PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Idaho Supplementation Studies - Umbrella Proposal

BPA project number: 20545
Contract renewal date (mm/yyyy): 1/2000 ☒ **Multiple actions?**

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

Business acronym (if appropriate) IDFG

Proposal contact person or principal investigator:

Name	Peter Hassemer
Mailing Address	IDFG, 1414 East Locust Lane
City, ST Zip	Nampa, Idaho 83706
Phone	208-465-8404
Fax	208-465-8434
Email address	phasseme@idfg.state.id.us

NPPC Program Measure Number(s) which this project addresses
7.3B.2, 7.0A, 7.1B.1, 7.1C.3, 7.2A

FWS/NMFS Biological Opinion Number(s) which this project addresses
Permitted under ESA Section 10

Other planning document references
4.5C, 4.1, 4.1B, 4.2 of NMFS draft Snake River Salmon recovery Plan; Wy Kan Ush Me Wa Kush Wit section 5B, pages 14-23

Short description
Evaluate various supplementation strategies for maintaining and rebuilding spring/summer chinook populations in Idaho. Develop recommendations for the use of supplementation to rebuild naturally spawning populations.

Target species
Spring/Summer Chinook Salmon (Oncorhynchus tshawytscha)

Section 2. Sorting and evaluation

Subbasin
Salmon River, Clearwater River

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type

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

Section 3. Relationships to other Bonneville projects

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

Project #	Project title/description
20545	Idaho Supplementation Studies - Umbrella
8909800	Idaho Supplementation Studies - Idaho Fish and Game
8909801	Idaho Supplementation Studies - US Fish and Wildlife Service
8909802	Idaho Supplementation Studies - Nez Perce Tribe
8909803	Idaho Supplementation Studies - Shoshone-Bannock Tribes

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
9005500	Steelhead Supplementatin Studies	Reciprocal transfer of data/coordination
9107300	Idaho Natural Production Monitoring and Evaluation	Reciprocal transfer of data/coordination
8335000	Nez Perce Tribal Hatchery O&M	Reciprocal transfer of data/coordination
9405000	Salmon River Habitat Enhancement - O&M, M&E	Reciprocal transfer of data/coordination
9705700	Salmon River Production Program	Reciprocal transfer of data/coordination
9703000	Monitor Listed Stock Adult Chinook Salmon Escapement	Reciprocal transfer of data/coordination
9102800	Monitoring smolt Migration of Wild Snake River Spring/Summer Chinook Salmon	Reciprocal transfer of data/coordination
9604300	Johnson Creek Artificial Propagation Enhancement- O&M, M&E	Reciprocal transfer of data/coordination

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?
1991	Identified study areas, brood stocks, facilities to be used.	Yes. Begin preliminary baseline data collection on treatment and control streams, target stock history, genetic sampling.
1991	Brood stock development	Initiated marking and development of local brood stocks to provide future releases.
1992	Begin supplementation and monitoring of treatment streams, and monitoring of control streams.	Yes. Initiated parr and smolt releases for treatment streams. Used existing hatchery brood stocks for first generation supplementation.
1996	Small scale investigations into chinook salmon	Yes. Completed small scale studies to

	supplementation strategies and techniques: 1992-1994. Technical Report. Peery, C.A. and T.C. Bjornn.	monitor behavioral interactions between natural and hatchery fish.
1997	First generation returns, a known brood stock for supplementation is established.	Yes. Brood stock selection begins with local stocks of known components.
1998	Five-year Report (1991-1996) in progress.	Yes. Summarize baseline data, review methodology, continue supplementation of treatment streams and monitoring of control streams, continue monitoring of juvenile survival and abundance, and monitoring of adult returns.

Objectives and tasks

Obj 1,2,3	**Objective**	**Task a,b,c**	**Task**
1	Monitor and evaluate the effects of supplementation on parr, pre smolt and smolt numbers, and spawning escapements of naturally produced salmon.	a	Develop and implement "standardized" spawning, rearing, marking, and release protocols.
1		b	Differentially mark all hatchery supplementation and general production fish released in or nearby the study streams.
1		c	PIT tag a minimum of 300 to 700 hatchery supplementation and general production fish released in or nearby the study streams.
1		d	Release various life stages of chinook salmon. Determine fish numbers for each life stage based on existing natural production and natural rearing capacity.
1		e	Estimate late summer parr densities from snorkel surveys.
1		f	PIT tag a minimum of 700 naturally produced parr from each treatment and control stream to estimate smolt production and survival.
1		g	Use existing weirs to collect, mark (PIT tag), and enumerate emigrating fish and to identify and enumerate returning adults.
1		h	Compare natural production of supplemented populations to unsupplemented populations and baseline data.
2	Monitor and evaluate changes in natural productivity and genetic composition of target and adjacent populations following supplementation.	a	Monitor productivity and genetic indices from supplemented populations and compare baseline and controls. Productivity characteristics will be evaluated as a function of density or percent carrying capacity to minimize density dependent effects confoundi
2		b	Monitor straying of hatchery supplementation fish into adjacent and control streams by weirs and carcass

			surveys.
2		c	Determine spawner to recruitment relationship based on determined production and productivity indices (parr and smolt numbers, adult escapements, survival, eggs/spawner etc.).
2		d	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.
3	Determine which supplementation strategies (brood stock and release stage) provide the quickest and highest response in natural production without adverse effects on productivity.	a	Monitor and evaluate natural production (pre smolt, Smolt and adult numbers) and productivity (survival, life stage characteristics, pathogens, straying, genetic composition) of supplemented populations and compare to baseline and controls.
3		b	Use local brood stocks with known natural component from the target population during the second generation of supplementation.
3		c	Compare natural production and productivity indices of supplemented populations using existing hatchery brood stocks (first generation) to populations using locally developed brood stocks (second generation).
3		d	Compare natural production and productivity indices among supplemented populations using parr, pre smolt, and smolt release strategies.
4	Develop supplementation recommendations. (Long term).	a	Guidelines and recommendations will be developed addressing risks and benefits of supplementation (augmentation and restoration) in general and specific supplementation strategies (brood stock and release stage).

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	5/1992	12/2007	Evaluation of supplementation effects on numbers of presmolt and smolt, and spawning excapements of naturally produced salmon. Supplement natural populations with juveniles and adults.	Yes	
2	5/1992	12/2007	Increased smolt outmigration and adults spawners for	Yes	

			natural spawning. Evaluate increases or decreases in number of naturally produced salmon. Evaluate genetic composition of target and adjacent populations following supplementation.		
3	5/1992	12/2007	Determine which brood stock and release stage result in the quickest and highest (if any) increase in natural production, without adversely effecting the productivity.	Yes	
4	1/1999	12/2007	Supplementation recommendations completed in final study report.	Yes	
				Total	0.00%

Schedule constraints
The continued decline of spring/summer chinook salmon returning to Idaho result in insufficient adult returns to provide target supplementation treatments.

Completion date
2007

Section 5. Budget

FY99 project budget (BPA obligated):

FY2000 budget by line item

Item	**Note**	**% of total**	**FY2000**
Personnel		%0	
Fringe benefits		%0	
Supplies, materials, non-expendable property		%0	
Operations & maintenance		%0	
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		%0	
NEPA costs		%0	
Construction-related support		%0	
PIT tags	# of tags:	%0	
Travel		%0	
Indirect costs		%0	
Subcontractor		%0	
Other		%0	
TOTAL BPA FY2000 BUDGET REQUEST			$ 0

Cost sharing

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

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget				

Section 6. References

Watershed?	Reference
☐	Bams, R.A. 1976. Results of a pink salmon transplant using males native to the recipient stream. Fisheries and Marine Service Technical Report No. 642.
☐	Chilcote, M.W., S.A. Leider, and J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Transactions of the American Fisheries Society 115:726-735.
☐	Columbia Basin Fish and Wildlife Authority. 1990. Integrated system plan for salmon and steelhead production in the Columbia River Basin. Public Review Draft. Prepared for Northwest Power Planning Council, Portland, Oregon.
☐	Currens, K.P., C.A. Busack, G.K. Meffe, D.P. Philipp, E.P. Pister, F.M. Utter, and S.P. Yundt. 1991 (MS). A hierarchical approach to conservation genetics and production of anadromous salmonids in the Columbia River Basin. Product of the 1990 Sustainabili
☐	Franklin, I.R. 1980. Evolutionary change in small populations. Pages 135-149 in M.E. Soule' and B.A. Wilcox (eds.). Conservation Biology: an evolutionary - ecological perspective. Sinauer Associates, Sunderland, Massachusetts.
☐	Gebhards, S.V. 1959. The effects of irrigation on the natural production of chinook salmon (Oncorhynchus tshawtscha) in the Lemhi River, Idaho. Master's Thesis, Utah State University, Logan, Utah.
☐	Herrig, D.M. 1990. A review of the Lower Snake River Compensation Plan hatchery program. U.S. Fish and Wildlife Service, Lower Snake River Compensation Plan Office, Boise, Idaho.
☐	Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54(2):187-211.
☐	Idaho Department of Fish and Game. 1985. Anadromous fisheries management plan, 1986-1990. Boise, Idaho.
☐	Idaho Department of Fish and Game. 1991. Anadromous fisheries management plan, 1991-1995. Boise, Idaho.
☐	Idaho Department of Fish and Game, Nez Perce Tribe of Idaho, and Shoshone-Bannock Tribes of Fort Hall. 1990. Salmon River sub-basin salmon and steelhead production plan. Northwest Power Planning Council, Portland, Oregon.
☐	Johnson, R.A., and D.W. Wichern. 1982. Applied Multivariate Statistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
☐	Kapucinski, A.R., C.R. Steward, M.L. Goodman, C.C. Krueger, J.H. Williamson, E.C. Bowles, and R. Carmichael. 1991 (MS). Genetic conservation guidelines for salmon and steelhead supplementation. Product of the 1990 Sustainability Workshop, Northwest Power
☐	Kennedy, G.J.A., and C.D. Strange. 1986. The effects of intra- and interspecific competition

	on the survival and growth of stocked juvenile Atlantic salmon Salmo salar L., and resident trout, Salmo trutta L., in an upland stream. Journal of Fish Biology 2
☐	Kijima, A., and Y. Fujio. 1984. Relationship between average heterozygosity and river population size in chum salmon. Bull. Jpn. Soc. Sci. Fish. 50:603-608.
☐	Lichatowich, J. and S. Cramer. 1979. Parameter selection and sample sizes in studies of anadromous salmonids. Oregon Department of Fish and Wildlife Information Report Series, Fisheries Number 80-1, Portland, Oregon.
☐	Miller, W.H., T.C. Coley, H.L. Burge, and T.T. Kisanuki. 1990. Analysis of salmon and steelhead supplementation: emphasis on unpublished reports and present programs. Part 1 in W.H. Miller (ed.). Analysis of salmon and steelhead supplementation, Parts 1-3
☐	Nez Perce Tribe of Idaho and Idaho Department of Fish and Game. 1990. Clearwater River sub-basin salmon and steelhead production plan. Prepared for Northwest Power Planning Council, Portland, Oregon.
☐	Nickelson, T.E., M.F. Solazzi, and S.L. Johnson. 1986. Use of hatchery coho salmon (Oncorhynchus kisutch) presmolts to rebuild wild populations in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 43(12):2443-2449.
☐	Peterman, R.M. 1990. Statistical power analysis can improve fisheries research and management. Canadian Journal of Fisheries and Aquatic Sciences 47:2-15.
☐	Petrosky, C.E., and T.C. Bjornn. 1988. Response of wild rainbows (Salmo gairdneri) and cutthroat trout (S. clarki) to stocked rainbow trout in fertile and infertile streams. Canadian Journal of Fisheries and Aquatic Sciences 45(12):2087-2105.
☐	Reisenbichler, R.R. 1981. Columbia River salmonid broodstock management - annual progress report (unpublished). National Fishery Research Center, U.S. Fish and Wildlife Service, Seattle, Washington.
☐	Reisenbichler, R.R. 1984. Outplanting: potential for harmful genetic change in naturally spawning salmonids. Pages 33-39 in J.M. Walton, and D.B. Houston (eds.). Proceedings of the Soviet-American symposium on aquaculture. National Fisheries Research Cent
☐	Reisenbichler, R.R. 1988. Relation between distance transferred from natal stream and recovery rate for hatchery coho salmon. North American Journal of Fisheries Management 8:172-174.
☐	Reisenbichler, R.R., and J.D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, Salmo gairdneri. Journal of the Fisheries Research Board of Canada 34:123-128.
☐	Reisenbichler, R.R., and J.D. McIntyre. 1986. Requirements for integrating natural and artificial production of anadromous salmonids in the Pacific Northwest. Pages 365-374 in R.H. Stroud (ed.). Fish Culture in Fisheries Management. American Fisheries Soc
☐	Smith, E.M., B.A. Miller, J.D. Rodgers, and M.A. Buckman. 1985. Outplanting anadromous salmonids - a literature survey. Bonneville Power Administration, U.S. Department of Energy, Project 85-68, Portland, Oregon.
☐	Snow, H.E. 1974. Effects of stocking northern pike in Murphy's Flowage. Wisconsin Department of Natural Resources Technical Bulletin 79, Madison.
☐	Steward, C.R., and T.C. Bjornn. 1990. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of published literature. Part 2 in W.H. Miller (ed.). Analysis of salmon and steelhead supplementation, Parts 1-3. Project 88-100, Bonnev
☐	Supplementation Technical Work Group (STWG). 1988. Supplementation research - proposed five-year work plan. Northwest Power Planning Council, Portland, Oregon.
☐	Verspoor, E. 1988. Reduced genetic variability in first-generation hatchery populations of Atlantic salmon (Salmo salar). Canadian Journal of Fisheries and Aquatic Sciences 45:1686-1690.
☐	Vincent, E.R. 1985. Effects of stocking catchable trout on wild trout populations. Pages 88-91 in W. King (ed.). Proceedings of the wild trout management symposium. Trout Unlimited.
☐	Vincent, E.R. 1987. Effects of stocking catchable-sized hatchery rainbow trout on two wild trout species in the Madison River and O'Dell Creek, Montana. North American Journal of Fisheries Management 7:91-105.

☐	Walters, C.J., J.S. Collie, and T. Webb. 1988. Experimental designs for estimating transient responses to management disturbances. Canadian Journal of Fisheries and Aquatic Sciences 45:530-538.
☐	

PART II - NARRATIVE

Section 7. Abstract

The goal of the Idaho Supplementation Studies (ISS) Project is to evaluate the utility of supplementation as a recovery/restoration strategy for depressed stocks of spring and summer chinook salmon in Idaho. The project is a multi-agency effort, covering 31 streams throughout the Salmon River and Clearwater River basins, working to help define the potential role of chinook salmon supplementation in managing Idaho's natural spring and summer chinook populations, and identify genetic and ecological impacts to existing natural populations. The ISS experimental design is split into three main approaches: (1) Large-scale population production and productivity studies designed to provide Snake River basin-wide inferences, (2) Using study streams to evaluate specific supplementation programs, and (3) Small-scale studies designed to evaluate specific hypotheses. Approaches (1) and (2) measure population responses to supplementation and are long-term studies. Approach (3) determines specific impacts of supplementation such as competition, dispersal, and behavior; and are short-term studies conducted in "controlled" environments. We expect this research to demonstrate the best methods for supplementing existing natural populations of chinook salmon and re-establishing natural populations in streams where chinook salmon have become extirpated. We expect supplementation effects and recommendations to be different for each stream. The study design called for a minimum of 15 years (three generations) of research (Leitzinger and Bowles 1991). Sampling was initiated in 1991 and implementation began in 1992. The supplementation effects will be monitored and evaluated by comparing juvenile production and survival, fecundity, age structure, and genetic structure and variability in treatment and control streams of similar ecological parameters.

Section 8. Project description

a. Technical and/or scientific background

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. 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 eleven state and federal anadromous hatcheries operating in Idaho: Clearwater, 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 operated in conjunction with the Clearwater Hatchery. 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 (*O. mykiss*) smolts, and 4 million B-run steelhead smolts annually.

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 Anadromous Fish Hatchery 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. 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. Furthermore, despite these hatchery mitigation efforts, anadromous fish stocks in Idaho continued to decline.

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, 1994).

The utility of supplementation as a viable recovery tool is the subject of much debate. 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 (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). 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 increased (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).

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 1:1 ratio (Kapuscinski et al. 1991).

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 brood stock 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 brood stock 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. Flow 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. However, supplementation can be used as an interim measure to prevent demographic extinctions. 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 the ISS 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 brood stock, 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 (completed) 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 was a cooperative project involving all the members of the ISTAC. The committee was 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.)

b. Rationale and significance to Regional Programs

The NPPC has called "for immediate efforts to gather data on wild and naturally spawning stocks, review impacts of the existing hatchery system and coordinate supplementation activities" to achieve its goal of doubling anadromous fish runs in the Columbia Basin as addressed in the Columbia Basin fish and Wildlife program (NPPC 1994). The relationships between FWP (1994) and ISS research objectives are summarized below.

FWP Section 7.3B.2 – ISS Research Objectives 1, 2, and 3 (Implementation Pahse): Implement the high priority supplementation programs including monitoring and evaluation.

FWP Section 7.0A – ISS Research Objectives 1 and 3: Identify which supplementation strategies (brood stock and release stage) will be most affective in increasing natural production without adverse effects on productivity.

FWP Section 7.1B.1 – ISS Research Objective 2: Monitor and evaluate changes in productivity and genetic composition of target and adjacent populations following supplementation.

FWP Section 7.1C.3 – ISS Research Objective 2: To establish a baseline profile for evaluation and monitoring, we will include a genetic profile analysis for treatment and control streams.

FWP Section 7.2A – ISS Research Objectives 1 through 4: Based on the results of each of the objectives we expect to document which methods are best for supplementing existing, naturally reproducing populations of chinook salmon and reestablishing naturally producing populations in streams where they have been extirpated. A major contributor in this effort has been our participation in the Regional Assessment of Supplementation Project (RASP 1991). The ISS experiment was designed parallel to development of the RASP process, and RASP guidelines were incorporated in the design.

c. Relationships to other projects

ISS is a cooperative effort between the Idaho Department of Fish and Game, U.S. Fish and Wildlife Service, the Nez Perce Tribe, and the Shoshone-Bannock Tribes. Each cooperating agency has the responsibility for investigations of different streams within Idaho (see specific project proposals included under this umbrella). All cooperators meet together to plan project activities and discuss adaptive changes necessary to maintain project relevancy and effectiveness.

Each ISS cooperator completes requirements for the National Environmental Policy Act (NEPA) with land management agencies where project activities occur on public land. ESA section 10 permits are also acquired through the national Marine Fisheries Service.

d. Project history (for ongoing projects)

The Idaho Salmon Supplementation (ISS) Studies in Idaho Rivers project started in 1989 as project 89098, (Idaho Department of Fish and Game, current project 8909800). In 1992, the Nez Perce Tribe, Shoshone-Bannock Tribes, and U.S. Fish and Wildlife Service were funded to assist in the ISS project as cooperative agencies with project numbers of 8909802, 8909803, and 8909801 respectively. The

Idaho Cooperative Fish and Wildlife Research Unit (ICFWRU, University of Idaho) was subcontracted by the Idaho Department of Fish and Game to conduct small scale investigations under the ISS study.

The ISS Experimental Design was completed and published in 1991. Baseline data collection and development of supplementation brood stocks (Phase I) began in 1991. The study is currently in Phase II – utilizing the brood stocks to supplement treatment streams. Juvenile fish releases through brood year 1996 include 1,281,755 fish in the Cleawater River basin and 1,954,048 fish in the Salmon River basin. Monitoring treatment effects is an on-going task. Small-scale studies subcontracted to the ICFWRU were completed and results and recommendations incorporated into subsequent fish releases.

Publications and reports to date include the initial study design (Bowles and Leitzinger 1991), small scale studies (Peery and Bjornn 1996), and annual reports; Arnsberg (1993), Hesse and Arnsberg (1994), Hesse et al. (1995), Keith et al. (1996), Leitzinger et al.(1996), Leitzinger et al. (1993), Nemeth et al. (1996), and Rockhold et al. (1997). A five year summary report encompassing information from all project coordinators is nearing completion (1999).

e. Proposal 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.

The specific RESEARCH GOALS of this project are:

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.

The specific RESEARCH OBJECTIVES of this project are:

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 (brood stock 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 questions relate directly to questions 2),3),6) and 7) specified as important critical uncertainties by the Supplementation Technical Work Group (STWG 1988). 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, smolt) 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?

f. Methods

Although interrelated, the design is split into three main approaches. The first and main level of evaluations 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-generation (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 existing natural populations and supplementation-restoration of extirpated populations. Supplementation (<u>augmentation</u>) 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 brood stocks with a high composition of natural fish. <u>Restoration</u> 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.

Small Scale Studies

"Small scale" studies were designed to address 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 spawners, 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. The following discussion on the experimental design pertains to the long-term supplementation/restoration objectives (first and second approaches).

<u>Statistical Design</u>

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. 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.

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 eight treatment streams in the Salmon River and 11 treatment streams in 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 eight control streams (experimental units) in the Salmon River and four 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).

Replication

Spatial and temporal replication are necessary to maximize the applicability of our research to long-term regional and Statewide 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 4-11 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). Assumptions of independence must be carefully qualified prior to using inferential statistics if pseudoreplication exists.

Power Analysis

Existing data bases on two of our evaluation points (parr density and redd counts) 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. Lognormal 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.

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, 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. 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 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.

g. Facilities and equipment

See specific project proposals covered by this umbrella.

h. Budget

Not applicable for umbrella proposal. See specific project proposals covered by this umbrella.

Section 9. Key personnel

See specific project proposals covered by this umbrella.

Section 10. Information/technology transfer

See specific project proposals covered by this umbrella.

Congratulations!