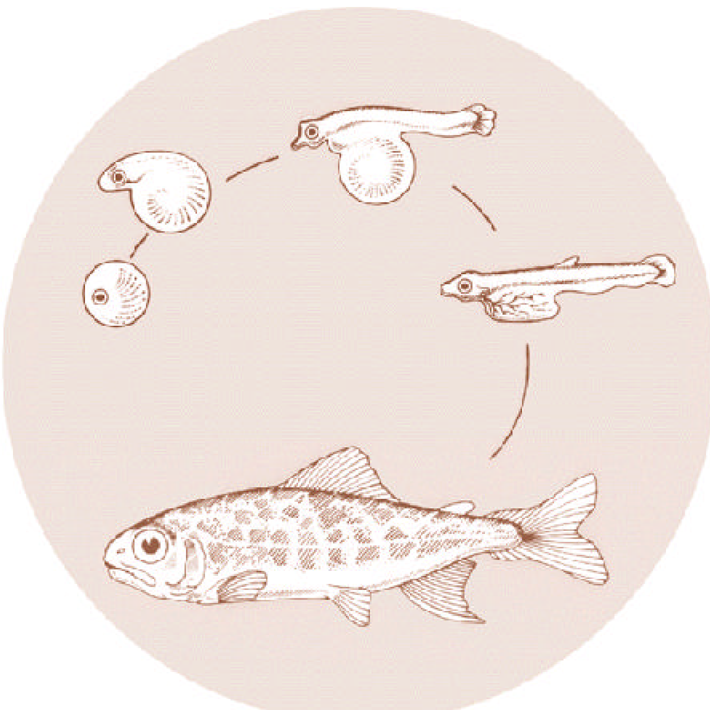
December 1991

SALMON SUPPLEMENTATION STUDIES IN IDAHO RIVERS (Idaho Supplementation Studies)

Experimental Design



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SALMON SUPPLEMENTATION STUDIES IN IDAHO RIVERS

(Idaho Supplementation Studies)

Experimental Design

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EXECUTIVE SUMMARY

The role of supplementation in helping recover declining anadromous stocks in the Columbia Basin is the subject of much debate. For upriver stocks of chinook salmon *(Oncorhynchus tshawytscha),* we believe supplementation should never be considered an alternative to reducing mortalities associated with the lower Snake River and Columbia River dams and reservoirs. As an interim recovery effort, concurrent with improvements in the overriding mainstem factors, we believe supplementation can potentially play an important role in the recovery process. Past failures and considerable risks associated with supplementation require careful developarent and evaluation of test supplementation programs prior to Basin-wide implementation.

The purpose of this study is to help determine the utility of supplementation as a potential recovery tool for decimated stocks of spring and summer chinook salmon in Idaho. Our goals are to assess the use of hatchery chinook to restore or augment natural populations, and to evaluate the effects of supplementation on the survival and fitness of existing natural populations.

We have adopted the definition of supplementation developed by the Regional Assessment of Supplementation Project:

> "Supplementation is the attempt to use artificial propagation to maintain or *increase* natural production while maintaining the long term fitness of the target population, and while keeping the ecological and genetic impacts on nontarget populations within specified biological limits." (RASP 1991)

Past supplementation was rarely implemented or evaluated within this context, making the utility of supplementation a critical uncertainty for enhancement of naturally reproducing salmon populations.

Cur experimental design represents three main approaches. The first and main level of evaluation is large-scale population production and productivity studies designed to provide relatively generic inferences state wide. The second level uses the same study streams as individual "case histories" to evaluate specific supplementation programs (e.g. supplementation from McCall Hatchery into the upper South Fork Salmon River), although inferences at this level are limited to only descriptive assessments. The third level represents small-scale studies designed to address specific hypotheses concerning the mechanisms of supplementation effects (e.g. spawning, dispersal, competition).

The long term design tests the response of populations to treatments (supplemented) over time as compared to controls (unsupplemented) and baseline data. The study is split into two main components: supplementation-augmentation of existing natural populations, and supplementation-restoration of extirpated populations. The design utilizes 20 treatment streams and 11 control streams in the Salmon River and Clearwater River drainages to provide adequate replication for each hypothesis.

To evaluate these treatment effects, we will monitor a number of production and productivity response variables. Production variables measure the effects of supplementation on fish numbers, and include adults, redds, Parr, emigrants, and smolts to the lower Snake River.

Productivity variables measure the effects of supplementation on the overall replacement ability and performance of natural populations. These variables include survival, fecundity, age structure and genetic composition, among others.

We followed several basic assumptions or guidelines in developing supplementation production plans for each treatment stream and associated hatchery facilities. Some of these include: maintain a clear distinction between supplementation programs and general hatchery production or harvest augmentation programs; in areas with existing natural populations, do not exceed a 50:50 balance between supplementation and natural fish spawning or rearing in target streams; in areas without existing natural populations, design supplementation programs to provide 25% to 50% of the natural summer rearing capacity within one or two generations; and, wherever possible, incorporate a relatively high proportion of natural fish in each supplementation broodstock.

Cur general hypothesis is that supplementation can increase natural production (i.e. total numbers produced) but not natural productivity (e.g. number of adults produced per natural spawner). We also hypothesize that reductions in natural productivity can be minimized through proper supplementation strategies so that enhanced production more than compensates for reduced productivity.

Our supplementation production plans include guidelines for broodstock collection, spawning, rearing, releases and allocation of adult returns. In general, broodstock strategies include collecting adults from the local population. Initially, a proportion of the total adult returns will be collected until marked fish become available after *one* generation. At that time supplementation broodstocks will be comprised of a known natural component, with the majority of natural returns allowed to spawn naturally. Fish will be spawned with a 1:l sex ratio as they ripen, without selection for size, age, appearance or hatchery-natural origin.

Rearing will take place predominantly in existing facilities and will generally follow standard hatchery practices. Where feasible, operations will be adapted to mimic natural rearing conditions (e.g. water temperature, photoperiod, velocity gradients, low rearing density). All supplementation and general hatchery production fish released in study areas will be marked prior to release. This will allow for proper evaluation and broodstock management, as well as keep general hatchery production fish from being passed over weirs to spawn naturally.

Idaho Supplementation Studies (ISS) includes supplementation with Parr, fall presmolt and smolt life stages. These releases will be predominantly off site at multiple release points distributed throughout the treatment streams. Presmolt and smolt releases will be timed to coincide with known physiological and environmental emigration cues. Although harvest opportunities will not be precluded from supplementation study areas, the objective will be to ensure escapement of enough natural and supplementation fish through terminal fisheries to allow for natural rebuilding and adequate evaluation.

In spite of the scale of our study, the relative genetic risks associated with the design are low. This is partially because approximately 70% of our treatments will be implemented in areas with existing hatchery programs that have at least partial supplementation objectives. Wherever possible we have followed genetic guidelines currently being developed in the Columbia River Basin. This has included utilizing local broodstocks wherever possible, allowing natural escapement criteria to drive the programs, non-selective mating, marking all hatchery fish, and timing releases to coincide with natural emigration. The greatest potential source of genetic risk associated with our supplementation programs is inadvertent selection resulting from hatchery rearing environments. Most of our experimental design will utilize existing hatcheries with ongoing production programs. Where necessary and feasible, genetic guidelines will be implemented to minimize this risk.

Although ISS comprises a large component of Idaho's anadromous management program, it represents a relatively small component of anadromous management opportunities in the state. Supplementation activities will occur in 17% of the natural production areas in Idaho and will utilize less than 30% of the available adult returns to egg-take facilities and only 17% of the available hatchery space.

ISS represents a cooperative effort *among* resource management agencies and tribes in the state. Implementation will begin January 1992 and may continue for at least three generations (15 years). In order to optimize efficiency and integration with ongoing programs, implementation of the experimental design has been partitioned among the various agnencies and tribes. These components will be contracted and implemented individually under the direction of an interagency steering conmnittee headed by IDFG.

BACKGROUND AND JUSTIFICATION

History and Status

Hatcheries and supplementation activities have existed in the Columbia Basin for over 100 years. The first hatchery in the Columbia Basin was built on the Clackamas River, Oregon in 1878. The number of hatcheries and level of supplementation in the basin has been increasing ever since.

The first recorded supplementation of chinook salmon *(Oncorhynchus tshawytscha)* in Idaho was in 1920 on the Lemhi River. Adult salmon were trapped in the Lemhi River and spawned at a cultural station in Salmon, Idaho. The eggs were reared to fry and then released back into the Lemhi. The station was abandoned in 1933 due to dwindling runs (Gebhards 1959).

The second record of outplanting was an attempt to reestablish chinook into the Clearwater River drainage above Lewiston Dam. From 1947 to 1953 an average of 100,000 eggs/year were taken from wild spring chinook in the headwaters of the Middle Fork of the Salmon River. These eggs were reared to fingerling size and released into the Little North Fork of the Clearwater River. Total fingerling releases during this period were approximately 250,000 fish (Nez Perce Tribe et al. 1990). Some adults returned to the Clearwater River as a result, but the exact numbers and their spawning success are unknown.

The second major attempt to reestablish chinook into the Clearwater began in 1961 with the advent of the Columbia River Fisheries Development Program. This program began with the removal of barriers to upstream migration and the collection of 850,000 spring chinook salmon eyed eggs from the upper Middle Fork of the Salmon River and 610,000 eggs from upriver adult spring chinook trapped at the Bonneville Dam fish ladders. These eggs were put into hatching channels in the upper Selway River (Nez Perce Tribe et al. 1990). Once again, adults returned as a result, but extent and spawning success were not evaluated.

Presently, there are ten state and federal anadromous hatcheries operating in Idaho: Oxbow, Rapid River, McCall, Sawtooth, Pahsimeroi, Dworshak, Kooskia, Hagerman National, Niagara Springs, and Magic Valley. There are also three satellite rearing ponds: Powell, Red River, and Crooked River. These will operate in conjunction with the Clearwater Hatchery presently under construction. These hatcheries have the combined capacity to produce 8.5 million spring chinook smolts, 2 million summer chinook smolts, 6.7 million A-run steelhead *(0. mykiss)* smolts, and 4 million B-run steelhead smolts annually. It should be noted that Hagerman National, Niagara Springs, and Magic Valley hatcheries produce steelhead only, thus they will not be part of chinook supplementation programs.

The Lower Snake River Compensation Plan was authorized in 1976 to mitigate losses resulting from the construction of the four lower Snake River dams (Herrig 1990). Sawtooth, McCall, Hagerman National, Magic Valley, Dworshak expansion, and the Clearwater hatchery (presently under construction) as well as the Red River, Crooked River, Powell, South Fork and East Fork of the Salmon River satellite facilities are part of this mitigation effort. Dworshak was constructed to mitigate Dworshak dam. Kooskia Hatchery was constructed to help mitigate Columbia River dams as mandated in the Mitchell Act. Oxbow, Rapid River, Pahsimeroi, and Niagara

Springs hatcheries were built by Idaho Power to mitigate the construction of Hell's Canyon, Brownlee, and Oxbow dams. In general, the primary purpose of all these hatcheries is to return adult salmon and steelhead above Lower Granite Dam to provide fishing opportunity lost as a result of hydropower development.

Supplementation of natural stocks is not a mandated mitigation objective, but has become an important part of the hatchery programs. Idaho has outplanted (i.e. off-site releases) over 5.5 million chinook fry, approximately 8 million smolts, and 8,000 adults into the Salmon River drainage since 1977 (IDFG et. al. 1990). During the same period, over 17 million fry, 3 million smolts, and 2,000 adults were outplanted into the Clearwater River drainage (Nez Perce Tribe et. al. 1990). In spite of widespread outplanting activities there has been little scientific evaluation of supplementation on rebuilding or influencing natural salmon populations both in Idaho and basin wide.

Future increases in hatchery production will come from two sources. The first is the Lower Snake River Compensation Plan's Clearwater Hatchery. It will have the production capacity of 1.4 million spring chinook and 2.5 million B steelhead smolts. The facility is scheduled to begin operation in spring 1992. This hatchery will increase opportunities to supplement both spring chinook and B-run steelhead populations. The second is the Nez Perce Tribal Hatchery which will produce a total of approximately 3.3 million spring chinook presmolts for streams in the Clearwater River drainage. The purpose of this facility is to expand harvest opportunities and increase natural production.

In spite of a myriad of mitigation efforts spearheaded by hatchery program anadromous fish stocks in Idaho continue to decline. At present, wild and natural stocks of both spring and summer chinook average 15% of full seeding, A-run steelhead average 35% and B-run steelhead average 19% of full seeding (Scully et. al. 1990). The precarious status of Snake River chinook has been recognized recently by the National Marine Fisheries Service (NMFS) in their recommendation for protection under the Endangered Species Act (NMFS 1991).

Role of Supplementation

It is well documented that most of the decline and continued depression of upriver chinook stocks is due predominately to poor survival (flows and passage problems) associated with the lower Snake and Columbia River dams and reservoirs (IDFG 1985; CBFWA 1990; IDFG 1991). Although mitigation efforts should be focused on direct alleviation of passage and flow constraints, concurrent recovery efforts such as supplementation have been recognized as necessary to meet the Northwest Power Planning Council's interim doubling goals (NPPC 1987).

The utility of supplementation as a viable recovery tool is the subject of much debate, which we address briefly in our text (see Potential Results Section). Although sound evaluation has been lacking, there is little doubt that past supplementation efforts have rarely met with success (Smith et al. 1985; Miller et al. 1990; Steward and Bjornn 1990). We believe the verdict on supplementation is still out because previous outplanting programs were typically directed by conventional hatchery guidelines and criteria, and not current natural production and genetic conservation theory. The potential benefits as well as risks associated with supplementation warrant more thorough investigation prior to negating or embracing supplementation as a recovery tool. The following discussion provides a brief synopsis of current knowledge and theory on supplementation effects.

While there has been conflicting evidence, the majority of the research points out that outplanting programs have not been successful, especially when the intent was to boost natural production (Reisenbichler and McIntyre 1986; Miller et al. 1990). Reestablishing runs (i.e. restoration) have shown some success. Salmon with shorter freshwater life cycles and shorter migrations have had higher success than those with longer freshwater residency and longer migrations (Miller et al. 1990). Miller et al. also states that the introduction of "locally adapted" smolts will yield adults but they warn smolt quality must be good (e.g. disease not a significant mortality factor). Wild and natural fish do not perform as well in a hatchery as hatchery fish (Reisenbichler and McIntyre 1977). Fish from distant stocks do not survive as well as fish from the local stocks. Survival decreases as transfer distance increases (Ritter 1975; Kijima and Fujo 1982; Reisenbichler 1988).

With traditional hatchery practices, hatchery fish tend to become a different stock. They adapt to the hatchery and can become different genetically (altered heterozygosity, gene frequency shifts) from the natural/wild stock from which it was derived (Reisenbichler and McIntyre 1977; Steward and Bjornn 1990; McIntyre in press). These changes can be observed in fitness, growth, survival and disease resistance. Hatchery fish have shown increased straying rates compared to wild and natural fish (Steward and Bjornn 1990). This could pose a significant threat to non-target wild stocks.

Offspring resulting from hatchery X wild/natural crosses can have lower fitness for the local habitats. Fitness was found to decrease as differences between hatchery and wild/natural fish increase (Bams 1976; Reisenbichler and McIntyre 1986; Chilcote et al. 1986). Quantification of the relationship between some measure of "distance" (e.g. geographic, genetic) between stocks and resulting fitness of crosses is lacking. Productivity of wild/natural stocks can also be reduced after introgression by hatchery fish (Snow 1974; Vincent 1985, 1987; Kennedy and Strange 1986; Petrosky and Bjornn 1988). Offspring of hatchery adults can have relatively low survival in natural habitats relative to wild/natural offspring (Chilcote et al. 1986; Nickelson et al. 1986). Genetic changes in hatchery fish even over a few generations can affect survival negatively in the natural environment (Reisenbichler and McIntyre 1977; Steward and Bjornn 1990; McIntyre in press).

It is generally felt that supplementation can increase natural production (i.e. total numbers produced) but not natural productivity (e.g. number of adults produced per natural spawner). Reductions in natural productivity can be minimized through proper supplementation strategies so that enhanced production more than compensates for reduced productivity. These same hatchery practices can minimize genetic drift of the hatchery stock away from the local stock from which it was derived by collecting eggs from throughout the run, using wild fish in the egg-take periodically and spawning males and females in a 1:l ratio (Kapuscinski et al. 1991).

Hatchery stocking increases the potential for density dependent mortality. This may be disproportionally greater for wild/natural fish if hatchery fish have a size advantage.

Interbasin stock transfers can result in "serious" risk to the fitness of native stocks. Several biologists have recommended that if a supplementation program is initiated, the hatchery broodstock should be taken from the stock to be supplemented in order to maintain genetic identity and avoid disrupting locally attuned co-adapted gene complexes (Bams 1976, Reisenbichler 1981, 1984; Chilcote et al. 1986; Currens et al. 1991; Kapuscinski et al. 1991; McIntyre in press). Estimates of the number of adults needed to start the broodstock range from 50 (Verspoor 1988) to 500 (Franklin 1980). They also recommend that in order for supplementation to have the best chances of success one needs to understand the ecology of the area (e.g. carrying capacity, survival rates and densities, habitat quantity and quality etc.), factors limiting present production, the unique qualities of the stock, and optimum methods of supplementation.

Certain life stages may have less of an impact on native stocks. Introduction of locally adapted adults appears to minimize negative interaction potential between their offspring and offspring of wild fish. It is assumed that spawning would occur in the same time frame, emergence timing would be similar and the fry would be subject to the same selective pressures as the wild/natural fish. There would be no size advantage. Locally adapted eggs on the other hand are questionable, one must make sure that the thermal history of the eggs in the hatchery is similar to the wild eggs in the stream to avoid a size advantage in the hatchery fry.

Fry appear to have the highest potential for harmful interactions with wild fish during the first generation (typically the hatchery fish have a size advantage over the wild/natural fish). Second generation impacts are probably greater for smolts because the carrying capacity restraint is lifted. Because the natural rearing carrying capacity can be exceeded with smolts, there stands a greater chance of swamping the natural population with returning hatchery adults. This in turn can result in diluting the locally adapted gene complexes of the native fish. If introgression of the hatchery and natural stocks is desired, brood, rearing and release strategies should mimic the natural conditions as best possible. Genetic changes in the natural population resulting from supplementation can persist several generations after outplanting is discontinued.

It is widely held that for upriver stocks, supplementation cannot be considered an alternative to reducing downriver mortalities. Success is dependent on concurrent improvement in flows and passage. Flows and passage related mortality through the eight lower Snake and Columbia River dams and reservoirs is thought to be the most important limiting factor for upper Snake River stocks. Other than flows and passage, the primary determinants of the success of outplanting are the source of parents, rearing density and environment, size, and time of year fish are released.

Idaho Supplementation Studies

IDFG spearheaded development of this experimental design to address questions identified in the Supplementation Technical Work Group (STWG) Five Year Workplan (STWG 1988), as well as help define the potential role of supplementation in managing Idaho's anadromous fisheries and as a recovery tool for the basin. Answers to these questions will help determine the best broodstock, rearing and release strategies for augmentation or restoring natural populations in various streams and the effects of these activities on target and non-target natural populations.

The Idaho Supplementation Study (ISS) is being conducted in two phases. Phase I is near completion and included formation of the Idaho Supplementation Technical Advisory Committee (ISTAC), development of a comprehensive experimental design and database, and initial collection of baseline genetic, physical and biological data.

The research plan is a cooperative project involving all the members of the ISTAC. The committee is made up of representatives from the Forest Service (USFS) Intermountain and Northern regions, United States Fish and Wildlife Service (USFWS), Nez Perce Tribe (NPT), Shoshone-Bannock Tribes (SBT), Northwest Power Planning Council (NPPC), Bonneville Power Administration (BPA), Idaho Cooperative Fish and Wildlife Research Unit (ICFWRU), and Idaho Department of Fish and Game (IDFG). Their roles were to technically review and provide input on the research design and coordinate with their respective management, research, and user groups. This insures that long and short term management plans of respective agencies and tribes will not compromise the supplementation research design and that management and research concerns of the respective agencies and tribes were represented in the supplementation research design. Through a subcontract with IDFG, the Idaho Cooperative Fish and Wildlife Research Unit (ICFWRU) assisted directly in the development of the experimental design, with particular emphasis on the genetic and ecological effects of supplementation on natural populations.

The ISTAC also assisted with baseline data collection where appropriate. IDFG has baseline parr density, and habitat data for much of the state's anadromous waters. The tribes, USFWS, USFS and ICPWRU helped collect data where it was missing or incomplete. ICFWRU also collected baseline genetic data (electrophoretic) in cooperation with NMFS and WDF to obtain genetic profiles for each population, and investigate the feasibility of developing and using genetic marks.

Implementation (phase II) is scheduled to begin early 1992. ISTAC will continue technical advisory and agency coordination roles. We anticipate the ISTAC will also provide the basis for a steering committee to insure quality control and accountability of the various project components and contributors. It is anticipated that IDFG, ICFWRU, Nez Perce Tribe, Shoshone-Bannock Tribes, and USFS will share direct responsibilities for implementation and evaluation.

Relation to Fish and Wildlife Program

The Northwest Power Planning Council (NPPC) has identified supplementation as a high priority to achieve its interim goal of doubling anadromous fish runs in the Columbia Basin (NPPC 1987). This research relates directly to basin-wide needs and concerns addressed in the Columbia Basin Fish and Wildlife Program (NPPC 1987). Section 206(b)(l)(D) mandates supplementation research to assess the potential of supplementation to increase natural production. Section 204(D) stresses the importance of evaluating genetic and ecological effects from outplanting hatchery fish on natural populations. The need to address supplementation questions for upriver stocks is specified in Section 703(h)(l).

Relation to Supplementation Technical Work Group

The Fish and Wildlife Program also mandated the development of a Supplementation Technical Work Group (STWG) and Five-year Work Plan (WP) (Section 206(b)(2),(3)) to identify specific research needs and to integrate and coordinate supplementation research activities. The STWG states in its WP that two types of studies were needed to 1) determine supplementation techniques that enhance smolt production and adult escapement, and 2) determine the effects of supplementation with hatchery fish on natural populations (STWG 1988). The studies are "by nature long term since they involve stocking hatchery fish of various life stages into different habitats and estimating their instream and ocean survival, their return as adults, and the ability of increased adult returns to maintain themselves through subsequent generations."

The major questions associated with these types of studies were identified as "What are the best techniques for supplementing wild and natural stocks?" and "What are the effects of supplementation on endemic populations?" Seven specific questions were identified encompassing synopsis of existing knowledge, rearing and release strategies, and imaediate and long-term effects on target and non-target stocks.

Aspects of both major questions in the STWG WP will be addressed by ISS. Overall species and geographic priority for this research is 1 and 6 out of 22 specified possibilities in the WP.

Relation to Other Supplementation Projects

Supplementation in Idaho parallels basin wide needs and concerns as well as addressing unique concerns for upriver stocks. At present there are two ongoing and three proposed supplementation projects in Oregon, seven ongoing and three proposed in Washington, three ongoing and one proposed in Idaho, and one ongoing and one proposed that would involve streams in all three states. These projects have been reviewed to enhance coordination and integration with ISS and to avoid unnecessary duplication of effort. This has helped strengthen our experimental design and ensure that priority supplementation questions are being addressed.

A major contributor in this effort has been our participation in the Regional Assessment of Supplementation Project (RASP). This project has focused on providing an overview of ongoing and planned supplementation activities; identifying critical uncertainties and how to technically address them; providing the framework for a "global" experimental design; and developing a model to identify realistic benefits and risks of supplementation (RASP 1991).

There are also numerous supportive research or monitoring projects in the state that are not studying supplementation but will provide valuable data for ISS. These include projects by IDFG, Sho-Ban Tribes, Nez Perce Tribe, USFS, and ICFWRU. Supportive information includes parr density estimates, redd counts, habitat characteristics, spawning distribution and behavior, fish marking, rearing density effects, and pathogen screening.

Refer to Appendix A for a more detailed description of other supplementation and supportive activities in the basin and their relation to ISS.

Relation to IDFG Anadromous Fish Plan

ISS is thoroughly integrated into the IDPG 1991-1996 Anadromous Fish Plan, which is currently under public review prior to Commission approval. ISS is a key component of this Five-year Plan to help develop and evaluate supplementation programs within an adaptive management framework. The Plan specifies drainage and sub-basin management directions and goals as well as policies and programs concerning harvest, broodstock management, hatchery production, fish marking, outplanting, disease, wild fish, natural fish, and survival constraints (IDPG 1991). All of these factors have been carefully coordinated and integrated with ISS to minimize conflict and insure a common direction. There are no plans for supplementation of chinook by the state outside of the ISS experimental design. This does not preclude outplanting hatchery fish for harvest augmentation purposes.

Interim goals identified in the plan include increasing natural production to approximately 70% of summer rearing capacity (see Appendix B) without any further reduction in genetic diversity and integrity of existing natural and hatchery stocks (IDFG 1991). There are no expectations that achieving this natural production goal is possible through supplementation alone. These gains are dependent on concurrent improvements in downstream passage and flow constraints.

Relation to Endangered species Act

Snake River chinook salmon, excluding the Clearwater drainage, have been recommended by NMFS for protection under the Endangered Species Act (ESA)(NMFS 1991). Their status was identified as threatened and included fall runs and spring and summer runs (undifferentiated) in the Snake, Salmon, Tucannon, Grande Rhonde and Imnaha rivers. Although the formal listing process will not be complete until spring, 1992, the experimental design has been developed under this assumption of listing and has tried to anticipate the direction of recovery efforts.

Although recovery efforts should and will be focused on improving mainstem passage and flow conditions, there is also the need to assess the relative benefits and risks of supplementation as an interim recovery tool. During this process it is important that evaluation activities themselves do not further jeopardize these threatened stocks. ISS has been designed to address critical uncertainties associated with supplementation while minimizing potential risks (see Risk Assessment section). Nearly all treatment streams are in areas with existing hatchery programs and facilities. In addition, these programs are shifting to a more genetically conservative natural production emphasis in response to the ISS design. This includes utilization of local or existing sub-basin broodstocks for supplementation, broodstock management based on natural production criteria, differentially marking general production and supplementation hatchery fish, passing only natural and supplementation fish above weirs to spawn naturally, and never exceeding a 50:50 ratio of supplementation and natural spawners. We are also establishing genetic, pathologic, environmental and biological baseline databases from which to measure change and provide "early warning" assessment of adverse effects.

We recognize the uncertainty associated with the listing and recovery process, and believe ISS has the flexibility to adjust accordingly should activities be curtailed or expanded as a result of ESA-based decisions.

Glossary

The following terms associated with supplementation often entail vague or varied usage. Since they occur frequently in our report, this glossary should help ease misunderstandings. We have tried wherever possible to embrace the nomenclature used most commonly in the basin. As appropriate, more detail has been given to the terms associated directly with supplementation.

Supplementation

In general, our use of supplementation concurs with the definition developed by the Regional Assessment of Supplementation Project (RASP):

> "Supplementation is the attempt to use artificial propagation to maintain or increase natural production while maintaining the long term fitness of the target population, and while keeping the ecological and genetic impacts on nontarget populations within specified biological limits." (RASP 1991)

RASP (1991) identified four characteristics shared by all true supplementation programs: 1) use of artificial spawning/or rearing conditions to bypass "survival bottlenecks" and increase survival above expected natural rates, 2) increasing natural production or maintaining production in the face of anticipated declines, 3) long term preservation of the fitness and fundamental genetic integrity of target populations, and 4) limitation of ecological and genetic impacts on both target and non-target populations.

There are two types of supplementation associated with our study:

Supplementation-augmentation: Supplementation in areas with existing natural target populations.

Primary objective is to enhance existing natural production to fully utilize available habitat or to maintain large enough effective population sizes to avoid extinction of the stock.

Secondary objectives include providing harvestable surpluses and natural gene banks.

Supplementation strategies (i.e. broodstock, rearing and release techniques) are selected to maximize compatibility and introgression with the natural stock and minimize reduction in productivity.

Supplementation-restoration: Supplementation in areas without existing natural target populations.

Primary objective is to establish natural production to fully utilize available habitat in areas without existing natural populations, or to diversify genetic resources.

Secondary objectives include providing harvestable surpluses and natural gene banks.

Supplementation strategies are selected based on compatibility with environmental conditions and similarity to historical or neighboring natural stocks.

We make clear distinction between supplementation programs and general hatchery production or harvest augmentation programs.

Harvest Augmentation: "The stocking of anadromous fish where the primary purpose is to return adults for sport, commercial, or tribal harvest." (Miller et. al. 1990)

Primary objective is to maximize adult returns for harvest, or to diversify harvest opportunities.

Secondary objectives may include escapement for natural reproduction in vacant habitats, but this is secondary to harvest and egg-take needs.

Harvest augmentation strategies are selected to maximize adult returns for harvest and minimize straying and interaction/introgression with natural populations.

ISS addresses natural production augmentation and restoration objectives in the Salmon and Clearwater basins but does not address harvest augmentation directly. Because objectives are similar, our use of the term supplementation includes natural production augmentation and restoration, except where differentiation is necessary.

Other Appropriate Terms

Natural Fish: progeny of parents which spawned voluntarily in the natural environment.

Wild Fish: natural fish whose ancestry has had little or no potential impact from artificial propagation or translocation.

Hatchery Fish: progeny of parents which were spawned artificially and held in an artificial environment for some segment of their incubation or rearing.

Supplementation Fish: hatchery fish which are or were spawned, incubated, reared and released for the primary purpose of increasing natural production.

General Hatchery Production Fish: hatchery fish which were spawned, incubated, reared and released for the primary purpose of increasing adult returns for harvest and egg-take needs.

Production: the number or biomass of fish produced.

Productivity: population replacement ability, which incorporates survival, fecundity, age structure and behavior.

Production Plan: operational guidelines designed to increase fish *numbers.*

Fry: chinook juveniles from swim-up through 50 mm total length, typically encompasses April through June for natural fish and November through January for hatchery fish.

Parr: chinook juveniles during their first summer rearing season, typically 50-90 mm total length and July through August for natural fish and April through June for hatchery fish.

Presmolt: chinook juveniles near the end of their first growing season (September) through their first winter (March).

smolt chinook juveniles during active springtime emigration, typically March through June for natural fish and April for hatchery fish.

STUDY AREA

ISS represents a state-wide research effort incorporating treatment and control streams throughout the Salmon and Clearwater drainages. The study includes seven treatment and eight control streams in the Salmon River drainage (Figure 1) and 12 treatment and three control streams in the Clearwater River drainage (Figure 2).

Most study streams reside in relatively sterile watersheds draining granitic parent material associated with the Idaho batholith (IDFG et al. 1989; Nez Perce Tribe et al. 1989). Several streams in the eastern part of the Salmon drainage are much more fertile resulting from basaltic parent material. Our study streams are predominantly low gradient "headwater" streams with an ideal mix of B- and C-channel characteristics (Rosgen 1985) for chinook spawning and rearing. Water quality is high with minimal contaminants and ideal water temperatures. Habitat quality is relatively pristine with some localized riparian degradation, sedimentation and dewatering from grazing, mining, logging, road building and irrigation diversions.

Fish comnunities are relatively similar throughout our study streams. Anadromous fish include wild, natural and hatchery-produced spring or summer chinook salmon and summer steelhead. Resident fish comprise a mix of native bull trout *(Salvelinus confluentus),* cutthroat trout (0. *clarki),* sguawfish *(Ptychocheilus egonensis),* red sided shiner *(Richardsonius balteatus),* sculpins *(Cottus sp.),* dace *(Rhinichthys sp.)* and suckers *(Catostomus sp.);* native and introduced rainbow trout (0. mykiss); and introduced brook trout *(S. fontinalis),*

Table 1 provides a brief overview of the study area. For detailed descriptions refer to appropriate sub-basin plans (IDFG et al. 1990; NPT et al. 1990) and the IDFG Anadromous Fish Management Plan (IDPG 1991).

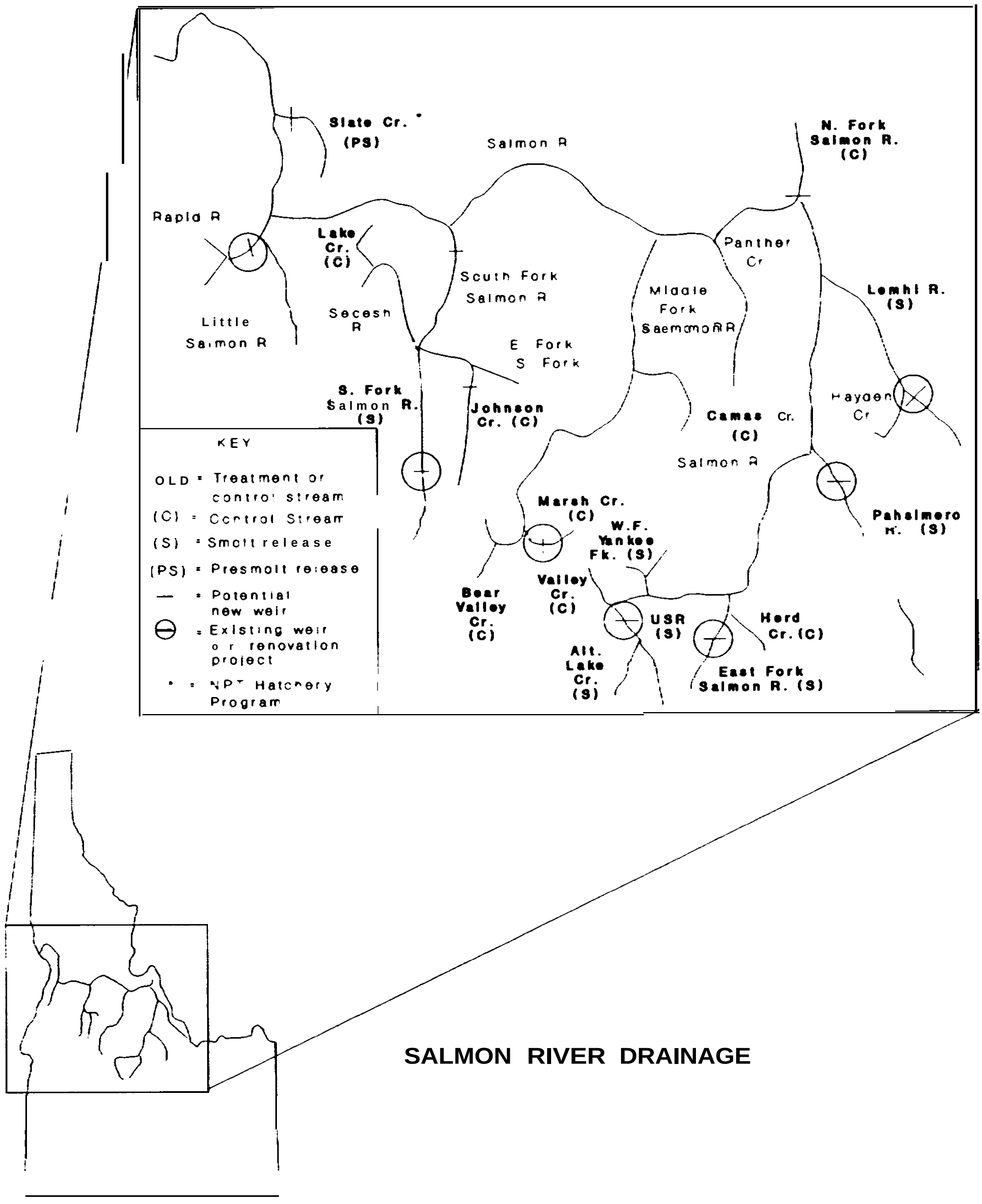

Figure 1 Treatment and control streams In the Salmon River drainage assocrated with Idaho Supplementation Studies

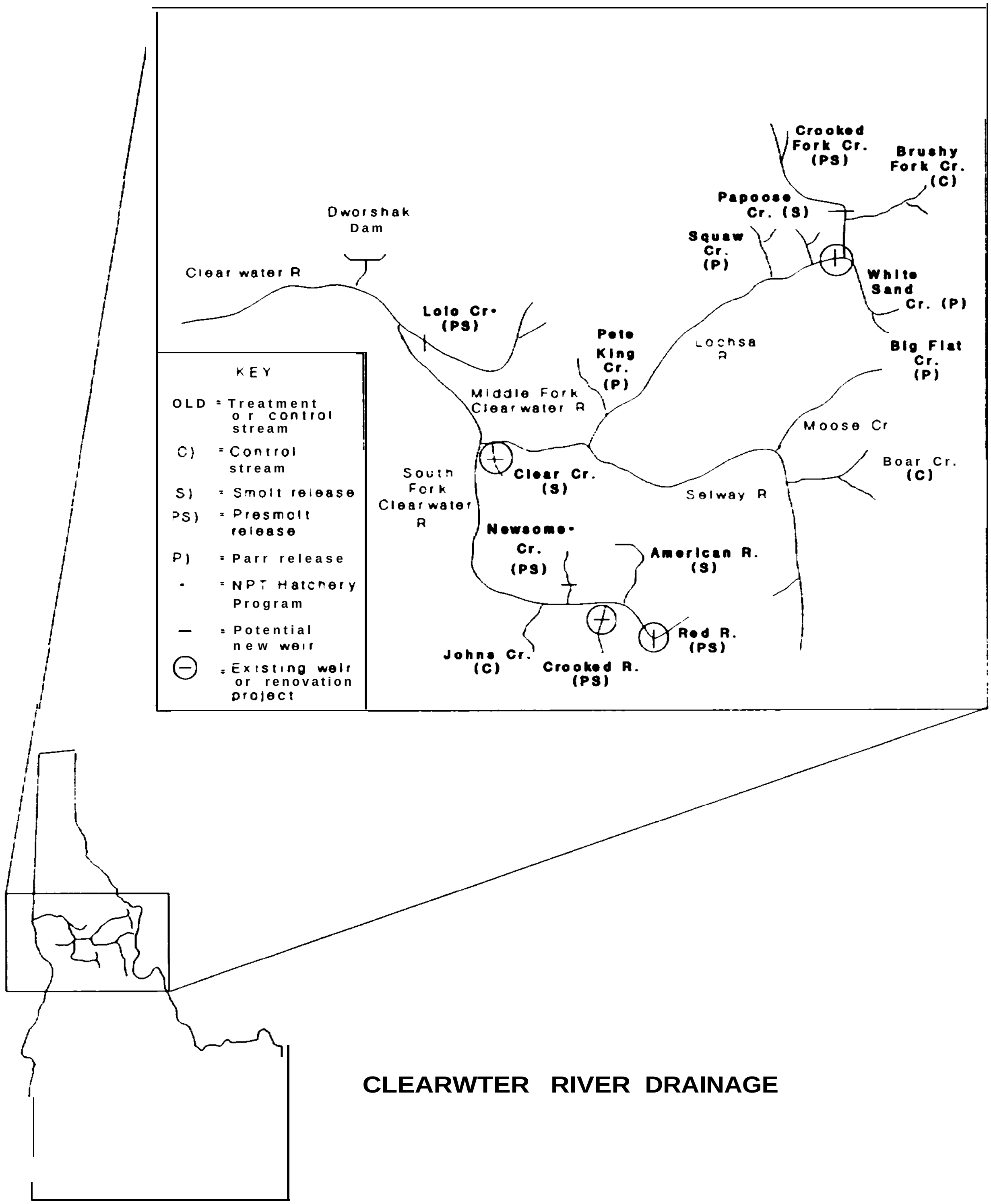

Figure 2 Treatment and control streams in the Clearwater River drainage associated with Idaho Supplementatlon Studies

Table 1. Study area characteristics for Idaho Supplementation Studies (ISS). Distances reflect miles to the mouth of the streams unless specified otherwise (i.e. weir), then they are in relation to the weir.

Stream	Treat./ Control	Dist. From Ocean (RM)	Elev. (ft)	Reach Length (mainstem miles)	Land Ownership	Geology	conduct. (umhos)	Habitat Qual. % in Category[a] 1 2 3 4	Channel[b] Type	Fish Community	Chinook Status[c] (% K)
SALMON RIVER DRAINAGE											
Slate Cr	T	580	1568	20.9	NPNF/PRIV	Batholith	--	0 30 70 0	B/C	SHD,CHS,WF,BUT	1
S. Fk Salmon (weir)	T	711	5102	13.5	BNF	Batholith	35	0 62 38 0	B/C	SHD,CHS,WF,CT,BRT	76
lake Cr	C	706	6027	12.0	PNF/PRIV	Batholith	--	0 6 8 3 2 0	B/C	SHD,CHS,WF,BUT,BRT	12
Johnson Cr	C	695	4659	37.5	BNF	Batholith	48	4 8 8 8 0	B/C	SHD,CHS,WF,BRT	11
N. Fk Salmon	C	751	3619	21.5	SNF/PRIV	Chal. Volc	41			SHD,CHS,WF,CT,BUT	6
Lemhi R (weir)	T	802	5141	30.0	PRIV	Chal. Volc	280	44 098 56 2 0 0 0	B/C	SHD,CHS,WF,BUT,BRT	8
Pahsimeroi R	T	817	4649	21.0	PRIV	Chal. Volc	--	3 6 6 4 0 0	C	SHD,CHS,WF,CT,BUT,BRT	40
Herd Cr	C	865	5722	22.5	CNF/BLM/PRIV	Chal. Volc	--			SHD,CHS,WF	?
E. Fk Salmon (weir)	T	873	6060	22.0	CNF/SNRA/BLM/PRIV	Chal. Volc	90	33 0 89 54 11 13 0 0	B/C	SHD,CHS,WF,CT,BUT	2
W. Fk Yankee Fk	T	886	6240	11.8	CNF/PRIV	Chal. Volc	--	82 18 0 0	B/C	SHD,CHS,WF,CT,BUT,BRT	?
Camas Cr	C	746	3799	50.2	CNF/SNF	Batholith	86			SHD,CHS,WF	
Marsh Cr (weir)	C	818	6510	5.4	CNF	Batholith	54			SHD,CHS,WF,CT,BUT,BRT	2:
Bear Valley Cr	C	812	6162	25.7	BNF	Batholith	30	67 0 577180 90 24 10 0 9 0	B/CC	SHD,CHS,WF,CT,BUT,BRT	5
Valley Cr	C	891	6221	22.9	SNRA/PRIV	Batholith	55			SHD,CHS,WF,BUT,BRT	38
U. Salmon R (Sawtooth weir)	T	897	6500	26.7	SNRA/PRIV	Bath/Chal. Volc.	30	12 0 66 25 65 22 10 0	B/C	SHD,CHS,WF,CT,BUT,BRT	17
Alt. Lake Cr	T	909	6821	13.4	SNRA/PRIV	Bath/Chal. Volc.	..	7 3 2 7 0 0	C	SHD,CHS,WF,CT,BUT,BRT	9

[a] Habitat quality categories: 1 = Excellent; 2 = Good; 3 = Fair; 4 = Poor. From the NPPC's presence/absence database.

[b] Channel type follows Rosgen's (1985) stream classification system.

[c] Percent carrying capacity estimates are from the IDFG draft anadromous fish management plan, and the parr monitoring database. They are approximate numbers based on chinook parr densities in only a few monitoring sites per stream averaged over the years 1984 - 1990, and are thus subject to change as more data becomes available.

[d] Influenced by hatchery outplanting.

NPNF = Net Perce National Forest; BNF = Boise National Forest; PNF = Payette National Forest; SNF = Salmon National Forest; CNF = Challis National Forest; CLNF = Clearwater National Forest; BLM = Bureau of Land Management; SNRA = Sawtooth National Recreation Area; PRIV = Private property; NPRES = Nez Perce Reservation; ST = State owned land. Chal. Volc = Challis Volcanics; Gn/S = Gneiss and Schist. SHD = Steelhead; CHS = chinook Salmon; WF = Hountain Whitefish; CT = Cutthroat Trout; BUT = Bull Trout; BAT = Brook Trout.

Table 1. Continued.

Stream	Treat./ Control	Dist. From Ocean (RM)	Elev. (ft)	Reach Length (mainstem miles)	Land Ownership	Geology	conduct. (umhos)	Habitat Qual. % in Category[a] 1	2	3	4	Channel[b] Type	Fish Community	Chinook Status[c] (% K)
CLEARWATER RIVER **DRAINAGE**														
Lolo Cr	T	521	1079	43.3	CLNF,BLM,ST NPRES,PRIV	Basalt	25	0	31	17	52	B/C	SHD,CHS,WF,CT,BUT,BRT	12[d]
Clear Cr	T	546	1270	17.1	NPNF,PRIV	Basalt/Gn/S	--	0	0	86	14	B/C	SHD,CHS,WF	?
Johns Cr Newsome Cr	C	578	2402 3619	20.3 13.8	NPNF	Basalt/Bath	--	0	0100		0	B/C?	SHD,CHS,WF,BUT	1
	T	596			NPNF	Gn/S/Bath	--	0	62	38	0	B/C	SHD,CHS,WF,CT,BUT	18[d]
Crooked R	T	599	3819	12.3	NPNF,PRIV	Batholith	--	0	61	39			SHD,CHS,WF,CT,BUT,BRT	44[d]
American R	T	603	3881	21.8	NPNF,PRIV	Gn/S/Bath	--	0	38	62	0	B/C	SHD,CHS,WF,CT,BUT,BRT	29[d]
Red R (mouth)					NPNF,PRIV	Batholith	31	6 4 3 5 1			0	B/C	SHD,CHS,WF,CT,BUT,BRT	46[d]
(weir)		616	4321	11.6										
Pete King Cr	T			9.2	CLNF	Batholith	--	0	0100		0	B/C	SHD,CT,CHS	?
Squaw Cr	T	622	3120	12.7	CLNF	Batholith	--	0	0100		0	B/C?	SHD,CHS	?
Papoose Cr	T	628 648	4853 3261	11.3	CLNF,PRIV	Batholith	--	0	67	16	17	B/C?	SHD,CT	?
White Sand Cr (at Big Flat Cr)	T				CLNF	Batholith	20	100	0	0	0	C	SHD,CHS,CT,BUT	1?
Big Flat Cr	T	648	4853	9.0	CLNF	Batholith	--	100	0	0	0	C	SHD,CT,BUT	0
Crooked Fork Cr	T	632	3431	22.5	CLNF,PRIV	Batholith	10	0 8 6 1 4			0	B/C	SHD,CHS,WF,CT,BUT	8
Brushy Fork Cr	C	639	3901	19.7	CLNF,PRIV	Batholith	--	2 3 7 5		0	2	B/C	SHD,CHS,WF,CT,BUT	?
Bear Cr	C	620	2467	23.6	NPNF	Batholith	--	59	41	0	0	B/C?	SHD,CHS,WF,CT,BUT	1

[a] Habitat quality categories: 1 = Excellent; 2 = Good; 3 = Fair; 4 = Poor. From the NPPC's presence/absence database.
[b] Channel type follows Rosgen's (1985) stream classification system.
[c] Percent carrying capacity estimates are from the IDFG draft anadromous fish management plan, and the parr monitoring database. They are approximate numbers based on chinook parr densities in only a few monitoring sites per stream averaged over the years 1984 - 1990, and are thus subject to change as more data becomes available.
[d] Influenced by hatchery outplanting.

NPNF = Nez Perce National Forest; BNF = Boise National Forest; PNF = Payette National Forest; SNF = Salmon National Forest; CNF = Challis National Forest; CLNF = Clearwater National Forest; BLM = Bureau of Land Management; SNRA = Sawtooth National Recreation Area; PRIV = Private property; NPRES = Nez Perce Reservation; ST = State owned land. Chal. Volc = Challis Volcanics; Gn/S = Gneiss and Schist. SHD = Steelhead; CHS = Chinook Salmon; WF = Mountain Whitefish; CT = Cutthroat Trout; BUT = Bull Trout; BRT = Brook Trout.

GOALS AND OBJECTIVES

OVERALL MANAGEMENT GOAL FOR SUPPLEMENTATION:

The general expectation for supplementation among management entities and user groups in Idaho is to use artificial propagation to help build self sustaining and harvestable populations of chinook salmon in the Salmon and Clearwater River drainages without adversely impacting existing wild and natural populations.

RESEARCH GOALS

1. Assess the use of hatchery chinook salmon to increase natural populations of spring and summer chinook in the Salmon and Clearwater River drainages.

2. Evaluate the genetic and ecological impacts of hatchery chinook salmon on naturally reproducing chinook populations.

RESEARCH OBJECTIVES

1. Monitor and evaluate the effects of supplementation on presmolt and smolt numbers and spawning escapements of naturally produced salmon.

2. Monitor and evaluate changes in natural productivity and genetic composition of target and adjacent populations following supplementation.

3. Determine which supplementation strategies (broodstock and release stage) provide the quickest and highest response in natural production without adverse effects on productivity.

4. Develop supplementation recommendations.

RESEARCH QUESTIONS

In Idaho we have the opportunity to address several questions associated with the two broad uncertainties: "Can supplementation work?" and "What supplementation strategies work best?" These specific questions are:

1. Does supplementation-augmentation of existing chinook populations in Idaho enhance natural production?

2. Does supplementation-restoration utilizing existing hatchery stocks establish natural populations of chinook salmon in Idaho?

3. Does supplementation-augmentation of existing chinook populations in Idaho reduce natural productivity of target or adjacent populations below acceptable levels (e.g. replacement)?

4. How often is supplementation required to maintain populations at satisfactory levels?

5. Can existing hatcheries and brood stocks be used effectively to supplement target populations within local or adjacent subbasins?

6. Is there an advantage to developing new, localized brood stocks with a known natural component for supplementation of existing natural populations?

7. Which life stage released (i.e. Parr, presmolt, molt) provides the quickest and highest response in rebuilding natural populations?

8. Which life stage released results in the least deleterious effects on existing natural productivity and genetic composition?

These questions relate directly to questions 2),3),6) and 7) specified as important critical uncertainties by the Supplementation Technical Work Group (STWG 1988). In addition to addressing these questions with general application to the Basin, our design will provide important case history evaluations of several ongoing or proposed supplementation programs in Idaho.

HYPOTHESES AND TASKS

Objective 1: Monitor and evaluate the effects of supplementation on presmolt and smolt numbers and spawning escapements of naturally produced salmon.

H_{01a}: Supplementation-augmentation of existing chinook populations in Idaho does not affect natural production.

Corollary: Rejecting H_{01a} indicates that supplementation can enhance or deter natural production.

Criteria for rejection of H_{01a}: The null hypothesis will be rejected when therehas been a significant ($P < 0.10$) increase or decrease in presmolt, smolt, and adult escapements in natural populations following supplementation as compared to control and pretreatment data.

H_{01b}: Supplementation-restoration utilizing existing hatchery stocks does not establish natural populations of chinook salmon in Idaho.

Corollary: Rejecting H_{01b} indicates that existing hatchery stocks can be used to restore natural populations of chinook salmon in Idaho.

Criteria for rejection of H_{01b}: The null hypothesis will be rejected if there is a significant ($P<0.10$) increase in presmolt, smolt and adult escapements in natural populations following supplementation as compared to control and pretreatment data.

Task 1.1 Identify study areas (experimental units) based on research opportunities, general applicability, stock status, management plans, and relative risks (Tables 2 and 3).

Task 1.2 Identify brood stocks and facilities to be used for supplementation (Tables 2 and 3; Appendix D).

Task 1.3 Sunmrarize existing knowledge or measure baseline information on habitat (e.g. quality, quantity, estimated carrying capacity) and fish populations (e.g. production, productivity, life history characteristics, genetic

Table 2. Study streams, brood sources, relative genetic risk associated uith supplementation, and proposed weir site locations in the Salmon River drainage.

Stream	Race	T/C	Natural Pop. Classification	Brood Stock	Brood Stock Classification	Suppl. Risk	Life Stage	Weir
Slate Cr.	Spr.	T	Marginal N.	Rapid River	Adj. Sub. NN.	Low	presmolt	Y (NPT)
South Fork Salmon	Su.	T	Viable SN.	USFSR/McCall	Subbasin SN.	Lou	Smolt	Y
Lemhi R.	Spr.	T	Viable SN.	Lemhi	Local SN.	Med/Low	Parr & Smolt	Y
Pahsimeroi R.	su.	T	Viable SN.	Pahsimeroi	Subbasin SN.	Lou	Smolt	Y
East Fork Salmon	Spr.	T	Viable SN.	East Fork	Subbasin SN.	Lou	Smolt	Y
West Fk Yankee Fk	Spr.	T	Marginal SN.	Sawtooth	Adj. Sub. NN.	Med	Smolt	Y(TEMP)
Upper Salmon	Spr.	T	Viable SN.	USR/Sawtooth	Subbasin SN.	Lou	Smolt	Y
Alturas Lake Cr	Spr.	T	Viable SN.	Sawtooth	Subbasin SN.	tied/Lou	Smolt	N
North Fork Salmon	Spr.	C	Viable N.					Y
Valley Cr.	Spr.	C	Viable N.					N
Harsh Cr.	Spr.	C	Viable N.					Y
Bear Valley Cr.	Spr.	C	Viable N.					N
Camas Cr.	Spr.	C	Viable N.					N
Lake Cr.	Su.	C	Viable N.					N
Johnson Cr.	su.	C	Viable N.					Y

Note: Four criteria were used to determine risk: 1) geographic distance between hatchery and natural stocks; 2) previous outplanting history of hatchery fish into study streams; 3) hatchery brood stock history (origin, domestication etc.); and 4) natural population status. See text and Appendix D for discussion and rationale for risk assessment.

Native natural populations are those that have received little or no hatchery influence.
Semi-native natural populations have received "moderate" levels of hatchery outplanting, but the native genes are most likely still present to a certain degree.
Non-native stocks are used to describe hatchery fish used in a drainage they did not originate from.
Subbasin stocks are hatchery stocks presently being reared uithin that subbasin.

Spr = spring chinook; Su = Summer chinook; N = Native; SN = Semi-Native; NN = Non-Native; T = Treatment stream; C = Control stream.

Table 3. Study streams, brood sources, relative genetic risk associated uith supplementation, and proposed weir site locations in the Clearwater River drainage.

Stream	Race	T/C	Natural Pop. Classification	Brood Stock	Brood Stock Classification	Suppl. Risk	Life Stage	Weir
Red R.	Spr.	T	Reest. viable out of basin	Duorshak/ Red R.	Local, Non-Native	Lou	Presmol t	Y
Newsome Cr.	Spr .	T	Marginal out of basin	Duorshak/ Kooski a	Non-Native	Lou	Presmolt	Y(NPT)
Crooked R.	Spr .	T	Marginal out of basin	Duorshak/ Kooski a	Non-Native	Lou	Prrsmol t	Y
Lolo Cr.	Spr .	T	Viable SN.	Lolo/Duorshak	Local, SN.	Med.	Prrsmol t	Y(NPT)
Crooked Fk. Cr.	Spr.	T	Margi nal NN.	Crooked Fk/ Duorshak	Local, SN.	Lou	Presmol t	Y
Clear Cr.	Spr.	T	Margi nal NN.	Kooski a	Local, Cosmop.	Lou	Smolt	Y
Papoose Cr.	Spr .	T	Margi nal NN.	Powell	Non-Native	Lou	Smol t	Y(TEMP)
American R.	Spr.	T	Marginal NN.	Duorshak/ Rapid R.	Non-Native	Lou	Smol t	Y(TEMP)
U. Whi te Sand	Spr.	T	None	Duorshak/ Rapid R.	Non-Native	Lou	Parr	Y(Powell)
Big Flat Cr.	Spr .	T	None	Duorshak/ Rapid R.	Non-Native	Lou	Parr	N
Pete King Cr.	Spr.	T	Marginal NN.	Kooski a	Subbasi n, Non-Native	Lou	Parr	N
Squaw Cr.	Spr .	T	Marginal NN.	Duorshak	Non-Native	Lou	Parr	Y(TEMP)
Brushy Fk. Cr.	Spr .	C	Viable NN.					N
Johns Cr.	Spr.	C	Marginal NN.					N
Bear Cr.	Spr .	C	Margi nal NN.					N

Note: Four criteria were used to determine risk: 1) geographic distance between hatchery and natural stocks; 2) previous outplanting history of hatchery fish into study streams; 3) hatchery brood stock history <origin, domestication etc.); and 4) natural population status. See text and Appendix D for discussion and rationale for risk assessment.

Native natural populations arc those that have received little or no hatchery influence. Semi-native natural populations have received "moderate" levels of hatchery outplanting, but the native genes are most likely still present to a certain degree. Non-native stocks are used to describe hatchery fish used in a drainage they did not originate from.
Subbasin stocks arc hatchery stocks presently being reared within that subbasin.

Spr = Spring chinook; N = Native; SN = Semi-Native; NN = Non-Native; T = Treatment stream; C = Control stream.

composition, stock histories, species composition) in study areas (treatment and control) prior to supplementation and for hatchery facilities and stocks (Appendices B and C).

Task 1.4 Develop and implement "standardized" spawning, rearing, marking and release protocols for supplementation programs (Appendix D).

Task 1.5 Differentially mark (e.g. pelvic or adipose fin clip, maxillary bone clip) all hatchery supplementation and general production fish released in or nearby the study streams.

Task 1.6 PIT tag a minimum of 300 to 700 hatchery supplementation fish prior to release for estimating smolt-to-smolt survival.

Task 1.7 Release various life stages (i.e. smolts, parr and presmolts) of chinook salmon into study areas for a minimum of one to two generations (5-10 years). Determine fish numbers for each life stage based on existing natural production and natural rearing capacity (Table 4).

Task 1.8 Estimate late summer parr abundance from snorkeling surveys (Appendix E) utilizing stratified random sampling designed to provide a coefficient of variation (SEM/mean) of approximately 15%. Streams too turbid for accurate snorkeling (e.g. Lemhi River) will be sampled with multiple pass electrofishing techniques.

Task 1.9 PIT tag a minimum of 300 to 500 naturally produced parr from each treatment and control stream (except vacant streams) to estimate smolt production and survival. Seining and electrofishing sites for fish collection will be distributed throughout each study stream.

Task 1.10 Use existing weirs where possible and construct new weirs downstream of the study areas to collect, mark (PIT tag), and enumerate emigrating fish and to identify and enumerate returning adults (Note: weirs are not planned on all treatment and control streams, see Appendix F for location and type).

Task 1.11 Compare natural production (e.g. numbers of presmolts, smolts and adults) of supplemented populations (treatments) to unsupplemented populations (controls) and baseline data (see Appendix G for basic designs).

Objective 2: Monitor and evaluate changes in natural productivity and genetic composition of target and adjacent populations following supplementation.

H_{O2a}: Supplementation-augmentation of existing chinook populations in Idaho does not reduce productivity of target or adjacent populations below acceptable levels (e.g. replacement).

Corollary: Rejecting H_{O2a} indicates that supplementation can adversely affect survival and performance of existing natural populations.

Table 4. Proposed supplementation life stage and hatchery fish supplementation requirements[a]

TREATMENT STREAM	LIFE STAGE	NUMBER (x1000) 1st GEN. (BY 91-95)	2nd GEN. (BY 96-2000)	SOURCE	CRITERIA
CLEARWATER RIVER DRAINAGE					
American R.	smolts	128	--	Dworshak	1/4 CC; nat smolt equiv
Clear Cr.	smolts	49	--	Kooskia	DE - adult equivalents[e]
Papoose Cr.	smolts	50	--	Dworshak	7X CC; NPT harvest opp.
Whitesand Cr.	parr	80	--	Dworshak	1/2 CC above Big Flat
Big Flat Cr.	parr	40	--	Dworshak	1/2 cc
Squaw Cr.	parr	12	--	Dworshak	1/2 cc
Pete King Cr.	parr	13	--	Dworshak	1/2 cc
Crooked Fk. Cr.[c]	presmolts	50	50	Crooked Fk/Powell	DE - parr density
Red R.	presmolts	80	80	Red River	DE - parr density
Newsome Cr.	presmolts	100	?	Nez Perce[bc] (Dworshak?)	1/4 cc; nat smolt equiv
Lolo Cr.	presmolts[d]	175	?	Lolo Cr.[bc]	DE - adult equivalents[e]
Crooked R.	presmolts	400	400	Rapid R/Dworshak	1/3 CC; nat smolt equiv
SALMON RIVER DRAINAGE					
Upper Salmon R.	smolts	500'	290[e]	USR/Sawtooth	DE - adult equivalents[e]
U. EF Salmon R[c]	smolts	173	83	East Fork	DE - adult equivalents'
U. SF Salmon R[c] (above weir)	smolts	238	130	McCall	DE - adult equivalents[e]
Lemhi R. (above weir)[c]	smolts	50	100	Lemhi R.	DE - redd counts
	parr	60	0		
WF Yankee FK.[c]	smolts	61	25	Sawtooth(1st Gen) WFYF (2nd Gen)	DE - adult equivalents[e]
Pahsimeroi	smolts	134	80	Pahsimeroi	DE - adult equivalents[e]
Slate Cr.	presmolts	240	?	Rapid River	1/3 cc; nat smolt equiv

SUMMARY BY HATCHERY[a]

	Dworshak/ Kooskia/ Powell	Red R.	Sawtooth	East Fk	McCall	Pahsimeroi	Local	NPT
Parr and Presmolts	595	80	0	0	0	0	225	340
Smolts	227	0	561	173	238	134	60	0
Total	822	80	561	173	238	134	285	340

a = Please note that these are estimates of the MINIMUM number of fish required.
b = These fish will be supplied by the Nez Perce Tribe as part of their chinook hatchery program.
c = These numbers may vary depending on adult returns to collection facilities.
d = Based on existing stock density, not on adult returns available for brood stock.
e = 1st generation based on adult equivalents to natural production. 2nd generation based on projected adults and brood stock strategies.
DE = Double existing population, based on average redd counts over the past 5 - 10 years or mean parr density estimates for when data is available.
CC = Carrying capacity estimate from NPPC's presence/absence database in terms of smolt production.

Criteria for rejection of H_{O2a}: The null hypothesis will be rejected if there is a significant ($P<0.10$) decrease in productivity curves or genetic identity of natural populations subsequent to supplementation, as compared to control, pretreatment and theoretical productivity curves and baseline genetic composition.

Task 2.1 Monitor productivity (e.g. survival, life history characteristics, pathogens) and genetic (e.g. allelic frequencies) indices from supplemented populations and compare to baseline and controls. Productivity characteristics will be evaluated as a function of density or percent carrying capacity to minimize density dependent effects confounding treatment effects.

Task 2.2 Monitor straying of hatchery supplementation fish (adult returns) into adjacent and control streams by weirs or carcass *surveys.*

Task 2.3 Develop "small scale" experiments to monitor behavioral interactions between natural and hatchery fish (e.g. fry dispersal and displacement, size of release; Appendix H).

H_{O2b}: Supplementation does not lead to self-sustaining populations *at* some enhanced level (e.g. 50% increase in abundance maintained over time).

Corollary: Rejection of H_{O2b} indicates that certain supplementation strategies are successful in establishing self-sustaining populations or enhancing the level at which populations maintain themselves.

Criteria for rejection of H_{O2b}: The null hypothesis will be rejected when self-sustaining populations have been established (after approximately two generations) at significantly ($P < 0.10$) higher population levels than in control or pretreatment populations.

Task 2.4 Determine spawner to recruitment relationship based on determined production and productivity indices (parr and smolt numbers, adult escapements, survival, eggs/spawner etc.)

Task 2.5 Predict population viability based *on* spawner to recruitment relationship to determine if the population will maintain itself through time in the absence of additional supplementation.

Task 2.6 Predict level and frequency of supplementation required to maintain natural populations at enhanced levels.

Objective 3: Determine which supplementation strategies (broodstock and release stage) provide the quickest and highest response in naturalproductionwithoutadverse effects on productivity.

H_{O3a}: Utilization of existing hatchery broodstocks in Idaho is not *an* effective strategy to supplement existing populations of chinook salmon within local or adjacent subbasins.

Corollary: Rejection of H_{03a} indicates that established hatchery broodstocks within Idaho can be used successfully to supplement existing natural populations of chinook in local or adjacent subbasins.

Criteria for rejection of H_{03a}: The null hypothesis will be rejected if there is a significant $(P<0.10)$ increase in natural production of presmolts, smolts and adults following supplementation with existing broodstocks, without an unacceptable loss in natural productivity.

Task 3.1 Utilize existing hatchery brood stocks (obtained primarily from adults returning to the local target stream) during the first generation (5 years) of supplementation. (Note: inability to differentiate natural and hatchery returns preclude use of known natural-component broodstocks during the first generation of supplementation [except for the Lemhi River]).

Task 3.2 Monitor and evaluate natural production (presmolt, smolt and adult numbers) and productivity (survival, life stage characteristics, pathogens, straying, genetic composition) of supplemented populations and compare to baseline and controls (unsupplemented).

H_{03b}: Development of new, local broodstocks with known natural component for supplementation does not provide an advantage over utilization of existing hatchery broodstocks for supplementation within the local or adjacent subbasin.

Corollary: Rejection of H_{03b} indicates that development of new supplementation broodstocks from the target populations can be more successful for supplementation than utilization of existing hatchery broodstocks.

Criteria for rejection of H_{03b}: The null hypothesis will be rejected if natural production or productivity indices are significantly $(P<0.10)$ higher for treatments using local brood stocks than treatments using existing hatchery broodstocks.

Task 3.3 Utilize local broodstocks with known natural component from the target population during the second generation of supplementation (differentiation of natural and hatchery returns possible through fin clips). (Note: Lemhi River will use local broodstock with known natural components for both generations).

Task 3.4 Compare natural production and productivity indices of supplemented populations using existing hatchery broodstocks (first generation) to populations using locally developed broodstocks (second generation).

H_{03c}: The effects of supplementation on natural production and productivity does not differ among life stages (parr, presmolt, smolt) of hatchery fish released.

Corollary: Rejecting H_{03c} indicates which supplementation release strategies (life stage) are most effective (or least deleterious) in rebuilding natural populations.

Criteria for rejection of H_{03c}: The null hypothesis will be rejected if significant ($P<0.10$) differences in natural production are detected among release strategies as compared to the controls and pretreatment data. Multiple or pairwise comparisons will be used to detect specific differences attributed to life stage released.

Task 3.5 Compare natural production and productivity indices among supplemented populations using parr, fall presmolt and smolt release strategies.

Objective 4: Develop supplementation recommendations.

Task 4.1 Guidelines and recommendations will be developed addressing risks and benefits of supplementation (augmentation and restoration) in general and specific supplementation strategies (broodstock and release stage).

Several of the tasks associated with ISS objectives have been initiated and completed during the development of this experimental design. Other tasks will begin during the implementation phase (Table 5).

TABLE 5. ANTICIPATED STARTING AND COMPLETION DATES FOR THE VARIOUS TASKS ASSOCIATED WITH ISS. NOTE THAT CERTAIN TASKS HAVE BEEN COMPLETED.

YEAR: 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 06 06 07

TASK	YEAR
1.1 IDENTIFY STUDY STREAMS	COMPLETED DEC 1991
1.2 IDENTIFY BROOD STOCKS	COMPLETED DEC 1991
13 SUMMARIZE EXISTING KNOW 8 BASELINE DATA	BASELINE DATA ANTICIPATED COMPLETION 1992; EXISTING KNOWLEDGE COMPLETED DEC 1991
1.4 DEVEL SUP. PROTOCOLS	COMPLETED DEC 1991
1.5 DIFFER MARK FISH	START 1991 ONGOING
1 6 PIT TAG HATCH SUP FISH	ANTICIPATED START 1992 ANTICIPATED COMPLETION 2002
1.7 RELEASE VAR LIFE STAGES IN STUD? STREAMS	ANTICIPATED START 1993 ANTICIPATED COMPLETION 2002
1.8 ESTIMATE PARR ABUNDANCI	START 1991 ONGOING
1.9 PIT TAG NATURAL FISH	ANTICIPATED START 1992 ONGOING
1.10 USE EXIST WEIRS & CONST. NEW WEIRS	CONSTRUCTION, START 1992, ANTICIPATED COMPLETION 1993; WEIR USE START 1992 ONGOINO
1.11 COMPARE NAT PROD. IN TREAT VS CONT	START 1992 ONGOING

TABLE 5 (CONT'D). ANTICIPATED STARTING AND COMPLETION DATES FOR THE VARIOUS TASKS ASSOCIATED WITH ISS. NOTE THAT CERTAIN TASKS HAVE BEEN COMPLETED.

YEAR: 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07

TASK	SCHEDULE
2.1 MONITOR PRODUCTIVITY & GEN. INDICES	ANTICIPATED START 1994 — ONGOING (bar from 92 to 07)
2.2 MONITOR ADULT STRAYING	ANTICIPATED START 1994 — ONGOING (bar from 94 to 07)
2.3 DEV. SMALL SCALE EXPER.	COMPLETED ``C 1 99 (bar from 90 to 91)
2.4 DETERMINE S/R RELATIONS	ANTICIPATED START 995 — ONGOING (bar from 95 to 07)
2.5 PREDICT POP VIABILITY	ANTICIPATED START 996 — ONGOING (bar from 96 to 07)
2.6 PREDICT LEVEL & FREQ	ANTICIPATED START 996 — ONGOING (bar from 96 to 07)
3.1 USE EXIST. HATCH. BS 1ST GENERATION	ANTICIPATED START 993 — ANTICIPATED COMPLETION 1997 (bar from 93 to 97)
3.2 MONITOR & EVAL NAT. PROD	START 1991 — ONGOING (bar from 91 to 07)
3.3 USE LOCAL BS W/ KNOWN NAT COMPONENT	ANTICIPATED START 998 — ANTICIPATED COMPLETION 2002 (bar from 98 to 02)
3.4 COMPARE 1ST GEN. BS TO 2ND GEN BS	ANTICIPATED START 2003 — ONGOING (bar from 03 to 07)
3.5 COMPARE NAT PROD & PRODUCT	ANTICIPATED START 1993 — ONGOING (bar from 93 to 07)
4.1 DEVELOP GUIDELINES & RECOMMEND.	ANTICIPATED START 1998 — ONGOING (bar from 98 to 07)

EXPERIMENTAL DESIGN

General Approach

Although interrelated, the design is split into three main approaches. The first and main level of evaluation are large-scale population production and productivity studies designed to provide relatively generic inferences statewide. The second level utilizes these same study streams as individual "case histories" to evaluate specific supplementation programs (e.g. supplementation from Sawtooth Hatchery into the upper Salmon River). This is essentially a default scenario in case the statistical power for spatial inferences is too weak. The third level represents small-scale studies designed to evaluate specific hypotheses. The first two levels will focus on measuring population responses to supplementation and identifying critical life history intervals where supplementation effects are evident. The third level will help determine the mechanisms and specific impacts of supplementation on these critical life history intervals.

Long Term Studies

The overall measure of success for supplementation is the relative increase in natural production as compared to the relative loss or maintenance of existing natural productivity. Multi-generational (10-15 years) studies designed to monitor and evaluate these large scale population responses are necessary to adequately measure the success of supplementation programs. Limited research opportunities (e.g. potential treatment and control streams) and unacceptable risks preclude application of this approach throughout most of the basin. This "big picture" approach to supplementation evaluation is ideally suited to Idaho because of the relative availability of treatment and control streams in grossly underseeded habitats. A major emphasis of this research will be to monitor and evaluate these population responses to supplementation. In addition, focusing research on existing supplementation programs reduces the potential risks associated with supplementation research.

Our long term studies are split into two main categories: supplementation-augmentation of exieting natural populations and supplementation-restoration of extirpated populations. Supplementation (augmentation) research activities will be limited predominantly to streams with existing populations located in the Salmon River drainage. *A* primary research emphasis will be to determine effects of supplementation on these natural populations. Our approach will evaluate supplementation with smolts from existing sub-basin hatchery/natural stocks for one generation, followed by supplementation with smolts from locally developed broodstocks with a high composition of natural fish. Restoration efforts will be evaluated predominantly in the Clearwater River drainage where existing natural populations are scarce. Research will determine relative success of rebuilding natural populations through outplanting parr (fingerling), acclimated presmolts, and smolts.

&all Scale Studies

"Small scale" studies *were* designed to addrese specific hypotheses concerning the mechanisms of supplementation effects (e.g. competition, dispersal and behavior). These studies are relatively short-term and will be conducted in laboratory streams or "controlled" field environments.

They were developed to provide valuable information without requiring large resource commitments.

Although we have identified several areas of critical uncertainty, these studies will remain flexible to respond to feedback from the long term studies. Potential research includes: 1) evaluation of juvenile performance and survival of progeny from various ratios of hatchery: natural spawnings, 2) identification of random vs. selective mortality events associated with natural incubation and rearing environments, 3) effects of releasing larger hatchery fry and parr on top of smaller natural fish, 4) dispersal and interactions associated with multiple vs. single release sites, 5) effects of hatchery releases on resident fish, and vice versa, 6) overwinter habitat selection and carrying capacity for hatchery-reared and natural presmolts, 7) emigration survival for volitional vs. forced releases of presmolts and smolts, and 8) effects of steelhead smolt releases and residualism on natural chinook survival and performance. Brief justification and experimental designs for some of these studies are included in Appendix H.

The following discussion on the experimental design pertains to the long-term supplementation/restoration objectives (first and second approaches).

Statistical Design

This research will utilize a repeated measures profile analysis (split-plot through time) statistical design to evaluate supplementation effects (Johnson and Wichern 1982). This multivariate design uses parametric statistics and thus requires that normality, homogeneity of variance and independence assumptions be met. Strengths of this design include utilization of the "synchrony" of treatment and control streams to factor out variability associated with broad ranging environmental and system effects in order to enhance precision and power of detecting treatment effects (Figure 3). A weakness of this design is that it does not handle a phased implementation of treatments over time very well. Utilization of a "staircase" design (Walters et al. 1988) would allow for a phased approach, but the inability to adapt to missing data points (years) once the treatment has been implemented makes this option undesirable.

Our basic design tests the *response* of populations to treatments (supplemented) over time as compared to controls (unsupplemented) and baseline data. Appendix G outlines the basic design, duration and assumptions for each research question.

Treatments

Treatment (e.g. supplementation in general, supplementation with a particular life stage, supplementation with a particular brood source) effects will be tested directly by hypotheses. In general, treatments will be applied for one to two generations (5-10 years) following approximately *one* generation of pretreatment data. Population responses to supplementation will be monitored a minimum of one generation (5 years) following supplementation.

The experimental units are the study streams themselves. We will use seven treatment streams in the Salmon River and 12 treatment streams in

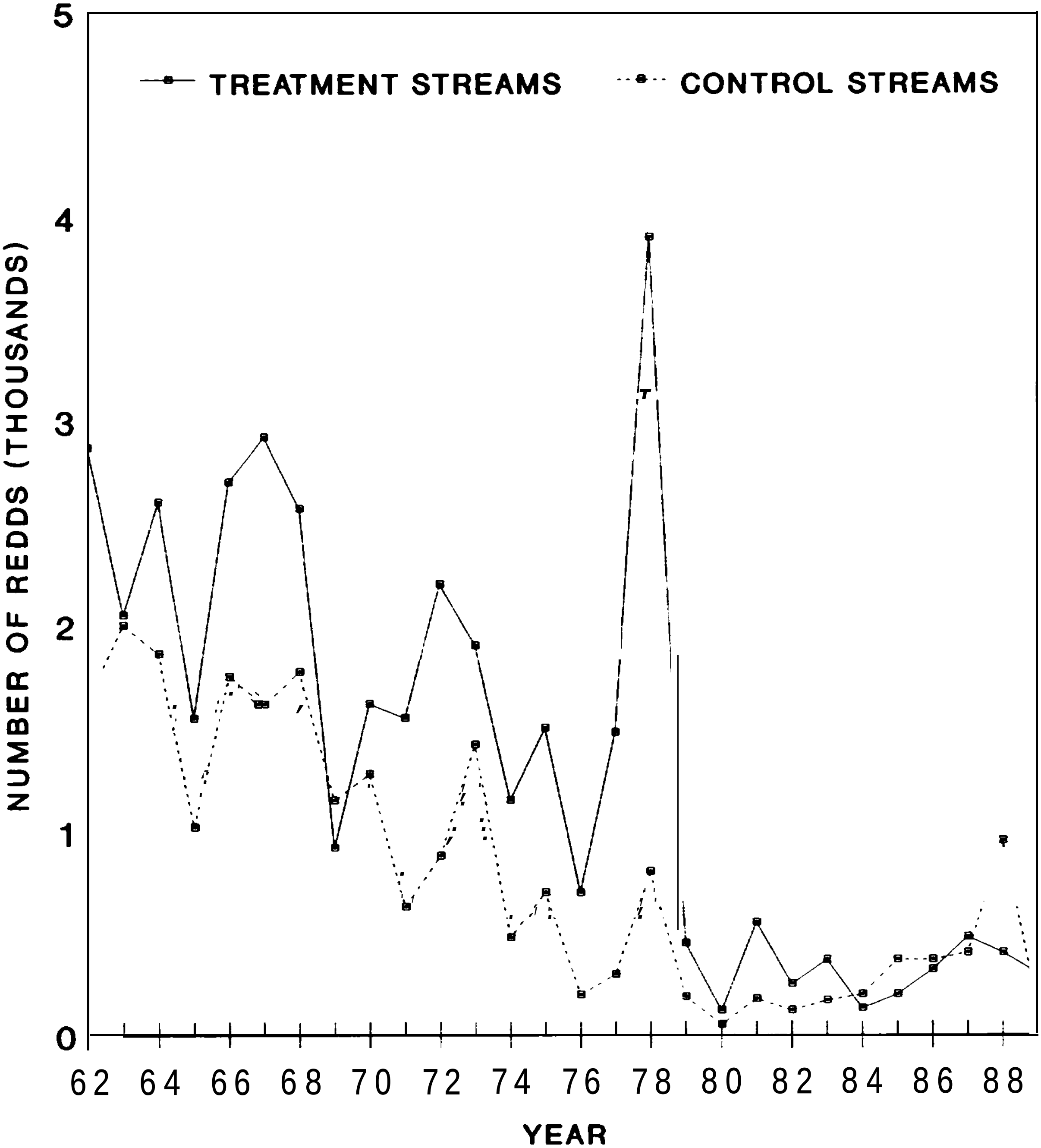

Figure 3 Mean annual trend redd counts of spring chinook during 1962 - 1989 from six control streams (unsupplemented) and five treatment streams (to be supplemented) associated with Idaho Supplementation Studies

the Clearwater River to test objectives one, two and three. Treatment streams were selected on the basis of agency management plans, habitat suitability, stock status and history, and supplementation risk. Although limited research opportunities precluded complete randomization of study streams and treatments, "biological" independence has been maximized.

Blocks

To help partition variability, some of our hypotheses utilize a block design under the assumption that variability of treatment effects within blocks will be less than variability among blocks. Depending on the hypothesis, the blocks may include: status of existing population, brood source, life stage outplanted and stream productivity.

Controls

The primary purpose of our control streams is to help "control" population responses unrelated to treatments (e.g. trends and variability of passage, ocean survival, harvest, etc.). We will use seven control streams (experimental units) in the Salmon River and three in the Clearwater River to test hypotheses for objectives one, two and three.

Wherever possible, control streams were selected to be representative of treatment streams (e.g. similar habitat, location, etc.) and independent of treatment effects (e.g. straying, changes in production, changes in productivity). Because of management consideration and limited research opportunities, our control streams tend to be in slightly more pristine habitats and include populations with less supplementation history and more wild status than our treatment streams.

The effects of this misrepresentation may be seen in a more dramatic response to system improvements (e.g. flow, passage) in control streams than treatment streams. This could bias our study slightly by underestimating positive treatment effects and overestimating negative treatment effects. This is a conservative bias from a supplementation risk standpoint, and one that we believe will not confound our study.

Replication

Spatial and temporal replication are necessary to maximize the applicability of our research to long-term regional and State-wide needs. Temporal replication (one to two generations) in our design is adequate to provide descriptive inferences concerning site specific (case history) findings.

Spatial replication is much more tenuous in our design because of limited research opportunities constrained by agency management plans, scarcity of streams with viable natural populations, and limited supplementation facilities. In spite of these constraints, we have maintained 3-12 spatial replicates to test each hypothesis, which should provide adequate power for spatial inferences within our sampling realm (see following section on power analysis).

Because of the aforementioned constraints, true randomization of our treatment and control streams was not possible. We do not feel this imposes serious statistical interdependence because the design incorporates spatial interspersion, and allocations were determined by factors assumed predominantly independent of potential treatment effects. This in itself does not preclude the possibility of pseudoreplication (i.e. replicates not independent) occurring in our design (Hurlbert 1984). In spite of our best efforts to ensure independence among replicates, some of our hypothesis (e.g. Questions 5, 6, and 8 in Appendix G) incorporate designs that are limited by pseudoreplication. Assumptions of independence must be carefully qualified prior to using inferential statistics for these cases. Perhaps more useful knowledge can be gained in these situations through the use of descriptive statistics guided by "common sense, biological knowledge and intuition" (Hurlbert 1984).

Power *Analysis*

Existing data bases on two of our evaluation points (parr density and redd counts; see following section on Evaluation Points) were used to predict the power and sensitivity of our experimental design. These Monte-Carlo type computer simulations incorporated 10-15 years of data on 16 streams to provide estimates of temporal (annual) and spatial (statewide) variability following imposed supplementation effects of 25%, 50% and 100% on natural production. Log normal transformations were used to account for the expected negative binomial distributions and unequal variances. A univariate split-plot in time repeated measures design was used to approximate the multivariate design for "a priori" power analysis (Table 6).

The majority of within-stream, among-year variation is contributed by large-scale environmental and system effects (e.g. flows, passage, etc.) so the use of control streams keeps this large source of variation from masking true treatment effects. We also have relatively large among-stream, within-year variation. Some of this variation will be removed by analyzing data as a function of carrying capacity, relative stream productivity and parental adult escapement. Much of this variability will be largely uncontrolled and represents the spatial diversity we wish to make inferences across. Within-stream, within-year variation is mainly controlled by the intensity of our sampling design. Based on the previous results of intensive stream surveys (Konopacky et al. 1984), we anticipate our design will control this source of variation to approximately a 15% coefficient of variation (SEM/M).

Although "a priori" power analysis is rarely used in fisheries research (Peterman 1990), we believe this design provides good power for inferences compared to other field biological studies (Lichatowich and Cramer 1979). Analysis of trend redd count data indicates that for inferences within our sampling realm, our design should provide at least a 75% chance of detecting a 25% change (alpha=0.05, beta=0.25) in fish numbers following supplementation of 11 treatment streams (Table 7). This analysis utilized density, escapement and log transformations, and represents substantial improvement in power over analysis of the raw data (less than 33% chance of detecting a 25% change in fish numbers).

Reducing sample size (number of treatment streams) can potentially impair the sensitivity of the design. Reducing to five treatment streams provides only a 60% chance of detecting a 25% change in production, whereas we would still have over 95% chance of detecting a 50% change. Use of only three treatment streams reduces power to approximately a 50% chance of detecting a 25% change in production but still *over* 85% chance of detecting a 50% change in production.

It is difficult to make an "a priori" assessment of power associated with the parr density evaluation point. Existing databases represent predominantly trend data that does not necessarily incorporate

Table 6. Representative examples of the split-plot in time repeated measures design used to estimate the **power** to detect supplementation effects.

SOURCE OF VARIATION		DEGREES OF FREEDOM
	11 Treatment Streams, 15 Years	
2	Treatment	1
8 or 11	Replicates(Treatment), Error A	17
15	Years	14
	Treatment x year	14
	Error B	238[a]
	TOTAL	284
	11 Treatment Streams, 10 Years	
2	Treatment	1
8 or 11	Replicates(Treatment), Error *A*	17
10	Years	9
	Treatment x Year	9
	Error B	153[a]
	TOTAL	189
	5 Treatment Steams, 15 Years	
2	Treatment	1
8 or 5	Replicates(Treatment), Error A	11
15	Years	14
	Treatment x year	14
	Error B	154[a]
	TOTAL	194

[a] *Actual degrees of freedom used in power* analysis was *reduced by 63% (Epsilon = 0.368) to account for lack of independence of the error terms.*

Table 7. Estimated Power (l-beta) of the ISS Experimental Design to detect supplementation effects (treatment x year interaction term; alpha=0.05) of 25%, 50% and 100% increases in natural production (based on redd census).

Number of Streams		Supplementation	Log(redds+1)	Log(redds/mi+1)		Log(redds/mi/esc over IHD+1)	
Control	Treatment	Effect	8 yrs	10 yrs	15 yrs	10 yrs	15 yrs
8	11	1.25		0.43	0.53	0.75	0.85
		1.50		0.85	0.93	0.99	0.99
		2.00		0.99	0.99	0.99	0.99
8	7	1.25		0.37	0.45	0.67	0.78
		1.50	0.59	0.77	0.87	0.98	0.99
		2.00	0.94	0.99	0.99	0.99	0.99
8	5	1.25		0.32	0.40	0.59	0.71
		1.50	0.51	0.70	0.81	0.96	0.99
		2.00	0.90	0.98	0.99	0.99	0.99
8	3	1.25		0.25	0.31	0.53	0.57
		1.50	0.40	0.57	0.68	0.89	0.95
		2.00	0.78	0.93	0.97	0.99	0.99

Note : Power analysis assumed eight control streams and three to eleven treatment (supplemented) streams. Duration was assumed to be 8 years (4 pre, 4 post), 10 years (5 pre, 5 post) and 15 years (5 pre, 10 post). Original data was transformed to represent redds/mile and redds/mile/total escapement over Ice Harbor Dam (IHD) to reduce unwanted variation. Log transformations were used to correct for unequal variances and negative binominal distributions.

standardized or thorough sampling designs. Our analysis of these trend databases indicated at least 60% chance of detecting a 50% change in natural production following supplementation of eight streams. This should be viewed as a minimum estimation of power.

We anticipate actual power will be much higher because our design will quantify and effectively remove several major sources of variation not accounted for in the trend databases. For example, parr sample location with respect to redds and preferred rearing habitat is a major source of variation for trend data which often uses few (<6) sample sites per stream. Parental spawning escapement is another major source of variability among streams.

Our design will stratify sampling to help partition variability associated with habitat type, habitat quality and stream productivity. The design can also incorporate cohort analysis to account for variability associated with parental spawning escapement levels. In addition, parr sampling sites have been increased from typically less than six to over 36 in our study streams.

Evaluation Points

Like the design itself, there are basically two levels of evaluation to determine supplementation effects. The first level is designed to evaluate the overall effect of supplementation on natural production and productivity. The second level evaluates specific effects of supplementation treatments on specific performance and productivity response variables (e.g. behavior, survival, growth, health) hypothesized to be the most significant area of impact.

Production Response Variables

Although final evaluation is ideally dependent on the response of adult escapements to treatments, several interim evaluation points will be useful to indicate initial population responses and test specific hypotheses. We have identified seven evaluation points to partition crucial life history stages (Figure 4). Three of these (parr, smolt and redds) will be monitored in every experimental unit (study stream), other evaluation points will be monitored where feasible.

Mid-summer parr. Parr abundance will be estimated in all treatment and control streams. Number of parr will be estimated with standardized snorkeling techniques (Appendix E) utilizing stratified systematic sampling (Scheaffer et al. 1979) designed to provide a coefficient of variation (SEM/M) of approximately 15%. Parr densities will be expanded by strata to estimate total parr abundance within the experimental unit (treatment or control reach). Multiple pass (White et al. 1982; Van Deventer and Platts 1989) electrofishing will be used to estimate parr abundance in streams too turbid to snorkel effectively (e.g. Lemhi River).

Fall and spring emigrants (presmolt and smolt). We anticipate that substantial proportions (up to 60%) of juvenile chinook in our study streams will emigrate in the fall and overwinter in mainstem sections of the Salmon and Clearwater rivers (Kiefer and Forster 1990). Juvenile emigration numbers and timing will be estimated with outmigrant traps in nine treatment and four control streams (Tables 2 and 3; Appendix F). "Screw" traps (M. Wade, E.G. Solutions, Inc., personal communication) or

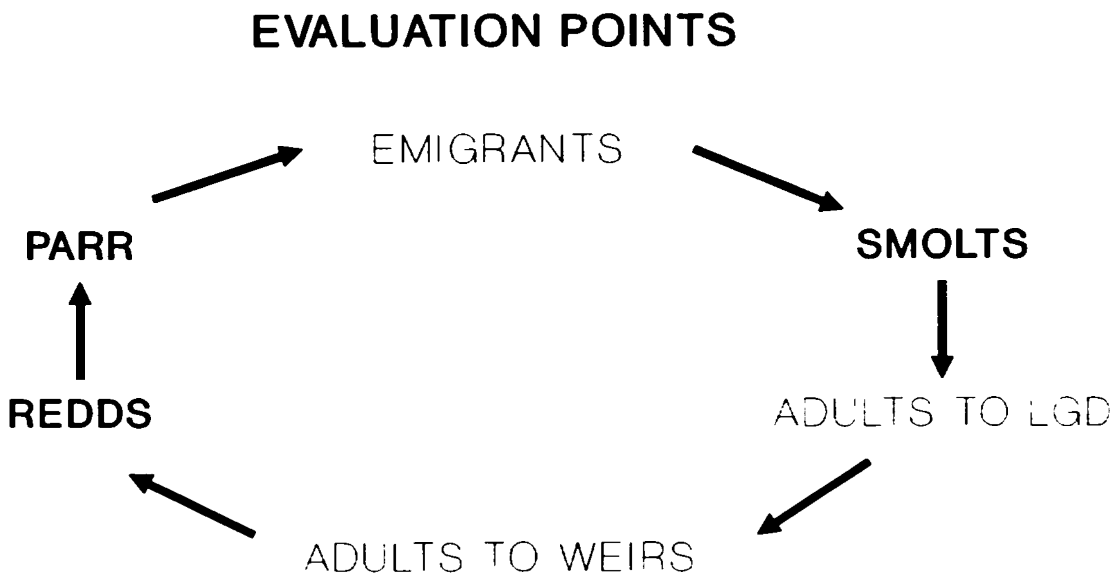

Figure 4 Life history intervals of spring and summer chinook salmon which will be monitored as evaluation points in Idaho Supplementation Studies Highlighted stages will be monitored in all study streams

scoop traps with traveling screens (Kiefer and Forster 1990) attached to adult weirs will be used in larger streams, whereas downstream migrant pipe traps set in riffle areas will be used in smaller streams (Eastwood 1990).

Traps will be operated to sample the entire fall and spring emigration period (late August - *November;* March - June) unless water velocity or icing becomes prohibitive. Capture efficiency will be estimated by recapturing marked emigrants transported approximately 1 km above the traps. Capture efficiencies will be monitored as a function of stream flow and water temperature throughout the sampling period. *Numbers* of fall and spring emigrants will be estimated by applying capture efficiencies to daily catch numbers (Kiefer and *Forster* 1990).

Smolt production. The number of smolts reaching Lower Granite Pool will be estimated for all treatment and control streams. Smolt production will be estimated by determining survival rates of PIT tagged emigrants and applying these rates to estimates of parr or presmolt abundance in each study stream.

Approximately 300-500 juveniles will be PIT tagged (see fish marking section) prior to or during emigration from the study streams and hatcheries. Hatchery fish will be PIT tagged prior to release into treatment streams. Naturally produced parr and emigrants will be PIT tagged following collection by electrofishing, seining or emigration traps. We determined the number of fish to PIT tag by applying estimated survival rates to meet the minimum statistical criteria of 35 PIT tag detections at lower Snake River dams (Buettner and Nelson 1990).

Smolt survival to the head of Lower Granite Pool will be estimated from PIT tag detections at the lower Snake River dams corrected by the detection rate of fish PIT tagged at the head of Lower Granite Pool for the IDFG Smolt Evaluation Study (Buettner and Nelson 1990; Kiefer and Forster 1990).

Adult escapement. Escapement to the lower Columbia and Snake rivers can potentially be estimated from adults interrogated at Bonneville and lower Snake River dams for select streams if additional juveniles are PIT tagged. Potential utilization of this evaluation point will be very limited because of the large number of PIT tags required to meet the minimum detection criteria of 35 fish (see Evaluation Tools and Methods section: Fish Marking).

Escapement to study streams will be determined for all treatment and control streams. Approximately 73% of our treatment and control streams will have weirs to census adult returns (Tables 2 and 3; Appendix F). Multiple redd counts will be used in study areas without adult weirs. Combined methods will be used on at least four streams to calibrate redd counts with known adult returns. Entire potential spawning area will be censused. Potential egg deposition will be estimated from fecundity schedules derived from fish spawned at appropriate hatchery racks. These schedules will be applied directly to natural fish in study streams with weirs and applied as a function of the measured female:redd ratio for streams without weirs.

Productivity Response Variables

Response variables measuring population productivity and performance are very important to determine supplementation effects on existing natural production as well as predict the long-term sustainability of the supplemented stock. Several survival relationships and life history characteristics will be monitored.

Survival. Natural production estimate5 for the above evaluation point5 will be used to estimate survival relationships for up to eight life stage intervals. Redd (egg)-to-parr, parr-to-smolt (at Lower Granite Pool), smolt-to-redd, and redd-to-redd survival rate5 will be estimated for all treatment and control populations in the natural environment.

These survival relationships will be estimated a5 a function of fish numbers or density to help define the shape of the productivity curve5 (Figure 5). We hypothesize that egg-to-parr survival will be density dependent (Beverton-Holt) as a function of summer rearing capacity, but in grossly underseeded habitats (< 35%) this relationship approaches linearity (Scully et al. 1990). Parr-to-smolt survival is probably also density dependent as a function of winter carrying capacity. We assume summer rearing capacity to be more limiting than winter carrying capacity so the parr-to-smolt relationship will likely be linear for natural populations. Hatchery fish released a5 fall presmolts will probably exhibit density dependent parr-to-smolt survival which may also affect naturally produced presmolts. Smolt-to-smolt survival within this broader interval will be density independent so it5 effect will dampen but not change the shape of the parr-to-smolt productivity relationship. Smolt (LG Pool)-to-redd survival will be regulated and limited predominantly by density independent factor5 operating during emigration. This high density-independent mortality will suppress smolt production prior to the ocean rearing phase of development. Ocean rearing survival is likely density dependent but Idaho fish make up such a small proportion of this ocean production that the compensatory effect will not be measurable.

In-hatchery survival relationship5 will be monitored for egg-to-fry, fry-to-fall presmolt, and fall presmolt-to-release intervals. These survival rates will be measured a5 a function of density but are assumed to be predominantly limited by density independent factor5 up to the hatchery capacities.

Shape, scale and variability associated with these productivity curves will be tested in this study as well as ongoing natural and hatchery production studies (see Intensive Smolt Monitoring and LSRCP Hatchery Evaluation studies; Appendix A).

Fecundity. Fecundity schedules by age and length will by monitored for each supplementation program. Fecundity will be measured from hatchery and natural fish collected for each supplementation broodstock and pooled across year5 for each generation. Supplementation effect5 will be measured as trend5 in these fecundity schedules. Fecundity will not be monitored directly for population5 in control streams.

Aae Structure. Age-of-return for adult male and female chinook will be determined from scales and CWT collected from carcasses surveyed in natural spawning areas and from fish returning to weirs.

Spawning Distribution. Temporal and spatial distribution of spawning will be monitored in all treatment and control streams. Run timing will

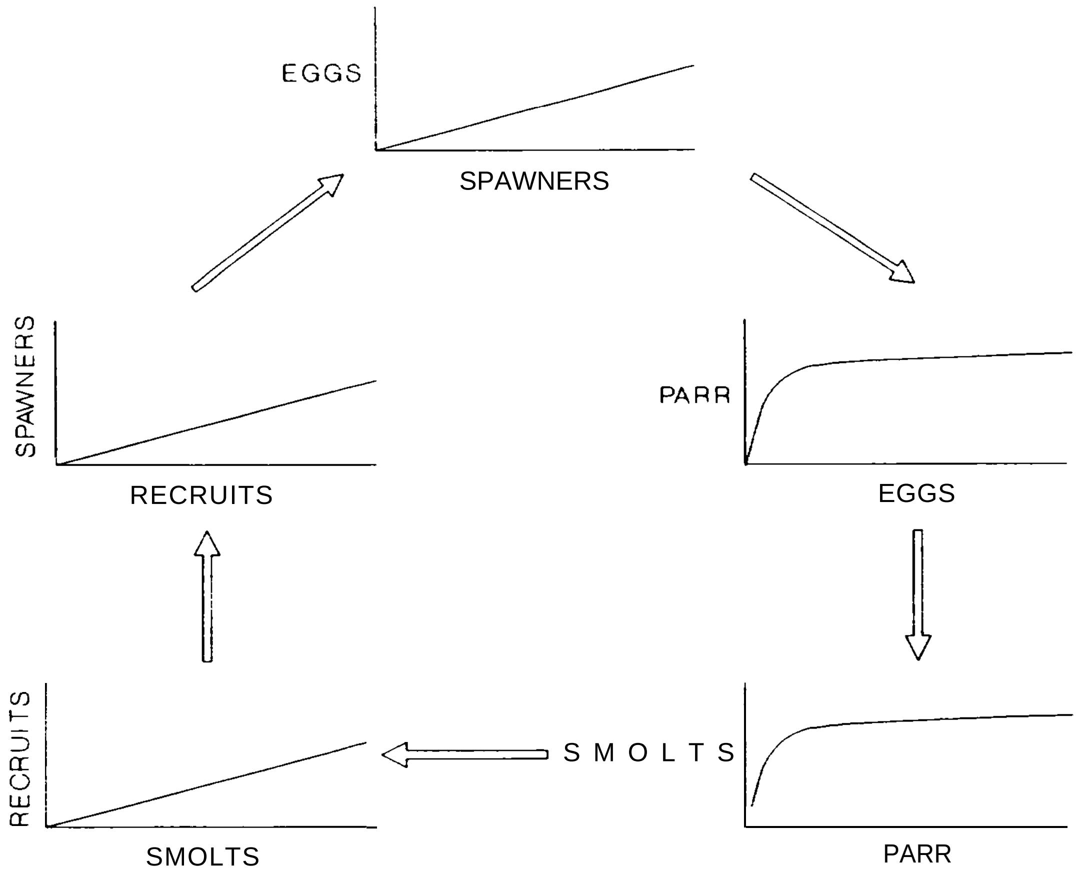

Figure 5 Hypothesized shape of survival relationships between life history Intervals of natural spring and summer chinook salmon in Idaho. Adapted from Bjornn and Steward (1990).

be quantified directly for streams with weirs and qualitatively for study streams without weirs. Spatial distribution of spawning will be monitored by peak redd counts (ground or aerial) conducted throughout the entire study stream. Intensive evaluation of spawning distribution is currently underway in three of our study stream5 (Appendix A).

Spawning Ratio. Beginning with BY 1995, the spawning ratio of supplementation and natural adults will be monitored for all treatment streams. This ratio will be determined by counting marked (supplementation) vs. unmarked (natural) adult return5 at weir5 followed by ground carcass surveys to estimate egg retention and prespawning mortality. This information will be analyzed directly or a5 a covariate to indicate spawning success and progeny survival associated with various proportions of hatchery and natural spawners.

Parr Distribution and Growth. Relative spatial distribution of mid-summer part will be monitored for each treatment and control stream during snorkeling and electrofishing activities. Parr length during mid-summer sampling will be used to indicate growth trends.

Emigration Timing. Emigration timing will be monitored for study streams with weirs and juvenile trap5 (Table5 2 and 3; Appendix F). This information will be used to indicate shifts in the proportion of fall and spring emigrants, and the temporal distribution of emigration within each season. Currently, this information is being obtained in two study streams as part of the Intensive Smolt Evaluation Study (Appendix A).

Genetic Composition. Genetic structure and variability will be monitored for natural and hatchery population5 associated with our research. Allelic frequencies will be monitored through starch gel electrophoresis a5 described in the following section. This information will provide a valuable tool to asses5 supplementation risk and track potential genetic impact5 of supplementation on long term population fitness.

It is important to stress that genetic profile analysis is not a panacea which will answer all our question5 about supplementation. It is only a tool to help make logical decision5 concerning where, why and how to proceed with supplementation and help measure its effects on natural production and productivity. All inferences from genetic data will incorporate other ecological (i.e. life history, health, behavior, abundance) and environmental (i.e. carrying capacity, temperature, flows, habitat) data.

With this in mind, additional benefit5 of genetic analysis include: better delineation of natural and hatchery stocks to improve treatment stream and brood source decisions; identification of genetically effective populations based *on* their measured genetic diversity (heterozygosity); possible measurement of the rate and direction of introgression following supplementation; determine if suitable genetic marker alleles exist in the study populations; and, evaluate the appropriateness of selected populations as experimental units based on genetic identities.

Evaluation Tools and Methods

genetic Monitoring

Cur genetic monitoring program will include intensive baseline genetic profile analysis for all treatment and control streams with existing natural populations as well as all potential brood sources (Table 8). Wherever possible, past information will be used to augment or replace our sampling. The ongoing Genetic Monitoring Study by NMFS (see Appendix A) will provide approximately 25% of our baseline data needs. Other studies have collected genetic profile data but few stocks were sampled and samples were often composites of several stocks. Also, recent changes in technology provide much greater resolution.

Baseline data needs require analysis of approximately 900 samples per year for two to three years prior to any supplementation effects. Samples would not necessarily have to be from consecutive years but should not be of the same cohort lineage. Collection would be aborted if a year class was deemed critical (based on previous year redd counts). Genetic monitoring will be much less comprehensive than that required to establish a baseline. We anticipate collecting samples every third generation from a core group of streams, depending on results from baseline analyses (e.g. possibly only one representative stream from the Middle Fork Salmon River).

Samples will include 50 presmolts collected from up to 14 streams and 100 smolts collected from two hatcheries. Presmolts will range from 50-100 mm fork length, with no more than 5% of fish less than 60 mm length. Smolts will range from 100-150 mm. We will also collect samples from adult carcasses located during redd count surveys on each study stream. Genetic analysis for additional study streams is being conducted by NMFS as part of their genetic monitoring study (Dr. Robin Waples).

Sampling protocols include collecting presmolte by seining or electrofishing during mid to late summer prior to emigration from their natal streams. *A* maximum of 10 fish will be collected from a minimum of five locations distributed throughout each study stream. Sampling location, date, fish length and qualitative abnormalities will be recorded for each sample. The adipose fin will be clipped from each fish, frozen in separate cryovials with liquid nitrogen and archived for potential DNA analysis. Each fish will be frozen whole in cryovials with liquid nitrogen and shipped as soon as possible to the WDF lab (Dr. Jim Shaklee) for analysis. Smolts will be collected from raceways or ponds several weeks prior to release and the entire fish frozen in liquid nitrogen and sent to WDF. Adult carcasses located in study streams will be necropsied for skeletal muscle, heart, liver and eye tissues which will be frozen and sent to WDF.

Analysis protocols will include state of the art protein gel electrophoresie designed to determine frequencies of critical alleles at approximately 30 polymorphic loci. This information should be adequate to determine the genetic composition and variability within and among stocks for *our* study streams and hatcheries. Standardized methods will be used and be comparable to analysis protocols used by the NMFS lab. Juvenile carcasses will be archived for later meristic analysis if warranted.

Table 8. Treatment (T) and control (C) streams and hatcheries designated for genetic profile baseline data collection of chinook salmon associated with Idaho Supplementation Studies.

Site	Race	T/C	Priority	Investigator
U. Salmon R.	Sp	T	1	NMFS
Alturus Lake Cr.	Sp	T	1	NMFS
West Fork YFSR	Sp	T	1	IDFG
U. East Fork SR	Sp	T	1	IDFG
Lemhi R.	Sp	T	1	IDFG
Pahsimerio R.	Su	T	1	IDFG
U. South Fork SR	Su	T	1	IDFG
Crooked Fork Cr.	Sp	T	1	IDFG
Red R.	Sp	T	1	IDFG
Lolo Cr.	Sp	T	1	NPT/IDFG
Sawtooth Hatchery	SP	-	1	NMFS
McCall Hatchery	su	-	1	NMFS
EFSR "Hatchery"	SP	-	1	IDFG
Rapid R. Hatchery	SP	-	1	NMFS
Dworshak Hatchery	SP	-	1	IDFG
North Fork SR	SP	C	2	IDFG
U. Valley Cr.	SP	C	2	IDFG/NMFS
Herd Cr.	SP	C	2	IDFG/SBT
Camas Cr.	SP	C	2	IDFG
Marsh Cr.	SP	C	2	NMFS
Bear Valley Cr.	SP	C	2	IDFG
Secesh/Lake Cr.	su	C	2	NMFS
L. Johnson Cr.	su	C	2	NMFS
Brushy Fork	SP	C	2	IDFG

Criteria for prioritization:

1 Baseline prior to supplementation.

2 Baseline for control streams (not necessarily required prior to supplementation).

Note: Those streams and stock5 without IDFG specified as investigator are part of the National Marine Fisheries Service genetic monitoring program.

Fish Marking

We will use several marks to enhance our ability to evaluate the effect5 of supplementation. These include PIT tags, Coded wire tags (CWT) and fin or maxillary clips. Other marks are also being considered based on marking mortality, retention and benign detectability.

No marks are necessary if we are only concerned with detecting overall changes in natural production and productivity in target streams following supplementation. An exception would be the necessary marking of all hatchery "production" fish released into evaluation areas to avoid confounding results. This scenario would not provide any intermediate evaluation points and requires four to eight years before the first inferences could be made. The power of the design would be reduced greatly because of the limited opportunity to partition variability. This scenario also precludes inferences concerning the mechanisms associated with treatment responses, as there would be no measure of survival for intermediate life stages and no ability to differentiate treatment fish from natural fish. The inability to document straying is also a serious limitation.

Marking representative groups of fish will allow for intermediate evaluation points, more timely feedback, and the ability to develop logical hypotheses as to why a particular strategy failed or succeeded. The following section outlines marks required to differentiate natural fish, treatment fish and hatchery "production* fish.

Natural fish. Juvenile chinook (i.e. parr) will be PIT tagged in every treatment and control stream to estimate smolt production and parr-to-smolt survival. A minimum of 500 parr will be tagged per study stream after collection by seining and electrofishing (Table 9). This number should ensure approximately 60 detections at the lower Snake River dams, based on an assumed parr-to-smolt survival rate of 12.5% (Kiefer and Forster 1990; Buettner and Nelson 1990). This will provide a buffer of approximately 25 detections above the minimum 35 detections required for statistical analysis.

Study streams with weirs and juvenile emigrant traps will have a minimum of 300 fall emigrants and 100 spring emigrants PIT tagged to estimate smolt-to-smolt survival. This number is based on assumed survival rates for fall and spring emigrants of 13% and 45% from emigration to the head of Lower Granite Pool for natural and wild chinook (Kiefer and Forster 1991). A minimum of 15,000 to 7,500 natural emigrants would have to be PIT tagged to estimate adult escapement to Lower Granite Dam and indicate natural straying rate. This number is based on an assumed 0.2% to 0.4% survival rate from emigration to adult escapement to the study stream to provide approximately 30 adult detections at Lower Granite Dam. Although hatchery smolt-to-adult returns (SAR) have been as low as 0.02%, we anticipate at least an order of magnitude higher return rates for wild and natural fish (0. Johnson, NMFS, personal communication; Petroeky 1991).

Treatment fish. All release groups of treatment fish will have representative fish PIT tagged to evaluate survival from time of release to detection at the lower Snake River dams (Table 9). Fish will be PIT tagged in the hatchery prior to release. Treatment fish released as parr will have a minimum of 600 fish PIT tagged to provide approximately 60 detections at the dams, based on an assumed survival rate of 10%. Fish released as fall presmolts will also have at least 600 tagged with an

Table 9. Minimum PIT tag requirements for Idaho Supplementation Studies (numbers in thousands).

FIRST GENERATION

	Dworshak/ Kooskia/ Rapid R.	Red R.	Sawtooth	East Fork Salmon	McCall	Pahsim.	Locals	NPT	Nat.
Parr	2,800	0	0	0	0	0	700	0	15,000
Presmolts	700	700	0	0	0	0	700	2,100	8,000
Smolts	1,500	0	1,500	500	500	500	500	0	8,000
Total	5,000	700	1,500	500	500	500	1,900	2,100	31,000

Σ of PIT tags for hatchery fish = 12,700; for natural fish = 31,000.
Σ = 43,700 total PIT tags per year first generation.

SECOND GENERATION

	Dworshak/ Kooskia/ Rapid R.	Red R.	Sawtooth	East Fork Salmon	McCall	Pahsim.	Locals	NPT	Nat.
Parr	0	0	0	0	0	0	0	0	15,000
presmolts	700	700	0	0	0	0	700	2,100	8,000
Smolts	500	0	1,000	500	500	500	1,000	0	8,000
Totals	1,200	700	1,000	500	500	500	1,000	2,100	31,000

Σ of PIT tags for hatchery fish = 8,200; for natural fish = 31,000.
Σ = 39,200 total PIT tags per year second generation.

NPT = Nez Perce Tribe. Their PIT tag needs will be supplied by the tribal hatchery program. The number shown here includes 700 for the hatchery fish each stream associated with the hatchery (Lolo, Newsome, and Slate Creeks). An additional 1700 tags are required for the natural population in each stream (700 for parr, 500 for fall outmigrants, and 500 for spring outmigrants) and are incorporated in the natural fish totals.

Nat. = Natural populations. This includes control streams as well as natural population5 in treatment streams.

Locals = A local stock from which a supplementation brood stock will be developed. This will be done on the Lemhi where adults returning to the Lemhi will be spawned and their progeny raised to parr and smolte (two separate release groups), then released back into the Lemhi. A local brood stock will also be developed for Crooked Fork Creek (first and second generation) and West Fork Yankee Fork (second generation).

assumed 10% survival rate. Smolt releases will have at least 500 fish PIT tagged with an assumed survival rate of 13%. If feasible, a couple of smolt release groups will be marked with PIT tags to estimate adult escapement to Lower Granite Dam and indicate straying rate.

All treatment fish will be marked initially with a right pelvic fin clip to enable evaluation of adult returns and insure differentiation from natural adults for broodstock collection. We anticipate approximately 15-30% additional mortality as a result of this marking, based *on* a range of 0% to 70% reported by Jacobs (1991). We would like to move toward utilization of an adipose clip or body tag to try to reduce marking mortality to less than 15% (R. Carmichael, ODFW, Personal Communication).

Hatchery production fish. All hatchery production fish to be released in evaluation areas must be marked to differentiate production fish from natural fish for broodstock selection, determination of return rates and estimation of straying rates. This will be a separate mark from that used on treatment fish. Adipose clipped and CWT fish for U.S. vs. Canada will be utilized. We are currently in the process of determining the best way to mark additional production fish (i.e. one that is external and easily detectable, relatively inexpensive, and minimizes mortality). Beginning with BY91 fish, IDFG will mark all "production" fish with a left pelvic fin clip if they are to be released in supplementation areas.

Other marks under consideration. The utility and cost of various other marks have been or are currently under investigation. These include genetic markers, scale pattern recognition, florescent markers, freeze brand, and body tags.

Through a subcontract with this project, ICFWRU conducted a pilot study on Dworshak Hatchery fish to determine the feasibility of developing electrophoretically detectable genetic markers for treatment fish. This mark would be very useful in tracking the magnitude and direction of introgression following supplementation and would allow us to track treatment fish beyond their first generation. The mark represents an abnormal allelic frequency created by selective fertilization in the hatchery to enhance the marker allele. This "mark" is passed along to offspring and is assumed to be selectively neutral. Although not conclusive, the pilot study indicated that development of potential marker alleles would require far more selective breeding than is realistic for our supplementation broodstocks (Appendix I). At this time we will not pursue genetic markers unless baseline genetic profile analysis indicates additional marker alleles at manipulative frequencies. We are also monitoring recent developments in the use of DNA fingerprinting techniques to develop genetic markers, and will incorporate this technology if proven useful and cost-effective.

Scale pattern recognition may prove to be a useful tool in differentiating hatchery fish from natural fish. This is a passive mark laid down in the circuli of the fish scale representing different embryo and early rearing growth conditions and time of ocean entry for hatchery and natural fish. This technology is currently too imprecise to meet our needs for differentiating natural, treatment and hatchery production fish. Scale samples from known hatchery and wild fish sent to ODFW for analysis indicated that only about 85% of the fish could be identified correctly for hatchery or wild origin (L. Borgerson, ODFW, personal communication). Sample sizes were small for the analysis so we will continue monitoring progress in refining this mark. Analysis of other stocks throughout the basin resulted in up to 90% resolution (Fryer and Schwartzberg and Fryer 1989).

Florescent markers may also prove useful in differentiating hatchery and natural fish. Tetracycline (TM-100) administered passively in the feed prior to release has proven effective in marking internal bony structures (e.g. otolith and vertebrae) detectable in adult return5 (Campana and Neilson 1985). The mark fluoresces when excited by ultra violet light. Detection in adults typically requires sacrificing the fish, which would severely limit the utility of this mark for supplementation research. IDFG is currently investigating the feasibility of detecting tetracycline marks from fin and maxillary clips taken from treated fish (D. Cannamela, IDFG, personal communication). This would allow detection without sacrificing the fish. Use of other florescent grit5 and dyes is not considered practical based on high expected mortalities or low retention time.

Body tags are being considered a5 an alternative to fin clips. These include Visible Implant Tag5 (VIP) and shallow implant5 of CWTs. Both of these marks require handling of individual fish but marking mortality should be less than incurred from fin or maxillary clip5 and deep implant5 of CWTs (i.e. in the snout). The VIP is often difficult to detect in adult fish, whereas shallow implants of CWTs can be detected with over 93% accuracy in any of nine body locations (Northwest Marine Technology, Inc. 1991). Recent progress in this technique is encouraging, but more information is needed concerning placement, retention and mortality associated with tagging small fish (i.e. parr and presmolts).

Freeze brands are not recommended based on indications of high mortality and difficulty in detection on returning adults.

Weirs

Weirs are an important evaluation tool for supplementation research. They will be used on selected treatment and control streams to measure adult escapement, collect broodstock, calibrate redd counts, document straying, and aid in trapping emigrants. Appendix F provides a thorough discussion of weir sites, designs and the construction process.

Redd counts

Redd counts will be used in all treatment and control streams to document spawning escapement and spatial spawning distribution. In areas above weirs, we will also document the average number of females per redd and the relationship between redd counts and weir counts. Redds will be censused by ground crews throughout all possible spawning areas following procedures outlined in the IDFG Redd Count Manual (Hassemer 1991). Air support will be used for large or inaccessible stream sections. In study areas without weirs, redds will be censused twice during the probable spawning period (peak and late in the run) to insure a total census. Redds located during the first census will be flagged or delineated on a map to avoid duplicate counts. All carcasses encountered will be sexed, unspent eggs counted and tissues collected for electrophoretic analysis.

Snorkeling and Electrofishing

Snorkeling and electrofishing will be used to survey late summer rearing abundance of all fish species in treatment and control steams.

Snorkeling techniques will be used in all stream5 with adequate visibility following protocol5 outlined in Appendix E. Multiple pass or mark recapture electrofishing techniques will be used in streams too turbid to snorkel effectively following procedure5 discussed in White et al. (1982) and Van Deventer and Platts (1983).

Emigrant traps

Emigrant trap5 will be used to survey juvenile chinook emigration timing and abundance for at least 53% of our treatment and control streams (Appendix F). Hardware will include "screw" traps (M. Wade, E.G. Solutions Inc., personal communication), scoop traps with traveling screens (Kiefer and Forster 1990), and pipe trap5 set in riffle sections (Eastwood 1990). Juvenile trap5 will be operated to encompass the entire fall and spring emigration period.

Dam detections

PIT tag detections at lower Snake River dam5 will be used to estimate parr and emigrant survival to the head of Lower Granite Pool. These detection5 will be corrected by the detection rate of fish PIT tagged at the head of Lower Granite Pool for the IDFG Smolt Monitoring Study in order to account for collection efficiencies at the dam5 and represent survival to the head of Lower Granite Pool (Buettner and Nelson 1990; Kiefer and Forster 1990).

PRODUCTION PLANS

Scale and Scow

ISS represents a large component of Idaho'5 anadromous management program. The design incorporates a total of 31 stream5 for treatments and control5 and directly affect5 all existing hatchery program5 for anadromous chinook in the state.

In spite of this substantial commitment, ISS includes a relatively small component of anadromous management opportunities in the state. *For* example, supplementation will take place in 17% of the total available natural production area5 in Idaho (Table 11). From a hatchery production standpoint, ISS will utilize approximately 28% of the total available adult return5 to major egg-take facilities currently used for hatchery broodstock collection (Table 10). Rearing these progeny will utilize only 17% of the total available hatchery space (exclude5 Rapid River and Dworshak hatcheries).

ISS incorporate5 nearly all ongoing and planned chinook supplementation activities in Idaho. Less than 15% of potential chinook supplementation will occur outside of the ISS design (Table 12). These include proposed activities by The Nez Perce or Shoshone-Bannock tribes, which will be incorporated into ISS a5 plan5 are developed. No chinook supplementation outside of ISS will be conducted by IDFG during the 1991-1995 planning period (IDFG 1991), although this does not preclude outplanting for harvest augmentation objectives.

Table 10. Proposed supplementation requirements with respect to available production and hatchery capacities.

Hatchery	Stream5	Life stage released	Number released (x1OOO)[a]	Proportion[b] of total avail.prod. from adult return5 to Hatchery	Brood-stock collect. site	Proportion of total avail. Hatchery smolt prod capacity
			CLEARWATER RIVER DRAINAGE			
CAFH	Whitesand	Parr				
	Big Flat	Parr	145	4%	Dworshak/	0%
	Squaw	Parr			Kooskia	
	Pete King	Parr				
	Crooked Fk	Presmolt	530	11%	Dworshak/	0%
	Red R	Presmolt	(w/o NPTH)		Kooskia	
	Crooked R	Presmolt				
	American R	Smolt	178	5%	Dworshak/	14%
	Papoose	Smolt			Kooskia	
Kooskia	Clear Cr	Smolt	49	12%	Kooskia	6%
			SALMON RIVER DRAINAGE			
McCall	U. SFSR	smolt	238	35%	SFSR Trap	24%
Sawtooth	EFSR	smolt	173	100%	EFSR Trap	6%
	USR, Alt.					
	Lake Cr	smolt	500	36%	Sawtooth	17%
	WFYF	smolt	61	4%	Sawtooth	2%
Pahsim.	Pahsim.	smolt	134	50%	Pahsimeroi	13%
			SUMMARY			
CAFH	9	parr,smolt presmolt	853	20%		14%
Kooskia	1	smolt	49	12%		6%
McCall	1	smolt	238	35%		24%
Sawtooth	2	smolt	561	40%		19%
EFSR	1	smolt	173	100%		6%
Pahsim.	1	smolt	134	50%		13%
Total	15		2,008	28%[b]		17%

a = Because supplementation numbers are determined as a percent of returns, actual supplementation requirements may vary. These estimates should be used as a general guideline only and are based on average runs during the past 5 - 10 years.

b = "Available" production includes only those fish allocated for hatchery broodstocks and does not include adult returns passed over weirs to spawn naturally.

Table 11. Percent of Idaho's total anadromous natural production area5 (in river miles) proposed for use in Idaho Supplementation Studies (ISS). This does not include the Snake River and tributaries (with the exception of the Salmon and Clearwater Rivers) between Lewiston and Hell'5 Canyon Dam. Includes total production areas in each study stream. Data is from IDFG anadromous plans (1984 - 1990; draft 1991 - 1995) and NPPC's presence/absence database.

	Includes Wild Manaaement Areas	Excludes Wild Manaaement Areas
Total Available Production: (Salmon and Clearwater Rivers)	5139 mile5	3973 miles
Total Production To Be Used As Treatment Streams in ISS:	865 miles (17% of total)	865 miles (22% of total)
Total Production To Be Used A5 Control Streams in ISS:	722 miles (14% of total)	415 mile5 (10% of total)
Total River Miles Used In ISS:	1587 miles (31% of total)	1280 miles (32% of total)
Other Supplementation Programs*:	128 miles (2% of total)	128 miles (3% of total)

' = These include the Sho-Ban Tribes proposed supplementation program on Yankee Fork and three streams (Mill and Meadow Creeks on the South Fork of the Clearwater, and Meadow Creek on the Selway River) that are proposed for inclusion in the Nez Perce Tribal Hatchery.

Table 12. Percent of the total chinook supplementation in Idaho incorporated into Idaho Supplementation Studies (ISS).

	Stream Mile5 Supplemented			% Total			# of Streams Supplemented			% Total		
	T	C	Total	T	C	Total	T	C	Total	T	C	Total
Total	993	722	1715	100	100	100	24	11	35	100	100	100
ISS	865	722	1587	87	100	93	20	11	31	83	100	89
Other[a]	128	0	128	13	0	7	4	0	4	17	0	11

[a] = These include the Sho-Ban Tribes proposed supplementation program on Yankee Fork and three streams (Mill and Meadow Creeks on the South Fork of the Clearwater, and Meadow Creek on the Selway River) that are proposed for inclusion in the Nez Perce Tribe's hatchery program.
T = Treatment stream.
C = Control Stream.

Study Streams

Study stream5 were classified into two categories based on the existing status and history of the chinook population. Target streams without existing natural populations are classified as supplementation-restoration streams; streams with existing natural population5 are classified as supplementation-augmentation. Cur design utilize5 11 treatment and 10 control streams classified as having existing natural populations. This classification pertain5 to all of our study streams in the upper Salmon River drainage and six stream5 (Red River and Crooked Fork, Lolo, Clear, Bear, and Brushy Fork creeks) in the Clearwater River drainage (Figure5 1 and 2). We will utilize nine treatment streams to evaluate supplementation-restoration in areas without existing natural populations. These streams are all located in the Clearwater River drainage, except Slate Creek located in the lower Salmon River drainage.

Databases describing the supplementation history, habitat characteristic5 and carrying capacity estimates can be found in appendices B and C.

General Criteria

Several basic assumptions or approaches were used to guide development of production plans for each treatment stream.

- For upriver chinook stocks, supplementation cannot be considered an alternative to reducing downriver mortalities. Success is dependent on concurrent improvement in flows, passage and harvest constraints.

- Supplementation can increase natural production (i.e. numbers) but not natural productivity (i.e. survival), except possibly in situations where natural population5 are suffering severe inbreeding depression. Reduction5 in natural productivity can be minimized through proper supplementation strategies so that enhanced production more than compensate5 for reduced natural productivity.

- Supplementation can potentially benefit only those populations limited by density-independent or depensatory smolt-to-adult mortality. Existing natural smolt production must be limited by adult escapement and not spawning or rearing habitat.

- For supplementation-augmentation programs to be successful, the hatchery component must provide a net survival benefit (adult-to-adult) for the target stock a5 compared to the natural component.

- Supplementation program5 should be kept separate and isolated from traditional harvest augmentation programs. We hypothesize that some of the past failures of supplementation have been because we have tried to supplement with the wrong product. Conventional hatchery programs are driven by the logical goal to maximize in-hatchery survival and adult returns. This approach may not necessarily be conducive to producing a product that is able to return and produce viable offspring in the natural environment.

- Supplementation strategies (e.g. broodstock, rearing and release techniques) should be selected to maximize compatibility and introgression with the natural stock and minimize reduction in natural productivity. Harvest augmentation strategies should be selected to maximize adult returns for harvest and minimize interaction/introgression with natural populations.

- Success of hatchery supplementation programs are dependent upon our ability to circumvent some early life history mortality without compromising natural selection processes or incurring hatchery selective mortality. Supplementation programs should be designed to minimize mortality events operating randomly (non-selective) and duplicate mortality events operating selectively on chinook in the natural environment. This, in essence, is the only role of a supplementation hatchery, to reduce randommortality effects in order to produce a net gain in productivity.

- Although our experimental design doe5 not pursue the above assumption vigorously, we encourage implementation of hatchery practice5 in an adaptive framework to investigate this assumption. Some of this will be initiated in our small-scale studies (Appendix H), or through the LSRCP Hatchery Evaluation Study (Appendix A). Careful design, monitoring and evaluation with treatment and control groups will be necessary to avoid confounding our study results.

- In areas with existing (target) natural populations, we recommend supplementation should not exceed a 50:50 balance between hatchery and natural fish spawning or rearing in the target streams. Under this criteria, supplementation programs are driven by natural fish escapement or rearing abundance, not necessarily hatchery fish availability. Adherence to this criteria result5 in a slow, patient supplementation approach when existing stocks are at only 10% to 20% carrying capacity, which is typical in Idaho. This concept is nothing new and is promulgated in the IDFG Anadromous Five Year Plan (IDFG 1991) and Oregon's Wild Fish Management Policy (Oregon Administrative Rule 635-07-525 through 529).

- In area5 with existing natural populations, we recommend supplementation broodstocks incorporate a relatively high proportion (>40%) of natural fish selected systematically from the target stock. This approach will minimize domestication effects and naturalize hatchery fish a5 quickly as possible.

- By following the criteria of using natural broodstock and mimicking natural selective pressure5 to some degree, we anticipate supplementation program5 will experience lower in-hatchery survival than is typical of conventional hatchery programs. We believe the very cause5 of higher in-hatchery mortality will also provide for substantially higher release-to-adult survival and long term fitness. Our modeling indicates that enhanced survival during this post-release stage is critical to the success of supplementation, much more so than the pre-release stage (see Potential Result5 of Supplementation section in text; Appendix D; and RASP 1991).

- In areas without existing (target) natural populations, we recommend supplementation-restoration programs be designed to provide 25% to 50% of the natural summer rearing capacity within one or two generations, depending on hatchery fish availability.

- In all instances, once interim management goals for natural production have been met (e.g. 70% summer carrying capacity), surplus natural and supplementation adults would be available for harvest or other broodstock needs. This criteria does not preclude flexibility for limited harvest prior to reaching management goals.

Supplementation Protocols

We have partitioned specific production plans into eight broad components: existing program, supplementation broodstock management, spawning, incubation, rearing, release, adult returns, and risk assessment. Where feasible, all phases will follow genetic guidelines currently being developed for the Basin (Currens et al. 1991; Emlen et al. 1991; Kapuscinski et al. 1991). The following provides a generalization for each component of the production plans. Refer to Appendix D for detailed production plans for each specific hatchery and treatment stream and modeled results.

Existing Programs

To minimize risk, the majority of our study (70%) is proposed for areas with existing hatchery programs that include supplementation objectives. Five of eight total treatment streams in the Salmon drainage and six of twelve in the Clear-water drainages have existing hatchery programs. An additional three treatment streams have hatchery programs planned independent to our supplementation research.

Existing programs in areas with viable natural populations typically include a weir to trap adults for broodstock and a hatchery facility nearby or in an adjacent sub-basin. Broodstock is collected systematically from adult returns comprised of an unknown proportion of hatchery and natural fish. Typically, one out of every three (33%) females and males is passed over the weir to spawn naturally and the remaining two out of three (67%) are brought into the hatchery for broodstock (Table 13). Fish are spawned non-selectively throughout the run at a 1:l sex ratio. Progeny are incubated in stacked, horizontal trays (Heath) and reared in concrete raceways or ponds. Rearing Density Index typically averages less than 0.3 $lbs/ft^3/in$ and Flow Indexes typically range from 1 to 2 lbs/in x gal/min (T. Rogers, IDFG, personal communication).

Most fish are reared to smolt and released unmarked during mid April. Releases are typically on-site or trucked to a single release site without an acclimation period. Some programs outplant progeny into on-site rearing and acclimation ponds in June and implement a forced release of presmolts from the ponds in October. The supplementation aspect of these programs is represented by the passage of an unknown component of hatchery adult returns over the weir to spawn naturally. In general, monitoring and evaluation of this supplementation is limited to trend redd counts and, in some cases, trend parr density estimates. No evaluation of adult returns is possible because fish cannot be differentiated between hatchery and natural origin.

Existing programs in areas without currently viable natural populations typically include outplanting Parr, presmolts and smolts developed from non-local hatchery broodstocks. In areas where hatchery returns to the target stream have been.used for brood stock, progeny are usually "topped off" with other fish to meet hatchery production and site-specific release goals.

Table 13. Past, transitional, and new broodstock strategies associated with adult collection facilities in Idaho Supplementation Studies.

ADULT COLLECTION FACILITY AND ASSOCIATED SUPPLEMENTATION STREAM

	SAWTOOTH (USR)	McCALL (USFSR)	E. FORK SAT. (UEFSR)	POWELL (CFC)	RED R. SAT. (RED R.)	CROOKED R. SAT. (CROOKED R.)	PAHSIMEROI (PAHSIMEROI)	HAYDEN CR. (LEMHI R.)
PAST								
NATURAL COMPONENT	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	ALL
HATCHERY COMPONENT	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NONE
ADULTS KEPT	2/3	2/3	2/3	2/3	2/3	2/3	2/3	NONE
ADULTS PASSED	1/3	1/3	1/3	1/3	1/3	1/3	1/3	ALL
JUVENILES MARKED	PARTIAL	PARTIAL	PARTIAL	PARTIAL	PARTIAL	PARTIAL	NONE	NONE
TRANSITION (1 generation - BY 90/91 - 95)								
NATURAL COMPONENT	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	ALL
HATCHERY COMPONENT	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NONE
ADULTS KEPT	2/3	2/3	1/2	1/3	1/3	NONE	2/3	1/2
ADULTS PASSED	1/3	1/3	1/2	2/3	2/3	ALL	1/3	1/2
NAT PROD DEDICATED	60%	60%	ALL	ALL	ALL	ALL	60%	ALL
SUPPLE DEDICATED	27%	27%	1/2	1/3	1/3	NONE (DWORSHAK)	27%	1/2
HATCH PROD DEDICATED	40%	40%	NONE	NONE	NONE	NONE	40%	NONE
JUVENILES MARKED	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL
NEW (BY 95+)								
NATURAL COMPONENT	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN
SUPPLEM COMPONENT	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN
HATCHERY COMPONENT	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN	KNOWN
NATURAL KEPT	1/3	1/3	1/3	1/3	1/3	1/3	1/3	1/3
NATURAL PASSED	2/3	2/3	2/3	2/3	2/3	2/3	2/3	2/3
SUPPLEM KEPT	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
SUPPLEM PASSED	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
HATCHERY KEPT	ALL	ALL	NA	NA	NA	NONE	ALL	NA
HATCHERY PASSED	NONE	NONE	NONE	NONE	NONE	ALL (DWORSHAK)	NONE	NA
JUVENILES MARKED	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL

Note: The "Natural Production Dedicated" represents the total of adults passed and supplementation dedicated fish.

Supplementation Broodstocks

Broodstocks used for target streams with existing natural populations will typically utilize weirs to collect natural and hatchery adults returning to the target stream. Using the target stock as a donor source for supplementation corresponds to the first priority choice specified for genetic conservation by Kapuscinski et al. (1991).

We are currently unable to differentiate hatchery and natural returns in areas with existing hatchery programs. Beginning with BY 1991 all hatchery fish released in study areas will be marked to differentiate supplementation fish, general hatchery production fish and natural fish. During this first (transitional) generation, supplementation broodstocks will be similar to general hatchery production broodstocks, comprised of an unknown component of hatchery and natural origin fish selected systematically from 33% to 50% of the returns (Table 13).

As soon as returns are comprised of known-origin fish (approximately 1996), broodstock selection will be modified (Table 13). Natural escapement criteria will drive the selection process. Typically this will entail releasing a minimum of two out of every three (67%) natural female, adult male and jack returns above the weir to spawn naturally. No more than 33% of the natural run will be brought into the hatchery for broodstock. This natural component will comprise a minimum of 50% of the supplementation broodstock. Thus hatchery returns can comprise no more than 50% of the supplementation broodstock. Surplus supplementation adult returns will be passed *over* the weir to supplement natural production up to natural equivalents; fish surplus to this need will be used for the general hatchery production broodstock.

Broodstocks used to supplement areas without existing natural production will be selected from existing hatchery broodstocks based on similarity to historical stocks, availability of fish, and expected or proven performance in the wild. Although this donor source represents the last alternative for broodstock selection as identified by Kapuscinski et al. (1991), it meets the criteria for first priority based on potential risk of collecting broodstock from severely depleted natural populations nearby. These broodstocks will typically be used for only one to two generations.

Spawning

Spawning protocols will typically follow existing hatchery practices. Sexes will be spawned 1:1 as they ripen, without selection for size, age, appearance and hatchery-natural origin. The only selection will be to segregate known disease carriers (BKD) from supplementation broodstock. Spawn timing will be dependent on ripeness, which is assumed to correspond with run timing. For stocks with low effective population sizes (N_e), factorial crosses or diallel crosses will be utilized to increase allelic diversity and N_e (Kapuscinski et al. 1991). Once differentiation of hatchery and natural returns is possible (1996), mating composition (e.g. HxH, NxH, NxN) will be documented to track relative survival to emergence, and for use as a covariate in our long-term productivity studies.

Incubation

Incubation protocols will typically follow existing hatchery practices. Where feasible, individual matings will be kept separate in incubation trays and isolated from disease vectors. Incubation water is typically a mixture of well and river water resulting in more thermal units and earlier emergence than occurs in nature.

Rearing

Rearing protocols will typically follow existing hatchery practices. Emergent fry are loaded into early rearing vats from mid December through February for feed training and reared to approximately 100 fish/pound (mid June) before release as parr or transfer into advanced rearing ponds or raceways. Rearing containers will be typically concrete or plastic with single-pass flow systems derived from well or river water. Baffles will be used in some hatcheries to facilitate cleaning and provide variable water velocity environments. Rearing density will range from 0.5 to 1.5 lbs/ft^3 and may be modified based on results of the rearing density study currently underway at Sawtooth and Dworshak hatcheries (Appendix A). Feeding is done manually at regular intervals throughout the ponds and raceways with moist commercial products.

Marking

All supplementation and general production fish released in study areas will be marked with a pelvic fin or maxillary clip until alternative marks are proven. Marks will be administered during early rearing, just prior to the transfer of fish from vats into advanced rearing raceways and ponds. Fish size will be approximately 75 mm and 100 fish/pound. Randomly selected fish will be PIT tagged at this time for parr and presmolt releases, and late summer for fish released as smolts.

Releases

Supplementation smolts will be released off site at multiple release points distributed throughout the treatment stream. Smolts will be trucked to release points and released directly into the stream without acclimation ponding, although natural slackwater areas such as side channels and beaver ponds will be utilized if available. Water temperature acclimation will be administered in the trucks if necessary (i.e. >5°C differential).

Where possible (e.g. Lemhi River), size and time of release will be programmed to mimic natural fish. This will require releasing smolts mid April at approximately 90-100 mm (48-66 fish/pound). Efforts will be made to coincide releases with environmental cues (e.g. lowering barometric pressure, freshets; Kiefer and Forster 1991). At present, most existing facilities do not have the ability to mimic the time and size of natural smolt emigration. Size and time of release is typically 20 smolts/pound released in March, whereas natural smolts emigrate from the upper Salmon River at approximately 66 fish/pound during mid April (Kiefer and Forster 1991). Chillers would be required on most of our hatcheries to meet these criteria. Our research is not proposing these modifications during the first generation of rearing.

Fall presmolts released for supplementation will be released directly from on-site rearing ponds or trucked to multiple release points throughout the study area. Fish will typically be released mid September to October to correspond with peak natural fall emigration (Kiefer and Forster 1990). Fish size will be slightly larger (100 mm vs. 80 mm) than the natural fish as a result of thermal constraints during incubation and early rearing.

Supplementation parr will be released off site at multiple release points distributed throughout the treatment stream. These unacclimated releases will be by helicopter or trucks. Fish will be released mid June, just prior to transfer from vats to advanced rearing containers. Fish size (>75 mm) will be substantially larger than expected for natural fish (40-50 mm) so fry and parr releases will only occur in streams without existing natural populations (except Lemhi River). One of our small scale studies will investigate the effects of hatchery parr size on natural fry and parr (Appendix H).

Adult Returns

Until interim management goals for escapement (e.g. 70% carrying capacity) are met, enough natural and supplementation fish (marked differently from harvest fish) need to be escaped through terminal fisheries to allow adequate rebuilding and evaluation. This will require non-lethal gear restrictions and catch and release of natural and supplementation fish in terminal areas, if fisheries targeting hatchery stocks are deemed prudent. Studies in British Columbia indicate that hooking mortality of chinook in terminal area catch and release fisheries will be approximately 5%, which is similar for steelhead (T. Gjernes, B.C. Dept. of Fish. and Oceans, personal communication). If lethal gear is used, weak-stock harvest quotas will be regulated to maintain minimal exploitation (e.g. no more than 10%) on natural and supplementation fish. In all instances, terminal fisheries on study stocks will require precise and accurate creel survey data.

Weir management for returning adults will include passing an established proportion of natural fish (e.g. 67%, 75% or 80%) which will in turn determine the number of supplementation fish to pass. Non-supplementation hatchery returns will not be passed over the weir.

Risk Assessment

Our risk assessment of supplementation is based primarily on genetic concerns and follows guidelines currently being developed in the Basin (Busack 1990; Currens et al. 1991; Emlen et al. 1991; Kapuscinski et al. 1991). All upriver stocks of chinook salmon are currently experiencing severe genetic risks to long-term stock viability (Riggs 1990; Mathews and Waples 1991; Nehlsen et al. 1991). We believe the major contributors to this genetic "bottlenecking" are system modifications (e.g. harvest, flows, and passage) which exert tremendous mortality and artificial selection pressures. These system constraints have forced many upriver stocks into a genetically vulnerable status warranting probable protection under the Endangered Species Act (NHFS 1991).

In addition to the overriding genetic risks imposed by system modifications, there are also genetic risks to natural stocks associated with the operation of mitigation hatcheries (Busack 1990; Kapuscinski 1990; RASP 1991). Busack (1990) identified four main types of genetic risk associated with hatchery activities: extinction, loss of within population variability, loss of population identity, and inadvertent selection. Kapuscinski et al. (1991) provides a discussion of these risks, possible causative hatchery practices, and the associated genetic process.

Most of our experimental treatments will be implemented in areas with existing hatchery programs that have at least partial supplementation objectives. In general, the genetic risk of our experimental design is quite low relative to these existing hatchery programs.

Broodstock management and non-selective spawning protocols should minimize risks to population variability and identity. In areas with existing natural populations, supplementation programs will typically utilize local broodstocks comprised of hatchery and natural fish. During the first generation (5 years) the relative composition will be unknown because of unmarked hatchery fish. By the second generation, all hatchery returns will be marked and a natural component criteria (e.g. >40% natural fish) will determine broodstock collection. In all cases, natural escapement criteria (e.g. 67%, 75% or 80% of natural run) will drive the programs.

Mating procedures will be non-selective for age, size or appearance, with pairings at 1:l sex ratios or factorial crosses. Progeny will typically be isolated from general hatchery production fish and marked prior to release. Releases will be timed to coincide with known environmental cues or peak natural emigration activity. In all instances, general hatchery production returns will not be passed over weirs to spawn naturally.

The greatest source of genetic risk associated with our supplementation programs is inadvertent selection resulting from hatchery rearing environments. Most of our experimental design will utilize existing hatcheries with ongoing production programs. These hatcheries were designed and are operated to maximize in-hatchery survival within the constraints of fish marking and production targets. These facilities were not designed to simulate selective pressures associated with natural rearing. In spite of the dramatic egg-to-release survival advantage experienced in the hatchery (up to 8-fold) it may be possible that those fish best suited for survival in the natural environment are the very fish lost in the hatchery environment (Reisenbichler and McIntyre 1977; Chilcote et al. 1986). In addition to this direct selection, there are indirect selection risks associated with hatchery environments not providing the necessary "training" required to maximize post-release survival. These risks are best alleviated by designing hatchery facilities and programs to simulate natural selective pressures and minimize mortality from random natural mortality events.

As discussed previously, we are not proposing dramatic modifications to hatchery facilities and programs during this first generation. Movement in this direction will be a result of LSRCP evaluations and recommendations. Although static and standardized hatchery facilities and practices would be best for statistically powerful inferences from our supplementation treatments, we do not recommend nor anticipate this scenario. We do recommend that changes in hatcheries follow adaptive management procedures and are fully monitored and evaluated with controls to avoid confounding our results.

The major risks associated with supplementation of extirpated populations is straying and introgression/interaction with adjacent natural populations. Introgression from straying can result in genetic drift, loss of identity and outplanting depression. To reduce this risk, selection of donor broodstocks followed criteria proposed by Kapuscinski et al. (1991) and Currens et al. (1991). Regrettably, suitable neighboring or out-of-basin natural stocks are typically unavailable or too vulnerable to extinction themselves to provide brood. As a result, hatchery broodstocks were selected based on the outplanting history of the target stream, location, availability of brood, and demonstrated performance.

Recent studies indicate high homing integrity to release sites for hatchery chinook (Fulton and Pearson 1981; Quinn and Fresh 1984; Sankovich 1990). Straying or wandering is apparently more probable in downriver areas than terminal areas, and is often accentuated if environmental factors (e.g. temperature, flows) inhibit passage (Phinney 1990). In general, our restoration treatment areas are located in areas without adjacent natural populations. We recommend that all general hatchery production fish released in natural production areas be imprinted on morpholine to minimize straying. Although inconclusive, chinook and other fish have been shown to imprint on dilute concentrations of morpholine, resulting in enhanced homing integrity to release site drip stations.

Genetic risks to other naturally reproducing fish populations (e.g. steelhead, cutthroat, rainbow) are minimal. All areas to be supplemented historically have maintained viable chinook populations which co-evolved with these populations. The main risks are associated with potential overestimation of carrying capacity resulting in a swamping of available habitats; elevated exposure to pathogens carried by hatchery fish; and, supplementation fish exhibiting characteristics (e.g. size, behavior, run timing, residualism, etc.) not evolved in the local habitat. These risks will be minimized by maintaining releases at less than 50% of estimated carrying capacity, only releasing fish certified to be free of detectable pathogens, and selecting donor stocks for supplementation that exhibit life history characteristics similar to locally evolved stocks.

Once again, we are weak in areas of hatchery induced behavioral and size differences. We will program size and time of release of supplementation fish to match the natural component as best possible, given the constraints of our facilities. In situations where the hatchery product represents an obvious risk, we will not incorporate it into our long term studies until the risk is assessed. For example, our inability to mimic natural incubation and early rearing growth conditions results in hatchery fry being larger than natural chinook fry at any given time. We will assess the competitive interaction associated with this size disparity prior to incorporating a large-scale fry or parr release into areas with existing natural chinook populations (Appendix H).

Potential Harvest Opportunities

Although it is not the role of ISS to recommend additional management strategies, nor would we presume that prerogative, we do feel it is important to address harvest augmentation opportunities. The justifiably high demand for recreational, ceremonial and subsistence fisheries may have a direct impact on the acceptance and long-term integrity of ISS. The ISS Design does not preclude potential harvest opportunities. Implementation of harvest augmentation programs using strategies designed to minimize risks to natural populations can provide for needed fisheries. These interim measures will also buy time and support for the slow, patient rebuilding process required to supplement natural populations. The IDFG Anadromous Fisheries Management Plan provides a detailed discussion of harvest opportunities and programs (IDFG 1991).

POTENTIAL RESULTS OF SUPPLEMENTATION

The perceived role of supplementation in recovering declining salmon stocks in the Columbia River Basin has varied from expectations of a panacea for compensation of mainstem survival bottlenecks (e.g. flows, passage, harvest) to expectations of accelerated declines and irreversible genetic dilution resulting from interaction and introgression with an inferior hatchery product. We believe the potential role of supplementation is yet to be understood and defined.

Existing knowledge on the subject, based on experimentation and experience, indicates that supplementation using traditional hatchery practices is rarely successful and can impose significant risk to the genetic integrity and long-term survivability of natural stocks (Miller et al. 1990; Steward and Bjornn 1990). The risk of failure is particularly high for upriver stocks experiencing extreme survival bottlenecks from mainstem passage constraints (Miller et al. 1990). Conversely, the need for supplementation as an interim recovery tool is most pertinent for these same upriver stocks, which are rapidly declining to the point where recovery may be impossible.

Our challenge is to develop strategies to maximize the benefits of supplementation and minimize its risk to target and neighboring natural populations. We then must evaluate these strategies prior to large scale management implementation in order to assess the utility of supplementation for recovering salmon stocks.

We can already put some realistic sideboards on the potential utility of supplementation. For upriver stocks, supplementation will never provide an alternative to remediation of mainstem passage and flow constraints. Even if we could do "everything right", the potential benefits to survival by routing natural fish through a hatchery will never compensate for current mainstem losses.

Supplementation can potentially increase natural production but it cannot increase natural productivity, except in vacant habitat or extreme cases of inbreeding depression and low heterozygosity of the natural population. Given this premise, the benefit in natural production from supplementation must more than compensate for any long term loss in natural productivity for the effort to be successful. The mechanism for supplementation to increase natural production is to use artificial propagation to provide an increase in net productivity (natural and hatchery components combined). This net increase in productivity is translated in more adult returns and subsequently higher natural reproduction. The problem lies in the fact that progeny (natural production) from this higher number of naturally spawning adults will at best experience the same survival as before supplementation, and perhaps even lower because of hatchery impacts and density dependent mortality. Bear in mind that, by definition, natural production represents progeny from naturally reproducing parents. Thus success can only be measured by the number and performance of these natural offspring.

The most genetically conservative role for supplementation would be as an interim measure to maintain or "jump start" stocks on the verge of extinction in order to increase natural production and maintain at least minimum viable populations. This conservative role of supplementation would require at best a one shot "hatchery fix" and at worst intermittent

A key component of this management objective is that success is measured entirely by the response of the natural component. This success would be evidenced in an increase in natural production without loss in natural productivity below some acceptable level (e.g. replacement).

In contrast, a less conservative management approach for supplementation would be the long term integration of hatchery and natural components. The hatchery would essentially become a super tributary for the stock with the express purpose of increasing total stock productivity (natural and hatchery combined) in order to enhance production. The natural component is only important as a component of total stock productivity and production. The only real difference between this approach and the previous conservative management approach is in the measurement of success. The less conservative approach measures success based on total stock production and productivity and anticipates a long term supplementation commitment, *and* possible hatchery dependence if natural productivity declines below replacement. Of course, both of these supplementation approaches assume artificial propagation will provide a net replacement (adult to adult) advantage over natural production.

Production (i.e. fish numbers) and productivity (i.e. adult-to-adult replacement ability) curves are provided for visual aids in understanding the potential results of supplementation.

Production Curve

Figure 6 represents a hypothetical production curve depicting fish numbers for a given cohort associated with the natural- and hatchery-produced smolt and the natural- and hatchery-produced adult components. Fish numbers are represented as a proportion of natural rearing capacity and are tracked over time before, during and after supplementation. In this and the following figures, annual and among stream variability is not depicted in order to better illustrate theoretical responses to supplementation. Also for clarity, smolts and the resulting adults are shown instantaneously on the time axis without the actual one to three year lag. Smolt and adult numbers from hatchery and natural origin are compared as a function of natural rearing capacity. For example, smolt production at 60% natural rearing capacity represents the number of smolts produced from presmolts that utilized 60% of available summer rearing habitat. Likewise, adult production at 60% natural rearing capacity represents the *number* of adults required to produce enough progeny *to* fill 60% of the available summer rearing habitat.

In this figure, the hatchery survival advantage is adequate to produce enough total smolts (hatchery and natural combined) to exceed the natural rearing capacity and even provide enough adult returns to fully seed the habitat. These progeny, however, are the true natural production component, and they can never produce enough natural adult returns to replace themselves because of the combined effect of carrying capacity constraints (density dependent) and excessive downriver mortality constraints (density independent). Thus when supplementation is stopped, natural production will decline until it reaches the presupplementation equilibrium point, or may continue to decline to extinction.

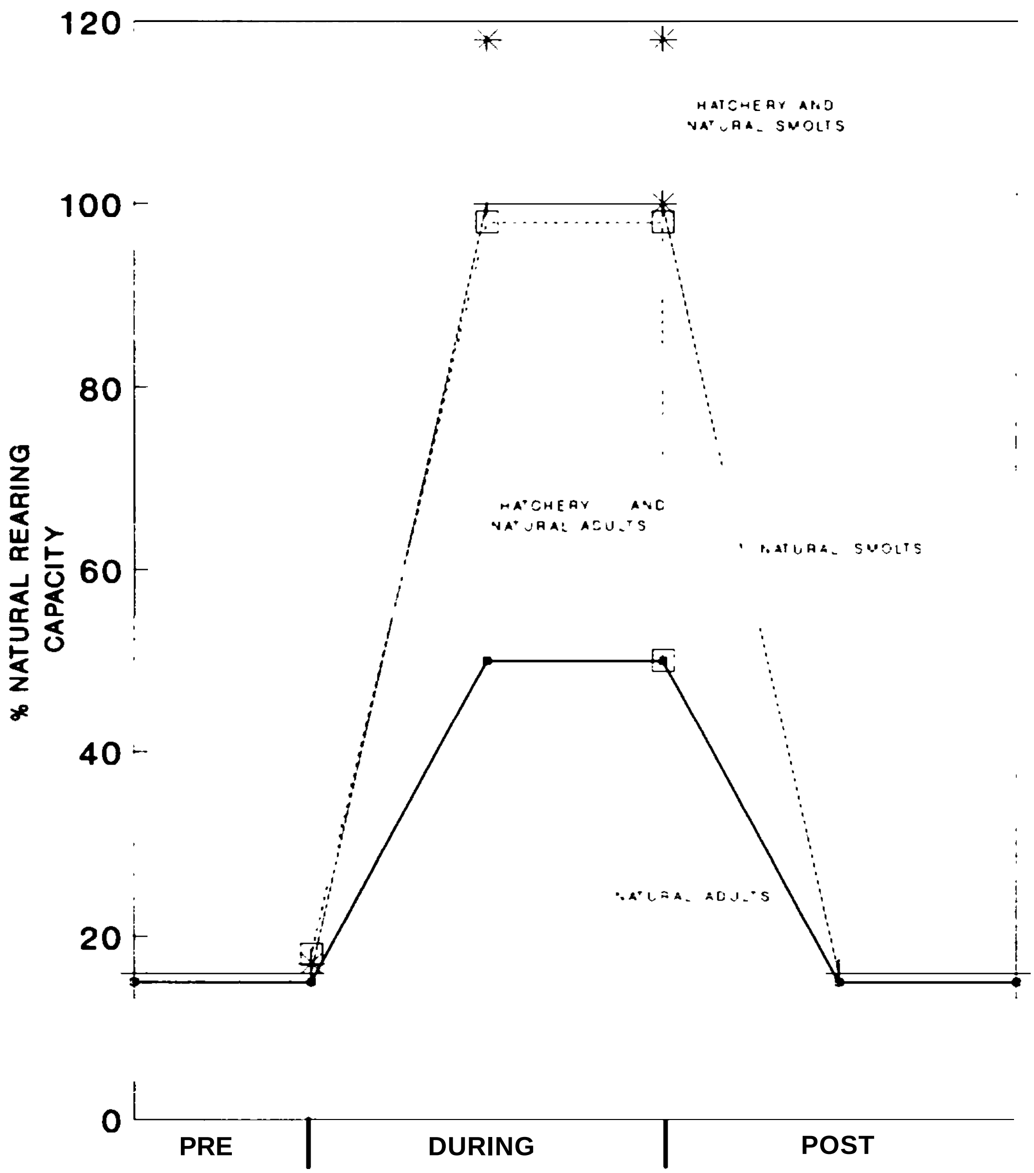

Figure 6 Hypothetical production curves for hatchery and naturally produced chinook salmon in Idaho before during and after supplementation

Productivity Curve

Figure 7 represents a hypothetical stock-recruitment (adult-to-returning adult) relationship (Beverton-Holt) typical for upriver salmon stocks. The upper *curve* (solid line) depicts historical natural stock productivity with large surpluses evident prior to hydropower development on the Columbia and Snake rivers. The third curve down (bold line) depicts current natural stock productivity reduced largely by density independent mortality during smolt emigration (e.g. flow and passage contraints). This curve indicates a very tenuous stock status with replacement occurring only at low densities. The second curve down (dashed line) depicts hypothetical total productivity of the supplemented stock (hatchery and natural components combined) and indicates the potential benefit in production resulting from supplementation.

The lowest curve (dotted line) depicts hypothetical natural productivity component of the supplemented stock in a worst case scenario. This particular curve indicates that, even though total stock productivity has increased, natural productivity has declined to the point that no equilibrium point exists above replacement. The problem with this potential scenario is that managers are locked into a hatchery program indefinitely until improvements in system survival occur. The population will decline to extinction without the hatchery component because of negative effects of supplementation on natural productivity. A best case scenario would be one in which natural productivity does not decline following supplementation. This is one of the null hypotheses that this research will test.

Our study will not track actual introgression (lack of genetic marker), but this rate can potentially have a major impact on the shape of the productivity curve resulting from supplementation. For example, if supplementation fish are equally viable in the wild as natural fish, the degree of introgression will not change the natural productivity curve. If supplementation fish are less viable in the wild than natural fish, natural productivity will be dampened as a function of the degree of introgression (i.e. higher introgression results in lower natural productivity).

Another important factor in altering the natural productivity curve is the longevity of hatchery influence on supplementation fish and their progeny. Possible scenarios range from progeny of hatchery fish attaining the characteristics of natural fish in the first generation removed from the hatchery, to hatchery fish never attaining all the characteristics of the natural fish. The sooner hatchery fish demonstrate natural characteristics, the less risk supplementation will have in reducing long-term natural productivity. These concepts have been discussed and illustrated in detail by the Regional Assessment of Supplementation Project (RASP 1991), which has identified the rate and effect of introgression as an important critical uncertainty for supplementation.

Although it is unlikely we will be able to monitor the actual rate of introgression in our treatment streams, we will track the ratio of supplementation to natural fish within each spawning population. This will allow us to evaluate relative spawning success for different hatchery and natural spawning ratios. In addition, other projects in the Basin (e.g. Tuccannan River, WDF; Methow and White rivers, USFWS) will be

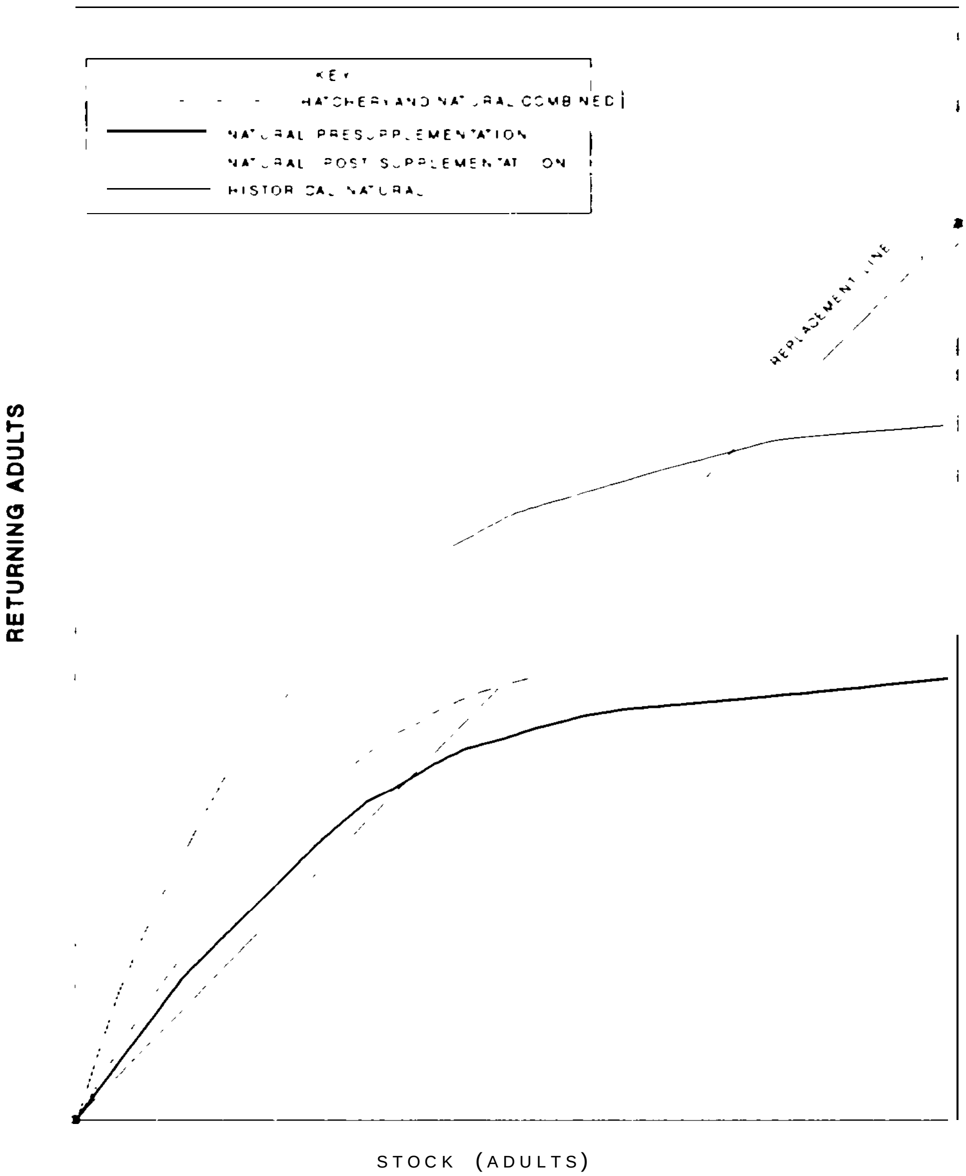

Figure 7. Hypothetical productivity curves (stock recruitment) for chinook populations in Idaho.

addressing introgreseion rates and their effects (Appendix A). Results from these projects will provide valuable information for our study.

The following production and productivity figures and text will build on these discussions to indicate several possible scenarios resulting from supplementation.

Scenario 1: Natural production increases, natural productivity is not impaired. Natural population is limited by density independent mortality during smolt-to-adult stage. Artificial propagation provides at least a short term replacement (adult-to-adult) advantage over natural production (Figure 8).

In general, our natural stocks have declined to an equilibrium point (A) well below natural carrying capacity. This level is typically just at or above replacement, dropping below during periods of additional environmental stress (e.g. drought). In the above scenario, the hatchery can be used to increase smolt production to provide enough adult returns (hatchery and natural origin) to fully seed the habitat and produce the maximum possible number of natural smolts (rearing carrying capacity). But in turn, these natural smolts will not produce enough adult returns to fully seed the habitat because of excessive smolt-to-adult mortality (density independent). Thus supplementation can never provide for recovery to historical levels of naturally produced adults.

In addition, the corresponding natural productivity curve demonstrates that as natural adults are increased through supplementation, the natural productivity declines in Beverton-Holt fashion due to density dependent natural rearing constraints. This higher level of natural production can be artificially maintained, but as soon as supplementation is stopped, the population will decline until the equilibrium point at replacement is reached (E), which should be the same level of production as before supplementation if natural productivity has not been impaired by artificial propagation.

Thus even under a best case scenario, supplementation is unable to provide self sustaining natural production at this higher level without reductions in downriver mortality. The rate of decline in production (slope of curve) after supplementation (D) will determine the frequency and magnitude of supplementation required to maintain the artificially high natural production levels. Modeling the productivity rate during supplementation will serve the same purpose if supplementation is not discontinued and monitored (assumes supplementation effects are heritable or transmittable).

Under this scenario, supplementation would be deemed a success because artificial propagation could be used either continually or intermittently to increase natural production without significant loss in natural productivity. The downside is that even under this somewhat optimal scenario for supplementation, natural production cannot rebuild to historical levels unless density independent smolt-to-adult survival constraints are alleviated.

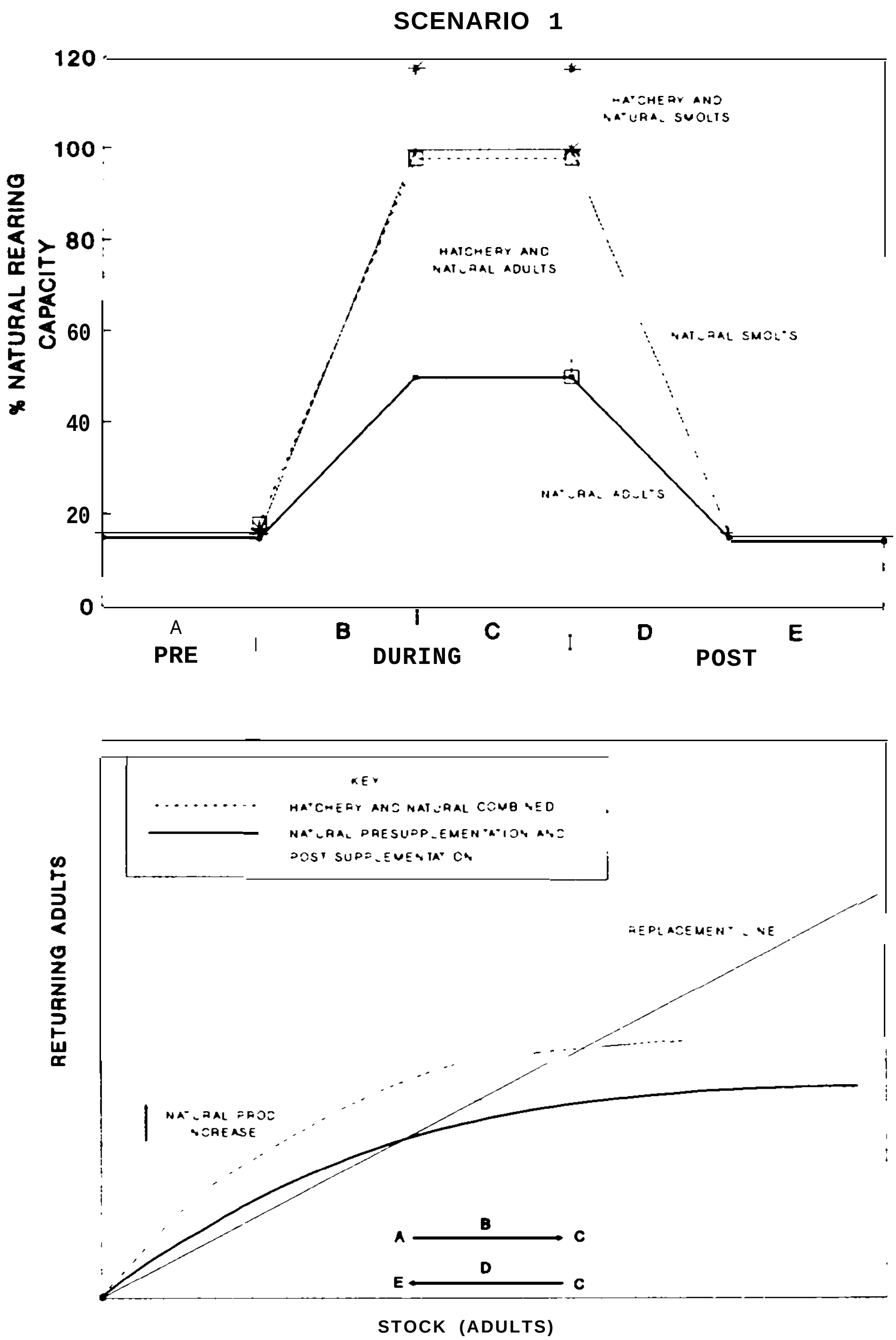

Figure 8. Productivity and production curves associated with hypothetical supplementation responses where **natural production increases and natural productivity remains unchanged.** Natural variability among streams and years, as well as time lag between smolts and adults have been omitted for illustrative purposes.

Scenario 2: Natural production increases. Natural productivity declines. Natural population limited by density independent mortality during smolt-to-adult stage. Artificial propagation provides at least a short term replacement (adult-to-adult) advantage over natural production (Figure 9).

Under this scenario, natural production is enhanced by supplementation but it come9 at the expense of natural productivity. Actual number9 of naturally produced adults has increased during supplementation because the total productivity of the stock (hatchery and natural components combined) has increased because of the net survival advantage gained during hatchery residence. Productivity of the stock in the natural environment, however, has been impaired by negative hatchery influence exerted through introgression (genetics) and interaction (behavior, pathogens).

In this scenario the natural population is originally at a very depressed but stable equilibrium level (A) near replacement. During supplementation the natural population increases to an higher equilibrium point (B and C), reflecting the hatchery survival advantage. Following supplementation the population operate9 completely from the lower productivity curve which has been pushed below replacement, driving the population to extinction (D). This effect will be lessened if most of the hatchery impact9 are non-heritable or transmittable (e.g. competition, predation, etc.).

A serious problem with this scenario is that we essentially become locked into a long term supplementation program, increasing the risks of further negative impact9 from artificial propagation. From Idaho's standpoint, this scenario would be considered a failure because natural productivity declined below acceptable limits. This scenario would be considered a success if management objectives were to increase natural production without a loss in total stock productivity (hatchery and natural combined).

SCENARIO 2

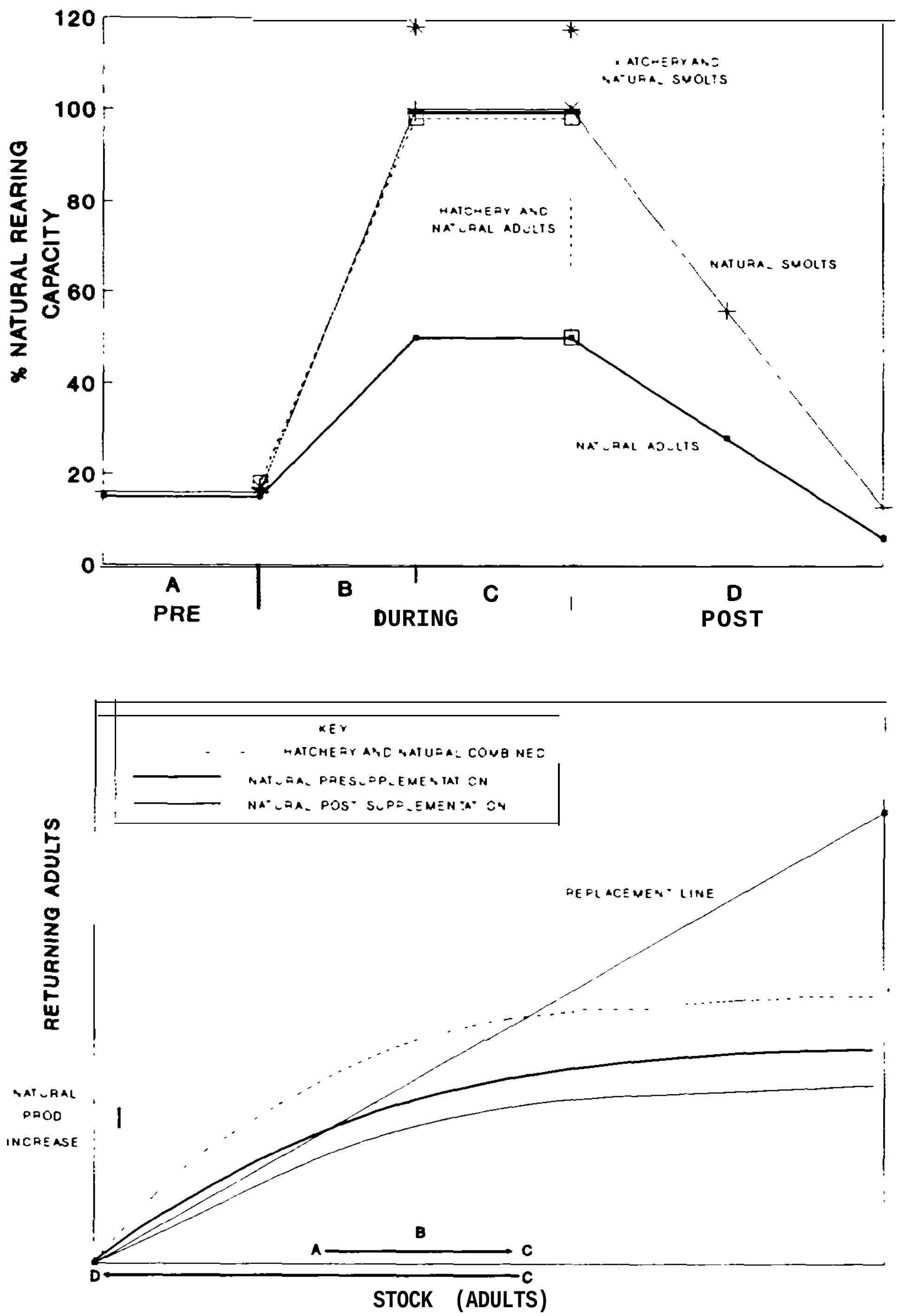

Figure 9. Productivity and production curves associated with hypothetical supplementation responses where **natural production** increases and natural **productivity** declines. Natural variability among streams and years, as well as time lag between smolts and adults have been ommitted for illustrative purposes.

Scenario 3: **Natural production and productivity remain unchanged.** Natural population limited by density independent mortality during smolt-to-adult stage. Artificial propagation provide8 at least a short term replacement (adult-to-adult) advantage over natural production (Figure 10).

Under this scenario no effect on natural production or productivity is detected from supplementation. Although natural production of adult may decline during supplementation because of broodstock needs, natural production bounces back when supplementation is terminated. Artificial propagation may actually increase total smolt production and total adult production (B), but this increase does not translate into naturally produced adults (B) because either the hatchery is providing no net benefit (adult-to-adult), or as in this case, the hatchery component increases adult returns, but they fail to spawn successfully. Because the hatchery component does not introgress or interact with the natural component, continuation *or* termination of supplementation does not change natural production and productivity (C).

This scenario would be considered a failure, based on the apparent incompatibility of the donor stock with the natural stock and natural environment.

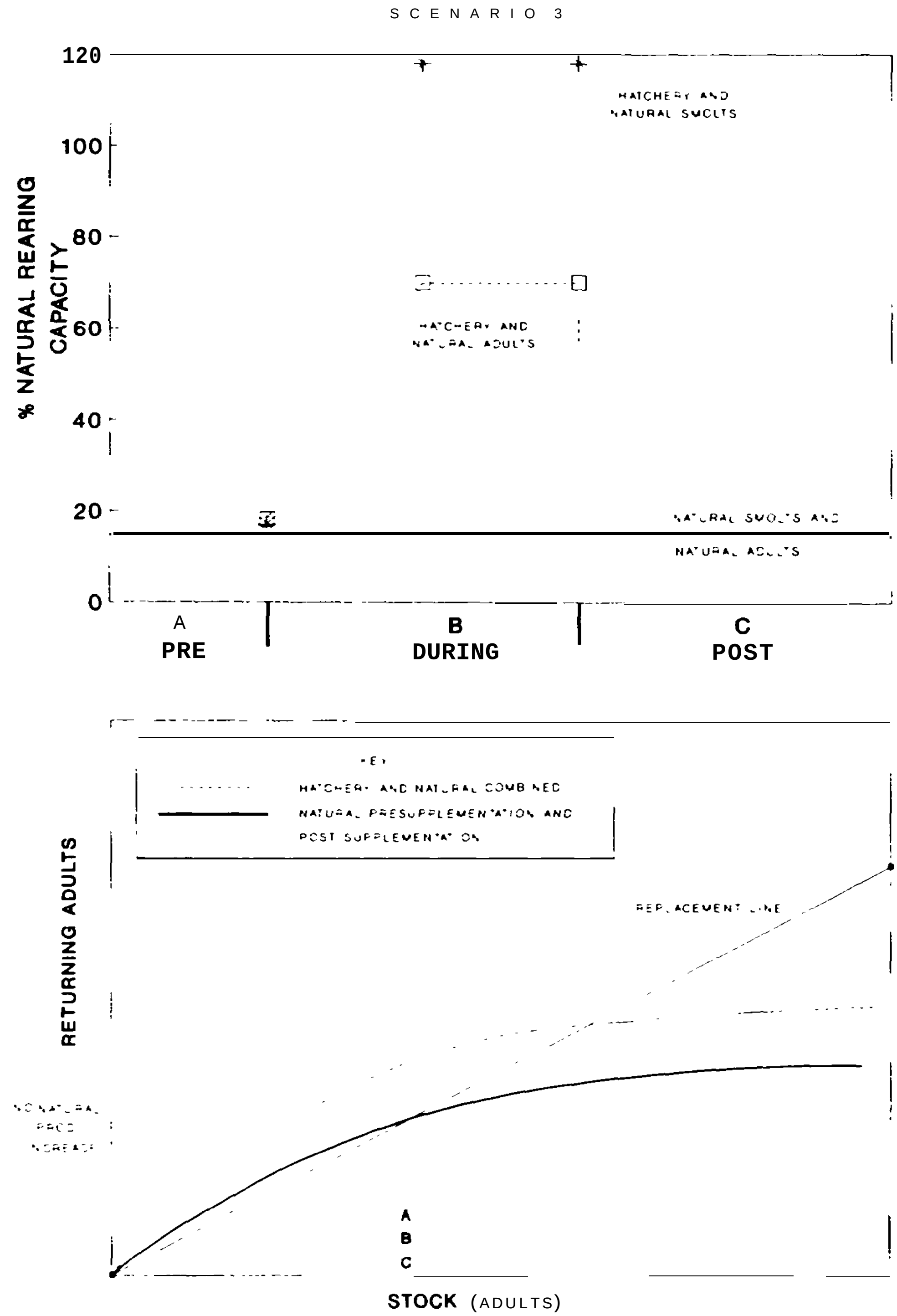

Figure [illegible]. Productivity and production curves associated with hypothetical supplemental 3' reductions where natural production and productivity remain unchanged. Natural variation among streams and years as well as time lag between smolts and adults have been omitted for illustrative purposes.

Scenario 4: Natural production does not change, natural productivity declines. Natural population limited by density independent mortality during smolt-to-adult stage. Artificial propagation provides at least a short term replacement (adult-to-adult) advantage over natural production (Figure 11).

This scenario is similar to the last one, except that the hatchery component produces a negative impact on the natural component through introgreseion and interaction. Total production is once again increased (B) as a result of the hatchery survival advantage (adult-to-adult), but the natural productivity curve has been dampened as a result of these interactions, resulting in the same number of recruits (progeny adults) as before supplementation.

If the negative effects of supplementation on natural productivity is predominantly non heritable or transmittable, then the natural population should bounce back if supplementation is terminated. If, as in this case, the supplementation effects are predominantly transmittable or heritable, then the population can become hatchery dependent, with a high risk of extinction (C) if supplementation is terminated (assuming flow and passage constraints remain unchanged).

This scenario would be considered a failure under any supplementation management objectives. No benefit is evident on natural production and the population is put at even greater risk of extinction because of lower natural productivity.

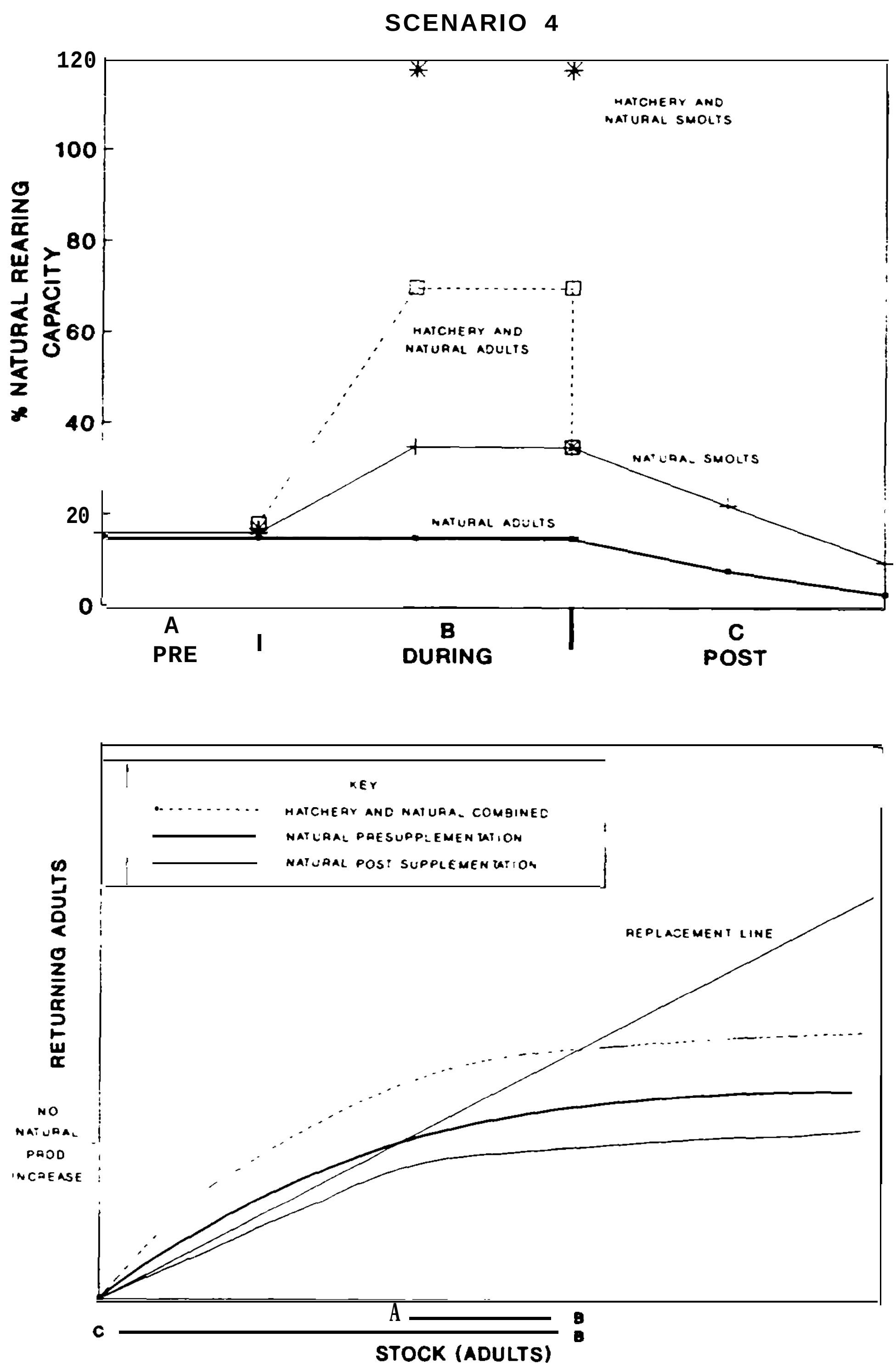

Figure 11 Productivity and production curves associated with hypothetical supplementation responses where natural production does not change and natural productivity declines. Natural variability among streams and years, as well as time lag between smolts and adults have been ommitted for illustrative purposes

Scenario 5: **Natural production and productivity declines.** Natural population limited by density independent mortality during smolt-to-adult stage. Artificial propagation provides at least a short term replacement (adult-to-adult) advantage over natural production (Figure 12).

This is obviously one of the worst case scenarios. Negative supplementation effects have caused natural production (A) to decline even during supplementation (B). The effects are heritable or transmittable resulting in continued low productivity and population decline after supplementation is stopped (C).

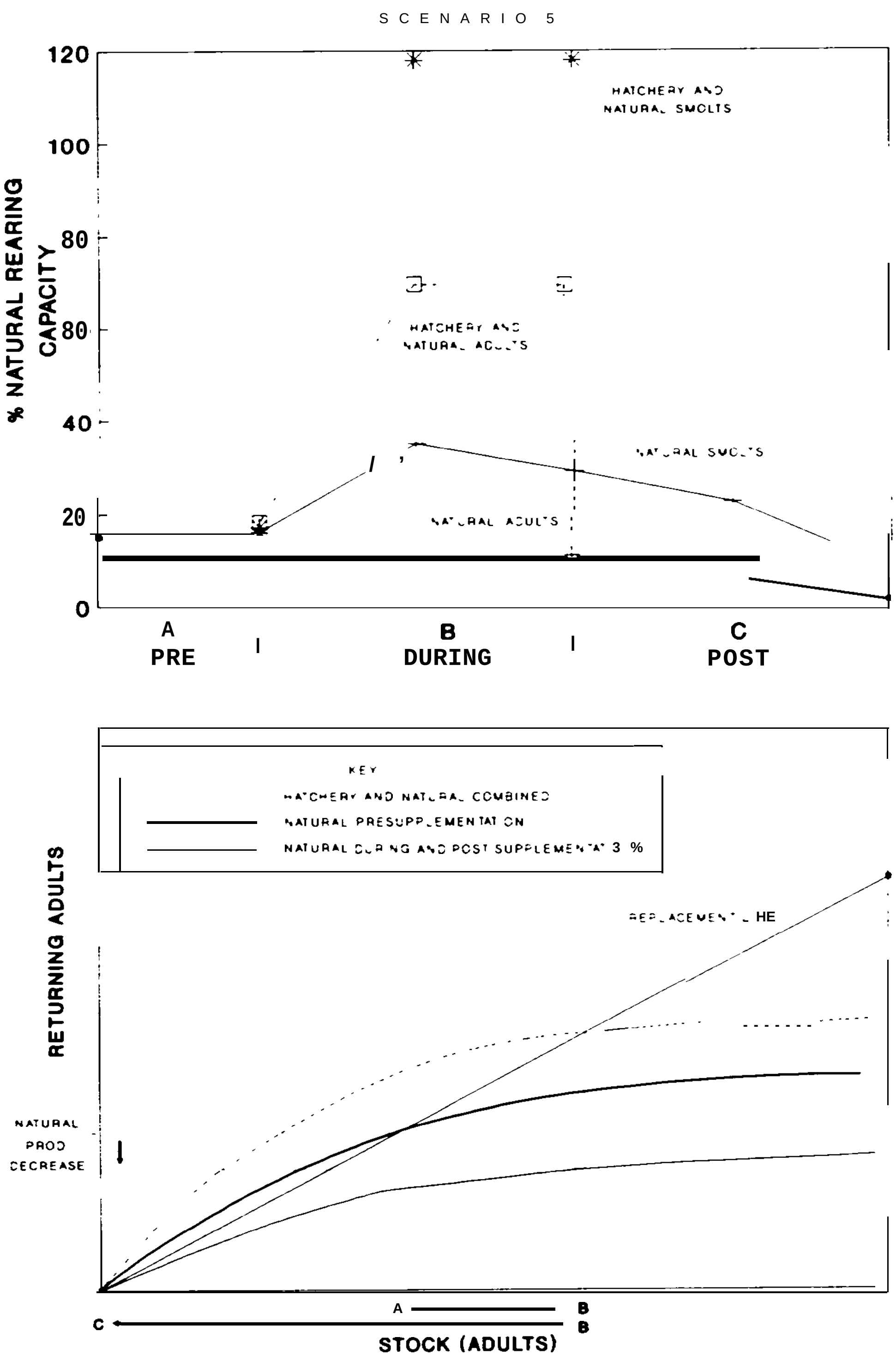

Figure 12 Productivity and production curves associated with hypothetical supplementation responses where **natural production and productivity decline.** Natural variability among streams and years as well as time lag between smolts and adults have been omitted for illustrative purposes.

These scenarios can be varied in both degree and direction and represent only a small component of potential results. *For* example, there can be instances where natural production declines during supplementation due to non heritable or transmittable effects on natural productivity (e.g. competition, predation). The population can then bounce back when supplementation is stopped. Another realistic result is where we are unable to produce a net replacement (adult-to-adult) benefit from artificial propagation, which essentially results in none of the potential benefits of artificial propagation and all of the risks.

Further discussion of these and other potential results of supplementation has been provided by the Regional Assessment of Supplementation Project (RASP 1991). Their discussions expand on multi-generational effects using scenarios which vary in both degree and duration of hatchery impacts. A supplementation model incorporating genetic impacts and stochastic environmental events is currently being finalized by RASP. When completed, we anticipate using the model to describe the range of potential supplementation results for Idaho salmon stocks, as well as highlight areas of critical uncertainty and response sensitivity.

In the interim we have used deterministic life history modeling to provide realistic expectations for our supplementation effects and illustrate potential recovery rates (see Specific Production Plans; Appendix D). This simplistic approach assumes our natural populations are vastly underseeded and are operating on the "linear" ascending limb of the Beverton-Holt productivity curve. Thus density-dependent survival effects are assumed minimal for modeling purposes.

IMPLEMENTATION

Implementation (phase II) of ISS will begin in 1992 and may continue for at least three generations (approximately 5 years/generation) (Figure 13). The foundation of the study will include an interagency steering committee (a subset of the already formed ISTAC committee) headed by IDFG and represented by each of the participating tribes and agencies. This committee will provide support to insure quality control and general accountability and coordination of the various project components and contributors. Each component will be contracted individually with BPA. Emphasis will be given to full integration and coordination of these components to minimize repetitive logistical, personnel, and equipment expenses. For example, some of this integration will be with ongoing projects already staffed and funded (Appendix A).

Discussions concerning the partitioning of this implementation phase have been minimal until recently. This was to insure that the overall experimental design was developed and evaluated on technical and biological merits, and not "turf" issues. Meetings were held with the potential cooperators during October, 1991, to detail the implementation components.

Study streams were partitioned among five resource management entities for implementation (Table 14). These included IDFG, NPT, SBT, IFRO and USFS. Allocations were based on interest, integration with on going programs, cost efficiency, logistics and, to a lesser extent,

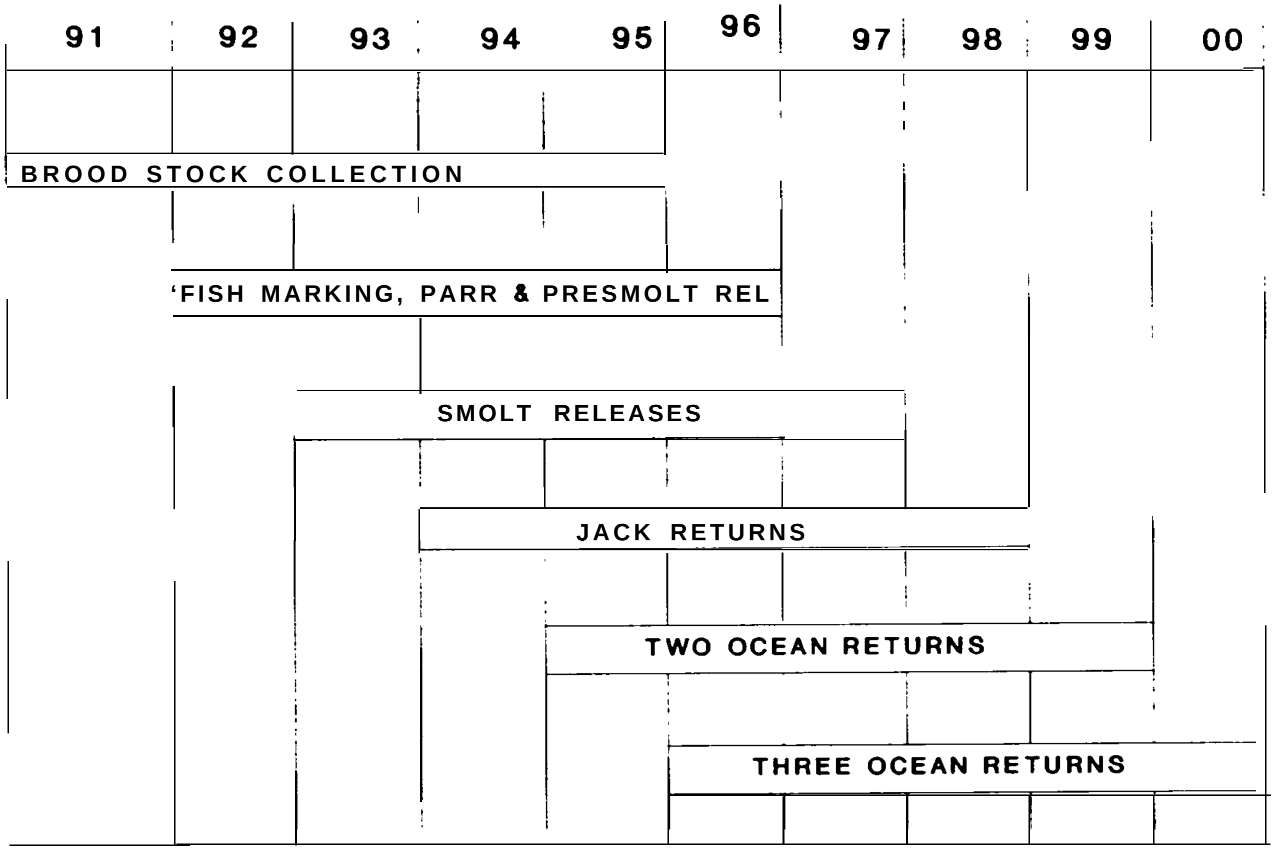

Figure 13 Basic time line associated with Idaho Supplementation Studies illustrating one generation with five replicates per generation

Table 14. Partitioning of study streams among agencies and tribes for implementation of Idaho Supplementation Studies **(ISS).**

IDFG						NPT		SBT		IFRO	USFS	
Supplem.	**ISM**	**GPM**	Reg.2	Reg.7	ICFWRU	NPTH	Supplem.	SRHE	Supplem.	Supplem.	**SNF**	NPNF
Pahsim.[a]	**USR**[a,c]	**Red**[b,c]	Red'	**NFSR**[a,b]	Lemhi'	**Lolo**[a,c]	**Papoose**[d]	**WFYF**[c]	Valley	Clear'	**NFSR**[a]	Johns
USFSR[a]	**ALC**[d]					**Newsome**[a,c]	**Squaw**[d]	**UEFSR**[a,d]	**USFSR**[b]	Pete King		
Marsh'	**CR**[a,c]					**Slate**[a,c]	**Lake**[d]	**BVC**[c]				
Camas								**Herd**[c]				
Johnson'												
Crooked Fork'												
White Sand												
Big Flat												
American												
Brushy **FK**												
Bear												

IDFG = Idaho Dept. of Fish and Game; NPT = **Nez Perce** Tribe; SBT = Shoshone - Bannock Tribes; **IFRO** = Idaho Fisheries Research Office; **ISM** = Intensive Smolt Monitoring Research; GPM = General Parr Monitoring Research; NPTH = **Nez Perce** Tribal Hatchery; SRHE = Salmon River Habitat Evaluation; **USR** = Upper Salmon River; **NFSR** = North Fork Salmon River; **WFYF** = West Fork Yankee Fork; USFSR = Upper South Fork Salmon River; ALC = Alturas Lake Creek; **UEFSR** = Upper East Fork Salmon River; CR = Crooked River; BVC = Bear Valley Creek; **SNF** = Salmon National Forest; NPNF = **Nez Perce** National Forest.

[a] stream with weir management for adults and juveniles.

[b] Snorkeling for parr monitoring only.

[c] Existing or planned program not requiring additional funding through ISS.

[d] Existing or planned program requiring supplemental funding through ISS.

relative equity. Approximately one-half of the study will be implemented by IDFG through the ISS contract with BPA. This includes contributions by the ICFWRU for investigations on the Lemhi River and the small scale studies, as well as contributions by several ongoing IDFG programs that are capable of full integration into the ISS design. The NPT and SBT have similar commitments to ISS, each comprising approximately 20% of the study. Both of these components rely heavily on integration of existing or proposed tribal programs (e.g. SBT Salmon River Habitat Enhancement and Nez Perce Tribal Hatchery). IFRO will contribute less than 10% of the study implementation, most coming from investigations on Clear Creek associated with evaluation of operations at Kooskia National Fish Hatchery. Contributions from the Forest Service are not yet resolved, but will probably include support to IDFG crews in collection of parr density and juvenile emigration data on one or two streams. Table 15 outlines the specific responsibilities of each agency and tribe in the implementation of ISS.

All of the experimental design will not be implemented simultaneously (Table 16). For example, renovation of the Lemhi weir will forestall supplementation in the Lemhi River until at least BY 1993, with releases in 1994 and 1995. Approval and implementation of the Nez Perce Tribal Hatchery program, which includes two of our study streams, is also an uncertainty. Other delays of one to two years will be necessary for some study streams to insure adequate baseline data has been obtained prior to supplementation. These time lags for full implementation are accounted for in our experimental design through the use of control streams and will not contribute significant variability to weaken the overall study.

BASELINE DATA

An important tool in the evaluation of supplementation is the comparison of treatment effects to pretreatment or baseline data. Three to five years of data are needed from all treatment and control streams prior to measuring supplementation effects to provide enough statistical power for valid inferences. This pretreatment database should include all appropriate response variables that will be measured after supplementation has begun (e.g. redd counts, parr abundance, smolt production, survival, distribution, genetic composition, and habitat characteristics). During 1991, researchers from several agencies and tribes cooperated in collecting parr density, habitat, genetic and redd count baseline data to get a head start on this important need Table 15. Data collection was coordinated between other IDFG research projects, the Nez Perce Tribe, Sho-Ban Tribe, U. S. Fish and Wildlife Service, and the U. S. Forest Service to avoid duplication of effort and to maximize the number of streams sampled.

All the treatment and several control streams were snorkeled intensively during the summer of 1991 to obtain total chinook parr production. Typically the snorkelers started at the bottom of a study area (e.g. mouth of the stream, or just upstream of a weir) and moved upstream every 1/4 to 1/2 mile depending on the size of the stream and the numbers of chinook seen. At each site a typical pool - riffle - run sequence was identified, flagged (at the upper and lower ends for future identification), and snorkeled. Sites varied in length from 30m - 50m. One stream, the Lemhi River was too turbid to snorkel, therefore it was

Table 15. Specific responsibilities of agencies and tribes associated with each study stream in Idaho Supplementation Studies.

Stream	Trtmt/Cntrl	Rearing: Harking, Release & Health Mgmt	Parr Monitoring & PIT tag	Fall/Spring Emigrant Trap & PIT tag	Multiple Redd Counts & Carcass ID	Weir Management: Broodstock Collection & Spawning	Weir Management: Adult Enumeration/ Innoculation	Data Analysis & Reporting
				Salmon River Drainage				
U. Salmon R	T	IDFG/Hatcheries[b]	IDFG/ISM[b]	IDFG/ISM[b]	IDFG/ISM[b]	IDFG/Hatch[b]	IDFG/Hatch[b]	IDFG/ISM[b]
Alt. Lake Cr	T	"	IDFG/ISM[c]	NA	"	NA	NA	"
West Fork YF	T	"	SBT[c]	"	SBT[c]	IDFG ('96)	IDFG ('96)	IDFG/Suppl
U. East Fk SR	T	"	"	SBT	"	IDFG/Hatch[b]	IDFG/Hatch[b]	SBT[c]
Pahsimeroi R	T	"	IDFG/Suppl	IDFG/Suppl	IDFG/Suppl	"	"	IDFG/Suppl
Lemhi R	T	IDFG/Hatcheries	ICFURU	ICFWRU	ICFWRU	IDFG/Hatch	IDFG/Hatch	ICFWRU
U. South Fk SR	T	IDFG/Hatch[b]	SBT	IDFG/Suppl	IDFG/Suppl	IDFG/Hatch[b]	IDFG/Hatch[b]	IDFG/Suppl
Slate Cr	T	NPT[b]	NPT	NPT[b]	NPT[b]	NPT[b]	NPT[b]	NPT[b]
Harsh Cr	C	NA	IDFG/Suppl	IDFG/Suppl	IDFG/Suppl	NA	IDFG/Suppl	IDFG/Suppl
Camas Cr	C	"	"	NA	"	"	NA	"
Bear Valley Cr	C	"	SBT[c]	"	SBT[c]	"	"	SBT[c]
Herd Cr	C	"	"	"	"	"	"	"
U. Valley Cr	C	"	"	"	"	"	"	SBT
North Fk SR	C	"	IDFG/Reg 7	USFS/SNF	IDFG/Reg 7	"	USFS/SNF	IDFG/Suppl
Lake Cr	C	"	NPT	NA	NPT	"	NA	NPT
Johnson Cr	C	"	IDFG/Suppl	IDFG/Suppl	IDFG/Suppl	"	IDFG/Suppl	IDFG/Supp
				Clearwater River Drainage				
Crooked Fk Cr	T	IDFG/Hatch[b]	IDFG/Suppl	IDFG/Suppl	IDFG/Suppl	IDFG/Hatch	IDFG/Hatch	IDFG/Suppl
White Sand Cr	T	"	"	NA	"	NA	NA	"
Big Flat Cr	T	"	"	"	"	"	"	"
American Cr	T	"	"	"	"	"	"	"
Red R	T	"	IDFG/GPM[b]	IDFG/Reg 2	IDFG/Reg 2[c]	IDFG/Hatch[b]	IDFG/Hatch[b]	"
Crooked R	T	"	IDFG/ISM[b]	IDFG/ISM[b]	IDFG/ISM[b]	"	"	IDFG/ISM[b]
Newsome Cr	T	NPT[b]	NPT	NPT[b]	NPT[b]	NPT[b]	NPT[b]	NPT[b]
Lolo Cr	T	"	"	"	"	"	"	"
Squaw Cr	T	IDFG/Hatch[b]	"	NA	NPT	NA	NA	"
Papoose Cr	T	"	"	"	"	"	"	"
Clear Cr	T	USFWS/Hatch[b]	USFWS/IFRO	USFWS/IFRO	USFWS/IFRO	USFWS/Hatch[b]	USFWS/Hatch[b]	USFWS/IFRO
Pete King Cr	T	IDFG/Hatch[b]	"	NA	"	NA	NA	"
Brushy Fk Cr	C	NA	IDFG/Suppl	"	IDFG/Suppl	"	"	IDFG/Suppl
Bear Cr	C	"	"	"	"	"	"	"
Johns Cr	C	"	USFS/NPNF	"	USFS/NPNF	"	"	"

[a] Harking expenses covered through BPA (ISS) and LSRCP.
[b] Part of existing or planned program not requiring additional funding through ISS.
[c] Part of existing or planned program requiring supplemental funding through ISS.
ISM = Intensive Smolt Monitoring Project
GPM = General Parr Monitoring Project
IFRO = Idaho Fisheries Research Office
SNF = Salmon National Forest
NPNF = Nez Perce National Forest

TABLE 16. Anticpated implementation schedule for supplementation in treatment streams associated with Idaho Supplementation Studies, Note: Only the first of a five - year replicate cycle for each generation is depicted. Some baseline data is available prior to 1991.

TREATMENT STREAMS	89	90	91	92	93	94	95	96	97	98	99	2000	01	02	03	04
CLEARWATER DRAINAGE																
Red River Crooked Fork Creek			BL —— TBS →	—— PSR →	—— →	—— AR →	—— →	SBS →	PSR →	→		AR/SBS				
Crooked River	BL ——	——	—— HBS →	—— PSR →	—— →	AR →	→	HBS- PSR	→	→	→	AR →	→			
White Sand Creek Big Flat Creek Squaw Creek Pete King Creek			BL →	HBS- PR →	→	→	AR →	→	→							
Clear Creek			BL —— TBS ——	—— ——	—— SR →	—— AR →	—— →	SBS →	→	SR →	→	AR/SBS				
American River Papoose Creek			BL ——	—— HBS →	—— →	—— SR →	AR →	→	→							
Lolo Creek Slate Creek (Salmon R.)			BL ——	——	—— TBS → OR HBS	PSR →	→	AR →	→	SBS →	PSR →	→	AR/SBS			
SALMON DRAINAGE																
Lemhi River			BL ——	——	TBS → ——	PR → ——	→ ——●	A R → SR-AR →	→ →	→ SBS →	→	→ SR →	AR/SBS			
Pahsimeroi River U.East Fork Salmon Upper Salmon River Alturas Lake Creek U. South Fork Salmon	——	→	BL —— T B	—— S -	—— SR →	AR →	→	SBS →	→	SR →	AR →	→	SBS			
W. Fk. Yankee Fk,	——	——	BL ——	—— HBS →	—— →	SR →	AR →	→	SBS →	→	SR →	AR →	→			

sampled using standard electrofishing gear. The results of this field season will be presented in the next annual report.

In addition to baseline parr production estimates, 50 chinook parr were collected from each stream for baseline genetic profile analysis using starch gel electrophoresis. To avoid sampling a single family, chinook were collected from at least five different locations spread throughout the study area. The fish will be sent to the Washington Department of Fisheries genetics lab in Olympia Washington (headed by Jim Shaklee) for analysis.

The majority of the study streams have redds counted annually by IDFG personnel as part of the U. S. versus Canada treaty. Other study streams not part of this will be counted by either the Nez Perce Tribe, Sho-Ban Tribe, USFWS, or ISS.

The plans for the summer of 1992 include a second year of snorkeling those streams listed in Table 17, plus intensive snorkeling on all control streams not snorkeled in 1991. Physical habitat data will be collected on all treatment and control streams in 1992 (Sensu Platts et al. 1983; Rosgen 1985). Also, fish will be collected for baseline genetic profile analysis. Redds will be counted in all treatment and control streams to estimate spawning escapement and egg deposition. Five hundred naturally produced chinook parr will be PIT tagged per study stream (treatment and control) and 500 fall outmigrants will be tagged in each stream with a weir to estimate survival to Lower Granite Dam. Also, 50 juvenile salmon will be collected from all treatment and control streams with natural populations for a second year of baseline genetic profiles. One hundred chinook juveniles from each hatchery used in ISS will also be sampled. This sampling is being coordinated with NMFS so that duplicate samples are not taken.

Table 17. Streams sampled during the summer of 1991 as part of Idaho Supplementation Studies (ISS) by agency or tribe.

IDFG (ISS)	IDFG (OTHER)	NEZ PERCE TRIBE	SHO-BAN TRIBE	USFWS
N Fk Salmon	Upper Salmon	Lolo Cr	Herd Cr	Crooked Fk
Cr* E Fk Salmon'	Alturas Lake Cr	Squaw Cr	E Fk Salmon*	Clear Cr*
S Fk Salmon	Red R	Papoose Cr	Bear Valley Cr	Newsome Cr*
Lemhi R	Crooked R		W Fk Yankee Fk*	
Big Springs Cr				
Pahsimeroi R				
W Fk Yankee Fk*				
American R				
Newsome Cr*				
Crooked Fk Cr*				
White Sand Cr				
Big Flat Cr				
Clear Cr*				
Pete King Cr				

* = Streams where more than one agency or project worked together to sample the stream.

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Members of the Idaho Supplementation Technical Advisory Committee helped develop and provided critical review of the design. Participants in the Regional Assessment of Supplementation Project have also provided valuable insights.

Collection of baseline field data was greatly assisted through the cooperation of The Nez Perce Tribe of Idaho, The Shoshone-Bannock Tribes of Fort Hall, U.S. Fish and Wildlife Service, U.S. Forest Service, and IDFG's Intensive Smolt Evaluation (Russ Kiefer), Habitat Evaluation (Bruce Rich), and LSRCP Hatchery Evaluation (Dave Cannamela) projects. ISS's field crew included Eric Reiland, Troy Rose, Dave Tueller and Eldon Cutlip. Dr. Jim Shaklee (WDF) assisted in the development of baseline genetic sampling protocols, and Dr. Robin Waples (NMFS) will provide baseline genetic information for 25% of our study populations through his related project.

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APPENDICES

Appendix A. Other supplementation evaluation projects in the Columbia Basin, and their relation to Idaho Supplementation Studies.

Several ongoing or proposed anadromous research projects and management activities will provide useful information for ISS. To receive optimal benefit from these efforts and avoid unnecessary duplication, it is crucial that thorough coordination and integration occur. To address this need and longstanding concerns by CBFWA, PNUCC and NPPC, the Regional Assessment of Supplementation Project (RASP) was initiated late 1990. One of the main objectives of RASP was to provide an overview of supplementation activities in the Basin that are currently underway or being planned. This product will help insure better regional coordination and integration of research and monitoring programs from a Basin-wide perspective.

Related objectives of RASP include development of a supplementation model to provide insight into critical uncertainties and expectations associated with supplementation. RASP has built on results presented in the supplementation literature synopsis (Miller et al. 1990; Steward and Bjornn 1990; Bjornn and Steward 1990), and will greatly enhance the efficiency and accountability of ongoing and proposed projects as well as provide a framework for planning future supplementation activities. ISS biologists will continue participation in RASP and integrate its products into our design where appropriate.

The following is a brief description of ongoing and proposed supplementation projects throughout the basin and their relation to ISS. More thorough description and integration will occur through the assessment project described above.

Oregon

Imnaha Steelhead

ODFW is developing an experimental design for supplementation research on A-run summer steelhead in the Imnaha River Basin. Development is on a similar schedule as this project (ISS). ODFW originally anticipated testing the hypothesis that supplementation with an endemic stock will not adversely affect productivity of existing natural steelhead populations. Because of limited opportunity for spatial replication of treatment and control streams, they probably will not be able to address long term effects on natural productivity and fitness. They will address intraspecific competition and predation associated with residual steelhead smolts and the rate and mechanisms of residualism. Oregon biologists believe this is a key question concerning steelhead supplementation.

Broodstock for this research was developed from native steelhead in Little Sheep Creek. Currently a smolt production goal is driving the hatchery program. To meet this goal more hatchery fish (85-90%) are being taken as broodstock than considered optimal from a supplementation standpoint. This broodstock will be used to supplement four treatment streams within the Imnaha basin. It is not known, but assumed, that these treatment streams contain similar stock as Little Sheep Creek. This situation is similar to what we would call a "subbasin" rather than "local" broodstock (e.g. McCall stock' to supplement all of South Fork Salmon River). The study will be temporally replicated but basin wide or even general upriver application is weakened by the lack of replication outside the drainage and with additional local broodstocks.

Umatilla

Proposed supplementation activities for the Umatilla River basin (ODFW, Umatilla Tribe) include spring and fall chinook and A-run summer steelhead. No viable natural populations of chinook exist in the Umatilla so the current chinook program is a restoration project with primary emphasis on harvest augmentation and not natural production. Size of release and rearing density strategies are being evaluated by monitoring reproductive success. Expansion of release strategies and their evaluation is proposed. Fall chinook are currently being reintroduced into the Umatilla without scientific evaluation, although research and evaluation are proposed.

Supplementation of summer steelhead would also be primarily for harvest augmentation and broodstock development. The Umatilla currently supports a natural run of native steelhead. Monitoring and evaluation of these programs are in development.

NEOH

The North East Oregon Hatcheries (NEOH) program (ODFW, NPT, LSRCP) includes several ongoing and proposed supplementation activities. Spring chinook in the Imnaha River basin are currently being supplemented with smolts produced from a broodstock developed from local endemic stock. At least 50% of returning natural and hatchery adults are allowed to spawn naturally. All hatchery fish are marked with CWT-AD clip or ventral fin clip. Success of the program has been very poor as a result of low egg-to-smolt survival, possibly indicating the difficulties of using wild fish to develop a hatchery brood stock.

Supplementation of spring chinook is also planned for the Lostine and Catharine-Wallowa drainages in the Grand Ronde basin. Broodstock will be developed from local endemic stocks, although low natural spawning escapement may constrain or delay this process. NEOH proposes large scale monitoring and evaluation but plans are still in development and questions to be addressed through research are not finalized. Potentials include evaluation of life stages, release techniques and long term fitness.

Washington

YKPP

The Yakima-Klickitat Production Project (YKPP; WDF, WDW, YIN), currently in the review and early-implementation process, incorporate5 both steelhead and chinook to test the effects of different smolt acclimation rate5 on supplementation success. Although not in the original plan, they are working to include a "O" acclimation treatment (Idaho's method). Their study streams contain both treatment and control areas because of lack of true control stream opportunities. Because of this, they are having difficulty addressing long term effects of supplementation on fitness. They will probably have to pool all acclimated groups and compare survival of acclimated hatchery smolts to survival of natural smolts in the same streams (these natural fish are potentially only one generation removed from the hatchery). Because of the lack of true controls there is not way to compare survival of natural smolts in supplemented streams to natural smolts in unsupplemented streams.

The YKPP is not testing the brood source issue directly but has opted to develop the "best possible" brood source scenario and maintain it as a constant while testing the acclimation question. To do this, all hatchery fish will be marked and only natural fish (at least one generation removed from the hatchery) used as broodstock. To avoid "mining" too many natural fish only 20% or less of natural returns will be used for broodstock.

Tucannon

Information from the hatchery program for the Tucannon River (LSRCP, WDW, WDF, Umatilla Tribe) will complement ISS well. The Tucannon supports wild spring chinook that had not been supplemented prior to 1986. Broodstock is being developed from this native population and progeny isolated and reared at Lyons Ferry Hatchery for smolt releases back into the Tucannon River. The first adults returned in 1990. The Tucannon represents an excellent research opportunity because supplementation did not occur prior to this project and they have established approximately ten years of baseline population dynamics, meristic and electrophoretic data. Unmarked hatchery strays from the Umatilla River may confound the success of this program and its research opportunities.

One hypothesis being tested examines relative performance and survival of hatchery, wild and hybrid fish reared in a hatchery environment. Beginning in 1990, specific pairings of WxW, HxH and WxH were made. Productivity and performance will be monitored in the hatchery until release as smolts. Smolts will be CWT-AD clipped to evaluate survival to adults. Their second hypothesis addresses relative survival and productivity of hatchery, wild and hybrid fish reared in a natural environment. This is proposed for 1992 and incorporates utilization of a genetic mark unique to the wild fish.

Rock Island and Douglas PUD

A detailed experimental design addressing supplementation strategies and monitoring-evaluation plans has not been developed for any of the Rock Island or Douglas PUD projects. These include five ongoing (RI) and three proposed (DPUD) projects for spring and summer chinook and summer steelhead. It is expected that these projects will evaluate several rearing and release strategies (e.g. time of release, size at release, rearing density) by monitoring productivity, performance and survival.

Idaho

Steelhead Supplementation

IDFG recently received funding approval for development of a comprehensive experimental design to evaluate steelhead supplementation in Idaho. The design will be completed during the coming year and will address similar hypotheses as the chinook project (ISS). We anticipate this project will be integrated directly into ISS for implementation. The steelhead study will directly complement the chinook project in areas where research opportunities for chinook are limited. In addition, many rivers in Idaho are co-managed for steelhead and chinook and inferences from the chinook study will be weakened if effects of interspecific supplementation are not addressed.

NPTH

The Nez Perce Tribal Hatchery Program is proposing development of several on-site rearing ponds for fall release of presmolt spring chinook. This project is being integrated directly into ISS to test the acclimated presmolt release strategy. NPTH contributions to ISS include Lolo, Newsome and Slate creeks as treatment streams. Additional proposed areas in the Selway River may also be included into ISS as appropriate. ISS and NPTH have been coordinated throughout development phases, and most technical aspects are directly compatible. Areas still needing resolution include broodstock and harvest management, which are currently being discussed. The Master Plan for NPTH was completed September, 1991, and is presently under review.

Miscellaneous

Other Idaho projects pertinent to ISS include the LSRCP Hatchery Evaluation project (IDFG, NPT, UI), Intensive Evaluation of Chinook and Steelhead Smolt Production project (IDFG, BPA, UI), Smolt Condition and Timing of Arrival at Lower Granite Reservoir project (IDFG, BPA), Idaho Habitat Evaluation for Off-Site Mitigation Record project (IDFG, BPA), and the Salmon River Habitat Enhancement project (SBT, BPA). These studies will provide stock histories, baseline and pretreatment data, fish population monitoring data, fish health data, spawning behavior and distribution, adult outplanting evaluation and fry emigration data.

The LSRCP Hatchery Evaluation Project is determining the effectiveness of hatchery practices in maximizing adult returns to Idaho. Several specific research projects are ongoing or proposed in addition to general monitoring and documenting hatchery practices and products. An experiment is underway at Sawtooth and Dworshak hatcheries (BY 89-91) to evaluate smolt survival and adult returns associated with three rearing densities - standard (1.6 lbs/ft^3), two thirds (1 lb/ft^3), and one third (0.5 lb/ft^3). Sawtooth Hatchery is also completing evaluation of fall releases and initiating cursory evaluation of raceway shading.

The LSRCP project has a chinook marking study underway at McCall Hatchery (BY 88-90) to evaluate smolt and adult survival associated with CWT/AD clip relative to the control group marked with tetracycline only. Adult returns will be arriving from 1991-1995. The LSRCP project, in cooperation with ODFW, is also evaluating scale pattern recognition to differentiate hatchery and natural fish. Research emphasis at McCall during the next five years will include initiation of studies to evaluate time and size at release with respect to physiological and environmental emigration cues.

We anticipate the initiation of a smolt acclimation study associated with the LSRCP Clearwater Anadromous Fish Hatchery satellite facilities. This study will compare direct releases to those acclimated for two weeks prior to release. The results will be very useful to ISS and will augment results from proposed YKPP acclimation research which does not include evaluation of zero acclimation.

A graduate study funded through LSRCP is underway to monitor spawning behavior, distribution and success of adult returns above hatchery weirs in the upper Salmon and South Fork Salmon rivers. Other proposed LSRCP projects include natural rearing evaluations in the Clearwater Anadromous Fish Hatchery satellite ponds, and a possible graduate study to assess the effects of steelhead residualism on chinook emergence and rearing.

The ongoing Intensive Evaluation of Chinook and Steelhead Smolt Production project is quantifying the relationship between redds, parr and smolt production in two treatment streams used for ISS (upper Salmon River and Crooked River). This study will provide nearly all evaluation data for supplementation of these streams (e.g. redd counts and distribution, parr production, emigrant timing, smolt production, survival, habitat characteristics). Adult outplants used in this study to help define natural rearing capacities will provide information to ISS on the effectiveness of that particular restoration strategy. An associated graduate study is investigating the magnitude, timing and relative contribution of fry emigration from the upper Salmon River.

The ongoing Idaho Habitat Evaluation for Off-Site Mitigation Record project estimates mid summer parr densities in 60% of ISS treatment and control streams. Although these streams are not snorkeled intensively enough to estimate parr production precisely, ISS will coordinate and cooperate with these researchers to minimize duplicate efforts and insure precise estimates are gained for ISS study streams. This cooperative effort was already evident during the 1991 field season (Table 17). Development of the System Monitoring and Evaluation Program during the next five years will also provide parr and redd count information to ISS.

The Smolt Condition and Timing of Arrival at Lower Granite Reservoir project will also provide valuable information for ISS. We will use their analysis to adjust our smolt survival estimates to the lower Snake River dams to represent smolt survival to the head of Lower Granite Pool.

ISS will benefit greatly from the ongoing Salmon River Habitat Enhancement project conducted by the Shoshone-Bannock Tribes. Three streams in this study (Bear Valley Creek, West Fork Yankee Fork, Herd Creek) are included as control streams for ISS and will be integrated directly into our study following careful coordination and standardization of sampling protocols and products. These are intensive evaluation studies and will require minimal alterations for integration will ISS.

The Shoshone-Bannock Tribes have proposed a supplementation program for the mainstem Yankee Fork Salmon River that will augment ISS investigations in that drainage. The proposal includes outplanting smolts from sub-basin (Sawtooth) or out-of-basin (Rapid River) broodstocks to provide adult returns for harvest and natural production. Natural production will be supplemented by collecting and spawning returning adults and using egg boxes to place the embryos in interconnecting rearing ponds created from dredge mining. We are coordinating with the SBT to insure this program will not conflict with the supplementation evaluation in West Fork Yankee Fork (e.g. marking fish prior to emigration from ponds, only utilizing harvest areas located above the confluence of Yankee Fork with West Fork Yankee Fork).

Interstate

The Genetic Monitoring and Evaluation Program (NMFS) is creating a large database of genetic and meristic information which will be applicable to ISS. The study is collecting genetic profile (allelic frequencies) and bilateralmeristic characteristics from hatchery, natural and wild chinook and steelhead populations associated with eight supplementation programs in Idaho, Oregon and Washington. The objectives include developing comprehensive baseline genetic data to monitor changes resulting from supplementation activities and provide inference5 concerning effect5 of supplementation on natural populations. Approximately 25% of the study areas proposed for ISS are included in the Genetics Monitoring and Evaluation Program and will be incorporated into our project.

Another interstate project addressing supplementation is the Performance/Stock Productivity Project (USFWS, BPA) proposed for implementation in 1992. The project will test the null hypothesis that there is no advantage of using endemic stocks for supplementation as compared to traditional hatchery stocks. Objectives include comparing growth and survival of genetically marked wild and hatchery fish reared in both hatchery and natural environments, and comparing reproductive success of wild and hatchery fish spawning in natural environments. Steelhead will be used to address these objectives in Idaho (Lochsa River) whereas spring chinook will be used in Washington (Methow River) and Oregon (White River). Results from this study will complement ISS as we do not anticipate testing supplementation effect5 from utilization of a domesticated non-endemic brood source and are not evaluating comparative performance of wild and hatchery fish in the hatchery.

The proposed Integrated Tribal Production Plan (CRITFC) includes supplementation of many of Idaho'5 anadromous waters. This plan emphasizes a phased approach using sub-basin or out-of-basin broodstocks initially to develop local broodstocks from the adult returns. Hatchery programs would be decentralized and include acclimation or rearing ponds for presmolt or smolt releases into each target stream. Most of the concepts set forth in the plan are embraced in the ISS design. The predominant difference is that ISS takes a more conservative approach to implementation of supplementation in order to evaluate risk5 and benefits prior to wide scale application. Inter-Tribe's Production Plan is currently under review. Any implementation plans will include full coordination and integration of supplementation activities into the ISS experimental design for monitoring and evaluation.

Appendix B. Habitat and summer rearing capacity database and outplanting history for chinook salmon in treatment and control streams associated with Idaho Supplementation Studies.

HABITAT AND CARRYING CAPACITY DATABASE
SALMON RIVER DRAINAGE

STREAM	TOTAL LENGTH (MI.)	MEAN WIDTH (FT.)	TOTAL AREA <HA.>	PERCENT USE	TOTAL AREA USED (HA.)	PERCENT HABITAT TYPE ** 1	2	3	4	SMOLT PRODUCTION CAPACITIES ***
SLATE CR.	52.10	17.46	44.61	81.40	36.31 (1)*	0.00	30.52	69.48	0.00	151,202.00
S.F. SALMON R.	53.80	15.88	41.91	69.85	29.27 (1)*	0.00	61.70	38.30	0.00	157,037.00
(ABOVE WEI R)										
LOWER JOHNSON	48.60	29.05	69.25	65.87	45.62 (1)*	0.00	10.90	89.10	0.00	182,158.00
UPPER JOHNSON	48.70	20.35	44.62	89.42	39.90 (1)*	7.72	5.39	86.89	0.00	166,175.00
LAKE CR. (SECESH)	20.90	12.36	12.68	84.13	10.66 (1)*	0.00	67.80	32.20	0.00	58,945.00
PAHSIMEROI SU. CHIN.	21.00	34.03	35.05	100.00	35.05 (1)*	36.53	63.48	0.00	0.00	257,620.00
(NO TRIBUTARIES INCLUDED BECAUSE OF PASSAGE BARRIERS)										
EAST FORK SALMON (ABOVE WEIR)										
SP. CHINOOK	70.20	16.82	57.93	78.27	45.34 (1)*	32.45	54.23	13.32	0.00	312,096.00
HERD CR.	48.40	10.43	24.76	69.14	17.12 (1)*	0.00	88.80	11.20	0.00	104,376.00
VALLEY CR.	70.80	15.56	54.03							
VALLEY CR. (SPCH)	65.40	12.66	40.61	98.07	39.83 (1)*	0.00	8.13	78.42	13.45	183,517.00
VALLEY CR. (SUCH)	5.40	50.65	13.42	100.00	13.42 (1)*	0.00	76.24	23.76	0.00	77,251.00
N. FORK SALMON	66.10	12.78	41.43	66.72	27.64 (1)*	0.00	97.70	2.30	0.00	175,177.00
LEMHI R.	30.00	31.83	46.85	100.00	46.85 (1)*	44.36	55.64	0.00	0.00	353,822.00
(ABOVE WEI R)										
UPPER SALMON	117.50	19.10	110.07	79.41	87.40 (1)*	12.04	65.82	22.14	0.00	501,532.00
(ABOVE WEIR; INCLUDES AREA ABOVE BUSTERBACK DIVERSION)										
ALTURAS LAKE CR.	17.20	30.19	25.47	100.00	25.47 (1)*	73.25	26.75	0.00	0.00	211,442.00
<INCLUDES AREA ABOVE BUSTERBACK DIVERSION; DOES NOT INCLUDE LAKE)										
W.F. YANKEE FK.	21.80	17.07	18.26	94.34	17.23 (1)*	82.05	17.94	0.00	0.00	147,007.00
HARSH CR.	30.80	11.13	16.82	82.90	13.94 (1)*	67.07	23.64	0.00	9.29	106,556.00
BEAR VALLEY CR	123.80	17.09	103.75	84.62	87.80 (1)*	5.23	76.45	18.33	0.00	530,347.00
CAMAS CR.	126.30	15.64	96.87	78.78	76.31 (1)*	0.00	90.34	9.66	0.00	468,464.00

CLEARWATER RIVER DRAINAGE

STREAM	TOTAL LENGTH (MI.)	MEAN WIDTH (FT.)	TOTAL AREA <HA.>	PERCENT USE	TOTAL AREA USED (HA.)	PERCENT HABITAT TYPE ** 1	2	3	4	SMOLT PRODUCTION CAPACITIES ***
LOLO CR.	93.10	23.19	105.9	90.81	96.17 (1)*	0.00	31.50	16.76	51.74	222,563.00
PETE KING CR.	13.60	10.74	7.16	49.32	3.53 (1)*	0.00	0.00	100.00	0.00	8,751.00
CLEAR CR.	44.00	15.00	32.39	68.26	22.11 (1)*	0.00	0.00	86.40	13.60	49,362.00
AMERICAN R.	67.00	13.00	42.72	72.69	31.05 (1)*	0.00	38.49	61.51	0.00	98,581.00
CROOKED R.	32.30	18.91	29.96	79.74	23.89 (1)*	0.00	60.84	39.16	0.00	85,507.00
RED R.	84.00	16.54	68.15	79.65	54.28 (1)*	5.45	43.55	51.00	0.00	187,800.00
NEWSOME CR.	61.90	12.97	39.38	54.89	21.61 (1)*	0.00	62.23	37.77	0.00	77,910.00
JOHNS CR	32.80	13.16	21.18	64.11	13.58 (1)*	0.00	0.00	100.00	0.00	33,657.00
SQUAW CR.	18.80	9.95	9.18	36.98	3.39 (1)*	0.00	0.00	100.00	0.00	8,411.00
PAPOOSE CR.	16.50	8.12	6.57	33.66	2.21 (1)*	0.00	66.52	15.95	17.53	7,444.00
CROOKED FORK	33.30	35.12	57.37	93.87	53.86 (1)*	0.00	85.97	14.03	0.00	217,256.00
(W/O BRUSHY FORK>										
BRUSHY FORK	27.30	21.38	28.63	59.17	16.94 (1)*	22.71	75.28	0.00	2.02	78,115.00
(W/O CROOKED FORK)										
WHITE SAND CR.	7.60	33.00	12.30	75.00	9.23 (1)*	100.00	0.00	0.00	0.00	55,637.00
(ABOVE BIG FLAT)										
BIG FLAT	9.00	16.00	7.06	67.00	4.73 (1)*	100.00	0.00	0.00	0.00	28,537.00
BEAR CR.	77.80	29.78	113.64	32.24	36.64 (1)*	58.76	41.24	0.00	0.00	194,603.00

* 1 = SPAWNING & REARING; 2 = REARING ONLY
** = HABITAT TYPE: 1 = EXCELLENT; 2 = GOOD; 3 = FAIR; 4 = POOR.
*** = FROM THE PNW RIVERS STUDY AND SUBBASIN PLANS.
NOTE: VALUES REPRESENT THE ENTIRE PRODUCTION FOR EACH SPECIFIED STREAM OR STREAM SECTION. THIS INCLUDES ALL TRIBUTARIES THAT ARE CAPABLE OF REARING CHINOOK SALMON.

SALMON RIVER OUTPLANTING HISTORY

STREAM	YRS SUPPL	HATCHERY BROOD SOURCE	TOTAL NUMBER OF EACH LIFE STAGE OUTPLANTED F/F	PRESMOLT	SMOLT	ADULT	EGG	HATCHERY RELEASE (Y/N)	ONGOING SUPPL. (Y/N)	YEAR BEGAN	LAST YEAR SUPPL.
SLATE CR.	0										
S.F. SALMON R.	13	McCall	338,913		5,827,987		3,000	Y	Y	1977	1989
LOWER JOHNSON	1	McCall		290,000				N	N	1989	1989
UPPER JOHNSON	4	McCall	790,933					N	N	1985	1989
LAKE CREEK	0										
LEMHI R.	6	Lemhi, Hayden Cr. Rapid R.	2,437,037			3s		N	N	1973	1989
PAHSIMEROI SPCH	8	Rapid R., Pahsimeroi Coulitz (fry, 1979)	72,090	148,247	2,703,089			Y	N	1970	1986
PAHSIMEROI SUCH	13	Pahsimeroi, McCall	289,900		3,413,998	205		Y	Y	1972	1989
N. F. SALMON R.	1	Rapid R.	45,360					N	N	1977	1977
E. F. SALMON R.	5	East Fork Salmon Rapid R. (fry, 1977)	403,960		642,500			Y	Y	1977	1989
HERD CR.	0										
W.F. YANKEE F.K.	1	Rapid R.	56,700					N	N	1977	1977
VALLEY CR.	1	Rapid R.	102,934					N	N	1978	1978
MARSH CR.	1	Rapid R.	21,840					N	N	1975	1975
BEAR VALLEY CR.	0										
CAMAS CR.	0										
UPPER SALMON R.	>15	Sawtooth, Rapid R. Hayden Cr. Marion Forks		4,595,000	5,373,895	2,040		Y	Y	1968	1989
ALTURAS LAKE CR.	2	Sawtooth	51,000	21,400				N	N	1988	1989

CLEARWATER RIVER OUTPLANTING HISTORY

STREAM	YRS SUPPL	HATCHERY BROOD SOURCE	TOTAL NUMBER OF EACH LIFE STAGE OUTPLANTED F/F	PRESMOLT	SMOLT	ADULT	EGG	HATCHERY RELEASE (Y/N)	ONGOING SUPPL. (Y/N)	YEAR BEGAN	LAST YEAR SUPPL.
LOLO CR. (includes	5	Rapid R.,	479,289 (Lolo)					N	Y	1977	1989
Eldorado Cr.)		Dworshak/Kooskia	623, SO3 (Eldorado)							1986	1989
CLEAR CR.	>15	Kooskia, Dworshak	3,528,224		9,693,562	130		Y	Y	1971	1989
PETE KING CR.	0										
SQUAW CR.	3	Rapid R.	565,700		30,000	583		N	N	1972	1978
PAPOOSE CR.	2	Rapid R. Kooskia (adults)	674,900			160		N	Y	1972	1989
CROOKED FORK CR.	7	Rapid R., Dworshak	1,414,952					N	Y	1972	1989
BRUSHY FORK CR.	8	Rapid R. Coulitz (fry, 1981)	1,410,450					N	Y	1972	1989
WHITE SAND CR.	4	Rapid R., Dworshak	583,064					N	N	1986	1989
BIG FLAT CR.	3	Rapid R., Dworshak	215,482					N	N	1987	1989
JOHNS CR.	0										
NEWSOME CR.	13	Rapid R., Dworshak	856,821		206,695		50,000	N	Y	1971	1991
CROOKED R.	10	Rapid R., Sawtooth Coulitz & Carson (eggs)	622,164	251,300	593,839		9,323,468 *	N	Y	1970	1989
RED R.	12	Rapid R., Kooskia Carson, Coulitz (eggs used once, 1975)	481,295	2,429,150	541,760		5,159,345	Y	Y	1970	1989
AMERICAN R.	5	Rapid R., Kooskia	455,812		33,772	170		N	Y	1972	1989
BEAR CR.	4	Carson National	89,795				3,569,000	N	N	1961	1969

* = SOME OF THE EMERGENT FRY WERE TRAPPED AND PLANTED IN NEWSOME CREEK AND RED RIVER.

Appendix C. Broodstock history for chinook salmon hatcheries in Idaho.

CHINOOK HATCHERY BROODSTOCK HISTORIES
Eric Leitzinger, IDFG, 7/21/90

SALMON RIVER DRAINAGE

1. Hayden Creek

- Constructed in 1966 to study steelhead pond rearing techniques.
- Began fall releases of spring chinook salmon in 1970.
- Closed in 1982.
- Presently used as a research facility by the University of Idaho. Not operating at this time.
- Brood source: Lemhi River, Hayden Creek, and Rapid River.
- Problems: High zinc and copper concentrations in the spring water cause significant mortality of eggs and deformity of fry.

2. Rapid River

- Built in 1964 as Idaho Power Company's (IPC) mitigation for the Hell's Canyon complex dams. IPC owns and finances.
- Capacity = 3 million spring chinook smolts; 2 million for Rapid River, 1 million for the Snake R.
- Origin: Wild adults trapped at Hell's Canyon Dam from 1964-1968. This is a mixed stock from upper Snake tributaries (e.g. Weiser, Boise, Eagle, Powder Rivers etc.)
- Volitional spring releases until April, then forced out.
- Disease: BKD a chronic problem. Cold water disease and the "spring thing" also present. IHN not a problem.

3. Sawtooth

- Began operation in February 1984 as part of the LSRCP.
- Capacity = 2.9 million spring chinook smolts.
- Goal: Return 19,000 adults to the Snake River system (1987 returned 1,616, Sawtooth and East Fork combined).
- Origin: Decker Flat Pond: 1966 - indigenous stock; subsequent years sources came from Hayden Creek and Rapid River; 1967 used Marion Forks Hatchery (Oregon) broodstock. Adult returns were poor. Only year lower river stocks were used. Sawtooth: indigenous chinook and Rapid River offspring released at hatchery site 1977-1979. Early - mid 1970's experimental releases of Rapid River fish - adult returns negligible. Now use only adults returning to the weir (mixture of natural and hatchery fish).
- Disease: Decker Flat: eye fluke present, prophylactic treatment worked well. Sawtooth: BKD is a chronic problem. Whirling disease also present - ozone treatment plus incubating eggs on well water minimizes problem.

4. McCall

Part of LSRCP. Purpose: Restore South Fork summer chinook runs.
Capacity: 1 million summer chinook smolts.
Goal: return 8,000 adults to South Fork.
Origin: 1978: adults trapped at Little Goose.
1979: adults trapped at Lower Granite.
1980: 50% from Lower Granite, 50% from South Fork.
1981 to present: 100% from South Fork.
Important to note that the majority of Snake River summer chinook return to the South Fork.

- Disease: "Spring Thing" major problem from 1980-1983. Believed to be related to nutrition and soft water. Addition of pantothenic acid to the diet has reduced mortality, but disease persists. BKD present but no serious losses yet.

5. Pahsimeroi

- IPC owns and finances. Been in production since mid 1960's.
- Purpose: relocate mid Snake River steelhead to the Salmon River. Expanded in 1980 & 81 to rear chinook.
- Chinook Capacity: 1 million summer chinook smolts (5 million green eggs, 3500 adults).
- Origin: Spring chinook were released from 1983-1986 to satisfy IPC's mitigation requirement of 1 million smolts into the Pahsimeroi River. Spring chinook broodstock came from Hayden Creek and Rapid River adults. Only summer chinook have been reared since 1987. Summer chinook broodstock came from the indigenous Pahsimeroi summer stock. These were first collected in 1968. In the early years, fish arriving prior to July 15 were passed above the weir, after July 15 they were taken into the hatchery and spawned. Eggs were reared at Mackay hatchery and returned to the Pahsimeroi as fingerlings. This evolved into a smolt outplant. The spring chinook program was initiated when the hatchery was expanded but they kept spawning and rearing summers. Due to low adult returns, the 1987 smolt release was a combination of Pahsimeroi and South Fork of the Salmon summers (part of the 1985 brood year egg lot from the South Fork was incubated and reared at Pahsimeroi).
- Disease: Exposed to whirling disease.

CLEARWATER RIVER DRAINAGE

1. The first attempt to reestablish chinook salmon to the Clearwater drainage began in 1947. An average of 100,000 eggs were taken from wild adult spring chinook in the headwaters of the Middle Fork of the Salmon River from 1947-1953. The fish were reared to fingerlings and planted in the Little North Fork of the Clearwater. Some adults did return to spawn but the exact number is unknown.

2. Columbia River Fisheries Development Program

- Began in 1961 with the reintroduction of spring chinook into the Selway River. Began removing passage barriers in 1962.

Completed Selway Falls fish ladder in 1966. The falls was considered a deterrent to adult steelhead and a block to adult chinook migration.
- During the 1960's, several incubation channels were constructed in the upper Selway.
- From 1961-1964 3.5 million eyed eggs from Bonneville Dam fish ladders (adults taken from the ladders when upriver chinook were passing - mixed stock; eggs were brought to Carson NFH) were put into the Bear Creek incubation channel. During the same time period 3.7 million eyed eggs from wild Salmon River stock (from Bear Valley Creek, Lemhi, Upper Salmon, and Stolle Meadows on the South Fork) were put into a channel on the upper main stem Selway above the Little Clearwater River. From 1964 to 1969 approximately 10 million eyed eggs from the Salmon River and Bonneville were placed into the Ditch Creek, Running creek, and Indian Creek incubation channels. In 1970, 3.3 million eyed eggs from Rapid River were put into these three channels. The Ditch and Running Creek channels were discontinued in 1971. From 1971 to 1981, 25 million eggs from Carson, Rapid River, and Cowlitz hatcheries were put into the Indian Creek incubation channel. The last egg plant in the Selway was 1.5 million spring chinook eggs from the Pahsimeroi hatchery in 1985. A grand total of 61.9 million eyed spring chinook eggs were introduced to the Selway between 1961 and 1985. Fall chinook eyed eggs were introduced into the lower Selway from 1960-1967. A total of 6.7 million eggs from Spring Creek NFH on the lower Columbia River were used. This program was discontinued in 1968 due to poor adult returns. Also, between 1970 and 1978 10.5 million eggs from Rapid River, 3.1 million from Cowlitz, and 800,000 from Bonneville were put into the South Fork of the Clearwater River. The Red River incubation channel received 3.7 million eggs from Rapid River and 1.4 million from Cowlitz, while the Crooked River channel received 6.8 million from Rapid River, 1.7 million from Cowlitz, and 800,000 from Bonneville.

3. Kooskia

- Constructed in 1966 and 1967 as mitigation for chinook lost due to Dworshak Dam.
- Capacity: 1.2 million spring chinook smolts, however water quality problems have limited it to 800,000.
- Origin: Kooskia stock is a mixture of fish from Rapid River SFH, Carson NFH, South Santiam SFH, Little White Salmon NFH, and Leavenworth NFH. All hatchery stocks (except Rapid River) were derived from the Carson stock. For a further description see the table at the end of this paper.
- The majority of the fish entering Clear Creek are taken into the hatchery. A few escape each year to spawn naturally (except in 1977 and 1978 when excess adults were allowed to pass the weir and spawn).
- 1978 Kooskia went under the management of Dworshak NFH. The eggs from the two facilities are pooled and then divided between them (they are considered one stock).
- Disease: BKD, IHN, and ICK are common. Bacterial gill disease (BGD), epithelial cystis and costia are minor problems.

4. Dworshak

- Built in 1969 to mitigate for lost steelhead production resulting from construction of Dworshak Dam. Spring chinook expansion was completed in 1982 and is part of the LSRCP.
- Capacity: 1.4 million spring chinook smolts.
- Origin: From 1982-1986 low adult returns to the Clearwater necessitated augmentation with eggs from other spring chinook hatcheries, namely Rapid River SFH, Leavenworth NFH, and Little White Salmon NFH.
- Adults from Kooskia are trucked over, pooled and spawned with Dworshak fish.
- Disease: same as for Kooskia, BKD and IHN are the major disease concerns.

5. Red River

- The Red River satellite facility began production in 1977. Fingerlings from Rapid River were released into the ponds in early June and released into Red River as fall presmolts.
- Capacity: 300,000 presmolts.
- A temporary weir was used to trap returning adults from 1983-1985. This was not a complete barrier, and in 1986 a permanent weir was installed.
- Origin: Rapid River fingerlings *were* brought to Red River in 1977-1980, 1983, and 1987. Carson NFH fish were released in 1981 (1980 brood year). Red River returns were used for the 1984 and 1985 releases (1983 and 1984 brood years). No adults were trapped in 1985 or 1986 (1986, and 1987 release years). Since 1987, just Red River returnees have been used at the facility. The 1987 brood year egg lot was reared at Kooskia but had to be destroyed due to an outbreak of IPN. Dworshak supplied the 1988 release fish. The run is a mix of hatchery and natural fish.
- Releases have been primarily fall volitional releases except 1984-1986 which were spring smolt releases.
- Present management call for early rearing to be done at Dworshak until the Clearwater Hatchery comes on line, for spawning the adults that return to the Red River weir, and for continued volitional fall releases. At least one third of the returning adults must be passed above the weir.
- Disease & Constraints: Ick is present. The major problem with the facility has been inadequate adult holding facilities resulting in high prespawning mortality (the 1986 construction helped alleviate this), water supply and high water temperature problems. In the event of warm water, the fish will be moved to the Clearwater Hatchery.

CHINOOK STOCK DEFINITIONS

From Miller, William. 1990. Dworshak FAO annual report. FY 1989.

KOOSKIA	"Any adult chinook returning to Kooskia, regardless of its parentage."
RAPID RIVER	"Developed from wild spring chinook, captured at Snake River dams, after their construction. Destined for Snake river tributaries in Idaho and Oregon."
CARSON	"From Carson NFH on the Wind River, Washington, tributary of the Columbia in Bonneville pool. Originally developed from spring chinook collected at Bonneville Dam from 1955-63. A heterogeneous collection of spring chinook destined to upriver areas."
SOUTH SANTIAM	"From ODFW's South Santiam hatchery, a Willamette River tributary which maintained two spring chinook stocks; one of Santiam River origin and the other from Carson NFH stock. Kooskia's fish came from the Carson stock."
LITTLE WHITE SALMON	"From the Little White Salmon NFH on the L. White River, Washington, tributary to the Columbia River in Bonneville pool. Developed from Carson stock."
LEAVENWORTH	"From Leavenworth NFH on Icicle Creek, Washington, tributary to the Wenatchee River. Originally from upriver spring chinook captured at Rock Island Dam in the early 1940's. Leavenworth went out of spring chinook production in the mid-1960's. In the 1970's, the hatchery stock was rebuilt primarily with Carson stock. The run is now self-perpetuating."
COWLITZ	On the Cowlitz River in Washington, a lower Columbia River tributary downstream of Bonneville Dam. Stock was derived from the local, endemic spring chinook returning to the Cowlitz River. They were collected at Mayfield Dam. There has been no outside stocks introduced to the Cowlitz.

Appendix D. Supplementation production plans for each hatchery and treatment stream used in Idaho Supplementation Studies.

SUPPLEMENTATION PRODUCTION PLANS

CLEARWATER RIVER DRAINAGE

Clearwater Anadromous Fish Hatchery (CAFH)

Red River: Supplementation of natural production evaluated with fall presmolts released from satellite pond. Temporary weir will be used near mouth to allow supplementation of all natural production areas.

1. Existing Program: No fishery since 1978. Managed for depressed run of naturalized spring chinook. Outplanting fish (eyed eggs, presmolts and smolts) from Rapid River broodstock occurred from the early 1970s through 1980s. Lesser contributions from Carson, Cowlitz and Dworshak-Kooskia broodstocks also occurred during this period. Consistent hatchery program since 1977. Adult trap and presmolt rearing pond located in the upper third of Red River was completed 1976. Current pond capacity is approximately 350K presmolts. Two thirds of adult returns used for broodstock, one third passed over weir to spawn naturally since 1981. Progeny reared at Dworshak or Kooskia hatcheries until transport to Red River Satellite Pond in June. Red River pond "topped off" with Dworshak-Kooskia or Rapid River hatchery stocks to meet production targets (has been typically over 60% of pond production). Approximately 60K fish marked with CWT and AD clip for LSRCP evaluations. All other production fish marked with pelvic fin clip beginning 1991. Fish released on site mid October as fall presmolts by removing barrier and draining the pond.

2. Broodstock: 1st generation, BY 1991-95. Differentiation of hatchery and natural adults not possible during first generation.
   - 67% adult returns (female) passed over weir.
   - 33% used for supplementation broodstock.

   Broodstock: 2nd generation, BY 1996+. External mark used to differentiate hatchery and natural fish.
   - Majority of natural fish put over *weir* (≥67% of females).
   - Natural fish comprise large component of supplementation broodstock (40%-50%).
   - Remainder of supplementation broodstock comprised of fall presmolt adult returns.
   - Presmolt returns surplus to broodstock needs will be passed over the weir to supplement natural production. Surplus will be estimated and fish passed throughout the run to avoid selection.

3. Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during second generation, mating composition will be documented (HxH, NxN, HxN).

4. Rearing: progeny isolated at Clearwater Hatchery, marked (differently from harvest augmentation fish, e.g. body tag, pelvic fin clip), and released into satellite pond as soon as possible.

   Note: Presmolt production at Red River pond would be for supplementation fish. Any presmolt harvest augmentation fish reared at the pond would be surplus to smolt production capacity at CAFH.

5. Release: Direct release from Red River pond mid September. Release timed to coincide with known environmental and physiological cues.

6. Adult Returns: If a fishery is deemed prudent, supplementation (marked differently from harvest fish) and natural (unmarked) adults will be escaped through the fishery (catch and release) to ensure adequate rebuilding and evaluation (e.g. ≤10% exploitation). No general production fish will be passed above the weir.

7. Genetic Risk Assessment: Low
   - An existing hatchery program is already on Red River.
   - Donor broodstock for supplementation will be from local population.
   - Brood selection and matings will be random with 1:1 sex ratio or factorial crosses.
   - Supplementation fish isolated in hatchery from general production fish.
   - All supplementation fish and general hatchery fish released in the drainage will be marked differentially.
   - Fall release timed to coincide with known environmental cues and estimated peak natural fall emigration.
   - No general production hatchery fish will be passed above weir.

Crooked River: Restoration of natural production evaluated with adult outplants and fall presmolts released from satellite ponds.

1. Existing Program: No fishery since 1978. Managed as extirpated population. Existing natural population extremely low and derived from hatchery outplants. Outplanting from numerous brood sources began in 1970 and has included eggs, fry, presmolts, smolts and adults (Appendix B). Adult weir located near mouth completed 1990. Satellite presmolt rearing ponds (2) located in upper third of drainage were completed 1990. Pond capacities total 700K presmolts. Broodstock strategy passes 1/3 returning adults over weir to spawn naturally, 2/3 kept for hatchery program. Due to low runs this strategy has not been implemented (all adult returns passed over weir in 1991). Pond capacities *were* met with Dworshak complex stock only. Approximately 60K fish marked with CWT-AD for LSRCP evaluation. All other production fish marked with pelvic fin clip beginning 1991 (BY90). Presmolts released mid October by removing barrier and draining ponds.

2. Supplementation Broodstock Strategies

   Adult Outplant Strategy: Int. Smolt Monitoring Project, BY 1991-94

   40 to 60 total female chinook/yr (-20 females (F)/yr from natural returns and 20-40 F/yr from Rapid River or Dworshak stock) released from trucks into designated spawning areas.

Acclimated Fall Presmolt Strategy: ISS, BY 1991+.

1st generation, BY 1991-95. Unable to differentiate hatchery and natural adult returns.
- 100% Dworshak-Rapid River stock (80-160 females).

2nd generation, BY 1996+. Hatchery and natural returns differentiated with external mark.
- All natural and supplementation adult returns put over weir to spawn naturally.
- Supplementation broodstock 100% Dworshak complex or Rapid River stock (80-160 females).

3. Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during second generation, mating composition will be documented (HxH, NxN, HxN).

4. Rearing: Progeny isolated at Clearwater Hatchery, marked differently from harvest fish, and released into satellite ponds as soon as possible.

   a. Natural rearing practices evaluated with two-pond setup (LSRCP Study).
      - 1 pond standard rearing
      - 1 pond "natural" rearing (McGehee 1990)
      - Differential mark for each pond (e.g. LV vs. RV)

5. Release: Direct release from Crooked River ponds mid September.

   Note: Total presmolt release from Crooked River ponds should not exceed 400k to avoid emigration conflicts with the Intensive Smolt Monitoring Project.

6. Adult Returns: If a fishery is deemed prudent, supplementation (marked differently from harvest fish) and natural (unmarked) adults will be escaped through the fishery (catch and release) to ensure adequate rebuilding and evaluation (e.g. ≤10% exploitation). No general production fish will be passed above the weir.

7. Genetic Risk Assessment: Low
   - Existing hatchery program already in Crooked River.
   - Predominant risk is associated with straying impacts on the adjacent natural population in Red River.
   - Donor broodstock (Dworshak complex) selected on basis of outplanting history, location and availability. Suitable adjacent or out-of-basin natural stocks are unavailable or too vulnerable to extinction to provide brood.
   - All supplementation and general production hatchery fish marked prior to release in drainage.
   - No hatchery returns from Crooked R. passed over weir on Red R.

Upper Lochsa: Supplementation of natural production in Crooked Fork Creek evaluated with acclimated fall presmolts reared at Powell pond. Restoration of natural production in White Sand Creek and Big Flat Creek evaluated with fry outplants from Rapid River or Dworshak.

Crooked Fork Creek

1. Existing Program: No fishery since 1974. Managed for remnant run of naturalized spring chinook. Varied outplanting history of fry, presmolts and smolts (Appendix B). Adult weir and satellite rearing pond located just below confluence of Crooked Fork and White Sands creeks completed 1989. Pond capacity is approximately 350K presmolts. Broodstock strategy passes 1/3 returning adults over weir to spawn naturally, 2/3 kept for hatchery program. Due to low runs and run timing this strategy has never been fully implemented. First egg-take occurred BY 1990 (8% of female returns were spawned). Progeny incubated and early-reared at Kooskia Hatchery. Advanced fry trucked to satellite rearing pond in June. Pond capacities met by topping off with Dworshak complex stock (>95% of pond production). Approximately 60K fish marked with CWT-AD for LSRCP evaluations. All other production fish marked with pelvic fin clip beginning 1991 (BY90). Presmolts released mid October by removing barrier and draining ponds.

2. Brood Stock: 1st brood year, BY 1991. Differentiation of hatchery and natural adults not possible.
   - 67% adult returns (female) passed over weir.
   - 33% used for supplementation broodstock.

   Broodstock: 1st generation, BY 1992-95. Differentiation of hatchery and natural adults attempted by scale analysis or return location.
   - Powell weir modified to include an adult trap on the Crooked Fork Creek side of the weir. Note: Powell weir located directly below the confluence of White Sand and Crooked Fork creeks.
   - Dig and maintain a diversion ditch through the isthmus at the confluence of Crooked Fork and White Sand creeks. This will provide a mix of Crooked Fork Creek water near the adult bypass pipe outlet from the Powell weir facility.
   - 67% adult returns (female) from both traps passed over weir.
   - 33% of returns to both traps used for supplementation broodstock.
   - If adequate returns are evident for the trap on the Crooked Fork side of the weir, modify the program to utilize only those fish for supplementation of Crooked Fork Creek.

   Broodstock: 2nd generation, BY 1996+. External mark used to differentiate hatchery and natural fish.
   - Majority of natural fish put over weir (≥67% of females).
   - Natural fish comprise large component of supplementation broodstock (40%-50%).
   - Remainder of supplementation broodstock comprised of hatchery adults returning from the fall presmolt release.
   - Surplus presmolt returns passed over weir to supplement natural production.

3. Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during second generation, mating composition will be documented (HxH, NxN, HxN).

4. Rearing: Progeny isolated at Clearwater Hatchery, marked (differently from harvest fish), and released into Powell pond as Boon as possible.

Note: Supplementation fish would have top priority for presmolt production at the Powell pond. Additional capacity would be utilized by harvest augmentation presmolts surplus to smolt production capacity at CAFH.

5. Release: Presmolts collected from Powell pond mid September and dispersed throughout Crooked Fork Creek where accessible by truck (e.g. Boogy Down Flat Bite near the headwaters and Shotgun Creek site).

   Note: During years that harvest and supplementation fish are reared together (CAFH smolt capacity has been exceeded), all presmolts would be released directly from the Powell pond.

6. Adult Returns: If a fishery is deemed prudent, supplementation (marked differently from harvest fish) and natural (unmarked) adults will be escaped through the fishery (catch and release) to ensure adequate rebuilding and evaluation (e.g. ≤10% exploitation). No general production fish will be passed above the weir.

7. Genetic Risk Assessment: Low
   - Existing hatchery program already in place for upper Lochsa drainage.
   - Predominant risk is associated with first generation broodstock collection from unknown hatchery-released or naturally produced adult returns.
   - Donor broodstock for supplementation will be from local adult returns. Efforts will be made to select only Crooked Fork Creek returns.
   - Brood selection and matings will be random with 1:1 sex ratio or factorial crosses.
   - Supplementation fish isolated in hatchery from general production fish.
   - All supplementation fish and general hatchery fish released in the drainage will be marked.
   - Fall release timed to coincide with known environmental cues and estimated peak natural fall emigration.
   - No general production hatchery fish will be passed above weir.

<u>White Sand and Big Flat Creeks</u>

1. Existing Program: No fishery since 1974. Assumed non viable existing natural populations requiring restoration efforts. Located above Powell weir so hatchery program is the same as specified for Crooked Fork Creek. Varied outplanting history (Appendix B).

2. Broodstock: 1st brood year, BY 1991. Hatchery and natural adults indistinguishable.
   - 100% Dworshak or Rapid River stock.

   Broodstock: 1st generation, BY 1992-95. Differentiation of hatchery and natural adults attempted at Powell weir.
   - All returns to trap on White Sand Creek side of weir used for supplementation broodstock.
   - Supplementation fish "topped off" with Dworshak or Rapid River stock to provide up to 50% of the natural summer rearing capacity of White Sand and Big Flat creeks (parr equivalents).

3. Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes.

4. Rearing: Progeny isolated at Clearwater Hatchery for early rearing until fish can be marked (differently from harvest and Crooked Fork Creek Supplementation fish).

5. Release: Advanced fry-parr dispersed by aircraft into upper White Sands Creek and Big Flat Creek during late June.

6. Adult Returns: All natural and WSC-BFC supplementation fish passed over the Powell weir to spawn naturally. Temporary weir put on Crooked Fork Creek to keep White Sand and Big Flat creeks supplementation fish from spawning in Crooked Fork Creek.

   Note: Anticipate outplanting would occur for one generation only, pending results of small scale study analyzing size-related effects from stocking hatchery fry on top of smaller natural fry (because WSC-BFC will have naturally produced fry after one generation).

7. Risk Assessment: Low
   - Existing hatchery program already in upper Lochsa drainage.
   - Predominant risk is associated with straying and broodstock selection impacts on the adjacent natural population in Crooked Fork Creek.
   - Donor broodstock (Dworshak complex) selected on basis of outplanting history, location and availability. Suitable adjacent or out-of-basin natural stocks are unavailable or too vulnerable to extinction to provide brood.
   - All supplementation and general production hatchery fish marked prior to release in drainage.
   - No known White Sand Creek adult returns will be used for Crooked Fork Creek broodstock or passed over weir on Crooked Fork Creek to spawn naturally. Some risk of introgression will occur from first generation natural fish (unmarked) produced in White Sand and Big Flat creeks from hatchery parentage.
   - Supplementation program implemented for one generation only to minimize effects of larger hatchery fry released on smaller natural fry.

American River and Papoose Creek: Restoration of natural production evaluated with smolt releases from Dworshak/Kooskia or Rapid River stock.

1. Existing Program: No fishery since 1978. Assumed non viable existing natural populations requiring restoration efforts. No broodstock collection from adult returns. Intermittent hatchery outplanting of smolts, fry, parr and adults from Dworshak complex and Rapid River stocks since 1972 (Appendix B).

2. Broodstock: 1st generation, BY 1991-95.
   - 100% Dworshak or Rapid River stock (general production fish at CAFH).

3. Rearing: Progeny marked and reared to smolt at CAFH.

4. Release: Unacclimated smolts distributed throughout the drainages during spring release (i.e. multiple release sites).

5. Adult Returns: If a fishery is deemed prudent, supplementation (marked differently from harvest fish) and natural (unmarked) adults will be escaped through the fishery (catch and release) to ensure adequate rebuilding and evaluation (e.g. $\leq$10% exploitation).

6. Risk Assessment: Low
   - Local populations assumed extirpated based on trend redd counts and parr density estimates.
   - Long history of hatchery outplants.
   - Predominant risk is associated with straying impacts on nearby natural populations in Crooked Fork Creek and Red River.
   - Donor broodstock (Dworshak complex) selected on basis of outplanting history, location and availability. Suitable adjacent or out-of-basin natural stocks are unavailable or too vulnerable to extinction to provide brood.
   - All supplementation and general production hatchery fish marked prior to release in drainage.
   - No known American River or Papoose Creek adult returns will be used for Crooked Fork Creek or Red River broodstocks, or passed over their weirs to spawn naturally.

Squaw and Pete King Creeks: Restoration of natural production evaluated with fry/Parr releases from Dworshak complex or Rapid River stock.

1. Existing Program: No fishery since 1974. Managed as extirpated population. Minimal outplanting during 1970s with Rapid River fry and smolts (Appendix B). No existing hatchery program.

2. Brood Stock: 1st generation, BY 1991-95.
   - 100% Dworshak complex or Rapid River stock (general production fish at CAFH).

3. Rearing: Progeny reared to advanced fry at CAFH. Fry marked prior to release.

4. Release: Advanced fry distributed throughout drainages by aircraft during late spring (June).

5. Adult Returns: If a fishery is deemed prudent, supplementation (marked differently from harvest fish) and natural (unmarked) adults will be escaped through the fishery (catch and release) to ensure adequate rebuilding and evaluation (e.g. $\leq$10% exploitation).

6. Genetic Risk Assessment: Low
   - Local populations assumed extirpated based on trend redd counts and parr density estimates.
   - Rapid River fry and smolts outplanted in 1970s.
   - Donor broodstock (Dworshak complex) selected on basis of outplanting history, location and availability. Suitable adjacent or out-of-basin natural stocks are unavailable or too vulnerable to extinction to provide brood.
   - Predominant risk is associated with straying impacts on the neighboring natural population in Crooked Fork Creek.

- All supplementation and general production hatchery fish marked prior to release in drainage.
- No known Squaw and Pete King creeks adult returns will be used for Crooked Fork Creek broodstock or passed over weir on Crooked Fork Creek to spawn naturally.
- Supplementation program implemented for one generation only to minimize effects of larger hatchery fry released on smaller natural fry.

Kooskia National Fish Hatchery

Clear Creek: **Supplementation of natural production evaluated with smolt releases from Kooskia Hatchery.**

1. **Existing Program: No fishery since 1978. Consistent hatchery program utilizing electric weir near mouth of Clear Creek for adult trapping since 1967. Program specifies collection of all adult returns for broodstock, spawn the fish at Dworshak mixed in with Dworshak returns. Progeny incubated and reared at Kooskia. An unknown escapement of hatchery returns through the electric weir has produced relatively high densities of natural chinook parr in Clear Creek as compared to other streams in the Clearwater drainage.**

2. **Broodstock: 1st generation, BY 1991-95. No differentiation of hatchery and natural adult returns possible.**
   - **10% of adult female and male returns passed over weir to spawn naturally (up to 30 females, which is approximately 70% of estimated full seeding).**
   - **90% of adult returns used for hatchery broodstock.**
     - **Same broodstock used for both supplementation and general production needs.**

   Broodstock: 2nd generation, BY 1996+. Hatchery and natural adults differentiated with external mark.
   - **Majority ($\geq$67%) of natural females and males passed over weir, remainder used for supplementation broodstock.**
   - **Natural fish comprise large component (40-50%) of supplementation broodstock.**
   - **Remainder of supplementation broodstock comprised of general production returns (marked).**
   - **Supplementation returns passed over weir up to equivalent to natural fish passed (50:50).**
   - **No general hatchery production fish passed over weir.**

3. **Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during second generation, mating composition will be documented (HxH, NxN, HxN). Thermal constraints for adult holding will still require isolation and spawning at Dworshak Hatchery.**

3. **Rearing: Progeny marked differently from general production fish and reared to smolt at Kooskia Hatchery.**

4. **Release: Supplementation smolts transported to upper reaches of drainage during April and thermally acclimated prior to release. As best possible, releases timed to coincide with known environmental and physiological cues.**

5. **Adult Returns: If a fishery is deemed prudent, supplementation (marked differently from harvest fish) and natural (unmarked) adults will be escaped through the fishery (catch and release) to ensure adequate rebuilding and evaluation (e.g. $\leq$10% exploitation).**

6. Risk Assessment: Low
   - Local population was extirpated, existing natural production resulted from hatchery returns from Carson, Rapid River and Dworshak complex broodstocks.
   - Existing hatchery program already in Clear Creek drainage (Kooskia NFH).
   - Current natural population has unknown natural/hatchery lineage.
   - Predominant risks are associated with first generation broodstock collection from unknown hatchery-released or naturally produced adult returns.
   - Donor broodstock for supplementation will include local adult returns to the Kooskia weir.
   - Broodstock management for the second generation and beyond is designed to strike a balance between risk of hatchery domestication (less than 50% of broodstock will be hatchery returns) and risk of mining out multi-generational natural fish (more than 67% of natural returns will be allowed to spawn naturally).
   - Brood selection and matings will be random with 1:1 sex ratio or factorial crosses.
   - Supplementation fish isolated in hatchery from general production fish.
   - All supplementation fish and general hatchery fish released in the drainage will be marked.
   - Spring release timed to coincide with known environmental cues and estimated peak natural spring emigration.
   - No general production hatchery fish will be passed above the weir after the first generation.

Nez Perce Tribal Hatchery **(NPTH)**

The Nez Perce Tribal Hatchery (NPTH) Master Plan includes three streams for supplementation that are part of our experimental design (Larson et al. 1991). These include Lolo and Newsome creeks in the Clearwater River drainage and Slate Creek in the lower Salmon River drainage.

Specific production plans for these streams have not been finalized yet, but in general follow the same criteria and guidelines of our experimental design. The following synopsis represents our interpretation of NPT plans as well as our requirements for inclusion in ISS.

Lolo Creek (Clearwater River Drainage): Supplementation of natural production evaluated with fall presmolts released from satellite ponds.

1. Existing Program: No fishery since 1978. Managed for remnant run of naturalized spring chinook. No weir or broodstock collection currently exists. Varied outplanting history (Appendix B). Five years of smolt releases into Eldorado Creek from Dworshak stock was initiated in 1989 to provide returns for supplementation broodstock. These fish were not marked for the 1989-1991 releases, but will be marked for the 1992 and 1993 releases.

2. Broodstock: 1st generation, BY 1992-95. Differentiation of hatchery and natural adults not possible.
   - 67% adult returns (female) passed over weir.
   - 33% used for supplementation broodstock.

   Broodstock: Subsequent generations, BY 1996+. External mark used to differentiate hatchery and natural adults.
   - Majority of natural fish put over weir (≥67% of females).
   - Natural fish comprise large component of supplementation broodstock (40%-50%).
   - Remainder of supplementation broodstock comprised of hatchery adults returning from the fall presmolt release.
   - Surplus presmolt returns passed over weir to supplement natural production (up to natural spawner equivalents).

3. Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during second generation, mating composition will be documented (HxH, NxN, HxN).

4. Rearing: progeny incubated and reared at NPTH facility or isolated at Clearwater Hatchery, marked (differently from harvest augmentation fish, e.g. body tag, pelvic fin clip), and released into satellite ponds as soon as possible.

5. Release: Direct release from satellite ponds mid September. Release timed to coincide with known environmental and physiological cues.

6. Adult Returns: Supplementation (marked differently from harvest fish in Clearwater River) and natural (unmarked) adults escaped through fishery (weak stock harvest management) with no more than 20% exploitation (estimated range of 4% to 17%). No general production fish will be passed above the weir.

7. Genetic Risk Assessment: Medium
   - No existing hatchery program is in place for Lolo Creek.
   - Donor broodstock for supplementation will be from local adult returns, but initial outplanting in Eldorado Creek to provide broodstock is from Dworshak stock. These smolts were unmarked until release year 1992 so unmarked Dworshak fish may be used for Lolo Creek broodstock. NPT may attempt to minimize this potential risk by collecting broodstock from Lolo Creek above the confluence with Eldorado Creek.
   - Brood selection and matings will be random with 1:1 sex ratio *or* factorial crosses using split gamete fertilization.
   - Supplementation fish isolated in hatchery from general production fish.
   - All supplementation fish and general hatchery fish released in the drainage will be marked beginning BY 1990.
   - Fall release timed to coincide with known environmental cues and estimated peak natural fall emigration.
   - No general production hatchery fish will be passed above weir.

Newsome Creek (Clearwater River Drainase): Restoration of natural production evaluated with fall presmolts released from satellite ponds. Temporary weir will be used near mouth to allow supplementation of all natural production areas.

1. Existing Program: No fishery since 1978. Assumed non viable existing natural population requiring restoration efforts. No weir or broodstock collection currently exists. Varied outplanting history (Appendix B). Five years of parr or smolt releases from Dworshak stock was initiated in 1991 to provide returns for supplementation broodstock. These fish were not marked for the 1991 release, but will be marked for any subsequent releases.

2. Broodstock: 1st generation, BY 1991-95. Unable to differentiate hatchery and natural adult returns.
   - 100% Dworshak complex stock.

   Broodstock: 2nd generation, BY 1996+. Hatchery and natural returns differentiated with external mark.
   - All natural and supplementation fish put over weir to spawn naturally.
   - Supplementation broodstock 100% Dworshak complex stock.

   Broodstock: Subsequent generations, BY 1996+. External mark used to differentiate hatchery and natural adults.
   - Majority of natural fish put over weir ($\geq$67% of females).
   - Natural fish comprise large component of supplementation broodstock (40%-50%).
   - Remainder of supplementation broodstock comprised of hatchery adults returning from the fall presmolt release.
   - Surplus presmolt returns passed over weir to supplement natural production (up to natural spawner equivalents).

3. Spawning: First two generations will use general hatchery protocols for spawning. Subsequent generations will be non selective for size, age and origin (natural vs. hatchery); 1:l sex ratio with factorial *crosses* utilized to enhance effective population sizes; during third generation and beyond, mating composition will be documented (HxH, NxN, HxN).

4. Rearing: Progeny incubated and reared at NPTH facility, marked (differently from harvest augmentation fish in Clearwater River, e.g. body tag, pelvic fin clip), and released into satellite ponds as soon as possible.

5. Release: Direct release from satellite ponds mid September. Release timed to coincide with known environmental and physiological cues.

6. Adult Returns: Supplementation (marked differently from harvest fish) and natural (unmarked) adults escaped through fishery (weak stock harvest management) with no more than 20% exploitation (estimated range of 4% to 17%). No general production fish will be passed above the weir.

7. Genetic Risk Assessment: Low
   - Local population assumed extirpated based on trend redd counts and parr density estimates.
   - Long and varied history of hatchery outplants.
   - Predominant risk is associated with straying impacts on the neighboring natural population in Red River.
   - Donor broodstock (Dworshak complex) selected on basis of outplanting history, location and availability. Suitable adjacent or out-of-basin natural stocks are unavailable or too vulnerable to extinction to provide brood.
   - All supplementation and general production hatchery fish marked prior to release in drainage.
   - No known Newsome Creek adult returns will be used for Red River broodstock or passed over weir on Red River to spawn naturally.

<u>Slate Creek (Salmon River Drainage):</u> Restoration of natural production evaluated with fall presmolts released from satellite ponds. Temporary weir will be used near mouth to allow supplementation of all natural production areas.

1. Existing Program: No fishery since 1978. Assumed non viable existing natural population requiring restoration efforts. Baseline data will be collected to confirm this assumption prior to outplanting hatchery fish. No weir or broodstock collection currently exists. Minimal outplanting history (Appendix B).

2. Broodstock: 1st generation, BY 1992-96. Unable to differentiate hatchery and natural adult returns.
   - 100% Rapid River stock.

   Broodstock: 2nd generation, BY 1997+. Hatchery and natural returns differentiated with external mark.
   - All natural and supplementation fish put over weir to spawn naturally.
   - Supplementation broodstock 100% Rapid River stock.

   Broodstock: Subsequent generations, BY 1996+. External mark used to differentiate hatchery and natural adults.
   - Majority of natural fish put over weir ($\geq$67% of females).
   - Natural fish comprise large component of supplementation broodstock (40%-50%).
   - Remainder of supplementation broodstock comprised of hatchery adults returning from the fall presmolt release.
   - Surplus presmolt returns passed over weir to supplement natural production (up to natural spawner equivalents).

3. Spawning: First two generations will use general hatchery protocols for spawning. Subsequent generations will be non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during third generation and beyond, mating composition will be documented (HxH, NxN, HxN).

4. Rearing: progeny during first two generations will be incubated and reared at Rapid River Hatchery until large enough to mark and prior to transfer to outside ponds *(no* isolation from general production fish necessary). Progeny during subsequent generations will be incubated and reared at NPTH facility. All fish will be marked (differently from harvest augmentation fish, e.g. body tag, pelvic fin clip), and released into satellite ponds as soon as possible.

5. Release: Direct release from satellite ponds mid September. Release timed to coincide with known environmental and physiological cues.

6. Adult Returns: Supplementation (marked differently from harvest fish) and natural (unmarked) adults escaped through fishery (weak stock harvest management) with no more than 20% exploitation (estimated range of 4% to 17%). No general production fish will be passed above the weir.

7. Genetic Risk Assessment: Low
   - Local population assumed extirpated based on trend redd counts and parr density estimates.
   - Long and varied history of hatchery outplants.
   - Lack of neighboring natural populations reduces straying risk.
   - Donor broodstock (Rapid River stock) selected on basis of outplanting history, location and availability. Suitable adjacent or out-of-basin natural stocks are unavailable or too vulnerable to extinction to provide brood.
   - All supplementation and general production hatchery fish marked prior to release in drainage.

SALMON RIVER DRAINAGE

Sawtooth Hatchery

Upper Salmon River and Alturus Lake Creek: Supplementation of natural production evaluated with adult and smolt releases from Sawtooth Hatchery.

1. Existing Program: No sport fishery since 1978. Tribal ceremonial fishery in 1990. Sawtooth Hatchery and weir on lower end of reach completed 1984. Hatchery and natural adult returns indistinguishable. One third of adults passed above weir to spawn naturally, 2/3 utilized for hatchery broodstock. Progeny reared to smolt and released during April at the Sawtooth weir. Irrigation diversions preclude adult passage into upper 2/3 of reach during the majority of the spawning season.

2. Broodstock: 1st generation, BY 1991-95. No differentiation of hatchery and natural adult returns possible.
   - 33% of adult female and male returns passed over weir to spawn naturally (assume ~2/3 hatchery component).
     - Approximately 60 females trucked to spawning sites on Pole, Frenchman and Smiley Creeks for Int. Smolt Eval. research (Appendix X).
     - Remainder of 1/3 component passed directly over weir.
   - 67% of adult returns used for hatchery broodstock (assume ~1/3 natural component).
     - Same broodstock used for both supplementation and general production needs.

   Broodstock: 2nd generation, BY 1996+. Hatchery and natural adults differentiated with external mark, body tag or scale analysis.
   - Majority ($\geq$67%) of natural females passed over weir (includes unmarked returns from adult outplants), remainder used for supplementation broodstock.
   - Natural fish comprise large component (40-50%) of supplementation broodstock.
   - Remainder of supplementation broodstock comprised of general production returns (marked).
   - Supplementation returns passed over weir up to equivalent to natural fish passed (50:50).
   - No general production fish passed over weir.

3. Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during second generation, mating composition will be documented (HxH, NxN, HxN).

4. Rearing: All hatchery fish reared to smolt at Sawtooth Hatchery. Isolation of supplementation fish prior to marking not required during first generation, but is necessary for subsequent generations (no conflict with LSRCP rearing density experiment; Appendix A).
   - Supplementation fish marked differently than general production fish.
   - Number of supplementation smolts determined by adult equivalents with estimated smolts produced naturally.

5. Release: Marked smolts (unacclimated) released throughout natural production areas in the upper Salmon River and Alturus Lake Creek

(above and below screened diversions). Release timed to coincide with natural emigration cues (environmental and physiological).

Although acclimation ponds are not proposed, slackwater release sites (e.g. side channels, beaver ponds) will be utilized wherever accessible.

6. Adult Returns: If a fishery is deemed prudent, enough supplementation (marked differently than harvest fish) and natural (unmarked) adults will be escaped through any Salmon River fishery (catch and release or weak stock harvest management) to ensure adequate rebuilding and evaluation. No harvest augmentation fish will be passed over the weir.

7. Genetic Risk Assessment: Low
   - Existing hatchery program already in place for upper Salmon River drainage.
   - Natural populations assumed depressed but viable with unknown natural/hatchery lineage.
   - Predominant risks are associated with first generation broodstock collection from unknown hatchery-released or naturally produced adult returns, and possible genetic homogenization for upper Salmon River and Alturus Lake Creek stocks (i.e. loss of among stock genetic variability). This latter risk is assumed low as a result of the existing hatchery program which manages for one stock above Sawtooth weir.
   - Donor broodstock for supplementation will be from local adult returns to the Sawtooth weir.
   - Broodstock management for the second generation and beyond is designed to strike a balance between risk of hatchery domestication (less than 50% of broodstock will be hatchery returns) and risk of mining out multi-generational natural fish (more than 67% of natural returns will be allowed to spawn naturally).
   - Brood selection and matings will be random with 1:1 sex ratio or factorial crosses.
   - Supplementation fish isolated in hatchery from general production fish.
   - All supplementation fish and general hatchery fish released in the drainage will be marked.
   - Spring release timed to coincide with known environmental cues and estimated peak natural spring emigration.
   - No general production hatchery fish will be passed above weir.

<u>West Fork Yankee Fork</u>: Supplementation of natural production evaluated with smolt releases from Sawtooth Hatchery.

1. Existing Program: *No* sport fishery since 1978. Tribal ceremonial fishery on Upper mainstem Yankee Fork Salmon River since 1984 (Rapid River and Pahsimeroi stock trucked to designated areas between upper and lower temporary weirs). No consistent hatchery program and minimal outplanting history (Appendix B). Shoshone-Bannock Tribes are developing plans for hatchery supplementation on mainstem Yankee Fork near the West Fork utilizing Rapid River or Sawtooth stock for on-site incubation and rearing in interconnected ponds created during dredge mining (Appendix A). West Fork Yankee Fork is managed for remnant wild-natural stock currently at very depressed levels (trend count averaged 7 redds/year from 1980-1989).

2. Broodstock: 1st generation, BY 1991-95. Sawtooth Hatchery general production broodstock surplus to interim production needs (to be determined by management).

   Broodstock: 2nd generation, BY 1996+. External mark used to differentiate supplementation and natural fish returning to temporary weir on WFYF.
   - Majority (≥67%) natural females passed, remainder kept for supplementation broodstock.
   - Natural fish comprise large component (40-50%) of supplementation broodstock.
   - Remainder of supplementation broodstock comprised of supplementation returns.
   - Extra supplementation adult returns passed over weir up to natural equivalents.

3. Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during second generation, mating composition will be documented (HxH, NxN, HxN).

4. Rearing: Progeny reared to smolt at Sawtooth Hatchery.
   - Do not need to isolate at hatchery until 2nd generation (avoid conflict with LSRCP rearing density experiment).
   - Supplementation fish marked differently from general production fish.

5. Release: Marked smolts released into WFYF near the campground (if possible, packed farther upstream).

6. Adult Returns: If a fishery is deemed prudent, enough supplementation and natural fish escaped through fishery to ensure adequate rebuilding and evaluation (e.g. ≤10% exploitation). No harvest augmentation adults (marked) will be passed over temporary weir on WFYF.

7. Genetic Risk Assessment: Medium

   - Natural population assumed extremely depressed but viable based on trend redd counts and parr density estimates.
   - Minimal outplanting history in West Fork Yankee Fork.
   - Extensive outplanting history in mainstem Yankee Fork.
   - Predominant risks are associated with using non-local broodstock (loss of genetic identity) during the first generation, and effects of introgression of hatchery-reared fish with relatively unaltered natural fish.
   - First generation donor broodstock (Sawtooth returns) selected on basis of stock similarity, proximity (sub-basin broodstock) and availability. Suitable local, adjacent or out-of-basin natural stocks are unavailable or too vulnerable to extinction to provide brood. Based on the unknown hatchery effects of supplementation and problems associated with very low effective population sizes, we believe there is more risk associated with taking the last few local fish into the hatchery than in using a sub-basin broodstock for supplementing the remnant run.
   - Second generation broodstock will be selected from local adult returns to West Fork Yankee Fork.
   - All supplementation and general production hatchery fish marked prior to release in drainage.

East Fork Salmon River: Supplementation of natural production evaluated with smolts released from Sawtooth Hatchery.

1. **Existing Program: No fishery since 1978. Parr released in 1977 from Rapid River stock is the only outplanting (Appendix B). Velocity barrier and adult trap at lower end of reach completed late 1983. Consistent hatchery program since 1984. Differentiation of hatchery and natural adult returns not possible (unmarked). One third of adults passed over barrier to spawn naturally, 2/3 used for hatchery broodstock. Progeny incubated and reared at Sawtooth Hatchery (isolated from upper Salmon River fish). Unacclimated smolts released at East Fork trap during April.**

2. **Broodstock: 1st generation, BY 1991-95. No differentiation of natural and hatchery adult returns.**
   - **50% of adult returns to EFSR trap passed over weir.**
   - **50% of adult returns used for EFSR hatchery broodstock.**
   - **General production broodstock not maintained; short-term hatchery role entirely for supplementation of natural production.**

   Broodstock: Subsequent generations, BY 1996+. External mark, body tag or scale analysis used to differentiate natural and hatchery adults.
   - **Majority (≥67%) natural females passed, remainder kept for supplementation broodstock.**
   - **Natural fish comprise large component (40-50%) of supplementation broodstock.**
   - **Remainder of supplementation broodstock comprised of supplementation returns.**
   - **Extra supplementation adult returns passed over weir.**

3. **Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during second generation, mating composition will be documented (HxH, NxN, HxN).**

4. **Rearing: Progeny reared to smolt at Sawtooth Hatchery.**
   - **Isolated from other hatchery groups.**
   - **Marked differently from Sawtooth general production fish.**

5. **Release: Fish trucked to EFSR and distributed throughout drainage above weir during April. Releases timed as best possible to coincide with known environmental and physiological emigration cues.**

6. **Adult Returns: If fishery is deemed prudent, enough supplementation and natural fish escaped through fishery to ensure adequate rebuilding and evaluation.**

7. **Genetic Risk Assessment:** Low
   - **Existing hatchery program already in place for upper East Fork Salmon River drainage.**
   - **Natural populations assumed depressed but viable with unknown natural/hatchery lineage.**
   - **Predominant risks are associated with first generation broodstock collection from unknown hatchery-released or naturally produced adult returns.**

- Donor broodstock for supplementation will be from local adult returns to the East Fork weir.
- Broodstock management for the second generation and beyond is designed to strike a balance between risk of hatchery domestication (less than 50% of broodstock will be hatchery returns) and risk of mining out multi-generational natural fish (more than 67% of natural returns will be allowed to spawn naturally).
- Brood selection and matings will be random with 1:1 sex ratio or factorial crosses.
- Supplementation fish isolated in hatchery from general production fish.
- All supplementation fish and general hatchery fish released in the drainage will be marked.
- Spring release timed to coincide with known environmental cues and estimated peak natural spring emigration.
- No general production hatchery fish will be passed above weir. Note: General production hatchery fish are not planned for release in the upper East Fork during the next five years.

Hayden Creek Hatchery

Lemhi River: Supplementation of natural production evaluated with parr and smolts produced in Hayden Creek Hatchery.

1. Existing Program: No sport fishery since 1978. Tribal subsistence/ceremonial fishery in 1989 on Rapid River stock spring chinook returning to Pahsimeroi Hatchery (fishery isolated with a weir from natural adults in the Lemhi River). Escapement and spawning success of these harvest fish (35 adults released) were not determined. No juvenile outplants have occurred in the Lemhi River since 1976, although outplanting continued intermittently in Hayden Creek (Appendix B). Prior to 1976 the hatchery program was predominantly research oriented and utilized local as well as Rapid River broodstocks. Hayden Creek Hatchery was operational from 1966 through 1982. Renovation and operation of this facility is being evaluated for the Lemhi River program.

2. Broodstock: 1st generation, BY 1992-96. No hatchery-reared fish in system, run comprised of natural/wild stock.
   - Lemhi adult weir and trap made operational (Appendix G).
   - 1/2 adult returns passed over weir to spawn naturally.
   - 1/2 adult returns used for supplementation broodstock (up to 50 females).

   Broodstock: subsequent generations, BY 1996+. Hatchery fish differentiated from natural fish by external mark *or* body tag.
   - Majority (≥67%) natural females passed, remainder kept for supplementation broodstock.
   - Natural fish comprise large component (40-50%) of supplementation broodstock.
   - Remainder of supplementation broodstock comprised of supplementation returns.
   - Extra supplementation adult returns passed over weir.

3. Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during second generation, mating composition will be documented (HxH, NxN, HxN).

4. Rearing: Progeny for supplementation reared to parr or smolt at Hayden Creek Hatchery and will be the only production fish at the facility.
   - Hatchery renovated and made operational for smolt production (feasibility currently being evaluated).
   - Incubation and rearing will be with Hayden Creek water to match the natural rate of development.
   - Early rearing will be in small tanks followed by raceways. Fish to be released as smolts will be moved to two large ponds (1.5 million smolt capacity) early July and reared until the following spring (<0.3 density index).
   - All fish will be marked prior to release. Parr and smolt release groups will be marked differentially (e.g. LV, RV). Marks will be administered early July for both groups.

5. Release: During the first generation (4-6 years), marked hatchery parr will be released late spring to increase the number of fish produced in the stream. Parr releases will cease when adults from smolt releases begin to return. Smolt releases will be made during

May and continue through the first and subsequent generations. These unacclimated parr and smolts will be distributed by truck throughout the entire production area above Lemhi weir. Releases will be timed to coincide with known environmental and physiological cues.

6. **Adult Returns:** If fishery is deemed prudent, enough supplementation (marked) and natural fish will be escaped through the fishery to ensure adequate rebuilding and evaluation. All fish will be differentiated at the Lemhi weir.

7. **Genetic Risk Assessment:** Medium-low
   - Natural population assumed depressed but viable based on trend redd counts and parr density estimates.
   - No existing hatchery program in place on Lemhi River; moderate outplanting history but predominantly with local stock.
   - Predominant risks are associated with implementing a hatchery program on a (recently) unsupplemented stock. This risk will be mainly evident in inadvertent hatchery selection, which will be minimized by the following operational guidelines.
   - Donor broodstock for supplementation will be from local adult returns to the Lemhi weir.
   - Supplemental production will be designed to never exceed natural production (parr and adult equivalents, depending on life stage released).
   - Broodstock management for the second generation and beyond is designed to strike a balance between risk of hatchery domestication (less than 50% of broodstock will be hatchery returns) and risk of mining out multi-generational natural fish (more than 67% of natural returns will be allowed to spawn naturally).
   - Brood selection and matings will be random with 1:1 sex ratio or factorial crosses.
   - Supplementation fish growth in the hatchery will be programmed to mimic natural counterparts.
   - All supplementation fish will be marked prior to release.
   - Smolt release timed to coincide with known environmental cues and estimated peak natural spring emigration.
   - No general production hatchery fish will be reared at Hayden Creek Hatchery or released in the Lemhi River.

Pahsireroi Hatchery

Pahsimeroi River: Supplementation of natural production evaluated with smolts produced at Pahsimeroi Hatchery.

1. Existing Program: No sport fishery since 1978. Summer chinook hatchery program has been in place since 1968, although intermittent releases of spring chinook from various sources has occurred through 1986 (Appendix B). From 1987 through 1989 smolt releases were from adult returns (summer chinook) to Pahsimeroi weir, with hatchery production "topped off" with South Fork Salmon River summer chinook from McCall Hatchery. Hatchery and natural adult returns to the Pahsimeroi River are currently indistinguishable. One third of adults are passed above the weir to spawn naturally, 2/3 are utilized for hatchery broodstock. Progeny are incubated and early-reared at the main hatchery facility until April and then transported seven miles upriver to four earthen ponds for advanced rearing to smolt. Smolts are released directly from the ponds mid March.

2. Broodstock: 1st generation, BY 1991-95. No differentiation of hatchery vs. natural returns.
   - 33% females and males passed, 67% kept for hatchery broodstock.
   - Same broodstock used for both supplementation and general production needs.

   Broodstock: 2nd generation, BY 1996+. External marks or body tags used to determine natural vs. hatchery origin of returning adults.
   - Majority (≥67%) natural females passed, remainder kept for supplementation broodstock.
   - Natural fish comprise large component (40-50%) of supplementation broodstock.
   - Remainder of supplementation broodstock comprised of supplementation returns.
   - Extra supplementation adult returns passed over weir up to natural equivalents.
   - No harvest augmentation fish (marked) passed over weir.

3. Rearing: Progeny reared to smolt at Pahsimeroi Hatchery facilities.
   - Progeny for supplementation isolated from general production fish (not necessary during 1st generation).
   - All supplementation fish marked for differentiation from harvest and natural fish prior to ponding or integration with general production fish.
   - Supplementation fish isolated from general production fish while ponded unless general production fish exceed recommended pond capacity.

4. Release: Supplementation smolts distributed (unacclimated) throughout accessible spawning areas (multiple release sites) during April. As best possible, releases will be timed to coincide with known environmental and physiological emigration cues.

   Note: The general production smolts reared in the supplementation ponds would also be distributed throughout the upper Pahsimeroi drainage with the supplementation smolts.

5. Adult Returns: If a fishery is deemed prudent, enough supplementation and natural fish will be escaped through the fishery

to ensure adequate rebuilding and evaluation. No general production hatchery fish will be passed over the weir.

6. Genetic Risk Assessment: Low
   - Existing hatchery program already in place for summer chinook in the Pahsimeroi drainage.
   - Natural populations assumed depressed but viable with unknown natural/hatchery lineage.
   - Predominant risks are associated with first generation broodstock collection from unknown hatchery-released or naturally produced adult returns.
   - Donor broodstock for supplementation will be from local adult returns to the Pahsimeroi weir.
   - Broodstock management for the second generation and beyond is designed to strike a balance between risk of hatchery domestication (less than 50% of broodstock will be hatchery returns) and risk of mining out multi-generational natural fish (more than 67% of natural returns will be allowed to spawn naturally).
   - Brood selection and matings will be random with 1:1 sex ratio or factorial crosses.
   - Supplementation fish isolated in hatchery from general production fish.
   - All supplementation fish and general hatchery fish released in the drainage will be marked.
   - Smolt release timed to coincide with known environmental cues and estimated peak natural spring emigration.
   - No general production hatchery fish will be passed above weir.

McCall Hatchery

Upper South Fork Salmon River: Supplementation of natural production evaluated with smolts produced at McCall Hatchery.

1. Existing Program: No sport fishery since 1964. Consistent hatchery program since 1981, upon completion of McCall Hatchery (off-site hatchery) renovation and South Fork weir and adult trap in 1980. No outplanting prior to hatchery program except from summer chinook collected at dams to boost existing broodstock (Appendix B). Hatchery and natural adult returns indistinguishable. One third of adults passed above weir to spawn naturally, 2/3 utilized for hatchery broodstock. Progeny reared to smolt and released during April near the South Fork weir.

2. Broodstock: 1st generation, BY 1991-95. No differentiation of hatchery vs. natural returns.
   - 33% females and males passed, 67% kept for hatchery broodstock.
   - Same broodstock used for both supplementation and general production needs.

   Broodstock: 2nd generation, BY 1996+. External marks, body tags or scale analysis used to determine natural vs. hatchery origin.
   - Majority (≥67%) natural females passed, remainder kept for supplementation broodstock.
   - Natural fish comprise large component (40-50%) of supplementation broodstock.
   - Remainder of supplementation broodstock comprised of supplementation returns.
   - Extra supplementation adult returns passed over weir.
   - No harvest augmentation fish (marked) passed over weir.

3. Spawning: non selective for size, age and origin (natural vs. hatchery); 1:1 sex ratio with factorial crosses utilized to enhance effective population sizes; during second generation, mating composition will be documented (HxH, NxN, HxN).

4. Rearing: Progeny reared to smolt at McCall Hatchery located on the North Fork Payette River.
   - Progeny for supplementation isolated from harvest augmentation fish prior to marking at McCall Hatchery.
   - All supplementation fish marked for differentiation from harvest and natural fish prior to ponding or integration with general production fish.
   - Supplementation fish isolated from general production fish while ponded (one pond for each program) unless general production fish exceed recommended pond capacity.

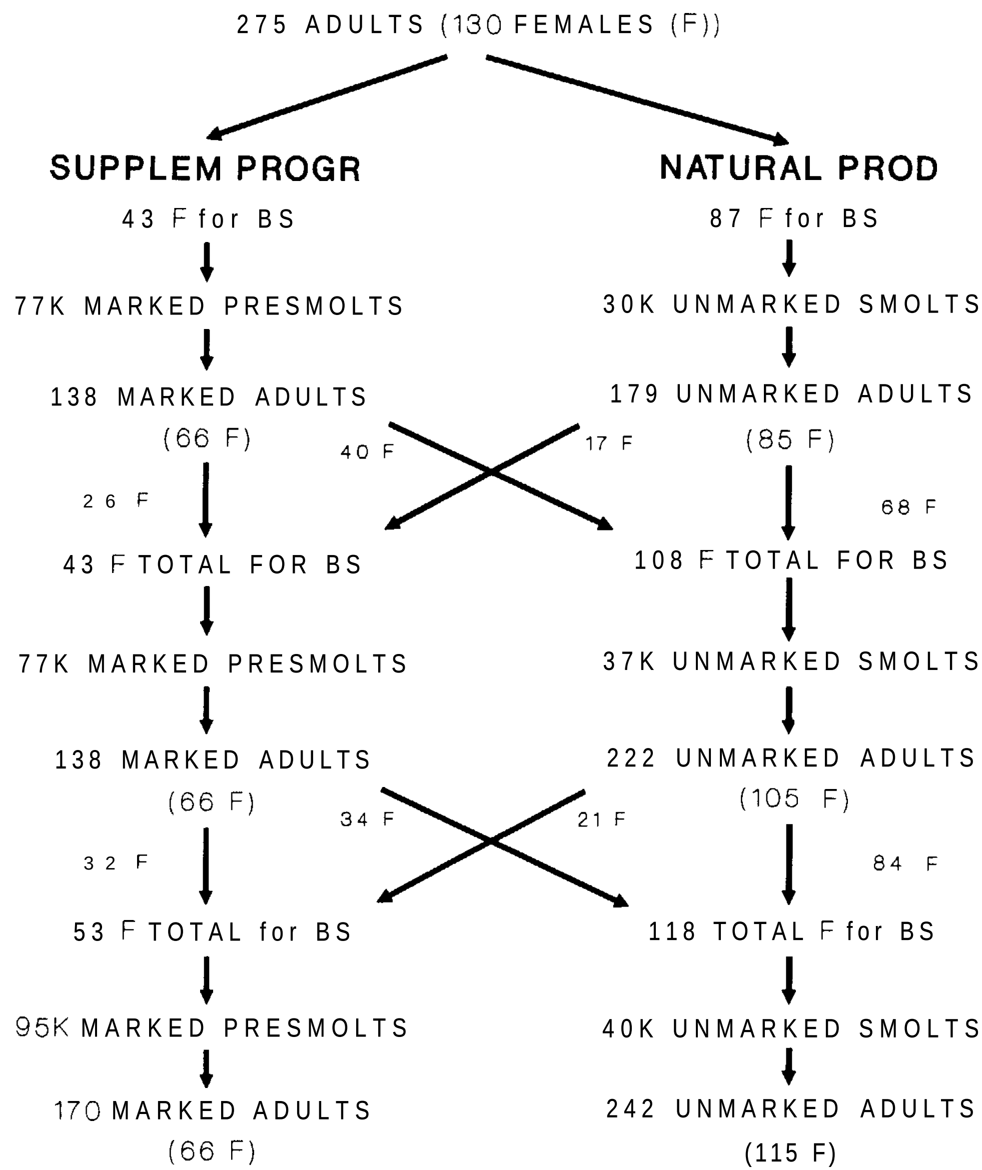
5. Release: Supplementation smolts transported to upper SFSR and distributed (unacclimated) throughout accessible spawning areas (multiple release sites) during April. As best possible, releases will be timed to coincide with known environmental and physiological emigration cues.

   Note: The general production smolts reared in the supplementation pond would also be trucked and released into the upper South Fork of the Salmon River with the supplementation smolts.

6. Adult Returns: If a fishery is deemed prudent, enough supplementation and natural fish will be escaped through the fishery to ensure adequate rebuilding and evaluation. No general production hatchery fish will be passed over the weir.

7. Genetic Risk Assessment: Low
   - Existing hatchery program already in place for upper South Fork Salmon River drainage.
   - Natural populations assumed depressed but viable with unknown natural/hatchery lineage.
   - Predominant risks are associated with first generation broodstock collection from unknown hatchery-released or naturally produced adult returns.
   - Donor broodstock for supplementation will be from local adult returns to the South Fork weir.
   - Broodstock management for the second generation and beyond is designed to strike a balance between risk of hatchery domestication (less than 50% of broodstock will be hatchery returns) and risk of mining out multi-generational natural fish (more than 67% of natural returns will be allowed to spawn naturally).
   - Brood selection and matings will be random with 1:1 sex ratio or factorial crosses.
   - Supplementation fish isolated in hatchery from general production fish.
   - All supplementation fish and general hatchery fish released in the drainage will be marked.
   - Smolt release timed to coincide with known environmental cues and estimated peak natural spring emigration.
   - No general production hatchery fish will be passed above weir.

RED RIVER PRODUCTION MODEL



Assumptions used in modeling Red River production scenario:

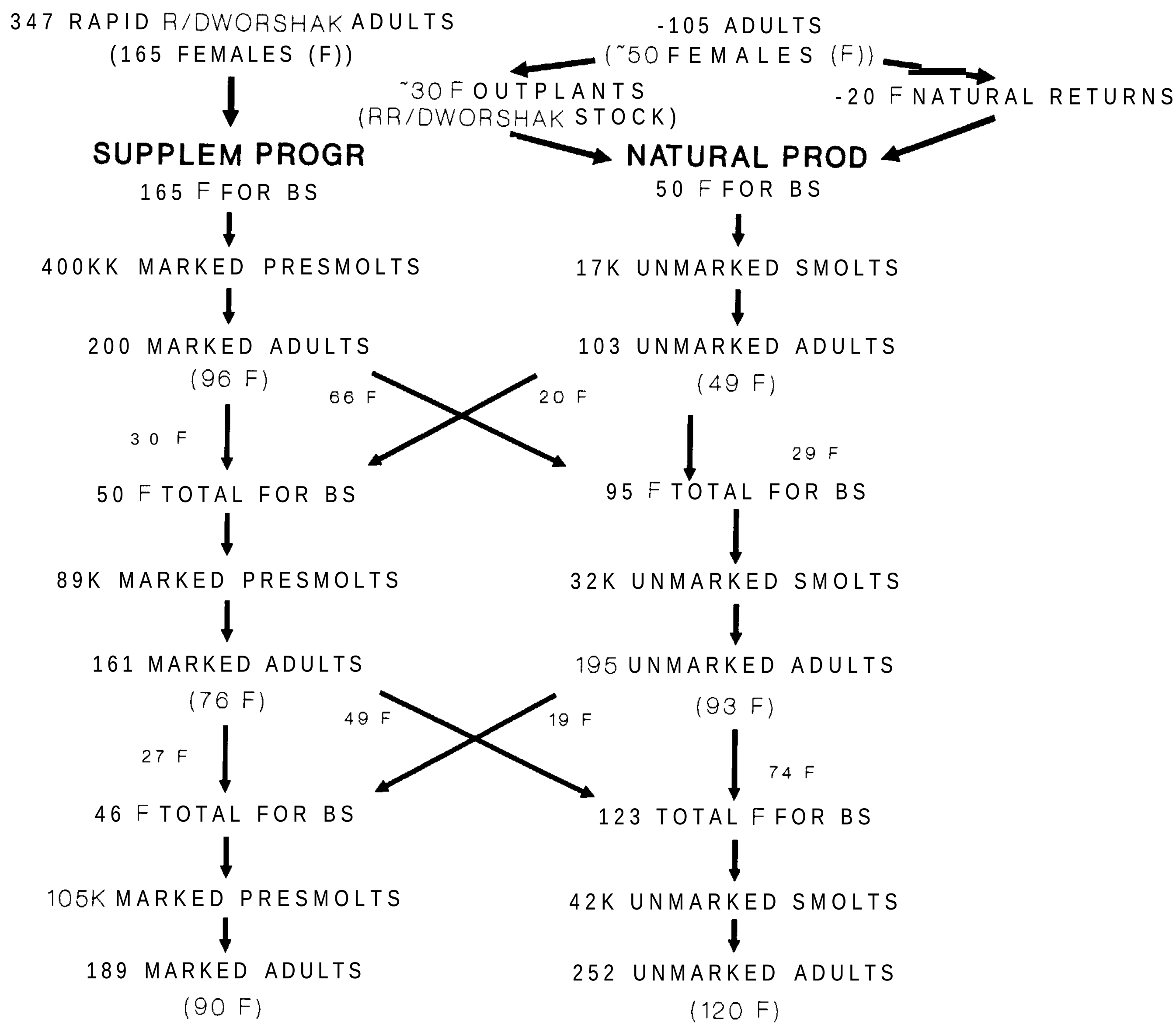
Brood stock strategy BY 1991-1995:

67% of the female returns passed over the weir
33% of the female returns used for supplementation BS

Supplementation brood stock strategy, second generation 1996-2000:
≥80% of natural female returns passed over the weir
≤20% of natural female returns used for supplementation BS
≥40% of supplementation BS females comprised of natural females
≤60% of supplementation BS females comprised of hatchery females

	Production Fish (smolts)	Supplem. Fish (presmolts)	Natural Fish
% not jacks	95	95	95
% F w/o jacks	50	50	50
% prespawn. surv.	95	95	95
% marking survival	85	85	--
% green egg to emigrant (w/ marking mortality)	54	47	9
% emigrant to adult (presmolt)	0.05	0.18	0.6
eggs per female	4,000	4,000	4,000

CROOKED RIVER PRODUCTION MODEL



Assumptions used in modeling Crooked River production scenario:

Supplementation brood stock strategy, first generation 1991-1995:

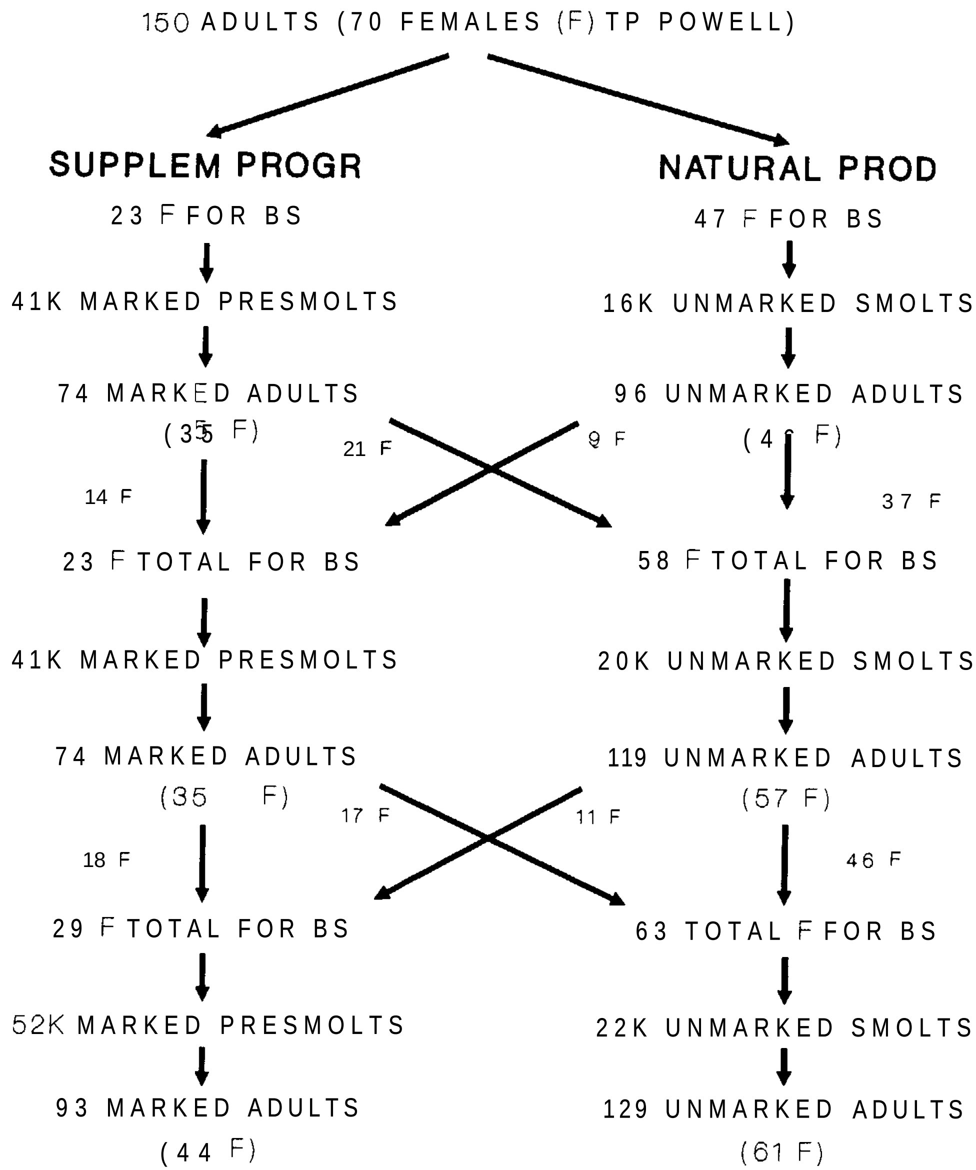
presmolt supplementation 100% Dworshak/Kooskia or Rapid River stock

Supplementation brood stock strategy, second generation 1996-2000:

- ≥60% of natural female returns passed progeny from adult supplementation over the weir (includes
- ≤40% of natural female returns used for supplementation BS
- ≥40% of supplementation BS females comprised of natural females
- ≤60% of supplementation BS females comprised of hatchery females

	Outside BS 1st (& 2nd?) gen	Local BS 2nd gen	Natural Fish
% not jacks	95	95	95
% F w/o jacks	50	50	50
% prespawn. surv.	95	95	95
% marking survival	85	85	--
% green egg to emigrant (w/ marking mortality)	61	47	9
% emigrant to adult (presmolt)	0.05	0.18	0.6
eggs per female	4,000	4,000	4,000

POWELL (CROOKED FORK CREEK) PRODUCTION MODEL



Assumptions used in modeling Powell production scenario:

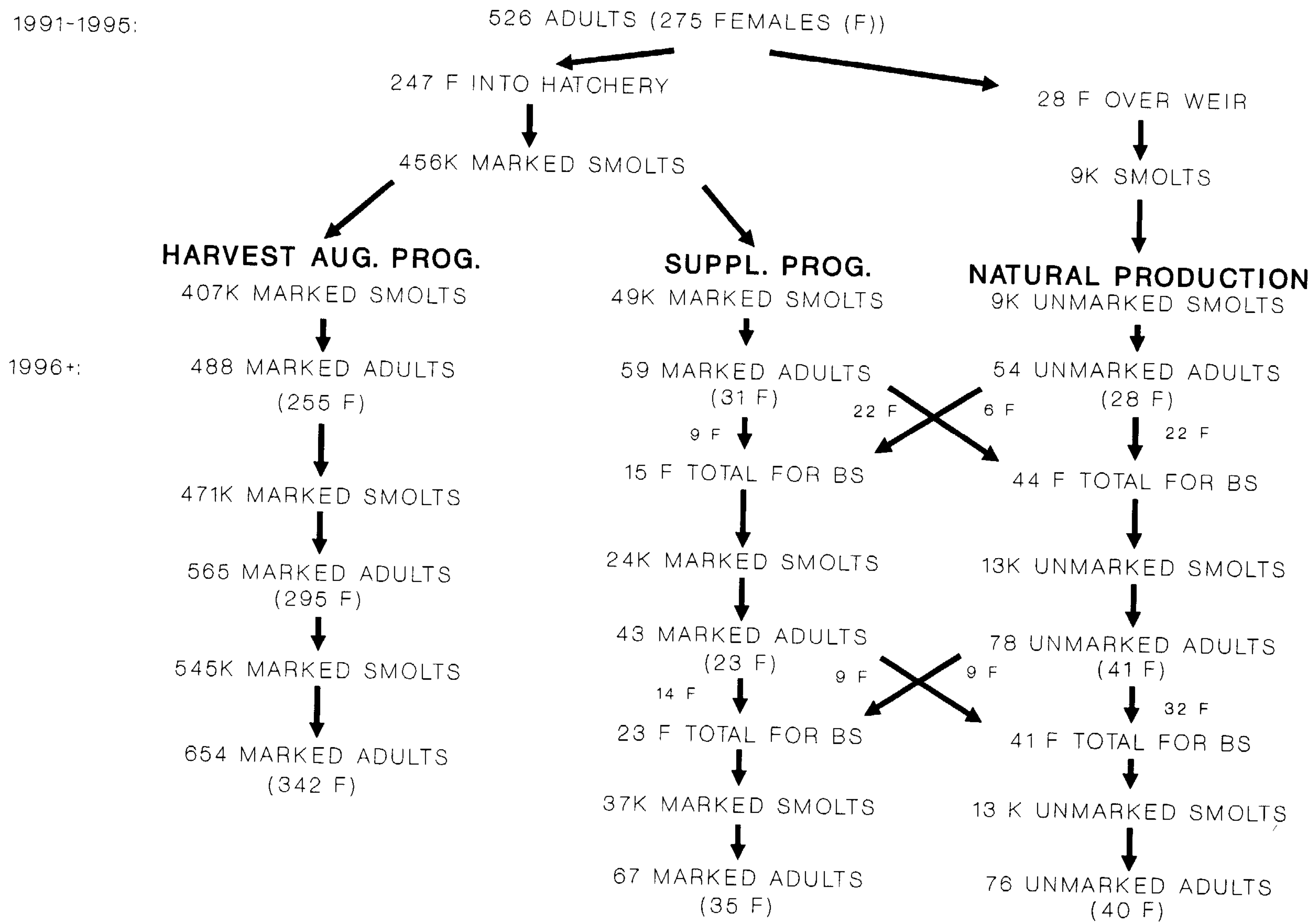
Brood stock strategy By 1991-1995:

67% of the female returns passed over the weir
33% of the female returns taken into the hatchery

Supplementation brood stock strategy, second generation BY 1996-2000:
≥80% of natural female returns passed over the weir
≤20% of natural female returns used for supplementation BS
≥40% of supplementation BS females comprised of natural females
≤60% of supplementation BS females comprised of hatchery females

	Prod. Fish (smolts)	Suppl. Fish Crooked Fk (presmolts)	Natural Fish (Cr Fk)	Suppl. Fish White Sand (Parr)
% not jacks	95	95	95	--
% F w/o jacks	50	50	50	--
% prespawn. surv.	95	95	95	--
% marking survival	85	85	--	85
% green egg to fry	75	65	--	65
% fry to emigrant	85	85	--	35
% green egg to emigrant (w/ marking mortality)	54	47	9	--
% emigrant to adult (smolt)	0.12	0.18	0.6	0.22
eggs per female	4,000	4,000	4,000	4,000

KOOSKIA PRODUCTION MODEL



Assumptions used in modeling Kooskia Hatchery production scenario:

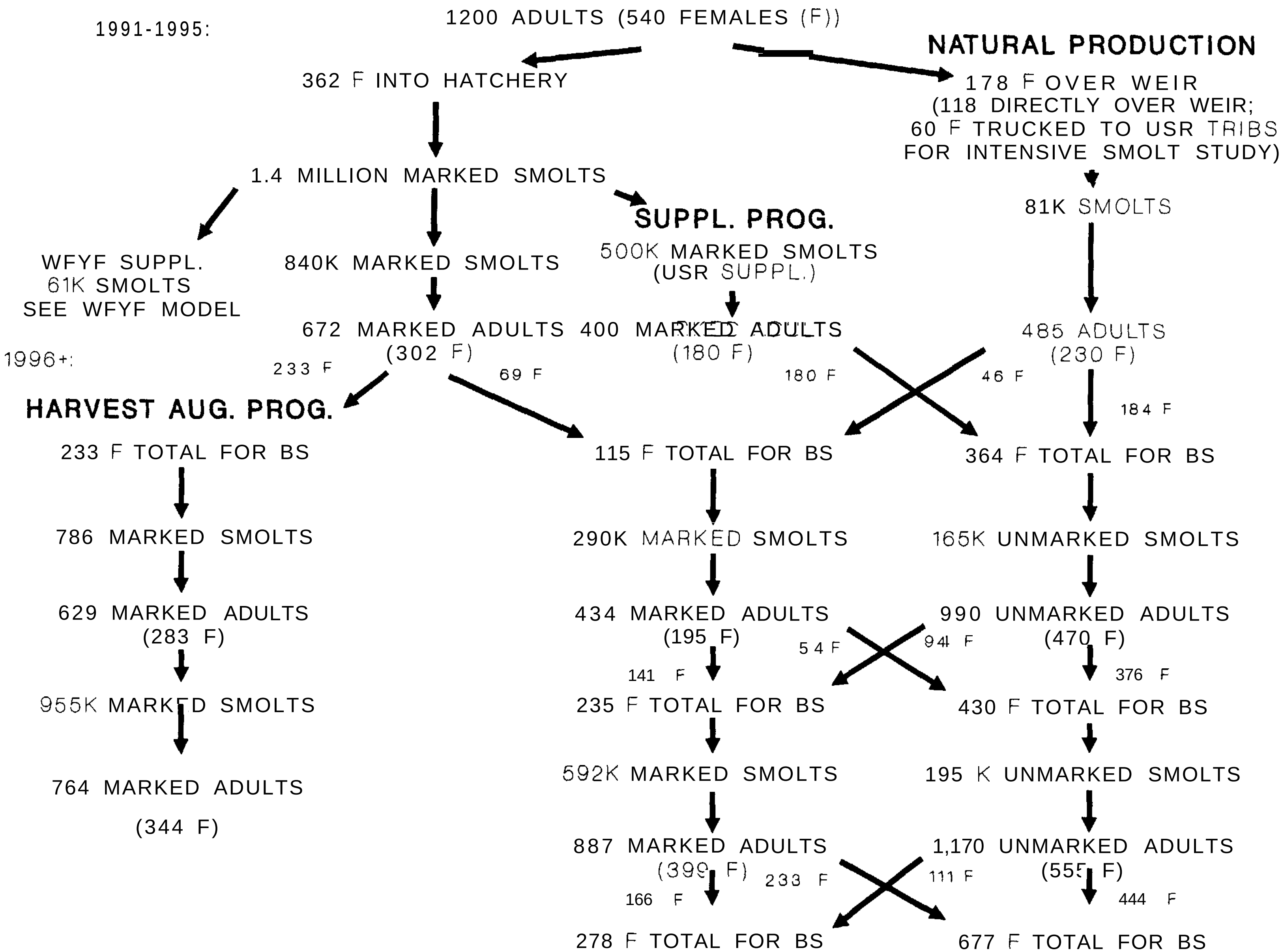
Brood stock strategy 1992-1995:

90% of the female returns taken into the hatchery
10% of the female returns passed over the weir (this represents approximately 35% of full seeding based on the last 10 run years).

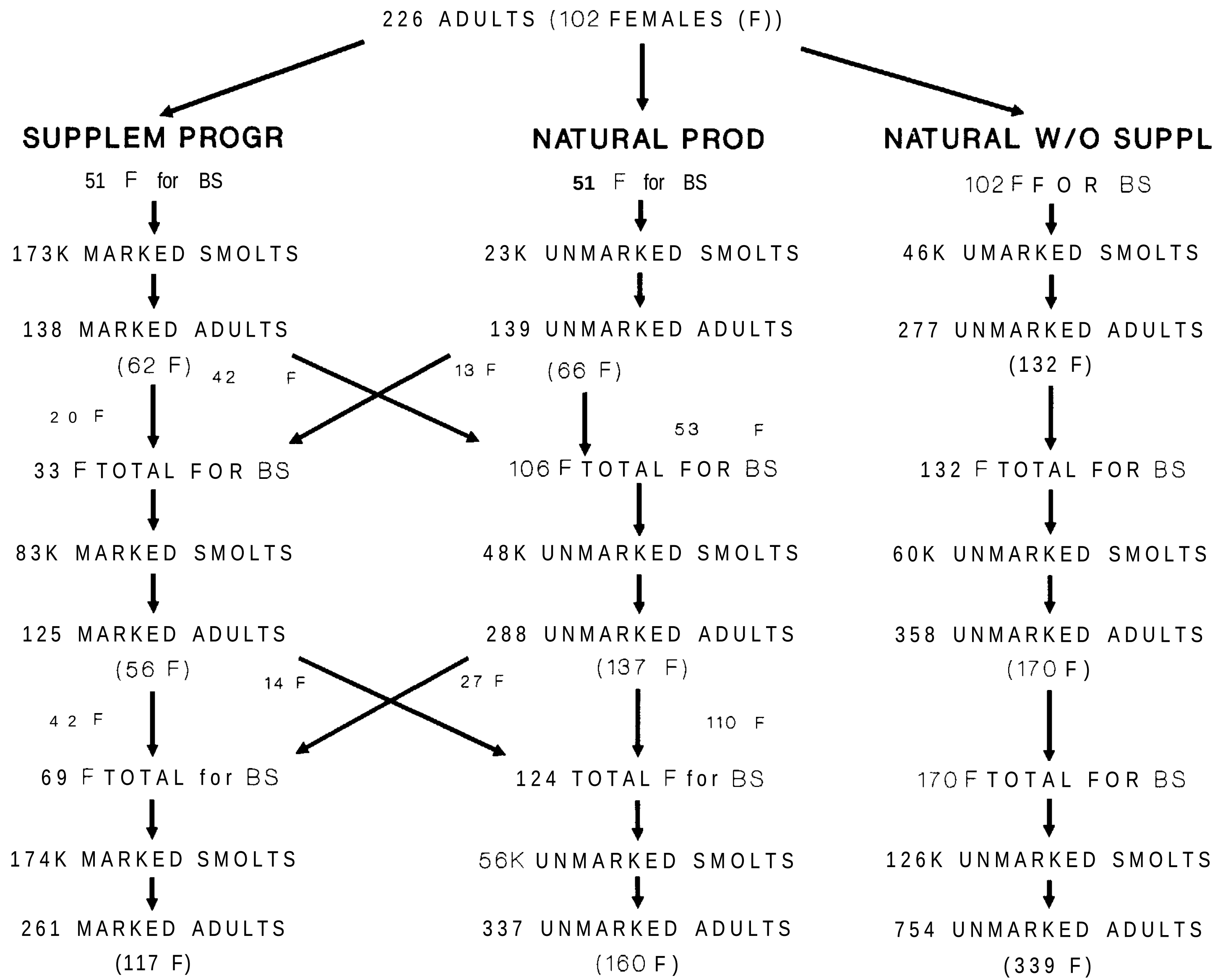
Supplementation brood stock strategy (BY 1996+):
≥80% of natural female returns passed over the weir
520% of natural female returns used for supplementation BS
≥40% of supplementation BS females comprised of natural females
(60% of supplementation BS females comprised of hatchery females

	Kooskia Production Fish	Supplementation Fish	Natural Fish
% not jacks	95	95	95
% F w/o jacks	55	55	55
% prespawn. surv.	95	95	95
% marking survival	85	85	--
% green egg to emigrant (w/ marking mortality)	54	47	9
% emigrant to adult (smolt)	0.12	0.18	0.6
eggs per female	3,600	3,600	3,600

SAWTOOTH PRODUCTION MODEL



EAST FORK SALMON RIVER CHINOOK PRODUCTION MODEL



Assumptions used in modeling Sawtooth Hatchery and East Fork production scenarios:

Brood stock strategy 1991-1995:

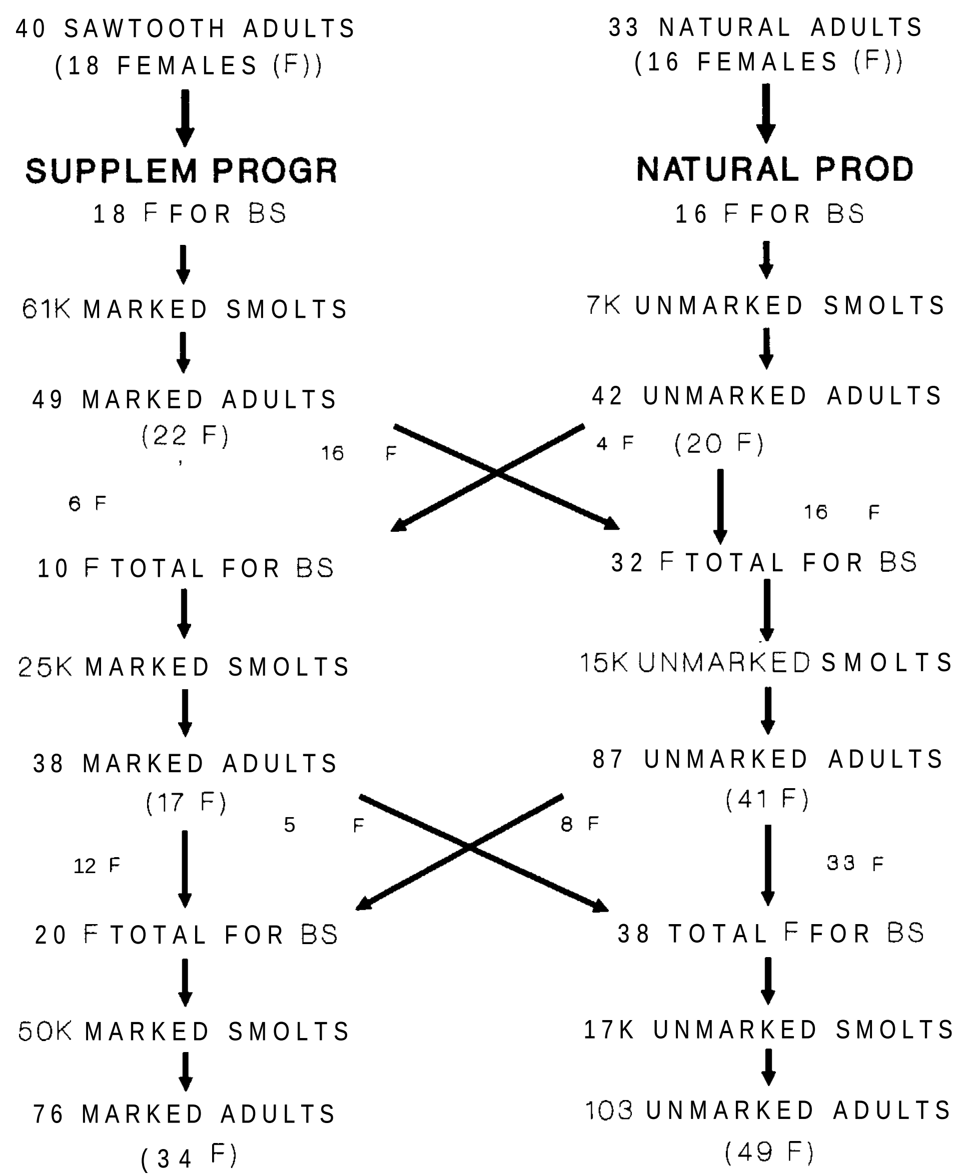
67% of the female returns taken into the hatchery
33% of the female returns passed over the weir

Supplementation brood stock strategy 1996+:

$\geq$80% of natural female return5 passed over the weir
$\leq$20% of natural female return5 used for supplementation BS
$\geq$40% of supplementation BS females comprised of natural females
$\leq$60% of supplementation BS females comprised of hatchery females

	Sawtooth Production Fish	Supplementation Fish	Natural Fish
% not jack5	90	90	95
% F w/o jacks	50	50	50
% prespawn. surv.	95	95	95
% marking survival	85	85	--
% green egg to emigrant (w/ marking mortality)	67	50	9
% emigrant to adult (smolt)	0.08	0.15	0.6
eggs per female	5,300	5,300	5,300

WEST FORK YANKEE FORK PRODUCTION MODEL



Assumptions used in modeling West Fork Yankee Fork production scenario:

Brood stock strategy BY 1991-1995:

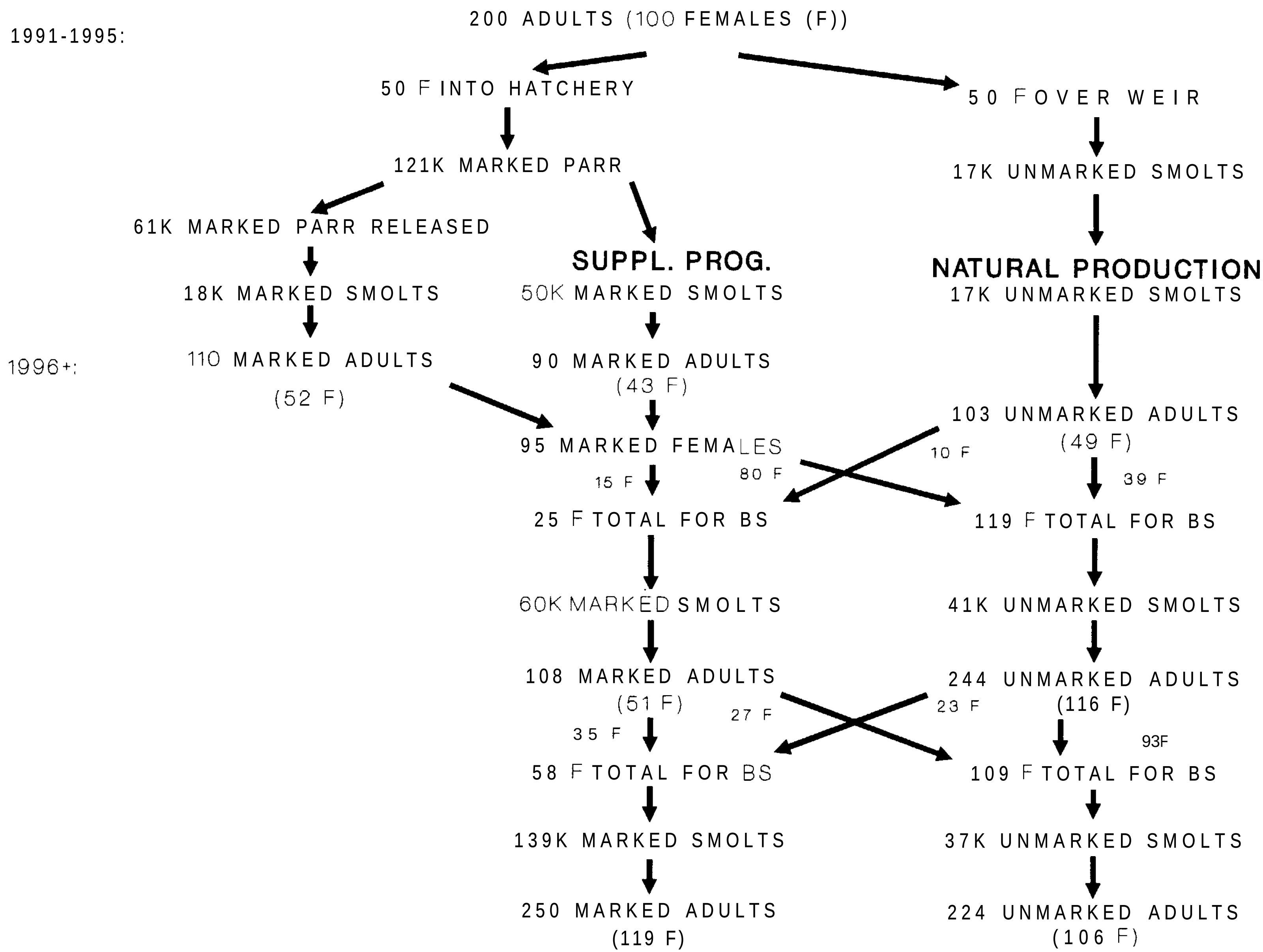
100% Sawtooth fish - Adult equivalent to natural production (-60,000 smolts)

Supplementation brood stock strategy:

Same level as first generation or same strategy as first generation

	Sawtooth Production Fish	Supplementation Fish	Natural Fish
% not jacks	90	90	95
% F w/o jacks	50	50	50
% prespawn. surv.	95	95	95
% marking survival	85	85	--
% greentegg emigrant (w/ marking mortality)	67	50	9
% emigrant to adult (smolt)	0.08	0.15	0.6
eggs per female	5,300	5,300	5,300

LEMHI RIVER PRODUCTION MODEL



Assumptions used in modeling Lemhi River production scenario:

Brood stock strategy 1992-1995:

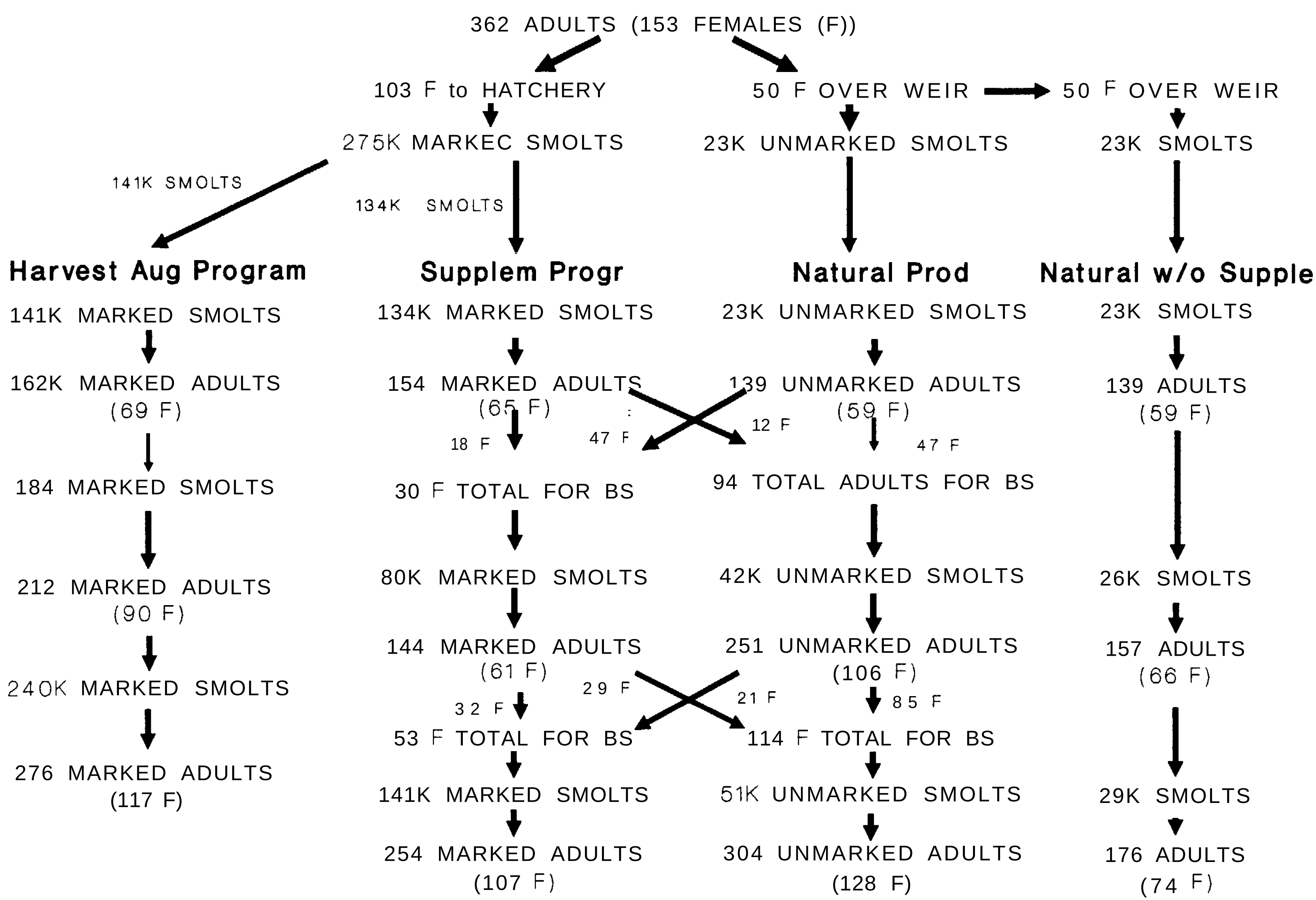
50% of the female returns taken into the hatchery
50% of the female returns passed over the weir

Supplementation brood stock strategy:

- ≥80% of natural female returns passed over the weir
- ≤20% of natural female returns used for supplementation BS
- ≥40% of supplementation BS females comprised of natural females
- ≤60% of supplementation BS females comprised of hatchery females

	Supplementation Fish	Natural Fish
% not jacks	95	95
% F w/o jacks	50	50
% prespawn. surv.	95	95
% marking survival	85	--
% green egg to fry	75	--
% green egg to emigrant	83	--
% parr to emigrant	--	30
% green egg to emigrant (w/ marking mortality)	63	9
% emigrant to adult (smolt)	0.18	0.6
eggs per female	4,000	4,000

PAHSIMEROI HATCHERY PRODUCTION MODEL



Assumptions used in modeling Pahsireroi Hatchery production scenario:

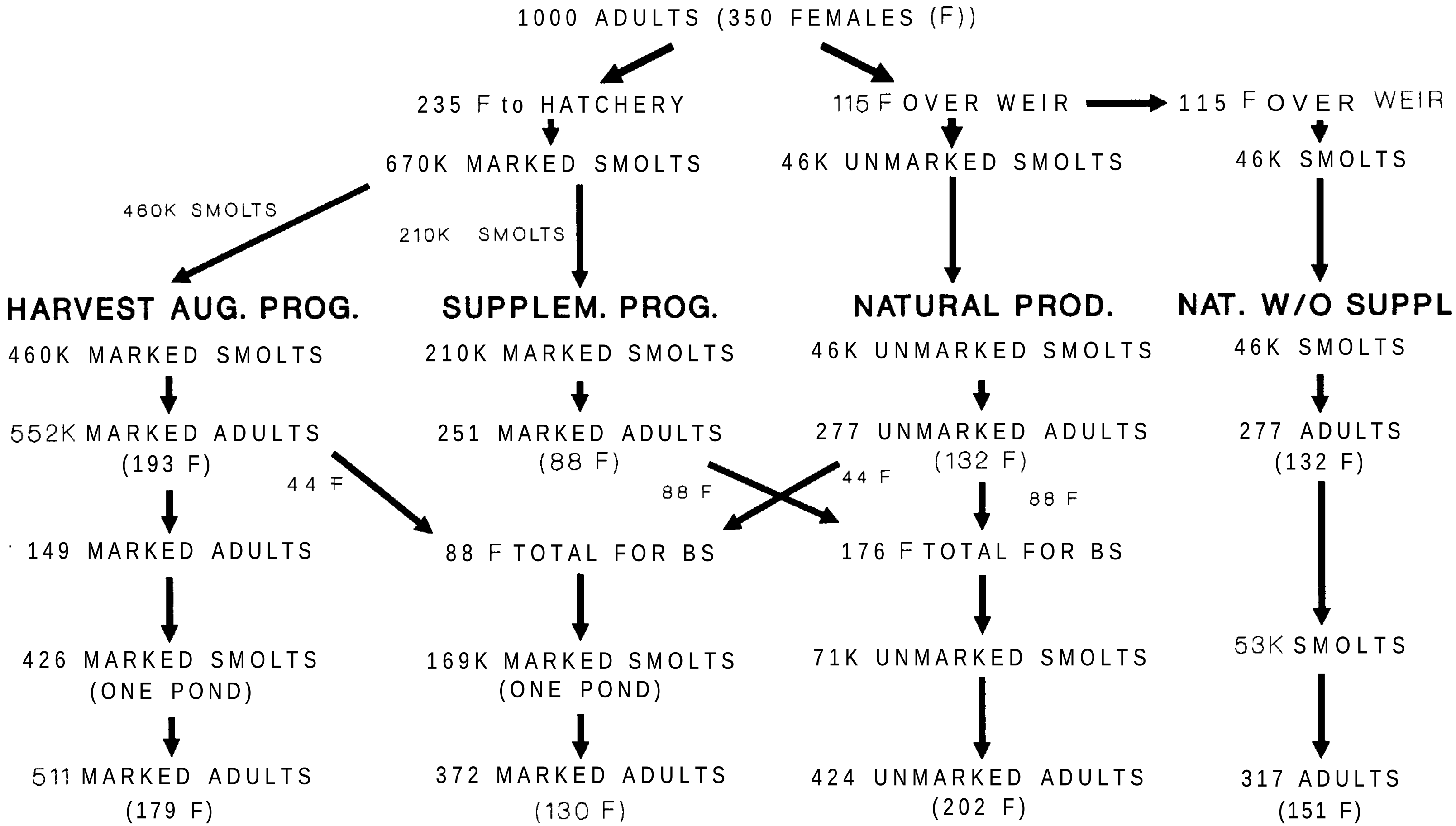
Brood stock strategy 1992-1995:

67% of the female returns taken into the hatchery
33% of the female returns passed over the weir

Supplementation brood stock strategy:
≥80% of natural female returns passed over the weir
(20% of natural female returns used for supplementation BS
≥40% of supplementation BS females comprised of natural females
≤60% of supplementation BS females comprised of hatchery females

	Pahsimeroi Production Fish	Supplementation Fish	Natural Fish
% not jacks	88	88	88
% F w/o jacks	48	48	48
% prespawn. surv.	95	95	95
% marking survival	85	85	--
% green egg to emigrant (w/ marking mortality)	54	54	9
% emigrant to adult (smolt)	0.115	0.18	0.6
eggs per female	5,200	5,200	5,200

MCCALL HATCHERY PRODUCTION MODEL



Assumptions used in modeling McCall Hatchery production scenario:

Brood stock strategy BY 1991-1995:

67% of the female returns taken into the hatchery
33% of the female returns passed over the weir

Supplementation brood stock strategy, second generation BY 1996-2000:
≥67% of natural female returns passed over the weir
(33% of natural female returns used for supplementation BS
≥50% of supplementation BS females comprised of natural females
≤50% of supplementation BS females comprised of hatchery females

	McCall Production Fish	Supplementation Fish	Natural Fish
% not jacks	70	70	95
% F w/o jacks	50	50	50
% prespawn. surv.	95	95	95
% marking survival	85	85	--
% green egg to emigrant (w/ marking mortality)	64	43	9
% emigrant to adult (smolt)	0.12	0.22	0.6
eggs per female	4,700	4,700	4,700

Appendix E. Standardized snorkeling techniques to be used in Idaho Supplementation Studies.

Methods:

The number of snorkelers depends on visibility and width of the stream.

Snorkelers move slowly but steadily upstream in an assigned lane. The widths of the lanes are determined by visibility. The snorkelers are not in a single line perpendicular to the stream. Instead, they are staggered. For example, if there are five snorkelers, one snorkeler will be close to each bank and counting fish between themselves and the banks. The next two divers will be slightly downstream (1-3m depending on visibility) and closer to the center of the stream. They count the fish that swim between themselves and the diver closest to the bank on their side. The final diver is in the middle of the stream downstream of the other four and counts all the fish the swim between the two divers and swim past him or her. In essence, the divers form a "V" in the stream. It is important that they maintain proper positioning in their respective lanes in order to maintain accuracy of the counts.

Chinook salmon are identified and counted as YOY, yearlings, or adults. All other salmonids are identified and lengths are estimated to the nearest inch. After several fish have been counted by an individual, he tells the data recorder walking on the bank behind the snorkelers. The recorder draws detailed sketch maps of the snorkeling reach, noting major habitat types, easily recognizable features of the surrounding land, etc. This person also gives detailed directions to the site, the starting and ending points, presence of flagging, and any other information that may be of value in locating the sites in the future. If a recorder is not available, all is recorded on plexiglass slates carried by the divers.

Field crews are trained prior to each field season in snorkeling techniques, fish identification, and size estimation. Calibrated dowels are carried by novices for more accurate size estimation.

Visibility is measured prior to snorkeling (with an orange and white nylon measuring tape held underwater) to insure that visibility is sufficient to allow accurate counts. In most streams, visibility is >3m. The Lemhi River is the only stream where snorkeling is not a viable option. Here, fish populations are estimated through standard electrofishing techniques.

Snorkeling is done in daylight hours, after streams temperatures have risen above 8°C. Juvenile salmonids have shown to conceal themselves when water temperatures drop to or below this level (Hillman et. al. in press; Riehle M. S. thesis ISU).

Prior to snorkeling, the streams were stratified. Streams were stratified according to Rosgen's channel classification system (i.e. "C" channel indicates a meandering low gradient reach; "B" channel indicates a higher gradient confined channel). Initial stratifications were done using USGS 7 1/2 minute topographic maps. Aerial photographs were used (where available) to double check the stratification. Also, the stratifications were validated in the field prior to any sampling.

Appendix F. Location, design and construction process for weirs to be used in Idaho Supplementation Studies.

Weirs are an important tool for evaluating the success of supplementation. They will allow us to make accurate estimates of adult escapement, calibrate redd count estimates, help determine origin and age of adult returns, and collect supplementation broodstocks.

IDFG has begun the process to renovate two existing weirs (Lemhi River and Marsh Creek) as well as an experimental hatchery facility (Hayden Creek Hatchery in the Lemhi River drainage). Preliminary design are presently being developed. Both will be picket weirs. No permits or NEPA documents are required for the Lemhi weir because it is a modification of an existing structure and no in-stream work is required. The property is owned by IDFG. A Special Use Permit and Biological Evaluation are required for the Marsh Creek weir because it is located on USFS property. NEPA documents are not required because the existing weir will only be modified and no in-stream work is needed.

Three new permanent weirs will be constructed for ISS through the cooperation of IDFG Engineering, BPA, and USFS. One will be located on the North Fork Salmon River near its mouth, another on lower Johnson Creek near Ice Hole Campground, and the third on Crooked Fork Creek near the mouth of Brushy Fork Creek. Environmental Assessments, Corp 404 permits and Stream Alteration Permits, Biological Evaluations, and Special use Permits will be required for all new construction. BPA will write the EAs, USFS will prepare the Biological Evaluations and Special Use Permits. IDFG Engineering will obtain the Corp 404 and Stream Alteration Permits. Preliminary design work will be done concurrently during the permiting process.

The following tables summarize the location, type and estimated costs of these weirs.

Table F.l. Locations, types, and estimated costs of weirs associated with ISS. Types include new or existing, rennovation projects, permanent or temporary adult weirs, picket, floating, electric, or velocity barriers.

Location	New/Exist. (N/E)	Type: Rennovation (R)	Type: Perm./Temp. (P/T)	Type: Picket/Float/E&. Electric/Veloc. (P/F/E/VB)	costs (x1000)
Clearwater River Drainage					
Crooked Fork	N		P	P/F	60
Papoose Cr	N		T	P	10
Powell	E		P	F	--
Squaw Cr	N		T	P	10
Clear Cr	E		P	E	--
Red R	E		P	P	--
Crooked R	E		P	P	--
Salmon River Drainage					
Lemhi R.	E	R	P	P	35*
Pahsimeroi R	E		P	P	--
N FK Salmon	N		P	P	50
E FK Salmon	E		P	P	--
W FK Yankee FK	N		T	P	10
Marsh Cr	E	R	P	P	20
Valley Cr	N		T	P	10
Upper Salmon	E		P	P	--
S FK Salmon	E	R**	P	P	50
Johnson Cr	N		P	P/VB	60

* = Includes money to rennovate Hayden Creek Hatchery.
** = Entails adding a concrete sill to make the weir functional during high water.

Table F.2. Treatment and control streams with existing or proposed weirs to be used for Idaho Supplementation Studies. These streams also will have juvenile outmigrant traps associated with them.

Treatment Streams	Control Streams
WEIRS IN TEE SALMON RIVER DRAINAGE	
NEW WEIRS AND WEIR RENOVATIONS - PERMANENT	
Lemhi River[a]	Marsh Creek[b]
Slate Creek	North Fork Salmon River
	Johnson Creek
EXISTING PERMANENT WEIRS	
South Fork Salmon River	
Pahsimeroi River	
East Fork of the Salmon River	
Upper Salmon River and Alturas Lake Creek	
TEMPORARY ADULT WEIRS	
Lower South Fork Salmon River	
West Fork Yankee Fork	
WEIRS IN THE CLEARWATER RIVER DRAINAGE	
NEW WEIRS -PERMANENT	
Lolo Creek[c]	
Newsome Creek[a]	
Upper Crooked Fork Creek	
EXISTING PERMANENT WEIRS	
Clear Creek	
Lochsa River (mouth of Crooked Fork and White Sands Creeks)	
Crooked River	
Red River	
TEMPORARY ADULT WEIRS	
Lower Red River	Brushy Fork Creek
American River	
Squaw Creek	
Papoose Creek	
Pete King Creek	

[a] Renovation of an existing weir with the downstream migrant trap built in to the weir.
[b] Renovation of an existing weir with the downstream migrant trap being a separate (removable) unit (i.e. a screw type trap).
[c] Part of the Nez Perce Tribe's hatchery program.

Note: Only permanent weirs will have downstream migrant traps associated with them. Traps for three streams (Lo10 Creek, Newsome Creek, and Slate Creek) will be provided by the Nez Perce Tribe as part of their hatchery program. The upper Salmon River and Crooked River presently have outmigrant traps operating as part of Russ Kiefer's (IDFG) intensive smolt monitoring project. The Lemhi River weir has a trap built into it, but it needs renovation.

Appendix G. Basic design, duration and assumptions for each research question associated with Idaho Supplementation Studies.

Question 1. Does supplementation of existing chinook populations enhance natural production?

Blocks

Life Stage:	Presmolt	Smolt

Treatment

Supplemented:	(3 reps) Lolo Cr. Red R. Crooked Fk. Cr.	(8 reps) Lemhi R. U. East Fk. S.R. U. Salmon R. U. South Fk. S.R. Pahsimeroi R. W.F. Yankee Fk. Alturus Lake Cr. Clear Cr.

Control

Unsupplemented:

(8 reps)
N.F. Salmon R.
Herd Cr.
Marsh Cr.
Bear Valley Cr.
U. Valley Cr.
Lake Cr.
Brushy Fk. Cr.
Camas Cr.

Response (dependent) variables:

Redd or adult numbers, parr numbers, smolt numbers.

Duration:

5 yrs pre-treatment (1 generation), 10+ years treatment (2 gen.)

Assumptions:

Precision of point estimates (per stream per year):
- Redd or adults - complete census
- parr and smolts - CV of 15% (alpha=0.10).

Geographic (Salmon R. vs. Clearwater R.) effects are insignificant.
Race effects are insignificant.
Broodstock management effects are insignificant.
Domestication effects are insignificant.
Individual hatchery effects are insignificant.
Habitat effects are insignificant.

Note: The assumptions of insignificance for this and the following tables refer to the experimental design (non confounding) and NOT necessarily to supplementation in general.

Question 2. Does restoration utilizing existing hatchery stocks establish natural production?

Blocks

	Parr	Presmolt	Smolt
Life stage:			

Treatment

	Parr	Presmolt	Smolt
Supplemented:	(3 reps) White Sand Cr. Big Flat Cr. Pete King Cr.	(3 reps) Crooked R. Newsome Cr. Slate Cr.	(2 reps) Papoose Cr. American R.

Control

	Parr
Unsupplemented:	(3 reps) Brushy Fk. John's Cr. Bear Cr.

Note: Salmon River control streams will be used to help control post release variability.

Response Variables

Redd or adult, parr, and smolt numbers, survival between life stages, recruits per spawner.

Duration

5 yrs pretreatment (1 gen), 5 yrs treatment (1 gen).

Assumptions

Precision of point estimates:
- Redd or adult numbers - complete census
- Parr and smolt numbers - CV of 15% (alpha=0.10).
- Survival between life stages - undetermined (assume CV of 15%; alpha=0.10).

Geographic effects are insignificant.
Individual hatchery effects insignificant.
Habitat effects are insignificant.

Question 3. Does supplementation of existing populations reduce natural productivity below acceptable levels?

Blocks

Life Stage:	Presmolt	Smolt

Treatment

Supplemented:	(3 reps) Lolo Cr. Red R. Crooked Fk. Cr.	(8 reps) Lemhi R. U. East Fk. S.R. U. Salmon R. U. South Fk. S.R. Pahsimeroi R. W.F. Yankee Fk. Alturus Lake Cr. Clear Cr.

Control

Unsupplemented:	(8 reps) N.F. Salmon R. Herd Cr. Marsh Cr. Bear Valley Cr. U. Valley Cr. Lake Cr. Brushy Fk. Cr. Camas Cr.

Response (dependent) variables:
Age of maturity, fecundity, survival, recruits per spawner.

Duration:
5 yrs pre-treatment (1 generation), 10+ yrs treatment (2 gen.)

Assumptions:
- Precision of point estimates undetermined (assume CV of 15%; alpha = 0.10)
- Geographic effects are insignificant
- Race effects are insignificant
- Individual hatchery effects are insignificant
- Habitat effects are insignificant
- Broodstock management effects are insignificant

Question 4. Can existing hatcheries and broodstocks be used effectively to supplement existing populations within local or adjacent subbasins?

Blocks
None

Treatment

Supplemented:	(7 reps)
BY 91-95	U.SR
(1st Generation)	U.EFSR
	U.SFSR
	Pahsimeroi
	Alturas Lake Cr.
	WF Yankee Fork
	Clear

Control

Unsupplemented:	(7 reps)
	NFSR
	Marsh
	Bear Valley
	Lake Cr.
	U. Valley
	Herd
	Camas

Response (dependent) variables:
Redd or adult, parr, and smolt numbers; survival between life stages; recruits per spawner.

Duration:
5 yrs pre-treatment (1 generation), 5 yrs treatment (1 generation).

Assumptions:
Precision of point estimates:
Redd or adult numbers - complete census
Parr and smolt numbers - CV of 15% (alpha=0.10).
Survival between life stages - undetermined (assume CV of 15%; alpha=0.10).
Race effects are insignificant.
Individual hatchery effects insignificant.
Habitat effects are insignificant.

Question 5. Is there an advantage to developing new, localized broodstock with a known natural component for supplementation of existing natural populations?

Treatment

Supplemented with existing hatchery Broodstock: BY 91-95 (1st Generation)	(8 reps) U. Salmon River U. East Fork SR U. South Fork SR Pahsimeroi R. Alt. Lake Cr. WF Yankee Fork Red R. Clear Cr.
Supplemented with new, localized Brood Stock: BY 95-00 (2nd Generation)	(10 reps) U.SR/Alt. Lake Cr. U. East Fork SR U. South Fork SR Pahsimeroi R. WF Yankee Fork Red R. Clear Cr. Lolo Cr.
BY 91-00 (1st & 2nd Gen)	Lemhi R. Crooked Fork *Cr.*

Control

Unsupplemented:	(8 reps) N.F. Salmon R. Herd Cr. Marsh Cr. Bear Valley Cr. U. Valley Cr. Lake Cr. Brushy Fk. Camas Cr.

Response (dependent) variables:
Redd or adult, parr, and smolt numbers; survival between life stages; recruits per spawner.

Duration:
5 yrs pretreatment (1 generation), 5 yrs 1st treatment (1 generation), 5+ yrs 2nd treatment (1 generation).

Assumptions:
Precision of point estimates:
Redd or adult numbers - complete census
Parr and smolt numbers - CV of 15% (alpha=0.10).
Survival between life stages - undetermined (assume CV of 15%; alpha=0.10).
Geographic, habitat, race and life stage effects are insignificant.
Individual hatchery effects are insignificant.

Question 6. What life stage released (smolt, presmolt, parr) provides quickest and highest response in natural production?

		Existing Pop.	No Existing Pop.
Blocks	Present Status:	Existing Pop.	No Existing Pop.
Treatment	Parr:	(0 reps)	(4 reps) Squaw White Sand Big Flat Pete King
	Presmolt:	(3 reps) Lolo Red Crooked Fork	(3 reps) Newsome Crooked Slate
	Smolt:	(8 reps) WFYF Alt. Lake Cr. U.SR U.EFSR U.SFSR Pahsimeroi Lemhi Clear	(2 reps) Papoose American
Control	unsupplemented:	(7 reps) NFSR U. Valley Marsh BVC Lake Herd Camas Cr.	(3 reps) Brushy Fork Bear Johns

Response (dependent) variables:
Redd or adult, parr, and smolt numbers.

Duration:
5 *yrs* pretreatment (1 Generation), 5-10+ yrs treatment (l-2 Gen.).

Assumptions:
Precision of point estimates (per stream per year):
Redd or adults - complete census
parr and smolts - CV of 15% (alpha=0.10).
Geographic (Salmon R. vs. Clearwater R.) effects are insignificant.
Race, habitat and domestication effects are insignificant.
Broodstock management effects are insignificant.
Individual hatchery effects are insignificant.

Question 7. How often is supplemenation required to maintain populations at satisfactory levels?

Blocks Supplementation Program:	Restoration	Augmentation
Treatment Supplemented:	(9 reps) Squaw White Sand Big Flat Pete King Newsome Crooked Slate Papoose American	(11 reps) Lolo Red Crooked Fork WFYF Alturas Lk. Cr. U.SR U.EFSR U.SFSR Pahsimeroi Lemhi Clear
Control Unsupplemented:	(3 reps) Brushy Fk. Bear Johns	(7 reps) North Fork SR U. Valley Cr. Marsh Cr. Bear Valley Cr. Lake Cr. Herd Cr. Camas Cr.

Response (dependent) variables:
Recruits per spawner; rate of change in numbers following termination of supplementation.

Duration:
5-10 years treatment (l-2 generations), 0-5+ yrs post treatment.

Assumptions:
- Precision of point estimates undetermined (assume CV of 15%; alpha = 0.10).
- Geographic effects are insignificant.
- Race effects are insignificant.
- Broodstock management effects are insignificant.
- Domestication effects are insignificant.
- Individual hatchery effects are insignificant.
- Habitat effects are insignificant.

Question 8. What life stage released (parr, presmolt, smolt) results in least deleterious effects on existing natural productivity and genetic integrity?

Treatment
Supplemented:

Parr	Inferences made from small scale studies.
Presmolt	(3 reps) Crooked Red Lolo
Smolt	(7 reps) U.SR/Alt Lake Cr. U.EFSR U.SFSR Pahsimeroi WFYF Lemhi Clear

Control
Unsupplemented:

(8 reps)
NFSR
Marsh Cr.
Bear Valley Cr.
Lake Cr.
U. Valley
Herd Cr.
Brushy Fk.
Camas Cr.

Response (dependent) variables:
Age of maturity, fecundity, survival, recruits per spawner, genetic profiles (allelic frequencies, heterozygosity).

Duration:
5 yrs pretreatment (1 Generation), 10+ yrs treatment (2 Generation), 0-10 years post treatment.

Assumptions:
- Precision of point estimates undetermined (CV of 15%; alpha = 0.10)
- Geographic effects are insignificant
- Race effects are insignificant
- Individual hatchery effects are insignificant
- Habitat effects are insignificant

Appendix H. Basic hypotheses and designs of small-scale studies associated with Idaho Supplementation Studies.

Appendix I. Pilot study to assess the feasibility of developing and using genetic markers to differentiate natural and supplementation fish used in Idaho Supplementation Studies.

IDAHO SUPPLEMENTATION STUDIES
SHORT-TERM STUDIES

Research Proposal: Executive Summary

Project title: Ecological effects of hatchery reared chinook salmon on natural produced chinook salmon.

Investiaators: T.C. Bjornn, and C.A. Peery, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho.

Time Period: 1 January 1992 - 1 March 1995.

Backaround: The use of hatchery-produced salmon and steelhead to supplement natural stocks has increased as the abundance of natural stocks have declined. It is known, however, that intensive hatchery practices yields fish which vary genetically and behaviorally from their wild counterparts (Waples 1990). It is the concern of researchers and managers that indiscriminate use of these hatchery fish may jeopardize the genetic purity of the remaining naturally-produced salmon and steelhead stocks. But it is also important that the hatchery-produced fish be used in an efficient manner, so as to achieve the maximum returns for the resources invested. It is a goal of the Idaho Supplementation Studies (ISSI to address both of these concerns using both a long and short-term series of studies. This proposal summarizes the procedures to be used during some short-term studies. A short-term study will last two to four years and will focus on seasonal effects of stocking techniques and the interactions between hatchery and naturally produced chinook salmon, using both field observations and control experiments conducted in artificial stream channels.

In general, the interactions between hatchery and natural chinook salmon can include predation and competition for food and habitat. These interactions can lead to modified movement, migration behavior, growth rates, reproductive success, and genetic makeup in the natural populations (Steward and Bjornn 1990).

Objectives

Obiective 1. Determine if hatchery-produced juveniles chinook salmon successfully disperse, survive, and grow following release into infertile Idaho streams.

Obiective 2. Determine the importance of size and density of hatchery fish at time of stocking on the interactions between hatchery and naturally-produced chinook salmon.

Obiective 3. Determine if resident trout, particularly brook trout, reduce the productivity of released hatchery chinook salmon.

Obiective 4. Determine the effects of passage constraints on the survival of chinook salmon smolts migrating from the Lemhi River to Lower Granite Dam.

Procedures

The study will consist of both field observations and experiments conducted in artificial stream channels.

Objective 1. Dispersion, survival, and growth of hatchery chinook salmon parr and presmolts will be monitored in selected streams in the Salmon River drainage using both snorkel surveys and trapping operations. The number and locations of streams stocked will depend on the availability of hatchery fish during the given year. Prior to stocking, snorkel surveys will be conducted at selected streams sites to classify the size and distribution of the natural salmon and trout populations in the streams. During, and following, addition of the hatchery parr the surveys will be repeated weekly to monitor dispersion of the hatchery fish up and downstream from the stocking site(s), their habitat use, and if they are displacing, or are displaced by the natural salmon and trout populations. All hatchery fish will be marked with a fin clip or with a Panjet marker so they can be differentiated from natural fish. We will attempt to use one of three stocking strategies, releasing all fish at a single site, at two sites, or at three sites. One of the three release treatments will be used in one stream alternately over a three year period. The use of more than one release strategy during any given year will depend on the availability of hatchery fish and the number of streams stocked during that year.

Concurrent with the snorkel surveys, trapping operations will be conducted at existing weirs, or at temporary fence weirs, placed downstream from the lowest snorkel site. The trapping operation will be used to monitor the growth and dispersion/displacement of the hatchery and natural fish from the area between the release site and the trap. Fish collected in the traps will be checked for marks, lengthed, weighed, and released downstream from the trap. Selected releases of marked fish will be made to determine the capture efficiency of the trap. Seining and electrofishing may also be used at the end of the summer growing season to estimate growth and dispersion of the hatchery fish throughout the stream. These observations can be used to assess the potential productivity of planting hatchery chinook salmon parr and presmolts in Idaho streams.

Objective 2. The importance of fish size and density on the potential interactions that occur between hatchery and natural chinook salmon will be investigated using experiments conducted in artificial stream channels at the Hayden Creek Research Station, and at Big Springs Creek, on the Lemhi River. The channels will be divided into 12 stream sections mimicking a natural riffle-pool-riffle complex. Individual experimental trials will consist of placing various sizes and densities of hatchery and/or natural chinook salmon into the stream sections for periods of time, during which observations will be made through view ports set into the sides of the channel. All hatchery fish used during for the trials will be marked so that they can be differentiate from the natural fish during observation periods. Trials will last approximately two weeks, after which the experiment will be terminated and a new series run. Hatchery fish used for these trials will be provided from hatcheries, while natural fish will be collected from the Lemhi River using traps.

During a trial, observations will be made four or more times a day, for five minutes each per stream section, to record feeding position and habitat use by the hatchery and natural fish. In addition, longer observation periods will be conducted periodically to monitor other behavior, such as aggressive encounters, habitat displacement, and feeding techniques. Traps placed at the up and downstream ends of each stream section will be emptied daily to monitor voluntary movement by the fish out of the sections. Following completion of a trial the natural fish will be released back into the Lemhi River and hatchery fish will be removed to holding tanks. We will attempt to use only naive hatchery fish in each experimental trial so that learned behavior by the hatchery fish will not bias the results of subsequent trials.

Experimental trials will be initiated in the spring and continued through the summer and into the fall to investigate the interactions as the fish increase in size. Two hatchery "planting" densities will be used to produce 0.5:l and 1 :l ratios of hatchery:natural fish during the trials. The results from these experiments can be used for developing stocking strategies which optimize hatchery productivity and minimize effects on the natural salmon populations.

Objective 3. The effect of resident trout on the survival of naturally produced and hatchery chinook salmon will be observed using flume experimental trials and during stream studies. Experimental trials in the Hayden Creek flume will be used the determine the predation pressure resident trout inflict on hatchery and natural chinook salmon juveniles, and the preference juvenile salmon have to migrate from stream sections containing trout.

Following the initial experimental trials at Hayden Creek, further studies can be conducted at selected stream sites. During the stream studies we would monitor the size and distribution of the resident trout and salmon populations prior to and following stocking of hatchery Parr. The resident trout may also be removed from stream sections prior to natural production to compare fingerling survival with that in sections still containing trout. Possible streams to be used for observations of natural chinook salmon with trout removal include Marsh and Valley Creeks and their tributaries. The results from these trials could be used to assess the effects of resident trout at potential hatchery outplanting sites.

Objective 4. Migration success and survival of chinook salmon smolts in the Lemhi River and to Lower Granite Dam will be assessed using PIT tagged chinook salmon. During the fall of 1991, we will release 500 PIT tagged natural chinook salmon smolts moving down the Lemhi River and in 1992, 900 chinook salmon smolts will be collected and PIT tagged at the Lemhi River Weir and released at three sites: the upper Lemhi, at the weir, and downstream at the confluence of the Lemhi and Salmon rivers. The survival of smolts from these four releases will help us determine the problems associated with the downstream migration of smolts through the Lemhi River and to Lower Granite Dam.

References

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Prepared; 17 December 1991

Research Proposal

ECOLOGICAL EFFECTS OF HATCHERY-REARED CHINOOK SALMON ON NATURALLY PRODUCED CHINOOK SALMON

by the

Idaho Cooperative Fish and Wildlife Research Unit

University of Idaho, Moscow, Idaho 83843, USA

December 199 1

Study Plan

Project title: Ecological effects of hatchery-reared chinook salmon on naturally produced chinook salmon.

Principle investiaator: T. C. Bjornn.

Student Investioator: C. A. Peery.

Fundina source: Idaho Department of Fish and Game.

Time period: 1 January 1992 - 1 March 1995.

Backaround: The decline of the salmon and steelhead populations in the Columbia River basin has been due in part to the construction of dams on the Columbia and Snake Rivers. As partial compensation for the loss of salmon stocks caused by dams, state and federal governments have constructed and operated several hatcheries to help increase production of salmon and steelhead. However, although hatchery production has increased over the years, the size of the remaining natural salmonid populations have continued to decline. It has become a high priority within Idaho and the Columbia River Basin to assess the benefits and risks associated with using hatcheries to enhance naturally reproducing salmon and steelhead populations. These efforts are necessary to determine the relative utility of supplementation as a recovery tool for anadromous stocks. Towards this purpose the Idaho Department of Fish and Game, in cooperation with several other state and federal agencies, has undertaken an extensive project to evaluate and enhance hatchery supplementation activities in the state of Idaho. The goal for supplementation in Idaho, as identified in the Idaho Supplementation Studies (IS!3 design, is to develop self sustaining and harvestable populations of chinook salmon and steelhead in the Salmon and Clearwater River drainages without adversely impacting existing natural populations. The ISS is to be a long term project encompassing three generations of chinook salmon production over a period of 12 to 15 years.

The two main objectives of the project are, (1) to develop optimal supplementation strategies, and (2) to evaluate the effects of supplementation on the natural chinook salmon populations. These objectives will be carried out using both long term and short-term studies. In general, the long term study of the ISS project will monitor several different stocking techniques to determine which produces the greatest adult returns one, two, and three generations later. The short term projects will last two to four years and will focus on seasonal effects of stocking techniques on hatchery and naturally produced chinook salmon productivity, and on the potential interactions between hatchery and natural fish in Idaho streams. This proposal outlines the procedures to be used during a short-term study.

Hatchery-reared chinook salmon have been stocked in drainages throughout Idaho for many years now, but little is known of the resulting productivities of these fish, or of the effects they have on the natural/wild populations present in those streams. It is a concern of fisheries managers that the intensive rearing practices used at modern hatcheries are producing fish which are ecologically inferior to their wild counterparts. The productivity of hatchery reared chinook salmon after release will depend on their abilities to disperse, feed, and avoid predation. These factors will be especially important for chinook salmon stocked as parr because of the extended time they will spend in streams before emigrating as smolts.

Few studies have been completed investigating the fate of hatchery-reared chinook salmon parr following their release into infertile Idaho streams. Hillman and Mullan (1989) reported that hatchery chinook salmon parr released into the Wenatchee River, Washington, were observed to drift downstream as a group near the surface of the water, feeding in a random fashion on debris as it was encountered. This was in sharp contrast to the natural chinook juveniles in the river which typically maintained a set station in shallow water near instream cover. The survival or growth of these hatchery chinook salmon was not monitored following their release. But in a separate study, hatchery coho salmon subyearlings released into two side channels of the Wenatchee River showed lower growth than the natural chinook salmon and steelhead in the same system (Spaulding et al. 1989). Similarly, hatchery-reared catchable rainbow trout released into a stream in California continually lost weight through the summer and fall, reducing their ability to survive the winter (Reimers 1963). It was thought that this weight loss was due to an inability of the rainbow trout to effectively feed on the natural food items in the stream.

It is uncertain how hatchery-reared chinook salmon parr and presmolts will disperse following their release into streams. Hillman and Mullan (1989) reported that the juvenile chinook salmon left the Wenatchee River in about 1.5 days (35 km/day) following their release. This quick emigration from the stocking area was probably related to the large size of the fish (84-100 mm fl), nearing smolt size. In contrast, Richards and Cernera (1988) reported that chinook salmon parr averaging 56 mm total length released into the Yankee Fork of the Salmon River remained within 1 to 2 km of the release sites, suggesting that dispersion of hatchery chinook salmon may be related to their size at release. Predation by resident trout can affect the survival of outplanted hatchery chinook salmon, especially in streams where trout have become established since the decline of the local wild salmon stock. Kennedy and Strange (1986) reported that Atlantic salmon eyed eggs planted in a Northern Ireland stream had twice the survival as fry in a section with trout removed than in sections with trout present. Similar manipulations may be successful in Idaho streams.

The types of interactions possible between hatchery and natural fish include intra- and interspecific predation, and competition for food and habitat. These interactions can result in modifications in the movement patterns, migration behavior, growth rates, reproductive success, and genetic makeup of the natural populations (Steward and Bjornn 1990). The degree of interactions occurring between hatchery and natural chinook salmon will be dependent on the size and density of hatchery fish stocked and the characteristics of the system they are stocked into.

Hatchery fish typically spawn earlier than the associated local natural stocks, due to selection at hatcheries. Early spawners would produce offspring which emerge and begin growing sooner, and thus have a size advantage over the offspring from the natural (later) spawners. When present in large numbers these larger hatchery fish may displace the local natural fish, facilitating their premature emigration from the system. This phenomenon was investigated by Chandler and Bjornn (1988) using early and late emerging steelhead fry in the Big Springs Creek channels, on the Lemhi River. They found that when early emerging steelhead fry were present, the late emerging fish were more likely to emigrate from the channels. There was also an indication that the presence of the early fish could reduce the growth of the late fish. Chapman (1962) observed that the coho salmon fry migrating downstream following emergence tended to be smaller than the coho fry not moving. Further studies conducted in experimental stream channels lead Chapman (1962) to suggest that aggressive behavior by the larger stationary coho salmon contributed to the emigration of the smaller fish from the natal rearing area.

The results of these studies should be considered with regards to the supplementation of natural chinook salmon stocks with hatchery fish. Unfortunately, few studies have been made which specifically investigate chinook salmon hatchery-natural interactions occurring in Idaho rivers and streams. In the one study where hatchery reared juveniles chinook salmon were observed following their release into the Wenatchee River it was noted that the natural subyearling chinook salmon would leave their stations at the margins of the river and join the hatchery fish as they drifted downstream (Hillman and Mullan 1989). These natural chinook salmon juveniles then became the selective targets of predacious attacks by rainbow trout. The selective attacks by the trout on the natural fish may have been due to the fact that the wild fish were half the size (40-50 mm) of the hatchery chinook salmon (Hillman and Mullan 1989). In another study it was reported that coho salmon fingerlings stocked in Oregon coastal streams resulted in displacement of 44% of the natural coho salmon juveniles (Nickelson et al. 1986). And, when hatchery coho salmon parr were stocked into blocked off side channels of the Wenatchee River there was observed a shift in the habitat used by the local natural chinook salmon juveniles to segregate themselves from the larger hatchery coho salmon; although the coho salmon appeared to have no effect on the numbers or growth of the chinook salmon (Spaulding et al. 1989). Effects on natural trout populations from the stocking of hatchery reared rainbow trout catchables have been mixed. Vincent (1975; 1987) reported drastic improvements in the wild trout production following cessation of stocking catchable rainbow trout in the Madison River, Montana, while other researchers observed no significant interactions between natural and hatchery trout stocks (Hillman and Chapman 1989; Petrosky and Bjornn 1988; Pollard and Bjornn 1973). One indirect effect of stocking hatchery catchable trout however, was that anglers attracted to an area by the stocked fish could remove a significant portion of the natural steelhead smolts from the system (Hillman and Chapman 1989; Pollard and Bjornn 1973).

Another potential result of adding hatchery fish to a system is a reduction of the genetic fitness in the natural stocks. For example, Deschutes River steelhead raised in a hatchery were found to be genetically different from their wild counterparts, and the offspring resulting from crosses with these hatchery fish (HxW and HxH crosses) had lower survival rates than the offspring from pure wild crosses (WxW) (Reisenbilcher and McIntyre 1977). Also, in the Oregon coastal streams supplemented with hatchery coho salmon three years previously it was seen that returning adults tended to spawn earlier than the coho salmon in the unstocked streams, resulting in an earlier emergence and lower survival of their offspring (Nickelson et al. 1986).

It is the purpose of this study to investigate the factors associated with the supplementation of natural chinook salmon populations with chinook salmon juveniles raised in intensive culture hatcheries. Specifically, we will document the survival, dispersion, and growth of hatchery chinook salmon parr and presmolts during the period of time they spend rearing in Idaho streams. We will also use artificial stream channels to observe the types and degree of interactions occurring between the natural and hatchery chinook salmon at various size and density levels. The results from these studies will be related to the effectiveness of different stocking strategies to enhance natural production of chinook salmon stocks in Idaho rivers and streams.

Objectives: for 1992 - 1995

The overall goal of this study is to determine the effects stocking hatchery-reared chinook salmon will have on the productivity of both the hatchery fish and the natural populations of chinook salmon juveniles existing in the streams. During this study we will focus on the interactions occurring between hatchery-reared chinook salmon juveniles, naturally produced chinook salmon juveniles, and resident trout.

The objectives and the associated null hypothesis pertaining to the investigation of these interactions are as follows.

Obiective 1, Determine if hatchery reared parr and presmolt chinook salmon will successfully disperse, survive, and grow following release into infertile Idaho streams.

> Hola: Hatchery produced chinook salmon will disperse in a uniform pattern throughout the streams in which they are stocked.
>
> Ho1 b: Hatchery reared chinook salmon will successfully feed and will continue to grow following their release into infertile Idaho streams.

Obiective 2. Determine the importance of size and density of hatchery fish at time of stocking on the interactions between hatchery and naturally-produced chinook salmon.

> Ho2a: The density of hatchery chinook salmon will have no affect on the survival, habitat use, or movement patterns of the hatchery and natural chinook salmon in the system.
>
> Ho2b: The size of the hatchery chinook salmon will have no affect on the survival, habitat use, or movement patterns of the hatchery and natural chinook salmon in the system.

Obiective 3. Determine if resident trout, particularly brook trout, reduce the abundance and habitat use of wild or hatchery chinook salmon.

> Ho3a: The presence of resident trout will have no affect on the survival and growth of wild or hatchery chinook salmon in the system.

Obiective 4. Determine the effects of sub basin passage constraints on the survival of chinook salmon smolts migrating from the Lemhi River to Lower Granite Dam.

> Ho4a: There is no difference in the survival of chinook salmon to Lower Granite Dam of smolts migrating from the upper, middle, or lower stretches of the Lemhi River.

Studv area: Initially it had been proposed that hatchery reared chinook salmon Parr, presmolt, and smolts would be stocked in the rivers and streams outlined in table 1, which would have allowed observations of hatchery fish in these streams. However, due to the low returns of adult spawners to the Snake River drainage this past fall it is questionable how many of the planned releases will be carried out in the coming 1992 and 1993 field season. Snorkel surveys will be carried out in 1992 in selected streams to monitor natural chinook salmon and resident trout populations, as well as hatchery releases where fish are available. Controlled experiments will be conducted in flumes at the Hayden Creek Research Station and at Big Springs Creek, tributaries of the Lemhi River (Figure I).

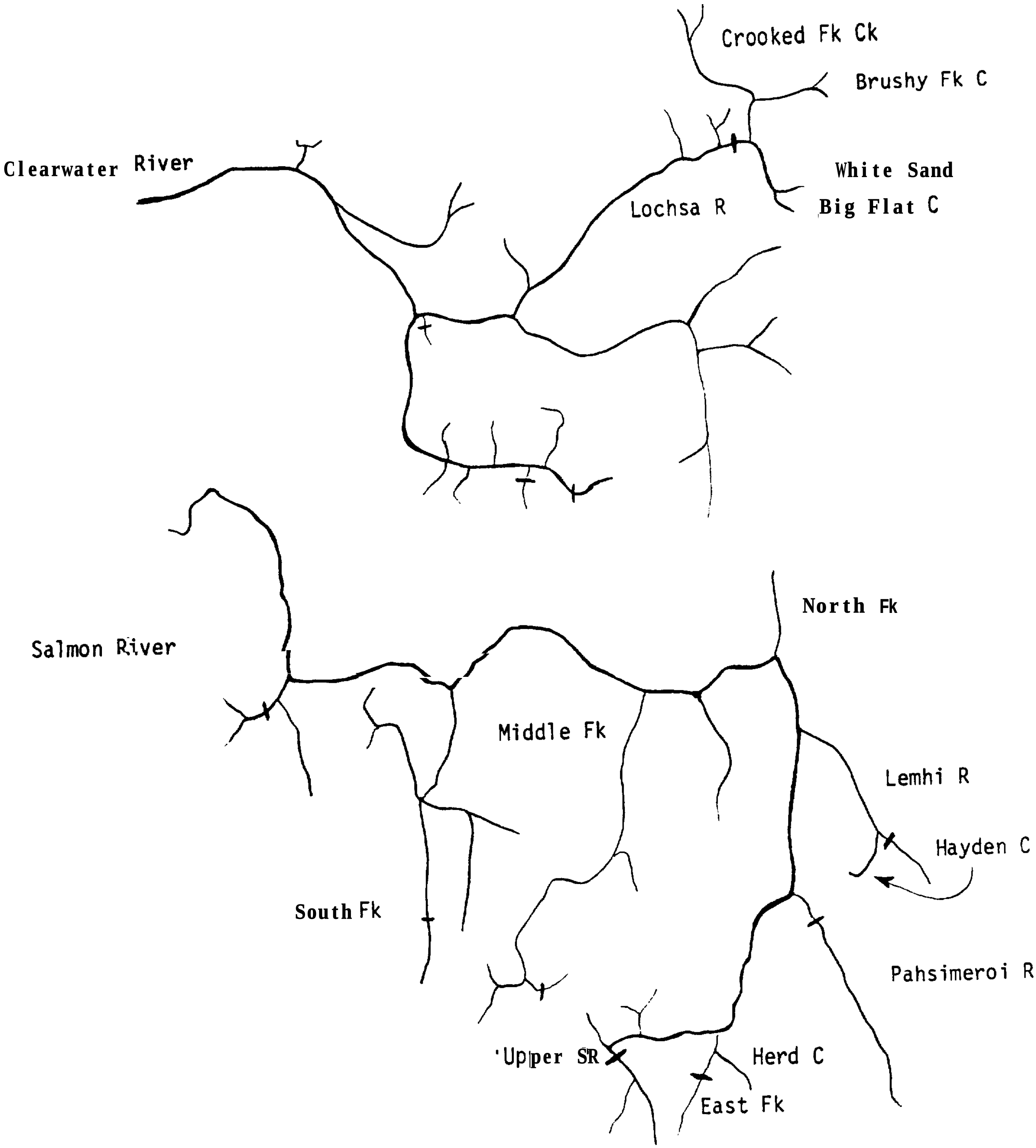

Figure 1. Snorkel survey and trapping sites in the Salmon and Clearwater River Basins.

Table 1. Proposed sites for supplementing spring and summer chinook salmon for Idaho Supplementation Studies.

Stream	Life stage	Stream	Life stage
Clearwater River drainage		Salmon River drainage	
American River	smolt	Upper Salmon River	smolt
Clear Creek	smolt	Alturas Lake Creek	smolt
Papoose Creek	smolt	Upper EF Salmon River	smolt
White sand Creek	parr	Upper SF Salmon River	smolt
Big Flat Creek	parr	Lemhi River	parr/smolt
Squaw Creek	parr	WF Yankee Fork	smolt
Pete King Creek	parr	Pahsimeroi River	smolt
Crooked Fork Creek	presmolt	Slate Creek	presmolt
Red River	presmolt	Bear Valley Creek	control
Newsome Creek	presmolt	Upper Valley Creek	control
Lolo Creek	presmolt	Marsh Creek	control
Crooked River	presmolt	Bear Valley Creek	control
Brushy Fork	control	Johnson Creek	control
Bear Creek	control	Lake Creek	control
Johns Creek	control	Herd Creek	control
		Camas Creek	control

Procedures

The study will consist of both field observations in the streams and rivers being supplemented, and experiments conducted in artificial stream channels. The species and life stages of fish being focused on during this study will be hatchery-reared chinook salmon Parr, presmolts and smolts, naturally-produced chinook salmon parr and smolts, and naturally-produced trout.

Obiective 1. Survival of hatchery fish in infertile streams. Proceeding with this objective will be dependent on the availability of hatchery chinook salmon for stocking.

Dispersion, survival, and growth of hatchery chinook salmon parr and presmolts will be monitored in selected streams in the Salmon and Clearwater drainages using snorkel surveys and trapping operations. One or more unstocked streams will also be monitored as controls for the stocked streams. The number and locations of streams used for observations will depend on the stocking schedule for that year. Within each stream to be stocked four or five stream sections will be selected for monitoring. One section will be at the stocking site(s), one will be upstream from the stocking site, and two or three will be downstream from the stocking site. A stream section will contain at least one riffle-pool-riffle complex. Prior to addition of the hatchery fish the stream sections will be snorkeled by one or two workers moving slowly upstream through the site to classify the size and distribution of the natural salmon and trout populations. Observations to be made will include the location and habitat type associated by each natural chinook salmon seen, and the number of other species in the area. Locations will be classified by the depth of water column, distance up from substrate, and distance from shore. Habitat type will be classified as pool, riffle, or run, substrate type immediately below the fish, and the type and proximity to cover (riparian, overhead, undercut bank, instream woody debris, or none). Following the survey a sketch will be made of the locations of all observed fish within the stream section. Water surface area, average depth, water flow and temperature at each snorkel site will also be recorded.

At the time of stocking a worker will be in the water to observe the dispersion behavior of the hatchery chinook salmon. Hatchery fish released will be marked with a fin clip or with a Panjet marker so that they can be differentiated from the natural fish. Releases of hatchery fish will done using one of three strategies, releasing all the fish at single site, at two sites, or at three sites. The number of release strategies to be used during a field season will depend on the number of streams to stocked during that year. Following the release of the hatchery chinook salmon parr the snorkel surveys will be repeated every seven to 14 days to monitor the density, distribution, and habitat use by the hatchery and natural fish upstream and downstream from the stocking site(s). Snorkel surveys will continue through the field season and into the winter months. From these surveys we hope to be able to determine dispersion rates and if the hatchery fish are displacing, or are being displaced by the natural chinook salmon and trout.

Traps will be used to monitor the growth and dispersion of the hatchery and natural chinook salmon from the area of stream between the release site and the trap. Traps will be at existing weirs, or at temporary fence weirs placed downstream from the lowest snorkel site. Fish collected at the traps will be anesthetized, checked for marks, lengthed, weighed, and released downstream from the trap. Seining and electrofishing may also be used (if no traps are available) at the end of the summer growing season to monitor the growth and dispersion of the hatchery fish throughout the stream.

Snorkel surveys will be made in selected streams in 1992 to be used for comparison to years when hatchery fish are available for stocking.

Data Analysis. Differences in densities between hatchery and natural chinook salmon within a site, and differences between sampling dates will be tested using a univariate analysis of variance (ANOVA) procedure. Two-way multivariate analysis of variance (MANOVA) will be used to determine if hatchery and wild chinook salmon use the same habitat type at each site, and if habitat use changes between survey dates. Differences in the size and growth rates of hatchery and wild chinook salmon will be tested using ANOVA. All tests will be significant at the 0.10 alpha level.

<u>Objective 2.</u> Hatchery-natural chinook salmon interactions. Experiments conducted in artificial stream channels will be used to monitor interactions between hatchery and natural chinook salmon under varying conditions of fish size and density.

Artificial stream channels. These studies will carried out in flumes at the Hayden Creek Research Station and Big Springs Creek, on the Lemhi River. The Hayden Creek Research Station is owned by IDFG and used by the University of Idaho for research purposes. The station contains one large flume, and associated support facilities, in which the experiments will be conducted. The flume is approximately 43.3 m long, 1.8 m wide and 1.3 m tall, and will be divided into twelve equal sections mimicking a riffle-pool-riffle complex (figure 2). Willow branches and woody debris will be added to supply instream and overhead cover. The riffle and pool area of each section will be covered with appropriate sized cobble and gravel substrate. Upstream and downstream traps in each of the channel sections will be used to monitor volitional emigration, and view ports set into the sides of the flume allow visual observations of the section during tests. The water supply to the flume can be provided from Hayden Creek, or from natural springs, or from a mixture of both.

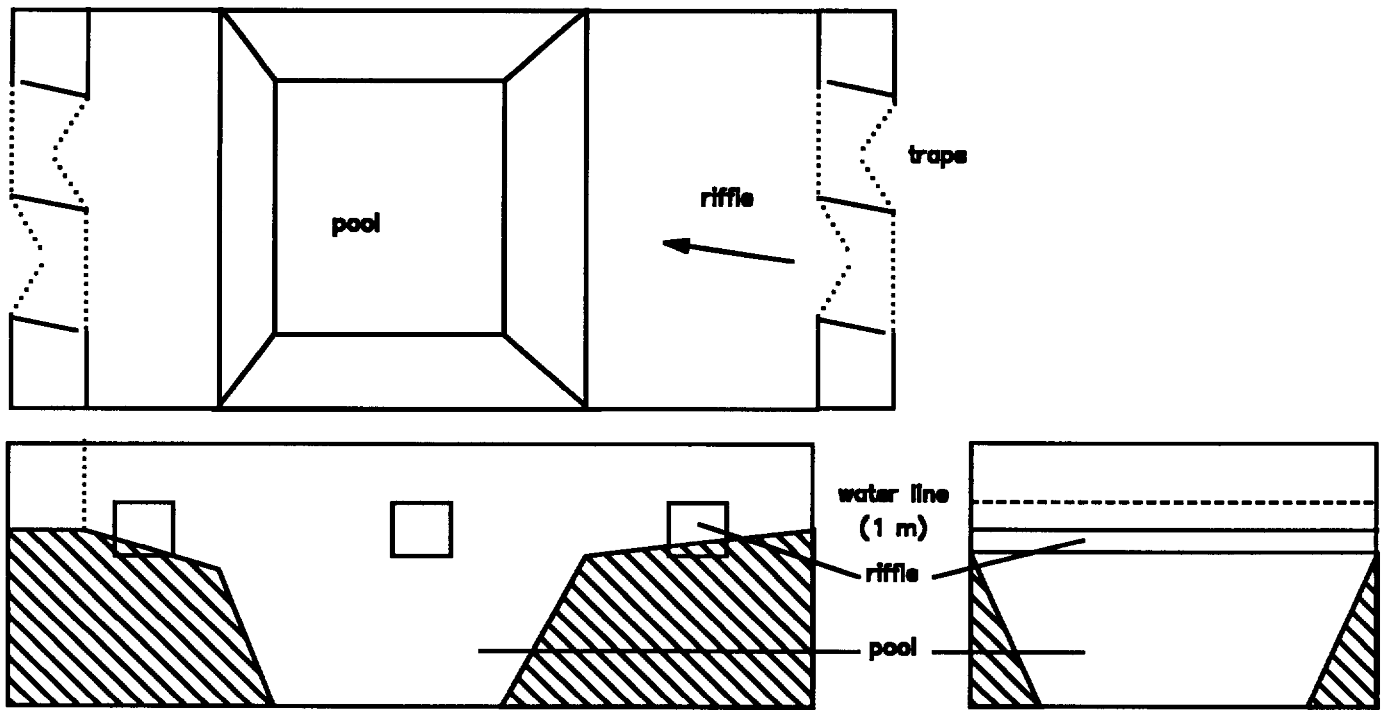

Figure 2. Hayden Creek artificial stream sections.
Dimensions; 3.6 m x 1.8 m x 1.2 m. Area $=6\ m^2$.

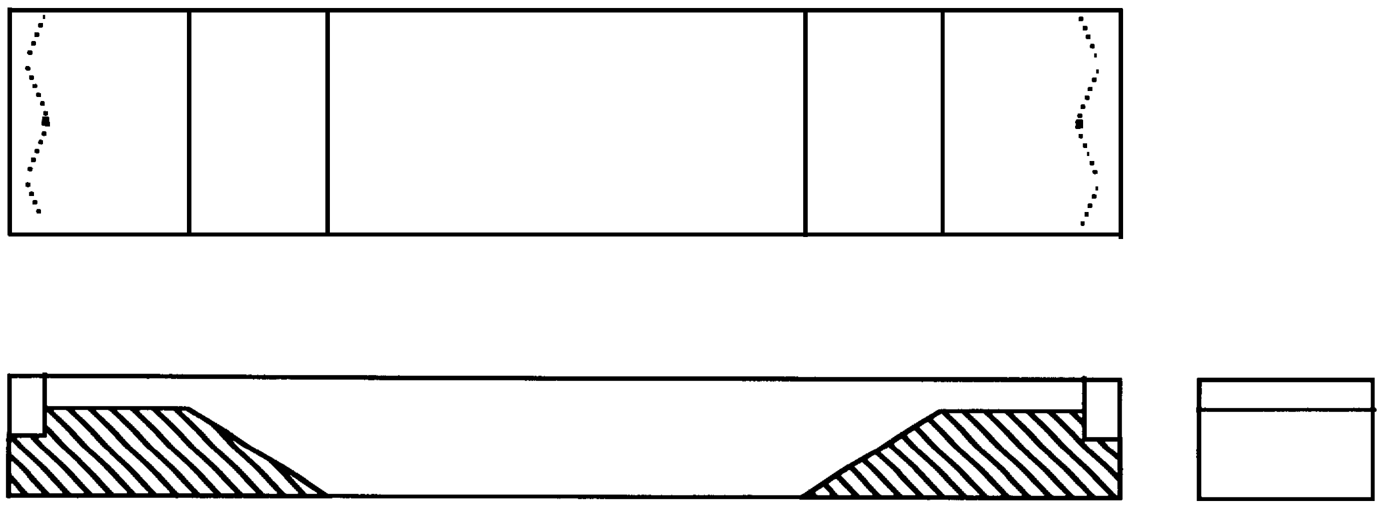

Figure 3. Big Springs Creek artificial stream section.
Dimensions; 6.7 m x 1.2 m x 0.6 m. Area = 8 m^2

The Big Springs Creek channels are built across a small oxbow in the Big Springs Creek, a tributary of the Lemhi River, located about 15 miles upstream from Hayden Creek. The channels are made up of three flumes lying side-by-side. Two of the flumes contain six artificial stream sections each, for a total twelve sections. The sections are each 7.3 m long, by 1.2 m wide, and 0.6 m deep (figure 3). The third flume running along the side of the other two channels supplies creek water to each section individually. Each section will contain a riffle-pool-riffle configuration and will be set up similar to the Hayden Creek channel.

Experimental trials will consist of placing various combinations of hatchery chinook salmon and/or natural chinook salmon, and resident trout in artificial stream channels for periods of time, during which observations of will be made. All hatchery fish used during the experiments will be marked so that they can be differentiated from natural fish during observation periods. Trials will last approximately two weeks, after which the experiments will be terminated and a new series run. Hatchery chinook salmon used for the these trials will be provided as fry from hatcheries, while the natural chinook salmon will be collected as fry using the downstream migrant trap located at the Lemhi River weir. Adult trout will be collected by electroshocking from tributaries of the Lemhi River. Following completion of an experimental trial the natural chinook salmon will be released back into the Lemhi River and the hatchery chinook salmon will be removed to holding tanks. We will attempt to use only naive hatchery fish for each trial to reduce the chance that learned behavior by the hatchery fish could bias subsequent trials.

Test procedure. The treatments to be used during the experimental trials (figure 4) will be assigned at random to the 12 artificial stream sections. Stream sections with test treatments will contain hatchery and natural chinook parr combined, while control treatments will have either all hatchery fish or all natural fish in a section. Two hatchery densities will be used during trials to produce 1:1 and 0.5:1 ratios of hatchery:natural chinook salmon in the test treatments. The total number fish initially placed in a section will always total 60, so that there will be 60 hatchery or 60 natural fish for the controls, 30 hatchery and 30 natural fish in the 1:1 test treatment, and 20 hatchery and 40 natural fish in the 0.5: 1 test treatment. Typically, hatchery produced chinook salmon juveniles are larger than the natural fish at a given time in the year, which constrains the size matchings of hatchery and natural chinook salmon juveniles possible during the trials. Experiments using natural chinook salmon juveniles with hatchery fish of equal or smaller size may also be possible, depending on the supply of hatchery fish available. Each treatment combination will be duplicated during a trial, and trials will be replicated per series to produce a total of four replicates of the six treatment combinations per series. The trials will be initiated in the early spring using hatchery and wild fry, and will be run in five series (early spring, late spring, summer fall, and winter) so that interactions between the hatchery and natural chinook salmon can be monitored as the fish grow through the year (see schedule of trials in appendix).

Prior to beginning a trial all fish to be used will be measured for length and a subsample will be weighed to determine the condition factor (K). In the early (spring) tests, hatchery chinook salmon fry will be added first to allow them to acclimate to the artificial stream sections. Observations will be made of the hatchery fish's behavior during this period. Two days later natural fish will be added to the channel sections to simulate a condition where natural fish emerge into a stream already stocked with hatchery fish. Later in the year the order of entry of fish to the sections will be reversed to simulated the stocking of hatchery fish in streams where naturally produced fish are already present. During a trial, visual observations will be made through the side view ports four or five times daily, for five minutes per section. During these observation periods a worker will record the number of hatchery and natural fish in the section and their location and use of habitat. Observations of location and habitat use will be made as described above for objective 1. Traps will be emptied following observations to monitor daily upstream and downstream movements. In addition, longer observation of 20 minutes will be conducted daily at four of the sections (two test and two controls). During these longer observation periods detailed records will

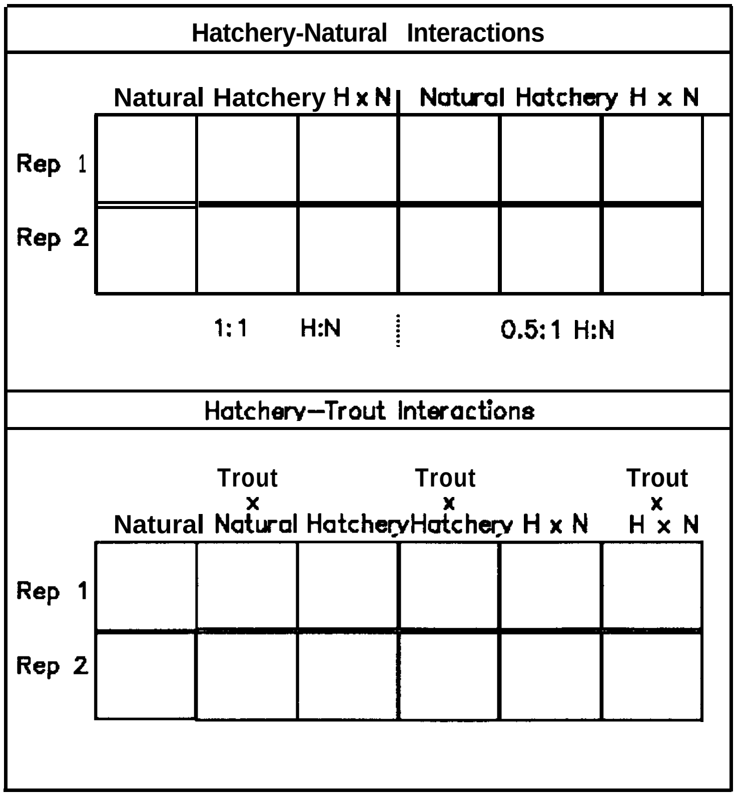

Figure 4. Artificial stream channels studies treatments for hatchery-natural and hatchery-trout experimental trials. All fish are chinook salmon.

be taken of feeding behavior, habitat use, movement patterns, and agnostic behavior. Aggressive encounters between fish will be classified as nips, charges, drives, or displays, and by the types of fish (hatchery and/or natural) involved. The trials will continue for 12 days following addition of the hatchery fish, after which the natural fish will be released, and the hatchery fish will be removed to holding tanks. Upon removal the fish will be measured for length and weight to determine the growth or loss of condition occurring during trials.

Data analysis. A two-way ANOVA will be used to test for differences between treatments of the percent fish remaining in a section at the end of a trial, and between hatchery and natural fish within test treatments. MANOVA will be used to test for differences in habitat type used by hatchery and natural fish between treatments. The change in growth of hatchery and natural chinook salmon over time will be compared using ANOVA using the percent change as the dependent variable.

Objective 3. Effects of trout on hatchery chinook salmon. Experiments conducted in artificial stream channels will be used to determine the predation pressure on hatchery chinook salmon symmpatric and allopatric with wild chinook salmon. Observations in natural streams where brook trout and chinook salmon populations have and have not been manipulated, will be used to determine if chinook salmon use of streams is being constrained by trout.

Artificial stream channel. Experimental trials will be conducted in the Big Springs Creek channels and/or in the Hayden Creek channel between the series run for objective 2.

Test procedure. Treatments for this series of experiments (figure 4) will be randomly assigned to the 12 sections. Stream sections with test treatments will contain either hatchery or natural chinook salmon and one large brook trout (>150 mm fl), or hatchery and natural chinook salmon combined and one large brook trout. Control treatments will have either all hatchery fish or all natural fish or hatchery and natural fish combined, and no brook trout. Only one hatchery fish density will be used due to limited amount of space available. The total number of fish initially placed in a section will 60 hatchery, or 60 natural fish, or 30 hatchery and 30 natural fish combined. Each treatment combination will be duplicated during a trial, and trials will be replicated during a series to produce a total of four replicates of the six treatment combinations per series. The trials will be initiated in the spring and will be run in four series (spring, early summer, late summer and fall).

The procedures to be used for these experiments will be similar to those described for objective 2. Predation events and aggressive encounters seen during observation periods will be classified by the location and type of prey involved. Fish added to the channel sections but not accounted for at the end of the trial by emigration or death by natural causes will also be assumed to have been preyed upon.

Field observations. Along with the initial experimental trials at Hayden Creek in 1992, field studies of trout-chinook salmon interactions will be observed in selected stream sites. During these field studies, we would monitor the size and distribution of the resident trout and salmon populations through the year. We could also remove brook trout from stream sites prior to natural production in order compare how the natural chinook salmon respond to the reduced predation pressure with sections still containing trout. in some sections, chinook might be added to streams with brook trout present or removed. Possible streams to be used for observations of natural chinook salmon with trout removal include Marsh and Valley Creeks and their tributaries.

Data analysis. Statistical analysis for these sets of experiments will be similar to those described for objective 2. Differences in the number of fish lost to predation between treatments will be analyzed using ANOVA, using percent mortality as the independent variable.

Objective 4. Passage constraint in the Lemhi River. Pit tagged natural chinook salmon smolts will be used to determine the migration success and survival of smolts from the Lemhi River to Lower Granite Dam. During the fall of 1991 over 500 chinook salmon smolts were collected, Pit tagged, and released at the Lemhi River weir, about 30 miles upstream with the confluence with the Salmon River. In the spring of 1992, we plan to PIT tag 900 chinook salmon smolts and release them at three locations on the Lemhi River, near the town of Leadore about 45 miles upstream from the Lemhi-Salmon River confluence, at the Lemhi weir, and at the mouth of the Lemhi River. During the usual summer sampling to assess Parr-density, we will put PIT tag into 500 chinook salmon parr and release them back into the stream. In the fall of 1992, 500 migrating chinook salmon will be PIT tagged and released at the Lemhi weir. The PIT tagged chinook salmon will detected as they cross Lower Granite Dam.

Data Analysis. The survival of smolts reaching Lower Granite Dam will be determined from the number of PIT tagged fish detected and the sampling efficiency of the collection facilities. Differences between smolt survival from the three release sites, and from the weir release site between 1991 and 1992 will be tested using Chi-square or ANOVA procedures, using percent survival as the independent variable. Analysis relating survival of the PIT tagged fish with river flow and temperature data will also be conducted using ANCOVA and regression techniques.

Fish requirements: Using a density of 10 fish/m^2 (60 fish) per test treatment the minimum number of fish required to complete the above described experiments during the first year would be 7,000 hatchery chinook salmon juveniles, 7,400 natural chinook salmon juveniles, and 60 trout.

Anticipated results

Objective 1. Fish reared in a hatchery come under less strenuous natural selective pressures than are found in a natural stream, which reduces the chance that maladaptive behavioral traits will be eliminated. Hatchery fish are held in cement raceways and ponds at high densities and are fed commercial fish feed. This produces fish that may not feed efficiently on natural food items, and they are inexperienced at predator avoidance in the natural environment. The longer a fish is held in a hatchery the more pronounced and lasting these deficiencies seem to become. This would suggest that the sooner hatchery fish are released, the better will be their chances to survive and develop into a natural-like fish.

Chinook salmon juveniles averaging 84-l 00 mm fork length released in the Wenatchee River drifted downstream at a steady rate of 35 km/day, leaving the system in about 1.5 days (Hillman and Mullan 1989). But, smaller chinook salmon fry, averaging 59 mm total length, remained within 1 to 2 km of stocking sites (Richards and Cernera 1988). Chinook salmon fry and parr will likely disperse slowly, suggesting the need for several release sites to distribute the fish throughout a stream if necessary to avoid abnormally high densities and reduce growth (figure 5).

Hatchery coho salmon stocked into side channels of the Wenatchee River showed little growth until the third week following their release (Spaulding et al. 1989), while catchable rainbow trout planted into Convict Creek, California, continued to lose weight for several months following their release. Hatchery chinook salmon parr may undergo a period of limited growth or even weight loss for several weeks following their release as they adapt to feeding on natural food items and competing with natural fish for the available food supply. If the hatchery fish lose too much weight, their overwinter survival may be reduced (figures 6 and 7).

Objective 2. The potential interactions that can occur between hatchery and natural chinook salmon include competition for food and space, and intraspecific predation. These types of interactions can lead to reduced growth and survival, habitat displacement, premature migrations, and increased risk of interspecific predation for both the hatchery and natural chinook salmon (Steward and Bjornn 1990). The effect that hatchery fish will have on natural fish populations will depend on the number and size of hatchery fish planted, the productivity and complexity of the habitat, and the size of the local population. In instances where hatchery and natural fish are relatively equally competitive, the group present in higher numbers will have the advantage. If fish, either hatchery or natural, are displaced due to lack of habitat they can become vulnerable to predation (Hillman and Mullan 1989). The hatchery fish, being inexperienced with predators, will be more susceptible to predation. Given a large enough difference in the hatchery and natural fish sizes (i.e. between fry and smolts) intraspecific predation can also ensue. A portion of the chinook salmon fry and parr

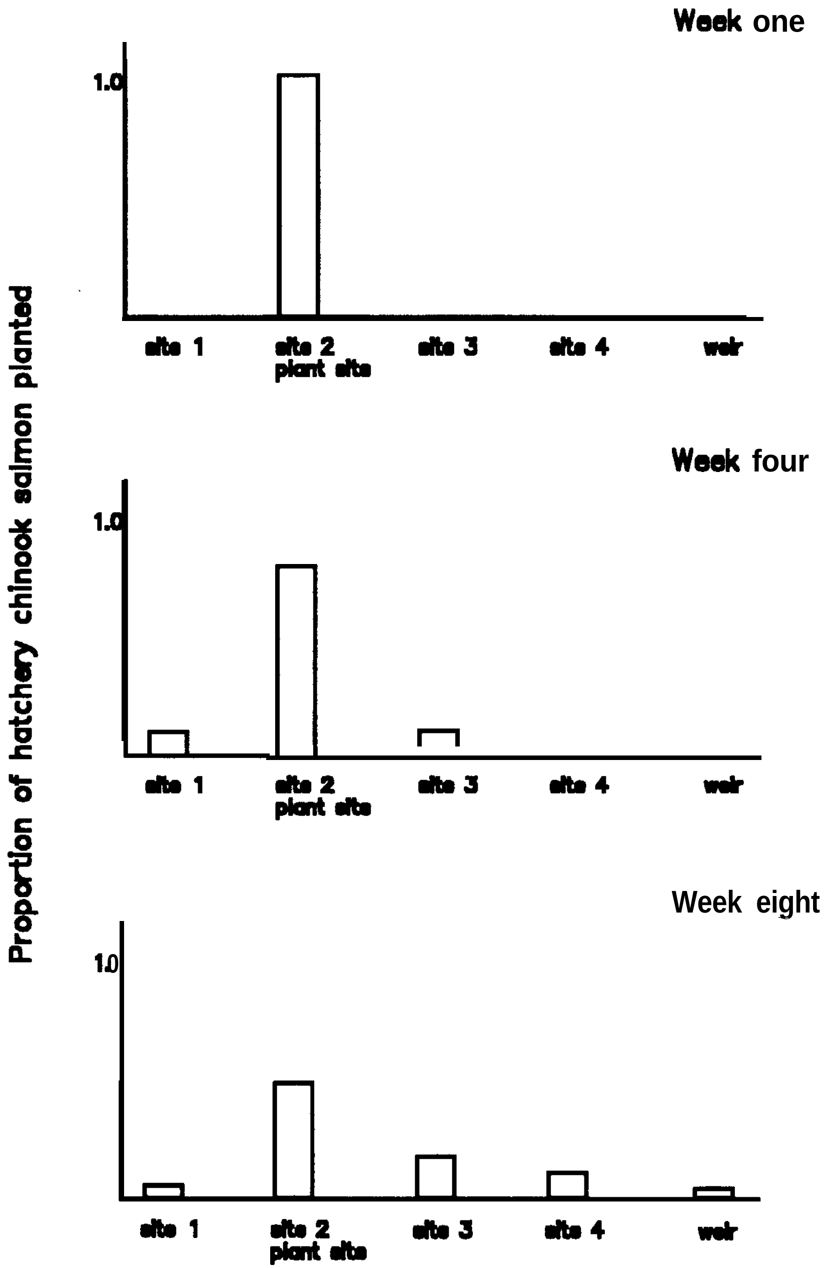

Figure 5. Anticipated dispersion of hatchery chinook salmon following stocking in Idaho streams using single release site.

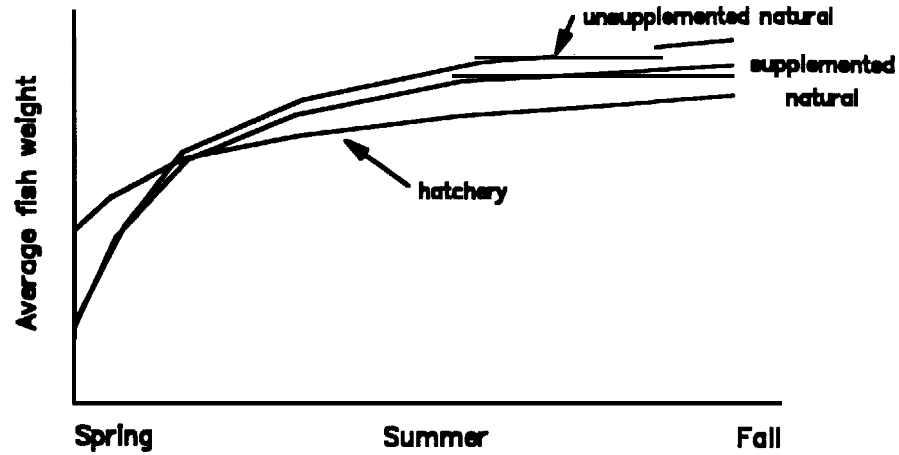

Figure 6. Growth of natural, supplemented—natural, and stocked hatchery chinook salmon Idaho streams.

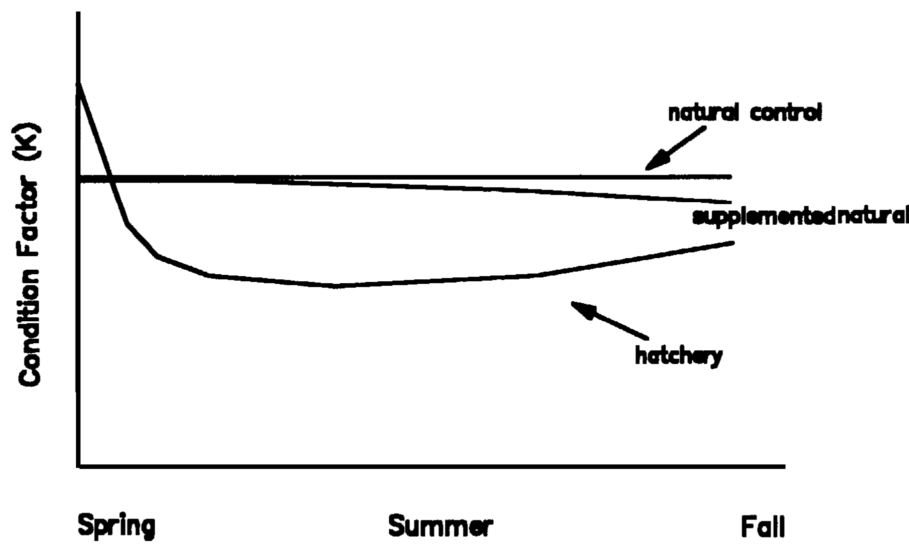

Figure 7. Condition factor (K) of natural chinook salmon alone (control), supplemented, and hatchery chinook salmon in Idaho streams during spring, summer, and fall of 1992.

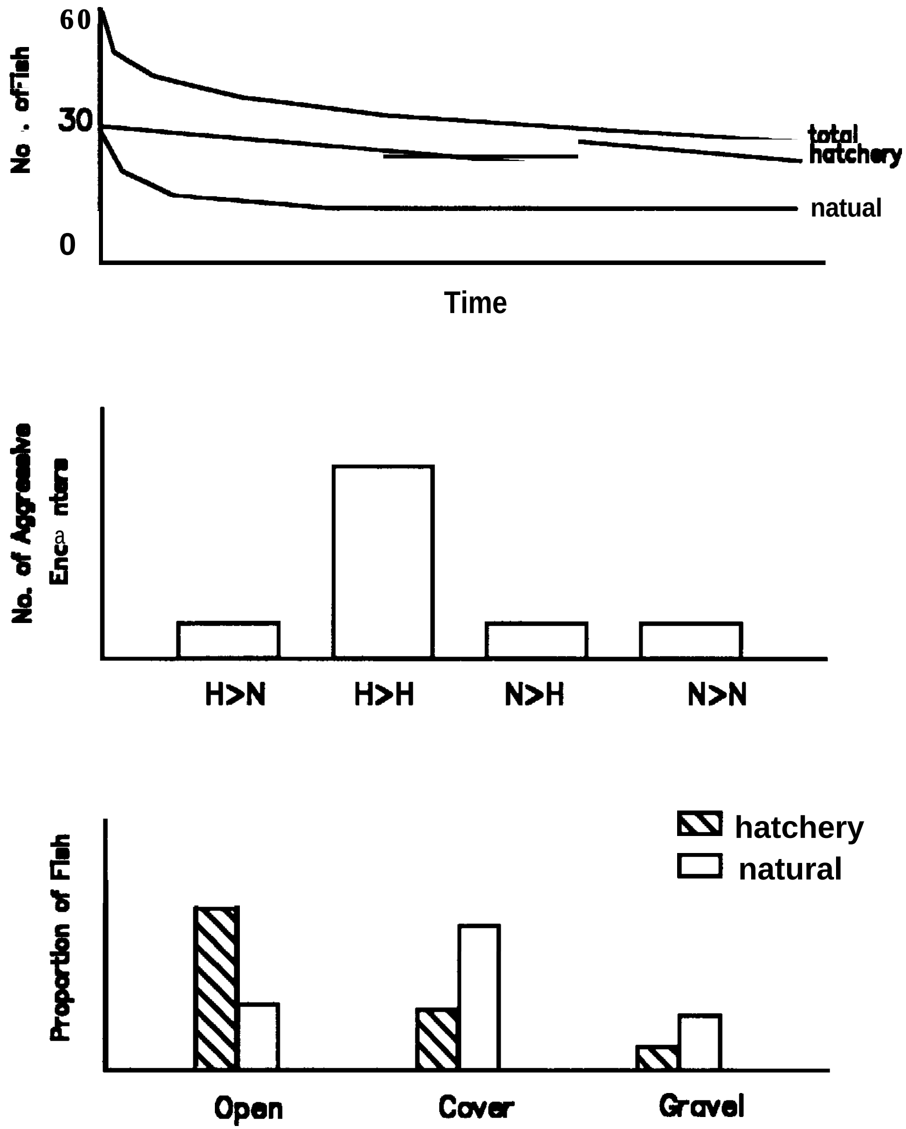

Figure 8. Number of total, hatchery and natural chinook salmon remaining in stream sections (top), number of aggressive encounters between hatchery and natural chinook salmon in stream sections (middle), and average habitat use by hatchery and natural chinook salmon in Hayden Creek stream sections during Spring trials.

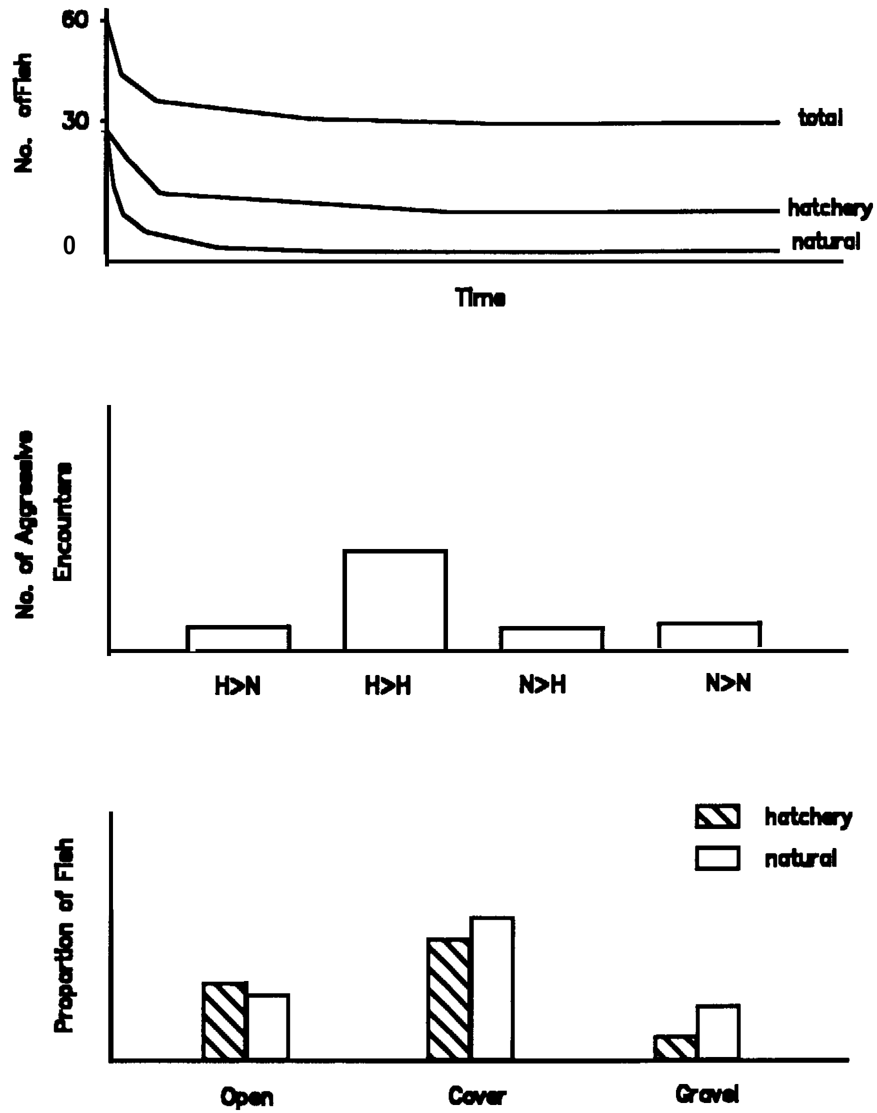

Figure 9. Number of total, hatchery and natural chinook salmon remaining in stream sections (top), number of aggressive encounters between hatchery and natural chinook salmon in stream sections (middle), and average habitat use by hatchery and natural chinook salmon in Hayden Creek stream sections during Spring series with Trout present.

will move downstream through the spring, summer, and fall. If enough hatchery fish are added to a system the natural fish can be displaced and be forced to move downstream prematurely (Nickelson et al. 1986). Or, a mass movement of hatchery released smolts could entrain natural smolts, also causing them to move downstream prematurely (Hillman and Mullan 1989).

The number of fish counted within the Hayden Creek artificial stream sections should drop noticeably during the first week of the trial, but the numbers should stabilize during the second week (figure 8). A portion of the hatchery and wild chinook salmon are expected to move out of the sections due to the artificially high densities (10 fish/m^2) present. Given that the hatchery fish will generally be larger than the wild fish the majority of emigrating fish may be natural. Predation by the larger hatchery fish on the natural fish may also aid in the decline. Wild fish should hold the prime feeding and refuge sites, while the hatchery fish will remain more in the open snapping at food as it is encountered. Hatchery fish can be aggressive, and should be the instigators of more aggressive encounters against other hatchery fish and wild fish.

Objective 3. At the time hatchery chinook salmon are released into streams they have had no experience avoiding natural predators. During the ISS Idaho Fish and Game will attempt to establish or re-establish hatchery chinook salmon parr and presmolts into streams in which trout have become established. Hatchery fish are known to choose habitat closer to the surface and more in the open than their wild counterparts, making them more susceptible to predation from large trout (Hillman and Mullan 1989; Hillman and Chapman 1989). During the experimental trials fewer fish will remain in the sections containing a trout predator than in the sections without trout, due to increased emigration and predation losses (figure 9). Losses afforded to predation pressure should be higher for hatchery fish than for the wild fish.

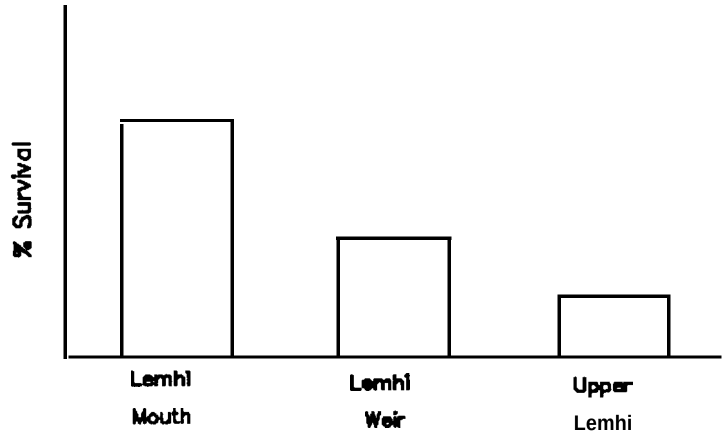

Figure 10. Percent durvival of PIT tagged chinook salmon smolts from Wee release sites on the Lemhi River to Lower Granite Dam.

Objective 4. Little is known of the fate of chinook salmon smolts during the final stage in their freshwater existence, the downstream migration to the ocean. We speculate, however, that smolts moving through river sections in which extensive irrigation occurs, such as the Lemhi River, can easily pass into the water diversions for extended periods of time, significantly lengthening the migration period. An extended migration period can increase the chance that predation or other factors can prohibit the smolts from completing their passage downstream. From the detection of PIT tagged chinook salmon smolts we expect to find a lower survival to Lower Granite Dam for the fish which have to pass the longest distance down the Lemhi River (figure 10).

Work schedule: see attached sheet.

Budoet: see attached sheet.

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Small scale supplementation project — Work Schedule — 1991-92

199 1	Summer/Fall	Repairs to Hayden Creek hatchery Construction of Hayden Creek flume Repairs to Big Springs Creek channels Repair and operation of downstream trap PIT tag 500 chinook smolts Planning and organkatlon
1992	Jan/Feb	Complete repairs to facilities Install trap Select snorkeling transects Hire personnel Begin collection of natural fish needed for experiments
	March	Begin field snorkel surveys Begin trapping operations and PIT tagging Initiate spring series of experimental trials
	June/July/Aug	Continue field ● narkel surveys Continue trapping operations Initiate summer series of experimental trials
	Sept/Oct	Continue field snorkel surveys Continue trapping operations Initiate fall series of experimental trials
	Nov/Dec	Complete field snorkel surveys Complete trapping operations Initiate and complete wink series of experimental trials

Schedule of channel trials

Month	Week	Hatc-Nat Series	Hatch-Trout Series
March	1		
	2	Early spring	
	3		
	4		
April	5		
	6		
	7		
	6		Spring
May	9		
	10		
	11		
	12		
	13	Late spring	
June	14		
	13		
	16		
	17		Early mummer
July	16		
	19		
	20		
	21	Summer	
August	22		
	23		
	24		
	25		Late summer
	26		
Sept	27		
	26		
	29		
	30	Fall	
Oct	31		
	32		
	33		
	34		Fall
	35		
Nov	36		
	37		
	36		
	39		
	40	Winter	
Dec	41		
	42		

Progress Report

Feasibility of Using Genetic Marks to Assess Long Term Effects of Supplementing Chinook Salmon Stocks in Idaho

by

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for

Idaho Department of Fish and Game
and
Bonneville Power Administration

November 1991

Preliminary studies were conducted in 1990 and 1991 to determine if genetic marks were available that could be used to monitor the long term effects of supplementing wild/natural stocks of chinook salmon in Idaho with hatchery stocks. Genetic marks would be created by intentionally altering the allelic frequencies of hatchery fish to make them distinct from wild fish. Genetics marks offer one of the few means of measuring the relative contribution of hatchery and wild fish following spawning (Reisenbichler and McIntyre 1977; Taggart and Ferguson 1984; Lane 1984; Seeb et al. 1986; Chilcote et al. 1986).

An allele is one of the alternative forms of the same gene that occur at the same locus. For many of the loci, the common allele occurs in nearly all the fish. The useful loci for genetic mark development are those where the variant allele is present in enough fish to provide adequate numbers of broodstock to produce sufficient offspring for testing. If the marked fish are to be introduced into an area where the allele they carry is unique, then there is no concern about the naturally occurring frequency of the marker allele. On the other hand, a low natural occurrence of the allele chosen for marking is desired in tests where hatchery fish produced from the local stock are added to the stream with the local stock of fish.

Test With 1990 Brood Year Fish

Prior to sampling fish at a hatchery, four loci were selected for study, based on allelic frequencies reported in the literature and reports of recent studies by scientists at the Montlake Lab (National Marine Fisheries Service) in Seattle, and the Washington Department of Fisheries lab in Olympia. The four loci, IDH-3,4; TPI-4; TAPEP-1; and PGK-2; were selected because the variant alleles were thought to be fairly common (5-10%) and they could be easily distinguished on electrophoretic gels.

In the fall of 1990, more than 1000 adult spring chinook salmon at Dworshak National Fish Hatchery were screened to assess the frequency of the alleles at the four loci. The fish were screened by taking a muscle plug from fish as they were spawned. The muscle plugs were taken to the University of Idaho for electrophoretic analysis. Female salmon that were homogeneous or heterogeneous for the variant allele of each locus were identified and compared with the genetic makeup of the males they were mated with to produce a list of matings in which both parents were either homozygous or heterozygous for the variant allele.

At Dworshak NFH in 1990, the fertilized eggs from each mating (1 female and 1 male) were kept in separate trays during incubation, thereby making it possible to identify and set aside those matings which, by chance alone, had created the offspring we needed with the variant alleles.

Because of the low frequency of the variant alleles (<10%), almost no matings between parents that were homozygous for the variant allele occurred during the more or less random mating that occurred during spawning at the hatchery. We then selected those matings between heterozygous parents to get enough offspring with the variant allele for subsequent testing. By using heterozygous parents, 25% of the offspring would theoretically be homozygous for the variant allele and 50% heterozygous.

In the 1990 sample of fish from Dworshak NFH, the IDH-3,4 loci was more difficult to read than we anticipated, and the frequency of the variant allele was 3-4%. Frequencies of the variant allele for the other three loci were 9-10% for PGK-2, 7-8% for TPI-4, and 5-6% for TAPEP-1.

During incubation in the trays, mortality of embryos was low and similar for all groups of eggs. When the fish reached the button-up stage, 8 trays of fish with offspring from parents that were both heterozygous for TPI, and 8 trays that contained offspring from heterozygous parents for the PGK loci were selected for extended study. The fish were transferred from the trays to 16 fry tanks (1 tray of fish per tank) at Dworshak NFH in November of 1990 and held there until 17 January 1991. During that period there was almost no mortality.

On 17 January 1990, 300 fish from each of 6 tanks (three each of TPI and PGK) were transferred to the University of Idaho lab for additional rearing to determine in any differential mortality might occur. Space restraints at the Hatchery and University prevented us from continuing to rear fish from all 16 tanks separately. Four of the six tanks of fish were reared at the University until 10 April 1990, and the remaining two were continued until 31 May 1990. During the 3-5 months of rearing at the University, only 10 of the 1800 fish died (0.6%), and the survivors grew and developed normally.

In the spring of 1991, we decided that the use of genetic marks, although preferred, would not be practical in the early phases of the Idaho chinook salmon supplementation study. The primary factors were the small numbers of spawners returning to hatcheries and streams, and the low frequencies of the variant alleles at most loci. The groups of genetically marked fish we could create would have been small, from only a limited number of adults, and would have required screening virtually every returning adult at the supplementation sites. We have deferred additional work on genetic marks until fish abundance increases.

Although our work on genetic mark development was limited, there is evidence, from the lack of mortality during rearing, that the variant allele for both the TPI and PGK loci may be neutral from a fish survival viewpoint. Additional full life cycle testing will be necessary if the use of genetic marks becomes possible in future years of the project.