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# Review of Idaho Supplementation Studies

(IDFG/IOSC # 198909800; USFWS # 198909801; NPT # 19899802 and #199604300; SBT # 19899803)

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# ISRP Review of Idaho Supplementation Studies

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## Review Request

At the request of the Council, the Independent Scientific Review Panel reviewed a March 28, 2003 submittal from the project sponsors of the Idaho Supplementation Studies (ISS). The submittal was requested by the Council to address issues and concerns raised by the ISRP (ISRP 2001-12A) and subsequent conditions the Council placed on the ISS as part of Fiscal Year 2002 Mountain Snake Province project selection process (Programmatic Issue #10).

The ISS includes the following projects:

#1989-098-00, *Idaho Supplementation Studies* (IDFG, Salmon Subbasin).

#1989-098-01, *Evaluate Supplementation Studies in Idaho Rivers* (USFWS, Clearwater Subbasin).

#1989-098-02, *Evaluate Salmon Supplementation Studies in Idaho Rivers* (NPT, Salmon Subbasin).

#1989-098-03, *Salmon Supplementation Studies in Idaho* (SBT, Salmon Subbasin)

#1990-055-00, *Steelhead Supplementation Studies in Idaho Rivers* (IDFG/IOSC, Clearwater Subbasin)

#1996-043-00, *Johnson Creek Artificial Propagation Enhancement Project* (NPT, Salmon Subbasin).

In the provincial review, the ISRP recommended "not fundable until the ISRP concerns are adequately addressed." The ISRP commented that the ISS's experimental design had not been adhered to and, moreover, the current experimental design was not adequately defined. The ISRP recommended that the ISS sponsors provide a table specifying timelines for termination of the treatments on a stream-by-stream basis. Future commitment to treatment durations, particularly to the Phase III portion of the study design in which supplementation ceases, would enable the project sponsors to analyze the effects of the treatments. In the past, sponsors have not maintained the agreed upon control streams. How confounded are the treatment and control streams? This points to the need for submittal of a certified statistical design. The ISRP requested that the following elements be adequately addressed prior to a favorable recommendation.

*1. A written protocol for complete statistical analysis, certified by an independent statistician team should be presented to Council during the contracting period. The ISRP is not comfortable with the implications that "problems" with the study design can be "fixed" during the statistical analysis stage. Considerable thought and effort should be placed in planning the statistical analyses of these potentially controversial data before final decisions are made on criteria for stopping supplementation and before data are available.*

*2. The protocol for statistical analysis must indicate how straying of hatchery fish into "control streams" and "partial treatments" will be analyzed. For example, the response to the ISRP preliminary review indicated that the straying rate of hatchery fish into the Secesh River from 1996 - 2001 varied from 0.83% to 14.71%. This is de facto supplementation. It is unclear to the ISRP how partial treatment and de facto supplementation of control streams will be addressed in the statistical analysis of the ISS.*

*3. Development of a specific stream-by-stream protocol and timetable for implementation of Phase III of the ISS. Included in this is the immediate cessation of supplementation activities in Johnson Creek (see comments below on proposal 1996-043-00) and inclusion of Johnson Creek once again as a control stream in the ISS experimental design.*

The Council recommended that the ISS sponsors, provide the material as suggested by the ISRP in points 1 through 3 above. The exceptions were that the sponsors need not use an "independent statistician team;" and that the recommendation to halt supplementation activities in Johnson Creek and return it to "control" stream status is not absolutely required. The Council recommended that the Johnson Creek cooperators (Nez Perce Tribe, Idaho Department of Fish and Wildlife; U.S. Fish and Wildlife Service, and Shoshone Bannock Tribe) specifically detail how they agreed to move Johnson Creek from a control stream in the ISS study to one that is supplemented. This confirmation must include: (1) the understanding of the cooperators in 1996 regarding the use of this stream in the ISS study design; and (2) any agreements reached at that time regarding the magnitude of the Johnson Creek supplementation program, and any current agreement about the magnitude of the program currently underway. This information needs to be provided to the Council prior to the step two submittal.

The Council recommended that the Nez Perce Tribe and other ISS project sponsors investigate the possibility of managing the ISS study design and/or the Johnson Creek supplementation activities to maximize the quality of information that the ISS study can derive from Johnson Creek.

## Executive Summary and ISRP Recommendations based on the Current Review of the Idaho Supplementation Studies

The above concerns raised by the ISRP in its FY2002 review of the Idaho Supplementation Studies in the Mountain Snake provincial review were communicated to the ISS staff. ISS staff revisited its experimental design and anticipated analysis for the ISS effort. They have recently completed an updated description of the experimental design and prototype analytical protocol for statistical analysis (Lutch et al. 2003). The protocol attempts to specifically address ISRP concerns about the staggered timetable, partial treatment streams, statistical power, and statistical analysis in the face of straying by conventional hatchery fish into control and treatment streams. Our review and recommendations are based on previous reports and the new information in Lutch et al. (2003).

We first address the ISS response to our previous concerns.

*1. A written protocol for complete statistical analysis, certified by an independent statistician team should be presented to Council during the contracting period. The ISRP is not comfortable with the implications that "problems" with the study design can be "fixed" during the statistical analysis stage. Considerable thought and effort should be placed in planning the statistical analyses of these potentially controversial data before final decisions are made on criteria for stopping supplementation and before data are available.*

? Dr. Kirk Steinhorst, University of Idaho, is a professional statistician who helped in the original design of the ISS and is an author on the response by Lutch et al. (2003). The ISRP accepts the assistance of Dr. Steinhorst to meet the intent of the recommendation.

? ISS investigators report a preliminary analysis using a prototype analytical protocol that attempts to model and adjust for the effects of the strays on evaluation of supplementation results using a subset of streams with complete carcass data (Lutch et al. 2003). We agree that variations of the prototype statistical analyses are appropriate for analysis of the ISS. However, certain technical mathematical and statistical modeling issues remain.

? In the time available for this review, the ISRP was unable to determine the best plans for managing strays in **Phase III** and to analyze resulting data, to optimize information concerning effects of supplementation fish and effects of *de facto* supplementation by conventional hatchery strays. It is possible that the best approach is to analyze the data assuming that there are no "control" streams in the ISS, but instead there are streams with two types of supplementation; at levels ranging from 0% to somewhat less than

67% for supplementation by conventional hatchery strays and 0% to some unreported level X% for supplementation by Idaho Supplementation Study fish. The proportion of strays, proportion of ISS supplementation adults, and proportion of "naturally" produced adults varied from year to year on the spawning grounds of each stream during **Phase II**. The possibility exists for complex interaction between the two types of supplementation. The unresolved issue is how to best manage the levels of the two types of supplementation during **Phase III** to maximize information concerning effects of the intended supplementation by more appropriate broodstock and the unintended *de facto* supplementation by conventional hatchery strays. Our reaction is that during **Phase III**, supplementation with ISS fish should stop and the straying by conventional hatchery fish should be managed to continue to provide a range of levels of strays in the data set. This reaction is consistent with current ISS plans for **Phase III**. However, it is possible that information could be maximized by management controls (e.g., additional weirs on streams) to decrease the level of strays in some streams during **Phase III** or by continuing supplementation with ISS fish on some streams**.** For example, perhaps Johnson Creek and some of the other treatment streams should continue to receive supplementation by ISS fish during **Phase III.** These are complex design and statistical analysis issues that cannot be resolved by the ISRP during the time allowed for this review.

> **Recommendation. Phase III** of the ISS provides the sponsors an opportunity to re-focus the study and attempt to address as many of the original objectives as possible. We recommend therefore that during 2003 the sponsors conduct another pilot statistical analysis and direct significant effort to review current data and how to best re-direct the program for the start of **Phase III** in 2004.

2. *The protocol for statistical analysis must indicate how straying of hatchery fish into "control streams" and "partial treatments" will be analyzed. For example, the response to the ISRP preliminary review indicated that the straying rate of hatchery fish into the Secesh River from 1996 - 2001 varied from 0.83% to 14.71%. This is de facto supplementation. It is unclear to the ISRP how partial treatment and de facto supplementation of control streams will be addressed in the statistical analysis of the ISS.*

? ISS cooperators agreed with the need to address the effects of straying in the study streams. For treatment streams, strays were defined as non-ISS hatchery-produced fish that strayed into ISS study reaches. For control streams, all hatchery-origin chinook (supplementation and general production) were considered strays. Proportions of strays in study streams for which data exists varied from 0% to 67% in the Salmon Basin (treatment streams averaged 12% and control streams averaged 6%) and from 0% to 64% in the Clearwater Basin (treatment streams averaged 38% strays and control streams averaged 41% strays) (Table 2.1, Lutch et al. (2003) reproduced later in this report). Significant straying occurred in both supplemented streams and control streams.

? The pilot analysis conducted by Lutch et al. (2003) was limited to redd density per kilometer on a small number of streams where carcass data were collected annually and could be used to estimate the density of strays. Carcass data are apparently incomplete on the other study streams. The ability to meaningfully analyze the ISS for even one parameter, density of redds per kilometer of stream, at the end of **Phase III** depends critically on complete carcass data for estimation of density of strays and density of ISS fish on all streams (Lutch et al. 2003).

> **Recommendation.** The ISRP recommends that collection of carcass data be required in 2003 on all ISS study streams for estimation of abundance of strays and abundance of ISS supplementation fish and continued through **Phase III** of the study.

*3. Development of a specific stream-by-stream protocol and timetable for implementation of Phase III of the ISS. Included in this is the immediate cessation of supplementation activities in Johnson Creek (see comments below on proposal 1996-043-00) and inclusion of Johnson Creek once again as a control stream in the ISS experimental design.*

? Analytical difficulties caused by the staggered timetable have been addressed in two ways by ISS researchers. First, all treatment streams will move into the **Phase III** evaluation portion of the study in the spring of 2004, after the last smolt releases occur. This allows most of the supplemented streams to receive enough smolt releases to be classified within the study design as having received a full **Phase II** treatment. Monitoring of production and productivity response variables in **Phase III** will occur from 2004 through 2014, or approximately for two generations. The ISRP agrees that the timetable presented is an appropriate plan for implementation of **Phase III** of the ISS.

? The Council ruled earlier that it was not necessary to halt supplementation activities in Johnson Creek and return it to "control" stream status. The ISS updated report (Lutch et al. 2003) discusses the details of the decision to remove Johnson Creek from the ISS; however, see our response concerning no. 1 above, where we mention the possibility that Johnson Creek can contribute information to the ISS.

? Important questions to be answered by the ISS are those associated with objectives concerning fitness of the native stocks, displacement of wild fish, etc. The analysis conducted by Lutch et al. (2003) demonstrates that insufficient data are being collected on many important parameters, e.g. juvenile emigration/abundance, and parr density/abundance. The study is apparently left only with redd density adjusted for the effect of strays as a measure of supplementation effects. With current data collection it will not be possible to meet many original objectives of the study. Many questions that were to be addressed by this project, now seem destined to remain unanswered. The primary project objective in our view was "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)." Unfortunately, it appears that little or no information to meet this objective will be forthcoming unless considerable effort be extended to adjust the design and data collection during 2003 and **Phase III.**

? The ISRP is uncertain of the current status of chinook tissue collections throughout the ISS populations and stream types (treatment, control). The principal investigators of the ISS need to assess the status of collections, plan **Phase III** of the study, and use DNA level microsatellite analysis to identify parentage relationships between spawning adults, outmigrating smolts, and adults that return to spawn in the next generation (including the use of assignment tests) in order to separate non-ISS strays from natural production within distinct tributary systems. A second step, and subset of this analysis, would be to then separate ISS supplementation fish from natural-origin fish in the same system using the same methods. If collections are not sufficient or feasible in the future to allow the type of DNA analysis described above throughout the study streams, then the project sponsors should assess the overall project and identify locations, opportunities, and schedules (and budgets) that will provide for this critically needed analysis.

**Recommendation.** The ISRP recommends that DNA-based assessment of ISS treatment and control populations be used in order to separate the reproductive contributions of non-ISS strays from natural production in each tributary system. The varying levels of straying, and in several instances the very high levels of straying, documented in both control and treatment systems requires that a genetic-based tool like microsatellite DNA parentage analysis and assignment classification be used to assess the effect of the non-ISS strays on the study design and objectives. In addition, the feasibility of collection of data on other important parameters such as juvenile emigration/abundance, and parr density/abundance on all study streams should be reconsidered.

**Final ISRP Recommendation**

**Recommendation.** The ISRP recommends funding of the Idaho Supplementation Study for one year subject to the above stated requirements for carcass data collection in 2003. Further, the pilot analysis following the 2003 field season and the final design of the **Phase III** segment should be peer reviewed before the 2004 field season.

## Introduction and Background on the Idaho Supplementation Studies

The ISRP has freely used material from Lutch et al. (2003) in preparation of this summary and review of the ISS. Much of the text below will be included in the Independent Scientific Advisory Board's upcoming review of supplementation.

### *Idaho Supplementation Study (ISS)*

The Salmon and Clearwater subbasins support an important and diverse group of the Pacific Northwest's wild, indigenous salmonid populations. Many of them reside in habitat strongholds within large areas of designated wilderness and other roadless terrain. The two subbasins provide a core of remaining connected habitat for five species of salmonids: bull trout, westslope cutthroat trout, redband trout (sympatric with steelhead), stream-type chinook salmon, and summer steelhead (Thurow et al. 2000). They also support critical habitat for listed sockeye salmon, and large connected habitats for Pacific lamprey, white sturgeon, and a variety of other native nongame fishes.

Although resident salmonid populations within many of the Salmon and Clearwater subbasin's undeveloped areas are recognized as some of the strongest in the region, the ESA-listed salmon and steelhead in these areas are struggling to persist upstream of eight hydroelectric dams on the mainstem Columbia and Snake rivers and in the face of degraded or non-accessible habitat in many watersheds. Regional decision-makers have developed plans focusing on restoring habitats within degraded watersheds as an alternative to breaching lower Snake River dams as a restoration measure for anadromous salmonids. This is intended to increase in-subbasin survival rates of anadromous fish and improve habitat conditions for important populations of resident salmonids and other sensitive species within the subbasin.

In addition to these habitat actions, plans to conserve and restore salmon and steelhead populations involve using artificial production techniques. Techniques of artificial production vary by species and stock and include captive rearing for the endangered Redfish Lake sockeye, conventional harvest-oriented production of spring chinook (Rapid River) and steelhead (Lower Snake River Compensation Program (LSRCP)), and supplementation production for spring/summer chinook (ISS project). This review is confined to the Idaho Supplementation Studies on spring/summer chinook. Supplementation activities for steelhead in the Salmon and Clearwater subbasins are not organized into a systematic and rigorous experimental design, but occur at smaller scales on specific populations.

### *Salmon River Subbasin*

The Salmon Subbasin covers approximately 14,000 square miles or 16.7% of the land area of Idaho. Ten major hydrologic units (watersheds) occur within the subbasin: the Upper Salmon, Pahsimeroi, Middle Salmon-Panther, Lemhi, Upper Middle Fork Salmon, Lower Middle Fork Salmon, South Fork Salmon, Lower Salmon, and Little Salmon watersheds. The subbasin has nearly 1700 named streams with a combined length of nearly 17,000 stream miles. These streams flow from headwaters in the Beaverhead, Salmon River, Lemhi, Lost River, Sawtooth, and smaller mountain ranges to the mouth of the Salmon River at its confluence with Snake River in lower Hells Canyon. The largest of the major watersheds is the Upper Salmon, and the smallest the Little Salmon.

Public lands account for approximately 91 percent of the Salmon Subbasin, with most being in federal ownership and managed by seven National Forests or the Bureau of Land Management. Public lands within the subbasin are managed to produce wood products, forage for domestic livestock, and minerals, and to provide recreation, wilderness, and terrestrial and aquatic habitats. Approximately nine percent of the subbasin land area is privately owned. Private lands are primarily in agricultural cultivation, and are concentrated in valley bottom areas within the upper and lower portions of the subbasin.

No year-round, total barriers to fish migration currently exist on the Salmon River and its larger tributaries, however total barriers exist on many smaller tributaries. Partial, total, and seasonal barriers to anadromous fish exist on Panther Creek in the form of acid mine drainage, and on the Lemhi, Pahsimeroi and upper Salmon rivers at water diversions for irrigation. Twenty minor tributaries contain dams that are used for numerous purposes such as irrigation, recreation and fish propagation (Salmon Subbasin Summary, 1990).

Two power dams were constructed on rivers in the Salmon Subbasin in the early 1900s but have since been removed. These were Sunbeam Dam on the mainstem Salmon River immediately upstream from the Yankee Fork confluence and a power dam on the lower Lemhi River. Sunbeam Dam, constructed in 1910 by the Golden Sunbeam Mining Company, remained intact until it was intentionally breached in 1934. Sunbeam Dam constituted a complete blockage for adult anadromous fish to the uppermost Salmon River subbasin for most of the period between 1911 and 1934. In 1934, the rock abutment on the south side of the dam was breached with explosives. A power dam blocked the lower Lemhi River in the 1920's and 30's, isolating the Lemhi basin except during high water periods when water bypassed the dam. A combination of the dam and hatchery and commercial take contributed to the collapse of the chinook stock and by the late 1930's the run had dwindled to about 200 fish. The power dam was removed in 1938 and fish runs began to rebuild until the 1960's. They have declined since, with only 7 redds found in a 1994 aerial survey of the Lemhi watershed (ISCC 1995).

### *Clearwater River Subbasin*

The Clearwater River subbasin, lying immediately north of the Salmon River subbasin, drains approximately a 9,645 square mile area in north central Idaho. There are four major tributaries that drain into the mainstem Clearwater River: the Lochsa, Selway, South Fork Clearwater, and North Fork Clearwater Rivers. Dworshak Dam, constructed in 1972, is located two miles above the mouth of the North Fork Clearwater River where it blocks access to one of the most productive tributary systems for anadromous fish in the subbasin. It is the only major water regulating facility in the subbasin.

More than two thirds of the total acreage of the Clearwater subbasin is evergreen forests (over four million acres), largely in the mountainous eastern portion of the subbasin. The western third of the subbasin is part of the Columbia plateau and is comprised almost entirely of crop and pastureland. Most of the forested land within the Clearwater subbasin is owned by the federal government and managed by the USFS (over 3.5 million acres), but the state of Idaho, Potlatch Corporation, and Plum Creek Timber Company also own extensive forested tracts. The western half of the subbasin is primarily in the private ownership of small forest landowners and timber companies, as well as farming and ranching families and companies. Nez Perce Tribal lands are located primarily within or adjacent to Lewis, Nez Perce, and Idaho Counties within the current boundaries of the Nez Perce reservation.

Seventy dams currently exist within the boundaries of the Clearwater subbasin, the vast majority of which exist in the Lower Clearwater (56), although dams also currently exist in the Lower North Fork (3), Lolo/Middle Fork (5), and South Fork (6) areas. Of the 70 dams, descriptive data concerning the size, capacity and ownership is available for only 46; the remainder are thought to be small earthen structures with minimal storage capacity.

At 219 m in height with a reservoir approximately 86 km long and a maximum depth of 194 m, Dworshak Dam is the largest straight axis concrete dam in the United States. Dworshak reservoir extends 54 miles into the North Fork Clearwater River Canyon and provides 3.453 million acre-feet of storage, making it the largest storage project within the Nez Perce Tribe ceded area and the state of Idaho. Located two miles above the mouth of the North Fork Clearwater River the dam blocked fish passage for anadromous fish to spawning habitat that could accommodate approximately 109,000 steelhead trout redds and 74,000 chinook salmon redds. The dam also inundated 16,970 acres of terrestrial and riverine habitats at full pool.

Drawdowns for flood control may lower the surface elevation of Dworshak Reservoir 47 m and reduce surface area by as much as 52%. The reservoir has a mean retention time of 10.2 months and a mean annual discharge of 162 $m^3$/s (Falter 1982). High releases from the reservoir occur during spring run-off, during late summer when water is released for anadromous fish flows, and during the fall when the reservoir is lowered for flood control.

Numerous dams, having had substantial impacts on fishery resources, have been removed from the Clearwater subbasin. Lewiston dam, constructed in 1927 on the lower Clearwater River near the present site of the Potlatch pulp mill (RM 4) and operated by Washington Water Power, virtually eliminated chinook salmon runs and substantially reduced steelhead runs into the Clearwater subbasin (Nez Perce Tribe and Idaho Department of Fish and Game 1990). Modifications were later made to Lewiston Dam to facilitate fish passage, and the dam was removed in 1973 as part of the Lower Granite Lock and Dam Project. A dam constructed in 1910 on the lower South Fork Clearwater (RM 22) near the town of Harpster by Washington Water Power blocked anadromous salmon species from the South Fork Clearwater River. The dam formed a complete barrier to fish migration from 1911-1935 and from 1949-1963, when the dam was removed (Paradis et al. 1999). A fish ladder was installed in the dam in 1935 and was destroyed in 1949 by high flows (Paradis et al. 1999).

### *Chinook Salmon in the Salmon and Clearwater Subbasins*

Two chinook salmon ESUs are recognized by the National Marine Fisheries Service (NMFS) under the Endangered Species Act, spring/summer and fall chinook salmon. Historical numbers of chinook salmon entering the Clearwater River subbasin are assumed to be substantial, but no documentation on actual numbers is available (Nez Perce Tribe and Idaho Department of Fish and Game 1990). Chapman (1981) estimated that 1.5 million smolts were produced annually from Clearwater chinook stocks resulting in 87,433 adults returning to the mouth of the Columbia River. The majority of historical chinook salmon production was thought to occur in major tributary systems of the Clearwater River (North, South, and Middle Forks), with less than 10% of total production in the mainstem reach (Clearwater National Forest 1997). Within the mainstem portion of the Clearwater River, the most substantial production of spring chinook salmon probably occurred in the Lolo and Potlatch Creek drainages (Clearwater National Forest 1997; Clearwater Basin Bull Trout Technical Advisory Team 1998b). Redd counts for chinook (spring/summer) have varied between approximately 50 and 400 over the last 35 years.

Re-introduction of spring chinook salmon following removal of the Lewiston Dam has resulted in naturally reproducing runs in Lolo Creek, and mainstems and tributaries of the Lochsa, Selway, and South Fork Clearwater Rivers (Larson and Mobrand 1992). Founding hatchery stocks used for spring chinook salmon re-introductions were primarily obtained from the Rapid River Hatchery (Kiefer et al. 1992; Nez Perce Tribe and Idaho Department of Fish and Game 1990). Initially however, spring chinook stocks imported for restoration came from Carson, Big White, Little White or other spring chinook captured at Bonneville dam (Nez Perce Tribe and Idaho Department of Fish and Game 1990). Genetic analyses confirm that existing natural spring chinook salmon in the Clearwater River subbasin are derived from reintroduced Snake River stocks (Matthews and Waples 1991). Consequently, spring chinook salmon within the Clearwater subbasin are excluded from the ESU encompassing other spring/summer stocks throughout the Snake River basin, but represent an important effort aimed at restoring an indigenous fish population to an area from which they had been extirpated.

Natural recolonized and re-introduced fall chinook salmon within the Clearwater subbasin are part of the Snake River evolutionarily significant unit (ESU) as defined by the ESA. As such, fall chinook salmon within the Clearwater subbasin represent an important metapopulation within the Snake River ESU. Maintenance and function of fall chinook salmon metapopulation dynamics within the Clearwater subbasin itself will play an important role in recovery of the Snake River ESU.

### *ISS Overview*

The Idaho Department of Fish and Game (IDFG) spearheaded development of the Idaho Supplementation Studies to help define the potential role of supplementation in managing Idaho's anadromous fisheries and as a recovery tool for the basin (NPPC 1987), and to address questions identified in the Supplementation Technical Work Group (STWG) Five Year Workplan (STWG 1988). The goal of the Idaho Supplementation Studies is to evaluate various supplementation strategies for maintaining and rebuilding spring/summer chinook salmon populations in Idaho and to develop recommendations for using supplementation to rebuild naturally spawning populations.

The ISS project is an Idaho statewide research effort occurring throughout the Salmon and Clearwater subbasins. The study and all related research activities are operated under an “umbrella” agreement among four cooperating agencies: 1) IDFG (lead agency), 2) Nez Perce Tribe (NPT), 3) Shoshone-Bannock Tribes (SBT), and 4) US Fish and Wildlife Service (USFWS). Due to the large geographic scope of this study, study streams were partitioned among four resource management entities for implementation. These include Idaho Department of Fish and Game (IDFG), Nez Perce Tribe (NPT), Shoshone-Bannock Tribe (SBT), and the U.S. Fish and Wildlife Service-Idaho Fishery Resource Office (USFWS). Approximately one-half of the study is being implemented by IDFG through the ISS contract with BPA. The Nez Perce Tribe and Shoshone-Bannock Tribe 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. The USFWS implements about ten percent of the project. The IDFG is the lead agency regarding project development, coordination, and implementation.

As stated in the review request, projects directly involved in the ISS are:

Salmon Subbasin

1. Project ID 198909800. Idaho Supplementation Studies. Sponsor: Idaho Department of Fish and Game and Idaho Office of Species Conservation.

2. Project ID 198909802. Evaluate Salmon Supplementation Studies in Idaho Rivers- Nez Perce Tribe. Sponsor: Nez Perce Tribe.

3. Project ID 198909803. Salmon Supplementation Studies in Idaho- Shoshone-Bannock Tribes. Sponsor: Shoshone-Bannock Tribes.

4. Project ID 199604300. Johnson Creek Artificial Propagation Enhancement Project. Sponsor: Nez Perce Tribe

Clearwater Subbasin

5. Project ID 198909801. Evaluate Supplementation Studies in Idaho Rivers (ISS). Sponsor: U.S. Fish and Wildlife Service - Idaho Fishery Resource Office.

6. Project ID 199005500. Steelhead Supplementation Studies in Idaho Rivers. Sponsor: Idaho Department of Fish and Game and Idaho Office of Species Conservation.

ISS coordinates field activities and data collection efforts with the Idaho Habitat/ Natural Production Monitoring project (199107300). ISS also coordinates with and transfers data to projects in the Salmon River subbasin including the Monitoring Smolt Migration of Wild Snake River Spring/Summer Chinook Salmon (199102800), Salmon River Habitat Enhancement (9405000), and Salmon River Production Program (199705700). ISS also works closely with the Lower Snake River Compensation Plan (LSRCP) to coordinate on hatchery supplementation treatments and evaluations.

### *ISS Study Design*

The ISS study design called for a minimum of 15 years (three generations) of research (Bowles and Leitzinger 1991). Sampling was initiated in 1991, and implementation began in 1992. Supplementation effects were to be monitored and evaluated by comparing juvenile abundance and survival, adult fecundity, age structure, and genetic diversity in treatment and control (reference) streams of similar ecological parameters, however pilot analyses were only possible on density of redds due to incomplete data on other parameters. The words "reference stream" are preferred by the ISRP because perfect "control streams" are not usually feasible; however, here we use the term "control" to be consistent with ISS usage. The study design called for three phases: Phase I, local broodstock development; Phase II, treatment period; Phase III, evaluation period. Each phase was anticipated to last five years; however, low adult returns in the 1990s slowed broodstock development and treatments in some study streams. This has resulted in many treatments being out-of-phase with the original study design.

Broodstock development for the ISS treatment streams did not follow RASP guidelines of development from a local wild source. Instead, broodstocks were developed using local wild/natural adults crossed with hatchery-origin adults from the hatchery stock already being outplanted into the treatment stream at the inception of the ISS program. Progeny from these initial crosses that returned as adults were again crossed with wild/natural adults and progeny from this second set of crosses were released (all marked) as the first set of ISS smolt releases and treatments.

The mixed hatchery and wild/natural heritage of the broodstocks means that a straightforward evaluation of the fitness effects of supplementation treatments will not be possible in the forthcoming Phase III portion of the study. Additionally, because not all hatchery-origin adults were marked at the time the ISS broodstocks were being developed, the wild/natural adults used to establish the local broodstock could have been from several sources including the indigenous wild chinook populations, the hatchery stock used at that time in the treatment stream, or a hatchery-origin adult from another conventional hatchery that strayed into the treatment stream.

These difficulties and other critical issues raised by the ISRP in its FY2002 review of the Idaho Supplementation Studies in the Mountain Snake provincial review led the ISS staff to revisit its experimental design. They have recently completed an updated experimental design and protocol for statistical analysis (Lutch et al. 2003). The protocol attempts to specifically address ISRP concerns about the staggered timetable, partial treatment streams, statistical power, and statistical analysis in the face of straying by conventional hatchery fish into control and treatment streams.

Analytical difficulties caused by the staggered timetable have been addressed in two ways by IDFG researchers. First, all treatment streams will move into the Phase III evaluation portion of the study in the spring of 2004, after the last smolt releases occur. This allows 12 of the 15 treatment streams to receive enough smolt releases to be classified within the study design as having received a full Phase II treatment. The remaining three streams will be classified as having only a partial treatment. Presently only 5 of the 15 treatment streams have received a full Phase II treatment. Second, in conducting preliminary analyses, IDFG researchers discovered that a calendar year did not provide a statistically meaningful unit of time due to the staggered timetable of Phase II treatments, which had been imposed by the difficulties of establishing local broodstocks (p. 14; Lutch et al. 2003). Consequently, IDFG researchers used an alternative unit of time, where positive integers (1,2,3, …8 as needed) denote the first, second, third, etc, years where supplementation produced fish could have come back and reproduced in the treatment stream (also called the Time II period). Years prior to that (Time I), where supplementation produced fish could not have come back and reproduced in the treatment stream (i.e., Phase I and early Phase II of study design), were coded as -8, -7, …., -1, and 0.

The initial ISS Experimental Design was completed and published in 1991. Baseline data collection and development of supplementation brood stocks (Phase I) began in 1991. Over a period of about five years, supplementation brood stocks were developed for seven hatchery trap/release locations as identified in the experimental design. These are:

Artificial Production Facilities

1. Sawtooth Fish Hatchery – Upper Salmon River
2. Pahsimeroi Fish Hatchery – Pahsimeroi River
3. McCall Fish Hatchery – South Fork Salmon River

Clearwater Fish Hatchery Satellites

4. Crooked River
5. Red River
6. Powell (Colt-killed Creek)
7. Clear Creek – Kooskia National Fish Hatchery

As adult fish began to return from the Phase I supplementation brood stock juvenile releases, the project progressed into Phase II. Phase II utilizes the returning adults to supplement natural origin recruits in treatment streams and maintains supplementation broodstocks for juvenile production and release. Juvenile fish releases through brood year 1996 include 1,281,755 fish in the Clearwater River basin and 1,954,048 fish in the Salmon River basin.

The project is now transitioning from Phase II to Phase III, monitoring the effects of supplementation. In Phase III, juvenile releases from supplementation brood stocks are to be terminated. At present, this will occur in the spring of 2004. In Phase III, returning hatchery-origin adults from prior juvenile releases are expected to supplement spawning of natural origin recruits. Monitoring of production and productivity response variables in control and treatment streams will occur from 2004 through 2014; approximately two generations. IDFG researchers felt it necessary to track the treatment (and control) populations for a minimum of two generations in order to assess whether the abundance increase achieved during the treatment phase was maintained in the non-supplemented population. However, researchers expect to collect data beyond 2014 as well.

## *Summary of ISS Results To Date*

Lutch et al. (2003) summarize the most recent results from the ISS in their updated report on experimental and statistical design. Parts of that summary, several tables, and a figure from that report are duplicated below. The original ISS study design included 20 treatment and 11 control streams. The current design includes 16 treatment and 14 control streams (Figure 1.1 and Table 1.2 from Lutch et al. 2003). Changes in the original and present design are primarily due to low adult returns in the 1990s and difficulties in establishing treatment broodstocks from each local population.

The estimated proportion of non-ISS fish recovered annually in each stream suggests that substantial straying is occurring in many ISS study reaches (Table 2.1 from Lutch et al. 2003). In the Salmon River subbasin, straying averaged more than 25% in two treatment streams. Treatment streams in the Clearwater River subbasin experienced even higher rates of straying, with estimates exceeding 50%. Because most Clearwater treatment streams are located adjacent to satellite conventional hatchery facilities that maintain LSRCP mitigation and other subbasin activities, the result is disturbing but not surprising. IDFG suspected that these estimates were fairly representative of the straying component to the ISS project.

IDFG conducted a preliminary analysis on the relationship between straying and redd density for a limited number of streams. Not surprisingly, they found a positive relationship between redd density and straying. This was particularly evident in streams where the most complete carcass data were available, such as Crooked Fork Creek, Red River, and the South Fork Salmon River. They then conducted an analysis of variance of the data with and without straying as a covariate. Results of the test of equality of slopes indicated that the supplementation treatment by stray interaction was statistically non-significant ($F_{2,45} = 0.297$, $p = 0.774$), which suggested that the slopes of the lines across all study streams were not significantly different from each other. Using ANCOVA, they found the covariate (straying) was significant ($F_{1,47} = 40.26$, $p = 0.000$) and the supplementation treatment and time interaction not significant ($F_{12,47}=1.489$, $p=0.162$). When the covariate is omitted, the test of interaction is also not significant ($F_{12,48}=1.191$, $p = 0.317$). Based on this preliminary analysis, the investigators concluded that there is a relationship between redd production and straying, but no statistically significant effect on the treatment by time interaction was observed for the 11 streams analyzed. In further statistical analyses, the investigators dropped the effect of straying from the model. The investigators note and the ISRP agree that this conclusion is preliminary, may not hold in the analysis of additional data, and data on straying needs to be collected on all ISS streams.

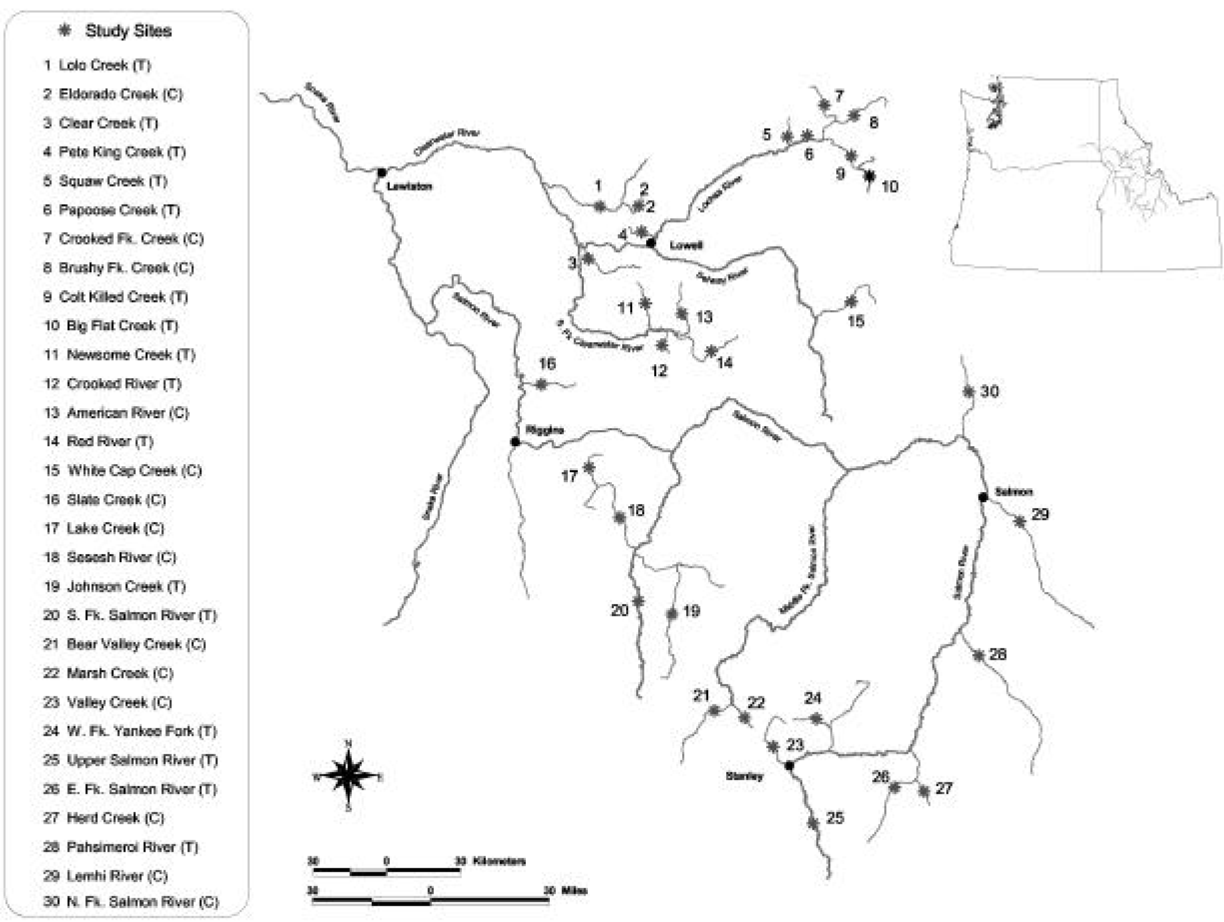


Figure 1.1. From Lutch et al. (2003) showing the current treatment and control streams for the Idaho Supplementation Studies.

The new design also attempts to account for lack of implementation of the full design by incorporating a partial treatment category for streams that have received less than 50% of the treatments prescribed in the original study (Table 1.3 from Lutch et al. 2003). IDFG believed that it would be unwise to assume that streams receiving only a few treatments were directly comparable to streams receiving nearly all prescribed treatments. Preliminary analyses of the ISS treatment effects (Lutch et al. 2003) uses redd count data, expressed as redds/km, because data on this variable were the most complete. Incomplete data on carcass recoveries, weir counts, juvenile emigration/abundance, and parr density/abundance remain unanalyzed.

The ISRP identified straying to be a problem that needed additional attention in the ISS study and the analysis protocol. ISS cooperators agreed with this assessment. For treatment streams, strays were defined as non-ISS hatchery-produced fish that strayed into ISS study reaches. For control streams, all hatchery-origin chinook (supplementation and general production) were considered strays.

Table 1.3 from Lutch et al. 2003. Number of treatments completed to date in ISS study streams. Partial treatment refers to streams that have received <50% of annual treatments prescribed in the original study design.

| | Status through Brood Year 1999 | | |
|---|---|---|---|
| Treatment Stream | Number of treatments | Percent treatment | Treatment designation |
| Clearwater Basin | | | |
| Lolo Creek | 3 | 33 | Partial |
| Newsome Creek | 4 | 40 | Partial |
| Crooked River | 4 | 44 | Partial |
| Red River | 7 | 78 | Treatment |
| Clear Creek | 5 | 56 | Treatment |
| Pete King Creek | 3 | 33 | Partial |
| Squaw Creek | 4 | 44 | Partial |
| Papoose Creek | 3 | 33 | Partial |
| Colt Killed Creek | 4 | 44 | Partial |
| Big Flat Creek | 2 | 22 | Partial |
| American River | 1 | 11 | Partial |
| Salmon Basin | | | |
| SF Salmon River | 9 | 100 | Treatment |
| Pahsimeroi River | 7 | 78 | Treatment |
| EF Salmon River | 3 | 33 | Partial |
| WF Yankee Fork | 1 | 11 | Partial |
| Upper Salmon River | 9 | 100 | Treatment |

Table 2.1 from Lutch et al. (2003). Average proportion of non-ISS chinook salmon carcasses recovered in ISS study streams during carcass surveys. N = the number of years with covariate estimates out of a possible of seven. ND = no data.

| Subbasin | Study Stream | Category | N | Proportion Stray |
|---|---|---|---|---|
| Clearwater River | American River | Treatment | 7 | 0.61 |
| | Big Flat Creek | Treatment | 7 | 0.63 |
| | Brushy Fork Creek | Control | 7 | 0.44 |
| | Clear Creek | Treatment | 7 | 0.31 |
| | Colt Killed Creek | Treatment | 6 | 0.64 |
| | Crooked Fork Creek | Control | 7 | 0.58 |
| | Crooked River | Treatment | 7 | 0.30 |
| | Eldorado Creek | Control | 3 | 0.22 |
| | Herd Creek | Treatment | 4 | 0.08 |
| | Lolo Creek | Treatment | 7 | 0.38 |
| | Newsome Creek | Treatment | 5 | 0.44 |
| | Papoose | Treatment | 7 | 0.41 |
| | Pete King Creek | Treatment | 1 | 0 |
| | Red River | Treatment | 7 | 0.43 |
| | Squaw Creek | Treatment | 3 | 0.33 |
| | White Cap Creek | Control | | ND |
| Salmon River | Bear Valley Creek | Control | 7 | 0 |
| | EF Salmon River | Treatment | 2 | 0 |
| | Johnson Creek | Control | 7 | 0.02 |
| | Lake Creek | Control | 7 | 0.05 |
| | Lemhi River | Treatment | 6 | 0 |
| | Marsh Creek | Control | 5 | 0.01 |
| | NF Salmon River | Treatment | 3 | 0 |
| | Pahsimeroi River | Treatment | 4 | 0.27 |
| | Secesh River | Control | 7 | 0.05 |
| | Slate Creek | Control | 3 | 0.21 |
| | SF Salmon River | Treatment | 7 | 0.67 |
| | Upper Salmon River | Treatment | 4 | 0 |
| | Valley Creek | Treatment | 6 | 0 |
| | WF Yankee Fork | Treatment | 2 | 0 |

The next major refinement of the ISS study design was an attempt to standardize for the treatment type by assigning treatment streams to the categories: full, partial or control, and for the differing time schedules among the many treatment and control streams, due to the staggering of broodstock development, and treatment duration resulting from the low adult returns in the 1990s. Results of the prototype Partial F tests of fixed effects yielded a highly significant treatment by time interaction, suggesting that supplementation affected redd counts (Table 3.2). Scrutinizing the least squared means (Table 3.3) and differences between least squared means (Table 3.4), the investigators reached the preliminary conclusion that the significance of the treatment by time interaction results largely from an increase in the partially treated category from Time I to Time II. In general, it appears that at the inception of the ISS study partially treated streams had fewer redds per km than control streams, while fully treated streams had more. Thus far, it appears that supplementation increased redds per km in partially treated streams, which now surpass redds per km in control streams, on average. Again, the investigators note and the ISRP agreed that this conclusion is preliminary and may not hold in the analysis of additional data. In particular, it would not be appropriate to ignore the effect of strays in future analyses.

Table 3.2 from Lutch et al. (2003) showing Type 3 tests of fixed effects from the prototype analysis of ISS redds per kilometer data.

| Effect | Numerator DF | Denominator DF | F-Value | Pr>F |
|---|---|---|---|---|
| Treatment | 2 | 19 | 0.82 | 0.4572 |
| Time | 1 | 14 | 4.15 | 0.0610 |
| Treatment x Time | 2 | 240 | 18.11 | <0.0001 |

Table 3.3 from Lutch et al. (2003) showing least squared means associated with control, partial, and fully treated ISS streams during Time I and Time II of the ISS project.

| Treatment | Time | Estimate | Standard Error | Degrees of Freedom | t value | Pr>\|t\| |
|---|---|---|---|---|---|---|
| Control | 1 | 0.2420 | 0.1011 | 240 | 2.39 | 0.0175 |
| Control | 2 | 0.3416 | 0.09723 | 240 | 3.51 | 0.0005 |
| Partial | 1 | 0.1229 | 0.1084 | 240 | 1.13 | 0.2582 |
| Partial | 2 | 0.5605 | 0.1091 | 240 | 5.14 | <0.0001 |
| Treatment | 1 | 0.3991 | 0.1314 | 240 | 3.04 | 0.0027 |
| Treatment | 2 | 0.4510 | 0.1219 | 240 | 3.70 | 0.0003 |

Table 3.4 from Lutch et al. (2003) showing differences of Least Squared Means.

| Effect | Treatment | Time | Treatment | Time | Estimate | Error | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|---|
| Treatment x Time | Control | 1 | Control | 2 | -0.09961 | 0.1004 | 240 | -0.99 | 0.3222 |
| Treatment x Time | Control | 1 | Partial | 1 | 0.1191 | 0.09942 | 240 | 1.2 | 0.232 |
| Treatment x Time | Control | 1 | Partial | 2 | -0.3184 | 0.1354 | 240 | -2.35 | 0.0195 |
| Treatment x Time | Control | 1 | Treatment | 1 | -0.157 | 0.1161 | 240 | -1.35 | 0.1773 |
| Treatment x Time | Control | 1 | Treatment | 2 | -0.209 | 0.1416 | 240 | -1.48 | 0.1413 |
| Treatment x Time | Control | 2 | Partial | 1 | 0.2187 | 0.1324 | 240 | 1.65 | 0.0997 |
| Treatment x Time | Control | 2 | Partial | 2 | -0.2188 | 0.09705 | 240 | -2.25 | 0.0251 |
| Treatment x Time | Control | 2 | Treatment | 1 | -0.05743 | 0.1484 | 240 | -0.39 | 0.6992 |
| Treatment x Time | Control | 2 | Treatment | 2 | -0.1094 | 0.1067 | 240 | -1.03 | 0.3062 |
| Treatment x Time | Partial | 1 | Partial | 2 | -0.4376 | 0.1015 | 240 | -4.31 | <.0001 |
| Treatment x Time | Partial | 1 | Treatment | 1 | -0.2762 | 0.1263 | 240 | -2.19 | 0.0298 |
| Treatment x Time | Partial | 1 | Treatment | 2 | -0.3281 | 0.1483 | 240 | -2.21 | 0.0278 |
| Treatment x Time | Partial | 2 | Treatment | 1 | 0.1614 | 0.1577 | 240 | 1.02 | 0.3072 |
| Treatment x Time | Partial | 2 | Treatment | 2 | 0.1094 | 0.1194 | 240 | 0.92 | 0.3604 |
| Treatment x Time | Treatment | 1 | Treatment | 2 | -0.05195 | 0.1133 | 240 | -0.46 | 0.6469 |

Lutch et al. (2003) caution that these results and interpretations are preliminary. Adults from ISS Phase II juvenile treatments will continue to return through calendar year 2007, and thus are not reflected in these data. The preliminary interpretations above are presented by the investigators to demonstrate that a viable prototype statistical analysis has been formulated that is capable of handling the unique challenges associated with the ISS study (e.g., differing levels of treatment and timing of treatments) resulting from deviations from the original study design.

### *Bringing the ISS to Conclusion*

The ISS cooperators recommend ceasing development of supplementation broodstock for all treatment streams with Brood Year 2002. Projected treatments through BY02 will increase the number of treated (i.e. >50% treated) streams compared to partially treated streams (Table 4.2 from Lutch et al. 2003). Rather than staggering treatment among selected streams over a specific period, ISS cooperators felt that ceasing treatment simultaneously would likely reduce annual variation and error associated with differences in mainstem passage and ocean productivity. Broodstock created through 2002 will be released into ISS treatment streams through spring 2004 as prescribed in the study design (Bowles and Leitzinger, 1991). Transition from Phase II (Supplementation) to Phase III (Evaluation) will occur once all brood year releases are completed.

Table 4.2 from Lutch et al. (2003) showing current and expected levels of supplementation releases in ISS treatment streams from BY91–BY99. Partial treatment designation categorizes streams that have received <50% of annual treatments originally defined in the study design. * = no releases since BY93.

| | Status Through BY99 | | | Predicted Status Through BY02 | | |
|---|---|---|---|---|---|---|
| Treatment Stream | Number of Treatments | Percent Treatment | Treatment Designation | Number of Treatments | Percent Treatment | Treatment Designation |
| Clearwater Basin | | | | | | |
| Lolo Cr | 3 | 33 | Partial | 6 | 50 | Treatment |
| Newsome Cr | 4 | 40 | Partial | 7 | 54 | Treatment |
| Crooked R | 4 | 44 | Partial | 7 | 58 | Treatment |
| Red R | 7 | 78 | Treatment | 10 | 83 | Treatment |
| Clear Cr | 5 | 56 | Treatment | 8 | 67 | Treatment |
| Pete King Cr | 3 | 33 | Partial | 6 | 50 | Treatment |
| Squaw Cr | 4 | 44 | Partial | 7 | 58 | Treatment |
| Papoose Cr | 3 | 33 | Partial | 6 | 50 | Treatment |
| Colt Killed Cr | 4 | 44 | Partial | 7 | 58 | Treatment |
| Big Flat Cr | 2 | 22 | Partial | 2 | 17 | Partial |
| Salmon Basin | | | | | | |
| SF Salmon R | 9 | 100 | Treatment | 11 | 92 | Treatment |
| Pahsimeroi R | 7 | 78 | Treatment | 10 | 83 | Treatment |
| EF Salmon R | 3 | 33 | Partial | 3* | 25 | Partial |
| WF Yankee Fork | 1 | 11 | Partial | 1* | 8 | Partial |
| Upper Salmon R | 9 | 100 | Treatment | 12 | 100 | Treatment |

## Summary of ISS Study and Final Design of Phase III

It is clear that the recent ISRP reviews of the ISS suite of projects have led to a major re-evaluation of the study design and consideration of development of an analysis protocol. The project nears an important juncture in Spring 2004, when it transitions from Phase II supplementation treatments into the Phase III evaluation period, and supplementation treatments are modified or cease. The ISS project needs to be able to address (and answer) questions about the efficacy of supplementation as defined in its original objectives. Table A contains the original objectives in so far as the ISRP can determine. The current design and the changes that have occurred to the ISS design over the life of the project, and the degree of non-ISS straying seems to largely preclude the project from assessing most of its original research questions. The sponsors need to re-evaluate the current project and define how to more effectively address the original objectives in Table A.

Table A. Original objectives of the ISS in-so-far-as the ISRP can determine.

| **Objective** | **Task** | |
|---|---|---|
| Objective 1. Monitor and evaluate the effects of supplementation on parr, presmolt and smolt numbers and spawning escapements of naturally produced salmon. | a | Continue to implement "standardized" spawning, rearing, and marking and release protocols. |
| | b | Differentially mark all hatchery supplementation and general production fish released in or nearby study streams. |
| | c | PIT tag a minimum of 800 hatchery supplementation and general production fish released in or nearby study streams. |
| | d | Release various life stages of chinook salmon. Determine fish numbers for each life stage based on existing natural production and natural rearing capacity. |
| | e | Estimate late summer parr densities from snorkeling surveys. |
| | f | Pit tag a minimum of 800 naturally produced parr from each treatment and control stream to estimate smolt production and survival. |
| | g | Use existing weirs to collect, mark (PIT tag), and enumerate emigrating fish and to identify and enumerate returning adults. |
| | h | Compare natural production of supplemented populations to unsupplemented populations and baseline data. |

| | | |
|---|---|---|
| Objective 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. |
| | b | Monitor straying of hatchery supplementation fish into adjacent and control streams by weirs and carcass surveys. |
| | c | Determine spawner to recruitment relationship based on determined production and productivity indices (parr and smolt numbers, adult escapements, survival, eggs/spawner etc.). |
| | 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. |
| Objective 3. Determine which supplementation strategies (broodstock and release stage) provide the quickest and highest response in natural production without adverse effects on productivity. (Long Term) | a | 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. |
| | b | Use local broodstocks with known natural component from the target population during the second generation of supplementation. |
| | c | Compare natural production and productivity indices of supplemented populations using existing hatchery broodstocks (first generation) to populations using locally developed broodstocks (second generation). |
| | d | Compare natural production and productivity indices among supplemented populations using parr, fall presmolt and smolt release strategies. |
| Objective 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 (broodstock and release stage). |
| | b | Use local brood stocks with known natural component from the target population during the second generation of supplementation. |

The pilot analysis conducted by Lutch et al. (2003) was limited to redd density per kilometer on a small number of streams where carcass data were collected annually and could be used to estimate the density of strays. Necessary data are apparently incomplete on the other streams. The ability to meaningfully analyze the ISS for one parameter, density of redds, at the end of Phase III depends critically on complete carcass data for determination of strays on all streams. This critical data collection should be the top priority of the study in 2003. The principal investigators should reconsider whether data can be collected on other parameters, e.g. juvenile emigration/abundance, parr density/abundance, or DNA information, to allow for analysis. At any rate, it seems absolutely necessary to have redd density adjusted for the effect of strays as a measure of treatment effect.

The investigators report preliminary analyses using the prototype analytical protocol. These preliminary analyses on incomplete and subjectively selected data indicate that supplemented streams may have experienced an increase in density relative to control streams. The ISRP cautions that even this weak conclusion is premature because it is partially based on selected data and because the prototype statistical analysis considers "control", "partial treatment" and "treatment" streams as fixed categories when they are not. Also, it is likely that the effects of strays cannot be ignored in the final analysis. The ISS has features characteristic of an observational study that limits making cause and effect inferences. A primary confounding issue in interpretation of the results is the *de facto* supplementation arising from straying of non-ISS fish into both treatment and control streams. The most liberal interpretation, as taken in the preliminary analyses, is that the *de facto* supplementation affects the response profiles of redd density on all streams equally (profiles are parallel) and the effects of strays stay the same in the future. However, this seems to be far from the original objectives of the ISS study, namely to contrast the profiles of several important parameters of naturally producing fish (that had no supplementation during Phase II or Phase III) with the profiles of naturally producing fish (that had supplementation in Phase II, but no supplementation in Phase III). The current and future *de facto* supplementation and limitation to density of redds severely compromises the chances of meeting the original objective of the ISS. It seems unlikely that the ISS will contribute the compelling evidence for or against supplementation that managers in the region are likely expecting.

## Recommended DNA Analysis

There is a need to use DNA level microsatellite analysis to identify parentage relationships between spawning adults, outmigrating smolts, and adults that return to spawn in the next generation (including the use of assignment tests) in order to separate non-ISS strays from natural production within distinct tributary systems. A second step, and subset of this analysis, would be to then separate ISS supplementation fish from natural-origin fish in the same system using the same methods.

The principal investigators should evaluate the current status of chinook tissue collections throughout the ISS populations and stream types (treatment, control) to determine if collections are sufficient to allow this type of DNA analysis. If not, project sponsors should assess the overall project and identify locations, opportunities, and schedules (and budgets) that will provide for this critically needed analysis.

## Statistical Analysis of the Idaho Supplementation Studies

It is very difficult to design, implement, and maintain the integrity of large-scale field supplementation studies. When the integrity of the experiment is compromised a long-term field study may lose much of the basis for experimental determination of cause and effect relationships. Inferences are often limited to correlation and regression methods, and uncontrolled confounding factors often limit the interpretation of study results. For example, the Idaho Supplementation Studies (ISS) apparently included random selection of streams for “treatment” and “control” in the original plans. The ISS refers to control steams and we adopt that terminology in our review of the ISS; however, reference streams is a better phrase because it is recognized the streams are not perfectly matched on all important factors and in the end, randomization was not implemented. Substantial changes have been made in the assignment of treatment and control status to study streams limiting statistical inferences. Variation (noise) introduced by *de facto* supplementation by strays from conventional hatcheries may overshadow treatment effects in the ISS.

Variations of the prototype statistical analyses for the ISS (Lutch et al. 2003) are appropriate for analysis of the data. One criticism that we have of the prototype statistical analysis is that relatively too much emphasis is placed on statistical testing of null hypotheses and classical analysis of covariance instead of modeling and point estimation. As recognized by the ISS sponsors, statistical significance does not imply that results may be of practical importance and insignificance does not imply that results are not of practical importance. However, the temptation is strong to overstate the conclusions of statistical tests of null hypotheses.

In the current ISS data set, only one "control" stream, namely Bear Valley Creek in the Salmon River Basin was reported to have no strays. With the possible exception of White Cap Creek (where there are no data), all "control" streams in the Clearwater had *de facto* supplementation with substantial levels of strays (apparently both ISS and non-ISS fish). The annual density of strays in the streams varies and the levels are not controlled by the study design. The annual density of supplementation fish on the spawning grounds also varies so that consideration of "treatment" or "partial treatment" as fixed categories in the analysis of covariance is inaccurate. Regardless of the best intentions, the study has characteristics of an observational study that limits inferences to correlation and regression methods.

Point estimation of effects with measures of precision and fitting of models for prediction of effects are a natural part of the prototype statistical analysis and the report contains tables of point estimates adjusted for the fitted models. However, we recommend that point estimation of effects with measures of precision and modeling of effects play the dominant role in the statistical analyses. The analyses should also consider building models using criteria such as Akaike's Information Criterion (AIC, Burnham and Anderson 2002) in addition to classical hypothesis testing in analysis of covariance. For example, in the section entitled Straying Effect Results and Conclusions, point estimates and measures of precision might be reported instead of simply stating that certain effects were not significant at a certain significance level (p-value). The linear models should be specified in writing with an explicit list of accompanying assumptions.

Emphasis on modeling and estimation may also make it possible to more realistically incorporate the effects of *de facto* supplementation arising from strays (both ISS fish and strays from conventional hatcheries). An alternate that should be investigated for the design and analysis of Phase III is that there are no "controls" in the ISS, i.e., there are simply streams with various levels of two types of supplementation, at levels ranging from 0% to somewhat less than 67% for non-ISS strays and 0% to some unreported level X% for ISS fish. The effects of other predictor variables such as harvest and measures of primary productivity might also be modeled.

In the absence of more information on the data available on juvenile production, DNA sampling, age structured data, and accounting for strays in all streams, the ISRP is concerned that the original experimental design has been compromised to the extent that alternative approaches to Phase III should be considered. In Phase III, the design calls for stopping supplementation with ISS fish. The investigators should consider the merits of changing the design in Phase III to include stopping *de facto* supplementation by non-ISS fish in some of the streams (control, partial treatment, and/or treatment), perhaps by building additional weirs. Density of redds and other dependent variables in streams within groups (e.g., Lower Lochsa, Lower Salmon, etc.), might be modeled by multiphase regressions over the three Phases of the study (Seber and Wild 1989) to provide inferences concerning the effects of stopping or changing the levels of supplementation, non-ISS strays, and/or ISS strays during Phase III. ISS staff should investigate the affect of possible changes in the design of Phase III including the possibility of continued supplementation by ISS fish in some streams. Continued supplementation in Johnson Creek and other streams might contribute important information concerning the complex interactions between naturally produced fish, strays, and ISS fish. Ramifications of these suggested alternatives are beyond the charge of the ISRP in the current report. This recommendation does not call for a major change in the prototype statistical analysis, but rather a change in emphasis to modeling of an observational study and in methods for communication of the statistical results.

Finally, we note that the data necessary to conduct the protocol statistical analysis or modifications are apparently not being collected (Lutch et al. 2003). Only a subset of the ISS streams have annual carcass data sufficient to estimate the density of strays, naturally spawned adults, and ISS adults (i.e., adults from ISS hatchery produced juveniles) on the spawning grounds. Unless the redd counts and carcass data are collected annually on all ISS streams it will not be possible to analyze even one measure of success, namely density of redds.

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