Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Captive Rearing Initiative For Salmon River Chinook Salmon - M & E

Bonneville project number, if an ongoing project 9801002

Business name of agency, institution or organization requesting funding
Idaho Dept of Fish and Game

Business acronym (if appropriate) IDFG

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Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name
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National Marine Fisheries Service 9606700	Box 130	Manchester WA 98353	Tom Flagg
National Marine Fisheries Service 8909600	2725 Montlake Blvd. East	Seattle, WA 98112	Robin Waples

NPPC Program Measure Number(s) which this project addresses.
7.4D.2

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

Other planning document references.
Chapter 7 (Artificial Production) of the Draft Snake River Salmon Recovery Plan (Schmitten et al. 1997) discusses using hatchery intervention techniques to maintain or boost naturally spawning populations. This discussion includes numerous references to the maintenance of "captive reserves" for some populations. Strategies A, B, and C (pages 106 and 107 in Schmitten et al. 1997) specifically reference the use of artificial reserves or captive populations to accomplish spring/summer chinook objectives identified in the plan.
NWPPC Return to the River. Chapter 8, Conclusion 10 under Hatcheries identifies hatchery programs for severely depressed stocks important sources of genetic information. Evaluations called for by the ISG are essential and active components of this program.

Subbasin.
Salmon River (Lemhi R., East Fork Salmon River, and West Fork Yankee Fork Salmon River)

Short description.
Monitor and evaluate the success of a captive rearing program for Salmon River chinook salmon (Project No. 9700100) at maintaining stock structure and minimum number of adult spawners in three drainages.

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	X	Population dynamics
	Oceans/estuaries	X	Research		Ecosystems
	Climate	+	Monitoring/eval.		Flow/survival
	Other		Resource mgmt		Fish disease
			Planning/admin.	+	Supplementation
			Enforcement		Wildlife habitat enhancement/restoration
			Acquisitions		

Other keywords.
stock structure, hatchery-wild interactions, captive propagation, captive broodstock, metapopulation structure

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship

9700100	Captive Rearing Initiative for Salmon River Chinook Salmon	9700100 is responsible for developing hatchery rearing strategies and captively rearing juvenile chinook to adult sexual maturity. Adults are then outplanted to supplement natural spawning population.
8909600	Genetic Monitoring and Evaluation of Snake River Salmon and Steelhead	NMFS protein gel electrophoretic analysis of broodstock and wild chinook salmon.
9606700	Manchester Captive Brood Stock O & M	Saltwater rearing at NMFS Manchester, WA facility for one half of fish in program.
9305600	Assessment of Captive Broodstock Techniques	NMFS guidance for the refinement and use of captive broodstock technology for Pacific salmon.
9107200	Redfish Lake Sockeye Salmon Captive Broodstock Program	IDFG program at Eagle Fish Hatchery to establish captive broodstocks of Redfish Lake sockeye salmon.

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	**Objective**	**Task a,b,c**	**Task**
1	Monitor progress towards achieving program goals of fish size, sex ratio, body morphology, and age at maturity for each population.	a	Determine maturity schedule specific to each population.
1		b	Determine sex ratio at maturity specific to each population.
1		c	Establish size (length and weight) and body morphology (condition factor) targets at maturity specific to each population.
1		d	Inventory fish as needed to obtain length and weight information and monitor growth rates for each population.
1		e	Maintain a database of size and growth data for individual fish.

2	Establish a supplementation schedule by numbers and sex ratio for each cohort by return year and population.	a	Determine maturity schedules and sex ratio at maturity for each population.
2		b	Forecast (brood years 1999, 2000, and 2001) and monitor (brood year 1999) natural-origin adult returns to the Lemhi River, East Fork Salmon River, and West Fork Yankee Fork Salmon River
3	Establish a supplementation schedule incorporating brood year 1994, 1995, and 1996 collections.	a	Determine locations and numbers of brood year 1998 cohorts to collect in 1999 and 2000.
3		b	Use maturity schedules and sex ratios at maturity, specific to each stock, to determine numbers of fish, by age and sex, to outplant in 1998 and 1999.
4	Evaluate spawning success and behavior of wild and outplanted (captively-reared) adults.	a	Tag adults, prior to out planting, with externally identifiable tags.
4		b	After out planting, monitor movement, distribution, behavior, and spawning success of fish.
4		c	Map redd locations and note spawner pairing for each redd (e.g. natural x natural, natural x captive, etc.).
4		d	Summarize spawning behavior data and calculate spawning success for outplanted fish and for all observed spawner pairings.
5	Establish genetic protocols to guide supplementation schedules and avoid adverse genetic impacts.	a	Arrange with outside agency for electrophoretic analysis of any fish that die during rearing.
5		b	Arrange for contract with outside agency to perform genetic analysis (DNA marker, electrophoresis).
5		c	Summarize genetic information to develop genetic protocols for outplanting adults produced

			through captive rearing.
6	Coordinate the evaluation of progeny produced in streams supplemented with captively-reared adults.	a	Coordinate with and assist Idaho Supplementation Studies (BPA Project No. 8909800) personnel to snorkel streams and estimate parr production from spawning cohorts supplemented with adults.
6		b	Coordinate and assist Idaho Supplementation Studies personnel with estimates of fall presmolt and spring smolt production, using emigrant traps, from systems supplemented with adults.
6		c	Coordinate PIT-tagging juvenile emigrants from systems supplemented with adults to determine migration timing and detection rates at lower Snake River dams.
7	Information transfer.	a	Participate in Technical Oversight Committee process.
7		b	Develop and provide IDFG, other agency, and Tribe personnel with current, concise accounts of fish behavior-related information.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	10/1998	9/1999	7.00%
2	3/1999	5/1999	15.00%
3	6/1999	7/1999	10.00%
4	7/1999	11/1999	55.00%
5	10/1998	9/1999	3.00%
6	3/1999	8/1999	5.00%
7	10/1998	9/1999	5.00%
			TOTAL 100.00%

Schedule constraints.
No known constraints. The table above lists start and end dates specific to only the fiscal year 1999 contract period.

Completion date.
2005 for the demonstration project, Future implementation of captive rearing or brood stock techniques is unknown.

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		$39,000
Fringe benefits		$10,367
Supplies, materials, non-expendable property		$5,000
Operations & maintenance		$9,400
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	Radio-tags for fish tracking	$4,000
PIT tags	# of tags: 0	$0
Travel	Includes all costs associated with the conduct of field work (lodging and subsistence.	$6,030
Indirect costs	21.3% of all costs except capital acquis.	$14,867
Subcontracts		$0
Other		0
TOTAL		$88,664

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$83,000	$84,000	$80,000	$80,000
O&M as % of total	11.00%	11.00%	12.00%	12.00%

Section 6. Abstract

To maintain Snake River chinook salmon metapopulation or stock structure, the within and among population variability, IDFG initiated a captive rearing program for stocks at high risk of extinction. Captive rearing is a short term approach to species preservation. The main objective of the captive rearing approach is to avoid demographic and environmental risks of cohort extinction; maintaining the genetic identity of the breeding unit is an important but secondary objective. The strategy of captive rearing is to prevent cohort collapse of the specified target populations by providing captively reared adult spawners to the natural environment, which, in turn, maintain the continuum

of generation to generation smolt production. Each generation of smolts, then, provides the opportunity for population maintenance or increase should environmental conditions prove favorable for that cohort.

Development of the captive propagation technology is accomplished through BPA project #9700100. This is a demonstration project as identified in section 7.4D.2 of the Council's Fish and Wildlife program. The primary goal of 9700100 is to develop the technology for captive propagation of chinook salmon that satisfy program needs. This project (#9801002) provides for some monitoring and evaluation during the captive rearing phase. The most important element of this project is to monitor and evaluate the post-release behavior and spawning success of mature adult salmon produced through captive rearing. Success of the overall captive rearing program is dependent on the development of rearing technology and the biological performance of fish produced in the program. The year 2005 is the expected end date for the current demonstration project. The project may continue if the demonstration process is successful and leads to a recovery program.

Section 7. Project description

a. Technical and/or scientific background.

The combined counts of returning spring and summer chinook salmon to the Snake Basin were the lowest on record in 1994 (4,475) and again in 1995 (2,787). For perspective, from 1962 to 1971 an average of 148,000 adult anadromous salmonids per year crossed Ice Harbor Dam into the Snake River Basin. Most of these returnees were produced in and destined for production areas located upstream of Lower Granite Dam. The spring/summer component of the run was comprised primarily of wild fish and accounted for about 40 percent of the run, an average of 59,900 fish annually. In contrast, 3,915 adult spring and summer chinook salmon passed upstream of Lower Granite Dam in 1994, including 1,517 and 305 naturally produced springs and summers, respectively.

IDFG's long-term objective for salmon management is to maintain Snake River salmon populations at levels that will provide sustainable harvest (IDFG 1992). Restoring the number of returning chinook salmon to historic levels is a prerequisite to this condition. Artificial propagation of spring and summer chinook salmon in the Salmon River basin, through Lower Snake River Compensation Plan (LSRCP) and Idaho Power Company hatcheries, was initiated to compensate for lost production and productivity caused by the construction and operation of private and federal hydroelectric facilities in the Snake River. The mitigation approach was to trap, spawn, and rear a portion of the historically productive local brood stock to produce a large number of smolts (Bowles 1993). When chinook salmon trapping began in 1981 as part of the LSRCP, it was assumed that enough chinook salmon adults would return for harvest and continued hatchery production needs. It was also assumed that hatchery programs would not negatively impact the productivity or genetic viability of target or other populations, and that natural populations would remain self-sustaining even with hydropower dams in place. In reality, productivity (survival rates) of wild Snake River chinook salmon declined abruptly with completion of the federal hydroelectric system by the mid-1970s

(Petrosky and Schaller 1994). Survival rates used in the hatchery mitigation program models were substantially overestimated. Hence, hatchery programs have been unable to mitigate for the dams or stem the decline of target populations, and numbers of naturally produced salmon declined at various rates throughout the Snake River Basin. Spring/summer chinook salmon returns have been insufficient to meet artificial and natural smolt and adult production objectives, much less provide a consistent harvestable surplus of adults.

The only way to prevent further decline and secure eventual recovery of Snake River populations is to provide historical levels of survival in the migration corridor. Pending changes in the mainstem hydroelectric system, our immediate challenge becomes one of preserving the existing metapopulation structure of Snake River chinook salmon, so future recovery actions are possible. The listed Snake River spring/summer chinook salmon evolutionary significant unit (ESU) consists of 38 subpopulations (i.e. breeding units or stocks), 28 of which exist in the Salmon River Drainage (Schmitten et al. 1997). Preserving the current stock or metapopulation structure is consistent with the "Proposed Recovery Plan for Snake River Salmon" (Schmitten et al. 1997), and also supports the NPPC's goal of maintaining biological diversity while doubling salmon and steelhead runs (NPPC 1994). Metapopulation structure (or biodiveristy) can be maintained by preventing local or demographic extinctions.

The IDFG initiated a captive rearing approach for populations at high risk of extinction to maintain stock structure. Captive rearing is a short term approach to species preservation. The main objective of the captive rearing approach is to avoid demographic and environmental risks of cohort extinction; maintaining the genetic identity of the breeding unit is an important but secondary objective. The strategy of captive rearing is to prevent cohort collapse of the specified target populations by providing captively reared adult spawners to the natural environment, which, in turn, maintain the continuum of generation to generation smolt production. Each generation of smolts, then, provides the opportunity for population maintenance or increase should environmental conditions prove favorable for that cohort. The issue paper "Recovery Plan Recommendations for Hatchery Production" (IDFG 1994), provides the background, objectives, options, and approach relative to the captive rearing concept.

The captive rearing approach was developed primarily as a way to maximize the number of breeding units that could be addressed while minimizing intervention impacts. Under these guidelines we collect only enough juveniles from the target populations to provide what we feel are adequate spawners, about 20, to meet our demographic spawner goals. (According to members of the Snake Basin Sockeye Technical Oversight Committee, it is not unreasonable to assume that 20 fish could encompass 95 percent of the genetic diversity of the population.) The appropriate number of juveniles to collect remains somewhat speculative at this time because of the uncertainty associated with the ability of the captive rearing approach to produce adults with desired characteristics for release into the wild (Fleming and Gross 1992, 1993, Joyce et al. 1993, Flagg and Mahnken 1995a). Juveniles would be collected each year from cohorts of low resiliency populations, those not expected to return at least 10 spawning pair to their respective spawning areas. In order for this approach to provide the desired outcome we must be able to produce an adequate number of adults with the proper morphological, physiological, and behavioral attributes to successfully spawn and produce viable offspring in their native habitats. The successful evaluation of the captive rearing approach would require the synchronous development of successful propagation techniques while the fish are in captivity.

Little scientific information regarding captive propagation techniques for Pacific Salmonids was available at the inception of this program. This lack of information was also acknowledged in the Council's 1994 Fish and Wildlife Program measure 7.4D.1, calling for a scoping study to identify captive broodstock research needs. To address measure 7.4D.1, Flagg and Mahnken (1995b) completed a review of the status of captive broodstock technology.

Measure 7.4D.2 of the Fish and Wildlife Program called for funding captive broodstock demonstration projects. Following Flagg and Mahnken's (1995b) work and to address the need identified in Measure 7.4D.2, the IDFG captive rearing program was initiated, in part, as such a demonstration project. Development of the captive propagation technology is accomplished through BPA project #9700100. The primary goal of 9700100 is to develop the technology for captive propagation of chinook salmon that satisfy program needs. This project (#9801002) provides for some monitoring and evaluation during the captive rearing phase. The most important element of this project is to monitor and evaluate the post-release behavior and spawning success of mature adult salmon produced through captive rearing. Success of the overall captive rearing program is dependent on the development of rearing technology and the biological performance of fish produced in the program.

In addition to being considered a demonstration project for captive propagation technology, the IDFG program also addresses population dynamics and population persistence concerns. The population level concerns may be further defined as 1) maintaining a minimum number of spawners in high risk populations, and 2) maintaining stock structure by preventing local extinctions. These population level concerns were addressed by identifying those populaltions at the highest risk of extinction.

We have prioritized populations for hatchery preservation actions based on assumed relative importance to the Snake River spring/summer chinook salmon ESU, assumed retention of native population characteristics, estimated imminent extinction risk, and risk of exposure to experimental techniques. High priority populations have: 1) annual escapements of less than 20 fish; 2) adequate habitat for successful spawning and rearing; and 3) poor resiliency from the last survival bottleneck (1979-1984). An analysis of population status, history, isolation and resiliency determined that several spring and summer chinook salmon populations in the Salmon River are unlikely to remain viable beyond this current bottleneck (IDFG 1994).

b. Proposal objectives.

The overall goals of the captive rearing program are to develop and evaluate captive propagation techniques for chinook salmon and to maintain at least twenty adult spawners annually in depressed populations with a high risk of extirpation. The objectives of project #9801002, the monitoring and evaluation segment of the captive rearing program, are designed to test the biological performance, in the wild, of fish that were reared to sexual maturity in captivity. In broader terms, this project evaluates the utility of using captive rearing to maintain stock structure (metapopulation structure) by preventing local extinctions of high risk stocks. Specific objectives and hypotheses of project #9801002 are:

Objective 1. Monitor progress towards achieving program goals of fish size, sex ratio, body morphology, and age at maturity for each stock.

H_{01}: Chinook salmon reared in captivity do not exhibit the same morphological development and life history or population characteristics as their wild-reared counterparts.

Corrollary: Rejecting H_{01} indicates that chinook salmon can be reared in captivity to match the morphological development and life history or population characteristics of fish that spend their entire life in the wild.

Objective 2. Establish a supplementation schedule by numbers and sex ratio for each cohort by return year and stock.

Objective 3. Establish a supplementation schedule incorporating brood year 1994, 1995, and 1996 collections.

Testable hypotheses are not associated with objectives 2 and 3. These objectives pertain only to determining maturity schedules for captively reared fish and appropriate outplanting or adult supplementation schedules to satisfy overall programs goals.

Objective 4. Evaluate spawning success and behavior of wild and outplanted (captively-reared) adults.

H_{04}: Captively reared fish released as sexually mature adults into the wild do not exhibit typical chinook spawning behavior.

Corollary : Rejection of H_{04} indicates that sexually mature adults from the captive rearing program will exhibit typical chinook spawning behavior.

Objective 5. Establish genetic protocols to guide supplementation schedules and avoid adverse genetic impacts.

No testable hypothesis is addressed by this objective. The intended product is a set of genetic protocols to guide management decisions.

Objective 6. Coordinate the evaluation of progeny produced in streams supplemented with captively-reared adults.

H_{06}: Natural smolt production can not be increased by the release of adults (females) grown to maturity in a captivity and allowed to spawn in the wild.

Corollary: Rejection of H_{06} indicates that natural smolt production can be increased through the release of adult fish that were reared to sexual maturity in captivity.

Objective 7. Information transfer.

No testable hypothesis is addressed by this objective.

Several work products result from this project. An annual report is required by and produced for the National Marine Fisheries Service to satisfy requirements of the Endangered Species Act Section 10 permit for this project. An annual report of contract period activities is provided to the Bonneville Power Administration.

An important element of the entire project is participation with the Chinook Salmon Captive Propagation Technical Oversight Committee. The committee meets regulary to discuss project status, direction, and to resolve uncertainties. The purpose (adopted by the committee) of the technical committee is "…to provide a forum for: (1) project-related technical problem solving by technical experts, (2) review and monitoring of progress made on captive propagation of Snake River chinook salmon, and (3) coordination and technical information exchange among technical experts regarding the Snake River chinook salmon captive propagation projects." Representation on the committee includes the Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, National Marine Fisheries Service, Shoshone-Bannock Tribes, University of Idaho, U.S. Fish and Wildlife Service Lower Snake River Compensation Program, and Bonneville Power Administration.

c. Rationale and significance to Regional Programs.

Anadromous fishery managers in the basin are increasingly faced with two disparate objectives in their management programs, increasing the numbers of fish and maintaining the genetic and biological diversity of natural populations. The Council has noted the need to balance these two needs in Section 4.1 of its Fish and Wildlife program (NPPC 1994). The Council further notes that actions aimed at increasing fish numbers and conserving biological diversity are both important to maintianing a healthy ecosystem. In the draft Snake River Salmon Recovery Plan (Schmitten et al. 1997), NMFS discusses the importance of metapopulation structure and recognizes the importance of conserving smaller local populations in their Delisting Criterion 1. Also, the National Research Council (1995) described the need of recovery plans to include "the creation of multiple populations….." to ensure population viability.

Fishery managers in the Snake River basin convened to discuss possible means of maintaining overall stock structure of the Snake River chinook population by protecting small populations or stocks at high risk of extinction. It was agreed that a form of captive propagation may be appropriate for some populations. However, it was not known how captive propagation could be best used to ensure the continued existence of the poulations and at the same time maintain the genetic and/or biological diveristy of these same populations. Two approaches were identified: a conventional captive brood stock program and a captive rearing program. The two approaches share a similar goal, in general to maintain Snake River chinook salmon metapopulation structure by preventing local extinctions of high risk populations. Future population rebuilding opportunities can be exercised if this goal is met.

The Snake River basin Fishery managers agreed to test the utility of each captive propagation approach (broodstock versus rearing) by implementing each strategy in a separate basin. The Oregon Department of Fish and Wildlife has initiated a captive broodstock program with brood year 1994 Grand Ronde basin chinook salmon (BPA project #9604400). The Idaho Department of Fish and Game initiated the captive rearing program with brood year 1994 Salmon River basin chinook salmon. Collectively the two approaches aim at maintaining the entire Snake River basin chinook salmon metapopulation structure, while investigating two forms of captive propagation and determining their future utility.

d. Project history

Fiscal year 1998 was the first year this project received finding thorugh the basin Fish and Wildlife Program. An ESA Section 10 Report for activities from 1 January - 31 December, 1997 was submitted to the NMFS in January, 1998.

We collected brood year 1994 juvenile chinook salmon from three spring chinook salmon populations, Lemhi River, East Fork Salmon River, and West Fork of the Yankee Fork Salmon River in 1995 to initiate the captive rearing program. These populations had 20 or fewer redds counted in 1994 and are expected to have annual escapements of less than 20 fish during the next several years.

After the fish were collected in the summer of 1995 they were transported to the Sawtooth Fish Hatchery for rearing until they could be transferred to other rearing locations. In the spring of 1996 all fish were transferred to IDFG's Eagle Fish Hatchery. One-half of the fish will be reared to maturity at the Eagle facility. The remaining fish were transferred to NMFS' Manchester facility, west of Seattle, Washington, for saltwater rearing to maturity.

In July of 1996 the fish were examined for signs of sexual maturity (precocial males). The rate of precocial male development was very low, less than six percent for each of the three populations. This was a very positive finding as early maturity is a concern in captive propagation programs. No difference was found in maturtion rate for fresh water or salt water rearing and fish health was good.

In July 1997 fish were again sorted to separate out maturing jacks (three year old males). Maturing jacks from the saltwater rearing were transferred back to Eagle Fish Hatchery for final maturation in freshwater to correspond with normal life history events. Although the rate of jack maturation varied among the three populations, it was not regarded as excessively high. A small number of jacks (up to four) from each population were equipped with radio transmitters while in captivity. These fish were then outplanted to their source streams and their movement and behavior was monitored. The purpose of outplanting the jacks was only to observe and gain insights on their behavior in the wild. The ultimate objective of captive rearing is to provide mature females (and males) for natural spawning to maintain a base level of natural production. Mature (four year old) males and females will be outplanted in 1998. Information learned in 1997 will be used in the decision making process for 1998 outplants. The 1997 (jack) outplanting was considered successful. In general the fish remained in the streams where they were released, and exhibited searching and movemnet patterns typical of natural origin fish. It was encouraging to observe that even though the fish had been reared almost entirely in captivity, with no opportunity for normal migration and homing behaviors, they remained within their source streams after release. Semen from mature males (jacks) not released into the streams was cryopreserved for potential future use in captive brood stock programs.

In addition to the brood year 1994 collections, we collected brood year 1995 juveniles from the Lemhi River. Brood year 1995 adult spawner numbers in the East Fork Salmon River and West Fork Yankee Fork Salmon River were to low to effectively collect juveniles from these systems. Collection of brood year 1996 juveniles from each system is currently underway.

Past costs for this project were $78,000 in fiscal year 1998.

e. Methods.

This project is concerned with monitoring and evaluating the natural spawning performance of fish that had been reared to sexual maturity in captivity. Methods associated with the rearing of the fish are detailed in BPA project #9700100. Methods associated with this project are also described in the IDFG Section 10 permit application for the NMFS scientific permit to carry out this program. Specific methods for pertinent objectives are summarized below. However, the reviewers should be aware that some of the methods may change during the course of this study. The captive propagation of chinook salmon is a relatively new field, and very little is known about the natural spawning behavior of captively reared fish. Because of these two constraining factors, the role of the Chinook Salmon Captive Propagation Technical Oversight Committee (CSCPTOC) is very important to the success of the program. Participants in the CSCPTOC are listed in the Objectives section above. The CSCPTOC provides a forum for peer review and discussion of all activities associated with this program prior to the initiation of any activity. This allows for an adaptive managemnt approach to all phases of the program, and changes to the program or an activity can be made as new and better information becomes available.

Objective 1. Monitor progress towards achieving program goals of fish size, sex ratio, body morphology, and age at maturity for each stock. Fish reared in captivity will periodically be inventoried to collect and track growth data. This data will be analyzed using standard fisheries analysis techniques (Nielsen and Johnson 1983). Available historic fish morphology data for each population will be compiled to establish targets (length, weight) for the captive rearing program. Most available data was collected on spawning grounds after fish had spawned. This creates a constraint as the size of the fish when they entered freshwater as adults and prespawning size are not known. Lower Columbia River fishery information will be obtained as available to help develop size targets. The worst-case scenario is that we will only be able to establish length targets for captively reared fish. The importance of length and weight to spawning success are not well documented, but are being investigated by NMFS personnel in Manchester, Washington.

Objective 2. Establish a supplementation schedule by numbers and sex ratio for each population. The average sex ratio and age sturcture of the natural spawning population will be determined from historic data collected from each of the populations. Two forms of data may be available. Age and sex data obtained from spawner carcasses collected on the spawning grounds or from live fish intercepted at weirs will be analyzed. The sex ratio (females:males) of captively reared fish that are released will duplicate the average sex ratio of the natural spawners, not the sex ratio of fish held in captivity.

To account for the age-structured nature of spawning salmon populations, the contribution of each natural-returning cohort (age 3, 4, and 5) to the 1999 spawning population will be forecast. The forecast will be used to estimate the minimum number of captively reared fish needed for outplanting to meet the minimum target of twenty adult spawners in each stream. In 1999 five-year old fish from brood year 1994, four-year old fish from brood year 1995, and three-year old fish from brood year 1996 will be available to outplant. (Note: as indicated in the project history, brood year 1995 juveniles could not be collected from the East Fork Salmon River and West Fork Yankee Fork Salmon River.)

Objective 3. Establish a supplementation schedule incorporating brood years 1994, 1995, and 1996 collections. This objective consists of two parts. The first task is to examine spawner abundance information collected in the fall of 1998 to determine if and where juvenile collections should occur beginning in 1999. As described in the project technical description, we would collect juveniles from those populations where natural production was expected to return less than twenty adults for an annual spawning escapement. The determination to collect brood year 1998 juveniles will also be based on the spawning performance of adults outplanted in 1998 as part of this program.

The second task in this objective uses the information generated in Objective 2 to determine the absolute numbers of adults to outplant in 1999. This task will be coordinated through the CSCPTOC process. Considerations to be included in the decision process include the forecasted natural adult return (Objectve 2), the numbers of sexually mature captively reared fish on hand for each of the cohorts (brood years 1994, 1995, and 1996), and an assessment of potential genetic impacts from the outplanting activities (e.g. skewing the age structure of the natural population).

Objective 4. Evaluate spawning success and behavior of wild and outplanted (captively-reared) adults. Actual outplanting procedures to be employed in 1999 are unknown at this time, and are largely dependent on observations to be made in 1998 when four-year old adults from the captive rearing program are outplanted. Observations made in 1997 on radio-tagged jacks that were outplanted indicate that the fish will remain in the streams or locations where released and fences or weirs are not needed to prevent movement out of the system.

Plans for 1998, and most likely 1999, include radio-tagging some of the adults to be released so their movement can be monitored. Also, it is likely we will construct at least one enclosure in each stream in which a female/male pair from captivity will be released. The enclosures will be designed to provide all necessary habitat elements, such as suitable spawning substrate, holding water, and escape cover. These enclosures will allow for the close observation of the spawning behavior of captively reared fish. The outcome of observations in 1998 will dictate the need for releasing fish into enclosed areas in 1999.

All proposed work will be coordinated and discussed through the CSCPTOC. Also, we work in close coordination with NMFS personnel at the Manchester Marine Laboratory, who are examining the spawning behavior of hatchery-reared fish in a simulated natural environment. This work is currently on-going. Observations and findings from the NMFS research will be incorporated in designing our outplanting and evaluation regimes. We have cooperated with the NMFS personnel in designing our 1997 evaluations, and will do so again in 1998.

Objective 5. Establish genetic protocols to guide supplementation schedules and avoid adverse genetic impacts. Baseline genetic information for Salmon River basin chinook salmon was analyzed and reported by Waples et al. (1993). Two additional years of analysis was reported by Marshall (1994).

Tissue samples of all fish that die or are killed (e.g. males for semen cryopreservation) while in captivity are sent to NMFS personnel (BPA #8909600) for analyses. Tissue samples from carcasses of natural spawners also are collected for genetic analyses. Genetic principles discussed by Ryman et al. (1995) and Ryman and Laikre (1991) will be applied to maximize the total effective population size (captive and natural spawners combined), or in other terms, avoid loss of heterozygosity through inbreeding or genetic drift.

f. **Facilities and equipment**.

Eagle Hatchery is the primary Idaho site for the chinook captive rearing program. Artesian water from five wells is currently in use. Artesian flow is augmented through the use of four separate pump/motor systems. Water temperature remains a constant 13.3^{o}C and total dissolved gas averages 100% after degassing. Backup and system redundancy is in place for degassing, pumping, and power generation. Nine water level alarms are in use and linked through an emergency service operator. Additional security is provided by limiting public access and by the presence of three on-site residences occupied by IDFG hatchery personnel.

Facility layout at Eagle Hatchery remains flexible to accommodate culture activities. Several fiberglass tank sizes are used to culture chinook from pre-smolt to the adult stage including: 1) 1 m diameter semi-square tanks (0.30 m^3), 2) 2 m diameter semi-square tanks (1.42 m^3), 3) 3 m diameter circular tanks (6.50 m^3), 4) 4 m diameter semi-square tanks (8.89 m^3) and 5) 6 m diameter circular tanks (44.5 m^3). One meter tanks are used to acclimate pre-smolts to hatchery diets following collections. Two meter tanks are used to rear juveniles, by stream origin, to approximately 20 g. Three and four meter tanks are used to rear juveniles to approximately 1,000 g and to depot fish by stream origin prior to distribution to natal waters. Six-meter tanks are used to rear fish to age 3+ and 4+. Flows to all tanks are maintained at no less than 1.5 exchanges per hour. Shade covering (70%) and jump screens are used where appropriate. Tank discharge standpipes are assembled in two sections ("half pipe principal") to prevent tank dewatering when removed for tank cleaning.

Sawtooth Hatchery was completed in 1985 as part of the Lower Snake River Compensation Plan and is located on the Salmon river in the Stanley Basin. Sawtooth Hatchery personnel and facilities have been used continuously since 1995 to depot pre-smolts prior to their transfer to the Eagle Fish Hatchery. Following collection, pre-smolts are held in 2 m semi-square fiberglass tanks by stream origin. All fish rearing occurs on well water. Water temperature varies by time of year from approximately 2.5 C in January/February to 11.1 C in August/September. Back-up and redundancy systems are in place.

Live fish transfers occur in a variety of vehicles including customized pick-up trucks and standard fish transportation trucks. The vehicle and containers used will depend upon, among other things, the size and number of fish and the distance to be hauled. Idaho Department of Fish and Game has the following tank capacities available for use in the chinook captive rearing program; 300 gal. (1,136 L), 1000 gal. (3,785 L), and 2,500 gal. (9,463 L). All vehicles are equipped to provide the appropriate conditions (temperature, oxygen, capacity) to facilitate safe transport of fish to the specified destination. All vehicles are equipped with two-way radios or cellular phones to provide routine or emergency communications. Fish are transported by IDFG or cooperator personnel.

Computer equipment includes three desktop and two laptop units. PIT tag equipment includes one self-contained tagging station and two back-up readers and antennas. Two vehicles are assigned to the project with additional IDFG vehicles available as needed (fish transportation). Adequate office and storage space is available at the Nampa Research Office. Most equipment is available through the Lower Snake River Compensation Program Hatchery Evaluation Studies.

Critical linkages exist between this project and: project 9700100 for rearing of captive chinook released to naturally spawn, project 9606700 for co-culture of captive chinook salmon, project 9107200 for personnel, equipment, and cost sharing between captive sockeye and chinook programs at Eagle Fish Hatchery and, project 8909600 for genetic monitoring and evaluation of captive chinook salmon.

g. References.

Bowles, E. 1993. Operation of compensation hatcheries within a conservation framework, an issue paper. Idaho Department of Fish and Game, Boise.

Flagg, T.A. and C.V. W. Mahnken. 1995a. Captive broodstocks for recovery of Snake River sockeye salmon. American Fisheries Society Symposium 15:81-90.

Flagg, T.A. and C.V. W. Mahnken. 1995b. An assessment of the status of captive broodstock technology for Pacific Salmon. Final report to the Bonneville Power Administration, Project No.93-56, Contract No. DE-AI79-93BP55064. Protland, OR.

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

Fleming, I.A. and M.R.Gross. 1993. Breeding success of hatchery and wild coho salmon (*Oncorhynchus kisutch*) in competition. Ecological Applications 3(2):230-245.

Idaho Department of Fish and Game. 1992. Anadromous fish management plan 1992. Idaho Department of Fish and Game, Boise.

Idaho Department of Fish and Game. 1994. Recovery plan recommendations for hatchery production, an issue paper. Idaho Department of Fish and Game, Boise.

Joyce,J.E., R.M. Martin, and F.P. Thrower. 1993. Successful maturation of captive chinook salmon brood stock. Progressive Fish-Culturist. 55:191-194.

Marshall, A. 1994. Genetic analysis of 1993-94 Idaho chinook salmon baseline collections, and a multi-year comparative analysis. Appendix A *in* Nemeth, D., K. Plaster, K. Apperson, J. Brostrom, T. Curet, and E. Brown. 1996. Idaho Supplementation Studies, Annual Report 1994. Idaho Department of Fish and Game Report No. 96-20. Prepared for Bonneville Power Administration. Project No. 89-098, Contract No. DE-BI79-89BP01466. Portland, OR.

NRC (National Research Council). 1995. Science and the Endangered Species Act. National Academy Press, Washington, D.C.

Nielsen, L.A. and D.L. Johnson, editors. 1983. Fisheries Techniques. American Fisheries Society. Bethesda, MD.

Northwest Power Planning Council. 1994. 1994 Columbia River Basin Fish and Wildlife Program.

Northwest Power Planning Council. 1996. Return to the River: Restoration of Salmonid Fishes in the Columbia River.

Petrosky, C.E. and H.A. Schaller. 1994. A comparison of productivities for Snake River and lower Columbia River spring and summer chinook stocks. *in* Salmon Management in the 21st Century: Recovering Stocks in Decline. Proceedings of the 1992 Northeast Pacific Chinook and Coho Workshop. Idaho Chapter of the American Fisheries Society, Boise.

Ryman, N., P.E. Jorde, and L. Laikre. 1995. Supportive breeding and variance effective population size. Conservation Biology 9(6):1619-1628.

Ryman, N. and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size. Conservation Biology 5(3):325-329.

Schmitten, R., W. Stelle, and M. Brentwood. 1997 (in review). Snake River Salmon Recovery Plan. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Waples, R.S., O.W. Johnson, P.B. Aebersold, C.K. Shiflett, D.M. VanDoornik, D.J. Teel, and A.E. Cook. 1993. A genetic monitoring and evaluation program for supplemented populations of salmonand steelhead in the Snake River basin. Annual Report 1992. Bonneville Power Administraion. Project No. 89-096, Contract No. DE-AI79-89BP00911. Portland, OR.

Section 8. Relationships to other projects

The Oregon Department of Fish and Wildlife has initiated a captive broodstock program with brood year 1994 Grande Ronde Basin chinook salmon (BPA 9604400). This program differs from the IDFG program in that it emphasizes captive broodstock rather than captive rearing methods. Collectively, both programs aim at maintaining Snake River Basin chinook salmon metapopulation structure, while investigating two forms of captive propagation and determining their future utility.

The IDFG Captive Rearing Initiative for Salmon River Chinook Salmon operates in association with the LSRCP funded Sawtooth Fish Hatchery in Stanley Idaho. Juvenile chinook collected from the Lemhi River, East Fork Salmon River, and West Fork Yankee Fork Salmon River are transferred to Sawtooth for initial holding.

Cooperative fish culture activities conducted by NMFS at Washington State locations (BPA 920400) are an integral component of the overall program. Duplicate chinook salmon cohorts are maintained in Idaho and Washington to guard against catastrophic loss at any one facility. In addition, culture activities at the NMFS Manchester site are carried out in sea water.

Genetic investigations of Idaho and regional chinook salmon populations (8909600) provide essential information to the program. Conducted by NMFS, these studies generate baseline information on the genetic variability of target subpopulations. This information is an essential part of the Regional effort presently underway to maintain Snake River Basin chinook salmon metapopulation structure.

IDFG fish propagation activities associated with the chinook salmon captive rearing initiative are conducted at the Eagle Fish Hatchery; a facility presently in use to develop sockeye salmon captive broodstocks (BPA 9107200). Although managed as separate projects, program responsibilities overlap and complement each other.

Section 9. Key personnel

The principal investigator on the project is Peter F. Hassemer, Principal Fishery Research Biologist. He has worked for the Idaho Department of Fish and Game for eight years, with six of those years in fisheries research. He received a B.S. (1979) and M.S. (1984) in Fisheries Science from the University of Idaho.

The Senior Fisheries Technician on this project is Kurtis Plaster. Kurtis has been employed since 1989. He has a B.S. in Fisheries Resources from the University of Idaho 1991. Kurtis has been employed on several Chinook salmon research projects including General Parr Monitoring, Idaho Supplementation Studies, and Hatchery Evaluation Studies.   Kurtis has co-authored annual reports for Idaho Supplementation Studies (1992-1994), and Hatchery Evaluation Studies (1994-1996).

The principal investigator for the fish rearing portion of the project (9700100) is Paul Kline. Mr. Kline has worked for IDFG since 1992 in resident and anadromous fisheries research sub-sections. He has been affiliated with sockeye salmon recovery efforts since 1993 and with chinook salmon captive rearing efforts since 1994. Prior to assuming the position of principal investigator, Mr. Kline served as sockeye project research biologist. He received a B.S. and M.S. in Natural Resources and Fisheries from Humboldt State University (1975, 1980). Prior to coming to IDFG, Mr. Kline worked for the United States Forest Service and for a private consulting firm in Northern California. As a consultant, Mr. Kline was involved with habitat and population surveys of coastal chinook salmon, coho salmon and steelhead populations.

Section 10. Information/technology transfer

Considerable local attention is drawn to project activities in the upper Salmon River Basin of Idaho. Project cooperators strive to maintain an up-to-date awareness at this local level. IDFG Sawtooth Hatchery personnel, Salmon Region personnel, and immediate project personnel make public contacts on a regular basis to discuss project-related issues. IDFG information and education and enforcement personnel address different audiences several times each year to distribute project-related information. Idaho and regional news media interview project cooperators frequently contributing to the publics' awareness of regional salmon issues.

Project cooperators meet monthly (CSCPTOC) to discuss findings and review planned activities. BPA chairs this process and develops concise meeting minutes that are available to the public. Annual reports of program activities are written and are available from the BPA library. Annual reports of program activities required by Section 10 of the Endangered Species Act are also prepared. Presentations are made at regional fish culture and fish health conferences and at meetings held by the Idaho Chapter of the American Fisheries Society.