depending on run size. Gametes will be used for evaluation of some adult traits, but mainly for production of juveniles for research. Ideally this research will be done at CESRF, but because of disease considerations it may have to be done offsite.

C. *Hatchery control line (HC):* a subline of the Upper Yakima population, to be founded from returning hatchery fish, collected from throughout the run, in 2002. Two of the 18 CESRF raceways (randomly chosen each year) will be dedicated to rearing of this line. These fish will be the offspring of a minimum of 36 pairs of fish, which should provide the HC line an effective size of at least 100 per generation. A larger line of HC fish was deemed to be politically untenable because of the large number of fish that would potentially have to be removed at Roza Dam. Although larger effective size would be preferable, but this is far larger than the minimum of 50 for quantitative genetic studies deemed to be adequate by Roff (1997). Because the number of fish used to found the HC line is relatively small, the decision was made to have a single line to avoid the possibility of smaller replicate lines going extinct. HC fish will be reared and released exactly as will their supplementation line (S) counterparts. No HC fish will be allowed to spawn in the wild; any returnees in excess of broodstock needs will be removed at the Roza adult monitoring facility (RAMF, Fig. 1).

By comparing the supplemented line to both controls, we will address two key questions: 1) how much domestication is incurred by a population undergoing YKFP-style supplementation?; 2) how much less domestication is incurred under YKFP-style supplementation than would be incurred under continuous hatchery culture?. As already mentioned, because the wild control line is not an internal control we know at the outset that there will be differences in mean performance at several traits. As supplementation proceeds, if there is no discernible effect of domestication, the differences in mean trait values between the two lines should not change except for random fluctuations. If domestication does occur, however, the S line means will change, and should continue to change over generations as domestication proceeds and change directionally. The net effect will be a trend of increasing or decreasing differences between the supplemented and wild control line over generations. Comparisons between the hatchery control and supplemented lines will be somewhat different. Performance in the two lines should be equivalent initially because the hatchery control is an internal control. If domestication does not occur, performance of the two lines should remain the same except for random fluctuations and a small amount of drift due to the relatively low effective size of the hatchery control line. If domestication does occur, both lines will be affected, and the hatchery control line should be more affected. Thus performance at any trait should change in the same direction in both lines, but change should be greater in the hatchery control line. The rate at which the two lines diverge will be a reflection of the extent to which domestication can be retarded by the regular cycling of hatchery fish into the wild environment facilitated by the use of only natural-origin broodstock. Details on expectations for individual traits are found in the next section.

One critical issue regarding this design that is still under discussion is "leakage" from the H line into the S line through precocious males from the H line spawning in the wild with S-line females. If this occurs at an appreciable rate, the effect will be to increase the amount of domestication incurred by the S line. This issue raises two concerns. First, it will bias the H-S and S-W comparisons, making the supplementation treatment appear more domesticating than it is. Second, the S line will undergo more domestication than it should for the lifespan of the H line, a conservation concern. Assuming that adequate monitoring can be done of the reproductive success of H-line precocials, the first issue can be dealt with, but not the second. Work is currently underway to evaluate this risk from a variety of angles, including measures for reducing production of precocious fish.

We also intend to cryopreserve the sperm of approximately 200 presupplementation Upper Yakima males. This will give us the potential to evaluate divergence of the supplementation line from its presupplementation state. This design concept has a number of issues associated with it, but it may be desirable to do this type of work at some level at some time in the future. Storing sperm from the presupplementation population is a worthwhile gene-banking exercise anyway, and the cost is very low.

Trait, Protocol, and Analysis Overview

The following pages provide details in a standard format, one trait at a time, on the 13 adult and 17 juvenile traits we intend to evaluate with this design. Most traits will be evaluated annually in order to maximize power, but some may be done less frequently due to logistical limitations. Protocols may vary from year to year to allow collection of key baseline information some years, and experimental data in others. For many traits it is important to distinguish between S line fish of hatchery-origin and those of natural origin: we call these two "sublines" SH and SN in the write-ups. This distinction is made to allow a cleaner measure of genetic differences. Consider nearly any comparison of HC and S fish. Part of the difference in performance between SN and HC fish will be genetic, but part may also be phenotypic, due to the effect of being reared in a hatchery. If HC fish are compared to SH fish, because they share the phenotypic effect of hatchery rearing, the performance difference will be exclusively genetic. It is important to keep in mind when reading the write-ups, however, that although we call SN and SH lines in describing experimental designs, they differ only in their rearing history. Any given pair of SN and SH fish can have the same grandparents.

Although we will make most comparisons annually, annual comparisons within a supplementation generation (slightly more than 4 years) are merely replicates. Although significant domestication effects may be detected in a single generation, we expect the big results to be trends in performance over generations, so the write-ups stress the importance of trends. Our analyses are focused on measures of central tendency (means and medians). We have not focused on variability, primarily because we have virtually no expectations based on the literature on how variability should change under domestication at individual traits. We do have a working hypothesis that variability should decline during domestication because the considerably more homogeneous environment allows directional selection to be more effective. On the other hand, relaxation of selection caused by the hatchery environment could cause an increase in phenotypic variability. Variability at traits is therefore of interest to us. We doubt we will have enough power at any trait to detect a change in variability statistically, but we may see qualitative changes that will inspire further research.

We list 13 adult traits and 15 juvenile traits to be evaluated. One juvenile trait proposed earlier has been dropped, but to prevent confusion we did not renumber the other traits: thus there is no trait J7. The number of traits can be misleading. Many of the traits are measured on the same fish with no difference in protocol except for the measurement. Thus, the "effective" number of traits in terms of logistics and cost is considerably lower. The best example of this is the set of traits A7-A9, which are all measurements of reproductive traits on the same fish. We list the measurements as separate traits because we consider them all important, and because we want to insure they are all done. Some traits require considerable effort and cost, whereas others will be measured in the course of ordinary fish culture operations. Our guiding philosophy was to take advantage of the opportunities offered by the CESRF and other facilities in the basin to measure as many traits relevant to domestication as feasible while minimizing impacts to the supplementation effort and the wild control population.

This is a living document. Our goal in this document is to provide a short but reasonably comprehensive write-up on each trait so that a reader can quickly grasp what we are doing, how and why we are doing it, and what our experimental power is. Write-ups for the individual traits vary widely in how closely they have achieved this. Although some have been extensively developed, at this point the write-up for no trait is as complete as intended. Some write-ups date back to the last comprehensive evaluation of the plan by MIPT, on 11/07/2002; others have been very recently revised. Dates on which substantive changes are made in protocol, power, or analytical approach have been made are noted in the individual write-ups.

Nomenclature for Experimental Groups

The key to making sense of the write-ups is understanding which groups of fish are being compared. In previous versions of the domestication monitoring plan the nomenclature system for the fish to be used in the various comparisons has caused considerable confusion. In this revision we introduce a new system that should clear the confusion. Here is the new system of codes:

SN - naturally produced fish from the supplemented line. This designation is used for both juveniles and adults. Any natural-origin fish in the Upper Yakima qualifies as an SN fish.

SH – hatchery-origin fish from the supplemented line. This designation is used for both juveniles and adults produced by the CESRF as part of its normal supplementation effort (i.e., not part of HC or any experimental production group).

SH_P – hatchery-origin progeny of SH adults. This designation is used only for juveniles. With the exception of the spawnings needed to start the HC line, no SH adults are ordinarily spawned at the CESRF. For some comparisons, however, it will be necessary to spawn small numbers of SH adults at CESRF. The juveniles produced from these spawnings will not be reared past early stages and will not be released.

HC- fish from the hatchery control line. This designation is used for both juveniles and adults. All HC fish are of hatchery origin. The hatchery control line was founded from first-generation hatchery returnees, so in that generation there is no distinction between SH adults and HC adults, but thereafter the disticntion is clear.

WC-natural-origin fish from the wild control line. This designation is used for both juveniles and adults. Any natural-origin fish in the Naches qualifies as an WC fish.

WC_P – hatchery-origin progeny of WC adults. This designation is used for juvenile fish. Small numbers of WC adults will be captured and spawned. Some of the resulting hatchery-origin progeny will be used in comparisons.

Trait	*Revised 11/07/02*

A1. Adult Recruits/Adult-Adult Survival

Justification

Supplementation success is ultimately measured as the increase in natural origin recruits produced by the population. Measuring adult-adult survival is measure of population fitness, the overall trait of key interest in domestication.

Location(s)

Roza and Prosser Dams, Upper Yakima, Naches, American spawning ground

Start Date

2002

Frequency

Annually

Groups Compared***:***

WC,HC,SN, SH
(Naches wild, hatchery control, natural-origin Upper Yakima, hatchery-origin fish from CESRF)

Protocol

At Prosser all adults from all populations in the basin are counted and classified as hatchery or natural, resulting in counts for hatchery origin (HC+SH) and natural origin (SN + America + Naches(WC)). At Roza SH, SN, and HC are counted and sampled for sex and age. An estimate of Naches + American abundance will be made by comparing Prosser and Roza counts after adjustment for harvest and incidental in-river mortality. Redd counts will be obtained from spawning ground surveys on the Naches and the American. Final Naches adult counts will be calculated as the product of the Naches+ American escapement and the Naches proportion of the Naches+American redd counts. Additional adjustments may be made to correct for fish/redd and sex ratio on the spawning grounds. Adult-adult survival by brood year can be estimated for WC, HC, SH, and S natural spawners (mix of SN and SH spawning in wild).

Expectations/Hypotheses

If domestication does not occur, differences in survival among all four groups will remain constant over time. Conversely, if domestication does occur we would expect HC and SH survivals to increase over time. Furthermore, HC survival should increase at a greater rate than SH. In addition, the survival of S fish spawning in the wild will decrease.

Analytical/Statistical Methods and Issues

Within brood years no statistical analysis will be done, as no variance estimates will be available. Over brood years analysis of covariance will be used to evaluate differences in trends. Trend analysis will take into account year-to-year environmental fluctuations and temporal autocorrelations.
Power Analysis Completed?
No.

Trait	*Revised 11/07/02*
A2. Age composition by sex	
Justification	
Location(s)	
RAMF, CESRF, Naches spawning grounds	
Start Date	
2002	
Frequency	
Annually	
Groups Compared***:***	
WC,HC,SN, SH (Naches wild, hatchery control, natural-origin Upper Yakima, hatchery-origin fish from CESRF)	
Protocol	
Requires sex and age determination of adequate samples of fish. For all fish used in the hatchery (SN and HC for production, few SH for research) and for those sampled on the spawning grounds as carcasses (WC), sex can be determined visually. Sex determination based on visual inspection of green fish is not reliable (e.g.,30% of the fish classified at Roza as males are females) so sex determination based on DNA will be used on most SH, and HC fish. Age will be determined on all fish by scale analysis. Minimum target sample size is 140 for WC and 200 for SH (this analysis will not be needed on SN or HC fish because they will all be sexed at spawning or removal). This will provide estimates of age composition with multinomial confidence intervals of $\pm$10% or less at α=0.05 (Thompson 1987).	
Expectations/Hypotheses	
Hatchery fish tend to return at younger ages than naturally produced fish, so younger age structures would be expected for HC and SH relative to naturally produced fish, and these differences may be only phenotypic. If domestication does not occur, differences in age structure among all four groups will remain constant over time. If domestication does occur we would expect age structure to decrease (Reisenbichler and Rubin 1999). Because HC should be most domesticated, its age structure should decrease more, but age structure of S should decrease as well.	
Analytical/Statistical Methods and Issues	
Within years multinomial contingency tests will be used to compare age structures. Comparison of HC and SH will be especially informative for determining genetic effects.	

Over years analysis of covariance will be used to evaluate differences in trends. Analysis will be complicated by the fact that age structure is in part a reflection of the genetic composition of the population, but can be strongly influenced by environmental fluctuations in brood-year survival.
Power Analysis Completed?
No.

Literature Cited

Bams, R.A. 1970. Evaluation of a revised hatchery method tested on pink and chum salmon fry. J. Fish. Res. Bd. Canada 27:1429-1452.

Berejikian, B.A., E.P. Tezak, L..Park, E. LaHood, S.L. Schroder, and E.Beall. 2000. Male competition and breeding success in captively reared and wild coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquat. Sci. 58:804-810.

Berejikian, B.A., E.P. Tezak, S.L. Schroder, C.M. Knudsen, and J.J. Hard.1997. Reproductive behavioral interactions between wild and captively reared coho salmon (*Oncorhynchus kisutch*). ICES Journal of Marine Science 54:1040-1050.

Busack, C., and A. Marshall. 1991. Genetic analysis of YFP chinook salmon stocks. Pages 2-45 in C. Busack, C. Knudsen, A. Marshall, S. Phelps, and D. Seiler. Yakima Hatchery Experimental Design. Progress Report, DOE/BP-00102. Bonneville Power Administration, Portland, OR.

Fleming, I.A. and M.R. Gross. 1989. Evolution of adult female life history and morphology in a Pacific salmon (coho: *Oncorhynchus kisutch*). Evolution 43:141-157.

Fleming, I.A. and M.R. Gross. 1992. Reproductive behavior of hatchery and wild coho salmon (*Oncorhynchus kisutch*): does it differ? Aquaculture 103:101-121.

Fleming, I.A. and M.R. Gross. 1993. Breeding success of hatchery and wild coho salmon (*Oncorhynchus kisutch*) in competition. Ecological Applications 3:230-245.

Fresh, K.L., S.L. Schroder, E.C. Volk, J.J. Grimm, and M. Mizell. In Press. Evaluation of the Cedar River sockeye salmon hatchery: Analyses of adult otolith recoveries. Wash. Dept. Of Fish and Wildlife Report to the State Legislature.

Gallinat, M., J. Bumgarner, L. Ross, and M. Varney. 2001. Tucannon River spring chinook salmon hatchery evaluation Program, 2000 Annual Report No. FPA01-05. 44 pp.

Hard, J.J., B.A. Berejikian, E.P. Tezak, S.L. Schroder, C.M. Knudsen, and L.T. Parker. 2000. Evidence for morphometric differentiation of wild and captively reared adult coho salmon: a geometric analysis. Environmental Biology of Fishes 58:61-73.

Hockersmith, E., J. Vella, L. Stuehrenberg, R. Iwamoto and G. Swan 1994. Yakima River radio-telemetry study: spring chinook salmon, 1991-1992. Project Number 89-089. 98 pp.

Jonsson, N., B. Jonsson, and I. Fleming. 1996. Does early growth cause a phenotypically plastic response in egg production of Atlantic salmon? Functional Ecology 10:89-96.

Kincaid, H.L. 1976. Inbreeding in rainbow trout (*Salmo gairdneri*). J. Fish. Res. Bd. Canada 33: 2420-2426.

Knudsen, C. 1991. Scale pattern and age/length analysis of 1989 and 1990 Yakima River spring chinook. Pages 101-121 *In* Busack, C., C. Knudsen, D. Seiler, B. Hopley, A. Marshall, and S. Phelps. 1992. Yakima hatchery experimental design. DOE/BP-00102. Progress report to Bonneville Power Administration.

Knudsen, C., S. Schroder, J. Rau, M. Johnston, C. Stromm, and M. Hammlin. 2002. Monitoring phenotypic and demographic traits of Yakima River hatchery and wild spring chinook: Spawner traits. YKFP 2001 Annual Report.

Lura, H., B.T. Barlaup, and H. Sægrov. 1993. Spawning behaviour of a farmed escaped female Atlantic salmon (*Salmo salar*). J. Fish Biology 42:311-313.

Marshall, A., C. Smith, R. Brix, W. Dammer, J. Hymer, and L. LaVoy. 1995. Genetic diversity units and major ancestral lineages for chinook salmon in Washington. In Busack, C. , and J. Shaklee, eds, Genetic diversity units and major ancestral lineages for salmonid fishes in Washington. WDFW Tech. Report RAD 95-02, Olympia, WA.

Petersson, E., T. Jarvi, N.G. Steffner, and B. Ragnarsson. 1996. The effect of domestication on some life history traits of sea trout and Atlantic salmon. Journal of Fish Biology 48:776-791.

Petersson, E. and T. Jarvi. 1993. Differences in reproductive traits between sea-ranched and wild sea-trout (*Salmo trutta*) originating from a common stock. Nordic J. Freshw. Res. 68:91-97.

Petersson, E. and T. Jarvi. 1997. Reproductive behaviour of sea trout (*Salmon trutta*)—The consequences of sea-ranching. Behaviour 134:1-22.

Reisenbichler, R.R., and J.D. McIntyre. 1977. Genetic differences in growth and survival of hatchery and wild steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 34: 123-128.

Reisenbichler, R.R., and S.P. Rubin. 1999. Genetic changes from artificial propagation of Pacific salmon affect the productivity and viability of supplemented populations. ICES Journal of Marine Science. 56:459-466.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin 191. Fisheries Research Board of Canada.

Roff, D.A. 1997. Evolutionary quantitative genetics. Chapman and Hall, New York. 493p.

Schroder, S.L. 1981. The role of sexual selection in determining overall mating patterns and mate choice in chum salmon. Doctoral dissertation, university of Washington, Seattle, Washington.

Schroder, S., C. Knudsen, B. Watson, T. Pearsons, and J. Rau. 2002. Comparing the reproductive success of Yakima River hatchery and wild spring chinook. YKFP 2001 Annual Report.

Thompson, S.K. 1987. Sample size for estimating multinomial proportions. The American Statistician
41(1):32-46.

Volk, E.C., S.L. Schroder, and J.J. Grimm. 1999. Otolith thermal marking. Fisheries Research 43: 205-219.

Webb, J.H., D.W. Hay, P.D. Cunningham, and A.F. Youngson. 1991. The spawning behaviour of escaped farmed and wild adult Atlantic salmon (*Salmo salar* L.) in a northern Scottish river. Aquaculture 98:97-110.

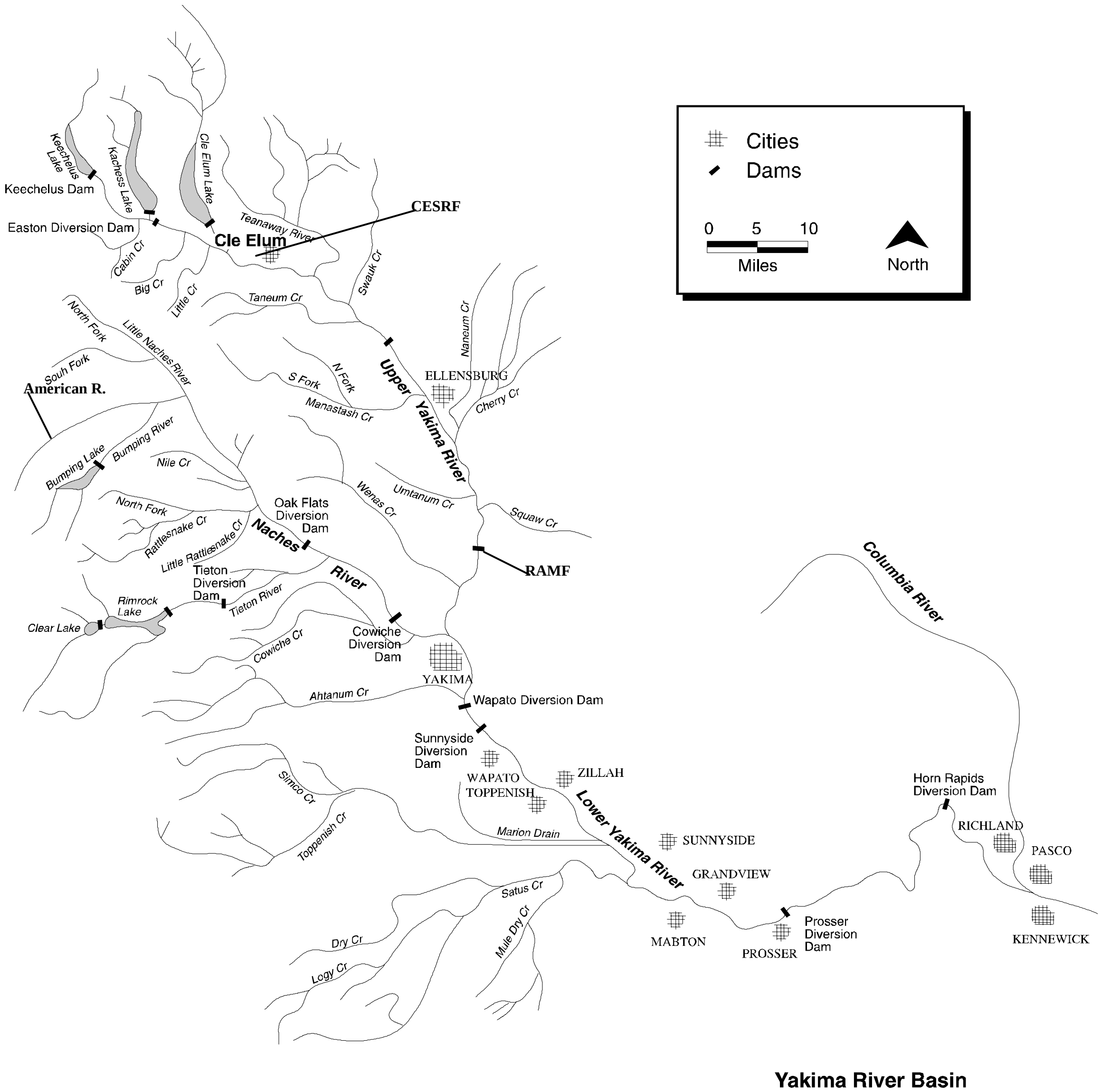

Figure 1. Map of Yakima basin.

Appendix X - Part C.

Steelhead Kelt Reconditioning

ABSTRACT

Repeat spawning is a life history strategy that is expressed by some species from the family Salmonidae. Rates of repeat spawning for post-development Columbia River steelhead *Oncorhynchus mykiss* populations range from 1.6 to 17%. It is expected that currently observed iteroparity rates for wild steelhead in the Basin are severely depressed due to development and operation of the hydropower system and various additional anthropogenic factors. Increasing the natural expression of historical repeat spawning rates using fish culturing means could be a viable technique to assist the recovery of depressed steelhead populations. Reconditioning is the process of culturing post-spawned fish (kelts) in a captive environment until they are able to reinitiate feeding, growth, and again develop mature gonads. Kelt reconditioning techniques were initially developed for Atlantic salmon *Salmo salar* and sea-trout *S. trutta*. The recent Endangered Species Act listing of many Columbia Basin steelhead populations has prompted interest in developing reconditioning methods for wild steelhead populations within the Basin. To test kelt steelhead reconditioning as a potential recovery tool, we captured wild emigrating steelhead kelts from the Yakima River and evaluated reconditioning (short and long-term) success and diet formulations at Prosser Hatchery on the Yakima River.

Steelhead kelts from the Yakima River were collected at the Chandler Juvenile Evaluation Facility (CJEF, located at Yakima River kilometer 48) from March 12 to May 28, 2003. In total, 690 kelts were collected for reconditioning at Prosser Hatchery. Captive specimens represented 25.7% (690 of 2,676) of the entire 2002-2003 Yakima River wild steelhead population, based on fish ladder counts at Prosser Dam. All steelhead kelts were reconditioned in circular tanks and were fed freeze-dried krill and received multi vitamin dietary supplement; long-term steelhead kelts also received Moore-Clark pellets. Oxytetracycline was administered to reconditioned fish to boost immune system response following the stress of initial capture. Formalin was also administered to prevent outbreaks of fungus and we also intubated the fish that were collected with Ivermectin™ to control internal parasites (e.g., *Salmincola spp.*). Captured kelts were separated into two experimental groups: long-term and short-term reconditioning. Long-term steelhead kelts were held for 5-9 months then released on December 8, 2003. Long-term success indicators include the proportion of fish that survived the reconditioning process and the proportion of surviving fish that successfully remature. Survival and rematuration for long-term kelts increased as well with 61.4% surviving to release and 87.3 % rematuring. Success indicators for the short-term experiment include the proportion of fish that survived the reconditioning process and the proportion of fish that initiated a feeding response. Short-term kelts were reconditioned for 3 to 9 weeks.

Surviving specimens were released for natural spawning on June 4, 2003. Survival-to-release was very good for the short-term experiment, with a rate of 89.9%. A total of 48 reconditioned kelts were radio tagged to assess their spawning migration behavior and success following release from Prosser Hatchery and to evaluate in-season homing fidelity.

History

Populations of wild steelhead *Oncorhynchus mykiss* have declined dramatically from historical levels in the Columbia and Snake rivers. Since 1997[1] steelhead in the upper Columbia River have been listed as endangered under the Endangered Species Act (ESA). Those in the Snake River have been listed as threatened, also since 1997[1]. Those in the mid-Columbia were listed as threatened in 1999. Regional plans recognize the need to protect and enhance weak upriver steelhead populations while maintaining the genetic integrity of those stocks.

Iteroparity rates for *0. mykiss* were estimated to be as high as 79% for 1994-96 in the Utkholok River of Kamchatka. Reported iteroparity rates for Columbia basin steelhead are considerably lower, due largely to high mortality of downstream migrating kelts at hydropower dams and to inherent differences in iteroparity rate based on latitudinal and inland distance effects. The highest recent estimates of repeat spawners from the Columbia River Basin were in the Kalama River (tributary of the unimpounded lower Columbia River) have exceeded 17%. Farther upstream, 4.6% of the summer run in the Hood River (above only one mainstem dam) are repeat spawners. Iteroparity rates for Klickitat River steelhead were reported at 3.3% from 1979 to 1981. Repeat spawners composed only 1.6% of the Yakima River wild run and 1.5% of the Columbia River run upstream from Priest Rapids Dam.

Objectives

In order to experimentally evaluate the feasibility of kelt reconditioning as a potential recovery and restoration strategy for wild steelhead in the Columbia River basin, this project was designed to address the following research objectives:

Objective 1: Continue to refine and improve efficiency and success of long-term steelhead reconditioning at the Prosser Hatchery.

Objective 2: Implement and evaluate short-term kelt reconditioning, transportation and release downstream from Bonneville Dam.

Objective 3: Assess homing fidelity of steelhead kelts following their release from the reconditioning program.

Objective 4: Evaluate reproductive success of reconditioned kelts beginning in 2004.

Long-term Reconditioning Study

We have defined long-term reconditioning as holding and feeding post-spawn steelhead until approximately the end of the calendar year and then releasing them at Prosser Hatchery, thus allowing them to mingle with the upstream run. By this time most surviving fish remature. Based on the past two years' results, long-term feasibility of steelhead reconditioning looks promising. We made substantial progress in 2001 and 2002 regarding long-term kelt reconditioning, at the time of release we achieved a survival rate of 38% and rematuration of 19.6% in 2001 and in 2002 the highest survival (47%) from the starter krill diet then switched to altered Moore-Clarke pellets and unaltered Moore-Clarke pellets, while the highest level of maturity (74%) were fed a krill starter diet then moved to Moore-Clarke pellets. During 2003, we continued with the most efficient and successful of the long-term steelhead reconditioning regimes by repeating the most successful diet and treatment identified during the 2001 and 2002 studies (krill and Moore-Clark pellets).

Short-Term Reconditioning Study

In addition to the long-term reconditioning investigation, short-term reconditioning issues also require study to evaluate steelhead kelt reconditioning. Successful expression of iteroparity in steelhead may be limited by post-spawning starvation and downstream passage through the mainstem corridor. Thus, short-term reconditioning may augment iteroparity rates by initiating the feeding process and allowing kelts to naturally undergo gonadal recrudescence in the estuary and marine environments. Short-term reconditioning is defined as the period of time needed (approx. 3-9 weeks) for kelts to initiate post-spawning feeding, followed by the transportation of kelts around mainstem hydroelectric facilities for release and natural rearing and rematuration in the Pacific Ocean. Last year we had high levels of survival at 78% for the 2-month reconditioning, with a small amount of "feeders" (fish maintaining or increasing weight) 25.1%.

Biotelemetry

The ultimate success of kelt reconditioning should be assessed based on the number of individuals that successfully spawn in the wild following reconditioning and release. Although it is difficult to witness individual fish spawning in the wild, and even more difficult to assess the viability and quality of gametes, we have designed future experiments to determine if reconditioned kelts contribute to subsequent generations.

Because the kelts collected at Prosser Dam are wild fish that could have originated in any of several upstream areas, we cannot know locations of specific spawning grounds for specific individuals. However, use of radio telemetry techniques and Passive Integrated Transponder (PIT) tags can help address such critical uncertainties.

Area and Facilities

Kelt reconditioning research was conducted at the Prosser Fish Hatchery in Prosser, Washington. Prosser Hatchery is located on the Yakima River (river kilometer, (rkm) 48), downstream from Prosser Dam, and adjacent to the Chandler Juvenile Evaluation Facility (CJEF). Summer steelhead populations primarily spawn upstream from Prosser Dam in Satus Creek, Toppenish Creek, Naches River, and other tributaries of the Yakima River.

After naturally spawning in tributaries of the Yakima River, a proportion of the steelhead kelts that encounter Prosser Dam facility during emigration are diverted into the Chandler Juvenile Evaluation Facility. The CJEF was used to capture emigrating kelts. Yakama Nation (YN) staff monitored the Chandler bypass separator 24 hours a day from 12 March to 21 June 2003. All adult steelhead arriving at the CJEF separator, regardless of maturation status (kelt or pre-spawn[2]), were placed into a temporary holding tank.

All specimens visually determined to be prespawn individuals were immediately returned to the Yakima River. Following kelt identification, we collected data on weight, condition, coloration, and presence or absence of physical anomalies. Steelhead kelt in poor condition and dark in color were released back in the river, all others were retained for reconditioning. Passive Integrated Transponder (PIT) tags were then implanted in the fish's pelvic girdle for individual fish identification during reconditioning.

Upon admission of kelts to the reconditioning program at Prosser Hatchery, all kelts were retained in circular tanks with a carrying capacity at a maximum of 200 fish.

Maturation Assessment and Release for Spawning

Upon release all surviving steelhead in the long-term experiment were examined with ultrasound equipment to assess maturation status. Fish in the long-term experiment were released on 12 December 2003. Growth measurement data and rematuration status were recorded on all released individuals

RESULTS/DISCUSSION

General Population Characteristics

A total of 690 kelts were kept for reconditioning while 136 were culled due to poor condition or found to be dead on arrival, at Prosser Hatchery from 12 March to 21 June 2003. Total kelts used for reconditioning represented 25.7% (690 of 2,676) of the entire Yakima River ESA-listed population, based on fish ladder counts obtained from Prosser Dam for the period July 1, 2002 to June 30, 2003. It is possible that many of the emigrating kelts from the Yakima River were never diverted into the irrigation channel preventing their collection for reconditioning, and may have passed instead over the dam's spillway.

The overwhelming majority of kelts captured as part of this reconditioning research project were female. A consistent finding in our previous steelhead kelt reconditioning work is that the large majority of all kelts available for reconditioning are female (approx. 88% during 2000 and 2001 at Prosser Dam) which may be indicative of the evolutionary advantage of female iteroparity. The fact that females are naturally able to reproduce with males during different years increases the probability of increased gene flow between and among cohorts or year classes. This has a direct theoretical benefit in the form of increasing the number of breeders (N_b), and the effective population size (N_e) during each spawning season, thus contributing to increased population viability and persistence, crucial to threatened and endangered fish restoration. Rather than a genetic hazard, experimental reconditioning should be viewed as a potential demographic and population genetic enhancement measure, aimed at restoring a recently jeopardized, but naturally occurring evolutionarily stable life history strategy.

Long-Term Reconditioning

Objective 1: Continue to refine and improve efficiency and success of long-term steelhead reconditioning at the Prosser Hatchery.

Kelt Survival and Rematuration

Long-term kelts were held for 5-9-months in three different tanks. All of the tanks were started on a krill diet for 2.5 months and then switched to a maintenance diet of Moore-Clarke pellets for the duration of their stay. Survival percentages for all tanks were similar to each other. Maturation levels were very high for tank C3 with a 95.9% rematuring while C2 and C4 did well with ~80% rematuring.

Table 3: Population statistics for kelts in the long-term reconditioning experiment.

Tank	C2	C3	C4
No. Collected	205	69	208
No. (%) Released	123 (60.0%)	49 (71.0%)	126(60.6%)

No. (%) Mature	99 (80.5%)	47 (95.9%)	108 (85.7%)
In-Weight (kg.)	2.17	2.39	2.52
Out-Weight (kg.)	2.82	3.70	3.14
Mature Feeders (%) (Mature feeders/total mature fish)	88/99 (88.8%)	44/47 (93.6%)	95/109 (87.1%)
Immature Feeders (%) Immature (feeders/immature fish)	3/11 (27.3%)	1/2 (50%)	1/11 (9.1%)

Table 3: Fish population statistics by Tank No. for the long-term reconditioning experiments.

Feeding and Treatment Summary

For all of the long-term experiments, steelhead kelts were fed krill as a starter diet for 2.5 months and then were given Moore-Clarke pellets based on the strengths of the diet from 2001 and 2002 diet experiments. The majority of kelts showed appreciable weight gains (>80%), while 166 of 278 gained > 0.5 kg in mass. The largest individual weight increase was 152%. The amount of immature long-term reconditioned kelts at the time of release declined to nearly 8% in 2003. Long-term reconditioning in 2003 improved in every area, with decreases in mortality and immature kelt rates, while increasing maturity rates, individuals undergoing weight gain, and survival rate.

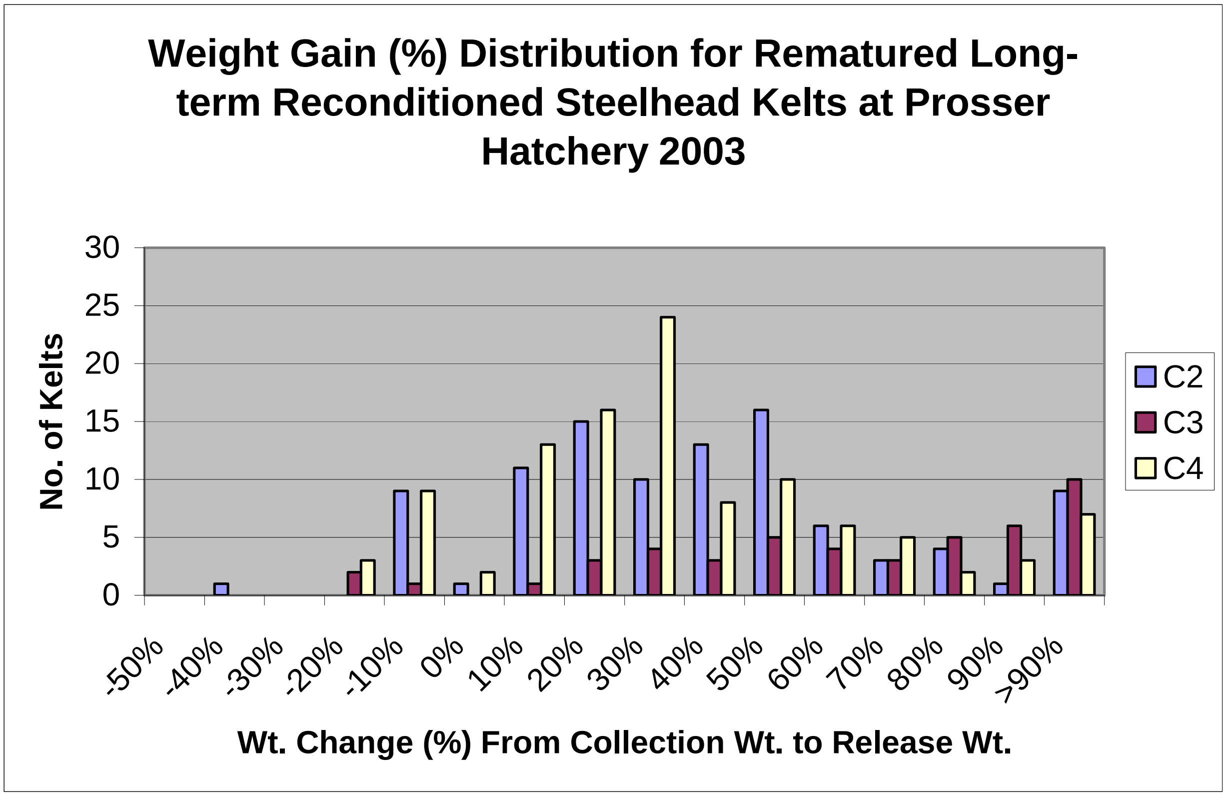

Figure 5: Weight gain (%) distribution for long-term rematured kelts at Prosser Hatchery, WA in 2003.

Short-Term Reconditioning

Objective 2: Implement and evaluate short-term kelt reconditioning, transportation and release downstream from Bonneville Dam.

Kelt Survival and Rematuration

For the short-term reconditioning experiment, kelts were captured from 16 April – 10 May 2003 and released on 4 June 2003. It was expected that kelts would not remature in such a short time span but that the fish would reinitiate feeding behavior and thus increase survival and maturation in the wild.

Mortality Statistics

The majority of mortalities for the short-term reconditioning experiment occurred within the first 10 days of capture. As with past experiments this can be attributed to handling stress, failure to accept starter feed, an inability to convert feed into an appreciable weight gain, or moribund status when collected. After the 10-day capture period mortalities drastically decrease.

Biotelemetry

Objective 3: Assess homing fidelity of iteroparous steelhead kelts following their release from the reconditioning programs

Radio Telemetry

2002 Experimental Data

During the 2002 season a total of 171 (33.3 %) long-term reconditioned kelts survived reconditioning to be released, with 76 kelts rematuring. A total of 60 kelts were radio-tagged with 33 tags and were released directly into Yakima River and 29 were released into the McNary pool to collect data on homing. We detected 6/33 (18%) of the radio-tagged long-term Yakima River release in natal tributaries. Based on radio-tagged returns, an estimated 26-52 (18-36%) individuals would have made it back to natal streams to spawn again for another season. As for the 29-steelhead kelts that were radio-tagged to monitor homing only 1 (.03%) kelt was observed returning to it's natal stream. Based on the return data it is estimated that 1-6 (.03-21%) individuals from this group returned to spawn.

2003 Experimental Data

During the 2003 season a total of 298 (61.8 %) long-term reconditioned kelts survived reconditioning to be released, with 254 kelts rematuring. A total of 47 kelts of the 298 were radio-tagged with 23 tags from UI and 24 from the Bureau of Reclamation then released. Each tag was inserted using the gastric insertion technique.

PIT Tag Tracking of Short term conditioned kelts

2002 Experimental Data

In 2002-03 we had a total of 41 reconditioned steelhead kelts detected at Bonneville dam, this coincides with typical spawning behavior. A total of 29 (70%) of these fish migrated upriver during September- November of 2002. The rest of the steelhead kelts 11 (26.8%) migrated in July-August of 2003. So far we have detected 6/187 (3.2%) out of the short-term reconditioned individuals at the Denil ladder at Prosser, WA. It should be noted however that the Denil ladder is just one of three ladders in operation at the Prosser facility and that there is a good chance that reconditioned kelts are utilizing these other ladders as well. The Yakama Nation is currently seeking funds to add PIT tag detectors at these other ladders

2003 Experimental Data

A total of 485 PIT tags were submitted to the regional PTAGIS database for short-term kelts released below Bonneville Dam on June 4, 2003.

As of February 2, 2004, a total of 4 (2.1%) of the 187 short-term reconditioned fish in the release had subsequent upstream detections. The remaining fish have no subsequent detections and are probably still in the ocean.

CONCLUSIONS

- Steelhead kelt reconditioning shows promise to assist restoration of imperiled wild steelhead populations in the Columbia basin, based on empirical results of this project.

  During 2000, the Yakama Nation collected 512 wild kelts (38% of the subbasin's run that year) at the Chandler Juvenile Evaluation Facility (CJEF) for reconditioning at Prosser Hatchery, producing a first year kelt survival rate of 10% (51/512). Subsequently, kelt rematuration rates in captivity more than doubled from 10% (2000), 21% (2001), 50% (2002), and 85% (2003).

  - This project is successfully refining techniques, which if further supported by additional, more rigorous future research, appear very applicable to increasing its success, and that of population enhancement efforts at larger geographic scales for wild Columbia Basin steelhead.

  - In general, we feel the results of the study still warrant additional research, but feel that we are much closer to devising a management program for ESA-listed steelhead populations in the Columbia River Basin.

  - Kelt reconditioning should be viewed at this time as experimental, which has been quite successful, rapidly improving, and very promising. The general approach should also be viewed as one of several available research techniques to guide enhancement of steelhead iteroparity expression. Implementation of best methods should be targeted following several years of rigorous, replicated studies of each approach, including ecological and economic cost/benefit analysis.

Interactions with Subbasin Focal Species

The level of interactions of the fish produced through the kelt reconditioning research program with the focal species in the Yakima Subbasin Plan should be minimal. The adults in the long term program are collected in the spring and held in reconditioning tanks until their release in the following December. Released fish are expected to hold in the mainstem Yakima through the duration of the winter, then migrate to their natal streams to spawn. They are not expected to actively prey on juveniles of any of the focal species during this time period. Once on the spawning grounds, they are expected to interact with other steelhead adults by participating in normal spawning activities, including potential competition with other females for spawning sites and successfully spawning with one or more steelhead males. The fact that females are naturally able to reproduce with males during different years increases the probability of increased gene flow between and among cohorts or year classes. This has a direct theoretical benefit in the form of increasing the number of breeders (N_b), and the effective population size (N_e) during each spawning season, thus contributing to increased population viability and persistence, crucial to threatened and endangered fish restoration. Steelhead, being spring spawners, would not be competing with the other focal species for spawning sites, but could potentially impact redds deposited the previous fall by some of these species, by redd superimposition. Most of the juveniles in the previously existing redds should be developed enough that this should cause minimal impact. After spawning, the steelhead would migrate out of the Yakima before most of the other salmon adults begin their spawning migrations. Little is known of the potential interactions between steelhead and lamprey.

Management Implications of Successful Kelt Reconditioning

Unlike other species of Pacific salmon *(Oncorhynchus spp.)* anadromous steelhead naturally exhibit varying degrees of iteroparity (repeat spawning). Wild steelhead populations have declined dramatically from historical levels in the Columbia and Snake Rivers, for many reasons. Successful steelhead iteroparity involves downstream migration of kelts (post-spawned steelhead) to estuary or ocean environments. Thousands of kelts (i.e., post-spawned fish) of ESA-listed steelhead populations in the Snake R. and mid-Columbia River are incidentally collected each spring (March - June) in the juvenile collection systems throughout the Snake and Columbia rivers. Despite the thousands of kelts that attempt out migration, results from a telemetry study Evans et al.(2001) suggested that only a very small percentile (<5%) successfully navigated the Snake and Columbia River hydropower system. However, resulting data occurred during low and no-spill years. In-river survival rates of emigrating kelts may increase considerably during average and above water years since emigration paths through open spillways may be available. For this life history expression (iteroparity) to persist in future steelhead runs, successful methods must be developed to augment the current rate of iteroparity among Snake and Columbia River steelhead populations.

Kelt reconditioning is a promising approach to increase natural production of wild steelhead to enhance their iteroparous life history strategy. Reconditioning promotes re-initiation of feeding for kelts, enabling them to survive and rebuild energy reserves required for gonad development and successful iteroparous spawning.