RFS # 012

Evaluating Relative Reproductive Success of Natural- and Hatchery-Origin Snake River Fall Chinook Spawners Upstream of Lower Granite Dam

(FCRPS BiOp Action #182)

Applicants

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Contributors to Study

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10 April 2003

Project Summary

Introduction-

Natural origin fall chinook in the Snake River, members of the Snake River Evolutionarily Significant Unit (ESU), are listed as "threatened" under the ESA. The spawning populations in the lower Grande Ronde, Clearwater, Imnaha, and Salmon rivers are considered part of the larger composite population for the entire Snake River Basin. The spawning population consists of natural and hatchery origin fish (Table 1). The majority of hatchery origin fish are of Snake River stock reared at Lyons Ferry Hatchery (LFH), however stray fish from other Columbia Basin hatcheries are documented annually passing Lower Granite (LGR) Dam (Milks et al. 2001). Lyons Ferry Hatchery fall chinook releases occur throughout the Snake River Basin from the hatchery itself and from acclimation facilities operated by the Nez Perce Tribe, and in the Clearwater Basin from a Nez Perce Tribe acclimation facility. Fall chinook production at LFH is dictated by the Columbia River Fish Management Plan (CRFMP), with annual negotiation of release numbers.

Productivity of Snake River Basin fall chinook is currently estimated from trends in redd counts (Table 1) for several basins including the Clearwater, Grande Ronde, Imnaha, and Salmon rivers. Redd counts often are underestimated due to water clarity and weather conditions, however counts appear to be increasing in some areas. Unfortunately, natural- and hatchery-origin fish productivity cannot be estimated separately, thus contributions of naturally spawning hatchery fish to increases in productivity are unknown. Broodstock trapping activities at LGR Dam provide an indication of natural and hatchery adult fish abundance in returns to the Snake River and of potential spawners above LGR Dam, and the proportion of hatchery-origin fish has increased in recent years. Determining reproductive success of natural spawners has been identified as a priority in the NMFS Biological Opinion for the Federal Columbia River Power System (FCRPS).

The proposal-

We propose to conduct a pilot study during the first phase of this project to determine whether a genetic mixture analysis approach will be an effective methodology for estimating relative reproductive success of hatchery and natural origin fall chinook spawning in the Snake River. Allozyme-based genetic data prior to 1997 (Marshall et al. 2000) indicate it is reasonable to assume genetic divergence occurs between natural origin fish and LFH broodstocks, as well as other Columbia Basin populations. We will use existing samples of Snake River natural fall chinook juveniles, LFH broodstock adults and natural origin adults to collect microsatellite DNA genotype data and determine if genetic divergence among natural and hatchery origin fish is large enough to accurately estimate separate contributions to annual production. We will use several statistical mixture analysis procedures to test contribution estimation. If the pilot study is successful, we plan to produce estimates of relative reproductive success of hatchery and natural origin spawners in the upper Snake River from 1992 to 1994. Dependent on pilot study success, we propose to continue our research by conducting sampling and analysis of natural origin Snake

River fall chinook from 2004 to 2008 to estimate the contributions of natural progeny of LFH fall chinook to natural spawning above LGR Dam.

This study is expected to determine whether hatchery-reared fall chinook are contributing to recovery of the Snake River population, which addresses concerns listed in FCRPS Biological Opinion Action 184. The Lyons Ferry Hatchery stock targeted in this proposal complements studies already in place and funded by the LSRCP. The LFH fall chinook stock originated from endemic Snake River stock, and hatchery practices were developed and implemented to maintain its integrity. The LFH stock is increasingly being used in recovery-based activities in the Snake Basin. An investigation of its relative reproductive success and its contribution to recovery is essential. Results of this study have the potential to change management in the Snake River basin, resulting in a biological benefit to the Snake River Fall chinook ESU.

Project Description

Background

The Lower Snake River Project was authorized by Congress on March 2, 1945 by Public Law 14, 79th Congress, First Session. The project was authorized under the Rivers and Harbors Act of 1945. It consists of Ice Harbor Dam, completed in 1962; Lower Monumental Dam, 1969; Little Goose Dam, 1970 and Lower Granite Dam, 1975. The project affected over 140 miles of the Snake River and tributaries from Pasco, Washington to upstream of Lewiston, Idaho. The authorized purposes of the project were primarily navigation and hydroelectric power production. The original authorizing legislation for the project made no mention of fish and wildlife measures needed to avoid or otherwise compensate for the losses or damage to these important resources.

The Fish and Wildlife Coordination Act (FWCAR) of 1958 (48 Stat. 401, 16 U.S.C. 661 et seq. as amended) requires an analysis of fish and wildlife impacts associated with federal water projects as well as compensation measures to avoid and/or mitigate for loss of or damage to wildlife resources (refer to Section 662 (b) of the Act). The U. S. Fish and Wildlife Service (USFWS) and NMFS provided the U.S. Army Corps of Engineers with a FWCAR on the Lower Snake River Project in 1972. Using the FWCAR, the U.S. Army Corps of Engineers (COE) wrote a report to Congress in 1975 (USACE 1975) detailing losses of fish and wildlife attributable to the Project. Congress authorized the Lower Snake River Compensation Plan (LSRCP) as part of the Water Resources Development Act of 1976 (Public Law 94-587). LFH and the resulting production of fall chinook is part of legally required mitigation provided to Washington under the LSRCP Program. The LSRCP agreement presumed that actions would be taken at the Hydro-facilities to prevent further erosion of the naturally spawning population

The mitigation program started in 1976 by trapping adult Snake River fall chinook at Snake River dams and implementing an egg bank program at Kalama Falls Hatchery in the lower Columbia River. This action continued until LFH was completed in 1984. Once on-line, LFH began receiving fall chinook transported from Ice Harbor Dam as well as fish trapped on-site at LFH. It has been formally documented in the 1999 BiOp that the fall chinook program at LFH is for Snake River fall chinook, and is intended to provide fish for mitigation/compensation, natural

production (recovery above LGR Dam), and Tribal Trust responsibilities. Over time, the program at LFH has changed to a supplementation program to enhance fall chinook production in the Snake River using Snake River stock.

The incidence of stray fish in the broodstock at LFH began increasing until 1989 when it was determined after spawning that 41% of fish used for broodstock were strays. Concern was raised that strays were spawning in the wild with natural Snake River stock chinook and the integrity of the natural population was being compromised. Washington decided that 1989 brood year production was derived from inappropriate broodstock for the Snake River system. Mating protocols were modified to avoid genetic divergence from the biologically appropriate population (as it was prior to the return of a high number of strays to the system), and returning adults from that broodyear would not be used as future broodstock at LFH.

In 1990, trapping began at LGR Dam to monitor and remove strays from the Snake River and to supplement broodstock for LFH. The removal of strays at LGR Dam was requested by NMFS to ensure the stray rate above LGR Dam not exceed 5% of the total run. Also, beginning in 1990, coded wire tags were read at LFH prior to spawning to determine origin of fish to be used for broodstock. Any fish of unknown origin, including wild Snake River fish, are excluded from the broodstock used for supplementation. The exclusion of non-Snake River fall chinook from the broodstock has kept LFH production substantially genetically intact. WDFW will continue to exclude non-Snake River origin fall chinook from its broodstock. Genetic (allozyme) results indicated that Snake River stock reared at Lyons Ferry Hatchery prior the high stray years were indeed closer to the natural population spawning in the Snake River, than to Columbia River stocks (Marshall et al. 2000).

In 1993 broodstock trapping ceased at Ice Harbor dam because of the high number of strays from the Columbia River that were detected during a three year telemetry project. We plan to continue trapping at LFH and supplementing the broodstock with fish trapped at LGR Dam in years of low returns.

The Snake River Stock at LFH was likely derived from a genetically distinct population of fall chinook in the Snake River Basin, some of which may have been of both hatchery and natural origin. Collection of broodstock fish from the LGR Dam adult trap has consisted entirely of hatchery-origin spawners (adipose clipped fish). Unmarked fish (i.e. presumably natural origin) are not targeted at this trap. The only unmarked/untagged fall chinook encountered during spawning at LFH are fish incidentally trapped at LFH. WDFW suspects these fish to be primarily Snake River origin hatchery-reared fish that were released unmarked from upriver Nez Perce Tribe (NPT) acclimation sites. Unfortunately, no data are available at this time to determine if they are in fact natural fish or unmarked hatchery fish, and thus they can not be used as broodstock.

Since 1990, unmarked/untagged fish have not been included in broodstock because of the possibility of encountering unmarked out-of-basin strays. Unmarked/untagged fish will also be excluded until NMFS allows their inclusion in our broodstock. Any Snake River origin fish not needed for production are passed upstream to "integrate" with the natural population. The majority of unmarked fish in the Snake River are allowed to spawn naturally in the Snake River

each year. To further promote integration of hatchery fish with natural fish, acclimation sites have been used since 1996 to encourage returning adults to spawn in the area of their release.

The program at LFH appears to be working to fulfill its mitigation/recovery goal. In 1999, the Biological Opinion on Artificial Propagation in the Columbia River Basin, concluded that the LFH program was not likely to jeopardize the continued existence of listed Snake River fall chinook ESU. In 2003, the West Coast Salmon Biological Review Team in a draft report, "Preliminarily Conclusions Regarding the Updated Status of Listed ESU's of West Coast Salmon and Steelhead", concluded by majority that Snake River fall-run chinook were "likely to become endangered in the foreseeable future." The resulting conclusion was an upgrade from the original status review of "in danger of extinction".

Fall chinook salmon passing Lower Granite Dam and accessing upper Snake River spawning ground have increased in abundance significantly since 1995, especially the numbers of natural origin fish (Table 2). During this period, relative proportions of Lyons Ferry Hatchery-origin fish in escapements have also increased, from approximately 0% in 1995 to as high as 64% in 1998 (Table 2). It is unknown what contribution hatchery-origin fish have provided to the increase in natural origin spawner abundance. Fall chinook from LFH continue to used in supplementation and rebuilding efforts throughout the Snake River Basin.

U.S Fish and Wildlife Service staff have sampled natural-origin juvenile chinook in areas upstream of Lower Granite Dam since 1991. Genetic analyses have been used to determine which subyearlings sampled were fall or spring/summer origin (Marshall et al. 2000). Fall chinook in these samples have been used to genetically characterize the natural origin population and compare them with a variety of Columbia Basin fall chinook populations, including LFH broodstocks (Marshall et al. 2000). In years when LFH fall chinook were not abundant in escapements above Lower Granite Dam, natural origin juveniles were particularly genetically divergent from LFH broodstocks, based on allozyme (protein) loci variation. It was concluded that the wild spawner population was an important and distinguishable component of genetic diversity within the Snake River fall chinook Evolutionarily Significant Unit (ESU).

Study Plan

Due to the nature and conditions of Snake River fall chinook spawning habitat, we were unable to design a suitable field-based study that would allow estimation of relative reproductive success of individual hatchery and wild fish through genetic pedigree-type analysis. Thus, we propose a pilot study to analyze existing samples and one new (2003) sample of natural and hatchery origin Snake River Basin fall chinook to determine whether a genetic mixture analysis approach to determining relative reproductive success will be an effective methodology. This pilot study will utilize microsatellite DNA markers and we expect that genetic divergence among wild and hatchery-origin fish samples will be at least as large as that measured by allozyme loci. The group of samples we will use for this study is shown in Table 3. Extraction of DNA from tissue, fin clip or scale samples will be done by WDFW, if usable DNA has not been extracted previously. We will collect genotype data for up to 15 microsatellite DNA loci per sampled fish, following standard protocols used by WDFW Genetics Lab for chinook salmon microsatellite markers.

If we find that genetic differentiation among hatchery and wild broodyear components is statistically significant, we expect to be able to estimate contributions of appropriate broodyear components to both natural origin juveniles and adults sampled at Lower Granite Dam. This will be accomplished using several mixture analysis approaches, such as admixture analysis (e.g. Long 1991), mixed-stock analysis using maximum likelihood models, and maximum likelihood or Bayesian genotypic assignment methodologies (e.g. Banks and Eichert 2000; Pritchard et al. 2000). We would expect the genetic profile of a natural origin brood year sample to reflect contributions of hatchery and wild components in the proportions found among parent spawners if relative reproductive success is similar. If relative reproductive success differs, we expect to get a measure of this by the proportional contributions of presumed spawner components. A diagram of how we expect genetic analysis of existing samples and our knowledge of potential annual hatchery and wild spawner composition to enable us to estimate relative reproductive success is shown in Figure 1.

One sample needed for the pilot study will be collected in 2003. We propose sampling unmarked adults at LGR Dam in 2003 because they will represent naturally-spawned progeny of the 1998, 1999, and 2000 broodyears that survived to adulthood. These three broodyears represent years at LGR Dam in which proportions of LFH-origin fish were very high, in contrast to 1993, 1994 and 1995 when they were very low. Comparing these sets of years should be important for understanding annual genetic variability in the natural spawning population. We may also obtain an estimate of reproductive success of the "F_2" generation of the earlier brood years from the 2003 unmarked adult sample.

If the proportion of LFH-origin natural spawners continues to increase and their reproductive success is high, we expect the genetic profile of natural origin fall chinook in future years to become more similar to that of LFH broodstocks. This pilot study will at least enable us to develop a time series of broodyear-based genetic data for Snake River fall chinook that should permit effective monitoring of change in the natural population as recovery efforts continue.

We propose the following phases to our study:

Phase 1 – Pilot Study. Existing samples will be brought together from archive locations. Sampling of 2003 natural origin adults at LGR Dam will take place. DNA analysis of samples by WDFW Genetics Lab will determine the magnitude of differences between fall chinook population samples. Mixture analysis methodologies will be tested with sample data. If analytical results are positive and it is apparent that the continuation of the study is feasible, then we will move to Phase two. Report on pilot study results will be written.

H_o: Genetic variation among wild and hatchery origin spawner components is large enough to allow accurate estimates of relative contributions to natural production of Snake River fall chinook.

Phase 2 – Study continuation to allow evaluation of F_2 generational reproductive success for broodyears we collected data for in Phase 1. We will collect DNA samples from adults allowed access to spawning areas above LGR Dam from 2004 to 2008. Adults may be sampled at the

adult trap at LGR Dam or on spawning grounds. This would require additional staff at the LGR Dam adult trap. Assistance for Phase two would come from University of Idaho (UofI) who would provide personnel to assist the NMFS crew at the LGR adult Trap, and USFWS and the Nez Perce Tribe (NPT) to sample carcasses. WDFW will assemble the database associated with the sampling of adults at LGR adult trap. Scales will be analyzed by WDFW to determine hatchery and natural components in the unmarked/untagged fish. DNA samples will be analyzed by WDFW Genetics Lab personnel. In addition, naturally produced juvenile fall chinook would be collected and sampled as they are outmigrating past LGR Dam or seined in the free flowing river prior to outmigration. Mixture analyses would be performed to estimate relative reproductive success of hatchery and wild fish.

H_o: There is no difference in reproductive success of F_2 generation of progeny produced from natural and hatchery Snake River stock fall chinook.

Timeline

Phase 1: DNA Samples are in hand which allow implementation by June 2003. Results will determinate whether Phase 2 is feasible for implementation by August 18, 2004. Report will be provided

Phase 2: If feasible, sampling of adult salmon at LGR Dam will be implemented August 18, 2004 and continue through December, 2008. Data will be analyzed by June of the following year. If feasible, sampling of juvenile salmon at LGR Dam will be implemented by June 2004 and continue annually to 2008. Annual reports will be provided.

Budget

A detailed budget for Phase 1 is listed in Attachment 1, with yearly estimates presented below.

FY2003	FY2004	FY2005	FY2006	FY2007	FY2008
$209,725	$138,000	$140,000	$242,000	$243,000	$244,000

Literature cited

Banks, M.A. and W. Eichert. 2000. WHICHRUN (version3.2): a computer program for population assignment of individuals based on multi-locus genotype data. Journal of Heredity 91:87-89

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Mendel, G. and D. Milks. 1997. Upstream passage, and spawning of fall chinook salmon in the Snake River. In Blankenship and Mendel, editors. Upstream passage, spawning, and stock identification in the Snake River, 1992 and 1993. Project number 92-046. Final report to Bonneville Power Administration, Portland, OR.

Pritchard, J.K., M. Stephens, and P.Donnelly. 2000. Inference of population structure using multilocus genotype data. Genetics 155:9945-959

Applicant and Contributor Qualifications

Qualifications of Applicants:

Anne Marshall, Fish and Wildlife Biologist, WDFW. **Education**: M.S., Marine Fisheries Science, College of William and Mary- VA Institute of Marine Science, Virginia. **Work history**: 1988 to present: Fish and Wildlife Biologist, Fish Program-Science Division, Conservation Biology Unit and former Genetics Unit. Current responsibilities include providing genetics expertise to regional NMFS Technical Recovery Teams, technical assistance with basin or population-specific salmonid recovery plans in Washington, risk assessments of hatchery production for supplementation or harvest augmentation, developing a fisheries and hatcheries management plan for Cowlitz Projects Re-licensing Settlement Agreement, and conducting research projects pertinent to salmon and steelhead recovery planning. 1986-1988: Staff Research Associate, Chinook Salmon Genetic Stock Identification Project, Department of Animal Science, University of California-Davis, Davis, CA. 1985-1986: Research Assistant, Endangered Species Program, California Department of Fish and Game, Sacramento, CA. 1981-1985: Sea Grant Program, University of Florida Cooperative Extension Service, Ft. Myers, FL; **Project expertise**: Knowledge and experience in regional and coast-wide chinook salmon population genetics. Have analyzed and applied chinook salmon genetic data for mixed stock harvest management, conservation of genetic diversity, and evaluation of hatchery programs for over 15 years. Have 10 years experience assisting with Snake River chinook genetics and life-history research and evaluation of fall chinook population genetics, and have similar experience with other Columbia Basin chinook populations. Published research results on Columbia Basin chinook population genetics in peer-reviewed journals. Recently performed genetic analyses for a steelhead wild and hatchery populations relative reproductive success study in Oregon, results of which will be published in summer 2003.

Deborah Milks, Fish Biologist, WDFW. **Education**: B. S. Animal Science, Washington State University, 1983. Post-graduate studies including Fish Ecology, Aquaculture, and Directed Study, University of Idaho, 1988. **Work history**: 1991 to present-Fish Biologist, Lower Snake River Compensation Plan hatcheries evaluation program. Responsible for data collection, analysis, and the reporting of appropriate research for LSRCP. Performed as associate fall chinook telemetry biologist until 1993. Assisted the lead fall chinook specialist until 2000 then

became the lead fall chinook specialist for the LSRCP program. Takes primary responsibility for the organization, writing, and data analysis for annual reports. **Project expertise**: Current duties include acting as WDFW's lead biologist monitoring and evaluating LFH releases and returns of fall chinook under the LSRCP. Assists LFH in current spawning activities and tracking of fall chinook matings. Compiles databases for use by NMFS for run reconstruction of fall chinook at LGR Dam. Coordinates research activities with other fall chinook co-managers and researchers in the Snake River Basin, including Nez Perce Tribe, Confederated Tribes of Umatilla Indian Reservation, USFWS, NMFS, Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, Washington State University, and the University of Idaho. Debbie will coordinate efforts between agencies to facilitate this study, compile and proof data collected during the different phases of this study, and assist in report writing.

Mark Schuck, Lead Fish Biologist at Snake River Lab, WDFW. **Education**: B.S. Fish Biology, Colorado State University, 1974. **Work history**: 1994-present - Project Leader; Lower Snake River Compensation Plan hatcheries evaluation program. Responsible for overseeing WDFW? s evaluation of a federal compensation/mitigation program designed to replace fish resources lost due to construction of the four Snake River power dams. Evaluation activities are currently being undertaken for spring and fall chinook salmon and steelhead in several rivers in S.E. Washington. Duties include assisting with experimental design and implementation of studies, budgeting and report writing. Reports are submitted in both annual progress report and final refereed journal formats. 1982-1994: Served as District Fish Management Biologist for WDFW in Asotin, Columbia, Garfield and Walla Walla counties. Concurrently served as Project Leader for LSRCP trout evaluations in Washington. 1978-1982: Research Biologist with WDFW on Lower Columbia River steelhead stock evaluation study, and assessing effects of Mt. St. Helens eruption on steelhead populations within the Toutle River drainage. **Project expertise**: Has managed or researched the fish resource in S.E. Washington since 1982. Has been actively involved with evaluation of the LSRCP compensation program since its inception in 1982 and with salmon and trout under the mitigation program since 1995. Helped conduct an evaluation of instream habitat improvements in Asotin Creek and Tucannon River in 1989 as part of the mitigation program.

Qualifications of contributors:

William P. Connor, Fishery Biologist, Idaho Fishery Resource Office, USFWS. Education: B.S. Fish and Wildlife Management, West Virginia University, 1984. M.S. Fish and Wildlife Management, Montana State University, 1988. Ph.D. Fisheries Resources, University of Idaho, 2001. **Work history**: 1991-Present-Principal researcher on the spawning, rearing, and migratory requirements of wild and hatchery fall chinook salmon in the Snake River basin. 1987-1991 – Principal researcher overseeing an assessment of fall chinook salmon production in the Clearwater River, Nez Perce Tribe. **Project expertise**: A total of 16 years studying fall chinook salmon in the Snake River basin. Coauthored 12 manuscripts in peer-reviewed journals on Snake River fall chinook salmon topics including: genetics, spawning habitat quantity, spawning habitat quality, emigrational behavior, survival, and growth. Recently submitted 3 papers to North American Journal of Fisheries Management on: demographics of Lyons Ferry Fish Hatchery fall chinook salmon adults, behavior of Lyons Ferry Fish Hatchery adults

returning to acclimation facilities on the Snake and Clearwater rivers; and post-release attributes of Lyons Ferry Fish Hatchery yearlings and subyearlings released in the Snake River.

NOAA staff operate the adult collection facility at LGR Dam. This staff will collect adult fall chinook for sampling at LGR Dam.

University of Idaho has staff which have performed numerous studies on the Columbia and Snake rivers including telemetry work on fall chinook in the Snake River. University of Idaho will employ staff to trap adult fall chinook at LGR Dam and collect juvenile fall chinook at LGR Dam if necessary.

Nez Perce Tribe is a co-manager for fall chinook on the Snake River. Staff operate acclimation facilities on the Snake and Clearwater rivers as well as a hatchery, Nez Perce Tribal Hatchery, on the Clearwater River. Staff is experienced in performing redd counts on the Snake and Clearwater rivers and have performed juvenile telemetry studies on fall chinook in the system. The Nez Perce Tribe will employ staff to perform carcass surveys on the Clearwater if deemed necessary.

Sewall Young, Fish and Wildlife Biologist, WDFW. **Education**: B.S. Wildlife Biology, University of Montana, 1978; M.S. Fishery and Wildlife Biology, Colorado State University, 1982 **Work Experience**: 1987 – 1997: Genetic Stock Identification Baseline Sampling Coordinator, WDFW; 1997 to present: Population geneticist - DNA, WDFW. **Project Expertise**: 1987 – 1997 Gained specific knowledge of chinook populations in British Columbia, Washington and Oregon while planning and coordinating WDFW's population genetics baseline sampling efforts. 1997 to present: As the lead biologist in WDFW's DNA lab, developed microsatellite screening protocols for 7 salmonid species, conducted studies of salmonid population structure in resident and anadromous populations, developed and applied statistical methods for analyzing stock mixtures and assigning individuals to stock-of-origin, developed species identification markers based on single nucleotide polymorphisms.

Table 1. Natural and hatchery origin (includes all hatcheries) adult fall chinook passed above LGR Dam to continue migration to spawning areas, and redd count estimates in these areas. Data compiled using LSRCP annual reports.

Year	Natural adults	Hatchery adults	Snake River redds	Grande Ronde River basin redds	Imnaha River basin redds	Salmon River basin redds	Clearwater River basin redds
1988	368	259	64	1	1	0	21
1989	295	411	58	0	1	0	10
1990	78	258	37	1	3	0	4
1991	316	274	46	0	4	0	4
1992	549	119	47	5	3	1	26
1993	742	210	127	49	4	3	36
1994	406	201	67	15	0	1	37
1995	350	285	71	18	4	2	20
1996	639	280	113	20	3	1	69
1997	796	211	58	55	3	1	72
1998	304	658	185	24	13	3	78
1999	905	957	373	13	9	0	184
2000	1167	1497	346	8	9	0	173
2001	6630	5847	710	197	38	22	336

Table 2. Origin of adult fall chinook passing Lower Granite Dam in the Snake River, as estimated by recoveries of marked fish at the dam (from LaVoy and Mendel, 1996 and WDFW Lyons Ferry Hatchery (LFH) Annual Reports to USFWS). Hatchery numbers were estimated by expanding marked fish observations by juvenile marking rate. Total counts are actual counts at the dam's passage facility. "Jack" chinook are males 56 cm or less in fork-length and are largely age two. Note that these values differ from values in Table 1 because of the inclusion of jacks.

Escapement – Number of Adults ("jacks" included)

	Lyons Ferry Hatchery		Other Hatchery		Natural		Total
Year	**N**	**%**	**N**	**%**	**N**	**%**	
1990	221	51	114	26	101	23	436
1991	202	-	70	-	318	-	960[1]
1992	103	14	25	3	620	83	748
1993	43	4	167	17	777	79	987
1994	42	6	191	27	484	68	717
1995	0	0	285	43	379	57	664
1996	242	19	205	16	840	65	1287
1997[2]	298	23	191	15	813	62	1302
1998[2]	1493	64	220	64	620	27	2333
1999[2]	1499	46	78	9	1677	52	3254
2000[2]	4349	53	153	2	3659	45	8161
2001	6831	46	656	4	7459	50	14,946

[1] The total 1991 count included jacks, but they were not included in the 1991 estimates of the three component groups.

[2] From 1997 to 2000 the number and proportion of jacks of LFH and natural origin increased greatly. The jack estimates are as follows:

	LFH	Natural
1997	~278	n/a
1998	1,012	316
1999	620	772
2000	2,956	2,492

Table 3. List of samples to be analyzed for Phase 1 . Sample materials consist of body tissue for outmigrant juveniles, and of scales for Lyons Ferry Hatchery, other Columbia hatchery and Lower Granite Dam adults.

Wild Snake River Fall Chinook Outmigrant Juveniles

Broodyear	Sample Year	Sample Size	WDFW Code
1990	1991	143	91FY
1992	1993	59	93FZ
1993	1994	115	94EP
1994	1995	111	95ET
1995	1996	45	96GC
1996	1997	50	97GI
1997	1998	122	n/a
1998	1999	196	n/a
1999	2000	127[1]	n/a
2000	2001	169[1]	n/a
Total Samples:		1,137	

Lyons Ferry Hatchery Fall Chinook Broodstock Adults

Sample Year	Sample Size	WDFW Code
1987	99	87BR
1988	100	88AI
1989	100	89CE[2]
1990	100	90DI[3]
1991	100	91FB
1992	100	92FE
1993	92	93FS
1994	100	94EN
Total Samples:	791	

Natural Origin Fall Chinook Adults At Lower Granite Dam

Sample Year	Sample Size
1999	110
2000	68
2003	200[4]
Total Samples:	378

Columbia Basin hatcheries Fall Chinook Broodstock Adults

Table 3. –continued.

We will use existing samples from two Columbia basin fall chinook hatchery production facilities such as Umatilla Hatchery or Priest Rapids Hatchery as appropriate based on stray fish data from Lower Granite Dam recoveries

Total Samples:	200
Grand Total Samples:	2,506

[1] Sample size estimated pending USFWS final results on fall chinook identification

[2] Returns from 1989 broodyear releases were not used as broodstock in subsequent years at Lyons Ferry Hatchery because of the high proportion of strays estimated in 1989 parents

[3] From 1990 forward only coded-wire tag Lyons Ferry Hatchery origin adults were used as broodstock and 1990 to 1994 samples contain only tagged fish.

[4] Approximate number; these samples will be collected during the pilot study

Figure 1. Diagrammatic example of how using existing samples and information about potential natural spawner population based on fish detected at Lower Granite Dam (LGD) could provide estimate of relative reproductive success of wild and hatchery-origin fall chinook, assuming sufficient genetic differentiation is found using microsatellite DNA loci. BY=Broodyear; X, Y, Z variables indicate the three major sources of potential spawners – Lyons Ferry Hatchery, Snake River wild, non-Snake River hatcheries, respectively. For illustration purposes we assumed all spawners are 3, 4 or 5 year olds.

	(from BY's 87, 88, 89)			(from BY's 88, 89, 90)			(from BY's 89, 90, 91)		
Adults at LGD* at year:	%X	%Y	%Z	%X	%Y	%Z	%X	%Y	%Z
Natural spawning									
Offspring sampled following spring	92BY			93BY			94BY		
Natural adults return**									
Add %X & %Z to spawning grounds*									
Natural spawning									
Offspring sampled following spring	95BY			96BY		97BY		98BY	99BY

Perform genetic mixture analyses of 1995 to 1999 naturally produced juveniles to determine whether genetic profile of each 1995 to 1999 sample reflects contributions proportionate to X, Y, Z annual spawner components as estimated by LGD passage. Baseline data would include 92, 93, and 94 BY (and others as necessary) wild juvenile samples, appropriate LFH broodyear samples, and non-Snake River hatcheries' samples as appropriate (based on CWT data from strays).

* see Table 2 for values
**other BY's contributing to 1995 and 1999 returns not shown