Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Yakima/Klickitat Monitoring And Evaluation Program

Bonneville project number, if an ongoing project 9506300

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

Business acronym (if appropriate) YIN

Proposal contact person or principal investigator:

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Subcontractors.

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Alden Labs, Inc.	30 Shrewsbury St.	Holden, MA 01520	Ned Taft

NPPC Program Measure Number(s) which this project addresses.

7.4K.1

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

Other planning document references.
Except for the Yakima Fisheries Project Final Environmental Impact Statement, which explicitly calls for this project on page 2/24; and the Yakima Fisheries Project Spring Chinook Supplementation Monitoring Plan (Busack et al, 1997), general or implicit endorsement may be found in the following documents:
1) Wy Kan Ush Me Wa Kush Wit, Vol 1: pp 5A-2; 5B-13 through 5B-12; Vol 2: pp57 &59.
2) the Yakima Subbasin Plan
3) Return to the River -- Restoration of Salmonid Fishes in the Columbia River Ecosystem: Chapter 2

Subbasin.
Yakima

Short description.
Monitors performance of YKFP in terms of natural production and harvest increases, and ecological and genetic impacts, to guide adaptive management within the project and to provide valuable information on supplementation for the region.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction	*	Watershed
*	Resident fish		O & M	*	Biodiversity/genetics
	Wildlife	*	Production	*	Population dynamics
	Oceans/estuaries	*	Research	*	Ecosystems
	Climate	X	Monitoring/eval.	*	Flow/survival
	Other	*	Resource mgmt	*	Fish disease
		*	Planning/admin.	X	Supplementation
			Enforcement		Wildlife habitat en-
			Acquisitions		hancement/restoration

Other keywords.
life history, modeling, predation, hatchery-wild interactions, ecological interactions, DNA, stock identification

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
8812001	Yakima/Klickitat Fisheries Project Management	Core Management/Admin. support for all YIN's YKFP Tasks.
8811500	Yakima Hatchery Construction	Final design/construction of needed acclimation facilities/wells for YFP.
9701300	Yakima Cle Elum Hatchery O&M	O&M costs for Cle Elum Suppl. and Research Facilities. Core facility
8811500	Fisheries Technician Field Activities	Provides essential technical support to fulfill diverse needs of the YKFP (e.g., M&E support, spawner surveys, juvenile facility operations, marking, etc.)
8812005	Fish Passage Video Monitoring	Monitors, at Prosser and Roza Dams, the number of adult salmonids returning to the Yakima Subbasin. A key element of YFP M&E.
9506404	Policy/Technical Involvement/Planning -- YKFP	Supports the required co-manager process for the YKFP.
9506406	Monitoring of Supplementation Response Variables for the YKFP	Essential for adequate M&E planning and technical participation as co-manager of the YKFP.
9506402	Upper Yakima Species Interaction Studies	Vital M&E function relative to impacts of YKFP on existing fish community in Yakima Subbasin, and relative to impacts of existing fish community on YKFP.
9503300	O&M of Yakima Fish Protection, Mitigation and Enhancement Facilities	Essential for maintaining effectiveness of Yakima Subbasin fish protection structures.
9704900	Teanaway Instream Flow Restoration	Tributary enhancement critical to success of YKFP.
0	Yakima River Basin Water	Irrigation water conserved by

	Enhancement Project (YRBWEP): Congressional Act.	YRBWEP may be allocated in part to benefit fish stocks analyzed by this planning/modeling project.

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Upgrade, maintain and test key monitoring facilities	a	Calibrate Chandler juvenile monitoring facility
		b	Install and maintain fish guidance system at Roza juvenile trap.
		c	Improve and maintain juvenile trapping equipment at Roza Dam
2	Evaluate reproductive success of hatchery fish relative to wild.	a	Maintain experimental spawning channles at Cle Elum Hatchery.
		b	Study reproductive success of wild spring chinook in experimental spawning channels.
3	Data Management and biometrical support	a	Fund a permanent project data manager to design and build a data management and dissemination system, including a project Home Page on the Internet.
		b	Retain half-time services of PhD-level biometrician to assist with power analyses of monitoring tasks and data analysis.
4	Establish genetic baseline for supplemented upper Yakima spring chinook	a	Generate allozyme allele frequency profile for 1998 upper Yakima broodstock.
		b	Generate DNA microsatellite profile for 1998 upper Yakima broodstock.
		c	Age all broodstock by scale analysis.
5	Establish pathogen baseline in wild spring chionook prior to introduction of hatchery fish.	a	Screen approximately 200 wild smolts for pathogens according to standard USFWS protocols.
6	Compare the performance of juvenile Optimal Conventional Treatment (OCT) and Semi-	a	Compare survival of PIT-tagged OCT/SNT/wild smolts from release point and/or Roza Dam (on

	Natural Treatment (SNT) and wild fish relative to each other and wild fish in terms of survival and phenotypic traits strongly linked to survival.		the upper Yakima) to the Chandler juvenile facility (on the lower Yakima) and to all mainstem Columbia Dams equipped with PIT-tag detectors.
		b	Compare OCT/SNT/wild fish in terms of morphometrics and cryptic coloration.
		c	Compare OCT/SNT/wild fish in terms of physiology.
		d	Compare OCT/SNT/wild fish in terms of behavior (predator avoidance ability, agonistic behavior, etc.)
7	Investigate direct and indirect predatory impacts of hatchery smolts on non-target species; and the predatory impact of non-target species on hatchery and wild chinook and coho.	a	Estimate the impacts hatchery smolt releases have on the survival of wild smolts, and whether survival is related to indirect predation.
		b	Develop field methods for calculating a predation index for birds and predatory fish on juvenile spring chinook.
		c	Estimate the predation impact of hatchery coho smolts on wild fall chinook.
8	Quantify the effects of key environmental variables to discriminate between the effects of intrinsic and extrinsic factors in limiting the success of supplementation.	a	Measure environmental variables via analysis of aerial videography and use of existing hydrological data, correlate with annual estimates of productivity, and statistically "filter out" impacts due to environmental fluctuations.
		b	Estimate impacts of environmental and harvest-related factors occurring outside the Yakima Subbasin on spring chinook production in the Yakima.
		c	Monitor the effect of stream sediment loads on survival and productivity of upper Yakima spring chinook.
9	Investigate the impact of inter-	a	Generate baseline prey abundance

	and intra-specific ecological interactions on success of supplementation.		indeces for spring chinook.
		b	Generate baseline competition indeces (space and food) between spring chinook and redside shiners, rainbow trout and mountain whitefish.
		c	Estimate baseline microhabitat utilization patterns for juvenile spring chinook in the upper Yakima.
		e	Estimate the baseline abundance of residual and precocial spring chinook.
10	Estimate the benefits to productivity and survival of wild spring chinook populations of fertilizing selected stream segments with salmon carcasses.	a	Compare growth and survival of selected wild spring chinook populations before and after carcass fertilization.
		b	Determine decay rates of carcasses and utilization of carcasses by invertebrates and juvenile fish
		c	Develop cost-effective methods of sterilizing carcasses to prevent disease transmission.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	1/1999	12/1999	36.10%
2	1/1999	12/1999	4.40%
3	1/1999	12/1999	10.70%
4	1/1999	12/1999	1.80%
5	1/1999	12/1999	0.60%
6	1/1999	12/1999	15.20%
7	1/1999	12/1999	20.30%
8	1/1999	12/1999	6.90%
9	1/1999	12/1999	2.70%
10	1/1999	12/1999	1.40%
			TOTAL 100.10%

Schedule constraints.
Many 1999 studies are contingent primarily on successful completion of preparatory facility work in 1998.

Completion date.
This project will be monitored indefinitely, but some elements may be dropped or reduced in intensity as understanding/resolution occurs.

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		467336
Fringe benefits		67628
Supplies, materials, non-expendable property		140127
Operations & maintenance		3526
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		221100
PIT tags	# of tags: 37,092	107566
Travel		7828
Indirect costs		248547
Subcontracts		112479
Other	Electrophoretic stock analysis of smolts	$27,765
TOTAL		$1,403,902

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$892,900	$827,900	$777,900	$777,900
O&M as % of total	1.00%	1.00%	1.00%	1.00%

Section 6. Abstract

Supplementation is a key feature of the *1994 Fish and Wildlife Program*. This project is part of a long-term comprehensive effort to monitor the performance of a large supplementation program, the YKFP, in terms of four basic elements of the ecology of anadromous salmonids: natural production, harvest, genetics and ecological interactions. For each of these four elements ,we propose empirical studies that will have been subjected to rigorous power analysis before implementation. Results of these studies will both guide adaptive management within the project and assist other fisheries managers

throughout the Region in developing effective supplementation programs. The expected outcomes of this work and related YKFP projects are to demonstrate rigorously: 1) success or failure to increase natural production and harvest opportunity; 2) unacceptable impacts to nontarget species; 3) whether supplementation success or failure is attributable to intrinsic factors (those directly controllable by project managers) or extrinsic factors (those outside the control of project managers); 4) the performance of semi-naturally versus conventionally reared smolts. Natural production will be monitored ultimately at the level of natural origin recruits as well as the component levels of egg-fry, fry-smolt, smolt-adult survival. Maintenance of genetic resources will be monitored by DNA and/or allozyme profiling. Project impacts on nontarget species will be monitored by comparing pre- and post-supplementation stock status (size, age structure and geographic distribution of populations). Impacts of nontarget species on project fish will be monitored by generating indices of impacts from five classes of strong interactors: predators, pathogens, competitors, mutualists, and prey.

Section 7. Project description

a. Technical and/or scientific background.

Supplementation is a cornerstone of efforts to rebuild runs of anadromous salmonids throughout the Pacific Northwest, but particularly in the Columbia Basin (RASP 1992; NPPC, 1994; CRITFC, 1995). However, there are concerns that supplementation will not work because of a number of factors, including: 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 dimished primary and secondary productivity attributable to the removal of removing salmon carcassess from streams which they would otherwise fertilize (Bilby et al, 1996).

This project is a component of an overall monitoring framework addressing all of the preceding risks as they affect spring chinook supplementation in the upper Yakima (Busack et al., 1997). Although the scope of this project is too broad to summarize in ten pages (see Busack et al., 1997, for a detailed description), it should be pointed out that particular attention is paid to:

- smolt-adult survival, including a test of semi-natural versus conventional rearing, and estimating relative hatchery/wild smolt survival through the Yakima and Columbia basins;
- comparative reproductive success of wild and hatchery fish as monitored by controlled spawning in test arenas and observations of spawning behavior in the wild; and
- ecological interactions, including predatory and competitive impacts of nontarget species on spring chinook, and of hatchery spring chinook on nontarget species.

Although monitoring and evaluation funding has been budgeted for the YKFP for several years, substantive monitoring work did not begin until 1997 (when the first broodstock were collected). This project is expected to be fully implemented in 1998, with an emphasis on preparing facilities for the first smolt release in 1999.

This project 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), and this project represents the implementation of most of that plan. Other efforts that have contributed to the evolution of the Monitoring Plan 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, 1998 *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).

b. Proposal objectives.

This project includes 24 separate monitoring tasks, each with its own unique objectives, hypotheses and assumptions. In an attempt to compress a methodological description into the allotted space, we have lumped these tasks operationally into 12 "subprojects", and present objectives for them below:

SUBPROJECT	OBJECTIVES	HYPOTHESES	PRODUCT(S)
1) Monitoring Facilities	1.1) To develop procedures to estimate stock-specific smolt passage with high accuracy at Chandler smolt trap in the lower Yakima. 1.2) To install an optimal smolt guidance system for Roza juvenile trap. 1.3) To improve the efficiency and safety of the juvenile collection system at Roza Dam.	a) A temporally stable relationship exists between smolt entrainment and measurable hydraulic variables at Prosser Dam, and stock-specific proportions of smolt outmigrants can accurately be estimated by electrophoretic techniques. b) 1998 evaluations will identify an effective guidance system. c) The existing collection system can be retrofitted to meet our needs for collecting hatchery and wild smolts for comparative survival studies.	A detailed protocol for describing confidence intervals about stock-specific passage estimates (current and historical) published in (at least) a BPA report. A system allowing safe capture substantial numbers of smolts over a brief period. A fully functional and efficient smolt/juvenile collection facility.

SUBPROJECT	OBJECTIVES	HYPOTHESES	PRODUCT(S)
2) Reproductive Success Studies	2.1) To evaluate relative hatchery/wild reproductive success in a controlled setting.	a) Behavior in a controlled setting represents behavior in the wild. b) H_0: no difference between hatchery and wild reproductive success.	A report on relative reproductive success published (at least) under BPA cover.
3) Data Management	3.1)To design, install and maintain an efficient data management and dissemination system, including an Internet Home Page.	Volume of project data requires a dedicated database manager to ensure security and timely availability to all users.	A secure and efficient data management and dissemination system and Home Page.
4)Biometrical Support	4.1)To complete power analyses of spring chinook monitoring protocols and to provide biometrical support for data analysis.	Size of project staff is inadequate to complete all statistical analyses when needed.	A complete set of power analyses for all elements of the Monitoring Plan, published (at least) under BPA cover.
5)Genetic Baseline Information	5.1)To establish baseline (pre-supplementation) allele frequency profiles for upper Yakima spring chinook.	Pertinent measures of genetic change will be discernable from changes in allele frequency over time.	A pre-supplementation allele frequency baseline against which a future, post-supplementation population may be compared, published (at least) under BPA cover.
6)Development of Pathogen Incidence Baseline in wild fish.	6.1)To establish baseline (pre-supplementation) pathogen incidence in wild upper Yakima spring chinook adults and smolts.	H_0: the incidence of fish carrying pathogens will not differ between pre- and post-supplementation eras.	A pre-supplementation pathogen incidence baseline against which a future, post-supplementation population may be compared, published (at least) under BPA cover.
7)Comparative OCT/SNT/wild smolt characteristics.	7.1)Identification of differences among OCT, SNT and wild smolts in terms of survival and morphological, physiological and behavioral characteristics strongly linked to survival.	H_0: There will be no differences between treatment groups in these areas.	A report published (at least under BPA cover) detailing differences in survival-linked characteristics between treatment groups.
8)Predation Studies	8.1) To estimate the indirect, impacts hatchery smolt releases have on wild smolts, and whether any impact is related to indirect predation. 8.2) To develop field methods for developing a bird predation index on juvenile spring chinook. 8.3) To estimate the existence and significance of direct predation by hatchery coho smolts on wild Yakima juvenile chinook. 8.4) To allow the YIN to	a) H_0: wild smolt survival does not differ between wild smolts released in the presence or absence of hatchery smolts. b) Avian predators are capable of significantly depressing spring chinook production and simple and accurate methods of indexing avian predation across years can be developed. c) H_0: Predation by hatchery coho does not pose a significant threat to juvenile chinook.	Reports, published at least under BPA cover, will be written covering the results of indirect predation studies, the development of an avian and fish predation index and the significance of predation by hatchery coho releases on juvenile chinook. Significant findings will be reflected in monitoring plans and/or release strategies (adaptive management).

SUBPROJECT	OBJECTIVES	HYPOTHESES	PRODUCT(S)
	collaborate with WDFW in efforts to develop an index of the impact of piscivorous fish on spring chinook juveniles.	d) Piscivorous nonsalmonid fish are capable of significantly depessing spring chinook production, and simple and accurate methods of indexing their impact across years can be developed.	
9)Quantifying Key Environmental Variables	9.1) Measure key environmental variables by analyzing data obtained through aerial videography and an existing hydrological database. 9.2) Obtain and utilize information affecting spring chinook recruitment from areas outside the Yakima Subbasin. 9.3) Assess impact of anthropogenic sediment loading on spring chinook production/productivity.	a) A significant proportion of the interannual variability in spring chinook productivity is attributable to fluctuations in key environmental factors inside the subbasin that can be measured by aerial videography and hydrological data. b) Environmental and anthropogenic factors outside the subbasin significantly affect spring chinook productivity. c) Anthropogenic sediment loading within the Yakima Subbasin is both relatively frequent and an important determinant of interannual productivity.	Besides BPA reports, these projects will result primarily in the development of procedures to assess the impact of these kinds of extrinsic factors on spring chinook production under supplementation.
10)Interaction Indices	10.1) Estimate indices of baseline prey abundance/availability for upper Yakima spring chinook. 10.2) Estimate baseline competition (space and food) indices between spring chinook and redside shiner, mountain whitefish and rainbow trout. 10.3) Estimate baseline microhabitat utilization of juvenile upper Yakima spring chinook .	Supplementation can be successful in the Yakima only if current spring chinook abundances are not near carrying capacity. Changes in prey abundance, level of competitive impacts, and microhabitat utilization with supplementation will reflect spring chinook seeding in the upper Yakima. Competitive impacts are an important extrinsic consideration apart from their relationship to carrying capacity.	Besides BPA reports, these projects will result primarily in the development of procedures to assess the impact of these kinds of extrinsic factors on spring chinook production under supplementation.
11)Precocial/Residual Monitoring	11.1)Estimate the baseline abundance of residual and precocial spring chinook juveniles and determine necessary sampling effort for long-term monitoring following supplementation.	H_0: Supplementation will not increase the abundance of precocial and residual spring chinook.	A pre-supplementation precocial/residual incidence baseline against which a future, post-supplementation population may be compared, published (at least) under BPA cover.
12)Trophic Enhancement	12.1)To determine whether and how salmon carcasses can be used to fertilize	A lack of nutrients in certain upper Yakima subbasin streams due to an	A report (at least) under BPA cover, and trophic enhancement strategies

SUBPROJECT	OBJECTIVES	HYPOTHESES	PRODUCT(S)
	nutrient-deficient streams in the Yakima subbasin.	insufficient number of salmon carcasses significantly depresses primary and secondary production	complementary to supplementation.

c. 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 project was developed (Busack et al., 1997), which addresses all of the objectives and tasks in this project and a number of allied projects. Project scientists believe the YKFP is unique in having been designed to test the efficacy of supplementation. Results will be used to optimize project operation, but are also intended to have Basin- and Region-wide significance.

The cooperating fishery managers on the YKFP are the Yakama Indian Nation (lead agency) and the Washington Department of Fish and Wildlife. A project management framework stipulates that project management is directed by a Policy Group, consisting of representatives of the fishery managers. The US Bureau of Reclamation is an interested party in the basin, and operates several monitoring facilities. BPA is the funding entity, and has the lead responsibility for NEPA document development and compliance.

d. Project history

Work on this project began in 1997. No reports on work completed have been written (although one – Neeley, 1998 -- is in preparation). Four major efforts were funded: outfitting of Roza adult trap for adult monitoring (cameras, balance, etc.), Chandler calibration/certification, coho predation on fall chinook, and a predator census. The total spent was approximately $606,000.

Summary of major results:

Chandler certification- logistic regression of old and new data lead to the development of a greatly improved diversion-entrainment relationship, and advances were made in estimating survival in Chandler canal.

Coho predation on fall chinook- coho proved very difficult to catch in the open river (possibly due to unusually high flows). Very little evidence of fish predation was seen, and virtually all that was seen occurred in irrigation bypasses rather than the main river. Fish collected in guts have not yet been identified to species, but the size distribution suggests very few, if any, of the fish consumed by coho were chinook.

Fish predator census- small (25cm) smallmouth bass proved to be surprisingly abundant in the lower Yakima River, and in the extreme lower reaches channel catfish were also very abundant. Bigmouth minnows occurred at much lower frequency than expected.

Adaptive management implications:

These results are really too preliminary to have adaptive management implications, but assuming that future work supports the current results, there are three important management implications. First, the Chandler facility may be a very useful facility for enumerating smolts, in contrast to earlier opinions. Second, the impact of coho predation on fall chinook may be within acceptable limits. Third, nonnative predatory fish may pose a higher risk to native anadromous salmonids than was previously believed.

e. Methods.

OBJ.	METHOD
1.1	Replicate releases of tagged smolts will be used to make a series of entrainment rate estimates, and a subsample of ~600 fish will be sacrificed for genetic stock identification work. The entrainment rate estimates will be used in concert with a suite of hydraulic variables to generate a multi-variate smolt passage relationship which will then be used to estimate future and historical passage estimates with confidence intervals. Sample sizes (80 fish/release/site) were determined via power analysis of expected recovery rates at McNary Dam. Analysis will be by logistic regression (Neeley 1998). The main factor potentially limiting success is the variability of stock-specific proportions as assessed by electrophoretic stock analysis.
1.2	An optimal fish guidance system (strobe lights or infrasound), designed in 1998 on the basis of research by Alden Labs, will be installed. The system is expected to be capable of collecting ~2000 wild and hatchery smolts over a 3-4 day period, to limit potential impacts on outmigrants. The main factor potentially limiting success is the number of wild smolts available at this mid-river collection point in the spring.
2.1	DNA-typed wild spring chinook adults collected at Roza Dam will be disk-tagged and placed into one of the spawning channels at Cle Elum. Data on the reproductive behavior of individual wild Yakima spring chinook will be collected. Reproductive success will be estimated by trapping post-emergent fry and identifying their parentage. This will then provide an estimate of the number of progeny produced by each spawning male and female. Sample sizes will be determined by 1998 power analyses. Analysis will be by ANOVA. The main factor potentially limiting success is the comparability of natural spawning areas with the experimental arena.
3.1	The purpose of this item is to develop an effective data management and dissemination capability. A large portion of this goal would be accomplished by the hiring of a dedicated Data Manager. During the prefacility years of the project, a large amount of data was collected on the fish and physical habitat, and as the monitoring effort gets underway, much more will become available. These data need to be organized into databases for ease of access and protection. But there is already too much to handle without dedicated help. The data manager will design and do the necessary programming for a data management system. He/she will also work with the STREAMNET staff to develop a project homepage on the Internet for simplifying data transfer among the technical staff, and to the public. Barring loss of funding, there are no plausible threats to success in this task.

OBJ.	METHOD
4.1	The funds requested under this item will be used to procure the services of a half-time PH.D. level biometrician for the project. Dedicated biometrical support is required for four reasons: 1) there are a large number of monitoring measures proposed in the monitoring plan that require power analyses to evaluate feasibility and sample size requirements, and the existing staff is too small to get the power analyses completed for timely implementation of the measures, 2) several of these measures will involved sophisticated experimental design beyond the statistical expertise of the existing staff, 3) the existing staff is too small to do all the statistical analysis required by the monitoring effort, and 4) a professional biometricican will provide the level of statistical quality and experimental design quality control that a project of this size and importance requires. Barring loss of funding and monitoring tasks entailing unrealistic effort levels, there are no plausible threats to success in this task.
5.1	Tissues from spawners (approx. 220 fish) will be analyzed according to standard allozyme WDFW protocols 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. Tissues from the same spawners will also be analyzed for microsatellite allele variability 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 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 eventually supplant allozyme-based assessments of genetic variability and stock identification, and a fair possibility that it will allow monitoring of the performance/fitness of distinct pedigrees. Comparison of allele frequency profiles from different time strata will be analyzed by log-likelihood ratio tests. Acetate impressions of mounted scales from the same spawners will be viewed with a micro-fiche reader and assigned an age. The work will be done according to standard WDFW protocols at the WDFW Scale Lab. 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, ageing the broodstock scales samples collected at the time of trapping will provide a baseline and be used to augment the biochemical genetic data. Barring funding loss, there are no plausible threats to success for the allozyme and ageing tasks. The major threat to stock identification and pedigree analysis based on DNA microsatellite frequencies is a lack of variability in microsatellite alleles.
6.1	Approximately 200 late-run smolts will be fully screened according to standard USFWS protocols at a USFWS fish health lab. This work will utilize the same fish collected for ongoing Chandler Smolt Trap calibration work. Inferential statistics are not applicable at this point. There do not appear to be any plausible threats to the success of this task.
7.1	Relative hatchery/wild smolt survival will be estimated by making four paired releases of pit-tagged hatchery and wild fish at Roza dam each spring. Survival will be estimated by relative group passage at Chandler and by relative interrogation rates of well-mixed groups of hatchery and wild fish at mainstem Columbia interrogation facilities. Based on power analysis and assumed interrogation rates, each release group should consist of 1000 fish. To minimize adverse impacts on outmigrants, collection periods for test fish will span no more than 4 days, and will make use of the fish guidance system at Roza described previously (1.2). Statistical analysis will be by t-test. The major potential threats to this study would be an inability to collect sufficient wild smolts at Roza Dam, and the failure of wild and hatchery groups to remain well-mixed as they pass Columbia River PIT-tag interrogation facilities. Behavior of hatchery and wild juveniles with respect to predator avoidance and perhaps agonistic behaviors will be compared in a test arena to be constructed at Cle Elum hatchery in 1998. The complete suite of behaviors to be examined, required sample sizes, and appropriate statistical methods will be determined by pilot studies in 1998. It would be premature to identify major potential threats to success inadvance of the pilot study. Juvenile morphometric and body coloration comparison will be made using digitized 35 mm slides of juvenile fish. The digital images will be measured using image processing software and the data analyzed using ANOVA, linear discriminate and/or principle component analysis. Barring loss of funding, no plausible threats to the success of this task are apparent. Physiological comparisons of OCT and SNT groups will be made by Walt Dickhoff's NMFS lab with costs covered under an existing NMFS budget. OCT and SNT groups (approximately 250 each) will be sampled over time beginning at Cle Elum and continuing at the acclimation sites through volitional release. A suite of physiological parameters will be compared between groups. Statistical analysis will

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	be by ANOVA. No plausible threats to the success of this task are apparent.
8.1	The release of hatchery smolts may enhance or decrease the survival of wild 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, or "shield" wild fish, resulting in enhanced survival of wild fish. To investigate this interaction, survival rates of PIT- tagged wild salmonid will be compared in the presence and absence of large releases of hatchery coho, hatchery fall chinook and hatchery spring chinook during the spring of 1999. 200 wild fish will be used in each test and control release, and test releases will be associated with groups of at least 100,000 hatchery smolts. Relative survival will be estimated by the ratio of test to contol group passage at Chandler and by relative test/control passage indices and/or relative interrogation rates (if groups are well-mixed) at McNary Dam. Statistical analysis will be by t-test. The major potential threat to this task is that an impact occurs below Chandler (and is therefore not detectable at Chandler), that test and control groups are not well-mixed at McNary, and that the McNary smolt passage index is not directly proportional to true passage.
8.2	The loss of wild spring chinook salmon juveniles to various types of birds could limit the success of supplementation. The proposed index will consist of two main components; 1) an index of bird abundance and 2) an index of consumption. An index will be calculated for each major bird predator. Feasibility and methods will have been determined by pilot studies in 1998. Piscivorous birds will be counted from either an inflatable raft, drift boat, 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) may be evaluated using behavioral observations and those that swallow their prey underwater (e.g., merganser) may be evaluated using direct methods such as stomach content examination. Required sample sizes and appropriate statistical methods will be determined by the 1998 pilot studies. It would be premature to identify major potential threats to success in advance of the pilot study.
8.3	Outmigrating hatchery coho smolts will be collected both in the open river and in the Chandler Canal and smolt trap. Open-river collections will be made as much as possible in the vicinity of known fall chinook spawning areas. The gut contents of the collected coho will be examined for recognizeable chinook or diagnostic chinook bones. From this data estimates of the proportion of coho consuming fall chinook will be made and compared with a maximum allowable proportion. Based upon power analysis (Type II error =0.2, Type I error =0.05, and an effect size of half the permissible proportion) 12,500 coho will have to be collected and analyzed above Prosser dam, and 5,000 below. Significance will be assessed by cumputing cumulative Poisson probability for X chinook-predatory coho in a sample of Y coho.
8.4	The loss of wild spring chinook salmon juveniles to various types of nonsalmonid predatory fish could limit the success of supplementation. The proposed index will consist of two main components; 1) an index of the abundance of predatory fish and 2) an index of consumption. An index will be calculated for each major predator fish. Feasibility and methods will have been determined by pilot studies in 1998. Piscivorous fish will be enumerated by mark-recapture techniques in representative reaches of the lower Yakima. Shortly after or during censuses a consumption index will be developed. Consumption of chinook juveniles will be estimated by gastric lavage and by excising and examining the stomach. The terms of a predation index for fish are predator density at a specified site or over a specified length of stream, 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:$CI=0.0209(T)^{1.60}(W)^{0.27}(S{\cdot}GW^{-0.61})$ Required sample sizes and appropriate statistical methods will be determined by the 1998 pilot studies. It would be premature to identify major potential threats to success in advance of the 1998 pilot study.
9.1	Aerial videos of the Yakima River system will be made and analyzed. The habitat conditions inferred from the videos will be checked by "ground truthing" -- dispatching crews of technicians to specific areas to verify that conditions are in fact as they appear on video. Some of the major habitat parameters to be examined videographically include: location of upwelling/thermal refuge areas (FLIR flights), number of hydraulically connected side channels by season and river stage, riparian conditions, and wetted surface area by reach and season. This data will be combined with an existing, historical database on riverflow, mean daily water temperature/cumulative seasonal thermal units and irrigation diversion rates, and these

OBJ.	METHOD
	environmental variables will be used as candidate independent variables for a multiple regression on annual/brood year productivity estimates (denisty-independent survival for egg-to-smolt survival and adult recruitment rate). A stepwise multiple regression will be performed to determine which combination of variables best predict productivity, and an ANOVA of residuals from this regression across supplemented/unsupplemented years/broods will reveal environmental impacts on the performance of the stock (see Busack et al., 1997 for further details). The major potential threat to the success of this approach is probably the large amount of variability in both enironmental and productivity data, and the possibility of falsely identifying key environmetal factors because of a few extreme points.
9.2	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 Yakima River spring chinook. The major threats to this task are the same as those identified in Objective 9.1.
9.3	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 different life stages of spring chinook. These impacts would be incorporated in analyses of impacts of extrinsic factors on natural production. The amount of sampling to be done is yet to be determined, pending power analysis. The statistical methodology is yet to be finalized, but will probably involve multiple regression. The major potential threat to this task is that significant events will go undetected.
10.1	The abundance of prey may limit the number of spring chinook salmon juveniles that can be produced in the upper Yakima basin. In order to monitor this possibility, the availability of prey will be assessed by examining the stomach fullness of spring chinook parr during the summer and fall in three index areas. 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 plenty of food is available and that it is not currently limiting spring chinook salmon production. Sample sizes are yet to be determined, pending power analysis. Statistical analysis will probably involve ANOVA.
10.2	A space index will be determined by comparing the frequency with which chinook salmon and competitor species are observed within 30 cm of each other, with the abundance of a competitor species. Snorkelers will drift downstream in the mainstem and move upstream in side channels counting all species as they are encountered. High spatial overlap and competitor abundance will suggest that competition is occurring. Optimal methods of statistical analysis have not been definitively determined, but may involve regression of space indices on spring chinok abundance (brood year escapement/redd deposition by reach). The major potential threat to the success of this task is that high flows and turbidity will seriously limit the effectiveness of observation by snorkling.
10.3	Under excessive densities, a significant proportion of spring chinook parr might be displaced into sub-optimal microhabitats. Accordingly, we will monitor the relative incidence of early spring chinook 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 then measure the physical parameters of the focal position. The complete sampling design is yet to be finalized, pending power analysis. Statistical methodology has yet to be determined, but will probably involve regression (proportion spring chinook in atypical microhabitat as a function of brood year escapement/redd deposition by reach) and chi-square (observations in "r" microhabitat classes under "c" abundance conditions) analysis. The major potential threat to this task is the same as 10.2.
11.1	*Residuals* - Snorkeling will be conducted in index areas to determine the abundance of spring chinook salmon that did not migrate as age 1+ smolts. Attempts will be made to collect scales from some of these fish to determine if they are age 2+. In addition, these fish will be examined to determine if their gonads are developing prematurely. Sampling and statistical methodology are yet to be finalized, pending 1998 power analyses. The major potential threat to this task is the same as 10.2. *Precocials* - To assess whether supplementation strategies increase the abundance of precocially mature spring chinook, snorkelers will count the number of precocial spring chinook salmon on active spring chinook salmon redds within index areas. Results from 1998 sampling will be the basis for determining the sampling effort necessary for long term monitoring of precocials following supplementation. Sampling and statistical methodology are yet to be finalized, pending 1998 power analyses. The major potential threat to this task is the same as 10.2.
12.1	Fall chinook carcasses from the Priest Rapids Hatchery will be "outplanted" in nutrient-deficient streams and tributaries. The fish will 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

OBJ.	METHOD
	survival rates of juvenile fish) will 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 will be earmarked for carcass "sterilization", perhaps using gamma ray irradiation. The number of carcasses to be outplanted, as well as the number and kind of recipient streams and statistical methodology will be determined during 1998 power analyses. The major potentiasl threat to the success of this task may be the inability to develop a cost-effective method of sterilizing the carcasses.

f. Facilities and equipment.

It is probable that anadromous salmonids in theYakima Subbasin already can be more thoroughly monitored than in any other river in the Pacific Northwest. Full implementation of this project will increase monitoring power even further. Adults are enumerated videographically at ProsserDam in the lower Yakima, as well as Roza Dam on the middle Yakima, where 100% of the run passes up a ladder and down a flume in an adult collection facility. Therefore, at Roza, the opportunity exists to monitor all upper Yakima hatchery and wild adults intrusively, as for marks that cannot be detected on video. 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 a 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 five 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 where particular circumstances warrant. Undeveloped but potential adult and smolt monitoring facilities also exist at Horn Rapids Dam on the extreme lower Yakima, Easton Dam on the extreme upper Yakima, and Wapatox Dam on the lower Naches.

Two of the tasks in this project would substantially increase monitoring power in the Yakima. The first involves the installation of a strobe light and/or infrasound smolt guidance system at Roza Dam which can be turned on and off at will. This system would cause the temporary diversion of a substantial proportion of outmigrants into the headworks of Roza Canal and the Roza Dam juvenile trap. In turn, this would permit the release of large numbers of PIT-tagged, hatchery and wild fish of upper Yakima stock, allowing the estimation of relative wild/hatchery survival to Chandler and Columbia River interrogation stations. The second involves the construction of two large artificial spawning channels at the Cle Elum Hatchery site. These spawning channels would allow reproductive success of hatchery and wild adults to be compared rigorously.

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 electrophoretic and 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.

The YKFP's only equipment deficiencies would be eliminated if this project is funded. Specifically, a minor part of Objective 3.1 would provide for the purchase of several

faster, higher-RAM computers for key personnel curently working with les powerful machines. Somehat more significantly, a portion of Objectives 8.3 and 8.4 would provide for the purchase of two boats (a jet sled and engine and a drift boat) and two boat-mounted electrofishing units. This equipment, in addition to the two electrofishing boats the project already has, would dramatically improve the ability to collect fish intensively during rapid outmigrations, and would virtually eliminate down-time associated with equipment failure.

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Section 8. Relationships to other projects

This project and the following six other FWP projects fully implement the Yakima Fisheries Project Spring Chinook Supplementation Monitoring Plan (submitted as an appendix).

Project 5507700, "Monitoring of Supplementatio Response Variables for the YKFP". This project addesses WDFW participation in spawning activities at the Cle Elum Hatchery, predictive modeling (probability of moving toward significantly increased natural production), spawning behavior observations (wild fish in the Yakima), and an experimental assessment of sex-specific gamete quality.

Project 9506402, "Upper Yakima Species Interaction Studies". This project addresses determination of baseline status of non-target species of concern, monitors potential impacts to baseline status attributable to supplementation and provides for WDFW participation in development of a piscivorous fish predation index.

Project 5522100, "Development and Refinement of Natural Production Objectives and Enhancement Strategies". This project diagnoses the causes of existing constraints on production and develops initial enhanceent strategies and objectives, for upper Yakima spring chinook and all other species and stocks potential targeted by the YKFP in the future.

Project 8812005, "Fish Passage Video Monitoring". This project is responsible for estimating adult passage by analyzing videos shot through observation windows in fish ladders at Prosser and Roza Dams.

Project 8812008, "Fish Technician Field Activities". This project provides for YIN fisheries technicians to assist in virtually all elements of monitoring, including assistance

with data management, routine Chandler operations, operating Roza adult trap, spawner surveys, harvest monitoring and participation in monitoring the status of nontarget species of concern.

An project of vital importance to the YKFP is project 8811500, "Yakima Hatchery – Construction". Although the Cle Elum hatchery per se has already been built and is in operation, the three clusters of *acclimation ponds* have not been built. ***Without off-site acclimation ponds, the YKFP ceases to be a supplementation project***.

Project 8812004, "Hatchery Training and Education". This project funds the education and on-the-job training of tribal individuals needed to operate fish cultural facilities and participate in monitoring and research.

Projects 8812001 ("Yakima/Klickitat Fisheries Project Management") and 9506404 ("Policy/Technical Involvement and Planning for the YKFP") provide essential funding for policy-level managers from, respectively, the YIN and WDFW.

The following twelve projects, while not directly related to monitoring, nevertheless complement and/or enhance prospects for upper Yakima spring chinook supplementation.

Project 9405900, "Yakima Basin Environmental Education". This project trains middle and high school science teachers in the Yakima Valley in stream and salmon ecology. Over time, and with the education of a substantial proportion of young people in the valley, it is hoped that this project will result in better land and water use practices.

Project 5510200, "Yakima River Basin Side Channel Survey and Rehabilitation". This project attempts to correct one of the most serious environmental problems in the upper Yaklima: the lack of fry rearing habitat provided by side channels. Projects 5511300, 5511600, and 5511700 are intended to accomplish the same thing in other portions of the Yakima Subbasin.

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.

Project 9701300, "Yakima River Cle Elum Hatchery O&M", provides for the obviously essential operation and maintenance of the Cle Elum Hatchery.

Finally, projects 9105700, 9107500, 9209900 and 9503300 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.

Section 9. Key personnel

Name (alphabetically within agency)	Title	Agency	FTE (mos.)	Expertise/Role
Bruce Watson	Information Specialist	YIN	12	Survival/recruitment studies; population modeling (EDT); habitat/productivity studies.
Mark Johnston	Field Crew Supervisor	YIN	12	Supervision of all monitoring facilities and (YIN) field studies.
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.
John McConnaughey	Fish Biologist	YIN	12	Analysis of Chandler data; predation studies.
Craig Busack	Research Scientist	WDFW	2.0	Genetic studies; population modelling; general power analysis
Kenneth Ham	Fish Biologist	WDFW	2.0	Ecological interaction studies; ecological power analysis
Curt Knudsen	Fish Biologist	WDFW	2.0	Reproductive success studies; semi-natural rearing stuides; general power analysis; marking methodologies
Geoff McMichael	Fish Biologist	WDFW	4.0	Ecological interaction studies
Todd Pearsons	Fish Biologist	WDFW	4.0	Ecological interaction studies
Steve Schroder	Research Scientist	WDFW	2.0	Reproductive success studies; semi-natural rearing stuides; fish marking

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BACKGROUND

1984-present:	Fisheries Biologist/information specialist, Yakama Indian Nation.
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 theYakama 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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Lichatowich, J. And B. Watson. 1993. Use of artificial propagation and supplementation for rebuilding salmon stocks listed under the Endangered Species Act. Bonneville Power Administration, Portland, OR.

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BACKGROUND

1997-present: Fisheries Biologist, Yakama Indian Nation, Toppenish, Washington.

1996-1997: Fisheries Biologist, US Forest Service, Coeur d' Alene Idaho.

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.

DAVID E. FAST

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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.

Fast, D.E., J.D. Hubble, T.B. Scribner, M.V. Johnston, W.R. Sharp.
1989. Yakima/Klickitat Natural Production and Enhancement Program. 1989 Annual Report to Bonneville Power Administration. Project 88-120. 107 pp.

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1997-present:	Fisheries Biologist, Yakama Indian Nation.
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1999-1992:	Research Analyst II, Alaska Dept. of Fish and Game, Division of Commercial Fisheries, juneau, AK.

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

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1988-present:	Research Scientist, Washignton Department of Fish and Wildlife (until 1994 Washington Department of Fisheries)
1983-1988:	Assistant Professorof Biology, University of Mississippi.
1981-1983:	NSERC Visiting Postdoctoral Fellowship, PacificBiological Station, Nanaimo, British Columbia.
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

Busack, C. 1990. Yakima/Klickitat Production Project genetic risk assessment. In Yakima/Klickitat Production Project Preliminary Design Report, Appendix A. Bonneville Power Administration, DOE/BP-00245-2.

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

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

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1996-present:	Fish and Wildlife Biologist, Washington Department of Fish and Wildlife
1994-1996:	Oak Ridge National Laboratory Postdoctoral Research Associate, Oak Ridge Associated Universities, Oak Ridge, Tennessee.
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., K.O. Winemiller, and K.A. Rose. submitted. Distribution of Life History Strategies in Northern Lake Fish Communities.

Adams, S.M.,K.D. Ham, and R.F. LeHew. In press. A framework for evaluating organism responses to multiple stressors: mechanisms of effect and importance of modifying ecological factors. In: J.J. Cech and B.W. Wilson (eds.), Multiple Stresses in Ecosystems. Lewis Publishers, Boca Raton, FL.

Ham, K.D., S.M. Adams, and M.J. Peterson. 1997. Application of multiple bioindicators to differentiate spatial and temporal variability from the effects of contaminant exposure on fish. Ecotoxicology and Environmental Safety 37:53-61.

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Adams, S.M., K.D. Ham, and J.J. Beauchamp. 1994. Application of canonical variate evaluation and presentation of multivariate biological response data. Environmental Toxicology and Chemistry 13:1673-1683.

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1982-1983: Fishery Biologist, Fisheries Research Institute, University of Washington
1979-1982: B.S. Fisheries Science - University of Washington

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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and C.V.W. Mahnken. BPA Progress Report Contract No. DE-AI79-91BP20651. Pg.128-166.

Berejikian, B.A., E.P. Tezak, S.L. Schroder, C.M. Knudsen, and J.J. Hard. 1997. Reproductive behavioral interactions between captively-reared and wild coho salmon (*Oncorhynchus kisutch*). ICES Journal of Marine Science 54: 000-000.

Busack, C., B. Watson, T. Pearsons, C. Knudsen, S. Phelps and M. Johnston. 1997. Spring Chinook Supplementation Monitoring Plan. YFP.

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1989:	Fish Biologist, The Nature Conservancy, Wisdom, Montana.
1987-1989:	Graduate Research Assistant, Montana State University
1987-1989:	M.S., Fish & Wildlife Mgt., Montana State University
1983-1987:	B.S., Fish & Wildlife Mgt., Montana State University

SELECTED PUBLICATIONS

McMichael, G. A., and T. N. Pearsons. In Press. Effects of wild juvenile spring chinook salmon on growth and abundance of wild rainbow trout. Transactions of the American Fisheries Society. March 1998.

McMichael, G. A., T. N. Pearsons, and S. A. Leider. In Press. Minimizing ecological impacts of hatchery-reared juvenile steelhead on wild salmonids in a Yakima basin watershed *In* E. E. Knudsen, editor, Proceedings of the Toward Sustainable Fisheries Conference,. Ann Arbor Press, Michigan. 1998.

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Pearsons, T. N., G.A. McMichael, S. W. Martin, E. L. Bartrand, J. Long, and S.A. Leider. 1994. Yakima River species interactions studies: Annual report 1994. Washington Department of Fish and Wildlife, Olympia, Washington. BPA, Portland,DOE/BP99852-3

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1992-present:	Fish Biologist, Washington Department of Fish and Wildlife (until 1994 Washington Department of Wildlife)
1986-1992:	Graduate Research Assistant, Oregon State University
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

SELECTED PUBLICATIONS

McMichael, G. A., and T. N. Pearsons. In Press. Effects of wild juvenile spring chinook salmon on growth and abundance of wild rainbow trout. Transactions of the American Fisheries Society. March 1998.

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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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1981-1990:	Research Scientist I, Washington Department of Fisheries
1980-1981:	Fisheries Biologist (III & IV), Washington Department of Fisheries
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.

Schroder, S.L., C.M. Knudsen, and E.C. Volk. 1995. Marking salmon fry with strontium chloride solutions. Can. J. Fish. Aquat. Sci. 52:1141-1149.

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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 54:000-000 (in press).

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 1998. 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 a workshop hosted by the YKFP, the AProject 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), and Monitoring Plans for Yakima fall chinook and coho will be written in 1998.