PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Yakima/Klickitat Fisheries Project Monitoring And Evaluation

BPA project number: 9506325
Contract renewal date (mm/yyyy): 01/2000 ☒ **Multiple actions?**

Business name of agency, institution or organization requesting funding
Yakama Indian Nation

Business acronym (if appropriate) YIN

Proposal contact person or principal investigator:

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NPPC Program Measure Number(s) which this project addresses
7.4K, 7.1A, 7.1B, 7.1C, 7.1D, 7.1F, 7.2D, 7.3B, 7.4A, 7.6A, 7.6A.2, 7.6B.3, 7.6B.6, 7.6D, 7.7, 7.8E

FWS/NMFS Biological Opinion Number(s) which this project addresses
7.4K.1

Other planning document references
1. Yakima Fisheries Project Final Environmental Impact Statement (1/96)
2. Yakima Fisheries Project Spring Chinook Supplementation Monitoring Plan (Busack et al, 1997).
3. Wy Kan Ush Me Wa Kush Wit, Vol 1: pp 5A-2; 5B-13 through 5B-12; Vol 2: pp57 &59.
4. NPPC Yakima and Klickitat Subbasin Plans
5. The ISRG's Return to the River (Williams et al. 1996) -- Restoration of Salmonid Fishes in the Columbia River Ecosystem: Chapter 2.

Short description
Monitors YKFP in terms of natural production, harvest , ecological and genetic impacts, guides adaptive management within the project and provides detailed information on supplementation to the region.

Target species
Yakima and Klickitat Subbasin spring chinook, fall chinook, coho and summer steelhead.

Section 2. Sorting and evaluation

Subbasin
Yakima and Klickitat

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type
Mark one or more caucus	If your project fits either of these processes, mark one or both	Mark one or more categories
☒ Anadromous fish ☐ Resident fish ☐ Wildlife	☐ Multi-year (milestone-based evaluation) ☐ Watershed project evaluation	☐ Watershed councils/model watersheds ☒ Information dissemination ☐ Operation & maintenance ☐ New construction ☒ Research & monitoring ☐ Implementation & management ☐ Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description
20510	Yakima/Klickitat Fisheries Project
8812025	YKFP Project Management (YIN)
9506404	YKFP Project Management (WDFW)
8811525	YKFP Construction
9701725	YKFP Operations and Management

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
9200220	Physiological assessment of wild and hatchery juvenile salmonids	Physiological/developmental monitoring of hatchery and wild spring chinook juveniles (parr/smolt)
5510200	Yakima River side channel survey	Complementary habitat enhancement

	and rehabilitation	in upper Yakima
5510800	Upper Yakima tributary irrigation improvement	Restores passage to tributaries blocked by irrigation diversions.
5510900	Teanaway River instream flow restoration	Complementary adult passage project (NF Teanaway is an acclimation/release site).
9705100	Yakima Subbasin Side Channels	Restores juvenile salmonid rearing habitat
9100	Re-establish safe access into tributaries of Yakima Subbasin	Improve juvenile salmonid passage and rearing.
9101	Restore upper Toppenish Creek watershed	Improve juvenile salmonid passage and rearing.
9102	Ahtanum Creek watershed assessment	Improve juvenile salmonid passage and rearing.
9603501	Satus Cr. Watershed Restoration	Improve juvenile salmonid passage and rearing.
9506404	WDFW Policy/Technical Involvement/Planning YKFP	Co-Managers, YKFP
9105500	Supplementation Fish Quality (Yakima Subbasin)	NMFS contract to develop rearing treatment alternatives to increase hatchery fish survival.
9200900	Yakima screens phase II O & M	Basin juvenile salmonid passage
9105700	Yakima phase II screen fabrication	Basin juvenile salmonid passage
9705600	Lower Klickitat ripairian & in-channel habitat enhancement project.	Critical habitat enhancement and information sharing.

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?
1998	Monitoring prescriptions for 16 non-target taxa of concern have been developed and are being implemented to meet conservation objectives	
1998	A practical approach for assessing ecological risks associated with stocking anadromous salmonids was developed to facilitate decision making and direct monitoring efforts.	
1998	Preliminary results of indirect predation experiments suggest that hatchery fish may decrease survival of commingled smolts during certain portions of the spring and increase survival at other	

	times.	
1998	Fish predation indices were developed for smallmouth bass and northern pikeminnow; a channel catfish index is under development. Preliminary estimates indicate that smallmouth bass consumed 524,000 chinook salmon juveniles in the spring of 1998.	
1998	Produced manuscript titled "A Production Function Based Model of Supplementation Dynamics" submitted to Trans. Am. Fish Soc.	
1998	Produced multi-year power analysis of OCT/SNT survival comparison	
1998	Modelled genetic effects of broodstock collection and usage rules	
1998	Recorded detailed behavioral observations on wild spawning spring chinook (first ethological description of these behaviors on Columbia River spring chinook)	
1998	Characterised detailed reproductive traits of Yakima wild spring chinook	
1998	Developed DNA microsatellite profiles of Yakima spring chinook populations	
1998	Developed 4 supplementation dynamics computer models	
1997	Produced Yakima Fisheries Project Spring Chinook Supplementation Monitoring Plan (DOE/BP-64878-1)	
1996	Developed "Pedigree" computer model for investigation of monitoring power using DNA markers.	
1994	Produced report "Experimental designs for testing differences in survival among salmonid populations" (DOE/BP-00029-3)	
1998	Refined species-specific outmigration estimators for Chandler smolt trap.	
1997	Began broodstock collection of upper Yakima spring chinook at Roza Dam in 1997 and continued in 1998 using outlined genetic selection guidelines (Busack et al. 1997).	
1998	The adult broodstock collection and monitoring facility at Roza Dam was	

	shown to have no adverse effects on passage timing or spawning distribution of wild Yakima spring chinook.	
1998	Strobe lights and infrasound were shown to be ineffective fish guidance methods at the juvenile trap at Roza Dam.	
1997	Studies indicated that smolts marked with VI-jet tags were not reliably identifiable as adults; therefore, CWTs implanted at multiple body locations were used in 1998 to mark YKFP hatchery spring chinook parr for smolt-to-adult monitoring.	
1997	A preliminary ecosystem diagnosis and treatment modeling analysis of Yakima fall chinook indicated that the major factor limiting natural production was a combination of excessive temperature in the lower river and late emergence timing.	
1997	Began development of locally-adapted coho and fall chinook broodstocks by collecting returning adults in the Yakima subbasin.	
1998	Preliminary results indicate low competitive impacts of outplanted hatchery coho parr on trout.	
1997	Survival studies showed benefits from the following rearing treatments: raceway color pattern, overhead cover and mid-water structure. 1997 SNT treatment includes these elements plus mid-water feed delivery.	
1998	Plans were developed to retrofit Lyle Falls fishway in the Klickitat subbasin to function as an effective broodstock collection and adult monitoring facility.	
1998	Refined and augmented in-basin Yakima harvest monitoring methods.	

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Natural Production: Develop methods of detecting indices of	a	Modeling: To design complementary

	increasing natural production, as well as methods of detecting a realized increase in natural production, with specified statistical power.		supplementation/habitat enhancement programs for coho, spring & fall chinook & steelhead in the Yakima and Klickitat Subbasins.
		b	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
		c	Coho life history study: Describe major features of the freshwater life history and survival rates of juvenile coho to guide location of future acclimation/release sites in coho re-introduction program.
		d	Klickitat juvenile salmonid population surveys: Determine the spatial distribution and relative abundance of salmonids throughout the Klickitat basin to guide design of initial enhancement program.
		e	Juvenile spring chinook micro-habitat utilization: Estimate baseline microhabitat utilization of juvenile spring chinook salmon. Future deviations in use will suggest carrying capacity problems.
		f	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.
		g	Roza juvenile wild/hatchery smolt PIT tagging: To capture, PIT-tag and release wild and hatchery spring chinook to estimate relative wild/hatchery smolt survival to Chandler and the McNary Dam.
		h	Wild/hatchery survival and enumeration (Chandler Juvenile Monitoring Facility):To refine operational and analytical procedures used in estimating

			hatchery and wild smolt passage at Chandler smolt trap.
		i	Fall chinook optimal rearing treatment: Develop an accelerated rearing treatment for fall chinook to enable early outmigration and increase overall smolt survival.
		j	Yakima coho stock and release study: Determine optimal location, date, and stock of release for Yakima coho re-introduction efforts.
		k	Yakima spring chinook juvenile behavior: Determine differences in hatchery & wild spring chinook smolt behavior closely related to survival
		l	Yakima hatchery spring chinook juvenile morphometric and coloration studies: Determine whether significant difference in body shape and coloration exist between OCT and SNT hatchery spring chinook before and during the time of release.
		m	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, at Chandler and at McNary Dam.
		n	Study of feasibility of using screw traps for long-term monitoring of juvenile production in the Klickitat Subbasin: Determine the feasibility of using screw traps to monitor long term juvenile salmonid production in the upper and lower Klickitat River.
		o	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.
		p	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).
		q	Spawning ground surveys (redd counts): Monitor spatiotemporal redd distribution in theYakima (spring chinook, Marion Drain fall chinook, coho, Satus/Toppenish steelhead), and Klickitat (spring/fall chinook, coho, steelhead) Basin & collect carcass data.
		r	Natural Spawning Observations: Characterize wild spring chinook reproductive behavior (adults & precocials) to serve as a baseline for future analysis of behavior of hatchery fish.
		s	Yakima spring chinook residuals/precocials studies: Estimate baseline abundance of residual and precocial spring chinook salmon and determine the necessary sampling effort for long term monitoring following supplementation.
		t	Relative hatchery/wild reproductive success: Determine whether spawning behavioral & reproductive success of wild spring chinook is affected by an artificial spawning channel, & estimate reproductive success of hatchery coho in a natural stream.
		u	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.
		v	Scale analysis: Determine age and stock composition of juvenile and adult salmonid stocks in the Yakima and Klickitat basins.
		w	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
		x	Habitat inventory aerial videos and ground truthing: Measure critical environmental variables by analyzing data extracted from aerial videos and verified by ground examinations.
		y	Out-of-basin environmental monitoring: Obtain and utilize information regarding mainstem and marine environmental and harvest-related impacts on all Yakima and Klickitat anadromous salmonids.
		z	Trophic enhancement research: Utilize fish carcasses to “fertilize” streams which are currently deficient in nutrients.
		A	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 and Klickitat Subbasins.
		B	Klickitat fish passage obstruction inventory assessment: Locate and describe existing salmonid fish migration barriers in the Klickitat Basin.
		C	Klickitat water quality inventory: Record water quality measurements at each habitat survey reach on a seasonal basis.
		D	Klickitat habitat inventory & analysis: Collect data on existing

			and historical fish populations, habitat and passage conditions throughout the basin for eventual use in the modeling runs that will generate initial enhancement plans.
		E	Yakima hatchery spring chinook predator avoidance training: Determine efficacy of exposing Yakima hatchery spring chinook to avian predation prior to release in terms of increasing survival to Chandler.
2	Harvest: Develop methods to detect increases in harvest of YKFP targeted stocks.	a	Out-of-basin harvest monitoring: Estimate group- and stock-specific harvest of hatchery and wild anadromous salmonids outside of the Yakima and Klickitat subbasins.
		b	In-basin harvest: Estimate group- and stock-specific harvest of hatchery and wild anadromous salmonids within theYakima and Klickitat subbasins.
3	Genetics: Develop methods of detecting significant Pre- & post-supplementation (PAPS) genetic changes in targeted stocks as reflected by changes in extinction risk, within-stock genetic variability, between-stock genetic variability, and domestication.	a	PVA analysis for all YKFP target stocks: Develop population viability analysis approaches for monitoring extinction risk of all YKFP target stocks by refining existing project models.
		b	Allozyme/DNA data collection and analysis: Augment allozyme and DNA microsatellite baselines of all Yakima chinook stocks for monitoring within- and between population genetic variability.
		c	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.
		d	Yakima spring chinook domestication: develop a domestication selection study for Upper Yakima spring chinook

			involving HxH and WxW matings that is sufficeitnly powerful to detect effects but also does not violate broodstock compositon rules.
4	Ecological Interactions: Determine if impacts to non-target taxa can be kept within specified biological limits, and determine if biotic interactions limit ability of supplementation to increase natural production.	a	Avian predation index: Develop methods to index impact of avian predation on annual smolt production of Yakima salmon and steelhead.
		b	Fish predation index: Develop methods to index impact of piscivorous fish on annual smolt production of Yakima salmon and steelhead.
		c	Coho/chinook predation study: Estimate the percent of emergent spring chinook fry in the upper Yakima consumed by hatchery coho smolts.
		d	Indirect predation: Determine the impact of the abundance of outmigrating hatchery smolts on the survival of commingled smolts (wild and hatchery) via alterations in predator behavior.
		e	Yakima River spring chinook competition/prey index: Determine whether prey abundance limits the production of upper Yakima spring chinook smolts.
		f	Upper Yakima 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 Subbasin.
		g	Pathogen sampling: Determine supplementation impacts on the incidence of pathogens in wild Yakima spring chinook smolts.

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	01/2000	12/2000	Natural Production: Develop and implement methods of detecting indices of increasing natural production, as well as methods of detecting a realized increase in natural production, with specified statistical power.		.833
2	01/2000	12/2000	Harvest: Develop and implement methods to detect increases in harvest of YKFP targeted stocks.		.001
3	01/2000	12/2000	Genetics: Develop methods of detecting significant pre- & post-supplementation (PAPS) genetic changes in targeted stocks as reflected by changes in extinction risk, within-stock genetic variability, between-stock genetic variability, and domestication.		.026
4	1/2000	12/2000	Ecological Interactions: Develop and implement methods to assess ecological impacts of supplementation on non-target taxa, and impacts of strong interactor taxa on project success.		.14
				Total	100.00%

Schedule constraints

The possibility that Yakima summer steelhead may be listed under the ESA could result in the imposition of constraints that would delay or preclude certain monitoring or production activities.

Completion date
Completion date is uncertain. After implementation, it will take three generations for natural origin recruits resulting from supplementation to appear, and it may take decades for an increase to be detectable statistically (Busack et al. 1997).

Section 5. Budget

FY99 project budget (BPA obligated): $3,939,458

FY2000 budget by line item

Item	Note	% of total	FY2000
Personnel		%32	1,473,287
Fringe benefits		%6	284,508
Supplies, materials, non-expendable property		%9	396,158
Operations & maintenance		%0	7,472
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		%0	5,585
NEPA costs		%0	0
Construction-related support		%0	0
PIT tags	# of tags: 105,144	%7	304,918
Travel		%1	27,428
Indirect costs		%11	514,380
Subcontractor	Various, including WDFW	%35	1,626,198
Subcontractor		%0	
Subcontractor		%0	
Subcontractor		%0	
Subcontractor		%0	
Subcontractor		%0	
Other		%0	0
TOTAL BPA FY2000 BUDGET REQUEST			$4,639,934

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
		%0	
		%0	
		%0	

		%0	
		Total project cost (including BPA portion)	$4,639,934

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	$4,918,330	$5,213,429	$5,213,429	$5,213,429

Section 6. References

Watershed?	Reference
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☐	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
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PART II - NARRATIVE

Section 7. Abstract

The Yakima/Klickitat Fisheries Project (YKFP) is a long-term effort to increase natural production and harvest opportunity of salmon and steelhead in the Yakima and Klickitat subbasins using a mix of supplementation and habitat improvements. The ultimate scope of the project potentially 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 early feasibility stages, whileYakima steelhead and all Klickitat programs involve only habitat/life history inventory, passage improvements and stock-status monitoring. The most complete program, and the focus of the most intense monitoring, 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 within each of 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 and whether they relate to fish management ("intrinsic" factors) or harvest and environmental conditions ("extrinsic" factors); and
- 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 will be 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.

Section 8. Project description

a. Technical and/or scientific background

Meaningful restoration of salmon and steelhead runs in the Columbia 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 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 stopgap measures, such as supplementation, are required to maintain fish runs for the foreseeable future. Although we are in the process of planning habitat restoration for future implementation by sister projects, the current focus of the YKFP is primarily on supplementation.

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 and Klickitat subbasins, 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 (McMichael et al., in press; Fast et al. 1991, Anonymous 1990a) and Klickitat (Anonymous 1990b) subbasins. 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 (Sholes and Hallock 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 Sections 4 and 8d). 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 these stocks will entail extrapolation from spring chinook findings where appropriate, facility sharing (e.g., smolt and adult counting facilities) and an emphasis on performance, impacts and risk monitoring over mechanism.

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 (YIN, unpublished documents) represent 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, in prep); reproductive success (Berejikian et al., 1997); spring chinook natural production objectives/strategies (Watson, 1993); Yakima flow/survival studies (Mundy and Watson, in press); 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 Steel-head	Klickitat Spring Chinook	Klickitat Fall Chinook	Klickitat Coho	Klickitat Steel-Head
Natural Production	Smolts per spawner	IM	im	-m	IM	-m	-m	-m	-m
	Smolt/adult survival	IM	Im	-m	IM	-m	-m	-m	-m
	Relative hatch/wild survival	-M	-m	-m	-m	-m	-m	-m	-m
	Optimal Spawning Distribution	IM	im	-m	IM	IM	IM	iM	IM
	Relative Hatch/Wild Spawning Behavior	-M	-m	-m	-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	im	-m	-m	-m
Harvest	In basin	IM	iM	-M	IM	IM	IM	IM	IM
	Out of basin	-m	im	im	im	-m	-m	-m	-m
Genetics	Extinction Risk	im	im	-m	im	im	-m	-m	-m
	Within population variability	IM	IM	iM	IM	IM	iM	-M	-M
	Between population variability	IM	IM	-m	IM	iM	iM	iM	iM
	Domestication	-m	-m	-m	-m	-m	-m	-m	-m
Ecological Interactions (re. hatchery fish)	Interactions with nontarget taxa	IM	Im	IM	Im	im	im	im	im
	Interactions with strong interactors	iM	Im	Im	Im	im	im	im	im

b. Rationale and significance to Regional Programs

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 in 1990. In both cases the NPPC instructed the managers (YIN and WDFW) to carry out planning functions that addressed uncertainties in regard to the adequacy 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 of the project. Therefore, monitoring is a key component of the project. 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.

c. Relationships to other projects

This project, "Yakima/Klickitat Monitoring and Evaluation", and the following four other FWP projects comprise the components of the Yakima/Klickitat Fisheries Project umbrella project: Project 8812025, "YKFP Management, Data and Habitat"; Project 9701725 "YKFP Operations and Maintenance"; Project 8811525, "YKFP Design and Construction"; and Project 9506404, "Policy/Technical Involvement and Planning for YKFP (WDFW)".

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 FWP project 9200200, "Physiological Assessment of Wild and Hatchery Juvenile Salmonids".

FWP habitat improvement projects in the Yakima subbasin relate to this project as they will influence the quality of the environment the fish face. Projects 5510200 and 9705100, "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 Indian Reservation – and therefore primarily benefitting steelhead – include projects Projects 9100, 9101, 9102, and 9603501: "Re-establish Safe Access into Tributaries of the Yakima Subbasin", "Restore Upper Toppenish Creek Watershed", "Ahtanum Creek Watershed Assessemnt", and "Satus Creek Watershed Restoration", respectively. Projects 5510800 ("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.

A critical habitat enhancement project in the Klickitat subbasin is project 9705600, "Lower Klickitat Riparian and In-channel Habitat Enhancement".

d. Project history (for ongoing projects)

YKFP M&E is now a consolidation of nine earlier YKFP monitoring projects. The old project number, title and a brief summary of accomplishments for each of these antecedent projects is as follows:

Project 9506300, "Yakima/Klickitat Monitoring and Evaluation Program", 1995 – 1998. The implementation phase of this project basically began in 1997. Consequently most of the many papers and reports it will generate have yet to be completed or published. This project has, however, already led to significant developments in the following areas:

- Chandler Juvenile Monitoring Facility. Species-specific passage estimators were developed and refined, confidence intervals were generated for seasonal passage estimates from 1983 to present.
- Indirect predation. Preliminary results from 1998 releases suggest that hatchery fish may decrease survival of commingled smolts during certain portions of the spring and increase survival at other times.
- Yakima spring chinook monitoring plan. Produced Yakima Fisheries Project Spring Chinook Supplementation Monitoring Plan (DOE/BP-64878-1) which will be the template monitoring plan for all stocks targeted by the YKFP.
- Facility QC monitoring:The adult broodstock collection and monitoring facility at Roza Dam was shown to have no adverse effects on passage timing or spawning distribution of wild Yakima spring chinook.
- Development of procedures to estimate wild/hatchery smolt survival from recaptures of smolts PIT-tagged and released at Roza Dam. The major need for this monitoring element is to develop an efficient method of collecting adequate numbers of fish (guiding them into an existing juvenile trap). Arrays of strobe lights or infrasound devices were tested. Strobe lights were effective at guiding spring chinook salmon smolts during the night but not during the day (Amaral et al. 1998). At night, strobe light could guide fish up to 6 m away when turbidities were 3.3 NTU. Infrasound and drop lights were ineffective at guiding spring chinook salmon at any time. A strobe light system was not recommended at Roza Dam because of the high cost per fish diverted.
- Coho/chinook predation studies. Although hatchery coho smolts consumed fall chinook juveniles up to 46% of their length in lab experiments, in field studies coho rarely consumed juvenile chinook, and the mean size of fish (primarily cyprinids) consumed by hatchery coho in the Yakima River was 17% of body length. During 1997 and 1998, 8,226 hatchery coho smolts were collected in the mid-lower Yakima River and irrigation facilities and only 13 contained salmonids in their stomach. During 1998, 1,097 hatchery coho salmon were collected in the upper Yakima River and only two salmonids were found in the stomach of one coho salmon.
- Prey abundance seeding index. The feasibility of using a measure of prey availability (spring chinook parr stomach fullness) as an index of "seeding" is currently being tested. Stomach fullness of juvenile spring chinook was approximately four times higher during the summer than the fall and many fish in the fall had empty stomachs.
- Microhabitat use seeding index. Microhabitat usage patterns of juvenile spring chinook salmon was measured during 1998 to provide baseline carrying capacity information. Focal point velocities averaged 0.23 m/s during the summer and 0.31 m/s during the fall; focal point depths (% of depth from the surface) averaged 72% during the summer and 76% during the fall; and total depths averaged 0.75 m during the summer and 0.67 m during the fall.
- Avian predation index. A bird predation index was calculated in 1998. Bird predation on salmon was strongly associated with low stream discharge and dams. Gulls and common mergansers had the greatest predatory impact on juvenile salmonids and have the potential to limit natural production during years of average or low flows.
- Baseline incidence of residual and precocial spring chinook. Residualized and precocial spring chinook salmon were counted during 1998. The ratio of precocial spring chinook salmon to anadromous males on active redds was 10 to 1. Approximately 65% of the precocials were age 0 and 35% age 1. The ratio of residualized spring chinook juveniles to subyearlings was 1.6 to 100.
- Interspecifc space/food competition index. The feasibility of using a competition index is currently being tested. There is currently a high degree of spatial and dietary overlap between *O. mykiss* and spring chinook, and low spatial/dietary overlap between spring chinook and redside shiner and mountain whitefish. These results, coupled with abundance and availability information, suggest that there is a high potential for competitive impacts on spring chinook salmon by *O. mykiss*, and moderate potential for redside shiner and mountain whitefish under current conditions.

Project 9506406, "Monitoring Supplementation Response Variables", 1995-1998. This project produced six technical reports and papers and led to significant developments in the following areas:

- Supplementation population dynamics modeling. Produced four models expressing natural production under supplementation as a function of release size, productivity of supplemented population, form of natural production function and variability of natural production. The models will, with refinements, be used to assess progress toward gaol of increasing natural production and identify pre-conditions of success.
- Power analysis for hatchery spring chinook survival test. Produced multi-year power analysis of OCT/SNT survival comparison. Release numbers to test OCT/SNT differences in smolt/adult survival with specified power (α=.05 β=.1, effect size = 50%) are based on this analysis.
- Genetic modeling: broodstock impacts. Modelled genetic effects of broodstock collection and usage rules. Preliminary results include the suggestion that a wild-only broodstock policy has little beneficial impact during the initial phase of supplementation.
- Genetic modeling: DNA pedigreeing. Developed "pedigree" computer model for investigation of monitoring power using DNA markers (e.g., monitoring abundance of progeny of DNA-sampled hatchery and wild spawners on scales ranging from tens of fish in artificial spawning channels to all upper Yakima spring chinook).
- Reproductive success baseline work. Recorded detailed behavioral observations on wild spawning spring chinook (first ethological description of these behaviors on Columbia River spring chinook) and characterised detailed reproductive traits of wild Yakima spring chinook.
- Genetic baseline development. Developed DNA microsatellite profiles of Yakima spring chinook populations.
- Spring chinook marking. Studies indicated that smolts marked with VI-jet tags were not reliably identifiable as adults. Therefore, because non-destructive marks are required, OCT and SNT spring chinook were marked in 1998 by CWT's implanted in treatment-specific body locations.
- Hatchery spring chinook treatment specification. Juvenile survival studies indicated positive impacts from rearing treatments that included the following elements: "naturalistic" raceway color patterns, overhead cover and mid-water structure. These features, plus mid-water feed delivery and predator avoidance training (shown by Maynard et al (1996) to increase survival) were included in the initial SNT treatment specification.

Project 9506402, "Yakima Species Interaction Studies", 1995 - 1998. This project produced 13 technical reports and papers and led to significant developments in the following areas:

- Non-target taxa monitoring. A practical approach for assessing ecological risks associated with stocking anadromous salmonids was developed to facilitate decision making and direct monitoring efforts. Field studies have provided requisite information for assessing risks of steelhead and spring chinook supplementation to wild rainbow trout and spring chinook salmon. In addition, monitoring prescriptions for 16 non-target taxa of concern (NTTOC) have been developed and are being implemented to meet conservation objectives. Preliminary analyses indicate that impacts on NTTOC detectable in 5 years ($\alpha=\beta=0.1$, proportional variance) range from 7% (mainstem Yakima rainbow) to 100% (sand roller) with a mean of about 50%.
- Fish predation index. A fish predation index has been calculated for smallmouth bass and northern pikeminnow, but is still being developed for channel catfish. Preliminary estimates indicate that smallmouth bass consumed 524,000 chinook salmon in the spring of 1998. Smallmouth bass and channel catfish are dominant in the lower Yakima River and pikeminnow in the mid-upper Yakima River.

Project 9706200, "Development and Refinement of Natural Production Objectives and Enhancement Strategies", 1997-1998. This project produced two technical reports and papers and led to significant developments in the following areas:

- Fall chinook limiting factors. A preliminary ecosystem diagnosis and treatment (EDT) modeling analysis of Yakima fall chinook indicated that the major factor limiting natural production was a combination of excessive temperature in the lower river and late emergence timing.
- Spring chinook natural production objectives. Used predecessor of EDT model to set natural production goals and conditions for Yakima spring chinook supplementation project.
- Enhancement project design. Currently using latest version of EDT model to integrate life history characteristics (of coho, fall chinook and steelhead) and habitat quality and quantity in order to identify limiting factors and assess alternative enhancement strategies.

Project 8812005, "Fish Passage Video Monitoring", 1988 - 1998. Besides annual reports, this project contributed to many Yakima-related technical reports and papers and led to significant developments in the following areas:

- Yakima subbasin returns and spawning escapement. Passage of jacks and adults are estimated by time-lapse videos shot through viewing windows in ladders on irrigation dams. Project developed videographic methods to estimate total returns to Yakima as Prosser Dam counts plus below-Prosser harvest (spring chinook, coho, steelhead and above-Prosser fall chinook); upper Yakima spawning escapement (steelhead and coho) as Roza Dam counts. Currently developing methods to estimate Naches spawning escapement for coho as Cowiche Dam counts.

Project 8812008, "Fish Technician Field Activities", 1988-1998. Besides annual reports, this project contributed to many Yakima-related reports, and led to significant developments in the following areas:

- Chandler smolt passage. At Chandler estimated seasonal passage of all species of wild smolts and pre-smolts, and all marked groups of experimental smolts (hatchery and wild), for the years 1983 to present. In combination with return monitoring at Prosser Dam (8812005), spawner surveys and harvest monitoring (other 8812008 tasks), generated pre-supplementation estimates of egg-to-smolt & smolt-to-adult survival for all above-Prosser Yakima stocks.
- In-basin harvest monitoring, Yakima. Refined and augmented in-basin Yakima harvest monitoring methods.
- Yakima subbasin spawner surveys. Counted redds throughout subbasin for spring chinook and estimated potential egg deposition (brood years 1981 to present); counted redds and estimated potential egg deposition for Satus/Toppenish Cr. steelhead and Marion Drain fall chinook (1989 to present); in process of developing effective redd counting/egg deposition methods for coho throughout subbasin.
- Roza adult facility operation. From 1997 to the present, operated Roza adult facility and collected and transported spring chinook broodstock, monitored demographic characteristics of wild run.
- Project support. Provided technical manpower as needed for all M&E activities.

Project 9506800, "Klickitat Passage/Habitat Improvement M&E", 1995 - 1998. This project produced portions of four technical reports and led to significant developments in the following areas:

- Adult monitoring/broodstock collection. Plans were developed to retrofit Lyle Falls fishway in the Klickitat subbasin to function as an effective broodstock collection and adult monitoring facility.
- Passage improvements. A series of alternative plans were developed to increase adult passage at the Castile Falls complex.
- Fish distribution. The first series of studies of species composition and distribution of naturally-produced salmon and steelhead in the subbasin were generated.

Project 9603301, "Supplement and Enhance the Two Existing Stocks of Yakima River Fall Chinook", 1996 - 1998. Experimental work on this project basically began in 1998. Consequently, this project has produced only one technical report to date, although a series are forthcoming in 1999 and 2000. The project has led to significant developments in the following areas:

- Locally-adapted broodstock. Began development of locally-adapted coho and fall chinook broodstocks by collecting and spawning returning adults in the Yakima subbasin (eyed eggs transported to hatcheries out of basin for rearing to smolt).
- Hatchery treatment specification. The efficacy of increasing hatchery fall chinook smolt survival by thermally accelerating incubation and growth to smolt size was tested by releasing differentially marked (left & right pelvic clips; 4,000 PIT-tagged fish) test and control (unaccelerated) smolts in the spring of 1999. Relative survival and outmigration timing were monitored at screw traps (clipped fish) on the lower Yakima near the confluence (RM 8), and at McNary Dam (PIT-tagged fish). Release sizes were based on a power analysis.
- Optimal supplementation reaches. The suitability of various portions of the lower Yakima River for fall chinook supplementation will be determined on the basis of ability to support additional natural production. The relative ability of three portions of the lower Yakima to support increased natural production was assessed in the spring of 1999 by releasing small (40-45 mm), fluorescent-grit-marked hatchery fall chinook fry in three candidate supplementation areas. Hatchery fry were released when they matched the size of resident fry. It was assumed that the hatchery fry would be a surrogate for wild residents, and that relative survival to a lower river screw trap would indicate the relative ability of candidate areas to support increased natural production.

Project 9603302, "Evaluate the Feasibility and Potential Risks of Restoring Yakima River Coho", 1996 - 1998. Experimental work on this project basically began in 1998. Consequently, the project has produced only two technical reports to date, although a series are forthcoming in 1999 and 2000. The project has led to significant developments in the following areas:

- Locally-adapted broodstock. Began development of locally-adapted coho and fall chinook broodstocks by collecting and spawning returning adults in the Yakima subbasin (eyed eggs transported to hatcheries out of basin for rearing to smolt).
- Coho/trout interactions. Preliminary results indicate low competitive impacts (displacement, sympatric/allopatric growth and survival) of outplanted hatchery coho parr on resident trout in the Little Naches drainage (Yakima Subbasin).
- Optimal supplementation areas and release timing. In spring of 1999 began multi-year study of impact on survival of acclimated hatchery coho smolts to Chandler and McNary of release date and release site (2X2 factorial with one rep per site). Release dates are May 7 and May 31 (fixed); release sites are upper Yakima and upper Naches (random). Releases include sufficient numbers of PIT-tagged fish to estimate differential survival to Chandler and McNary with specified power (α=.05, β=.1, effect size =50%).

e. Proposal objectives

Although the project entails only four fundamental objectives, there are 44 subobjectives which we have termed tasks to accommodate the structure of this document. These 44 subobjecitves and associated hypotheses/assumptions are summarized in the table below. Every subobjective will result in one or more of the following: a BPA report, a paper in refereed journal, a complete monitoring procedure including functional facilities and analytical techniques.

OBJECTIVE/TASK	HYPOTHESIS/ASSUMPTION
1- 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.	
1a- Modeling: To design complementary supplementation/habitat enhancement programs for coho, spring & fall chinook & steelhead in the Yakima and Klickitat Subbasins.	Ecosystem Diagnosis and Treatment computer modeling accurately integrates habitat quantity, quality, and life history data to evaluate alternative enhancement strategies.
1b- 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	The relative survival of hatchery fall chinook fry from candidate supplementation areas to the lower Yakima accurately reflects natural production potential of the candidate areas.
1c- Coho life history study: Describe major features of the freshwater life history and survival rates of juvenile coho.	The survival and migration patterns of naturalized coho juveniles can be deduced from survival and migration patterns of hatchery juveniles.
1d- Klickitat juvenile salmonid population surveys: Determine the spatial distribution and relative abundance of salmonids in the Klickitat subbasin.	An adequate sampling procedure can be designed and implemented.
1e- Juvenile spring chinook micro-habitat utilization: Estimate baseline microhabitat utilization of juvenile spring chinook salmon. Future deviations in use will suggest carrying capacity problems.	Changes in patterns of microhabitat utilization with supplementation will reflect spring chinook seeding in the upper Yakima.
1f- 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.	H_0: Survival of SNT-reared fish does not exceed survival of OCT-reared fish.
1g- Roza juvenile wild/hatchery smolt PIT tagging: To capture, PIT-tag and release wild and hatchery spring chinook to estimate relative wild/hatchery smolt survival to Chandler and the McNary Dam.	Survival of hatchery fish is high enough to result in an increase in natural origin recruits.
1h- Wild/hatchery survival and enumeration (Chandler Juvenile Monitoring Facility):To refine operational and analytical procedures used in estimating hatchery and wild smolt passage at Chandler smolt trap.	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 techniques.
1i- Fall chinook optimal rearing treatment: Develop an accelerated rearing treatment to enable early outmigration and increase overall smolt survival.	The survival of hatchery fall chinook can be increased to levels consistent with an increase in natural production.
1j- Yakima coho stock and release study: Determine optimal location, date, and stock of release for Yakima coho re-introduction efforts.	The survival of a suitable stock of hatchery coho can be increased to levels sufficient to establish a naturalized population.
1k- Yakima spring chinook juvenile behavior: Determine differences in hatchery & wild spring chinook smolt behavior closely related to survival	Analysis of relative behavior in hatchery and wild fish at release and after a substantial outmigration period will indicate which behaviors are tightly linked to survival.
1l- Yakima hatchery spring chinook juvenile morphometric and coloration studies: Determine whether significant differences in body shape and coloration exist between hatchery spring chinook before at release.	Analysis of differences in coloration and morphology between OCT, SNT, and wild smolts at release and after a substantial outmigration period will indicate which characteristics are tightly linked to survival.
1m- Yakima hatchery/wild spring chinook smolt physiology studies:	Analysis of physiological differences (lipid content, ILGF-1, gill-

Determine whether significant physiological differences exist among wild, OCT and SNT Yakima spring chinook smolts during rearing, at release, and at Chandler and at McNary Dam.	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.
1n- Study of feasibility of using screw traps for long-term monitoring of juvenile production in the Klickitat Subbasin: Determine the feasibility of using screw traps to monitor Klickitat smolt production.	Entrainment rates will be high enough and variability in entrainment will be low enough that total smolt production can be estimated with specified precision.
1o- 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.	Water clarity will allow videographic species-specific passage estimates of specified precision.
1p- 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).	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.
1q- Spawning ground surveys (redd counts): Monitor spatiotemporal redd distribution in theYakima (spring chinook, Marion Drain fall chinook, coho, Satus/Toppenish steelhead), and Klickitat (spring/fall chinook, coho, steelhead) subbasins & collect carcass data.	Redd counts accurately reflect potential egg deposition and age distribution from carcass recovery can be used to estimate age structure.
1r- Natural Spawning Observations: Characterize wild spring chinook reproductive behavior (adults & precocials) to serve as a baseline for future comparisons between hatchery & wild reproductive behavior.	Deviations from overall baseline behavioral patterns will indicate phenotypic and genotypic impacts from supplementation.
1s- Yakima spring chinook residuals/precocials studies: Estimate baseline abundance of residual and precocial spring chinook salmon and determine the necessary sampling effort for post-supplementation monitoring.	H_0: Supplementation will not change the proportionate abundance of precocial and residual spring chinook.
1t- Relative hatchery/wild reproductive success: Determine whether spawning behavioral & reproductive success of wild spring chinook are affected by an artificial spawning channel, & estimate reproductive success of hatchery coho in a natural stream.	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. Reproductive success of hatchery coho spawning in the natural environment is high enough to support a naturalized population.
1u- 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.	H_0: Supplementation will not change gamete quality.
1v- Scale analysis: Determine age and stock composition of juvenile and adult salmonid stocks in the Yakima and Klickitat basins.	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.
1w- 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	Disease mortalities at the Cle Elum Hatchery can be kept at negligible levels.
1x- Habitat inventory aerial videos and ground truthing: Measure critical environmental variables by analyzing data extracted from aerial videos and verified by ground observations.	A significant proportion of the interannual variability in salmon and steelhead productivity is attributable to fluctuations in key environmental factors inside the subbasins that can be measured by aerial videography and hydrological data.
1y- Out-of-basin environmental monitoring: Obtain and utilize information regarding mainstem and marine environmental and harvest-related impacts on all Yakima and Klickitat anadromous salmonids.	A significant proportion of the interannual variability in salmon and steelhead productivity is attributable to fluctuations in key environmental factors in the mainstem Columbia and ocean.
1z- Trophic enhancement research: Utilize fish carcasses to “fertilize” streams which are currently deficient in nutrients.	Salmon and steelhead production can be limited by the lack of nutrients provided by decomposing carcasses.
1A- 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 and Klickitat Subbasins.	Salmon and steelhead production can be limited by anthropogenic sediment loading.
1B- Klickitat fish passage obstruction inventory assessment: Locate and describe passage obstructions in the Klickitat Basin.	Salmon and steelhead production is limited by passage obstructions.
1C- Klickitat water quality inventory: Record water quality measurements in each habitat survey reach on a seasonal basis.	Salmon and steelhead production is limited by water quality.
1D- Klickitat habitat inventory & analysis: Collect data on existing and historical fish populations, habitat and passage conditions throughout the basin for use in modeling runs that will generate initial enhancement plans.	Ecosystem Diagnosis and Treatment computer modeling accurately integrates habitat quantity, quality, and life history data to evaluate alternative enhancement strategies.
1E- Yakima hatchery spring chinook predator avoidance training: Determine efficacy of exposing Yakima hatchery spring chinook to avian predation prior to release in terms of increasing survival to Chandler.	H_0: Predator avoidance training will have no impact on smolt survival.

2- Harvest: Develop methods to detect increases in harvest of YKFP targeted stocks.	
2a- Out-of-basin harvest monitoring: Estimate group- and stock-specific harvest of hatchery and wild anadromous salmonids outside of the Yakima and Klickitat subbasins.	H_0: Supplementation will not increase out-of-basin harvest.
2b- In-basin harvest: Estimate group- and stock-specific harvest of hatchery and wild anadromous salmonids within theYakima and Klickitat subbasins.	H_0: Supplementation will not increase harvest within the Yakima and Klickitat subbasins.
3- Genetics: Develop methods of detecting significant pre- & post-supplementation (PAPS) genetic changes in targeted stocks as reflected by changes in extinction risk, within-stock genetic variability, between-stock genetic variability, and domestication.	
3a- PVA analysis for all YKFP target stocks: Develop population viability analysis approaches for monitoring extinction risk of all YKFP target stocks by refining existing project models.	A PVA approach can be developed that will detect changes in extinction risk with specified precision.
3b- Allozyme/DNA data collection and analysis: Augment allozyme and DNA microsatellite baselines of all Yakima chinook stocks for monitoring within- and between population genetic variability.	Allozyme and/or DNA data will allow detection of changes in within- and between-population genetic variability with specified precision.
3c- 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.	Spawning ground recovery of strays will be complete enough to estimate maximum levels of gene flow with specified precision.
3d- 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.	A mating study can be designed and carried out that will detect domestication selection impacts at several traits of interest with specified precision.
4- 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.	
4a- Avian predation index: Develop methods to index impact of avian predation on annual smolt production of Yakima salmon and steelhead.	Avian predators are capable of significantly depressing smolt production and accurate methods of indexing avian predation across years can be developed.
4b- Fish predation index: Develop methods to index impact of piscivorous fish on annual smolt production of Yakima salmon and steelhead.	Fish predators are capable of significantly depressing smolt production and simple and accurate methods of indexing fish predation across years can be developed.
4c- Coho/chinook predation study: Estimate the percent of emergent spring chinook fry in the upper Yakima consumed by hatchery coho smolts.	H_0: A re-established coho run will not significantly depress chinook production in the Yakima.
4d- 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.	H_0: Survival does not differ for groups of outmigrants that are or are not commingled with hatchery smolts.
4e- Yakima River spring chinook competition/prey index: Determine whether inter-specific space competition or limited prey abundance restricts production of upper Yakima spring chinook smolts.	Inter-specific space competition can limit upper Yakima spring chinook production. Supplementation can increase spring chinook fry abundance enough to deplete prey & diminish sp chinook productivity.
4f- Upper Yakima 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 Subbasin.	H_0: Spring chinook supplementation will not depress the stock status of NTTOC below specified levels.
4g- Pathogen sampling: Determine supplementation impacts on the incidence of pathogens in wild Yakima spring chinook smolts.	H_0: Spring chinook supplementation will not increase the incidence of pathogens in wild smolts.

f. Methods

OBJ	METHOD
1.a	**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.
1.b	**Rationale:** Determine areas in the lower Yakima where potential for increased natural production of fall chinook is greatest (future acclimation/release sites). **Methods:** Release fluorescent-grit-marked hatchery fall chinook fry (40-50 mm) in three candidate reaches when natural fry are the same size. Evaluate size, condition factor and migration timing of marked smolts at 2 screw traps at RM 8. Relative productivity among reaches is indexed by relative fry-to-smolt survival. Analysis by binomial techniques.
1.c	**Rationale:** Need to understand the freshwater life history and survival of juvenile coho in the Yakima. **Methods:** Monitor hatchery coho fry as surrogates for wild. **1)** Describe spatiotemporal habitat utilization patterns by snorkel and electrofishing surveys and the use of fixed traps (panel and screw). **2)** Estimate fry-to-smolt survival for fish released in 4 different drainages by marking them distinctively with fluorescent grit. Smolts collected at Chandler will be interrogated under black light & ID'ed to group. Group survival will be estimated as the ratio of

	estimated passage to release number (see 1h). **3)** Interactions between coho and other salmonids will be evaluated by habitat overlap, population densities, sympatric/ allopatric differences in growth and condition factor and broad geographical displacement. Statistical analysis will be by ANOVA & binomial techniques.
1.d	**Rationale:** To determine the spatial distribution and relative abundance of salmonids throughout the Klickitat subbasin. **Methods:** Summer and winter snorkel and electrofishing surveys will be conducted in three mainstem reaches- McCormick Meadows to Castile Falls, Castile Falls to the Klickitat Hatchery (summer only), and Klickitat Hatchery to Lyle Falls. Species abundance will be indexed by direct counts and CPUE for snorkel and electrofishing surveys, respectively. Absolute summer abundance will be estimated in selected reaches of key Klickitat tributaries by electrofishing and depletion estimators.
1.e	**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.f	**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. **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 mutiple 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.g	**Rationale:** Relative hatchery/wild smolt survival to Chandler and McNary is a critical mechanistic element of project evaluation. **Methods:** Five screw traps fished below Roza Dam and the 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.h	**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. Fluorescent-grit-marked coho and fall chinook are identified by observing fish under ultrviolet light. Smolt–to-adult survival for wild fish is estimated as the ratio of brood year returns to brood year smolt production (PIT-tags are not needed). 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. A statistical comparison (log-odds-ratio) of the proportion of marked hatchery spring chinook to wild observed in a screw trap below Prosser Dam and inside Chandler will test for collection efficiency bias caused by body-tagging hatchery spring chinook with wire tags.
1.i	**Rationale:** To determine if hatchery fall chinook smolt survival can be increased by accelerated 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 rel survival at lower river screw traps. Analysis by binomial techniques.
1.j	**Rationale:** To determine the optimal date and place of release for Yakima coho re-introduction feasibilty 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 ANOVA.
1.k	**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.l	**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.m	**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.n	**Rationale:** To determine the feasibility of using screw traps to monitor smolt production in the upper and lower Klickitat River. **Methods:** Screw traps located above Castile Falls, at the Klickitat Hatchery and near RM 6 on the mainstem Klickitat will be fished on year-round. Calibration studies will determine feasibility of year-round operation and whether a stable discharge\entrainment relationship exists at each site. Logistic regression will be used to describe discharge\entrainment relationships.
1.o	**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.p	**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.q	**Rationale:** To describe spatiotemporal redd distribution for Yakima spring chinook, coho, fall chinook (Marion Drain), and steelhead (Satus/Toppenish), Klickitat spring and fall chinook, steelhead and coho 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.r	**Rationale:** Detailed observations will allow scientists to characterize typical spring chinook reproductive behavior to serve as a baseline for evaluations of hatchery fish behavior. **Methods:** Befoer returns of hatchery adults in 2001, field activities will focus on observation and description of naturally spawning spring chinook in the upper Yakima and Naches Rivers. A knowledge of natural variation (within-year and between-year) in behavioral repertoires and the frequency of individual behaviors will 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 will also be recorded. Observations will be recorded on audio tape and underwater video recordings.
1.s	**Rationale:** Estimate the baseline abundance of residual and precocial spring chinook and determine the sampling effort needed to detect post-supplementation changes. **Methods: 1)** Residuals – Direct counts of jvenile 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)** Precocials - 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.t	**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. In 1999 and 2000, we will build and "debug" an artificial spawning channel to measure baseline wild reproductive behavior in the channel and determine whether the behavior observed differs significantly from that observed in the wild. **Methods: 1)** Spring chinook: DNA-typed wild 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. Phenotypic and morphological traits will be collected and ethological characterizations of the reproductive behavior of individual fish will be made. The estimated number of progeny produced by each male and female will be estimated by trapping post-emergent fry and identifying their parentage via DNA analysis. 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: Egg-to-fry survival will be estimated by confining 40 adult hatchery coho (50:50 sex ratio) to a natural stream reach, "capping" the resulting redds and counting fry produced. Survival rates and gravel quality (% fines) within the enclosure will be compared to expected rates for wild coho in the literature.
1.u	**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 2001 and compared to their wild counterparts. Statistical analysis will include ANOVA, ANCOVA and linear regression.
1.v	**Rationale:** To determine age and stock composition of juvenile and adult salmonid stocks in the Yakima and Klickitat subbasins. **Methods: 1.** We will use scale analysis to achieve this task. 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.** 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 outmigration. 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.
1.w	**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.x	**Rationale:** To measure a number of environmental variables by analyzing data extracted from periodic aerial videos. **Methods:** Aerial videos of the Yakima and Klickitat subbasins 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.y	**Rationale:** To obtain and utilize information from outside sources, regarding environmental and harvest-related impacts on all anadromous salmonids occurring outside the Yakima and Klickitat subbasins. **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.z	**Rationale:** To utilize fish carcasses to "fertilize" streams which are currently deficient in nutrients. The lack of nutrients in many upper Yakima streams today is a result of not having sufficient numbers of adult salmon returning to spawn, die and decompose. The importance of carcasses to the food web of a stream is just now becoming appreciated. **Methods:** Fall chinook carcasses from the Priest Rapids Hatchery will be "outplanted". The fish would be brought into the basin and placed into study streams and various parameters (e.g., carcass decay timing, invertebrate utilization, juvenile fish utilization, and growth and survival rates of juvenile fish) would be measured. In addition to impacts to stream ecosystems, a major concern in this task is disease transmission. Accordingly, a portion of the funds allocated for the task may be earmarked for carcass sterilization.
1.A	**Rationale:** To monitor stream sediment loads associated with the operation of dams and other anthropogenic factors (e.g., logging, agriculture and road building) which can increase sediment loads in streams utilized by all salmonids in the Yakima and Klickitat subbasins. **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.B	**Rationale:** To locate and describe existing salmonid fish migration barriers in the Klickitat subbasin. **Methods:** To gather existing data that has been collected in past years by YIN Fisheries staff and other agencies (e.g. Dept. of Transportation, WDFW), as well as conducting field surveys to locate and assess passage problems not identified through existing reports.
1.C	**Rationale:** Record water quality measurements at each habitat survey reach on a seasonal basis. **Methods**: A HACH hydrolab will be deployed to measure and record the following parameters- temperature, dissolved oxygen, conductivity, total dissolved solids, and turbidity.
1.D	**Rationale:** The near term objective is to collect baseline data on existing habitat conditions, fish populations, and existing passage conditions throughout the basin. This information will be incorporated into the Ecosystem Diagnosis and Treatment (EDT) model, which will be used to generate initial enahcement strategies for Klickitat stocks. The long-term objective is to implement habitat restoration, hatchery supplementation, and fish passage improvement projects in the basin. Outcomes from the EDT model will be used to prioritize the implementation of these projects. **Methods:** The habitat inventories will be conducted using the TFW methodology (modules-Stream Segment Identification, Reference Point Survey, Habitat Unit Survey, Large Woody Debris Survey and Ambient Salmoind Spawning Gravel Composition). Mean daily water temperatures will be monitored on an annual basis for several key tributaries and mainstem sites using Hobo thermographs.
1.E	**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; Olla et al. 1994; Maynard et al. 1995). **Method:** Predator avoidance training will consist of introducing a hungry common merganser 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.
2.a	**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	**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 and Klickitat 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.a	**Rationale:** To develop population viability analysis approaches for monitoring extinction risk of all YKFP target stocks. **Methods:** Existing stochastic supplementation dynamics models (including log-normal variability functions) already developed for the project (Busack and Knudsen, in press) will be refined to incorporate stock-specific demographic and environmental data.
3.b	**Rationale (allozyme):** To augment the baseline data of all Yakima spring chinook stocks by making a full baseline-level screening (approx 60 loci) of the broodstock. This data will be used to monitor changes in within- and between-population genetic variability. **Methods:** Tissues from chinook spawners (approx. 220 fish) will be analyzed according to standard WDFW protocol at the WDFW Genetics Lab. These data will also be compared to the four years of prefacility data collected by WDFW to monitor changes that have taken place in the five years since the prefacility data were collected, and to estimate effective size of the population. We plan to do this annually through the first brood cycle, and then probably not again until the third or fourth generation of the operation. There is a good possibility that DNA data will totally supplant Allozyme work in time. **Rationale (DNA):** This will probably be (depending on impending developments in technique) a nine-locus screening of the broodstock to serve as baseline from which to monitor changes. **Methods:** Tissues from chinook spawners (approx. 220 fish) will be analyzed according to protocols developed by Dr. Paul Bentzen and colleagues at the University of Washington. The work will be

	done either at the University of Washington or at the WDFW Genetics Lab. We plan to do this annually at least through the first brood cycle, and then also analyze the returning adults. 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 a good chance of supplanting allozyme work, and may also become useful in a wide variety of monitoring needs. Therefore, this work is very critical.
3.c	**Rationale:** To determine the extent of gene flow from the supplemented Upper Yakima stock into the Naches and American River stocks. **Methods:** UY 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.
3.d	**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:** The approach taken will probably involve measurement of a suite of traits in the progeny of HxH, WxW, and possibly HxW matings. 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.a	**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 during 1998. 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	**Rationale:** Develop an index of the mortality rate of upper Yakima spring chinook attributable to non-salmonid piscivorous fish in the lower Yakima. This index will be used to estimate the contribution of in-basin predation to fluctuations in hatchery and wild smolt-to-adult survival rate. **Methods:** The densities of all major piscivorous fish species will be censused 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 (PI) will be calculated. The terms of the PI for fish are: predator density, water temperature (^{o}C) (T), mean weight (g) of predator (W), mean number of spring chinook salmon in each predator=s gut (S), and mean weight (g) of the gut contents (GW). These variables are used in the following equation (Ward et al. 1995) to estimate the fish PI: Predation Index for fish = (Predator Density)(Consumption index), and the consumption index (CI) is: $CI=0.0209(T)^{1.60}(W)^{0.27}(S{\cdot}GW^{-0.61})$. PI=s will be extrapolated to the entire lower river and a cumulative PI for the outmigration will be estimated.
4.c	**Rationale:** To estimate the percent of the emergent spring chinook fry population (Easton Dam to Teanaway confluence) consumed by the release of acclimated hatchery coho smolts. **Methods:** A release of acclimated hatchery smolts will be made in the vicinity of Easton Dam in late May. These smolts will subsequently be captured in a rotary trap located about six river miles downstream. A target number of 1,000 fish are to be collected for stomach content analysis. Smolts will be captured throughout the coho outmigration period. The data collected from this field task will be used to estimate the number or percent (relative to the Easton Dam-Teanaway reach) of total spring chinook consumed.
4.d	**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.e	**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.f	**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.g	**Rationale:** In order to determine if supplementation increases the incidence of pathogens, we will establish 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 examined for fish pathogens using standard USFWS protocols at a USFWS fish health laboratory to calculate a fish pathogen index.

g. Facilities and equipment

Anadromous salmonids in theYakima 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 videographically 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 outmigrating smolts can be made at the Chandler smolt trap (also located at Prosser Dam), which is equipped with two PIT-tag detectors. The project has two PIT-tagging station and a trained tagging crew. Smolts can be collected at Roza Dam (and at two other dams between Roza and Prosser), so that survival and outmigration timing data can easily be estimated from tagged fish released above Prosser. The project also has eight screw traps and 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 on the extreme lower Yakima, at Easton Dam on the extreme upper Yakima, and at Wapatox and Cowiche dams 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 which can be segregated into two experimental rearing treatments from the eyed egg stage through release. A planned 1999 addition to the hatchery is an experimental spawning channel for evaluating differences in reproductive success and associated behaviors of hatchery and wild fish. The hatchery and the Roza and Chandler juvenile traps also include facilities for juvenile behavior studies. The project has small hatcheries at Prosser Dam and Marion Drain capable of rearing multiple treatment groups of fall chinook. 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.

In the Klickitat subbasin, adult monitoring and broodstock collection will occur at Lyle Falls fishway after it is rebuilt (scheduled for 1999). If proven feasible, a battery of screw traps will be used to monitor smolt production in the Klickitat.

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. Budget

Personnel - Monies requested for personnel include all YIN biologists and technicians required to effectively carry out all monitoring and evaluation tasks outlined in Section 8e. Personnel accounts for approximately 34% of the overall budget due to the extensive monitoring and evaluation tasks required to determine whether the Project is meeting the objective of increasing natural production and harvest within prescribed genetic and ecological constraints.
Fringe – This amount is calculated on rates of 20% for non-tribal members and 17.6% for tribal members.
Supplies – This amount is based on the equipment needed for the extensive field monitoring efforts required to rigorously evaluate and monitor the Project. Equipment includes field operating supplies, vehicles and associated mileage.
O&M – This money is needed to maintain the artificial spawning channel that is to be constructed in 1999, at the Cle Elum spring chinook hatchery. This spawning channel is critical to evaluating reproductive success of hatchery relative to wild spring chinook.

Capital Equipment – This money will be used to purchase a raft to be used on the Klickitat to perform spawner surveys.
PIT tags – This money will be used to purchase 111,452 PIT tags to estimate fall and spring chinook and coho survival from smolt to adult lifestages. Minimum numbers of tags for each study (see Section 8e) was determined by performing power anlaysis.
Travel – This money is used to attend conferences, meetings, and workshops to develop technologies and techniques to improve monitoring, disseminate results from this project, and to mark fish.
Indirect – This money is based on an indirect rate negotiated by the YIN and the federal government consistent with applicable law.
Subcontracts – The subcontract to USFWS will be used to monitor fish health and fish marking. The subcontract to InSTATS is for biometrical support/assistance in data and power analyses. The subcontract to WDFW (co-managers) is for genetic and ecological interaction studies. An additional subcontract is included for aerial flights to monitor/evaluate physical habitat characteristics in the Yakima and Klickitat Subbasins.

Section 9. Key personnel

Name (alphabetically within agency)	Title	Agency	FTE (mos.)	Expertise/Role
Jim Dunnigan	Fish Biologist	YIN	12	Predation studies; population censuses.
Dave Fast	Research Director	YIN	12	Science and Technical Advisory Team; supervision of all YIN research.
Joel Hubble	Fish Biologist	YIN	12	Adult passage (videography); Yakima coho program
Mark Johnston	Field Crew Supervisor	YIN	12	Supervision of all monitoring facilities and (YIN) field studies.
John McConnaughey	Fish Biologist	YIN	12	Analysis of Chandler data; predation studies.
Bill Sharp	Fish Biologist	YIN	12	Klickitat Biologist
Bruce Watson	Information Specialist	YIN	12	Survival/recruitment studies; population modeling (EDT); habitat/productivity studies.
Craig Busack	Research Scientist	WDFW	8	Genetic studies; population modeling; general power analysis
Kenneth Ham	Fish Biologist	WDFW	12	Ecological interaction studies; ecological power analysis
Curt Knudsen	Fish Biologist	WDFW	12	Reproductive success studies; semi-natural rearing studies; general power analysis; marking methodologies
Geoff McMichael	Fish Biologist	WDFW	12	Ecological interaction studies
Todd Pearsons	Fish Biologist	WDFW	12	Ecological interaction studies
Steve Schroder	Research Scientist	WDFW	4	Reproductive success studies; semi-natural rearing studies; fish marking

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1994-1996:	M.S. Fisheries Resources, University of Idaho, Moscow.
1988-1993:	B.S. Fisheries Resources, University of Idaho, Moscow.
1988-1993:	B.S. Wildlife Resources, University of Idaho, Moscow.

SELECTED PUBLICATIONS

Dunnigan, J.L., D.H. Bennett, and B.E. Rieman. 1996. The effects of forest management on cutthroat trout in the Coeur d' Alene River system, Idaho. Proceedings of the Forest Fish Conference. Calgary, Alberta.

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Education

University of Washington, Seattle, Washington
Doctor of Philosophy in Fisheries Science, 1987.

University of Puerto Rico, Mayaguez, Puerto Rico
Master of Science in Marine Sciences, 1974.
St. John's University, Collegeville, Minnesota
Bachelor of Science in Zoology, 1969.

Research Experience

1988-Present: Research Manager. Fisheries Resource Management Program, Yakima Indian Nation. Responsible for the design, development, and implementation of a major supplementation and research facility to test the concept of using artificial production to rebuild natural spawning populations of spring
chinook salmon in the Yakima Basin. Write detailed project plans, develop short and long-term project goals and objectives, and supervise professional and technical staff.

1985-1988: Project Leader. Spring Chinook Enhancement Study.
Responsible for research project designed to determine the best methods of enhancing the spring chinook salmon population in the Yakima Basin. Evaluate survival through various life stages and total production of naturally producing salmon. Determine methods of supplementation with hatchery reared fish while minimizing adverse genetic impacts.

Fast, D.E. 1987. The Behavior of salmonid alevins in response to light, velocity and dissolved oxygen during incubation.
Pages 84-92 in Salmonid Migration and Distribution Symposium (E.L. Brannon, ed.), School of Fisheries, University of Washington, and Directorate for Nature Management, Norway, Trondheim, Norway.

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Fast, D.E., J.D. Hubble, M.S.Kohn, and B.D.Watson. 1991. Yakima River Spring Chinook Enhancement Study. Project Completion Report to Bonneville Power Administration. Project 82-16. Volume 1 - 345 pp. and Volume 2 (Appendices) 133 pp.

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1978-1979:	Fisheries Biologist I, Washington Department of Game

1992:	M.S. Biology, Central Washington University
1978:	B.S. Fisheries, University of Washington

SELECTED PUBLICATIONS

Fast D., J. Hubble, M. Kohn, B. Watson. 1991. Yakima River Spring Chinook Enhancement Study, Final Report. Bonneville Power Administration, DOE/BP-39461-9.

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1984-1985:	Fisheries Biologist I, Alaska Dept. of Fish and Game, Susitna River Hydro Studies, Anchorage, AK.
1982-1984:	M.S., Fisheries Science, University of Alaska Southeast.
1974-1977:	B.S., Biology, University of Oregon.

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1983-1986:	Fisheries Biologist, US Army Corps of Engineers, Portland

1987:	B.S., Natural Resource Management, Colorado State University

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1981-1984:	Masters Program, University of Idaho (did not complete thesis).
1974-1976:	B.S. Zoology, University of Massachusetts.
1967-1971:	B.S. Psychology, Dartmouth College

SELECTED PUBLICATIONS

[Principal author of] YIN (Confederated Tribes and Bands of the Yakama Indian Nation). 1990. *Yakima River Subbasin Salmon and Steelhead Production Plan*. Prepared by the Confederated Tribes and Bands of the Yakama Indian Nation, Toppenish, WA; and Washington Department of Fisheries and Department of Wildlife, Olympia, WA; for the northwest Power Planning Council and Agencies and Indian Tribes of the Columbia Basin Fish and Wildlife Authority.

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1977-1981:	Ph.D.Genetics, University of California, Davis.
1975-1977:	M.S. Genetics, University of California, Davis.
1973-1975:	B.S. Genetics, University of California, Davis.

SELECTED PUBLICATIONS

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1990-1994:	Ph.D. Ecology, University of Tennessee.
1986-1989:	M.S. Wildlife and Fisheries Sciences, Texas A&M University.
1982-1986:	B.S. Wildlife and Fisheries Sciences, University of Tennessee.

SELECTED PUBLICATIONS

Ham, K. D., and T. N. Pearsons. Submitted. Can fish stocking be adaptively managed to limit impacts to native fish abundance? Canadian Journal of Fisheries and Aquatic Sciences.

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Selected Publications:

Knudsen, C.M. 1988. Bias and variation in stock composition estimates due to scale regeneration. American Fisheries Society Symposium 7:63-71.

Hoffmann, A., C. Busack and C. Knudsen. 1994. Experimental designs for testing differences in survival among salmonid populations. Report to Bonneville Power Administration, Contract No.DEAI79-93BP00029. 71 pp.

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1987-1989:	M.S., Fish & Wildlife Mgt., Montana State University
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SELECTED PUBLICATIONS

McMichael, G. A., A. L. Fritts, and T. N. Pearsons. 1998. Electrofishing injury to stream salmonids; injury assessment at the sample, reach, and stream scales. North American Journal of Fisheries Management 18:xx-xx.

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1989-1994:	Ph.D., Fisheries Science, Oregon State University
1986-1989:	M.S., Fisheries Science, Oregon State University
1981-1985:	B.S., Aquatic Biology, Univ. of California, Santa Barbara

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Pearsons, T.N., H.W. Li, and G.A. Lamberti. 1992. Influence of habitat complexity on resistance to flooding and resilience of stream fish assemblages. Transactions of the American Fisheries Society 121:427-436.

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1973-1981:	Ph.D., University of Washington
1971-1973:	M.S., University of Washington
1969:	B.S., University of Washington

SELECTED PUBLICATIONS

Volk, E.C., S.L. Scroder, J.J. Grimm, and S. Ackley. 1994. Use of bar code symbology to produce multiple thermally induced otolith marks. Trans. Am. Fish. Soc. 123:811-816.

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Maynard, D.J., T.A. Flagg, C.V.W. Mahnken, and S.L. Schroder. 1996. Natural rearing technologies for increasing post release survival of hatchery-reared salmon. Bull. Nat. Res. Inst. Aquacult., Suppl. 2:71-77.

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.

Section 10. Information/technology transfer

The technical information resulting from this project (and its component tasks) will be distributed in the following ways:

- A completion (annual) report will be submitted to Bonneville at the close of the fiscal (calendar) year and Bonneville will distribute copies to all individuals and agencies on its mailing list.
- Where appropriate, results from this project will be presented in papers in peer-reviewed journals and at professional meetings.
- Excerpted data will be appropriately formatted and submitted to the Northwest Aquatic Information Network (StreamNet) and made available to the public via the Internet.
- As an element of the YKFP, the objectives and findings of this project will also be entered into the YKFP home-page on the Internet. This home-page is currently under construction, and should be operational some time in 1999. The kind of information posted to the YKFP home-page will differ somewhat from that posted to StreamNet. Specifically, the YKFP Internet site will contain more detailed and site-specific information than that in StreamNet, which has a regional perspective and therefore aggregates data in standardized units of larger geographic scope. There will also be more different kinds of data posted to the YKFP site than can presently be accommodated by StreamNet.
- The results of this study will also be presented and critiqued in an annual workshop hosted by the YKFP, the "Project Annual Review". The Yakama Indian Nation can be contacted for abstracts of presentations made at this workshop.
- Information pertinent to monitoring natural production and ecological interactions of species targeted by the YKFP will be incorporated into the appropriate species' Monitoring Plan. A Monitoring Plan for upper Yakima spring chinook has already been written (Busack et al., 1997): monitoring plans for Yakima fall chinook and coho will be written in 1999.

Congratulations!