U.S.
FISH & WILDLIFE
SERVICE
DEPARTMENT OF THE INTERIOR

LOWER SNAKE RIVER
COMPENSATION PLAN
Hatchery Program

Lower Snake River Compensation Plan Status Review Symposium

Doubletree Hotel Riverside
Boise, Idaho
February 3, 4, and 5, 1998

Proceedings of the Lower Snake River Compensation Plan Status Review Symposium

The goal of the Lower Snake River Compensation Plan Status Review Symposium was to inform the regional decision makers, public, and scientists of the purpose, status, and options of the Lower Snake River Compensation Plan Program in order to promote informed decisions on the future program direction.

Compiled by

U.S. Fish and Wildlife Service
Lower Snake River Compensation Plan Office
1387 South Vinnell Way, Suite 343
Boise, Idaho 83709

September 1998

Symposium Steering Committee

Peter Lofy, Confederated Tribes of the Umatilla Indian Reservation
Al Van Vooren, Pete Hassemer, and Bill Hutchinson, Idaho Dept of Fish and Game
Paul Kucera, Nez Perce Tribe
Rich Carmichael and Bruce Eddy, Oregon Dept of Fish and Wildlife
David Arthurd and Chris Reighn, Shoshone-Bannock Tribes
Mark Schuck, Washington Dept Fish and Wildlife
Howard Burge, Ed Crateau, Joe Krakker, and Dan Herrig,
U. S. Fish and Wildlife Service

Note: The steering committee of the Lower Snake River Compensation Plan Status Review Symposium agreed that the oral and poster presentations, science and stakeholder panel comments, and question and answer sessions should be documented and made available for use and reference. The committee agreed that the oral summaries would consist of the text of the presentations combined with some of the pertinent slides rather than a formal manuscript with literature citations, etc. Therefore, the author's addresses are provided at the beginning of each paper if the reader would like information or explanations beyond that provided in the presentations. The posters are summarized in one or two pages and, here to, author addresses are provided if more information is needed. The panels' comments and question and answer sessions were recorded and summarized by a professional note taker. We hope the summaries accurately capture those important questions, comments, and discussions. If you have additional questions or comments regarding the symposium or the program, please contact the LSRCP Office, 1387 South Vinnell Way, Suite 343, Boise, ID 83709.

Contents of Proceedings

Opening Comments and Introductions

Ed Crateau
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Welcome to the LSRCP Symposium! In December 1990 our office along with our cooperators: the Oregon, Washington and Idaho fish and wildlife agencies, the Nez Perce, Umatilla and Sho-Ban tribes, and Idaho Power held a meeting called the Snake River Hatchery Review Workshop. This was the first meeting of this nature held since we began production at the first LSRCP facility constructed and operated under our hatchery program, McCall Fish Hatchery in 1980.

Since the opening of that first facility, an additional 11 hatcheries and 11 associated satellite facilities were constructed in subsequent years culminating with the completion of Clearwater FH in 1991. Most recently, three additional acclimation and release sites have been constructed (2 on the Snake River and one on the Clearwater river) to accommodate our fall chinook program.

The purposes of the 1990 meeting were to present the status of the LSRCP program and progress to date and provide administrators sufficient information so they could make more informed decisions.

We were a relatively new program back in 1990 and had just completed what was then thought to be our last facility under the original LSRCP Program design. In terms of life cycles we had only completed about 2.5 life cycles for salmon and three for steelhead. This workshop did help us make some mid point adjustments and I think we achieved our objective. I believe through the information presented we sufficiently informed our decision makers of progress during the first 10 years of hatchery operations so they in turn could make better decisions on matters associated with our program.

Seven years have passed since the December 1990 workshop and, figuratively speaking, a lot of water has passed the four Lower Snake Dams since that time. I dare say, a lot more water then fish have passed these dams since that time. The LSRCP program is now 17 years old and we have nearly another two complete life cycles for salmon and slightly more for steelhead. Therefore, we and our cooperators believe it is time once again to present an update on the state of the LSRCP program using the additional seven years of data collected.

The format of this symposium is substantially different from the 1990 workshop. We've expanded the participation from mostly a cooperator agency and tribe presenter and audience to include representatives from nearly every interest group we could think of -- representatives who would have a stake or interest in what we do or how we stack up in meeting LSRCP program objectives.

In addition to opening this meeting to the general public, we've invited representatives of various interest groups to participate in a panel for the entire three days. We've appropriately called this group our stakeholders panel.

We've also invited representatives from the scientific community to form a scientific panel and participate in an interchange of questions and comments during the entire three days. I will introduce our distinguished panel representatives shortly.

And perhaps most importantly, we will have a wrap up sessions by both panels during our luncheon and early afternoon session on Thursday. I can't stress the importance of this session enough as the panels will be commenting on everything they heard during the previous 2 ½ days. Hopefully, we will receive some constructive comments. I like to use the word comment rather than criticism; the word comment has a more positive connotation and that's the atmosphere I hope we can generate during this symposium. A positive rather than negative atmosphere.

You will note as I introduce the members of the scientific and stakeholders panels, we did not select the members or their affiliations because we thought they would say all great things about what we've done. They were selected because we wanted to have a fair representation of interests and viewpoints. We know their comments and recommendations will help guide us in making better more informed decisions in the future and help guide us in the future direction of the LSRCP Program.

In addition to the individual presentations that will be given over the three days, of equal (and I can't stress this enough) or even greater importance, will be the information that is presented in our poster sessions in the Ponderosa Room just down the hall. In order to provide a total picture of our evaluation program, and the studies that are being conducted to collect data to help us make informed decisions, our state, tribal and federal cooperators have prepared over thirty posters illustrating results of their research studies and monitoring efforts. In order to understand the complex studies and evaluations that are being conducted which may or may not be included in the individual presentations, I urge you to spend as much time as possible reviewing these posters on your own. They will be on display during the entire meeting and all breaks will be held in the poster display area. We've also provided a perfect opportunity on Wednesday evening during our 6:00-9:00 pm social gathering in the Ponderosa Room to ask questions of individuals who will be available to you during this time. We also expect that each panelist will be familiar enough with these studies to include this information in comments during the regular and wrap up sessions.

The stakeholders panel members are:

Rich Lincoln, Anadromous and Freshwater Fish Program Manager, Washington Department of Fish and Wildlife, Olympia, WA

Dave Arthaud, Anadromous Fisheries Biologist, Shoshone-Bannock Tribes, Ft. Hall, ID (Substituting for Lionel Boyer, Fisheries Policy Representative)

Silas Whitman, Fisheries Manager, Nez Perce Tribe, Lapwai, ID
Steve Smith, Chief, Hatcheries & Inland Fisheries, National Marine Fisheries Service, Portland
Mitch Sanchotena, Executive Coordinator, Idaho Steelhead and Salmon Unlimited, Boise, ID
Fred Christensen, Past President, Idaho Wildlife Federation, Caldwell, ID
Steve Fick, President, Salmon For All, Astoria, OR

The members of our science panel are:

Rick Williams, Scientific and Technical Consultant, Portland, OR
Cindy Deacon-Williams, Senior Aquatic Ecologist, Pacific Rivers Council, Boise, ID
Peter Bisson, Forest Sciences Laboratory, U.S. Forest Service, Olympia, WA
Jack McIntyre, Retired fisheries research, USFWS, USFS, Henderson, NV
Mike Matylewich, Harvest Management, Columbia River Inter-Tribal Fish Commission, Portland
Dan Huppert, Economics Professor, School of Marine Affairs, UW, Seattle, WA
Dan Goodman, Biology Professor, Montana State University, Bozeman, MT

What do we expect from our stakeholders and you the audience? We've purposely called this meeting a symposium because according to Webster's Dictionary a symposium is "A Meeting or Conference for Discussion of Some Topic." The topic is the LSRCP Hatchery Production Program. Another definition that may also apply is a convivial meeting for drinking, music and intellectual discussion among the ancient Greeks. Also according to Webster "convivial" means "Fond of Feasting, Drinking and Good Company". So what we expect from all of you is a lively exchange of ideas and discussion in a sociable atmosphere! If we can achieve this, I know our meeting will be a success.

Now let me explain how this symposium is organized. At the end of each species section the session chair will provide a 15-minute summary with the section presenters assembled at the front table. The chair persons summary will be followed by a 15-minute segment for questions and answers of the presenters from both panels and the audience. Rick Williams, one of our science panelists, will then facilitate a 30-minute science panel comment period (45 minutes are being allowed for spring and summer chinook). We are giving Rick the flexibility to manage the panel comment period as he sees fit.

At the end of the panel comment session, we will have an additional 15-minute open question and answer period when anyone from the panels or audience can ask questions. We are recording the meeting so when you have a question or comment, please identify yourself and speak clearly into the microphone. We have microphones for both panels and two microphones for the audience.

The final one-hour science panel wrap-up on Thursday during or shortly after the luncheon will also be facilitated by Rick Williams. Just a suggestion to Rick, I propose that each panelist could be given about 5 minutes for a final comment/statement followed by discussions among and by all attendees.

The two-hour stakeholders panel wrap-up discussion will follow and be facilitated by keynote speaker Courtland Smith. Courtland, without trying to usurp your power as facilitator, I would also suggest that each of your panelists be given about 10 minutes for final comments and statements which will be followed by discussions among all attendees. I encourage the stakeholders to compile information for questions, comments and statements from all information presented during the entire meeting and through discussions with poster presenters.

We have two keynote speakers. Rick Applegate, a consultant and currently on contract as a senior policy advisor for the National Marine Fisheries Service, will be the first and will discuss the biological and political aspects of salmon and steelhead management in the Columbia River Basin. Our second keynote speaker, Courtland Smith, a cultural anthropologist on the faculty of Oregon State University, will address you on the social aspects of salmon and steelhead management in the Columbia River Basin.

Please remember that the success of this symposium is dependent upon all of us through an active, direct exchange of information, questions and ideas. With that said, I leave the success of this symposium in your hands.

The Science of Columbia River Salmon Production

Rick Applegate
Senior Policy Advisor
National Marine Fisheries Service
Portland, Oregon
(Summarized from overheads)

Overall Columbia Basin Issues

The science of Columbia River fish management is:

- Not a static set of conclusions
- Still evolving and always will be
- A disciplined search -- not resolute pronouncements

Therefore, we must keep an open mind and expect some contention and confusion. It is very important that we get used to continued uncertainty and not use science as a refuge for inaction.

In an effort to reduce some uncertainty, a number of scientific overviews have recently been developed, including the:

- Snake River Recovery Team
- National Research Council
- Independent Scientific Group

In addition to the teams, other types of overviews and reviews include:

- NMFS' Workshop on Effects of Straying
- Numerous Reports, Articles, Conference Proceedings, etc.
- Agency and Tribal Scientific Work

Two major themes have developed to help us deal with the anadromous fish production problems in the Columbia Basin.

Major Theme I

- Something's not working
- The ecosystem is badly degraded
- It can't be repaired solely by technological fixes
- We can't restore pristine, pre-development conditions
- We need a functioning ecosystem with "normative conditions"

Major Theme II

- We need a new "conceptual foundation" that will address the entire ecosystem
- We need a network of complex and interconnected habitats created and maintained by natural processes
- Life history diversity, genetic diversity and metapopulation organization are critical
- We can't ignore ocean/estuary conditions

Hatchery Programs

Hatchery programs have been a dominant feature in Columbia River:

- Over 70 facilities in the Basin
- Command substantial portion of the overall BPA fish-related budget
- Have associated costs that are not likely to decrease
- Account for over 70% of Columbia River adult salmon and steelhead returns

Concerns related to hatchery programs:

- Can promote over fishing
- Can have direct genetic effects
  - Decreased variability within hatchery-reared populations due to:
    - Insufficient broodstock numbers
    - Inappropriate mating practices
  - Decreased variability between populations in a basin due to:
    - Widespread use of non-indigenous broodstock
    - Straying of hatchery returns
- Can have indirect genetic effects through:
  - Domestication/directional selection
  - Genetic changes to hatchery stocks
  - Genetic changes to wild stocks
- Other miscellaneous effects
  - Behavior changes resulting from hatchery/natural interactions
  - Competition and predation by hatchery-reared fish on natural populations
  - Ecological problems: density-dependence, lack of carcasses in the stream, carrying capacity
  - Disease transmission
  - Post-release mortality

Some independent scientists are bluntly critical about hatcheries, they claim hatcheries:

- Have not met objectives
- Have been detrimental to wild runs
- Have not conserved biodiversity
- Have not been critically reviewed for scientific validity and feasibility
- Have insufficient monitoring and evaluation

The Future Role of Hatcheries

What is the future role of production?

- Can production restore fish runs?
- Can it help mitigate for past damage?
- How much risk is there to wild fish?
- How much will it cost?

- Are the objectives consistent with ESA, Treaty rights, and other applicable law?
- Is the overall program scientifically sound?

What is the prognosis?

- The controversy around hatcheries won't go away
- They can't be ignored
- We need to acknowledge and assess unintended and undesirable effects
- We must avoid tendency to defend the past or the status quo
- We must redouble solid experimental efforts

What are the implications for fish restoration?

- Credibility of management is vital given the cost, past failures and public controversy
- Depends in substantial part on the way artificial production concerns are handled
- Continuing battle between managers is not helpful nor are disorganized views of scientists

Where Do We Go From Here?

Renewed efforts and new directions will be necessary such as:

- Taking actions to restore natural processes and link hatcheries and natural production
- Carefully structuring new experiments with monitoring & comprehensive evaluation
- Improving practices along with creative new or modified facilities
- Conducting independent scientific review and audits of new and ongoing programs
- Reducing some artificial production programs

There is a need for a coordinated, understandable overview to clarify the science issues and determine:

- What is currently going on?
- What has worked? Why?
- What has not worked? Why not?
- What is still up in the air? Being debated?
- What is the quality of the M&E work?
- What should the public expect -- and how soon?

What Else Needs to be Done?

- Region must come to terms with a badly degraded river system
- Dramatic improvements are needed in main stem and tributaries
- Harvest will have to remain constrained and pressure will intensify for more selective methods
- We all must prepare for a long-term effort -- there will be no quick fix!

Social Aspects of Salmon and Steelhead Management in the Columbia River Basin

Courtland Smith
Cultural Anthropologist
Oregon State University
Corvallis, Oregon
(recorded and summarized)

Anthropologists are interested in cultures and values, Smith began. We see the salmon problem not as a science issue, but as more of a human and social problem. It is an interaction based on values, on those things people think are right and wrong, good and bad, important and unimportant.

Values aren't always something people wear on their sleeves, Smith continued -- they are inferred, through language, and through actions. I wanted to spend a few minutes today talking about the history of the salmon problem, and the different sets of values held by the Native Americans who originally settled this land, and by the Euro-Americans who came after them. However, while the past is important, this symposium is really about the future -- what kind of the future do we want for the Northwest, and for our children and grandchildren?

Values are the lens through which we view and focus reality, Smith said. The values the various participants in this debate bring to the process structure how those participants interpret information, how they evaluate the scientific findings, and how they think about the future. Smith spent a few minutes talking about the different perspectives of the Native Americans, who generally were content to accept the bounty provided by nature, and the later Euro-American settlers, who were focused on domesticating the land and its resources.

Smith spent a few minutes putting the salmon problem into historical perspective, beginning with the period prior to the arrival of Euro-American settlers in the Northwest, and ending with the present day. He made the point that salmon are one of the great cultural integrators in the Northwest, because it will be necessary for everyone in the Northwest -- farmers, fishermen, aluminum workers, the tribes, environmentalists and state and federal fish management agencies -- to work together if the problems facing Northwest salmon runs are to be solved.

Smith summarized his presentation by saying that, according to available survey data, there is fairly strong public support in the Northwest for saving salmon -- people want to see some improvement in the current situation, he said. Second, said Smith, I would observe that there are a lot of different ways to look at the salmon problem -- not everyone sees the causes of the decline, or the most desirable future scenario, in the same way. There are many different perspectives on the salmon issue, each of these perspectives rests on different values about the importance of salmon to the Pacific Northwest and the people living here.

Third, Smith continued, we are seeing a major change, in the last few years, in the philosophical approach to salmon restoration -- we are now talking about ecosystem management, riparian health, a normative river. Fourth, there appears to be a growing tendency, among some groups, to try to use science to refute other groups' positions; I would like to suggest that that is not likely to be a very productive or successful approach, Smith said.

Finally, he continued, in terms of a vision for the future, I think it is vital to bring together all of the various populations and viewpoints in the region to discuss these issues, to have a dialogue, to really listen to each other's views and to give some serious thought to the social relationships we need to forge in order to solve the salmon problem. Again, in my anthropological view, saving salmon is far more a human and social problem than it is a scientific problem, Smith said.

Lower Snake River Compensation Plan Background

Dan Herrig
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The four Lower Snake dams were authorized by Congress in 1945 with no mitigation identified for anadromous fish. When funding was appropriated for construction in 1954, adult fish ladders and other facilities were funded for salmon and steelhead mitigation. However, no artificial propagation measures for compensating for unmitigated fish losses were specified at that time.

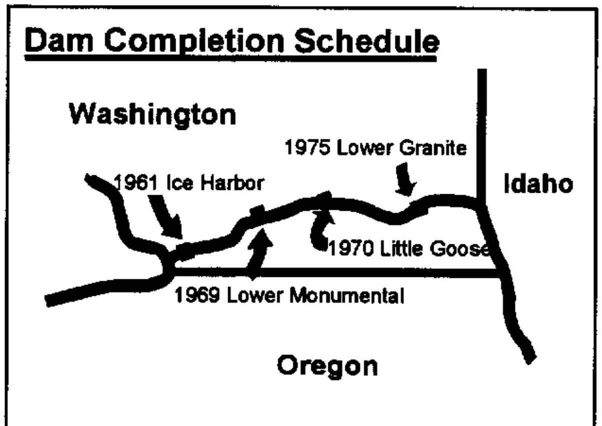

Figure 1

In the mid-1960s, after Ice Harbor had been constructed and Lower Monumental and Little Goose were underway (Figure 1), the Fish and Wildlife Service, National Marine Fisheries Service, and state fisheries agencies began to assess mitigation for project-related fish and wildlife losses under the Fish and Wildlife Coordination Act. A joint 1972 FWS/NMFS Coordination Act Report provided to the Corps described the short and long term impacts of all four Lower Snake dams and recommended mitigation and compensation for both fish and wildlife. That report provided the basis for the Corps's 1975 Lower Snake River Fish and Wildlife Compensation Plan (LSRCP) to Congress. A year later, the LSRCP was authorized by Congress as part of the Water Resources Development Act of 1976.

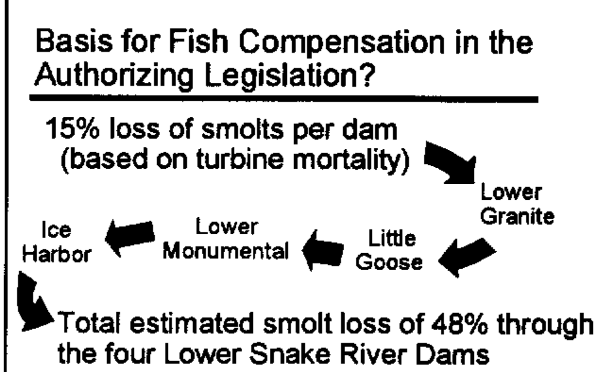

Figure 2

The basis for the anadromous fish compensation was a loss of 15% of the emigrating smolts passing through the turbines at each of the four Lower Snake facilities (Figure 2). The cumulative losses were estimated to total 48 percent of the pre-dam Snake River chinook salmon and steelhead runs. The plan called for the creation of hatcheries to produce sufficient juveniles to compensate for the 48% loss with two additional goals of replacing the adult returns in-kind and in-place. The compensation was focused on replacing adult spring/summer and fall chinook and summer steel-head, despite the fact that there were other anadromous species, such as coho and sockeye, still returning to the basin at that time of dam construction. Congress authorized the Corps to

LSRCP Compensation Goals

Species/Race	Snake R. Run (circa 1960)	Adult Goals
Fall Chinook	32,660	18,300
Spring/summer Chinook	122,200	58,700
Summer Steelhead	114,800	55,100
Resident trout	260,000 (86,000 lbs.)	

Figure 3

Idaho Facilities

Steelhead	Spr/summer Chinook
Magic Valley FH	Sawtooth FH (East Fork)
Hagerman NFH (East Fork)	McCall FH (South Fork)
Clearwater FH	Clearwater FH (Red R., Powell, Crooked R.)
	Dworshak NFH

Eagle Fish Health Lab
Research/Monitoring Offices: IDFG - Nampa, Salmon, Lewiston; NPT - Lapwai, McCall; FWS - Ahsahka

Figure 4

construct the facilities, BPA to repay the treasury for the cost of this program from revenues generated by power sales, and FWS or NMSF to administer of operations. In 1976 the Corps, FWS, and NMSF agreed that the FWS would administer the program.

The adult return goals contained in the compensation plan were based on the Snake River runs between 1959 and 1961 (Figure 3). The fall chinook goal is 18,300; the spring/summer chinook 58,700; the summer steelhead 55,100. The plan also calls for resident trout production to compensate for the loss of angler days when the dams inundated about 140 miles of spawning habitat.

Oregon Facilities

Steelhead	Sprg/Sum Chinook
Irrigon FH	Lookinglass FH
Wallowa FH	Imnaha
Big Canyon	
Little Sheep	

LaGrande Fish Health Lab
NE Oregon Research and Monitoring, La Grande (ODFW and CTUIR)
Nez Perce Tribe Research, Enterprise

Figure 5

LSRCP facilities consist of 26 production, acclimation, and trapping facilities, as well as a number of fish health and monitoring and evaluation offices in Washington, Oregon, and Idaho (Figures 4-6). The facilities are operated, monitored, and evaluated by the fisheries agencies of Oregon, Washington, Idaho, and the U.S. Fish and Wildlife Service and the Nez Perce and Umatilla tribes. The Shoshone-Bannock Tribes participate in the planning of the program.

The adults goals shown in Figure 3 are for returns to the Snake River basin. Figure 7 shows the origin of the adults by river basin. The originators of the plan anticipated the adults returns would provide harvest for sport anglers and tribes, brood stock for the hatcheries, and some natural spawning escapement.

Washington Facilities

Steelhead	Fall Chinook
Lyons Ferry FH	Lyons Ferry FH
Dayton Pond	Pittsburg Landing
Cottowood Pond	Capt. Johns
Curl Lake	Big Canyon
Resident Trout	**Spring Chinook**
Tucannon FH	Lyons Ferry FH
Instream Structures	Tucannon FH

Snake River Research/Monitoring Lab, Dayton

Figure 6

Adult Return Goals by River

Lower/Mid Snake River and tributaries
18,300 fall chinook
1,152 spring chinook
4,655 steelhead

Grande Ronde River	Imnaha River
5,820 spring chinook 9,184 steelhead	3,210 summer chinook 2,000 steelhead
Clearwater River	**Salmon River**
21,200 spring chinook 14,000 steelhead	27,232 spg/sum chinook 25,260 steelhead

Figure 7

In addition to the adult return goals identified in the compensation plan, the FWS LSRCP Program also has responsibilities to comply with the Endangered Species Act, to meet our tribal trust responsibilities, to adhere to federal laws and agreements and court orders, and to pursue FWS Mission and Vision. Under the ESA, we are to ensure that LSRCP actions do not jeopardize listed species and use our authorities for conservation of listed species whenever possible. Our tribal responsibilities require that we provide technical assistance, consult with tribes as co-managers, help fulfill restoration or mitigation needs as determined by co-managers, and recognize tribal management decisions on resources under their direct jurisdiction, i.e. on reservations. Among agreements and court orders that impact the LSRCP Program directly are the U.S.-Canada Treaty and US vs Oregon (the Columbia River Fish Management Plan). Finally, the FWS has adopted mission statements and vision statements that we are obligated to pursue (Figure 8).

FWS Mission and Vision Statements

Mission: "...preserve, protect, and enhance ... for continuing benefit..."

Wild Stock Vision: "...an ecologically sound and integrated fishery management system...includes... the preservation, mitigation and restoration of wild and natural runs."

Figure 8

The LSRCP Program has made a number of adaptive management changes over the years (Figure 9) and we and our cooperators foresee additional changes in the near future. The details of these changes are presented in the individual presentation summaries which follow in this document.

What changes have cooperators made in response to listings?

- ✔ Optimized rearing and release strategies to ensure best survival and fewest impacts
- ✔ Reduced releases of non-endemic stocks
- ✔ Initiated captive propagation programs for the most imperiled of listed populations
- ✔ Ensured hatchery programs are operated to conserve the numbers and genetic integrity of listed fish
- ✔ Initiated new supplementation programs to enhance natural production of listed populations
- ✔ Cryopreserved germ plasm of listed fish
- ✔ Monitored life history of listed populations

Figure 9

In summary, the Lower Snake Compensation Plan will not knowingly jeopardize listed populations, will continue to conserve listed populations wherever possible and will try to provide tribal and non-tribal fisheries wherever possible. Last year, for example, Idaho and the tribes were able to provide a substantial fishery on a large hatchery-reared adult return.

The program's past and current costs for construction, operations, monitoring, and evaluations along with production goals are summarized in Figures 10 and 11. Although the LSRCP budget has not seen an increase for several years, use of carryover monies from past years has allowed the program to function fairly well, inspite of increased costs. The 1997 operation, monitoring, and evaluation costs amounted to about $11.8 million. More funding may be available in 1999 if the Lower Snake Compensation Plan program's funding is provided directly through an agreement with BPA, as they are doing with the Corps of Engineer's and Bureau of Reclamation's reimbursable programs.

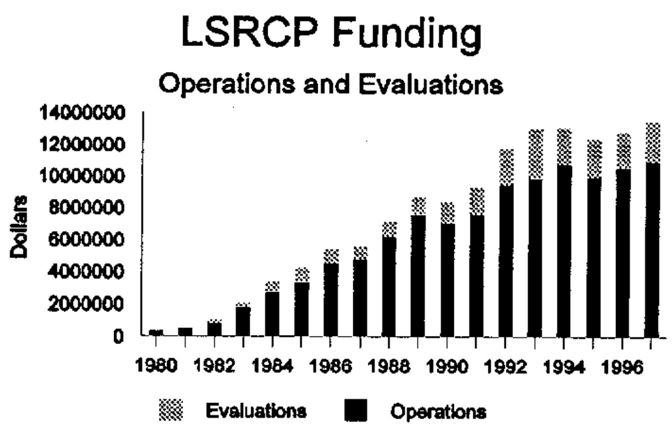

Figure 10

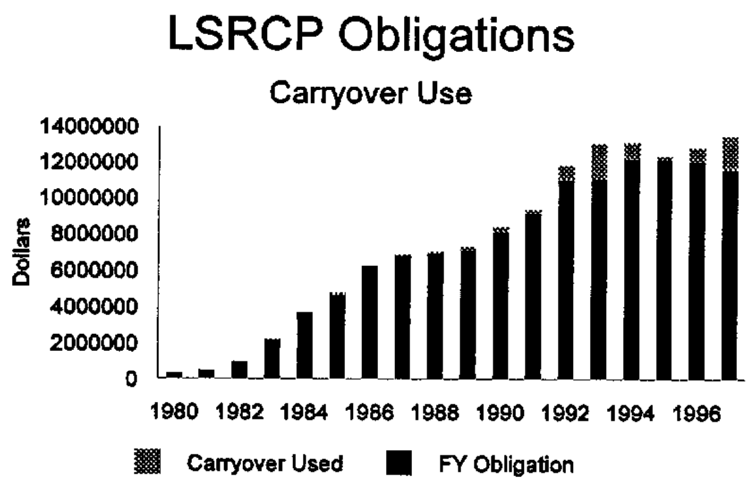

Figure 11

As noted above, the original goal of the LSRCP was to compensate for the loss of 48% of the juveniles migrating downstream through the system (Figures 12-14); the other 52% of the run was expected to be maintained with the mitigation modifications such as flip-lip construction at the dams, screening and bypass efforts, barging/trucking smolts, and habitat improvement work.

Based on our assessments, which are detailed in presentations provided below and illustrated in Figures 13, neither the (compensated) hatchery nor the naturally-spawning chinook populations have done as well as expected. Steelhead (compensated) hatchery populations have done quite well in a number of years, whereas the naturally-spawning populations have deteriorated to the point that all endemic populations are now listed in the Snake River basin (Figure 14).

In summary, the LSRCP Hatchery Program and the LSRCP mitigation efforts haven't been able meet expectations and come close to the pre-dam target levels for adult chinook returns (Figures 15). Although the steelhead picture is better, the post Lower Snake River dam project returns remain well below the pre-dam levels (Figure 16).

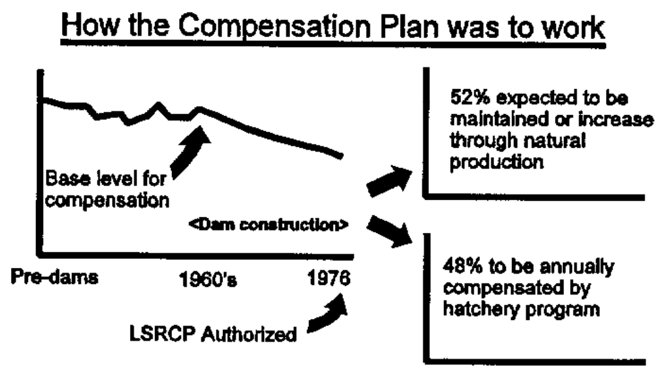

Figure 12

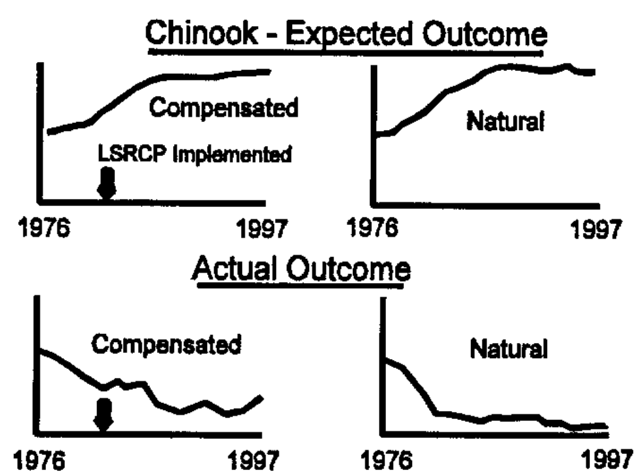

Figure 13

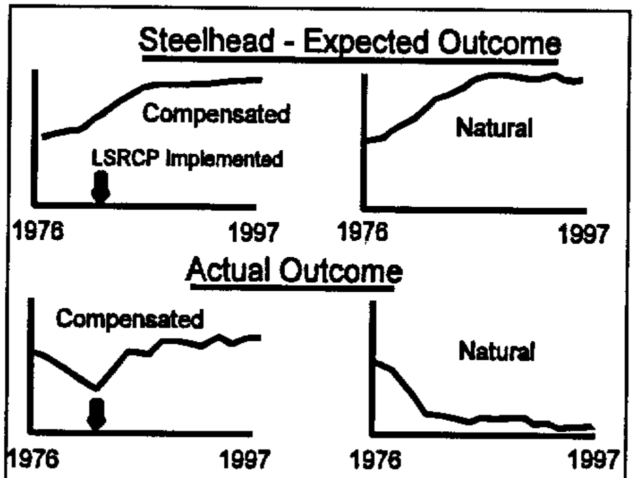

Figure 14

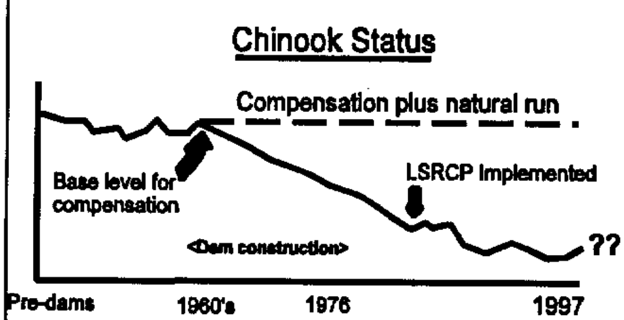

Figure 15

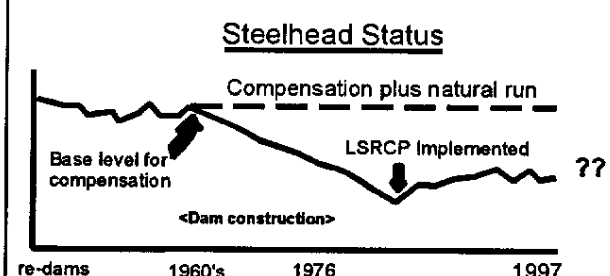

Figure 16

Opening Session Questions and Comment Session

Don Campton of the Fish and Wildlife Service asked Applegate about a remark from his presentation -- "Don't use science as a refuge for inaction." Could you go into more detail about that comment? Campton asked. What I hear most often is people saying, if we are going to take some relatively substantial and expensive step, we want to the very sure it is going to work, Applegate replied. The way that scenario typically plays out is not terribly well for the fish, in my view, he said -- my basic point was that fish shouldn't have to bear the strongest burden of proof. Scientists can do a lot by being clear about the kinds of conditions under which salmon populations prosper, Applegate said, and we ought to be able to move aggressively toward those conditions without waiting for what I would term an excessive amount of surety about the expected results of a given action. People talk a lot about the number of additional fish that could be expected to return per dollar amount invested -- I wish we could be that precise, said Applegate, but we can't.

Summer Steelhead in the Grande Ronde River Basin, Oregon

Timothy A. Whitesel, Richard W. Carmichael, Michael W. Flesher, and Debra L. Eddy

Oregon Department of Fish and Wildlife
211 Inlow Hall
Eastern Oregon University
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Introduction

Successful populations of *Oncorhynchus mykiss* were once the norm in watersheds of the lower Snake River. Steelhead, the anadromous form of *O. mykiss*, were abundant in the Grande Ronde River basin of northeast Oregon. In the mid 1960's, biologists estimated that the Wallowa River, Five Points Creek and Crow Creek (Figure 1), streams used to index escapement levels in the Grande Ronde River basin, averaged 5.8 redds per kilometer of stream (Figure 2). These steelhead provided opportunities for both sport and tribal harvest. Correlated with the completion of the dams on the lower Snake River, however, the run size of steelhead into the Grande Ronde River basin began to decline. From 1968 through 1975, the same index streams averaged 3.7 redds per kilometer (Figure 2). As a result of this decline, the steelhead fishery in the Grande Ronde River basin was closed by the Oregon Department of Fish and Wildlife (ODFW) in 1974.

In 1976, congress authorized the Lower Snake River Compensation Plan (LSRCP). The LSRCP mandated that the U.S. Fish and Wildlife Service oversee a program to compensate for the losses of anadromous fishes that were associated with the construction of the lower four dams (Ice Harbor, Lower Monumental, Little Goose and Lower Granite) on the Snake River. The LSRCP focused on the use of artificial propagation in an attempt to compensate for these losses. The LSRCP established compensation goals which, for the Grande Ronde River basin, include the production of 122,472 kg of fish resulting in the release of 1,350,000 smolts. At a smolt-to-adult return rate of 0.68%, the plan would provide 9,184 adults to the compensation area. The LSRCP also developed management goals to guide the artificial production programs. Relative to steelhead, these goals were to: establish an annual supply of brood fish that can provide an egg source capable of meeting compensation goals; restore and maintain the natural spawning population; reestablish sport and tribal fisheries; establish a total return of adult fish resulting from LSRCP activities that meets compensation goals; and minimize the impacts of the program on resident stocks of game fish. The hatchery program in the Grande Ronde River basin has focused on reestablishing sport and tribal fisheries.

Program overview

Comanagers of the Grande Ronde River basin (ODFW and the Confederated Tribes of the Umatilla Indian Reservation) have implemented a hatchery program for steelhead which involves three LSRCP facilities in Oregon. The hatchery program in the Grande Ronde River basin begins with the collection of hatchery adults at Wallowa Fish Hatchery (Enterprise, OR) and the Big Canyon Facility (Figure 1). Marked, adult fish of Wallowa stock origin are held and spawned at Wallowa Fish Hatchery where the resulting embryos go through early incubation. Once the embryos reach the eyed stage of development they are transferred to Irrigon Fish Hatchery (Irrigon, OR) for final incubation, hatching and juvenile rearing. During this rearing, all of the fish are marked and some of the juveniles receive either coded-wire or PIT tags, both of which allow us to monitor production and evaluate rearing and release strategies. Nine to 13 months after fertilization (from mid-February through mid-May) most juvenile steelhead are transported from Irrigon Fish Hatchery back to the Grande Ronde River basin. About 800,000 of these fish are reared in acclimation ponds at Wallowa Fish Hatchery for approximately three weeks before being released as smolts into Spring Creek, a tributary to the Wallowa River. Roughly 287,500 of these fish are reared in acclimation ponds at the Big Canyon Facility for approximately three weeks before being released as smolts into Deer Creek, also a tributary to the Wallowa River. For evaluation purposes, a small part of the steelhead released into Spring or Deer creeks used to be transported from Irrigon Fish Hatchery and released directly into the stream. Currently, however, all releases into Spring and Deer creeks are from the acclimation ponds. At each of these, sites roughly half of the release occurs in April while the other half occurs in May. The remaining 262,500 fish are released as smolts directly into the upper Grande Ronde River or into Catherine Creek in April.

The hatchery program in the Grande Ronde River basin has been functioning for 21 years. This program began in 1976 with the collection of adults trapped at Ice Harbor Dam. In 1978 we began releasing hatchery-reared smolts into the Grande Ronde River basin. Adults from hatchery-reared fish began to return to the basin in 1980. We have been evaluating the success of the hatchery program since it began. In 1985 we began a study to compare the performance of 91 g smolts to that of 113 g smolts. We have been monitoring the steelhead fishery since it reopened in 1986. In 1987 we began experiments to evaluate the utility of acclimating smolts prior to their release. In 1992 we began an evaluation on the juvenile steelhead that residualize when released. In 1995 we began exploring the merit of releasing smolts volitionally. The expansion of Wallowa Fish Hatchery was completed in 1985. Construction was finished at Irrigon Fish Hatchery in 1986 and at the Big Canyon Facility in 1987. Thus, the program has been fully functional for the past 11 years.

Program status

Establishing an annual supply of brood fish that can provide an egg source capable of meeting compensation goals.

As the hatchery program matured in 1986 it has generally provided enough fish, in terms of the overall number, for broodstock needs. Approximately 490 adult females and 490 adult males are needed to produce the number of hatchery-reared smolts that were estimated as necessary to achieve the compensation goals. During the 1986-97 return years, with the exceptions of 1990, 1991, 1994 and 1995, sufficient numbers of adults returned to Wallowa Fish Hatchery to meet broodstock needs (Figure 3). During this same period, with the inclusion of Wallowa stock adults returning to the Big Canyon Facility (Figure 4), sufficient numbers of fish returned to meet broodstock needs in all but 1991 (90%) and 1995 (68%). To meet broodstock needs in 1991 and 1995 we incorporated Wallowa stock adults returning to Cottonwood Creek (WA) into our hatchery program. In large part, however, broodstock needs have been met from Wallowa stock adults returning to hatchery facilities in northeast Oregon.

Despite relatively large numbers of Wallowa stock fish returning to hatchery facilities, these fish may no longer be appropriate for use as broodstock. The Wallowa stock originated from collections of adult steelhead at Ice Harbor (1976) and Little Goose (1977, 1978) dams as well as embryos from Pahsimeroi Fish Hatchery (ID) (1979) (Table 1). It is not clear whether steelhead adults collected at these dams were destined for the Grande Ronde River basin. It is fairly certain, however, that the embryos from Pahsimeroi Fish Hatchery were not derived from steelhead destined for the Grande Ronde River basin. In addition, relatively few fish were used to develop the Wallowa stock of steelhead (Table 1). Furthermore, since the Wallowa stock of steelhead was founded it has generally been domesticated through inbreeding. Thus, Wallowa stock steelhead and steelhead produced naturally in the Grande Ronde River basin may not be similarly adapted to the local conditions in this basin. Given the potentially different adaptations between the hatchery and natural fish, along with the 1997 listing of steelhead in the Grande Ronde River basin under the Endangered Species Act, it may no longer be appropriate to propagate the Wallowa stock of steelhead in the Grande Ronde River basin. If it becomes necessary to use locally-adapted broodstock in our hatchery program, it is likely that we will not be able to produce and release 1,350,000 smolts in the near future.

Restore and maintain the natural spawning population.

The Grande Ronde River basin hatchery program for steelhead was not designed to enhance or supplement the natural population. However, both hatchery and natural adults return to the Big Canyon Facility. The management strategy for the natural population of steelhead in Deer Creek has varied in the past. From 1987 to 1993 the weir was typically installed in late February or early March. This allowed any adult, natural or hatchery, to move freely throughout Deer Creek early in the year. The trap at the Big Canyon Facility was generally not opened until after April 15. This was to encourage the harvest of as many hatchery fish as possible, but prevented natural fish from moving up in Deer Creek during the peak of their run. Since 1994 the trap has been operated and fish passed into Deer Creek as soon as the weir was installed. Since 1995 the weir has been installed as early in the year as weather would permit, typically late January or early February. In most years, all the natural fish captured in the trap have been passed above the weir to spawn naturally. The number of hatchery

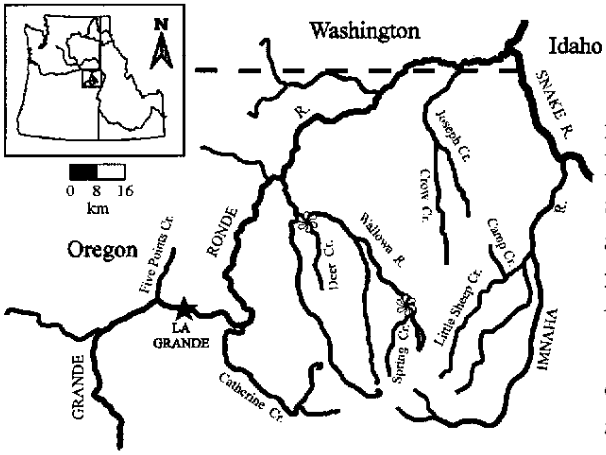

Figure 1. Major river basins in northeast Oregon. The Oregon Department of Fish and Wildlife's steelhead program has adult collection and juvenile acclimation facilities near the mouths of Spring and Deer creeks, both tributaries to the Wallowa River. Spawning ground surveys are conducted on Five Points Creek, the Wallowa River and Crow Creek.

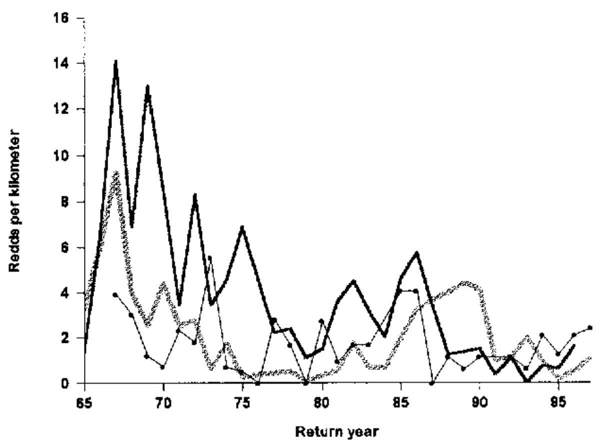

Figure 2. Natural escapement trends in Five Points Cr. (thin, black line marked with dots), the Wallowa R. (thick, black line) and Crow Cr. (thick, stippled line). Five Points Cr. and the Wallowa R. are tributaries to the upper Grande Ronde R. and directly influenced by the hatchery program. Crow Cr. is a tributary to Joseph Cr., which is a tributary to the lower Grande Ronde R.

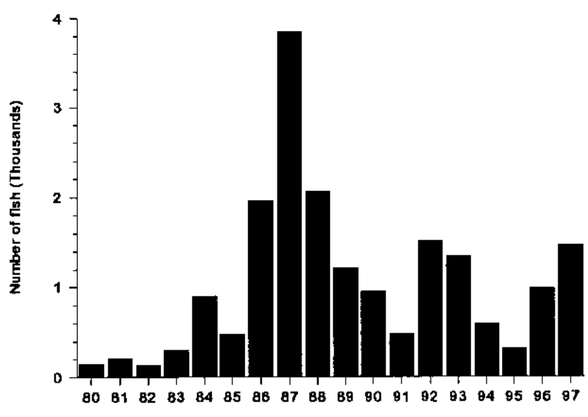

Figure 3. Escapement of adult steelhead to the adult weir in Spring Cr. at Wallowa Fish Hatchery. Essentially all of the adults returning to Wallowa Fish Hatchery were of Wallowa stock origin.

fish passed above the weir has ranged from zero to 242 (Figure 5). The percent of the fish passed above the weir that were of hatchery origin has ranged from 0% to 99% (Figure 5). Estimates of total escapement have ranged from 85 to 1,276 and this escapement has tended to increase since 1987 (Figure 4). Similarly, estimates of natural escapement have ranged from 10 to 56 and this escapement has tended to increase since 1987 (Figure 4). However, because of the variability in trap and weir operations it is difficult to interpret the biological significance of this data. Overall there is little information on how the hatchery program for steelhead in the Grande Ronde River basin has affected the natural spawning population of steelhead.

Reestablish sport and tribal fisheries.

A consumptive sport fishery for steelhead was reopened in the Grande Ronde River basin during 1986. In the past, anglers fished 14,424 hours annually in the basin. From the 1985-86 run year through the 1995-96 run year, anglers have fished approximately 33,394 hours annually in the basin (Figure 6), or 2.3 times as much as they did historically. In the past, harvest in the basin was 886 fish yearly. From the 1985-86 run year through the 1995-96 run year, anglers in the basin harvested roughly 1,750 fish yearly (Figure 7), or twice as many as they did historically. In the past, catch rate in the basin was 0.054 fish/hour each year. From the 1989-90 run year through the 1995-96 run year, anglers caught nearly 0.095 steelhead for each hour they fished during a given year (Figure 8), or 1.75 times the historic rate. Thus, in general, a sport fishery for steelhead has been reestablished in the Grande Ronde River basin. As evidenced by 54-85% of the fish captured being of hatchery origin, the hatchery program has played a large role in the reestablishment of this fishery. However, approximately 50% of the historic steelhead harvest was in the fall while the other 50% was in the spring. Currently, more than 75% of the steelhead harvest is in the spring. Furthermore, approximately 80% of the historic steelhead harvest was from the Grande Ronde River while only 20% was from the Wallowa River. Currently, about 60% of the harvested steelhead are from the Wallowa River while only 40% are from the Grande Ronde River. Although the volume of the current sport fishery surpasses that of the historic sport fishery, some of the attributes of the historic fishery have not been recovered. Furthermore, there is relatively poor documentation of the historic tribal steelhead fishery in the Grande Ronde River basin. Currently, there is not a significant tribal fishery for steelhead in the Grande Ronde River basin.

Establish a total return of adult fish resulting from LSRCP activities in Oregon that meets the compensation goals.

Generally, the hatchery program has not met its adult compensation goals despite being able to achieve its smolt production goals. The Grande Ronde River steelhead program was designed to release 1,350,000 smolts which, at an average smolt-to-adult survival rate of 0.68% to the compensation area, would provide 9,184 adults to this area annually. From 1976-85, prior to the completion of Wallowa and Irrigon fish hatcheries as well as the Big Canyon Facility, the production goal was not

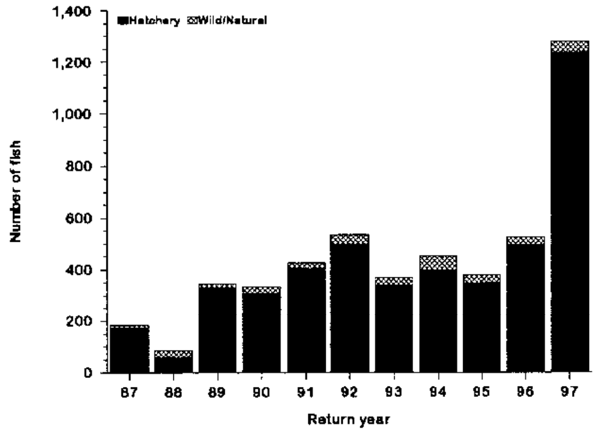

Figure 4. Escapement of adult steelhead to the adult weir in Deer Cr. The escapement was composed of wild or natural and hatchery fish. Wild fish are those that were produced naturally and did not have a hatchery fish as a parent. Hatchery fish are those that were produced in the hatchery and had hatchery parents. Natural fish are those that were produced naturally and may have had a hatchery fish as a parent.

Brood Year	Stock Source	Number of Spawned Females
1976	Ice Harbor Dam	35
1977	Little Goose Dam	48
1978	Little Goose Dam	43
1979	Pahsimeroi, ID (embryos)	*40-50*
1980	Wallowa Hatchery	85
1981	Wallowa Hatchery	142
1982	Wallowa Hatchery	111
1983	Wallowa Hatchery	216
1984	Wallowa Hatchery	385
1985	Wallowa Hatchery	318
1986	Wallowa Hatchery	812
1987	Wallowa Hatchery	602
	(Deer C., Lookingglass C.)	*12*
1988	Wallowa Hatchery	551
1989	Wallowa Hatchery	400
1990	Wallowa Hatchery	457
1991	Wallowa Hatchery (+CW)	473(+316)
1992	Wallowa Hatchery	594
1993	Wallowa Hatchery	495
1994	Wallowa Hatchery	680
1995	Wallowa Hatchery (+CW)	290(+106)
1996	Wallowa Hatchery	592
1997	Wallowa Hatchery	544

Table 1. Broodstock history for females spawned in the hatchery. The Wallowa stock originated from adults collected at mainstem dams and from steelhead embryos obtained from the Idaho Department of Fish and Game. Since 1980 the stock has essentially been domesticated at Wallowa Fish Hatchery. CW represents fish obtained from the Cottonwood facility (Washington Department of Fish and Wildlife).

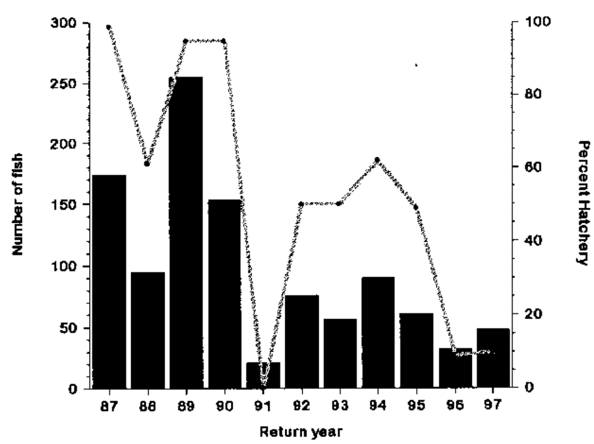

Figure 5. Escapement of adult steelhead above the weir in Deer Cr. The bars represent the number of fish passed above the weir. The thick, stippled line represents the percentage of these fish that were of hatchery origin. In 1996 we estimated that 150 hatchery adults escaped before the weir was installed. In 1997 we estimated that six hatchery adults and 23 natural adults escaped before the weir was installed.

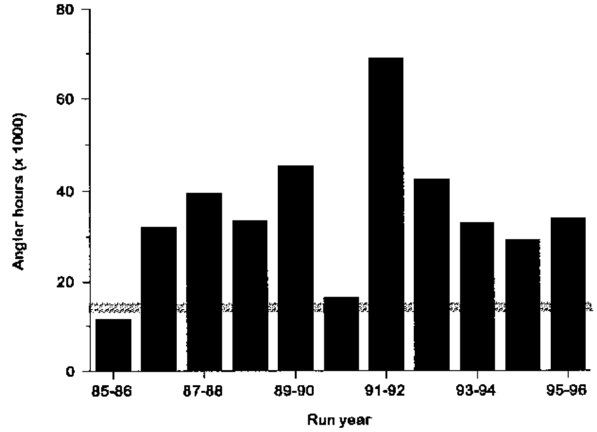

Figure 6. Historic (1960-1974) and current (1986-1996) angler effort for the recreational fishery in the Grande Ronde River basin. The thick, stippled line represents the historic median. The bars represent recent values. The fishery was closed from 1974 through 1986.

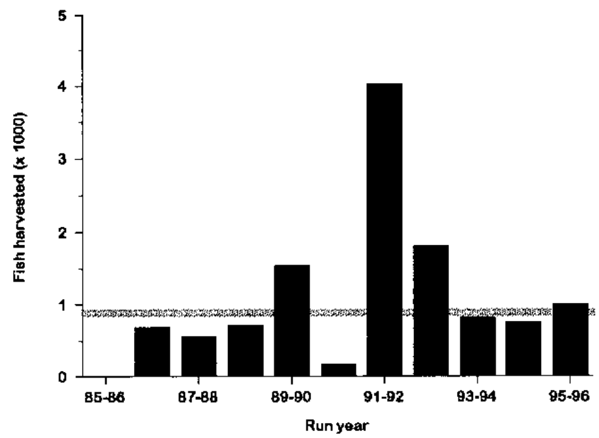

Figure 7. Historic (1957-1974) and current (1986-1996) harvest for the recreational fishery in the Grande Ronde River basin. This information was generated from punch card data. The thick, stippled line represents the historic median. The bars represent recent values. The fishery was closed from 1974 through 1986.

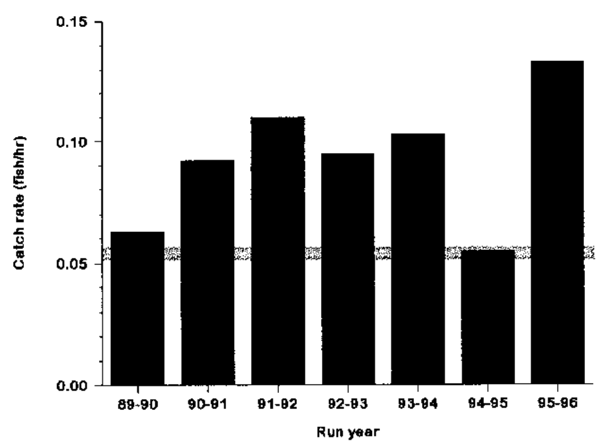

Figure 8. Historic (1949-1974) and current (1989-1996) catch rates for the recreational fishery in the Grande Ronde River basin. The thick, stippled line represents the historic median. The bars represent recent values. The fishery was closed from 1974 through 1986.

achieved and only 62,000-720,000 smolts were released (Figure 9). Since 1986, however, the hatchery program has generally met the production goal, releasing an average of 1,575,000 smolts. The program fell short of its goal with the 1989 brood when only 1,310,000 smolts were released. Typical smolt-to-adult survival rates have been well below what is necessary to achieve the compensation goal (Figure 10). For the 1986-92 broods, smolt-to-adult survival averaged 0.22%, and ranged from less than 0.01% (1976) to 0.54% (1985, 1989). As a result of these low survival rates, adult production to the compensation area has been below the LSRCP goal of 9,184 fish each year, and has averaged only 3,327 fish annually (Figure 11). Harvest outside of the compensation area may have a significant impact on our ability to provide adults for compensation. Estimates suggest that nearly 50% of the adult steelhead produced from this hatchery program are harvested in the Columbia and Deschutes rivers. Given the current conditions, a 0.68% smolt-to-adult survival rate appears to be an unrealistic goal and it is not likely that this hatchery program will be able to provide the desired compensation.

Minimize the impacts of the program on resident stocks of game fish.

The impacts of the hatchery program on resident stocks of game fish have not been well studied. Game fish indigenous to the Grande Ronde River basin include steelhead and rainbow trout (*O. mykiss*), chinook salmon (*O. tshawytscha*) and bull trout (*Salvelinus confluentus*). There are two major avenues by which this steelhead hatchery program might affect these stocks.

When hatchery smolts are released a variable number of fish do not migrate towards the ocean but residualize in fresh water. Although they may persist for a long period of time and over a wide area, these residuals tend to be concentrated near the release site and become less abundant with each season. Based on our studies, residuals do not appear to have very substantial or direct interactions with juvenile chinook salmon in the Grande Ronde River basin. Residuals probably do not interact much with bull trout because of different habitat preferences. It is unclear how residuals may be impacting naturally-produced *O. mykiss* juveniles.

When hatchery adults return to the Wallowa River, many are captured in the fishery or at the traps in Spring and Deers creeks. However, some steelhead smolts are released each year directly into the upper Grande Ronde River and Catherine Creek, where no adult traps are operated. Overall, some of the adult steelhead returning to the Grande Ronde River basin undoubtedly avoid capture in traps or the fishery and stray into local streams. During the past, biologists and anglers have reported stray hatchery adults in or near various tributaries of the Grande Ronde River basin. During the 1997 return year we began to evaluate the stray issue more closely. In 1997, eighty six percent of the fish or carcasses observed in Five Points Creek and 14% of the fish or carcasses captured at the weir in Lookingglass Creek were of hatchery origin. In contrast to this information, which suggests that steelhead straying is substantial, very few coded-wire-tagged fish have been observed straying between Wallowa Fish Hatchery and the Big Canyon Facility. In addition to strays,

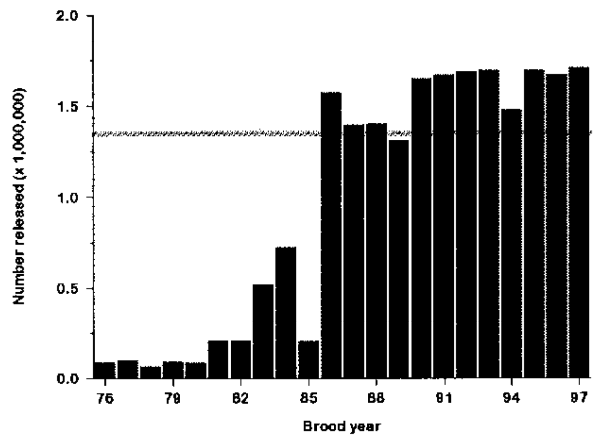

Figure 9. Steelhead smolt releases into the Grande Ronde R. basin. The program goal was to produce and release 1,350,000 smolts each year. Smolt releases included acclimated and direct-stream releases into Spring Cr., Deer Cr., the upper Grande Ronde R. and Catherine Cr.

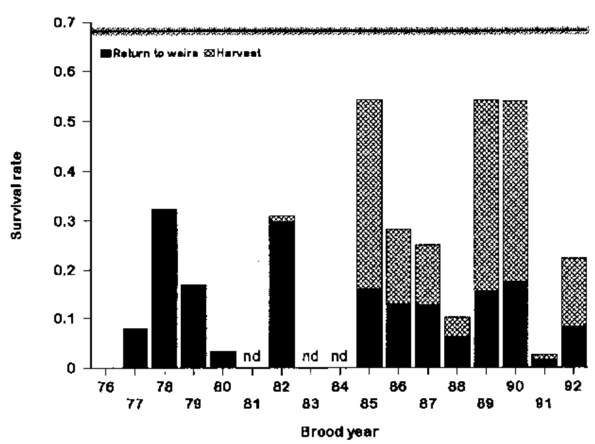

Figure 10. Smolt-to-adult survival rates for hatchery-produced steelhead to the compensation area. The program goal was to have 0.68% of the Wallowa stock smolts survive to the compensation area. The estimates of survival are based on expansions from the actual number of tagged fish recovered at the weirs in Spring and Deer creeks as well as from the number of tagged fish harvested from fisheries in the compensation area. nd indicates no data for that year.

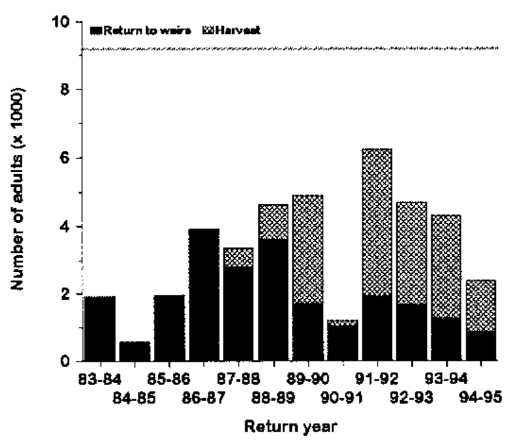

Figure 11. Adult production of hatchery-produced steelhead to the compensation area. The program goal was to provide 9,184 Wallowa stock steelhead to the compensation area. The estimates of adult production are based on expansions from the actual number of tagged fish recovered at the weirs in Spring and Deer creeks as well as from the number of tagged fish harvested from fisheries in the compensation area.

ODFW outplanted 226 adult steelhead into the upper Grande Ronde River basin in 1986, 1,096 adult steelhead into the upper Grande Ronde River basin and 535 adult steelhead into the Wallowa River basin in 1987, and 152 adult steelhead into the Wallowa River basin in 1988. All stray or outplanted fish had the opportunity to interact with resident stocks of fish and it is unknown whether these adult strays spawned with the natural population of steelhead or rainbow trout. Furthermore, it is unclear what kind of impact this introgression would have on the resident stocks.

Conclusion

The steelhead hatchery program in the Grande Ronde River basin has allowed for the reestablishment of a sport fishery but, despite meeting many of its production goals, has not been able to achieve its compensation goal. At the LSRCP status review in 1990, six factors were identified as limiting the success of the Grande Ronde River basin steelhead program. These factors were: highly variable smolt-to-adult survival rates; poor adult conversion from the Columbia River into the Snake River; high egg losses; the suitability of the Wallowa stock, especially given its migration patterns, as a broodstock source; poor water quality at Wallowa Fish Hatchery for adult holding and smolt acclimation; and a limited number of acclimation facilities in the basin. In this presentation, many of the obstacles we identified as limiting this program's success in 1998 were similar to those identified in 1990. These obstacles are: the original source of broodstock and the possible domestication of the Wallowa stock since it originated; no clear restoration of the natural spawning population; concentrated releases at relatively few locations along with limited acclimation facilities; relatively low and variable smolt-to-adult survival rates; variable and sometimes high rates of residualism; and little quantitative information on straying and adult escapements to non-target streams. With the recent listing of lower Snake River populations of steelhead under the Endangered Species Act, the LSRCP program assumes a different role with a newly emphasized importance. The sport fishery receives tremendous support from the public. However, it is not clear whether the stock of fish that supports this fishery is compatible with the concerns of the Endangered Species Act. If we continue using the Wallowa stock, comanagers have begun to discuss the possibility of increasing the use of acclimation, releasing smolts in areas that will minimize the impacts of returning adults on resident fish, and reducing the overall number of smolts being released. If we stop using the Wallowa stock, comanagers have begun to discuss changing to a locally-adapted broodstock. This would require identification of the appropriate stock unit in the basin, determining how to collect sufficient numbers of fish for broodstock, and deciding whether or not there could be harvest on these fish. In general, there is a critical need for information on the population dynamics of *O. mykiss* in the Grande Ronde River basin, including the interactions between resident and anadromous forms. LSRCP evaluations have resulted in recommendations that include release goals being reduced from 1,350,000 to 1,080,000 fish at a size of 113 g, all fish being acclimated prior to release, and the use of volitional releases from acclimation ponds to cull fish that are likely to residualize (small males) from the release group. For artificial propagation to be useful in recovery and compensation efforts it is essential that the steelhead hatchery program in the Grande Ronde River River basin be executed with consistent guidance from comanagers and the Endangered Species Act as well as with an increased emphasis on the natural poulations of *O. mykiss*.

Acknowledgments

We are grateful for the dedication and assistance of all of the employees, past and present, in ODFW's Fish Research program in NE Oregon, without whom this synthesis would not have been possible. We would like to thank biologists from ODFW, the Confederated Tribes of the Umatilla Indian Reservation, the Washington Department of Fish and Wildlife, and the Nez Perce for their regular discussions and oversight of the steelhead supplementation program in the Grande Ronde River basin. All of the work summarized in this report was financed by the Lower Snake River Compensation Plan of the U.S. Fish and Wildlife Service.

Summer Steelhead in the Imnaha River Basin, Oregon

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Introduction

Historically, anadromous forms of *Oncorhynchus mykiss* (steelhead) were abundant in watersheds of the lower Snake River. In particular, the Imnaha River basin of northeast Oregon supported a vital run of steelhead. In the mid 1960's, biologists estimated that Camp Creek (Figure 1), a small stream used to index escapement levels in the Imnaha River basin, had between five and 11 redds per kilometer of stream (Figure 2). Fish in the Imnaha River basin were abundant enough to provide opportunities for both sport and tribal harvest. Correlated with the completion of the dams on the lower Snake River, however, run sizes began to diminish. From the late 1960's through the mid 1970's, redd numbers per kilometer of Camp Creek ranged from six to fewer than one (Figure 2). As a result of this decline, the Oregon Department of Fish and Wildlife (ODFW) closed the recreational fishery for Imnaha River steelhead in 1974.

In 1976, congress authorized the Lower Snake River Compensation Plan (LSRCP). The LSRCP mandated that the U.S. Fish and Wildlife Service oversee a program to compensate for the losses of anadromous fishes that were associated with the construction of the lower four dams (Ice Harbor, Lower Monumental, Little Goose and Lower Granite) on the Snake River. The LSRCP focused on the use of artificial propagation in an attempt to compensate for these losses. The LSRCP established compensation goals which, for the Imnaha River basin, include the production of 29,938 kg of fish resulting in the release of 330,000 smolts. At a smolt-to-adult return rate of 0.61%, the plan would provide 2,000 adults to the compensation area. The LSRCP also developed management goals to guide the artificial production programs. Relative to steelhead, these goals were to: establish an annual supply of brood fish that can provide an egg source capable of meeting compensation goals; restore and maintain the natural spawning population; reestablish sport and tribal fisheries; establish a total return of adult fish resulting from LSRCP activities that meets compensation goals; and minimize the impacts of the program on resident stocks of game fish.

Program overview

Comanagers of the Imnaha River basin (ODFW and the Nez Perce Tribe) have implemented a steelhead supplementation program which involves three LSRCP facilities in Oregon. The supplementation program in the Imnaha River basin begins with the collection of both natural and hatchery adults. These fish are held and spawned at a permanent facility near river kilometer 8.0 of Little Sheep Creek (see Figure 1). Embryos are hauled to Wallowa Fish Hatchery (Enterprise, OR) where early incubation occurs. Once the embryos reach the eyed stage of development they are transferred to Irrigon Fish Hatchery (Irrigon, OR) for final incubation, hatching and juvenile rearing. During this rearing, all of the fish are marked and some of the juveniles receive either coded-wire or PIT tags, both of which allow us to monitor production and evaluate rearing and release strategies. Ten to 13 months after fertilization (from mid-March through mid-May) most juvenile steelhead are transported from Irrigon Fish Hatchery back to the Little Sheep Creek Facility where they are reared in an acclimation pond for approximately three weeks before being released as smolts. For evaluation purposes, a small part of the Imnaha stock steelhead production has been transported from Irrigon Fish Hatchery and released directly into Little Sheep Creek. Some fish have also been released directly into the Imnaha River. Currently, all releases are from the acclimation pond. As a supplementation program, the focus is on maintaining or increasing natural production while maintaining the long-term fitness of the target population, and keeping the ecological and genetic impacts on non-target populations within specified biological limits.

The steelhead supplementation program in the Imnaha River has been functioning for 16 years. This program began with the trapping of adults in 1982. In 1983 we began releasing hatchery-reared smolts into Little Sheep Creek and the Imnaha River. Adults from hatchery-reared fish began to return to the basin in 1985. We have been evaluating the success of the supplementation program since it began. We have been monitoring the steelhead fishery since 1985. In 1990 we began experiments to evaluate the utility of acclimating smolts prior to their release. In 1992 we began an evaluation on the juvenile steelhead that residualize when released. From 1982-87 the program operated with the use of temporary facilities at Little Sheep Creek. Irrigon Hatchery was completed in 1986 and the Little Sheep Creek Facility was completed in 1988. Thus, the program has been fully functional for the past 10 years.

Program status

Establishing an annual supply of brood fish that can provide an egg source capable of meeting compensation goals.

As the supplementation program matured it has generally provided enough fish, in terms of the overall number, for broodstock needs. Approximately 110 adult females and 110 adult males are necessary to produce the number of hatchery-reared smolts that were estimated as necessary to achieve the compensation goals. With the exception of 1994, sufficient numbers of adults returned to the Little Sheep Creek facility to meet broodstock needs during the 1987-97 return years (Figure 3). Broodstock needs have been met, in part, because of increases in the escapement of hatchery origin adults to the Imnaha River basin. For example, in most of these years, there was a sufficient number of hatchery fish to meet the broodstock needs of the program. However, in none of these years were

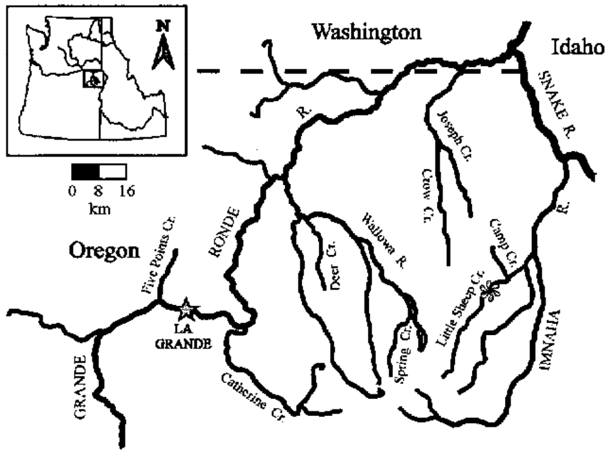

Figure 1. Major river basins in northeast Oregon. The Oregon Department of Fish and Wildlife's steelhead program has an adult collection and juvenile acclimation facility near river kilometer 8.0 of Little Sheep Cr. Little Sheep Creek is a tributary to Big Sheep Cr., which is a tributary to the Imnaha R.

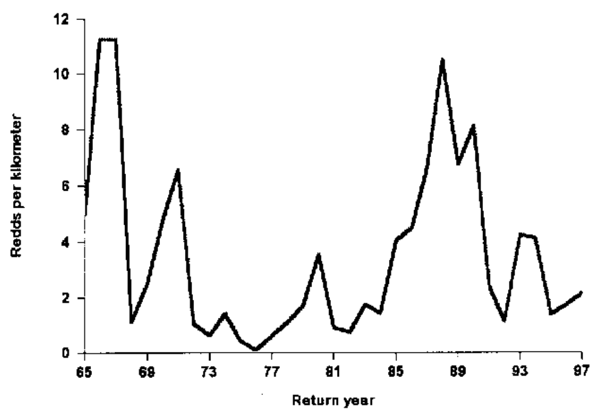

Figure 2. Natural escapement trends in Camp Cr. Camp Cr. is a tributary to Little Sheep Cr. and is one of the streams in the Imnaha R. basin used to index natural spawning escapement. The spawning ground surveys are conducted on foot.

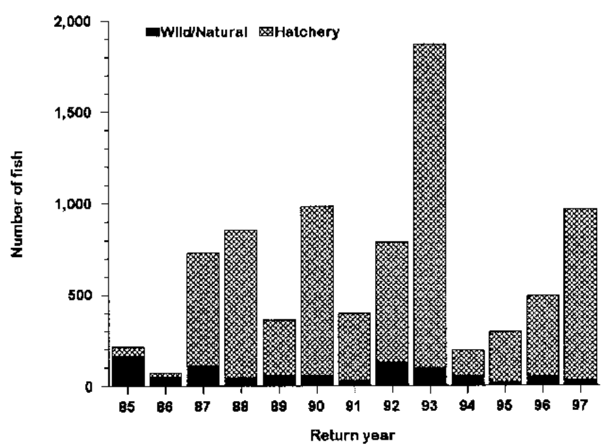

Figure 3. Escapement of adult steelhead to the adult weir in Little Sheep Cr. From 1985 to 1987 the escapement was composed of wild and hatchery fish. From 1988 to 1997 the escapement was composed of natural and hatchery fish. See Table 1 for a definition of wild, natural and hatchery.

there enough wild or natural fish to meet the broodstock needs of the program. Although the number of hatchery adults escaping to the weir in Litttle Sheep Creek is variable from year to year, the numbers of fish returning are still adequate to meet broodstock needs.

Despite relatively high numbers of fish returning to Little Sheep Creek, most of the fish have been of hatchery origin. For broodyears 1987-1992, progeny:parent ratios for naturally produced steelhead were below one (Figure 4). However, hatchery steelhead from the same cohorts exhibited progeny:parent ratios greater than one in 83% of these broodyears. Furthermore, more than five progeny were recruited from each adult in the 1989 and 1990 broods. As a result, except for 1994, hatchery origin fish have accounted for more than 80% of the escapement since 1987 (see Figure 3).

The composition of adult steelhead returning to Little Sheep Creek has not been appropriate to support the broodstock needs of the supplementation program. Under the auspices of Oregon's Wild Fish Management Policy (WFMP), which became law in the State of Oregon during 1990, this supplementation program is designed to use a mix of hatchery and natural origin adults for broodstock. The original goal was to manage this program under the Type 1 scenario of the WFMP where no more than 25% of the natural adults should be removed from the escapement, no more than 50% of the natural spawning population should be hatchery fish, and no more than 70% of the broodstock should be composed of hatchery fish. A retrospective look indicates that from 1982 to 1986 we were able to achieve this type of management in that 0-24% of the fish used for brood were of hatchery origin (Table 1). Since 1987, however, 81-97% of the fish used for brood have been of hatchery origin and we have not complied with the Type 1 guidelines of the WFMP. Thus, in 1993, a decision was made to relax the standards on the program and manage under a Type 2 scenario of the WFMP. Under this management scenario no more than 25% of the natural adults should be removed from the escapement, no more than 30% of the natural spawning population should be hatchery fish, and no more than 95% of the broodstock should be composed of hatchery fish. Since 1993, we have not complied with the Type 2 guidelines of the WFMP. In addition, modeling efforts have suggested that the WFMP is essentially incompatible with the typical composition and number of adult steelhead returning to Little Sheep Creek (Figure 5).

Restore and maintain the natural spawning population.

Neither the number nor the characteristics of natural steelhead in the Imnaha River basin have appeared to respond to the supplementation program. In opposition to the program goals, escapement levels of natural fish have evidently failed to increase. This is illustrated by the low but relatively stable returns to the Little Sheep Creek weir (see Figure 3). Since naturally-produced fish began to return from supplemented runs (1988), natural escapement to Little Sheep Creek has averaged 56 fish and varied from a high of 128 in 1992 to a low of 17 in 1995. In general support of the program goals, the characteristics of hatchery fish from Little Sheep Creek have remained similar to those of the

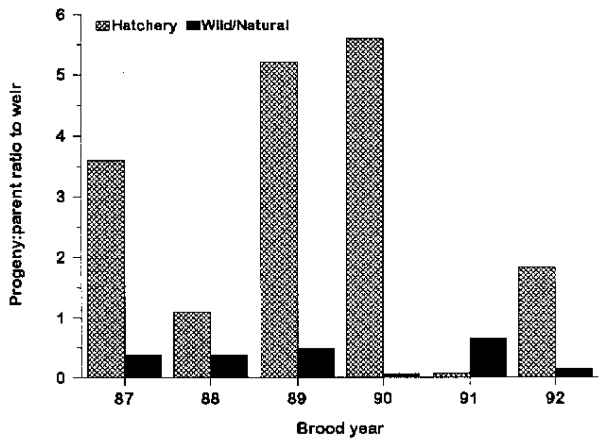

Figure 4. Progeny to parent ratios. These ratios are based on the numbers of adults collected at the weir in Little Sheep Cr. These fish are either retained for hatchery broodstock or passed above the weir and allowed to spawn naturally. Progeny resulting from fish spawned in the hatchery have their adipose fin excised. This fin-clip allows hatchery and natural fish to be distinguishable.

Brood Year	Stock Source	Spawned Females Number	Spawned Females Percent Hatchery
1982	wild	25	0
1983	wild	24	0
1984	wild	34	0
1985	wild/hatchery	94	20
1986	wild/hatchery	42	24
1987	wild/hatchery	162	93
1988	natural/hatchery	171	86
1989	natural/hatchery	129	84
1990	natural/hatchery	179	87
1991	natural/hatchery	130	93
1992	natural/hatchery	177	81
1993	natural/hatchery	134	87
1994	natural/hatchery	102	92
1995	natural/hatchery	99	96
1996	natural/hatchery	159	96
1997	natural/hatchery	30	97

Table 1. Broodstock history for females spawned in the hatchery. Wild fish are those that were produced naturally and did not have a hatchery fish as a parent. Hatchery fish are those that were produced in the hatchery and had either wild or hatchery parents. Natural fish are those that were produced naturally and may have had a hatchery fish as a parent.

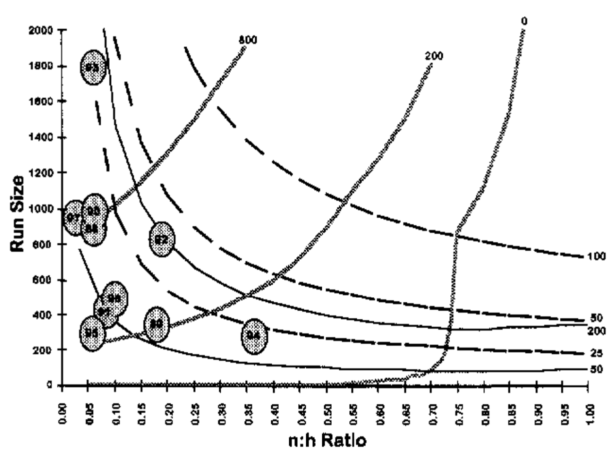

Figure 5. The implications of Oregon's Wild Fish Management Policy. Solid lines represent zones of escapement above the weir. Dashed lines represent zones of production, expressed as a percent of this program's goal. Thick, stippled lines represent zones of fish numbers in excess of program needs. The n:h ratio is the ratio of natural to hatchery fish in the escapement. Run size is to the weir. Circles represent actual run years in Little Sheep Creek.

natural fish in Little Sheep Creek. Hatchery-produced and naturally-produced steelhead from the 1989 and 1990 broods were genetically indistinguishable based on allozyme analyses conducted by Dr. Robin Waples. In addition, adults of hatchery and natural origin have returned at similar ages (Figures 6 and 7) and, notwithsatnding some loss of fish that return latest in the run, at fairly similar times (Figure 8) throughout the program. The characteristics of the natural fish in Little Sheep Creek also appear to have remained similar to their original state. The time when natural adults return still peaks in April, despite having become somewhat protracted in recent years (Figure 8). Approximately 72% of the naturally-produced males continue to return after one year in the ocean, with no consistent change in this value (Figure 6). However, naturally-produced females have tended to return at a younger age as the program has progressed (Figure 7). Thus, although hatchery fish may be replacing natural fish, these fish appear to be similar to one another.

Reestablish sport and tribal fisheries.

A consumptive steelhead fishery reopened in the Imnaha River during 1986. Steelhead are captured in this sport fishery from September through 15 April each year. Catch rates in the Imnaha fishery are frequently greater than 0.1 fish/hour (Figure 9). This rate exceeds historic values as well as most catch rates in other areas of the region. As evidenced by 50-90% of the fish captured being of hatchery origin, the supplementation program has played a large role in the reestablishment of this fishery. There is relatively poor documentation of the historic tribal steelhead fishery in the Imnaha River basin. Currently, there is not a significant tribal fishery for steelhead in the Imnaha River basin.

Establish a total return of adult fish resulting from LSRCP activities in Oregon that meets the compensation goals.

Generally, the supplementation program has not met its adult compensation goals despite being able to achieve its smolt production goals. The Imnaha steelhead program was designed to release 330,000 smolts which, at an average smolt-to-adult survival rate of 0.61% to the compensation area, would provide 2,000 adults to this area annually. From 1982-86, prior to the completion of the permanent facility at Little Sheep Creek, the production goal was not achieved and only 58,000-115,000 smolts were released (Figure 10). Since 1987, however, the supplementation program has generally met the production goal, releasing between 322,000-351,000 smolts. The notable exceptions were in the 1991 and 1994 broods when only 278,000 and 287,000 smolts, respectively, were released. Typical smolt-to-adult survival rates have been well below what is necessary to achieve the compensation goal (Figure 11). For the 1986-92 broods, smolt-to-adult survival averaged 0.27%, and ranged from less than 0.01% to just over 0.60%. As a result of these low survival rates, adult production to the compensation area has generally been below the LSRCP goal of 2,000 fish each year, and has averaged only 849 fish annually (Figure 12). Only in the 1992-93 return year, when 2,401 adults were estimated to have returned to the

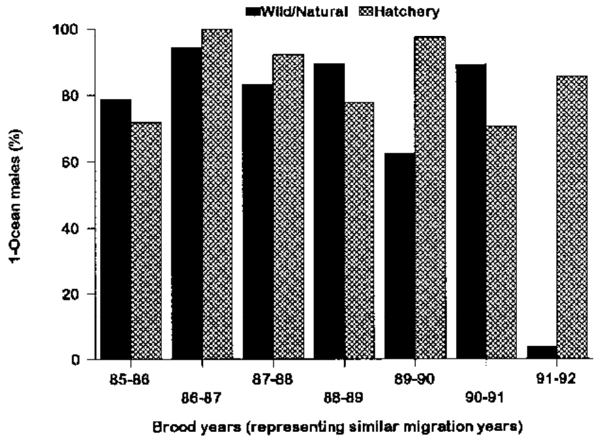

Figure 6. Length of ocean residence for male steelhead in Little Sheep Creek. The majority of hatchery fish smolt at one year of age. The majority of wild or natural fish smolt at two years of age. Thus, hatchery fish have similar migration years to wild or natural fish from the previous brood year. For definitions of wild, natural and hatchery see Table 1.

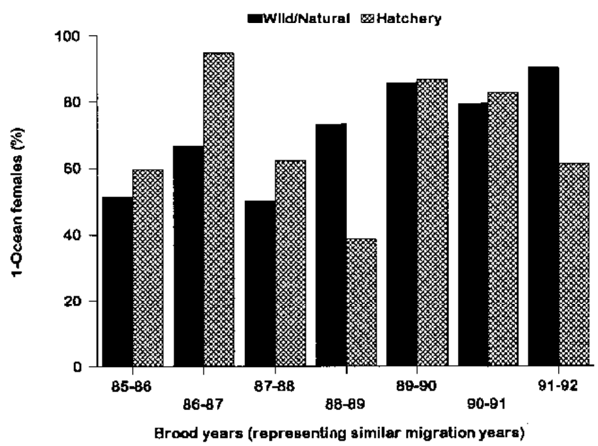

Figure 7. Length of ocean residence for female steelhead in Little Sheep Creek. The majority of hatchery fish smolt at one year of age. The majority of wild or natural fish smolt at two years of age. Thus, hatchery fish have similar migration years to wild or natural fish from the previous brood year. For definitions of wild, natural and hatchery see Table 1.

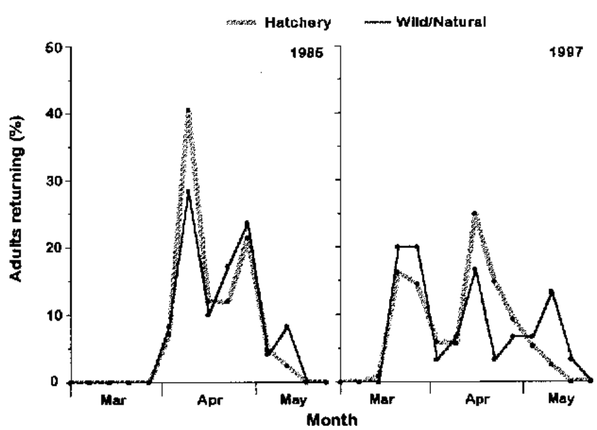

Figure 8. Adult run timing for adult steelhead returning to the weir in Little Sheep Creek. Thin, solid lines represent hatchery fish. Thick, stippled lines represent wild or natural fish. Hatchery fish began returning to Little Sheep Creek in 1985. For definitions of wild, natural and hatchery see Table 1.

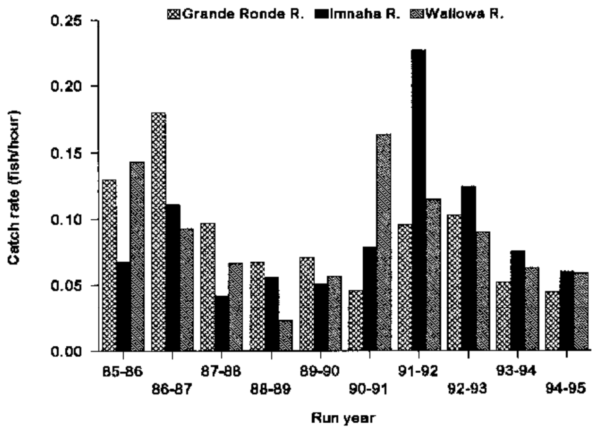

Figure 9. Catch rates for summer steelhead in the Grande Ronde R., Wallowa R. and Imnaha R. fisheries. The Grande Ronde R. data combine survey information from the lower (1 September - 15 April) and upper (15 February - 15 April) parts of the river. The Wallowa R. (1 February - 15 April) and Imnaha R. (1 March - 15 April) were only surveyed in the spring.

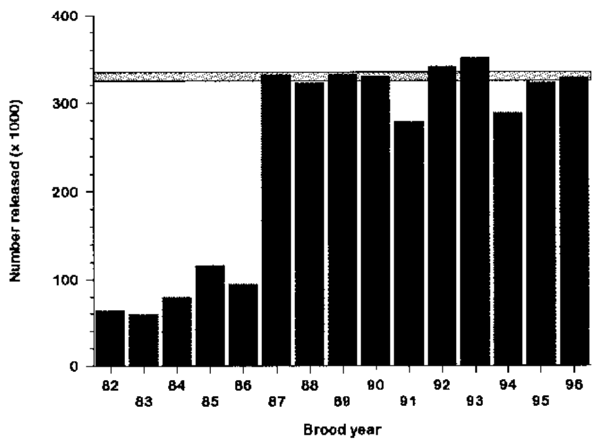

Figure 10. Steelhead smolt releases into the Imnaha R. basin. The program goal was to produce and release 330,000 smolts each year. Smolt releases included acclimated and direct-stream releases near river kilometer 8 of Little Sheep Cr. as well as direct-stream releases at various sites of the Imnaha R.

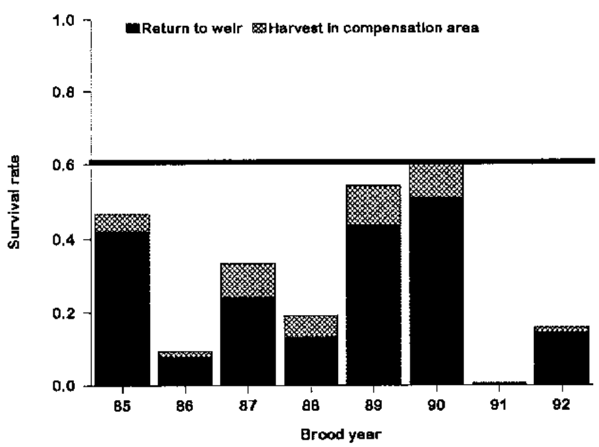

Figure 11. Smolt-to-adult survival rates for hatchery-produced steelhead to the compensation area. The program goal was to have 0.61% of the Imnaha stock smolts survive to the compensation area. The estimates of survival are based on expansions from the actual number of tagged fish recovered at the weir in Little Sheep Cr. and from the number of tagged fish harvested from fisheries in the compensation area.

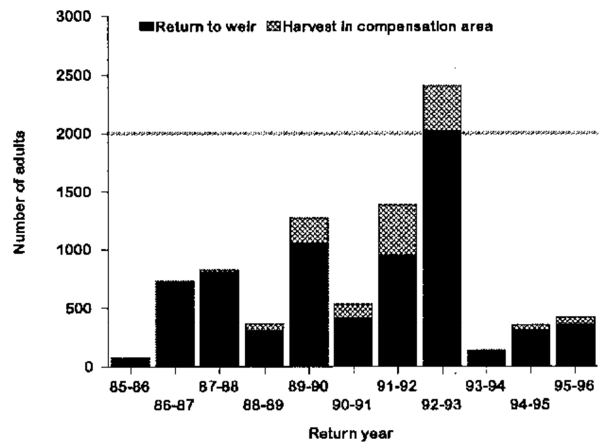

Figure 12. Adult production of hatchery-produced steelhead to the compensation area. The program goal was to provide 2,000 Imnaha stock steelhead to the compensation area. The estimates of adult production are based on expansions from the actual number of tagged fish recovered at the weir in Little Sheep Cr. and from the number of tagged fish harvested from fisheries in the compensation area.

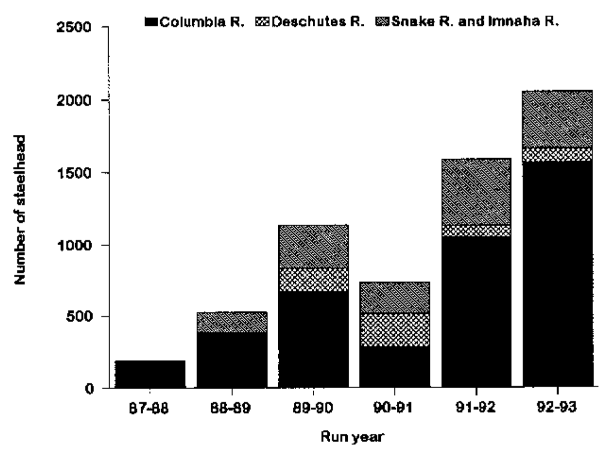

Figure 13. Exploitation of Imnaha stock hatchery steelhead. The estimates of total harvest are based on expansions from tagged fish harvested from fisheries in the Columbia R., the Deschutes R. and the compensation area (Snake R. and Imnaha R.).

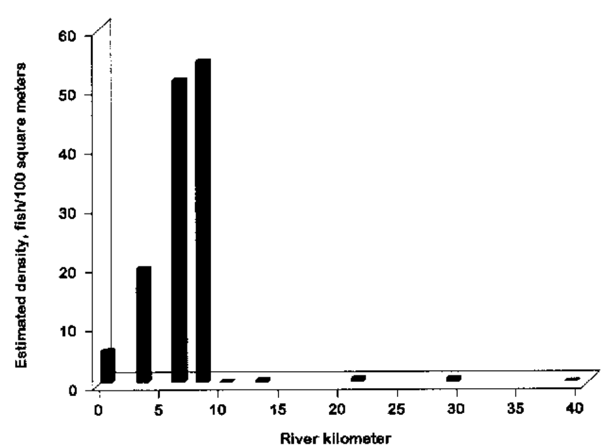

Figure 14. Density of hatchery-produced, residual steelhead found at index areas of Little Sheep Cr. during the summer of 1994. Hatchery steelhead were released at river kilometer 8.0. Residual steelhead were found in seven of the nine areas sampled (none found at river kilometer 10 or 39).

compensation area, was the goal achieved. Harvest outside of the compensation area may have a significant impact on our ability to provide adults for compensation. Estimates suggest that more than 50% of the adult steelhead produced from this supplementation program are harvested in the Columbia and Deschutes rivers (Figure 13). Given the current conditions, a 0.61% smolt-to-adult survival rate appears to be an unrealistic goal and it is not likely that this supplementation program will be able to provide the desired compensation on any regular basis.

Minimize the impacts of the program on resident stocks of game fish.

The impacts of the supplementation program on resident stocks of game fish have not been well studied. Game fish indigenous to the Imnaha River basin include steelhead and rainbow trout (*O. mykiss*), chinook salmon (*O. tshawytscha*) and bull trout (*Salvelinus confluentus*). There are two major avenues by which this steelhead supplementation program might affect these stocks. When hatchery smolts are released a variable number of fish do not migrate towards the ocean but residualize in fresh water. Although they may persist for a long period of time and over a wide area, these residuals tend to be concentrated near the release site (Figure 14) and become less abundant with each season. Based on our studies, residuals do not appear to have very substantial or direct interactions with juvenile chinook salmon in the Imnaha River basin. Residuals probably do not interact much with bull trout because of different habitat preferences. It is unclear how residuals may be impacting naturally-produced *O. mykiss* juveniles. When hatchery adults return to the Imnaha River basin, many are captured in the fishery or at the trap in Little Sheep Creek. However, some of these fish undoubtedly avoid capture in the fishery and stray into streams other than Little Sheep Creek. It is unknown whether these adult strays spawn with the natural population of steelhead or rainbow trout. Furthermore, it is unclear what kind of impact this introgression would have on the resident stocks.

Conclusion

Despite meeting many of its production goals and some of its management objectives, the steelhead supplementation program in the Imnaha River basin has not been able to achieve its compensation goal with any regularity nor restore and maintain the natural spawning population. At the LSRCP status review in 1990, four factors were identified as limiting the success of the Imnaha steelhead program. These factors were: highly variable smolt-to-adult survival rates; poor adult conversion from the Columbia River into the Snake River; high egg losses; and a lack of understanding of how to supplement natural production without affecting genetic and life history characteristics of the wild population. In this presentation, many of the obstacles we identified as limiting this program's success in 1998 were similar to those identified in 1990. These obstacles are: an inability to boost the production of the natural population; the apparently low carrying capacity of Little Sheep Creek; the disproportionately high number of hatchery fish returning to Little Sheep Creek; the lack of information on population dynamics in other areas of the Imnaha River basin; variable and sometimes high rates of residualism; and relatively low angling effort. With the recent listing of lower Snake River populations of steelhead under the Endangered Species Act, the LSRCP program assumes a different role with a newly emphasized importance. Comanagers are beginning to view the Imnaha River basin as a whole, rather than just the area of Little Sheep Creek above the facility, when overseeing the supplementation program. As such, comanagers are developing a sliding-scale that allows flexibility in the proportion of natural fish that are collected for broodstock, of hatchery fish that are allowed to spawn naturally, and of hatchery fish that are incorporated into the broodstock. LSRCP evaluations have resulted in recommendations that include release goals being reduced from 330,000 to 200,000 fish, all fish be acclimated prior to release, and the elimination of releases into the mainstem of the Imnaha River. For artificial propagation to be useful in recovery and compensation efforts it is essential that the steelhead supplementation program in the Imnaha River basin be executed with consistent guidance from comanagers and the Endangered Species Act as well as with diligent consideration of the biology of the species.

Acknowledgments

We are grateful for the dedication and assistance of all of the employees, past and present, in ODFW's Fish Research program in NE Oregon, without whom this synthesis would not have been possible. We would like to thank biologists from ODFW, the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation for their regular discussions and oversight of the steelhead supplementation program in the Imnaha River basin. All of the work summarized in this report was financed by the Lower Snake River Compensation Plan of the U.S. Fish and Wildlife Service.

Washington's LSRCP Trout Program: 1982-1996

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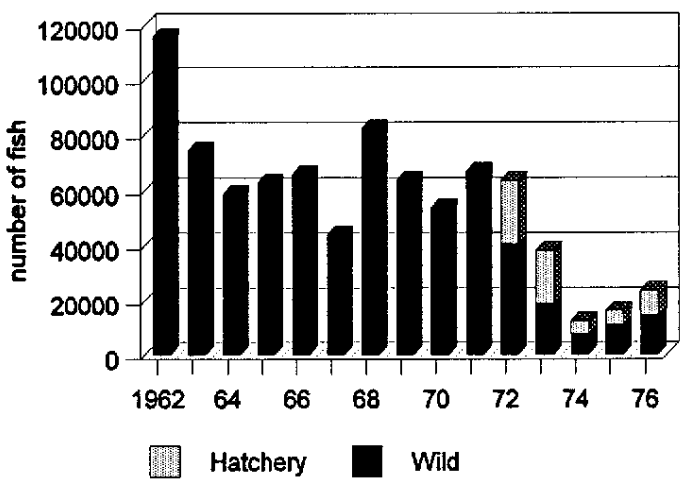
INTRODUCTION

A precipitous decline in numbers of Snake River steelhead (Fig. 1) and other anadromous fish between 1962 and the mid 1970s alarmed management agencies such as WDFW. The rapid decline in steelhead and a commensurate loss of recreational opportunity for Washington's residents spurred Washington to partner with other State and Federal management agencies. They negotiated with federal agencies such as the Corps of Engineers (COE) to mitigate for adult fish losses to anadromous populations and lost resident fishing opportunity caused by construction of the four lower Snake River power dams.

Fig. 1 Snake River Steelhead Escapement



As a result of the negotiations, the Lower Snake River Compensation Plan (LSRCP) was proposed by the COE in 1975. Hatchery production would be the means to replace lost resources and recreational opportunity. In Washington, Lyons Ferry Hatchery (LFH) on the Snake River would be constructed as the core of the mitigation program. Also, an existing state facility, the Tucannon Hatchery, was renovated and three acclimation ponds for steelhead constructed: Curl Lake on the Tucannon River; Cottonwood Pond on the Grande Ronde River; and Dayton Pond on the Touchet River. Washington's portion of the program would mitigate for 18,300 fall chinook, 1,152 spring chinook, 4,656 summer steelhead and 67,500 angler days of fishing opportunity. The trout segments of the program (the focus of this presentation) would be accomplished by annual production of 931,200 steelhead smolts (116,400 lbs @ 8 fish/lb) and 93,000 pounds of rainbow trout (at 3 fish/lb) to be planted into numerous lakes and streams throughout SE Washington, and including 6,100 pounds of trout production for Idaho.

Washington established short term goals by which they hoped to achieve the long term mitigation goals set in the LSRCP program. Those goals were:

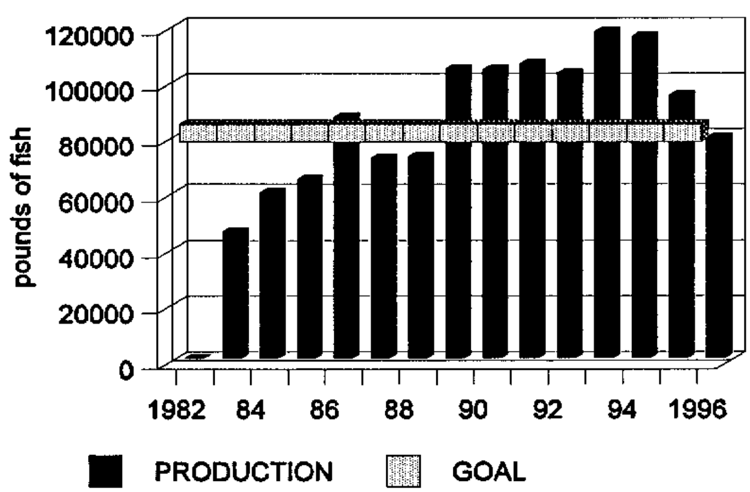
1. Establish steelhead broodstock(s) capable of meeting egg needs
2. Maintain and enhance natural populations of steelhead and other native salmonids.
3. Return adult steelhead to the LSRCP area which meets goal.
4. Improve or re-establish sport fisheries.
5. Coordinate actions with other basin managers.

These goals have directed actions taken by WDFW to ensure the success of the LSRCP program.

RESULTS

Trout (resident fishing opportunity)
To provide for fishing opportunity, catchable size (3 fish/lb) rainbow trout would be raised and released in lakes and streams. WDFW negotiated with the COE during the construction phase of Lyons Ferry Hatchery (LFH) to divert $273,000 of construction funds from the hatchery to construct instream habitat structures in local streams which had been damaged by the 1964 and 1973 floods. The amount diverted was the cost of one raceway at the new hatchery which could rear 7,000 pounds of trout annually. The annual production goal for the program was reduced to 86,000 pounds because of the change and is the current goal. Figure 2 presents trout production from LFH compared to the annual goal. After some early start up years, the goal has been achieved or exceeded nearly every year.

Fig. 2 Rainbow Trout Production at LFH



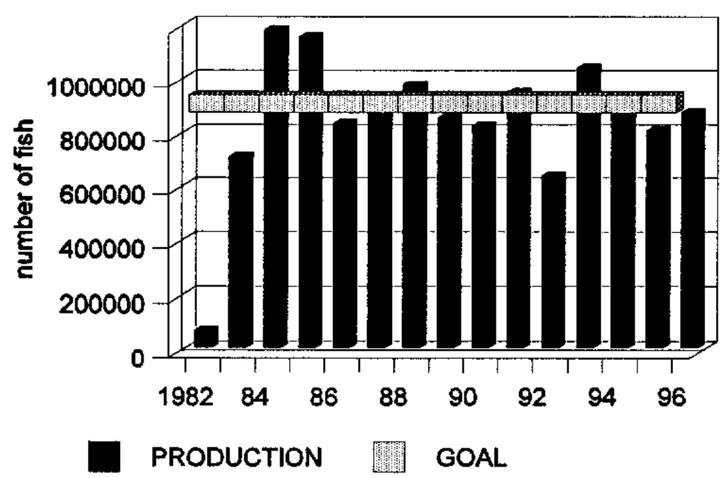
A study completed in 1985 by evaluation personnel estimated that over 80,000 angler days of fishing was provided by nearly 70,000 pounds of trout released that year (substantially less than the goal). This was substantially more than the 67,500 angler day goal. Based on these findings, WDFW concluded that full production of catchable trout would meet or exceed the LSRCP mitigation goal for resident fish. No further estimate of use has been made. WDFW continues to believe that full production of trout meets the established LSRCP goal for resident fish.

Steelhead

Once construction of LFH was completed, fish production was expected immediately by the COE who provided interim funding for the hatchery before the US Fish and Wildlife Service (FWS) assumed that responsibility. WDFW had not specified any remote facilities for broodstock development from LSRCP tributaries. The decision was made therefore to use existing hatchery broodstocks; one from the Snake Basin and one from the Columbia. The Wallowa stock of steelhead was developed by ODFW in the late 1970s for use in the Wallowa River LSRCP program. Snake River origin fish trapped at Lower Snake dams were used to start the stock. WDFW identified it as a stock of choice for use in the Grand Ronde River, and aided ODFW in building returns of fish. For the remainder of the program WDFW used Wells stock steelhead; an upper Columbia River stock used by WDFW throughout eastern Washington. Wells stock fish were released extensively in the Tucannon, Walla Walla and Snake rivers between 1983 - 1986. To make LFH self-sufficient, returning Wallowa and Wells stock fish trapped at LFH were the basis for a new LFH stock. Used in all production releases except the Grande Ronde River since 1987, the stock is likely to have some genetic influence from Skamania, Pahsimeroi, Oxbow and Clearwater stocks in the makeup because of the location of LFH in the system (RM 58 on the Snake River).

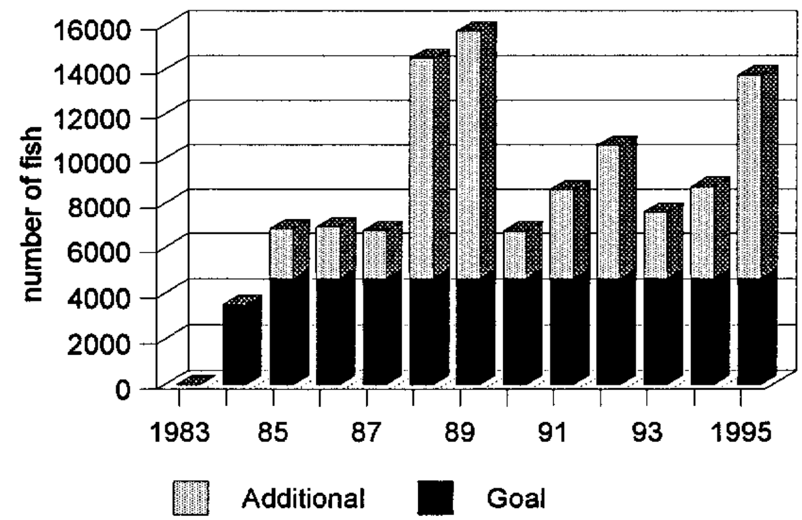
Production of steelhead at LFH since 1983 has achieved or closely approached the goal of number of fish to be released (Fig. 3). Pounds of fish released has greatly exceeded the original goal because of changes in size at release (to be discussed more later).

Fig. 3 LFH Steelhead Production

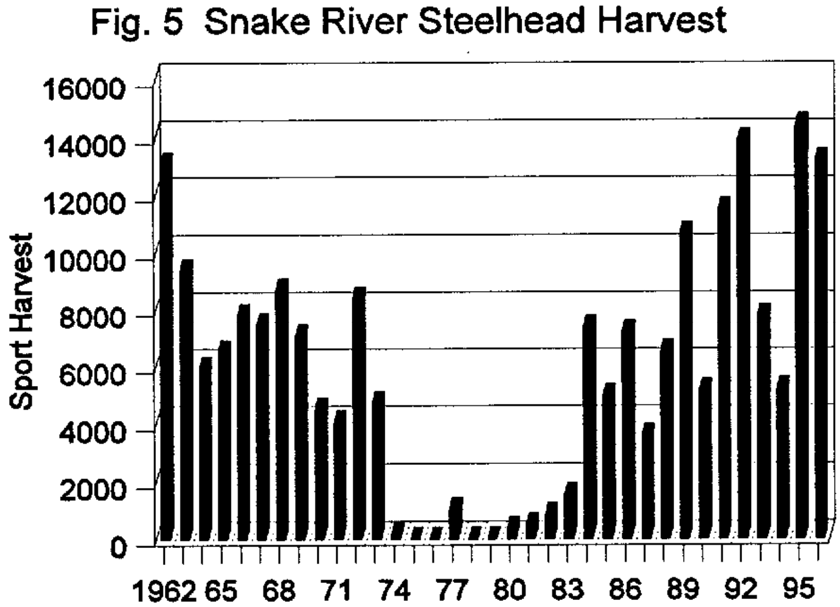


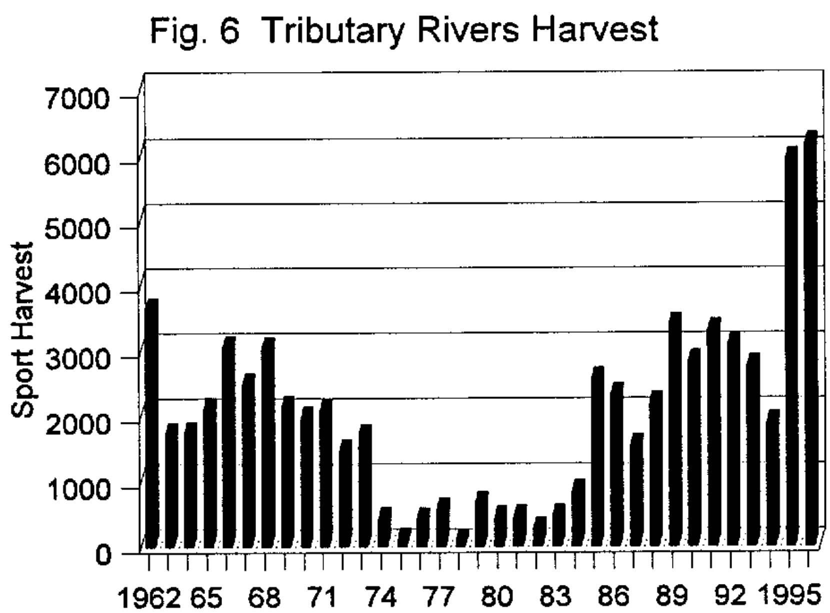
As noted above, production has proceeded well at LFH, but LSRCP goals and Washington's interim goals were defined in terms of returning adults. With the gradual completion of LSRCP facilities throughout Idaho, Oregon and Washington and production releases occurring on an annual basis, steelhead returns to the LSRCP area began to increase. Washington's steelhead program has been highly successful. The goal of 4,656 adult steelhead to the project area has been met in nearly every year of the program (Fig. 4). Some exceptional years (1988, 1989, and 1995) returned nearly three times the goal. Additional steelhead were taken in downriver sport, commercial and tribal fisheries.

Fig. 4 Adult Steelhead Returns to LSRCP Area



Washington wanted adult steelhead returns from the LFH program, however utilization of the fish was an integral part of the program from the start as defined in WDFW's interim goals. Steelhead sport harvest within the Washington portion of the Snake River had closely mirrored overall decline in fish abundance until sport fishing was closed for several years in the 1970s. Fisheries began to rebuild on the Snake in the mid 1980s, with near record harvests occurring in 1989, 1992, 1995 and 1996 (Fig. 5). Similarly, the decline of steelhead escapement into Washington's tributary streams such as the Tucannon, Grande Ronde and Walla Walla rivers, had a direct effect on sport harvest in those rivers. Hatchery production releases and subsequent adult returns were evidenced by steadily increasing sport harvest by the late 1980s, with all time record tributary harvests occurring in 1995 and 1996 (Fig. 6).

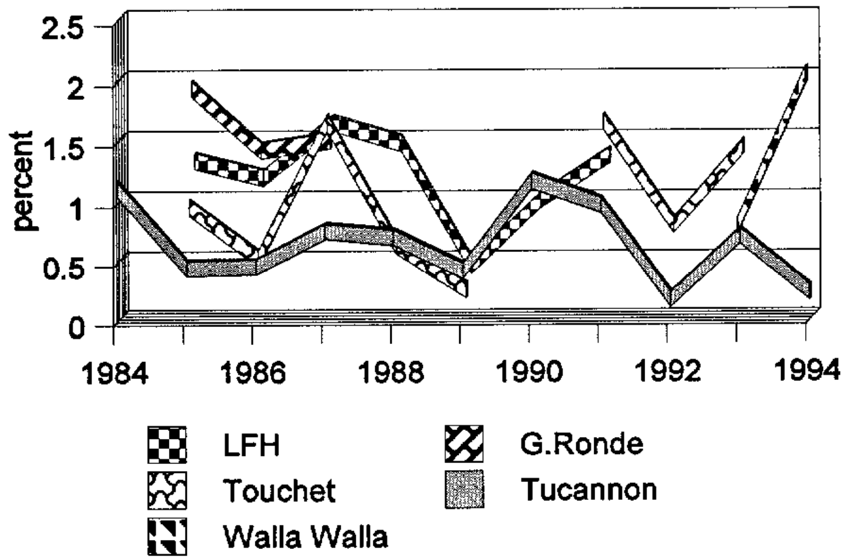




The resurgence of sport fisheries in Washington's portion of the Snake river and tributary rivers was in direct relation to returning number of hatchery fish from the LSRCP program.

Another criteria by which success of the LSRCP steelhead program would be measured was attaining an expected smolt-to-adult return (SAR) of 0.5%. Coded wire tag studies conducted by WDFW for releases of steelhead from several locations over a number of years show that average annual SAR for the LFH program exceeds the goal (Fig. 7). In some brood years for some releases, SARs have been nearly three times goal. In the Tucannon River, survivals have been above the goal about as many years as below the goal. Evaluation studies continue to seek the means to improve SARs.

Fig. 7 Smolt to Adult Survival



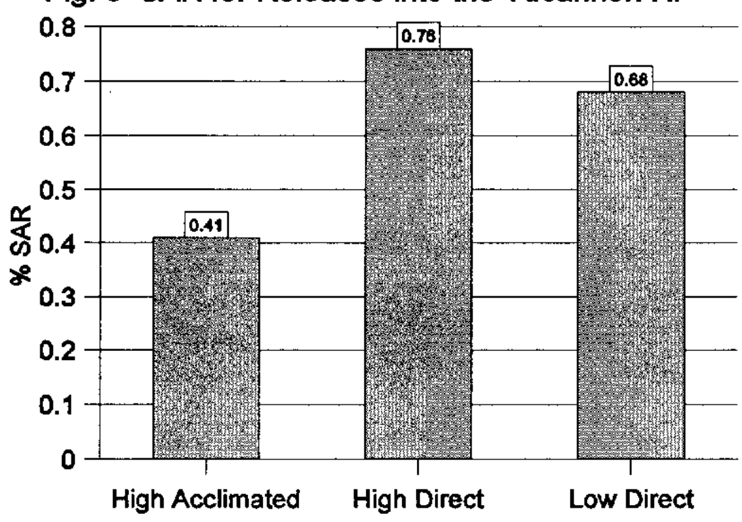
DISCUSSION

After years of successfully producing trout and steelhead that met annual goals, with estimated adult returns of steelhead and recreational opportunity exceeding the prescribed numbers in the LSRCP program, and having documented the reestablishment of fisheries throughout SE Washington, WDFW had substantially achieved most of the critical interim goals which had established (see above). The success of the program was not without challenges and significant yearly obstacles which had to be surmounted.

Fish health has generally not been a problem at LFH because of high quality pathogen free ground water. However in 1989, Infectious Hematopoietic Necrosis Virus (IHNV) was identified at the hatchery. The subsequent epizootic devastated the LFH stock juveniles on station and all 1989 brood steelhead were eventually destroyed to control the disease. Strict new spawning procedures that allowed for the incubation of individual females' gametes, and more stringent disinfection procedures within the hatchery were implemented. Although IHNV is detected at

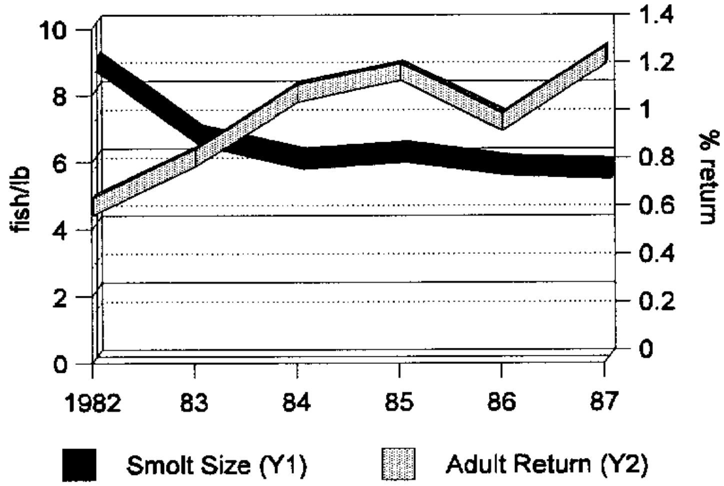
LFH most years, the disastrous effects of the virus have been effectively controlled. The environmental reality of operating an anadromous salmonid program in the hot dry Snake River basin requires constant adaptability to ensure success. Several years of serious drought in the late 1980s and early 1990s required special care in releasing fish during the spring out migration. Extreme low flows in the Snake River and tributaries made timing of release critical to smolt survival. Water budgets, utilized to "flush" fish through the system were inconsistent and releases often had to occur in anticipation of higher water budget flows. Contrarily, some of WDFW's facilities located high in the Blue Mountains faced different problems. Transfers of pre-smolts from the hatchery to acclimation ponds can either be delayed by heavy snow, or affected by extreme cold after fish had been placed in the ponds. These temperature fluctuations are highly variable from year to year and anticipating fish growth to allow smolts to be released at optimal size is difficult; often with fish being released significantly smaller than desired. Such environmental realities have a direct effect on smolt survival and adult return rates. Recent El Niño conditions have well documented effects as well. Evaluation studies focus on providing answers to problems and identifying means to improve program success through adaptive management. A study conducted from 1991-1993 showed that SAR's from un-acclimated steelhead released into the Tucannon River were higher than acclimated fish released from Curl Lake (Fig. 8). The study will be repeated because of some questions about whether fish size was a factor in the results, however WDFW is acting in the Tucannon to move releases downstream away from recently ESA listed populations of chinook salmon, with reasonable assurance of continued program success without acclimation.

Fig. 8 SAR for Releases into the Tucannon R.



The adaptability of the program through the efforts of production and evaluation staff have effectively refined the ability to achieve the successful results previously mentioned. Although the hatchery was designed with a criteria for releasing steelhead smolts at 8 fish/lb., fish culture knowledge at the time indicated that larger smolts should be produced to provide optimum survival. Size at release studies we completed showed a direct relationship between larger smolts (smaller numeric fish/lb) and higher survival (Fig. 9). These results were used to establish a new size at release criteria for LFH of 5 fish/lb. instead of 8 fish/lb. More recent information indicates that 4 fish/lb. may be still better in returning adult steelhead. Adaptive management will continue to be key to the program's success as new challenges are identified.

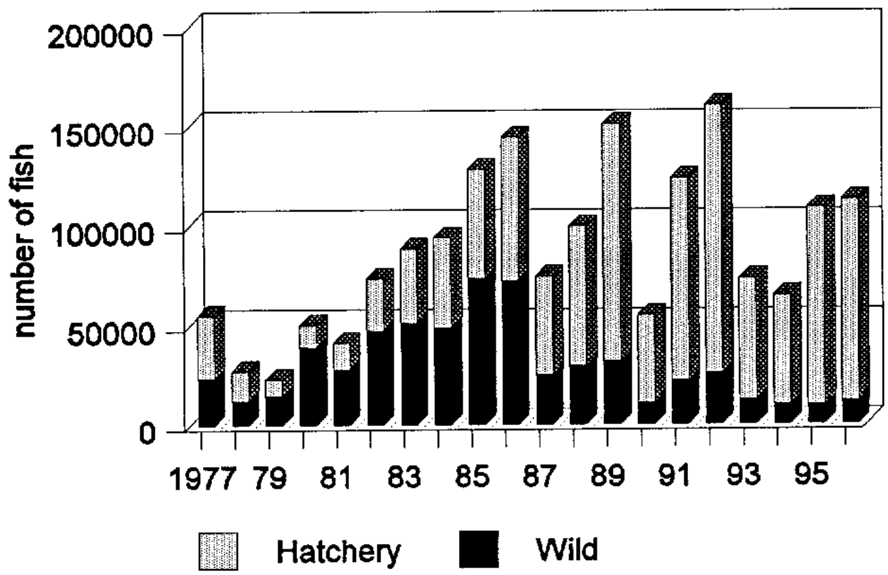
Fig. 9 Smolt Size vs Adult Return



Facility problems and limitations are inherent with any hatchery. A water line failure and excessive bird predation in 1992 caused nearly 40% losses in steelhead production (Fig. 3). Cooperation between WDFW and the COE and the FWS addressed these problems to minimize their impact to the program. Finally, system survival continues to plague the program. The root problem within the basin (dam mortality; that which caused the need for the LSRCP compensation program) remains a major factor in program success on a yearly basis. Although the COE has diligently attempted to reduce mortality at the dams for both juvenile out-migrants and adult migrants, the system's effectiveness at passing fish is highly variable.

Despite WDFW's adaptability to numerous problems and the resulting highly successful program, a significant objective of the program remains unmet. Natural populations that existed after the LSRCP program was negotiated, reached perilously low levels again in the 1990s. Chinook salmon were listed as threatened under ESA in 1992, coho disappeared from the basin and sockeye were listed as endangered. Finally steelhead were proposed for listing in 1997. After a resurgence in wild steelhead numbers in the Snake in the mid 1980s, escapement dropped steadily through 1996, even though overall steelhead runs (counted at Ice Harbor Dam) were high because of returning hatchery fish (Fig. 10). The apparent success of the LSRCP program in Washington to return adult steelhead, seemingly had little beneficial effect on wild escapement. Program goals and actions would have to be revisited in the light of ESA listing and WDFW's desire to preserve and rebuild depressed Snake River steelhead populations.

Fig. 10 Snake River Steelhead Escapement



The LSRCP program must now grapple with management priorities different from those established for the original mitigation program. In priority order, management of the Snake River would now be driven to:

1. Recover Threatened and Endangered Species (ESA)
2. Implement Washington's Wild Salmonid Policy (WSP) to prevent further ESA listings.
3. Mitigate (return adults and maintain fisheries)

Following new management direction will of necessity require changes in the existing WDFW trout production program. The establishment of refuge areas of rivers or entire drainages for wild /natural production would prevent out-planting of hatchery fish. Partnering with Federal and Tribal management agencies to promote recovery under ESA will likely change the size and nature of production, and cause management agencies to review whether mitigation and recovery can be conducted concurrently with the hatchery tool. The development of locally adapted broodstocks will require the redirection of resources, and careful decision making to ensure supplementation efforts are not detrimental to depressed populations. Washington's Wild Salmonid Policy (WSP) was drafted to promote stable salmonid populations throughout the state and prevent further listings under ESA; restrictions imposed by WSP on unlisted populations will require changes to existing programs that may be over and above ESA restrictions on listed populations. All of these actions will probably dictate some reduction in traditional LSRCP hatchery mitigation production.

These actions will require an expanded emphasis on WDFW's last interim goal for the LSRCP program; Coordination with other Basin Managers. Factors critical to the future success of our program include:

1. Establishment of joint goals with all managers - ever scarce natural and economic resources will demand careful prioritization of goals to ensure that those most critical to recovery and mitigation success are accomplished.

2. More Stock Characterization - development of local broodstocks or identification of critical sub-populations that must be protected will depend on a coordinated genetic sampling strategy to guide those efforts.

3. Identify Causes For Decline - despite 14 years of LSRCP mitigation, wild stocks of all salmonids in the Snake Basin remain in decline. Identifying limiting factors and directing efforts to correct them is paramount if species are to be saved.

4. Correct Limiting Factors - studies currently indicate that natural anadromous populations within the Snake River Basin are not replacing themselves. This is a prescription for extinction and must be corrected to above the replacement line or even hatchery programs may falter in the future.

5. Have Flexible Hatchery Programs - LSRCP programs have been, and can continue to be, adaptable to changing demands for both recovery and mitigation if properly funded.

Washington's trout program has generally been successful in its compensation role. We can make that statement with surety because goals of the program were clearly defined in the original authorizing document and provided a benchmark by which to measure success or failure. We now face a new set of challenges where the simple goal originally provided can no long suffice.

We must redefine success for the LSRCP program and for anadromous salmonids in the Snake River basin. We believe that success must include both recovery of depressed wild stocks, and opportunity for Washington's residents to partake of that resource which was lost to them as a result of the four lower Snake Power Dams. The steelhead fishery currently provided by LSRCP has a significant social and economic impact in the area, and forsaking opportunity solely for recovery will likely cause serious erosion of public support for recovery. Hatchery production has not been the answer to the problem; wild fish continue to decline. Correction of survival problems within the basin must occur or extinction is likely for all naturally reproducing anadromous populations. Without a clear definition of success for the new millennium, it is unlikely we will be capable of documenting our progress, good or bad, ten years from now. We will have planned for failure.

Summer Steelhead Program, Clearwater Fish Hatchery, Clearwater River Basin, Idaho

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Clearwater Fish Hatchery (FH) is located at the confluence of the North Fork Clearwater River and the Clearwater River in north-central Idaho (Figure 1). It was completed in 1991 and was the last of 12 hatcheries to be completed under the Corp's LSRCP construction program. Three satellite facilities are associated with the hatchery: Crooked River; Red River; and Powell. Juvenile steelhead are released at the Crooked River and Red River satellites, at Kooskia National Fish Hatchery (NFH), and into the South Fork Clearwater River.

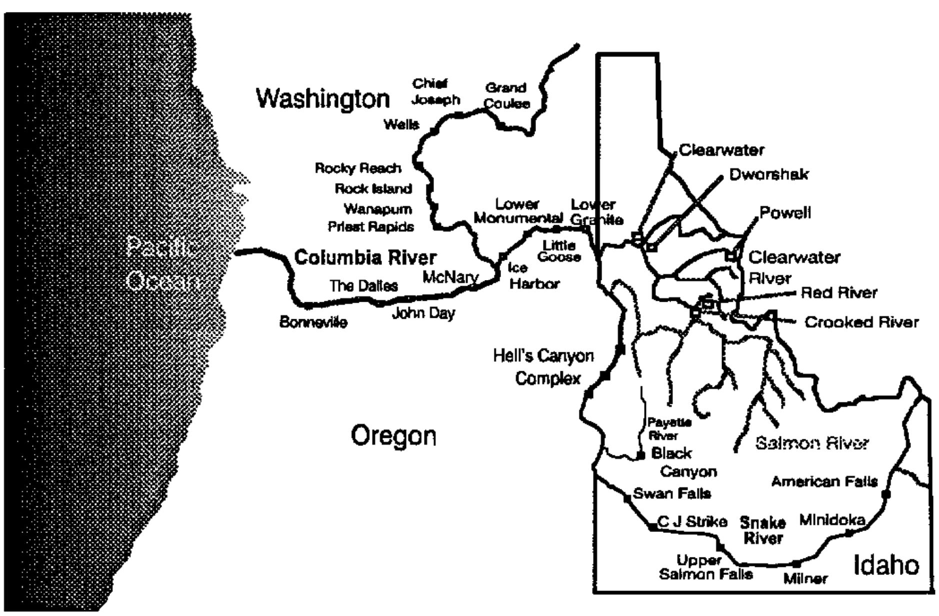

Figure 1. Location of Clearwater Fish Hatchery and the three satellite facilities associated with it: Crooked River; Red River; and Powell.

Clearwater FH was constructed to rear 350,000 pounds of steelhead smolts annually. The modeled adult return goal for Clearwater FH is to return 14,000 adults above Lower Granite Dam. Smolt-to-adult return rates (SAR) were estimated to be 0.8% and 0.5% for smolts released at 5 and 8 fish per pound, respectively. The number of smolts to release (production goal) was calculated by dividing the adult return goal (14,000) by the estimated SAR (Figure 2).

Clearwater Fish Hatchery
Modeled Projections

	5 fish per Pound	8 fish per Pound
Production Goal:	1,750,000	2,800,000
Return Rate	0.80 %	0.50 %
Adult Return Goal	14,000	14,000

Figure 2. Modeled number of steelhead smolts to release in order to return 14,000 adults. Return rates were estimated to be 0.8% and 0.5%, depending on smolt size at release.

Dworshak B-strain steelhead were used as the brood stock for Clearwater Fish Hatchery. This stock was indigenous to the North Fork Clearwater River. In the late 1960's the US Army Corps of Engineers constructed Dworshak Dam on the North Fork which totally blocked access to anadromous fish. To mitigate for the steelhead losses resulting from the dam, Dworshak NFH was constructed in the late 1960's. Wild B-strain steelhead were collected at the base of the dam and used as the brood stock for Dworshak NFH.

Since 1992, steelhead eggs collected at Dworshak NFH have been shipped as eyed eggs to Clearwater FH for incubation and rearing. The percentage of eyed egg being released as smolts averaged about 80% (Figure 3). Smolts are reared for 11 months before being released. Some steelhead smolts are tagged with passive integrated transponder (PIT) tags prior to release to evaluate emigration success. PIT tag interrogation rates provide a relative measure of minimum survival to downriver dams. In addition, some fish are tagged with

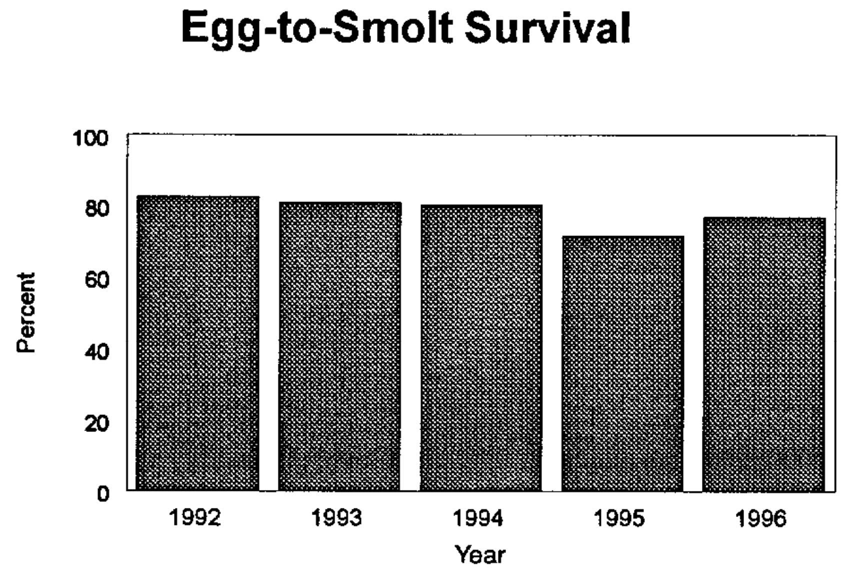

Figure 3. Percentage of eyed eggs that survived to be released as smolts from Clearwater Fish Hatchery.

coded wire tags (CWT) prior to release to evaluate adult returns. Release locations include the South Fork Clearwater River, Kooskia NFH, and Crooked River and Red River satellites. No smolts are released directly from Clearwater FH. Smolt size averages about 7 fish per pound at time of release.

The first steelhead smolts were released from Clearwater FH in 1993. Except for the first year, brood year 1992, Clearwater FH released about 700,000 smolts annually - not the modeled 2.8 million (Figure 4). The Idaho Department of Fish and Game (IDFG) reduced the number of steelhead produced at Clearwater FH in order to increase the size of the chinook program (also a LSRCP program) and because of the 1994 NMFS hatchery production cap for the Snake River basin. Under the production cap, IDFG released fewer steelhead smolts into the Clearwater River basin in-order to release a greater number of smolts in other areas of the state.

Interrogation rates for PIT tagged Dworshak stock smolts to downstream dams were around 70% (Figure 5). Interrogation rates for Selway stock smolts were quite a bit lower ≈ 35%. The Selway program was an experimental program started in 1993 using eggs from wild Selway stock steelhead. The program was later turned-over to the National Biological Survey (NBS) and has since been discontinued due to the low number of Selway stock steelhead.

The modeled adult return goal for Clearwater FH is 14,000 adults. As stated previously, this goal is based on releasing 2.8 million smolts with a SAR of 0.5% (Figure 2). Since

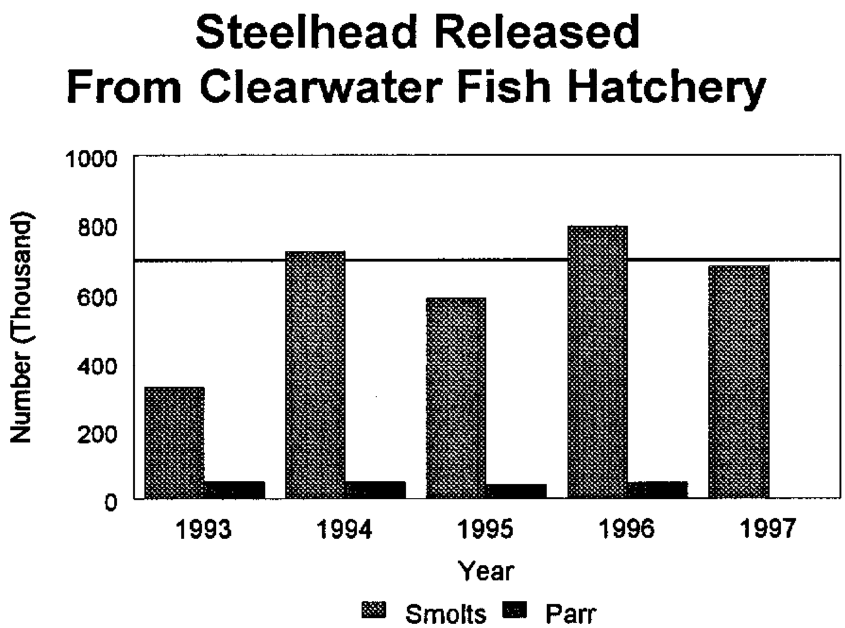

Figure 4. Number of steelhead released from Clearwater Fish Hatchery. Clearwater received the first steelhead eggs from Dworshak National Fish Hatchery in 1992.

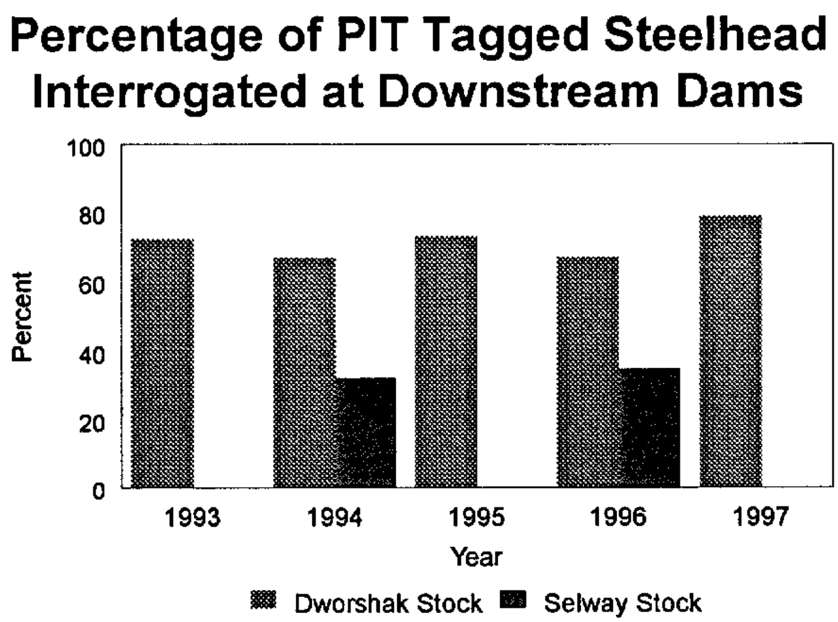

Figure 5. Percentage of PIT tagged steelhead smolts released from Clearwater Fish Hatchery that were interrogated at downstream dams on the Snake and Columbia rivers.

Clearwater FH released 700,000 smolts annually instead of the projected 2.8 million, the proportional adult return goal is 3,500 adults (Figure 6). Adult return data are only complete for one brood year, brood year 1992, and the SAR for that year is well below the modeled 0.5% (Figure 7). However, there are several reasons which may explain the low SAR.

First of all, the 1993 smolt release (brood year 1992) was an off-site release. That is, smolts were not released at a weir which would be used collect returning adults. Therefore, the number of adults returning to the project area (above Lower Granite Dam) had to be estimated from the sport fishery harvest of coded wire tagged fish. But in the fall of 1995, when the 2-ocean component for this brood year returned, the sport fishing season was closed to harvest due to an expected low return. Thus, no adult steelhead tagged with CWT were collected in the fall of 1995. Then during the spring of 1996, the Clearwater River basin experienced a major flood event which essentially washed out the 1996 sport fishing season. Therefore, CWT data for the 2-ocean component of brood year 1992 are missing. Since Dworshak B-strain steelhead primarily return as 2-ocean fish, the smolt to adult return rates for brood years 1992 are undoubtably underestimated (Figure 7). In later years, smolts tagged with CWT were released at Kooskia NFH to facilitate adult evaluations.

Another possible reason for the low SAR for the 1992 brood could be that smolts were exposed to supersaturated water while being shipped to off-site release sites. The water supply line used to fill the transport trucks was not equipped with a degassing station and the smolts were transported in water that was supersaturated with dissolved nitrogen. This problem was not discovered until affected smolts, which showed signs of gas bubble disease, were captured at downstream locations.

Adult return data for the 1993 and 1994 broods are incomplete at this time (Figure 7). Continued evaluation will determine if Clearwater FH can achieve its adult return goals.

So what is the take home message about Clearwater FH? How is the program working? Clearwater FH is a very new program and we don't have a lot of information about adult returns. However, if you look at some other measures of success, Clearwater FH is doing a respectable job. Eyed egg to smolt survival averages 80%. Smolts are healthy when released from Clearwater FH; disease epizootics are rare. Emigration rates of PIT tagged smolts to downstream dams average about 70%. Finally, adult steelhead are returning to the project area.

The future direction for Clearwater FH steelhead program is to stay the course. It is a new program and data are not available to warrant changes.

Clearwater Fish Hatchery

ACTUAL
PRODUCTION

	5 fish per Pound	8 fish per Pound
Production Goal:	**700,000**	**700,000**
Return Rate	**0.8 %**	**0.5 %**
Adult Return Goal	**5,600**	**3,500**

Figure 6. Modeled smolt to adult return rate applied to the actual number of steelhead smolts being released from Clearwater Fish Hatchery. The original model called for the release of 2.8 million smolts.

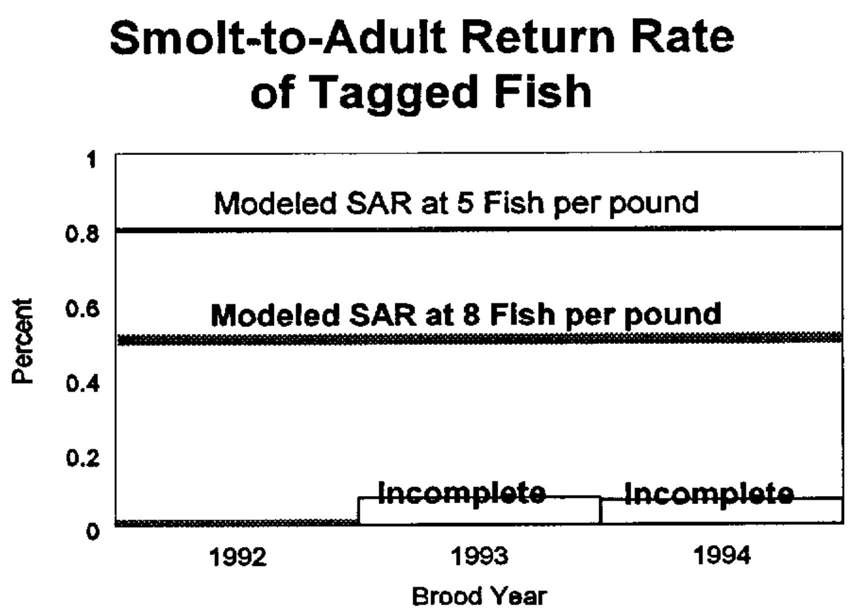

Figure 7. Smolt to adult return rate for coded wire tagged steelhead released from Clearwater Fish Hatchery.

upper basin provide additional spawning and rearing habitat; annual spawner escapement to these areas is not included in the index area redd counts. During the period 1979 to 1983 an average of only 93 redds was counted annually in spawner index areas, and by the period 1993 to 1997 an average of only 33 redds was counted each year. In addition to supporting natural spawning, adult escapements through the mid- to late 1970s supported substantial harvest opportunities. From 1970 through 1978 sport harvest in the Salmon River ranged from 400 to 2,260 chinook salmon annually. Not all of the fish harvested were destined for the upper Salmon River basin, as numerous stream miles down stream of the town of Stanley were open to fishing. No chinook salmon sport fisheries have occurred on the Salmon River or its tributaries (excluding the Little Salmon and South Fork Salmon rivers) since 1978.

Historical Facts

1958-62 481 redds /year

1979-83 93 redds /year

1993-97 33 redds /year

1970-78 400 to 2,260 annual sport harvest

Headwater Tributaries Spawning/Rearing

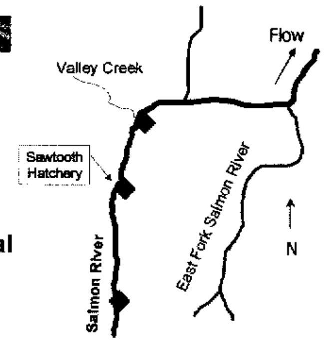

Figure 2.

Brood stock development associated with Sawtooth Hatchery was initiated in 1980 with the release of 168,000 smolts near the current hatchery site, and in 1981 230,550 smolts were released (Fig. 3). Both of these releases were from upper Salmon River stock. These fish were reared at McCall Fish Hatchery (Sawtooth Fish Hatchery was not completed until 1985) before being released into the upper Salmon River. During the late 1970s Rapid River stock juveniles were released into the East Fork Salmon River and upper Salmon River in response to severe declines in adult escapement (Fig. 4). It is not known what adult escapement to the upper Salmon River or East Fork Salmon River resulted from these releases. Since completion of Sawtooth Fish Hatchery and trapping facilities at the hatchery and on the East Fork Salmon River, only local brood stock has been used for the respective programs.

Brood Stock History

- **1980 - 168,000 smolts**
- **1981 - 230,550 smolts**
- **Upper Salmon River Stock**
- **Reared at McCall Hatchery (1985 = Sawtooth Hatchery Start-up)**

Figure 3.

Brood Stock History

1977 - 100,000 Rapid River fingerlings to East Fork Salmon River

1978 - 985,000 Rapid River smolts to Upper Salmon River

1979 - 1 mill. Rapid River smolts to Upper Salmon River

Figure 4.

Green egg to smolt survival rates for salmon reared at Sawtooth Fish Hatchery are shown in Figures 5 and 6. The 70% survival target shown is not a hatchery management goal, but rather is the value used in the original production model to identify facility needs. It is included here

Summer Steelhead In The Salmon River Basin, Idaho

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The Salmon River drainage has 14,100 square miles of habitat and 385 miles of fishing water (Figure 1). The mouth is 512 miles from the mouth of the Columbia River. Steelhead travel over 900 miles from the ocean to the headwaters. The Salmon River has two major tributaries, the South and Middle forks, which used to support steelhead harvest. But, during the past 20 years, harvest has been restricted to the mainstem only. The South Fork and the Middle Fork are managed for wild endemic populations.

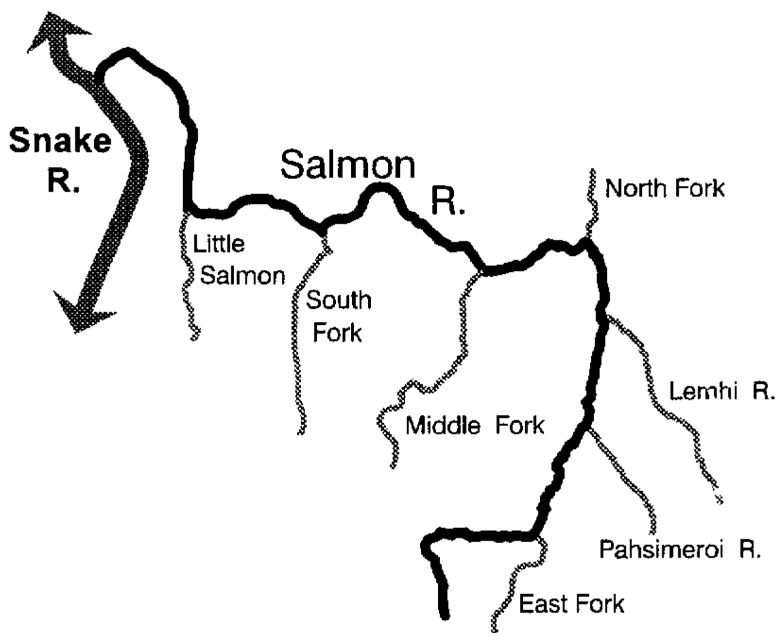

Figure 1. Salmon River and major tributaries: Little Salmon River, South Fork Salmon River, Middle Fork Salmon River, North Fork Salmon River, Lemhi River, Pahsimeroi River, and East Fork Salmon River.

The original production target in the LSRCP for the Salmon River was for 25,260 adults, which is 46% of the total production goal (Figure 2). Two hatcheries, Magic Valley Steelhead Hatchery and Hagerman National Fish Hatchery rear the fish for the Salmon River program. The original target was based on smolts reared to 8/pound, which has since been amended. Eggs are taken at adult collection facilities at Sawtooth Hatchery and the East Fork Satellite and then shipped to the production facilities (Figure 3).

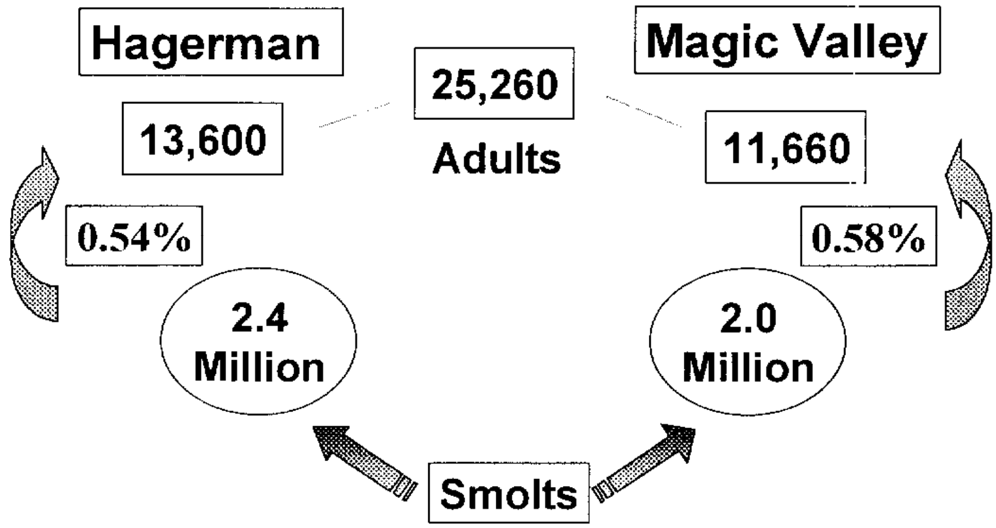

Figure 2. Original production targets in the Lower Snake River Compensation Plan for the Salmon River.

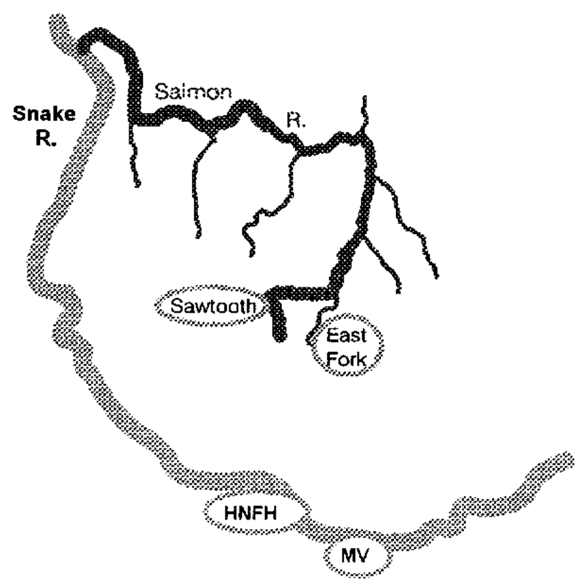

Figure 3. Lower Snake River Compensation Plan facilities.

The state of Idaho's objectives for steelhead management include maintaining existing naturally produced populations; maximizing harvest and fishing opportunities of hatchery produced steelhead; and achieving hatchery escapement goals. Idaho's objectives don't include numbers of lost fishing days due to dam construction.

Idaho's hatchery steelhead program began in 1965 after the Federal Power Commission ordered Idaho Power Company to transplant Snake River steelhead to the Salmon River for mitigation due to dam construction on the Snake River (Figure 4). The Snake River stock has been the basis for all hatchery A-strain programs in the Salmon River and is being reared at both of the LSRCP facilities. These A-strain fish make up 70% of the production.

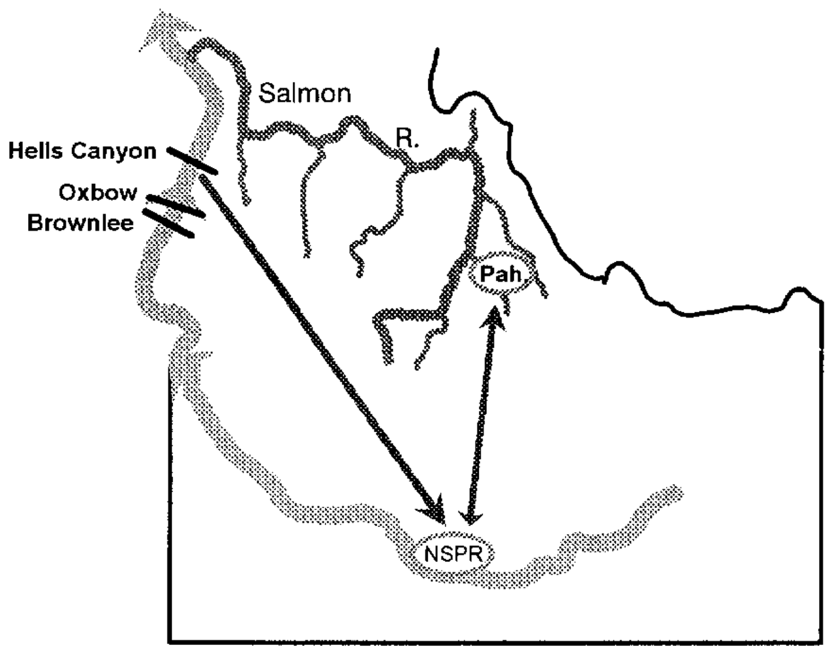

Figure 4. Idaho Power Commission mitigation.

B-strain fish are also being reared in the LSRCP facilities (Figure 5). Transplantation of B-strain fish from Dworshak National Fish Hatchery on the North Fork of the Clearwater River to the Salmon River drainage began in 1973, when the fish being raised at Niagara Springs hatchery were found to have Infectious Pancreatic Necrosis. The entire production was destroyed and replaced with B-strain fish from Dworshak. The target of B-strain fish for the East Fork Salmon River was one million smolts. B-strain fish make up 30% of the Salmon River program and all are now being raised at Magic Valley Steelhead Hatchery.

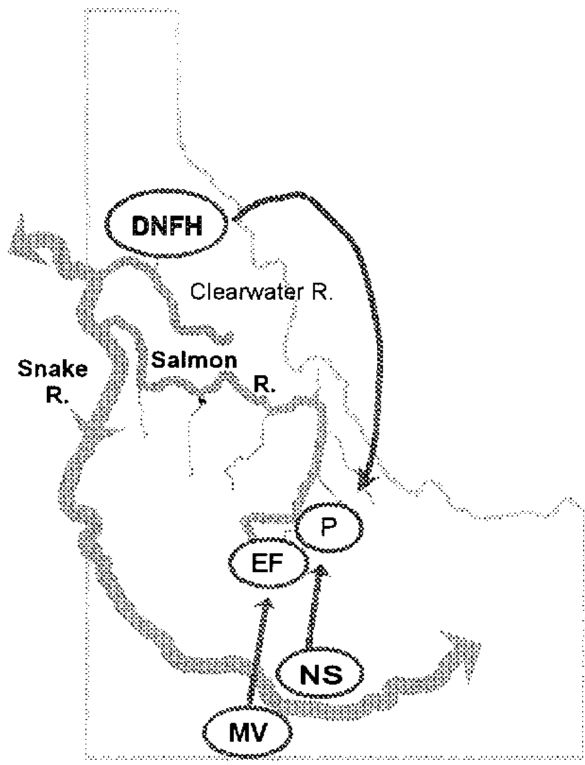

Figure 5. Origin of B-strain steelhead.

The production target for Hagerman National Fish Hatchery is 2,400,000 smolts. Water supply limitations have been a factor in their production (Figure 6). Magic Valley has a production target of 2,000,000 smolts (Figure 7). Both hatcheries have been doing a good job of raising healthy smolts and getting them to the river on time.

There are several ways to look at goal achievement. Over the long run, five-year averages should be used to account for aberrant years. The technique we use in Idaho is to sum the estimated non-tribal harvest and returns to hatchery racks (Figure 8). Note that these numbers do not include instate tribal harvest, river spawning and straying to tributaries. Hence they should be looked at as minimum numbers. Also, during most of these return years, the region was affected by drought. Drought has the greatest adverse impacts on headwater releases. When the LSRCP plan was conceived, few anglers released any of their catch. Today, there are large numbers of fish released (Figure 9). Is angler satisfaction of released fish the same as a fish harvested? In either case, some improvement in downstream survival appears to be necessary to reach the contribution targets.

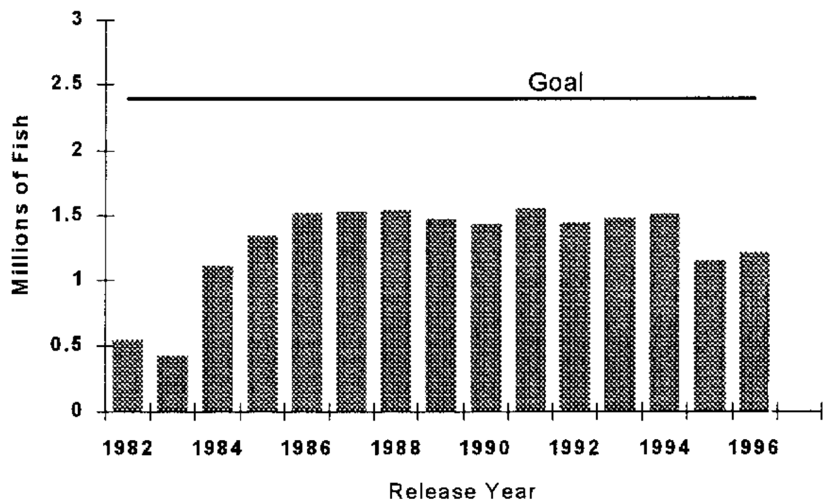

Figure 6. Smolt Production at Hagerman National Fish Hatchery.

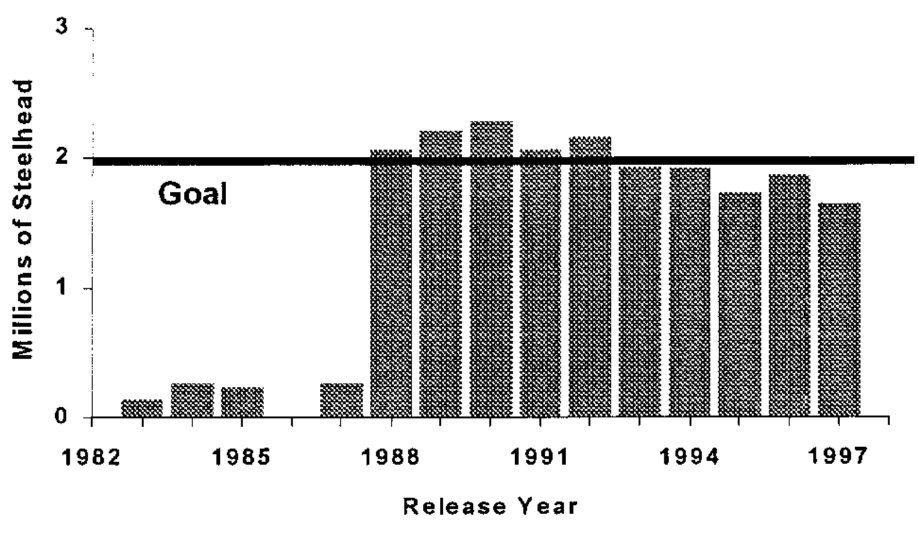

Figure 7. Smolt Production at Magic Valley Fish Hatchery.

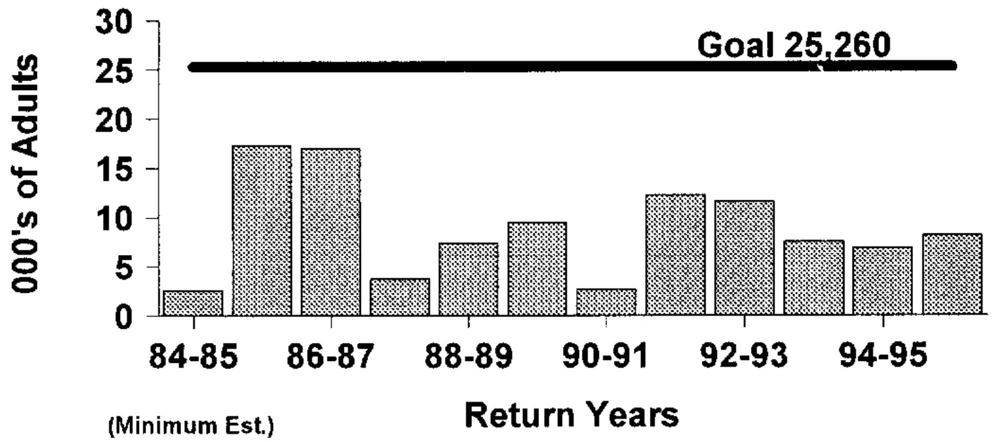

Figure 8. Estimated total of harvest and rack returns of steelhead to the Salmon River.

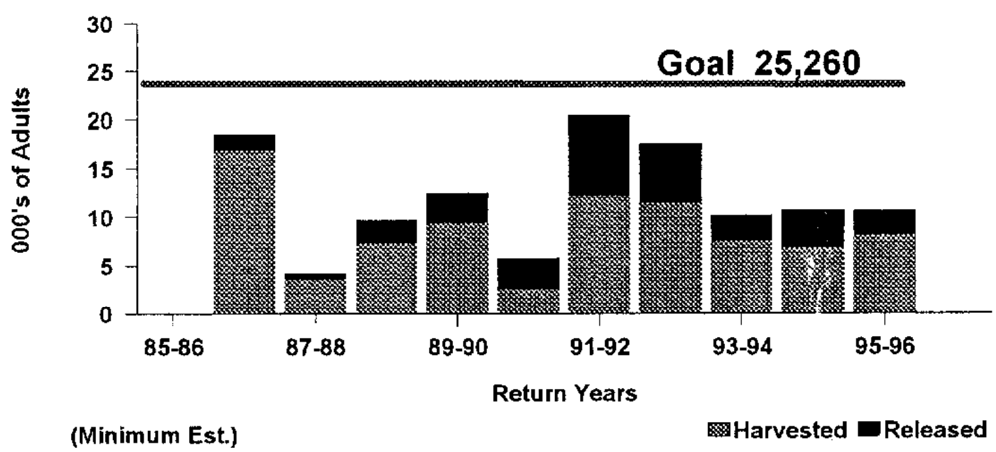

Figure 9. Estimated total steelhead returns, including releases.

Smolt to adult return rates (SAR's) are another way of measuring success. I prefer to describe them as release to adult return rates because they are a reflection of the number of adults returning from the number of fish produced. Because non-migrants are included in the release numbers, the number of true smolts is something less than the number of fish produced. Hagerman and Magic Valley SAR's are illustrated in Figures10 and 11, respectively.

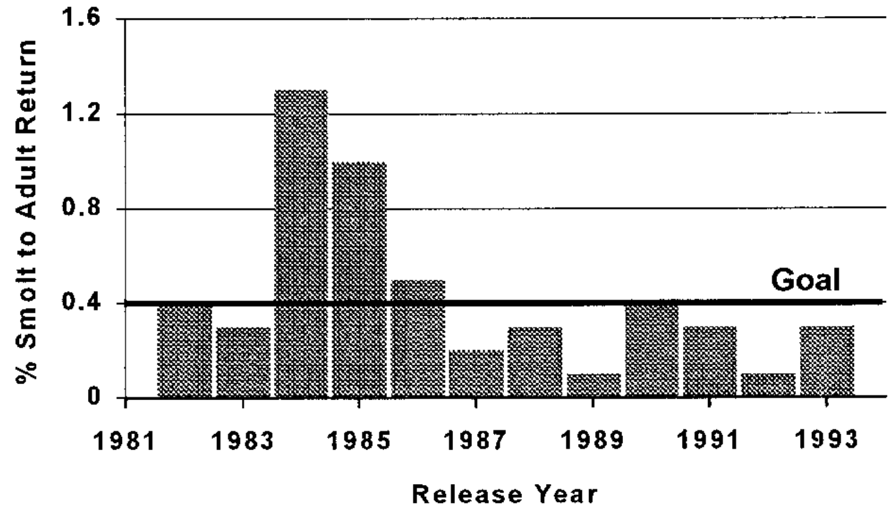

Figure 10. Smolt to adult ratios at Hagerman National Fish Hatchery.

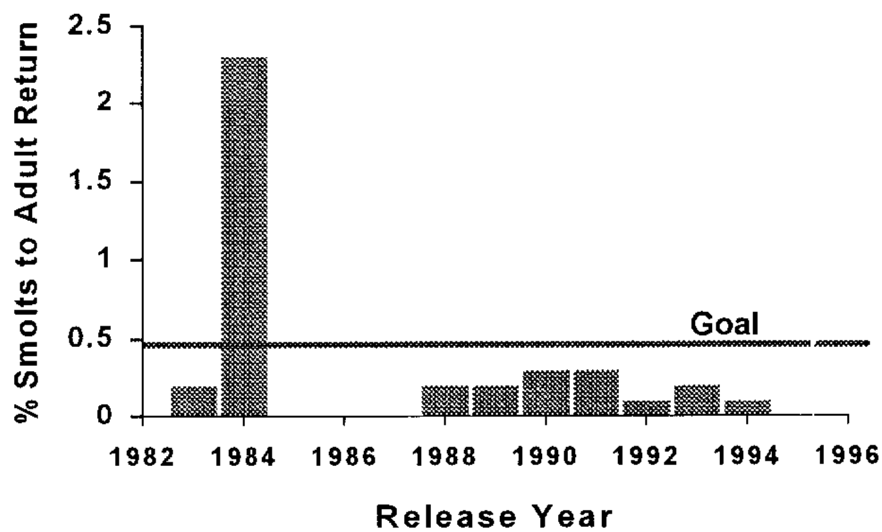

Figure 11. Smolt to adult ratios at Magic Valley Steelhead Hatchery.

Releasing steelhead in the headwaters of the Salmon River has achieved very high exploitation rates and has successfully spread the fishery out in space and in time (Figure 12). However, asking the fish to return higher in the basin has resulted in a portion of the fish spawning in-river and also some straying to tributaries. Idaho's plan for exploitation of steelhead was originally set at 80%. Subsequently, it was amended to 60-80%. We calculate exploitation as a function of the estimated harvest and the hatchery return. Adults returning to Sawtooth and the East Fork have consistently been exploited at 80%. We have not been able to quantify the exploitation of offsite or Little Salmon River releases, but we estimate them to be 50-65%.

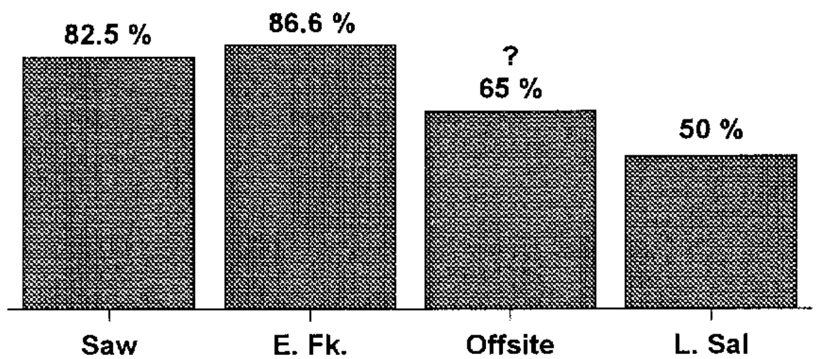

Figure 12. Exploitation rates of steelhead released in the headwaters of the Salmon River, 1984-95.

Straying of LSRCP fish between hatchery racks has been documented since the inception of the program and found to be quite low. Recently, we have been electrofishing tributaries and have found strays in all of the major tributaries to the upper Salmon River. One fish released at Sawtooth Hatchery was spawning in Indian Creek. 150 miles downstream (Figure 13).

The draft recovery plan for Chinook salmon identified strategies to reduce impacts of hatchery-reared steelhead. Squaw Creek Pond was recently constructed to investigate the benefits of acclimation. A portion of the B-strain smolts from Magic Valley will be released there beginning in 1998. Also, smolts from Hagerman Hatchery are being acclimated at Sawtooth Hatchery prior to release. Offsite releases is a technique that has been used for several years to spread the fishery in space and time as well as to increase harvest of hatchery fish (Figure 15). When limits were placed on the numbers of steelhead smolts that could be released in chinook salmon production areas, the numbers of fish released offsite was increased. In addition, a target smolt size of 4.5/pound was proposed to minimize residualism. The size of smolts raised at Magic Valley is illustrated in Figure 15. Smolt size at release from Hagerman Hatchery is not illustrated but is very similar. Both hatcheries have 57-58 degree water temperatures and have the

Upper Salmon River Spring Chinook Salmon

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Upper Salmon River spring chinook salmon are a very unique population of salmon. These fish represent the furthest migrating chinook salmon in the lower 48 states, with their spawning/nursery grounds located more than 900 river miles from the ocean. Also, spawning and nursery habitat for these fish is located at over 6,000 feet above mean sea level. The LSRCP program for spring chinook salmon in the upper Salmon River basin consists of the Sawtooth Fish Hatchery and its East Fork Salmon River satellite facility (Fig. 1). The hatchery, located near the town of Stanley, Idaho, was completed and the facilities became operational in 1985. The East Fork Salmon River satellite facility serves only adult trapping and spawning functions for chinook salmon, all rearing is performed at Sawtooth Fish Hatchery. The hatchery program provides in-kind mitigation for spring chinook salmon losses associated with the construction of the four lower Snake River hydroelectric projects.

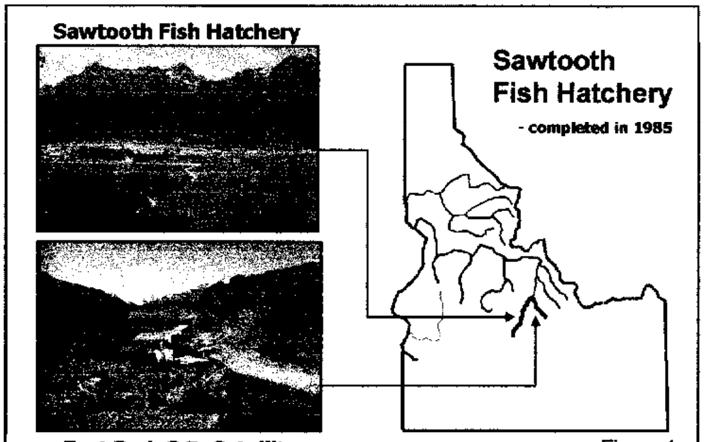

Figure 1.

Sawtooth Fish Hatchery consists of typical incubation and rearing facilities. Incubation and early rearing is performed indoors utilizing pumped well water. Final rearing, to fish release, is done in outside raceways utilizing raw river water. The outside raceways measure 12 feet wide by 200 feet long.

Production models used to identify facility needs included an assumed smolt-to-adult (SAR) survival rate of 0.87%, which was applied to the annual adult return goal of 19,445 adults to determine needed juvenile rearing capacity. The adult return goal is specified as fish returning to the LSRCP project area, above Lower Granite Dam. Annual salmon smolt production capacity at Sawtooth Fish Hatchery is 2.98 million smolts at 20 fish per pound or 2.3 million smolts at 15 fish per pound. Initial facilities-operation planning identified 1.3 million smolts to be released at Sawtooth Fish Hatchery (11,310 adult return at 0.87% SAR), and 700,000 smolts released into the East Fork Salmon River (6,090 adult return). The remaining 300,000 smolts, for a total annual release of 2.3 million, were to be released in Valley Creek in the upper Salmon River basin and the Yankee Fork Salmon River.

Natural production of chinook salmon in the upper Salmon River basin has declined substantially over the past three decades. From 1958 to 1962 an average of 481 redds was counted annually in spawner index areas upstream of Valley Creek (Fig. 2) (Valley Creek enters the main Salmon River at the town of Stanley). Tributaries to the Salmon River in the have the potential for rearing very large smolts. Chilling eggs is a technique being employed to reduce fish size.

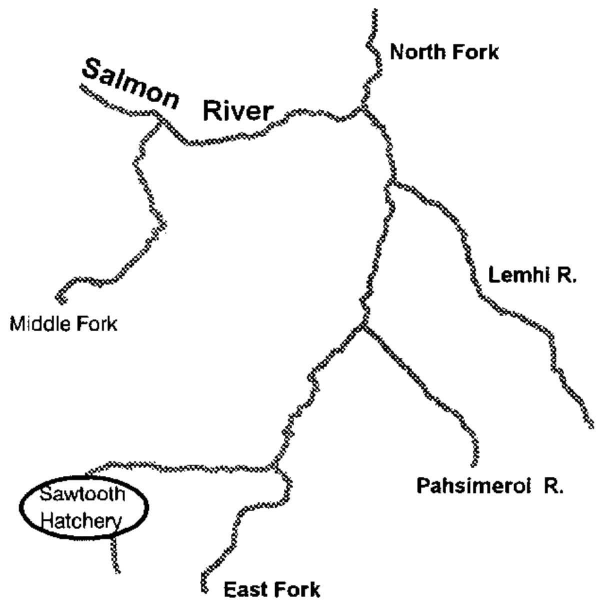

Figure 13. Major tributaries of upper Salmon River where strays have been found.

Data from Passive Integrated Transponders (PIT tags) have helped illustrate the tradeoffs of siting the program in the headwaters. Sawtooth releases have slower travel times and lower PIT tag detection rates than releases in the Little Salmon River.

The success of the LSRCP program in the Salmon River has been hurt by drought conditions, but out-migration survival conditions need to be improved in order for compensation goals to be met. Overall, the program has been successful in producing harvest without adversely impacting endemic stocks in the Middle and South Forks.

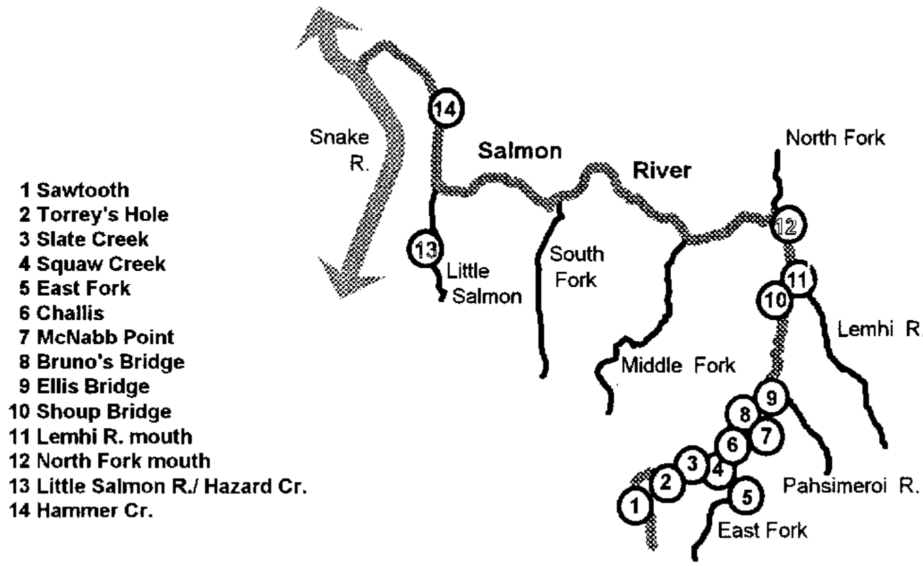

Figure 14. Offsite release locations for steelhead on the Salmon River.

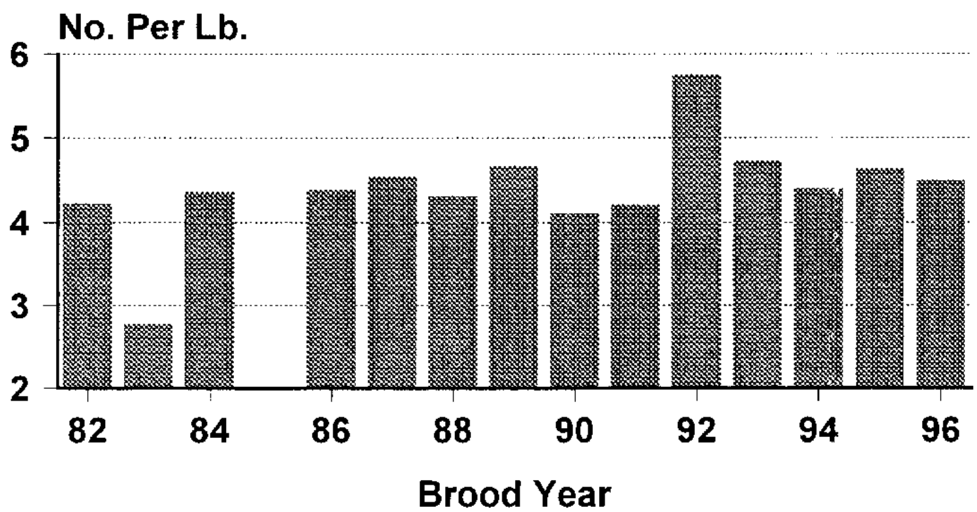

Figure 15. Size of smolts at release from Magic Valley Steelhead Hatchery.

Questions and Comments

Sanchotena questioned Ball's statement that Salmon River indigenous stocks were A-run steelhead; I think if you look at the length-frequency data on those stocks, it's pretty clear that that stock is made up primarily of B-run fish, he said. Also, Sanchotena said, run timing is both A-run and B-run. That's correct – it is both As and Bs, Ball replied. There has been a significant change in the distribution of harvest since the inception of the Lower Snake Compensation Plan, he said; if you go back to the 1960s, 60% of the harvest in Idaho occurred in the Middle Fork and the South Fork of the Salmon River. In those days, we had both A-run and B-run steelhead, and we still do.

Paul Moran of NMFS referenced another remark from Ball's presentation, to the effect that the Salmon River steelhead program had increased the number of catchable fish without impacting endemic populations -- perhaps I missed the line of reasoning you used to support that statement, Moran said. We release all of our fish either far up into the headwaters of the system, or downstream in the Little Salmon River, Ball replied -- so far as we know, we have never found any hatchery fish in either the Middle Fork or the South Fork.

Summary of Steelhead Session

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In summary what we have heard today is that, with the exception of the Imnaha steelhead program, the management objectives of the steelhead programs active today across the Snake River basin are very consistent. Those objectives are to restore and sustain recreational fisheries, with little or no emphasis on natural production enhancement. Broodstocks were developed from non-local populations, with the exception of the Clearwater and Imnaha broodstocks; this broodstock development strategy allowed for the rapid development of adequate broodstock numbers, and the ability to reach full smolt production goals in almost all of these programs very quickly, Carmichael said.

The steelhead culture programs are all very similar in nature, he continued -- the fish are reared in well or spring water; water temperatures are constant; fish growth is geared to the production of five smolts per pound, and they're all yearling smolts, in contrast to naturally-produced smolts, which rear in nature for anywhere from one year to four years.

With the exception of the Lyons Ferry hatchery program, survival rates and corresponding adult returns have not achieved mitigation goals in most programs in most years. The reasons for the relative success of the Lyons Ferry program are not well understood at this point; the Lyons Ferry smolts are released two dams lower in the system, and Lyons Ferry rearing occurs in large lakes, rather than the raceways used at the other steelhead facilities. The Lyons Ferry smolts are also more natural-looking than the smolts from many of the other steelhead facilities.

Although many of the LSRCP steelhead programs have not achieved adult mitigation return or survival goals, they have demonstrated a high degree of success in restoring and maintaining recreational steelhead fisheries in Idaho, Washington, and Oregon. These fisheries are extremely important, because they help support local economies, they enjoy tremendous public support, and they sell fishing licenses, which generates revenue for state management agencies. In many cases the steelhead fisheries are the only local community benefit in the form of recreational opportunity that is derived from the LSRCP.

Although it would be nice if we could continue to operate the steelhead programs according to the status quo and stay the course as a previous speaker suggested, that it is probably not a reasonable expectation, given our experience over the last three or four years with chinook salmon under the Endangered Species Act. For many reasons, I believe these programs may have to be significantly modified in the future: 1) natural steelhead populations are severely depressed in the basins where hatchery programs are operating, 2) naturally-spawning Snake River steelhead populations have been listed under the Endangered Species Act, 3) our emphasis will have to shift from enhancing recreational fishing opportunities to the recovery of natural populations, 4) there are a number of genetic risks associated with continued large-scale hatchery supplementation in this basin -- these facilities are currently introducing about 8 million steelhead smolts to the system annually, and there is risk associated with the genetic effects of non-endemic hatchery fish spawning with wild steelhead stocks, 5) there is significant potential for competitive interaction between the hatchery and wild stocks, and 6) there may be impacts of our recreational fishery on naturally-produced fish.

With that in mind, we have some major decisions to make regarding the future of the steelhead programs in the Lower Snake River Compensation Plan. The challenge will be to bring the impacts of these programs down to acceptable levels.

There are a number of adaptive management options available to us -- we can reduce production, we can change release strategies to emphasize acclimation and adult recapture, rather than large-scale direct stream releases. We can also emphasize local broodstock sources, and use the hatcheries to assist in the recovery of the natural populations. There is no single recipe for change; we will have to examine each program, assess the risks and make the necessary modifications, he said. In some cases, the recreational fishery may suffer in the near term, hopefully not permanently.

Audience Questions on Steelhead Session

Rich Lincoln of the stakeholders' panel referenced Mark Schuck's point that refuges may offer a way to assist in the recovery of Idaho steelhead stocks. I was wondering whether the panel presenters might have some comments about the usefulness of refuges in cases where the stocks are not able to sustain themselves, Lincoln said.

I raised the issue of refuges because that was one option that has been discussed over the years, Schuck said. In my youth, he said, I was always told that, if we have nothing by which to measure what we're doing, then we won't be able to determine whether or not we've accomplished anything at all. Despite the risks that are associated with designating a refuge area, the opportunity to observe what happens within that refuge area, separate from the other actions we are taking to recover Idaho steelhead stocks, may be the only way for us to measure the success of this component of the LSRCP. The risk, of course, is that, if we designate a refuge, we may be dooming that population to extinction. If anyone has any alternative suggestions to make, said Schuck, I would like to hear them.

Technically, I guess you could say that the Middle Fork of the Salmon River is a refuge, added Kent Ball of IDFG. We did some surveys in the mid-1970s, and there were thousands of fish in there at that time. There have been no adverse effects on the habitat since then; despite that fact, only a handful of returning adults remain -- perhaps 200 fish per year.

In response to a question from Herrig, Ball said IDFG's position it is that there are no wild steelhead stocks above North Fork -- the upper Salmon River stock has been considered a hatchery-augmented population for some time now. We have done some recent collections in that system for genetic evaluation, but my opinion is that the wild stocks in the headwaters of the Salmon River are gone, Ball said.

Mitch Sanchotena touched on Carmichael's point that the Lower Snake Compensation Plan has been successful in restoring the Idaho steelhead fishery. I would like to remind all of you, as fisheries managers, that that statement is a big part of the reason why many members of the general public view you as a major part of the problem, Sanchotena said. The Lower Snake Compensation Plan has not restored fisheries -- the wild stocks -- 52% of the total run -- are basically gone. I guess my question for Kent is, would there be naturally-producing fish in the Upper Salmon today if there have not been an Upper Salmon hatchery program? Not in my opinion, Ball replied.

Don Campton asked whether ODFW had been able to produce one-year-old smolts in the Grande Ronde and Imnaha steelhead programs. Pretty much everything is on a one-year schedule now, Tim Whitesel replied. What was done to those fish to get them to smolt after one year, rather than two years? Campton asked. Mainly by putting them on a growth regime that will get them to the release size we're looking for after one year, said Whitesel.

With respect to the southeast Washington steelhead program, said Cindy Deacon-Williams, you indicated that, fairly recently, this program has received some new guidance about recovering certain stocks and implementing the wild salmonid policy. What changes, if any, have you initiated in this program in response to that guidance?

We have had to review the entire program, Schuck replied. As far as specific examples, the work we have done on residualism has caused us to take a harder look at what is really happening in the acclimation ponds, physically, chemically and biologically, and whether or not we're really seeing any benefit from the use of acclimation ponds. We have altered our release regimens, and have found that, in at least one case -- the Tucannon River -- that we have been able to reduce residualism. We've also taken a look at what constitutes a true smolt, Schuck said; if you release a population, they're not all smolts, and one of the things we've looked at is how we can release only smolts, and use the portion of that population that has not smolted in some other fashion. If anything, the awareness of the requirements of the ESA and our own wild salmonid policy have made us more introspective about what we do – we've tried to become more adaptive, and to think ahead.

Have you explored any of the questions related to your broodstock source? asked Deacon Williams. At length, Schuck replied. Have you made any changes as a result of those explorations, Deacon Williams asked? We're still arguing about that, Schuck replied -- we had a meeting just a couple of weeks ago involving ODFW, IDFG and WDFW steelhead personnel, to try to chart a course as far as understanding the pitfalls involved in identifying a new broodstock source. We also explored whether or not we even have the capability, at this point in time, to develop new broodstock, or whether there may be other actions we can take to try to minimize the impacts of our ongoing program. There is a great deal of concern about the idea of starting from ground zero, Schuck said -- we made a lot of progress at that meeting, but have not yet developed any permanent answers.

Deacon-Williams observed that all of the steelhead programs reviewed today include a dual obligation -- they are intended to restore and maintain natural production, while at the same time, they are intended to re-establish sport and tribal fisheries. From the presentations I have heard this morning, it appears to me that the overall conclusion is that you have made some progress in the re-establishing some limited fisheries, but have had essentially no success in restoring natural production. If that is an accurate characterization, I would be interested in any thoughts the presenters might have about improvements that could be made in the natural production arena, Deacon-Williams said.

When the Lower Snake Comp Plan was originally authorized, said Crateau, the emphasis was on returning numbers of adults above Lower Granite Dam -- the enhancement of natural production was not an emphasis in the original authorization. In general, we have achieved the goal of replacing lost adults through hatchery production -- in most recent years, we have returned at least 55,000 adult steelhead above Lower Granite Dam. It is only in recent years that there has been a concern about and emphasis on supplementing natural stocks, and we have really just begun to sink our teeth into the supplementation concept, Crateau said.

I should probably clarify my earlier statement by saying that I am not blaming the Lower Snake Compensation Plan for the loss of wild stocks, Sanchotena said. In fact, I am saying just the opposite -- the Lower Snake Compensation Plan is failing mainly because of the refusal of the scientific community to call a spade a spade, and to admit that the dams will never allow the Lower Snake Comp Plan to achieve its mitigation goals and to provide a fishery. My intention is not to put the onus on the LSRCP, Sanchotena said -- what frustrates me is when I hear scientists say that we have met the fisheries goal for steelhead. We haven't come close to meeting that goal, and we never will as long as the present dam system is in place.

When you stop and think about it, said Crateau, since the original authorization for the LSRCP did not include an emphasis on restoring wild stocks, it only stands to reason that the wild populations would continue to decline, because they were in steep decline before we ever arrived on the scene

In response to a question about in-kind, in-place mitigation, Deacon-Williams said that, even if you assume that all we're evaluating at this point is whether or not the LSRCP has been successful in replacing the 48% fish loss it was intended to mitigate for, from what I've heard today, we have failed to meet that goal, with the exception of one area -- Southeast Washington.

Herrig said that, in terms of in-kind mitigation, the affected species in the Lower Snake were chinook salmon and steelhead, and that's what the LSRCP has tried to mitigate for. As far as in-place mitigation, there was some initial discussion about having a fall chinook facility below the mouth of the Snake River in the Columbia River, and simply forgetting about the fall chinook run that used to occur in the Snake River. However, the decision was ultimately made to replace those fish in-place. The agencies tasked with negotiating the type and location of the facilities to be built under the LSRCP decided that it would be better to have a number of smaller facilities and satellites, located in the basins of the stocks we were attempting to mitigate for, Herrig said. However, we did not venture into the Middle Fork or the South Fork Salmon, so the fish from those drainages were not replaced in-place.

Doug Dompier of CRITFC observed that he had been involved in the original negotiations on the LSRCP, and that it was indeed intended to supplement the runs. At the time, the people who wrote the plan may not have known exactly where it would be possible to supplement, but they did say you should supplement, he said. I would also observe that, with regard to fall chinook mitigation, there is only one facility -- a mega-hatchery in Lower Monumental pool, below, not above, Lower Granite pool.

Deacon-Williams restated her questions about whether or not the program's adult goals are being met, and what can be done, at a practical level, to shift the focus of the LSRCP to restoring natural production. First, said Tim Whitesel, I can confirm that current data indicates that we have not met our adult return goals, primarily because we are not meeting smolt-to-adult survival goals. It is also true that, the exception of the Imnaha component, the Grande Ronde program has focused very specifically on restoring the fishery. Schuck said the Southeast Washington steelhead program does appear to be meeting or exceeding its adult return goals on an annual basis; he added that the emphasis of this program has been very much on meeting those adult return goals. However, the information indicating that many wild populations are below the replacement line indicates that we have serious problems, which are still out there, he said. In Southeast Washington, we have shown that we can meet the simple goal of increasing adult returns through our hatchery program, but in the long term, if we fail to maintain and restore those natural populations, that's a major failure. Dean Rhine said the Clearwater Hatchery also failed to meet its adult return goals in the single year for which return data is available.

This program is predicated on not losing the rest of the populations this hatchery program was intended to mitigate for, said Rhine. However, there are limiting factors that must be addressed. By failing to address those limiting factors, we will only continue the downward spiral. It is up to us to determine whether or not hatcheries are part of the problem, he said; I think we need to do a better job of defining what those limiting factors are, then focus our efforts on correcting them. Unless we do that, we will be unable to continue under our current management plan, because it will be in conflict with federal and state law.

Whitesel observed that today's meeting illustrates a fundamental problem with the attitude toward steelhead among Northwest scientists and decision-makers -- the steelhead presenters have been allotted 30 minutes, while the chinook presenters have 45 minutes. The reason for that lesser emphasis on steelhead, he said, is the fact that people think that, because steelhead are generally more numerous than chinook, the problems they face are somehow less severe. However, if we push steelhead to the side while we focus on the chinook populations, we risk putting Columbia Basin steelhead into the same situation the chinook runs are in now. We have an opportunity to prevent that, Whitesel said, and we should really start thinking about that.

Carmichael agreed that there are many things that could be done to make the existing LSRCP steelhead programs more effective in assisting in the recovery of steelhead. We have started to take some steps in that direction in the LSRCP chinook programs, he said, but have hardly even begun to think about those steps in the steelhead programs. There are a number of reasons for that, including the fact that the steelhead life history is much more complex than the chinook life history, and the fact that the steelhead populations are spread out over a much wider geographic range in the basin. Despite this additional complexity, however, Carmichael said, I think there is a lot more we could be doing to make our steelhead programs more effective in assisting in recovery.

In response to a question, Herrig said the annual budget for the LSRCP is about $11.5 million; we have actually been spending closer to $12 million, and have used carryover funds to pay the difference. This amount includes operations, research and monitoring -- no capital construction, which was all incurred earlier in the life of the program. Are there any data available on comparative egg-to-smolt survival for the wild and hatchery steelhead stocks or on comparative

SARs for wild and hatchery steelhead? asked Rick Williams. I am not aware of any data on those specific life-history components, Whitesel replied, but the parent-progeny ratios I showed you suggest that, at least at some point, one or all of those is significantly low.

Science panel comments on Steelhead Session

Pete Bisson led off the science panel comments by saying that one thing that had struck him during the steelhead presentations was the variability in smolt-to-adult returns seen by many of the steelhead programs. One fairly obvious pattern was the fact that those SARs went down after 1987. That tells me that we are placing our supplementation fish into an environment that is quite variable from year to year, Bisson said. The advice I have for anyone contemplating a supplementation program is to be conscious of the fact that your productivity isn't going to be the same from one year to the next.

Next up was Rick Williams, who said that, overall, he had heard some encouraging things today, and some discouraging things. The encouraging things include the fact that there appears to be a general recognition that, for the LSRCP to fit into the larger fisheries goals in the basin, we need to start placing an increased emphasis on the restoration of native steelhead stocks -- that is going to be the bottom line on which this effort, ultimately, will be judged. On the discouraging side, Williams said, I would place the disappointing SARs we have seen to date, particularly given the fact that many of these programs are meeting their smolt targets.

Deacon-Williams said the take-home message from today's presentations, for her, is that we can't mitigate for the impact of the Lower Snake dams through hatchery programs alone. With the exception of the program in Southeast Washington, she said, we have been unable to raise the number of adults in a hatchery setting needed to replace the fish lost as a result of dam construction. To me, she said, that indicates very clearly that we need to tie the Lower Snake Compensation Plan more closely into the broader, basin wide recovery effort.

Jack McIntyre touched on the question of the impact of hatchery fish on wild fish in individual basins, and asked whether the steelhead program managers have looked at the decline rates in the Grande Ronde vs. the Little Sheep basin. In one of those basins, the native stock remains fairly pure, while in the other, you have a pretty mixed-up genetic situation, he said. If you look throughout the Snake River basin, with the exception of a few places where we trap fish we don't have a lot of real good population-specific estimates of runs on an annual basis, Carmichael replied -- we have some redd count information, but overall, the data that could support the type of evaluation you suggest is not very strong. In the Grande Ronde basin, there are some streams where we get good index information on an annual basis; there are others where all you are doing is indexing the quality of the streams you're surveying, rather than steelhead abundance. In my opinion, Carmichael said, the best data we have is on adults to Lower Granite, and adults back to Lower Granite -- that would be the best way to do a basinwide assessment of productivity and run reconstruction for Snake River steelhead.

Mike Matylewich harkened back to Courtland Smith's comments on values, and observed that, in his opinion, it would be worthwhile to encourage further discussion of the values people would like to see enhanced by the Lower Snake Compensation Plan. Like most of the other panelists, he said, I am extremely disturbed by the consistently low SARs we're seeing in this program; they indicate to me that the problem is much larger than simple fish numbers. I also see some of the values inherent in the LSRCP changing by force, he said -- primarily the force of the Endangered Species Act. As others have observed, I think we need to talk further about how this program interfaces with the ESA.

Dan Huppert said that, as the lone social scientist on the panel, a number of issues had occurred to him in the course of today's presentations. The first of these is the basic conflict between some of the program objectives, notably the conflict between raising fish for harvest vs. raising fish to preserve genetic diversity. The fact is, decisions are being made by default in a system that was never intended to deal with an issue of this sort, he said.

The second issue that occurred to me, Huppert continued, is data reliability regarding adult returns; I see that as a potential problem area, and one that probably deserves further discussion. The third thing that occurred to me, he said, is how young this program really is -- we still have a lot of learning to do in terms of the sophistication of this animal husbandry program. With that in mind, said Huppert, I would caution that, just because the first few SARs we have been able to measure have been discouraging, that doesn't mean this program is necessarily doomed to failure over the long term.

Dan Goodman said that, in his view, everything he heard during today's presentations indicates a need for further study of whether hatcheries are a contributing factor in the decline of wild populations, or whether they are neutral. However, he said, I think we need to bear in mind that the Lower Snake Compensation Plan was intended to be a hatchery program, and in many ways, it has been a successful hatchery program.

Final Comments on the Steelhead Session

Herb Pollard of NMFS said that, in the Deschutes and John Day systems, the straying of out-of-basin hatchery steelhead has proven to be a very serious problem. Coded-wire tag data indicates that over 70% of the out-of-basin strays in the Deschutes over the past two years have come from Lower Snake Comp Plan facilities -- that's 20,000 adults in the Deschutes and several thousand more in the John Day system, he said. In terms of the SARs you're seeing in this program, he said, those are fish we know are at least surviving to return to the Columbia system. However, they're causing a real ESA-related problem, in terms of their impacts on wild fish in the Deschutes and John Day systems. In my view, one of the coming train wrecks, in terms of the detrimental effects of hatcheries, is the genetic dilution caused by large-scale out-of-basin straying, he said; it's a problem that will need to be addressed as we move into the future of the Lower Snake Comp Plan.

In terms of what we can do with hatcheries to preserve and enhance the genetic integrity of the wild stocks in the basin, Deacon-Williams said, it seems very obvious to me that it is ludicrous to try to run a hatchery program -- whether the goal of that program is to produce harvestable adults or to recover threatened and endangered populations -- using broodstock of uncertain genetic origin. I think the evidence is clear that locally-adapted stocks are more successful in surviving to adulthood and returning to spawn than out-of-basin stocks. Despite the additional difficulty of using locally-adapted stocks in a hatchery program, I think that is the number one change we need to make in this program in the future.

One question about ocean conditions, said David Arthaud of the Shoshone-Bannock Tribes -- in the science panel's opinion, have ocean conditions ever been the same as they are right now during the last 10,000 years? Second, have the Columbia Basin stocks ever been as low, during that time period, as they are right now? The answer to the first question is obviously yes, McIntyre replied. The answer to your second question is probably yes as well, he said -- at some point in the last 5,000 years, populations were probably as low as they are today. We know that ocean conditions crash at relatively long intervals, added Deacon-Williams. However, we also know that Columbia River salmon have never gone extinct, which means that something other than ocean conditions is responsible for the present decline. There is something besides ocean conditions that has taken the resiliency the out of the ecosystem, she said. The same thing is true of marine mammal predation -- marine mammals have been preying on salmon for millennia, and despite that, salmon have evolved and thrived until recent years.

Sanchotena asked whether the same straying rates observed in the Deschutes and John Day systems have been observed in tributaries on the north side of the Columbia River, such as the Wind and White Salmon rivers; he also asked whether any chemical similarities have been noted between the water supplying Irrigon Hatchery and Deschutes and John Day river water. I think that, in general, we have seen an increase in straying in most mid-Columbia systems in the last decade, replied Rick Williams. It is fair to say that that increase in straying can be correlated with increased smolt output from the LSRCP hatcheries, as well as increased transportation in the last decade, he said -- whether it is fair to say that those two factors have caused the increase in straying is another question. The other thing to bear in mind is that it is fairly well established that the Deschutes provides a cool-water refuge for migrating adult salmonids during the late summer period, Williams added -- a lot of fish enter that system, then leave and continue upstream to spawn once mainstem temperatures have dropped.

Carmichael added that, to the best of his knowledge, there are few chemical similarities between the water used at the Irrigon hatchery and Deschutes and John Day river water.

Given the number of broodstock steelhead that have been released in recent years, do you think it is even possible, at this point, to develop hatchery programs in the Lower Snake Comp Plan area using locally-adapted broodstocks? Whitesel asked. It seems to me that there must be at least some systems in the basin where the naturally-spawning populations retain enough genetic integrity to support a locally-adapted broodstock approach, McIntyre replied. In other cases, that genetic integrity may not be all that high, but I still think we ought to use the best material we have at hand.

I would added that, in the past, NMFS has not been shy about declaring that a given stock is extinct due to hatchery introgression, added Deacon-Williams. However, NMFS has obviously made the decision to go ahead and list a number of Columbia basin steelhead stocks, which implies to me that sufficient locally-adapted populations are available to support such an approach. The local stocks may not be genetically pure in all cases, she said, but they are a lot closer than what we're currently using.

Goodman made the point that, given the radical changes that have occurred in the Columbia River system over the past century, it isn't necessarily logical to assume that a population that has adapted to survive well under local conditions in a given area will necessarily continue to survive well, unless a pristine Columbia River system could be restored. I would add that it would also be a mistake to write off any hatchery stock that shows success in terms of adult returns, he said -- we could be throwing out the solution, rather than throwing out the problem.

STATUS REVIEW
OF THE SPRING CHINOOK SALMON HATCHERY PROGRAM
IN THE GRANDE RONDE RIVER BASIN, OREGON

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INTRODUCTION

This paper summarizes a presentation given at the Lower Snake River Compensation Plan Status Review Symposium, February 4, 1998. We review the spring chinook salmon management program in the Grande Ronde River Basin for two periods since the hatchery program was initiated. The first represents the period from hatchery program initiation in the late 1970's until the early 1990's when spring chinook salmon in the Snake River Basin were listed as threatened under the Endangered Species Act (ESA). The second period covers the time from ESA listing until the present. In addition, we provide an overview of our outlook for the future.

PROGRAM BACKGROUND

Historically, the Grande Ronde Basin supported diverse and healthy populations of spring chinook salmon. Although escapement has been highly variable, there has been a steady decline in abundance since the late 1950's (Figure 1). The basin supported a popular recreational fishery in the main river as well as in its major tributaries. The recreational fishery was closed in 1974 due to the depressed status of the populations and has yet to be reopened. Grande Ronde spring chinook salmon also contributed extensively to tribal ceremonial and subsistence fisheries in the mainstem Columbia River and throughout the Grande Ronde Basin. The tribal fisheries have been severely curtailed or altogether eliminated.

The Grande Ronde Basin drains an area of 10,500 km^2 in Northeastern Oregon. The river flows 340 km from the headwaters in the Wallowa and Blue Mountains to its confluence with the Snake River at rkm 271. The headwaters originate primarily in National Forest lands and run through two large valleys, the Wallowa and Grande Ronde. Land which lies below the headwaters is primarily in private ownership. Two large valleys exist in the basin, the Wallowa and Grande Ronde. Eight dams in the Snake and Columbia rivers exist between the Grande Ronde River and the Pacific Ocean.

Historically, the major spring chinook salmon production areas were the Wenaha, Minam, Upper Grande Ronde, Lostine, and Wallowa rivers, as well as Catherine and Lookingglass creeks (Figure 2). A number of small tributaries also supported minor populations.

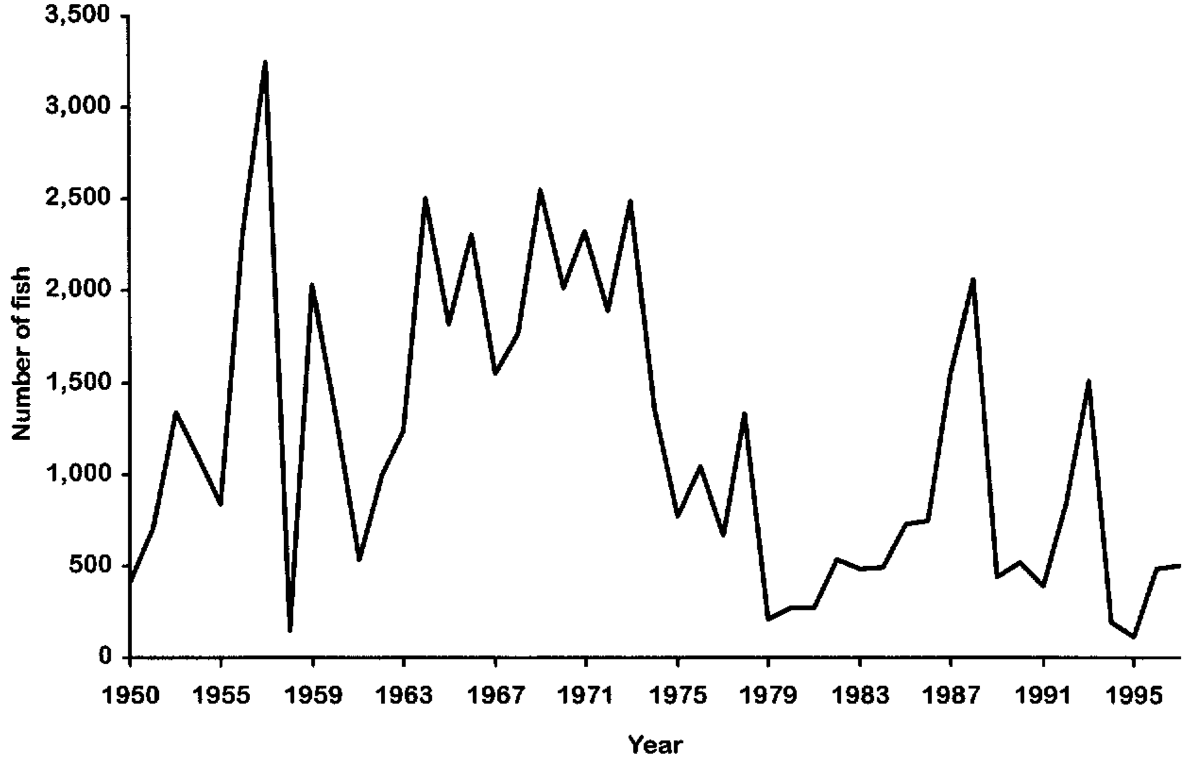

Figure 1. Estimated escapement to index survey areas in the Grande Ronde River Basin, 1950-1997. Estimates based on index redd counts and 3.26 fish per redd conversion factor.

Grande Ronde Basin spring chinook populations declined dramatically following closure of Lower Granite Dam, the last lower Snake River dam. In response to the depressed status and steady declines, the Lower Snake River Compensation Plan (LSRCP) was initiated in Oregon in the late 1970's. Compensation and production goals were established to compensate for the estimated annual loss of 48% of the basin's production (Figure 3). To guide implementation of the LSRCP in Oregon, the Oregon Department of Fish and Wildlife (ODFW) established six management objectives (Figure 4). These objectives have provided direction for program implementation for about the first 10 years.

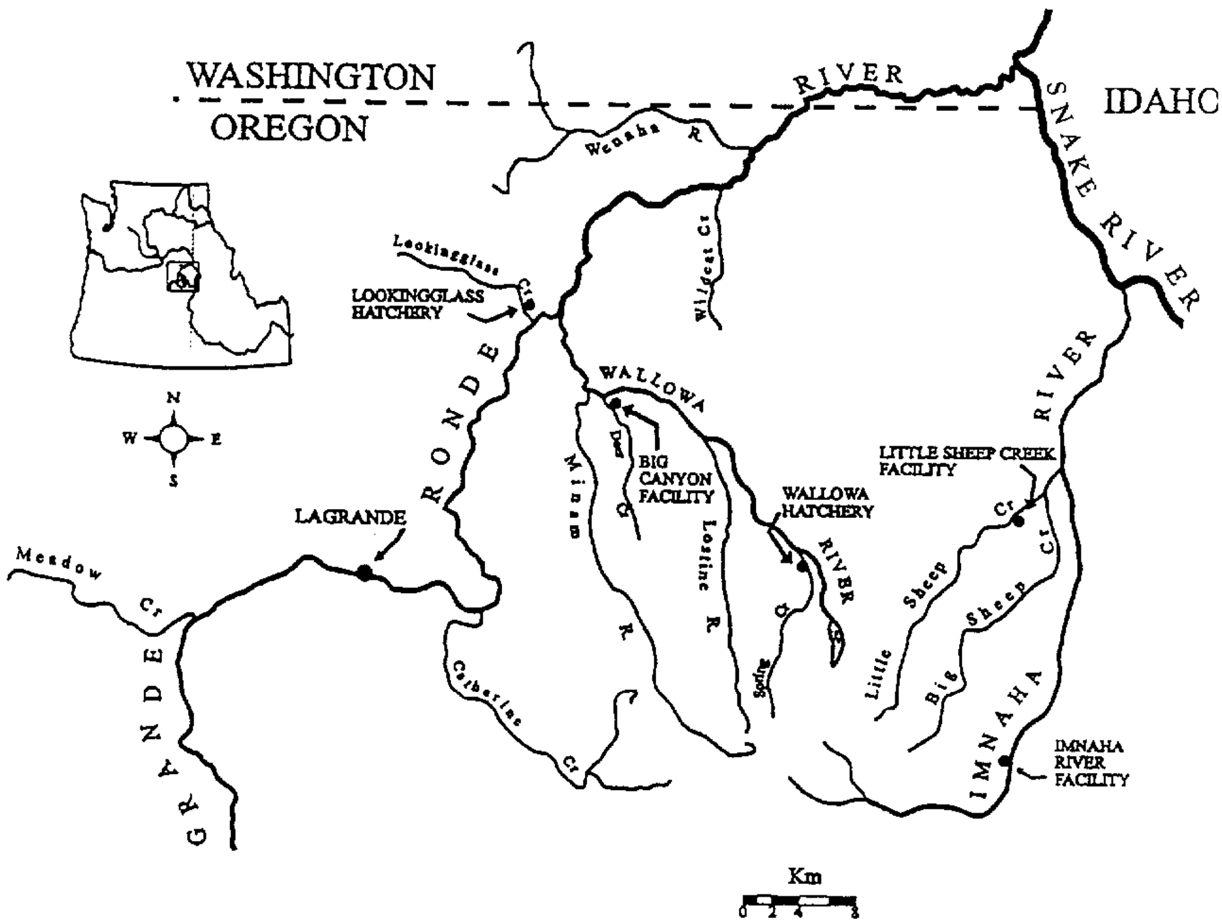

Figure 2. Map of the Grande Ronde River Basin.

Spring Chinook Salmon
Grande Ronde Basin

900,000 Smolts

45,000 Lbs.

5,820 Adults

0.65% Smolt-to-Adult Survival

Figure 3. Lower Snake River Compensation Plan goals for spring chinook salmon in the Grande Ronde River Basin.

Original Management Objectives

- **Establish adequate broodstock to meet annual production needs.**
- **Restore and maintain natural spawning populations of spring chinook salmon in the Grande Ronde Basin.**
- **Reestablish historic tribal and recreational fisheries.**
- **Establish an annual return of 5,820 hatchery fish.**
- **Maintain endemic wild populations of spring chinook salmon in the Minam and Wenaha rivers.**
- **Minimize impacts of hatchery program on resident stocks of game fish.**

Figure 4. Management objectives for spring chinook salmon in the Grande Ronde River Basin developed to guide implementation of the Lower Snake River Compensation Plan.

Lookingglass Hatchery serves as the primary production facility for the Grande Ronde Basin spring chinook program. The hatchery is located at rkm 3.7 on Lookingglass Creek (Figure 2). The hatchery is equipped with Heath incubation trays and Canadian troughs for early rearing. There are 18 single-pass outdoor raceways where juveniles are reared from the parr to smolt stage. Water is supplied to the facility from Lookingglass Creek and wells. Chillers are used for temperature control of well water for incubation and early rearing. The hatchery has two adult holding ponds and fish are diverted from the river into a trap via a floating weir.

STATUS REVIEW

Pre-ESA Listing Period

When initial broodstock development options were considered in the late 1970's, it was thought that there were too few natural fish returning to Lookingglass Creek to develop adequate broodstock in a short enough timeframe. Therefore, ODFW decided that smolt production goals could only be achieved quickly by importing hatchery stock from outside the basin. To initiate broodstock development, 1978 broodyear Rapid River stock (Idaho) smolts were released into Lookingglass Creek in 1980. Due to disease concerns and availability of eggs, use of Rapid River stock was discontinued for a period of time and replaced with Carson stock (Figure 5). Rapid River stock once again became the preferred stock and has been used since the mid-1980's.

Broodstock History

Brood year	Source
1978	Rapid River
1980-84	Carson / Willamette Hatchery
1985-87	Carson / Lookingglass Hatchery Rapid River / Idaho
1988	Rapid River / Idaho
1989	Carson / Lookingglass Hatchery Rapid River / Idaho
1990-97	Rapid River / Lookingglass Hatchery

Figure 5. History of spring chinook salmon broodstock sources used at Lookingglass Hatchery for the Grande Ronde River Basin.

A comprehensive monitoring and evaluation program has been ongoing since 1984. The objectives are described in Figure 6. In selecting our initial release strategies for Lookingglass Hatchery, two factors had a significant influence. First, during the first year of operation, Lookingglass Hatchery experienced severe winter icing conditions in December, which culminated in an ice slide into Lookingglass Creek that completely blocked the intake with ice and debris. Water flow was lost to the raceways and entire raceways of fish died. An emergency release of most of the fish had to be conducted. Second, studies in the late 1960's and 1970's showed that a majority of the juveniles produced in Lookingglass Creek migrated out between July and November of the first year of life (Figure 7). In response to this information, we chose to evaluate presmolt and smolt releases for five broodyears (Figure 8). Total production from Lookingglass Hatchery met or exceeded the production goal of 900,000 for most brood years between 1983 and 1992 (Figure 9). Although most releases occurred at Lookingglass Hatchery, presmolts, smolts, or adults were outplanted in Catherine Creek, the Upper Grande Ronde River and the Wallowa River periodically from 1980-1990.

Initial Evaluation Objectives

- **Document and assess fish culture and hatchery operation practices.**
  - *** Survival rates by lifestage**
  - *** Causes of mortality**
  - *** Releases**
- **Determine optimum rearing and release strategies that will produce maximum survival to adult.**
  - *** Time-of-release**
  - *** Size-at-release**
- **Determine total catch and escapement and assess if adult production meets mitigation goals.**
- **Determine the success of maintaining genetic integrity of endemic wild spring chinook salmon in the Minam and Wenaha rivers.**

Figure 6. Monitoring and evaluation objectives for the Grande Ronde River Basin spring chinook salmon hatchery program.

Migration Timing of Naturally-Produced Juveniles, Lookingglass Creek (1965-69)

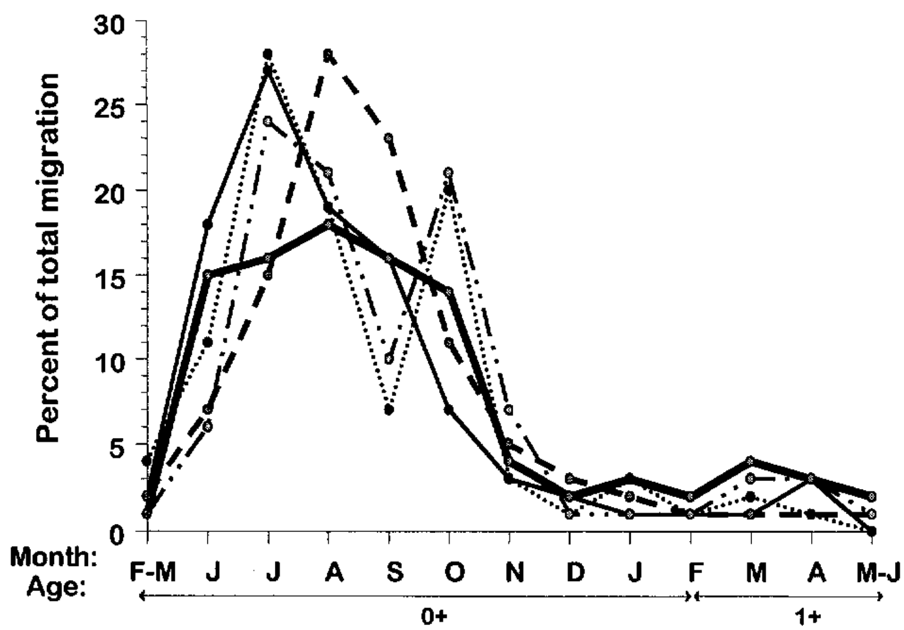

Figure 7. Migration patterns of naturally produced spring chinook salmon in Lookingglass Creek, 1965-1969.

Summary of Juvenile Releases from Lookingglass Hatchery

Stock	Brood years	Release date	Range of mean lengths (mm)	Range of mean weights (g)
Carson	1983-85	Jul	81-108	5.8-14.2
		Sep	109-125	13.8-23.6
		Nov	100-136	16.0-27.3
		Apr	121-140	20.6-29.8
Rapid River	1986-87	Sep	113-116	19.1-20.9
		Nov	114-120	19.5-22.5
		Apr	123-125	22.4-23.0

Figure 8. Spring chinook salmon release strategies that were evaluated at Lookingglass Hatchery, 1983-1987 broodyears.

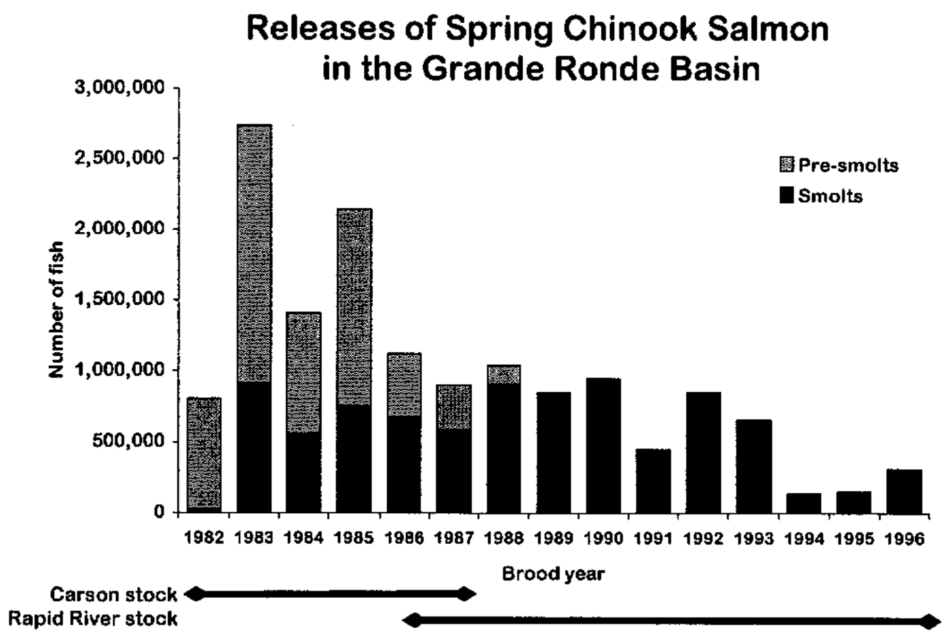

Figure 9. Summary of spring chinook salmon presmolt and smolt releases in the Grande Ronde River Basin for Carson and Rapid River Hatchery stocks, broodyears 1982-1996.

Adult returns to Lookingglass Hatchery have been highly variable from year to year. Peak returns occurred in 1987 and 1988, when approximately 2500 fish were collected (Figure 10). Smolt to adult survival rates have generally been poor and have never reached the goal of 0.65% (Figure 11). The only release strategy that achieved progeny-to-parent ratios greater than 1.0 was the yearling smolt strategy released in April (Figure 12).

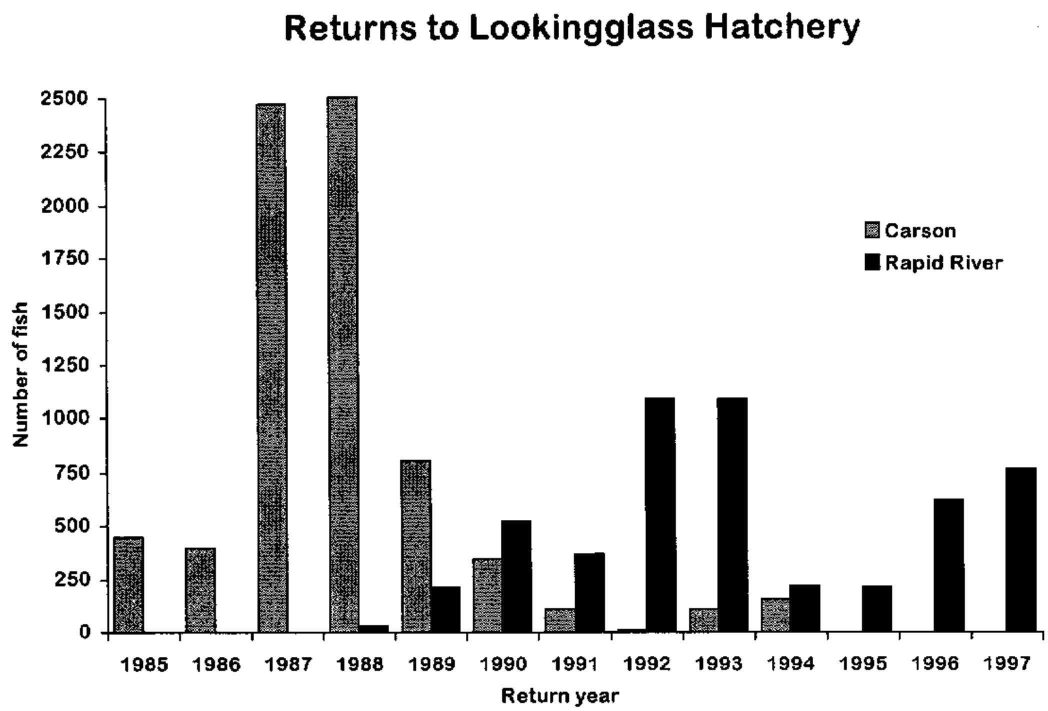

Figure 10. Spring chinook salmon adult returns to Lookingglass Hatchery, 1985-1997. Values for 1995-1997 include Rapid River stock adults collected and transported from Lower Granite Dam from 1995-1997.

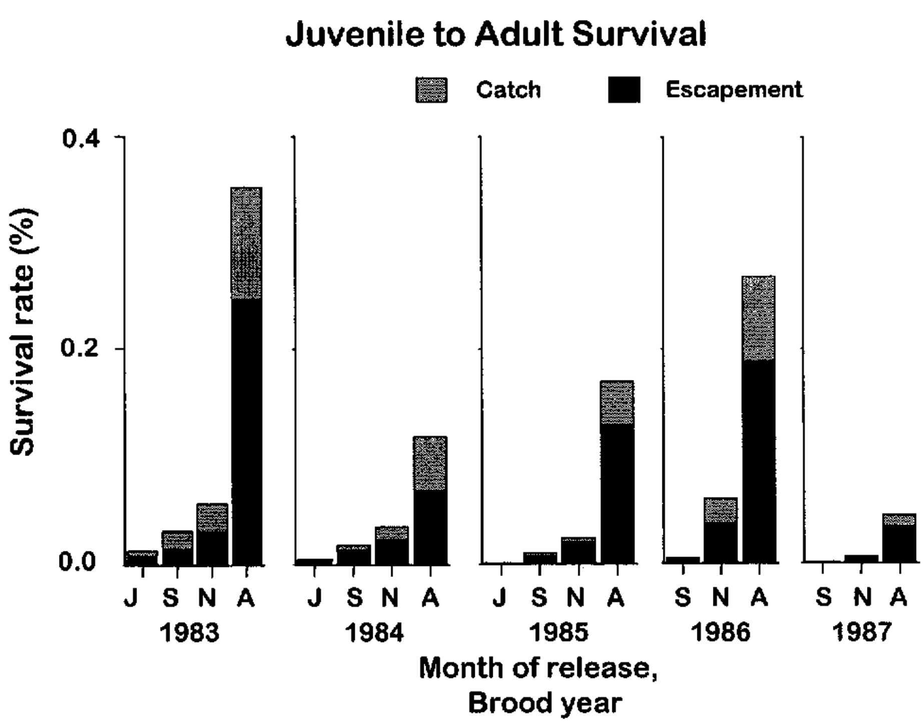

Figure 11. Smolt-to-adult survival rates for spring chinook salmon released from Lookingglass Hatchery at different times of the year, broodyears 1983-1987.

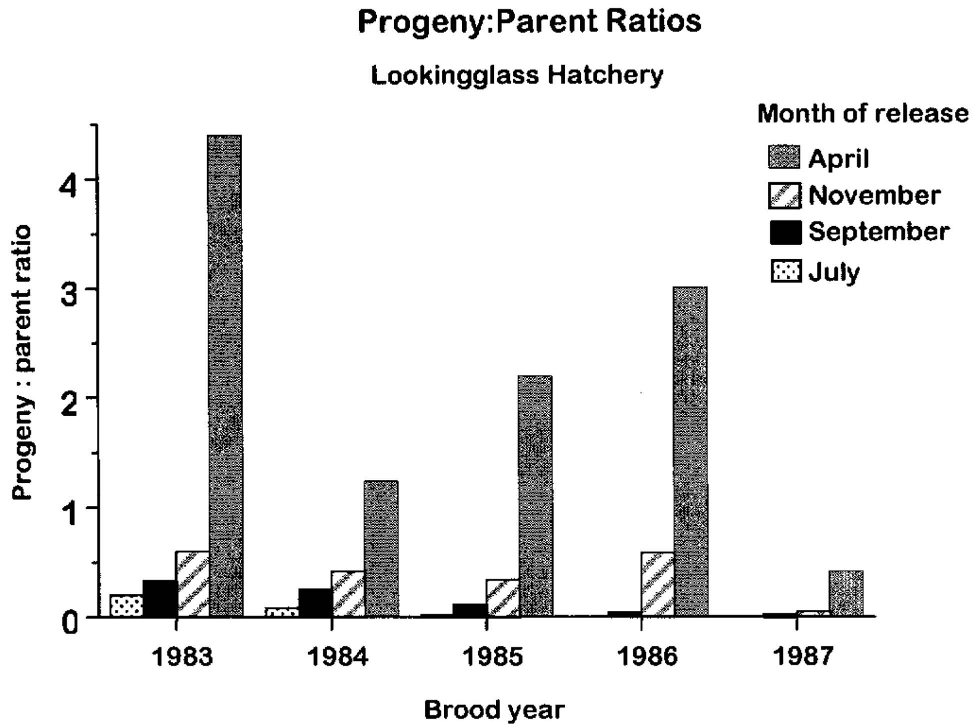

Figure 12. Progeny-to-parent ratios for spring chinook salmon released from Lookingglass Hatchery at different times of the year, broodyears 1983-1987.

We have assessed catch and escapement distribution for all broodyears since Lookingglass Hatchery began operation. For most broodyears, little harvest occurred in the ocean and the only significant harvest we observed occurred in the Columbia River Tribal Ceremonial and Subsistence and recreational fisheries (Figure 13).

Catch and Escapement (%) of Rapid River Stock Spring Chinook Salmon Released in the Grande Ronde Basin

	Brood year				
	1986	1987	1988	1989	1990
Ocean	0.5	3.2	0	0	0
Columbia River					
Treaty Net	0	0	0	0	0
Non-Treaty Net	2.0	0.8	0.5	0	1.6
Sport	16.2	8.0	4.5	2.8	8.1
C and S	10.3	20.8	22.9	6.8	4.8
Test Fishery	0.2	0	0.3	0	0
Deschutes River					
Sport	0	0	0.3	0	0
Strays					
Out of Snake Basin	1.2	2.4	1.4	0	9.7
In Snake Basin	0.7	0.8	4.8	3.4	0
Escapement	68.9	64.0	65.4	87.0	75.8

Figure 13. Catch and escapement profile for Rapid River stock spring chinook salmon produced at Lookingglass Hatchery, broodyears 1986-1990.

We monitored the proportion of natural spawners that were hatchery strays in the Wenaha, Minam, and Lostine rivers to determine the success in meeting our objective to maintain wild fish sanctuaries. Based on the origin of carcasses recovered on spawning ground surveys, we determined that a high proportion of natural spawners in these unsupplemented rivers were Lookingglass Hatchery produced strays (Figure 14). Estimated stray rates of hatchery fish into these unsupplemented areas were also quite high (Figure 15).

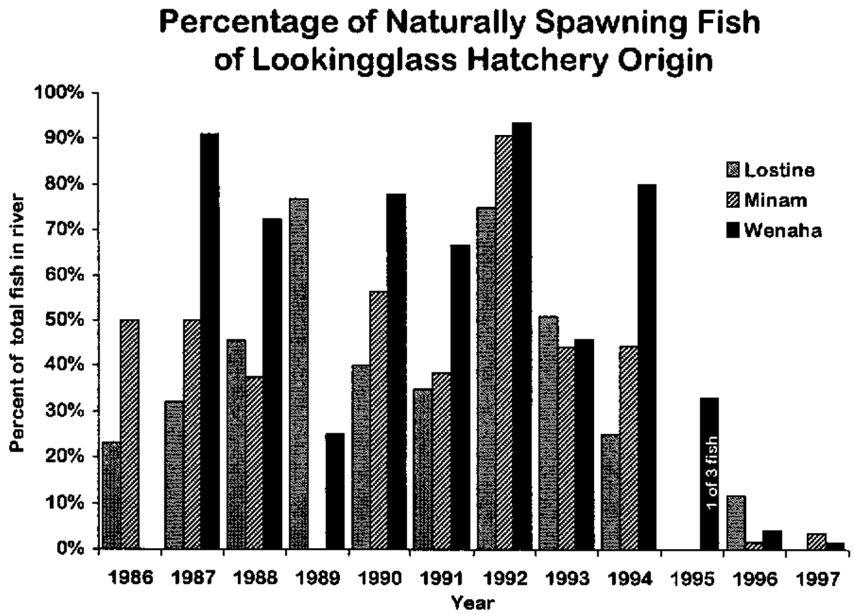

Figure 14. Estimated percentage of natural spawning fish in the Lostine, Minam, and Wenaha rivers that were Lookingglass Hatchery strays, 1986-1997. Estimates are based on origin of carcasses recovered on spawning grounds.

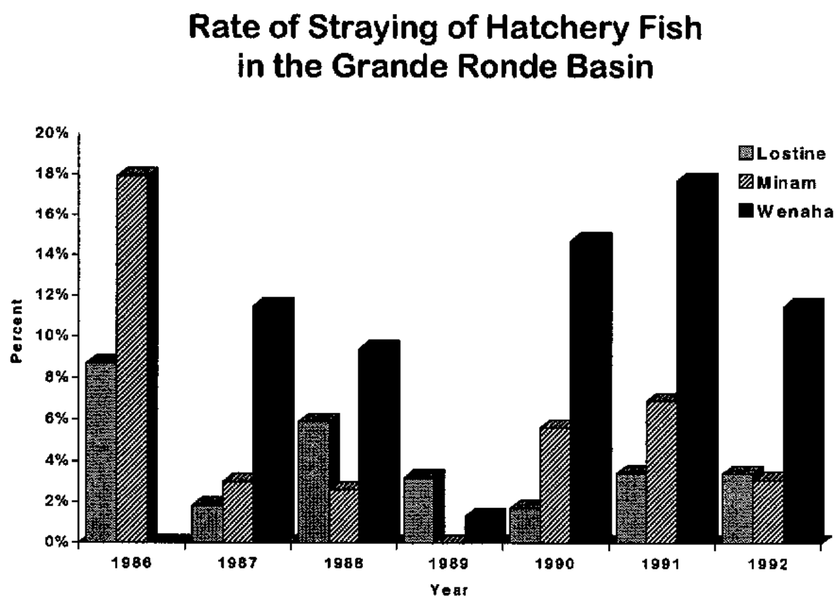

Figure 15. Stray rates of Lookingglass Hatchery spring chinook salmon into the Lostine, Minam, and Wenaha Rivers, 1986-1997.

A comprehensive fish health monitoring program has been underway since the mid-1980's. Significant disease problems have been encountered at various life stages. Bacterial kidney disease has been a consistent and ongoing challenge at Lookingglass Hatchery (Figure 16).

Disease or Disease Agents Observed Consistently in Spring Chinook Salmon

Life Stage	Disease or Disease Agent	Survival Impact
Juvenile	Erythrocytic Inclusion Body Syndrome (EIBS)	Minor significance
	Bacterial Kidney Disease (BKD)	Significant
	Infectious Hematopoietic Necrosis Virus (IHNV) (in 1993 brood year)	Significant (one time event)
	Redmouth	Not significant
Adult	IHNV	Unknown
	BKD	Significant
	Ceratomyxa shasta	Unknown
	Furunculosis	Moderate
	Redmouth	Unknown
	Headburn	Significant

Figure 16. Summary of disease or disease agents observed at Lookingglass Hatchery.

This brings us to a conclusion of the review for the first management time period that began in the late 1970's and ended in the early 1990's. The assessment for this time period can be summarized as follows:

- Importing Carson and Rapid River Hatchery stocks to Lookingglass Hatchery allowed us to achieve smolt production goals quickly and develop adequate broodstock to meet production goals.

- Smolt-to-adult survival rates were consistently poor and were well below the goal of 0.65%.

- Insufficient numbers of adults have returned on a consistent basis to reestablish recreational fisheries. Although tribal fishing opportunities were provided in some years, they were limited.

- Lookingglass Hatchery fish strayed at high rates into the Lostine, Minam, and Wenaha Rivers and represented a high proportion of the natural spawners in some years.

- All sub-smolt release strategies survived poorly and the only rearing-release strategy that demonstrated success was the yearling smolt release in the spring.

Post-ESA Listing Period

In the early 1990's, two major policy rulings influenced the direction of the Grande Ronde spring chinook salmon hatchery program. In 1990, ODFW adopted the Wild Fish Management Policy, which established guidelines for the maximum acceptable level of non-local origin hatchery fish that would spawn in nature with local wild populations. In addition, in 1992, naturally produced Grande Ronde Basin spring chinook salmon were listed as endangered by the National Marine Fisheries Service (NMFS) under the ESA. The hatchery program was operating well outside the Wild Fish Management Policy straying guidelines and was inconsistent with sound conservation principles and recovery of ESA-listed species. Two immediate interim actions were taken in response to concerns with use of the Rapid River stock:

1. Outplanting of all Rapid River stock was discontinued.

2. We reduced smolt production of Rapid River stock at Lookingglass Hatchery from the LSRCP goal of 900,000 to 350,000 annually.

We had reached a crossroads for this hatchery program where it became clear we could no longer pursue compensation goals with non-local broodstock and keep impacts to endemic populations within acceptable limits. To decide what direction to take we had to address two important management questions:

- What is the appropriate role of artificial propagation in Grande Ronde Basin spring chinook salmon management, given new priorities for conservation and recovery of endemic populations? and

- Given that there is a role, what type of hatchery program will best meet the long term management objectives under ESA recovery: continue on with Rapid River stock; begin conventional supplementation with local broodstock; or begin a captive broodstock program using local broodstock?

To assist in addressing the management questions we identified, the following genetic and biological issues needed to be addressed:

- What is the demographic status and near term risk of extinction of chinook salmon populations in the basin?

- What genetic effects have resulted from prior outplanting and straying of non-endemic hatchery stocks?

- Does there remain any genetic differentiation between natural and hatchery populations and between natural populations?

Escapement levels had declined rapidly throughout the Grande Ronde Basin, reaching all-time lows from 1994-1996. Spawning escapement was below 50 in Catherine Creek, Lostine River, and Upper Grande Ronde River populations in 1994 or 1995 (Figure 17).

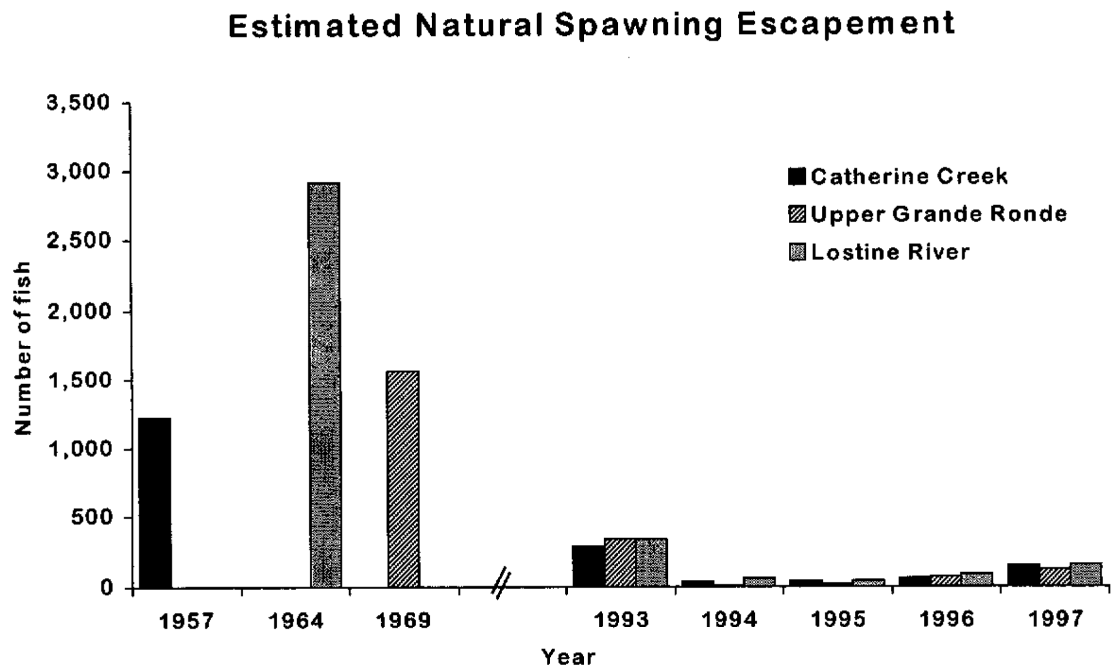

Figure 17. Recent historic peaks and recent natural spawner escapement estimates for spring chinook salmon in Catherine Creek and the Upper Grande Ronde and Lostine Rivers.

Although significant outplanting and straying of non-local hatchery fish had occurred throughout the Basin, a genetic assessment by NMFS indicated that there remained significant genetic differentiation between natural populations and between hatchery populations and the natural populations.

Given the demographic status and the genetic information, we reached the following conclusions regarding the management and science issues:

- Prior supplementation efforts with non-local hatchery stocks had failed, as indicated by low natural escapement levels in rivers which had been supplemented.
- Risk of extinction is high based on escapement trends, abundance of spawners, and low progeny-to-parent ratios for natural populations.
- There was still significant genetic differentiation between hatchery and natural populations and between the Minam, Wenaha, Grande Ronde, Lostine rivers and Catherine Creek natural populations.
- Hatchery programs using endemic broodstock should be initiated immediately in Catherine Creek, the Upper Grande Ronde and Lostine river populations.
- Given the uncertainties associated with use of artificial propagation to enhance natural production, we should use a diversified approach and maintain the Minam and Wenaha River basins as wild fish management areas.

We have implemented a number of management actions in direct response to our conclusions. First, in 1995, we initiated a captive broodstock program with collection of parr from Catherine Creek, the Upper Grande Ronde, and Lostine rivers. In 1997, we attempted to collect natural adults for broodstock from Catherine Creek and the Upper Grande Ronde and Lostine rivers. We were successful only in collecting a sufficient number of adults from the Lostine River. We also decided to maintain a reduced production (450,000) of Rapid River stock at Lookingglass hatchery and to mark all smolts uniquely so adults could be trapped at and hauled from Lower Granite Dam. The Rapid River stock is being maintained as a last resort back up stock in case all other efforts fail. All Lookingglass-produced Rapid River adults are trapped at Lower Granite Dam and trucked to Lookingglass Hatchery, thus reducing the potential number of fish that can stray.

OUTLOOK FOR THE FUTURE

Our outlook for the future is somewhat discouraging and our plans are very challenging.

- If we cannot improve mainstem passage survival and increase natural productivity so that progeny-to-parent ratios consistently exceed 1.0, recovery will never occur. Natural populations will go extinct and only hatchery fish will remain.

- We plan to continue the captive broodstock program at Bonneville Hatchery and the Manchester Marine Lab for Catherine Creek as well as Upper Grande Ronde and Lostine River populations.

- We plan to implement conventional supplementation programs using the sliding scale framework (Figure 18). This management framework is premised on the theory that at low population levels the greatest risk to population persistence is demographic. Therefore, at low population levels, we place fewer genetic risk constraints on the hatchery program in an attempt to boost population levels quickly, utilizing the survival advantage provided by the hatchery. As population levels increase above the threshold, the demographic risks are of less concern and more constraints are placed on the hatchery program to control genetic risks associated with artificial propagation (domestication selection, non-intentional directional selection, Ryman and Laikre effect). The sliding scale guides the allocation of natural and hatchery fish to broodstock, natural production and harvest. We will phase out use of Rapid River stock as endemic broodstock and production increase.

- Adult collection and juvenile acclimation facilities on Catherine Creek and the Upper Grande Ronde and Lostine rivers needed to implement captive and conventional endemic broodstocks and smolt production programs will be constructed in 1998.

- Lookingglass Hatchery needs to be modified to accommodate four endemic broodstocks and smolt production programs (including a river water treatment system). The hatchery was designed to hold, spawn, incubate and culture two stocks. Modifications are needed to increase flexibility and capacity for culture of all life stages.

Sliding Scale Management Framework

High Demographic Risk
- Use captive broodstock
- No constraints on % hatchery in nature
- No minimum % natural in broodstock

Manage Hatchery Genetic Risk
- Phase out captive broodstock
- Conventional supplementation
- Constrain % hatchery in nature
- Meet minimum % natural in broodstock

Figure 18. A sliding scale management framework for the use of hatcheries in management and recovery of threatened spring chinook salmon in the Grande Ronde River Basin.

Questions and comments

Rich, can you define "conventional supplementation?" asked Billy Conner of the Fish and Wildlife Service. The way I define it is using endemic broodstocks that come back to a given stream, spawning the returning adults in the hatchery, raising their progeny to smolt size, then returning them to their natal stream for volitional outmigration, Carmichael replied. You would then take subsequent generations of both hatchery and wild fish into the hatchery program for future broodstock, if additional years of supplementation are necessary.

Another meeting participant commented that, at Lookingglass hatchery, control measures have been implemented to prevent the straying of hatchery fish into natural production areas; it would appear that those measures have been at least partially effective, because in 1997, the percentage of strays in the natural production areas was very low. I agree, Carmichael said -- in both 1996 and 1997, the trap and haul strategy we've implemented appeared to be quite effective in preventing straying, based on carcass examination -- we found only 3%-7% strays in those years, he said.

In response to another question, Carmichael explained that the trap and haul system that was implemented at Lookingglass consisted of capturing coded-wire-tagged returning adults at Lower Granite, then trucking them to Lookingglass Hatchery.

Regarding the genetic information you presented, said Mark Schuck, you said that, in some years, the wild fish appear to be similar to some of the hatchery stocks. Were those the years in which you saw the highest incidence of straying? My recollection is that there wasn't a correlation between the proportion of natural spawners that were hatchery fish and genetic similarity, Carmichael replied. It really makes you shake your head and wonder what the heck is going on, he continued -- how can we have 90 % of our spawners be hatchery-origin fish and not homogenize to the entire basin? It tells me that we have a couple of things going on, he said -- first, in all likelihood, the reproductive success of those hatchery fish is poor, which is restricting gene flow into the natural population. Second, it is possible that our estimation is biased -- it's possible that the true percentage is less than 90%.

Washington's LSRCP Spring Chinook Program - Tucannon River

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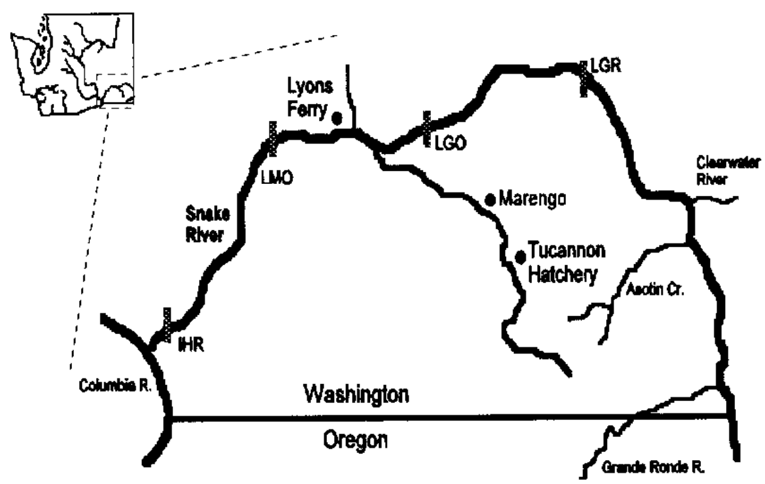
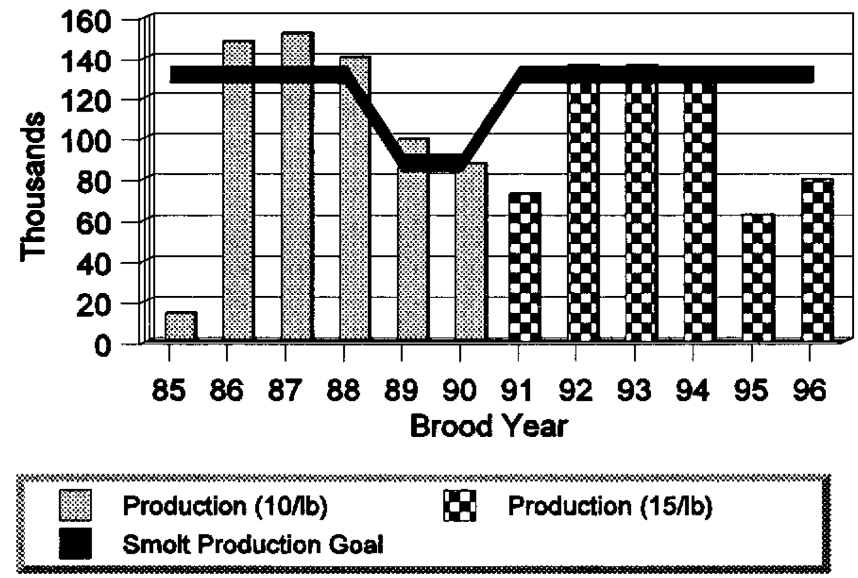
A hatchery supplementation program on the Tucannon River was initiated in 1984 with the first collection of wild adults for the hatchery broodstock in 1985. Spring chinook in the Tucannon River (wild and hatchery components) are currently listed as "threatened" under the Endangered Species Act (ESA). The Tucannon River is located in the southeast corner of Washington State, and enters the Snake River between Little Goose and Lower Monumental Dams (Figure 1), distinguishing it from other Snake River populations as having only six dams to migrate through. The spring chinook rearing area is upstream of Marengo (see map), and consists of about 45 river kilometers (RK) of spawning and rearing habitat. The upper 25 RK consists of state and forest service managed lands, with relatively good habitat for spawning and rearing. The lower 20 RK are privately owned and used for cattle grazing and agriculture practices. The two facilities associated with the program are Lyons Ferry and Tucannon Hatcheries. The Tucannon Hatchery is used for adult trapping, juvenile rearing and acclimation before release. Lyons Ferry is used for broodstock holding, spawning, egg incubation, and early juvenile rearing.



On an annual basis, about 100-160 salmon were trapped for the hatchery broodstock. Smolt production goals (88,000 or 132,000) have generally been achieved by the program (Figure 2), with the only limitations because of broodstock mortality, or inadequate broodstock numbers due to low runs. Age composition of returning hatchery fish required the program to shift its release numbers, and size of fish released. Current goals are for 132,000 smolts released at 15/lb. Current broodstock requirements to meet production are 100 total (50 wild and 50 hatchery). Spawning protocol guidelines limit the number of hatchery x hatchery crosses to avoid full second generation hatchery fish.

Figure 2 - Hatchery Smolt Production



Historical estimates of run size to the Tucannon River has not been well documented, but the run was estimated to be about 5,000-6,000 adults annually near the turn of the century, but had declined to about 2,000 adults during the 1950's. Redd counts conducted in a 5 kilometer section of river since 1954 are not useful for estimating run size because of the small survey area, but the data does show the apparent decline in the number of redds in that section (Figure 3).

Figure 3 - Index Redd Counts

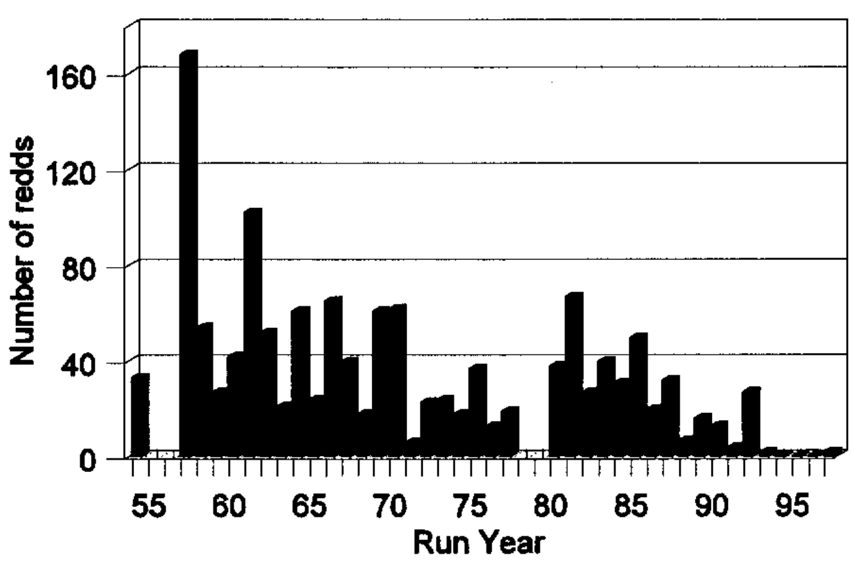
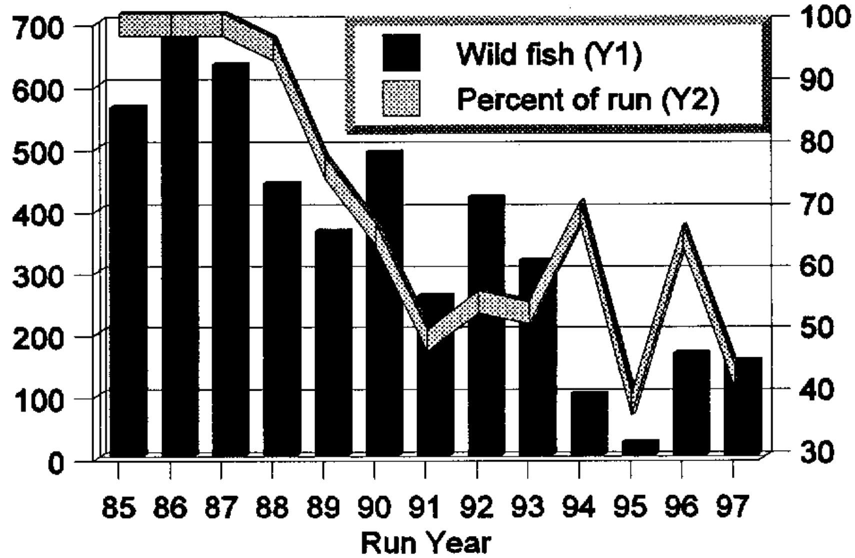


Figure 5 - Wild Population Status



been above that goal. Rearing conditions at Lyons Ferry are excellent because of the relatively cool, pathogen free, well water supply. In addition, the hatchery stock has had limited disease problems, with BKD outbreaks occurring only rarely. The wild population egg-to-smolt survival has been estimated to be about 5% each year, with the most recent years declines because of large scale floods in the river. The wild fish are also limited because of loss of spawning and rearing habitat, and associated warm water temperatures.

However, once the hatchery fish are released, they don't perform as well (Figure 8). We believe the high velocities and steep gradient of the Tucannon River may cause considerable mortality before the hatchery fish even leave the river. Once the hatchery and wild fish leave the river, they are both subjected to the migration problems on the Columbia and Snake, and unstable ocean conditions. Smolt-to-adult survival rate set up under the LSRCP for achieving the mitigation goal of 1,152 was 0.87%. Mean smolt-to-adult survival from eight complete brood years of wild and hatchery fish are 0.64% and 0.17%, respectively. Based on those survival estimates, it will not be possible to reach the mitigation goal until the limiting factors (habitat: in-basin, and migration corridor) are addressed.

By examining the parent to progeny success, the data we have to date shows the wild population is below the replacement level, and in some years the hatchery population is also (Figure 9). Currently the hatchery program is maintaining the population in the river, and is essentially providing a place to maintain the genetic make-up of the Tucannon stock. By examining all of the survival rates and identifying the limiting factors we have determined that the success of the

Figure 6 - Egg-to-Smolt Percent Survival

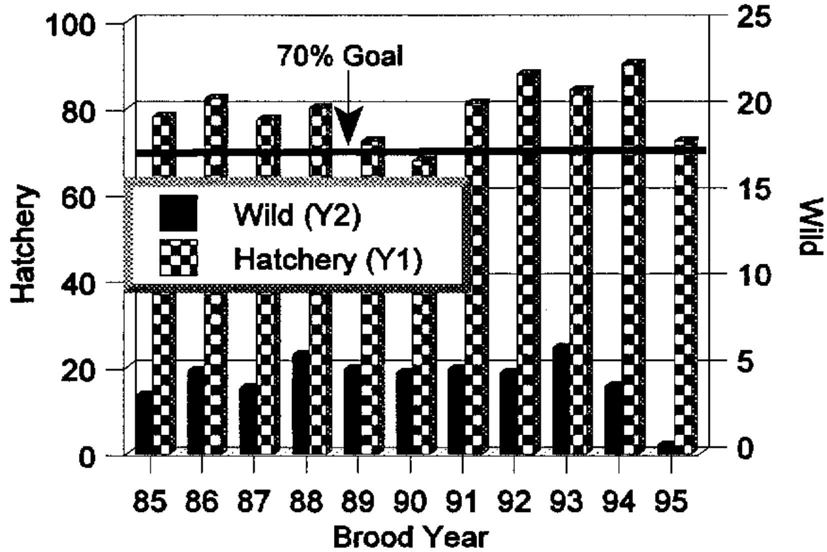
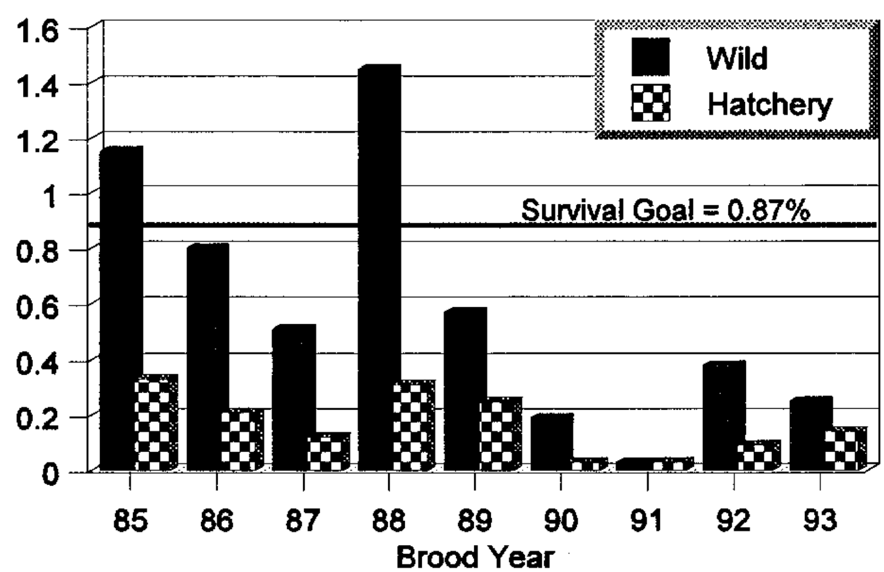
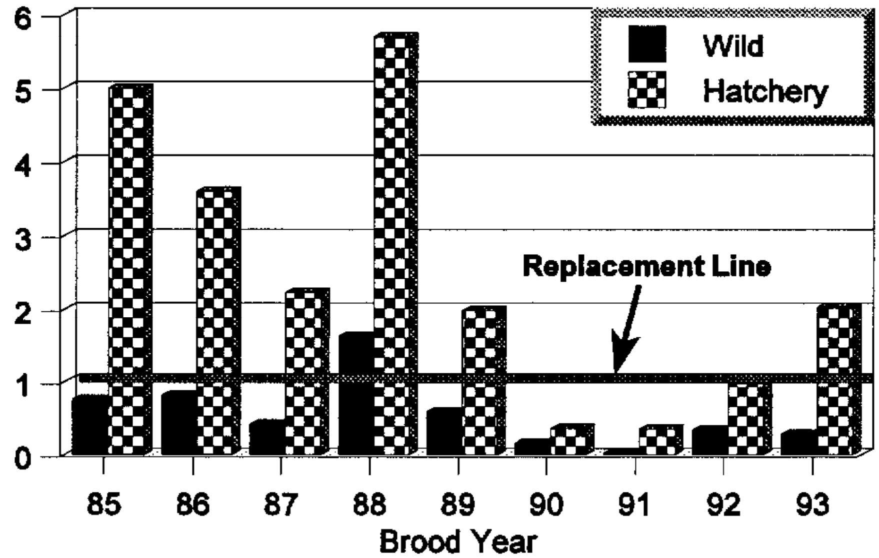


Figure 7 - Smolt-to-Adult Percent Survival



program is essentially out of our control. Out of program changes (improved mainstem passage or habitat improvements in the Tucannon River) will have to come from outside entities. Unless changes can be made soon to the system survival, the population will consist of hatchery derived fish, and extinction may occur in less than 25 years.

Figure 8 - Parent-to-Progeny Ratio



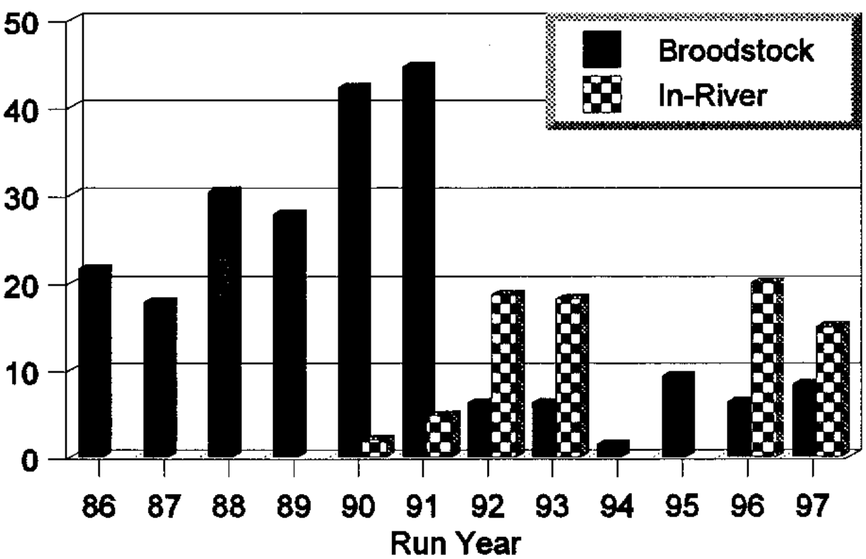
The program has adapted to problems identified directly with the hatchery program to try to improve survival and lessen our impacts to the wild population. Changes which have occurred were to address the following issues: 1) Adult age composition of returning hatchery fish, 2) broodstock mortality within the hatchery, 3) broodstock collection during years with low runs, and 4) spawning distribution of fish in the river.

With the first returns of the hatchery fish to the river, it was observed that adult age composition of the hatchery fish was significantly different (15-44% jacks) than that of the wild population (2-5% jacks). As stated previously, hatchery fish were also generally smaller in size and females were less fecund than wild fish at the same age. The programed release size of smolts was therefore changed from 10 fish/lb to 15 fish/lb in hopes of changing the characteristics of the returning hatchery fish. To make this change, a water chiller was installed at Lyons Ferry and is currently used during egg incubation to slow the development of the egg. From the data collected to date, the hatchery and wild fish are now more similar in returning age composition, size and fecundity. We may be further able to change the life history traits of the hatchery fish by reducing even further the release size (20-25 fish/lb); however, by releasing smaller fish, we will probably see in a decrease in the survival rate which would return fewer fish.

When the program was first initiated, adult broodstock were captured, held, and spawned at Tucannon Hatchery, with the fertilized eggs transferred to Lyons Ferry for incubation and early rearing. Pre-spawning mortality was always a problem (18-44%). Inoculations, formalin treatments, and providing shading in the pond did not help reduce this loss. It was finally determined that the holding water temperature was probably too warm (60°F), and that the captured adults should be transferred to Lyons Ferry for holding. Water temperature at Lyons Ferry is a constant 52°F. This change provided instant benefits by decreasing the annual pre-spawning loss to <10% since 1992 (Figure 9). Because of this, fewer fish are needed to maintain program goals, so more fish can remain in the river to spawn naturally.

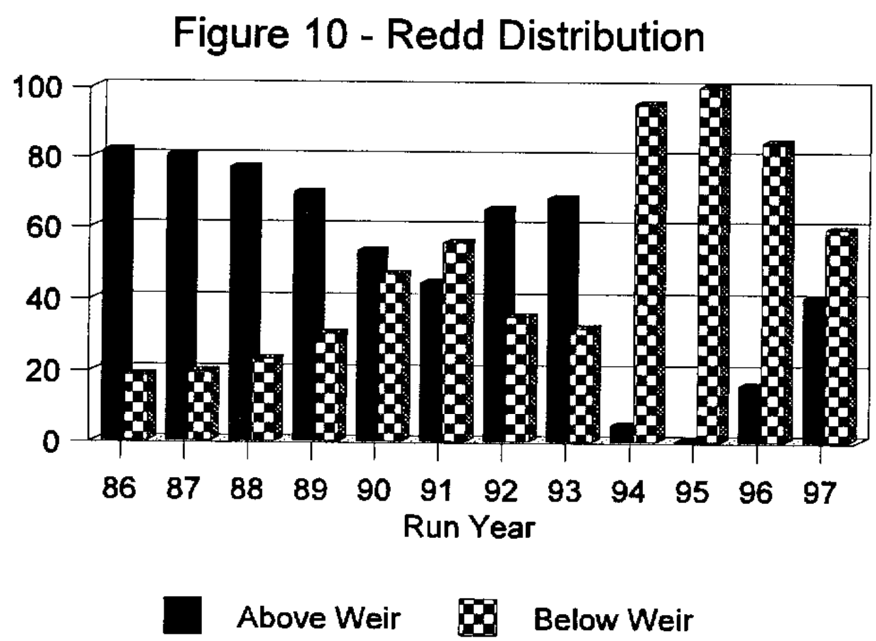
While we have improved the pre-spawning loss in the hatchery, we've observed an increase in the pre-spawning loss of fish are left in the river to spawn naturally (Figure 9). In 1992, 1993, 1996 and 1997, we documented a minimum of 15-20% pre-spawning loss in the river based on the number of fish passed and recovered upstream of the weir. We believe pre-spawning loss could be as high as 30% in some years. The majority (75-80%) of this pre-spawning loss has been attributed to "headburns", a condition which is linked with high spill rates on the Columbia and Snake River dams.

Figure 9 - Percent Pre-spawning Mortality



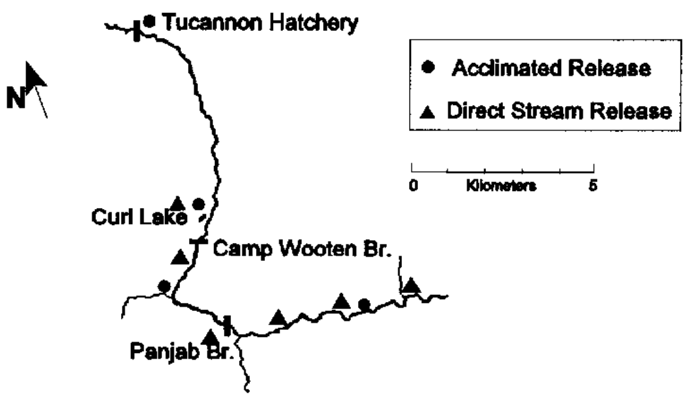
In 1994 and 1995, runs to the Tucannon River were predicted to be very low (<100 fish). The question arose as to whether we should collect fish for the hatchery broodstock, or pass all fish for natural spawning. Based on the parent to progeny survival rates between the hatchery and wild fish (4:1 advantage for hatchery fish), and high pre-spawning loss in the river in 1992 and 1993, it was decided to collect all returning fish for the broodstock, with the knowledge that a portion of each years run (typically 30%) remains below the weir and spawns in the river. Severe flooding in the Tucannon River in 1996 and 1997 nearly eliminated all natural production from the 1994 and 1995 brood years, and severely impacted the 1996 brood year as well. Because of our extreme intervention with the hatchery program, we preserved fish from those brood years to aid in our recovery efforts.

The most substantial change in the program has occurred with our concerns over the spawning distribution of fish in the river, and its relation to the best habitat. We've documented a shift in where the majority of spawning is occurring. The majority of spawning occurs in areas below the Tucannon Hatchery where poorer quality spawning and rearing habitat exist, possibly compromising survival. Many factors have influenced the spawning distribution: 1) the weir and trap may delay or cause some fish to remain below areas they were trying to reach, 2) broodstock collection has "mined" potential spawners from the upper river, 3) juvenile releases of hatchery fish historically occurred at Tucannon Hatchery and returning hatchery fish are homing in on the hatchery effluent, and 4) pre-spawning losses of fish above the weir may be higher than below the weir. All of these have contributed to the shift in spawning distribution (Figure 10). To rectify this potential problem, we've modified our juvenile releases, and have been evaluating the success of these modifications through smolt trapping, PIT tagging, and eventually adult returns.



Our first attempt in 1993 was with juvenile releases in the fall of the year. We had hoped by doing this fish would acclimate to the area of release (in the upper watershed), become more "wild" and potentially survive better. However, through our smolt trapping efforts, we estimate about 7% survived the winter to migrate in the following spring. Because of the poor success, we felt we needed to hold the fish over the winter in the safer hatchery environment, and acclimate them to upstream locations in the spring. Small ponds were set up in remote upstream locations to provide 2-3 weeks acclimation time (Figure 11). Limited capacity of the ponds also forced us into direct stream releases as well. Returns from the 1995-1997 releases are not complete yet,

Figure 11 - Acclimated / Direct Stream Releases



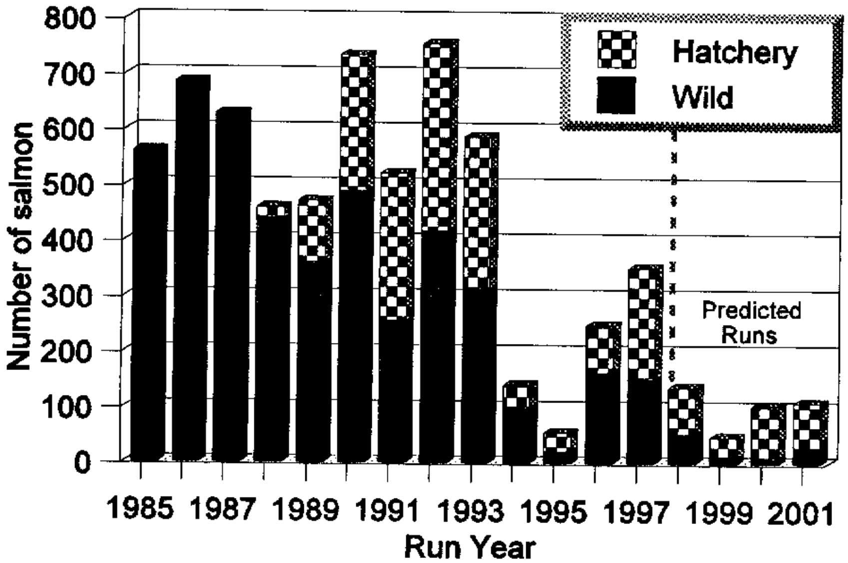
but PIT tag detections at downstream dams have identified the best release location. Release from the Curl Lake site (acclimated or direct) have the best detection (relative survival) rates, even better than fish released from Tucannon Hatchery.

With the removal of hatchery steelhead from the Curl Lake acclimation pond because of the recent ESA listing of Snake River summer steelhead, we will now utilize the 2.1 acre pond for acclimating juvenile chinook, instead of the small ponds. A small group of fish will still be released from Tucannon Hatchery until we evaluate the success of using Curl Lake for spring chinook.

In addition to moving juveniles into Curl Lake for acclimation, we are also conducting an experiment at Tucannon Hatchery before fish are released. Large circular ponds with directional flow (to increase velocities) are being used to "exercise" the fish before release. We've observed our juvenile releases over the last few years and have documented the hatchery fish having difficulty in adjusting to the current in the river. Many of the hatchery juveniles are badly descaled and injured by the time they reach the smolt trap. We hope this "exercise" will improve their swimming performance. Covers on the ponds are also being used to train the fish to use the natural cover in the river once the are released.

From the inception of the program in 1984 until 1993, the program was operating with supplementation goals and ideas to meet mitigation goals. With the low escapements since then, we shifted to conservation of the stock with the hope of eventual recovery, using supplementation as the tool to achieve this. Future run predictions for the Tucannon stock do not provide much positive outlook, and has raised the issue of starting a captive broodstock program to aid in recovery (Figure 12). We fully realize that captive brood will not recover the population on it's own. We hope that identified problems in the system survival, habitat within the Tucannon and mainstem passage for adults and juveniles, can be improved to the point that the wild population will be able to sustain itself with limited hatchery intervention. The current hatchery program is vital if we hope to maintain and recover the Tucannon stock. However, until changes can be made, we will continue to modify the hatchery practices to lessen any adverse affects the hatchery program may have on the wild population.

Figure 12 - Future Predictions



Questions and comments

You showed some data about egg-to-smolt and smolt-to-adult survival for your wild characteristic fish, said Tim Whitesel -- how did you generate that information? Also, what were the respective length frequencies for your 10-to-the-pound and 15-to-the-pound release groups? In answer to your first question, Bumgarner replied, those survival estimates were based primarily on smolt trapping estimates. Our estimate of egg numbers is based on redd counts, estimates of the number of spawners, both hatchery and wild, as well as fecundity estimates based on our hatchery females, he added. In response to Whitesel's second question, Bumgarner said CVs typically run somewhere around 13 or 14.

You mentioned the possibility that reducing the number of steelhead might improve the survival of your chinook smolts, said David Arthaud of CRITFC -- how many of the 86,000 pounds of rainbow trout produced by the Lower Snake Compensation Plan hatcheries are stocked into the Tucannon? In the last couple of years, rainbow trout releases have been limited to 4,000 total fish, Bumgarner replied, which is down from about 15,000 fish in previous years.

I had a question about your analysis of the influence of the weir on spawner distribution, said Carmichael -- did you take into account the influence of removing broodstock on redd abundance above the weir? No, Bumgarner replied. However, my conclusion would still be that the weir has had an effect -- we have seen a definite shift in our spawning distribution. Have you considered the possibility of modifying the weir to make it a more fish-friendly structure? asked Becky Ashe of the Nez Perce Tribe. Actually, we have a new trapping facility at the hatchery, which will be used for the first time this year, Bumgarner replied -- our engineers think it will work very well, and I guess we're about to find out. Frankly, the temporary weir we have been using was just a bad design, which never worked very well.

Do you have an estimate of the number of wild natural spawners that have been removed from this stream over the last ten years to supply this hatchery program? Arthaud asked. Since 1991, we have been allowed to collect 100 fish total annually for use in the broodstock program, Bumgarner replied -- that's 50 wild and 50 hatchery fish. During the 1980s, that figure sometimes went as high as 165 fish.

Upper Salmon River Spring Chinook Salmon

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Upper Salmon River spring chinook salmon are a very unique population of salmon. These fish represent the furthest migrating chinook salmon in the lower 48 states, with their spawning/nursery grounds located more than 900 river miles from the ocean. Also, spawning and nursery habitat for these fish is located at over 6,000 feet above mean sea level. The LSRCP program for spring chinook salmon in the upper Salmon River basin consists of the Sawtooth Fish Hatchery and its East Fork Salmon River satellite facility (Fig. 1). The hatchery, located near the town of Stanley, Idaho, was completed and the facilities became operational in 1985. The East Fork Salmon River satellite facility serves only adult trapping and spawning functions for chinook salmon, all rearing is performed at Sawtooth Fish Hatchery. The hatchery program provides in-kind mitigation for spring chinook salmon losses associated with the construction of the four lower Snake River hydroelectric projects.

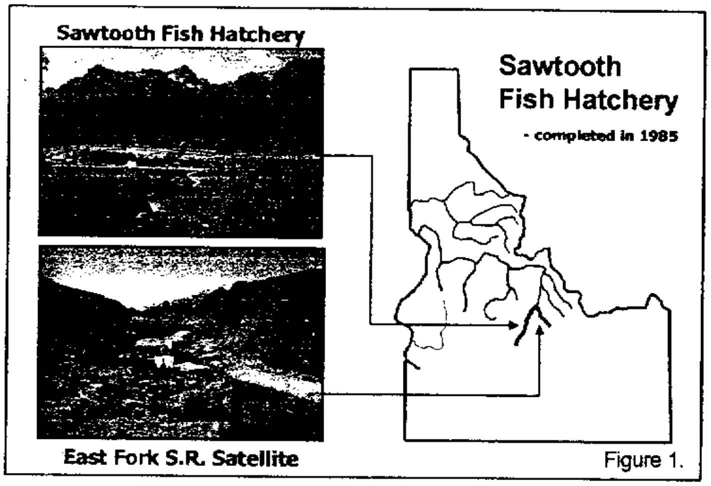

Figure 1.

Sawtooth Fish Hatchery consists of typical incubation and rearing facilities. Incubation and early rearing is performed indoors utilizing pumped well water. Final rearing, to fish release, is done in outside raceways utilizing raw river water. The outside raceways measure 12 feet wide by 200 feet long.

Production models used to identify facility needs included an assumed smolt-to-adult (SAR) survival rate of 0.87%, which was applied to the annual adult return goal of 19,445 adults to determine needed juvenile rearing capacity. The adult return goal is specified as fish returning to the LSRCP project area, above Lower Granite Dam. Annual salmon smolt production capacity at Sawtooth Fish Hatchery is 2.98 million smolts at 20 fish per pound or 2.3 million smolts at 15 fish per pound. Initial facilities-operation planning identified 1.3 million smolts to be released at Sawtooth Fish Hatchery (11,310 adult return at 0.87% SAR), and 700,000 smolts released into the East Fork Salmon River (6,090 adult return). The remaining 300,000 smolts, for a total annual release of 2.3 million, were to be released in Valley Creek in the upper Salmon River basin and the Yankee Fork Salmon River.

Natural production of chinook salmon in the upper Salmon River basin has declined substantially over the past three decades. From 1958 to 1962 an average of 481 redds was counted annually in spawner index areas upstream of Valley Creek (Fig. 2) (Valley Creek enters the main Salmon River at the town of Stanley). Tributaries to the Salmon River in the upper basin provide additional spawning and rearing habitat; annual spawner escapement to these areas is not included in the index area redd counts. During the period 1979 to 1983 an average of only 93 redds was counted annually in spawner index areas, and by the period 1993 to 1997 an average of only 33 redds was counted each year. In addition to supporting natural spawning, adult escapements through the mid- to late 1970s supported substantial harvest opportunities. From 1970 through 1978 sport harvest in the Salmon River ranged from 400 to 2,260 chinook salmon annually. Not all of the fish harvested were destined for the upper Salmon River basin, as numerous stream miles down stream of the town of Stanley were open to fishing. No chinook salmon sport fisheries have occurred on the Salmon River or its tributaries (excluding the Little Salmon and South Fork Salmon rivers) since 1978.

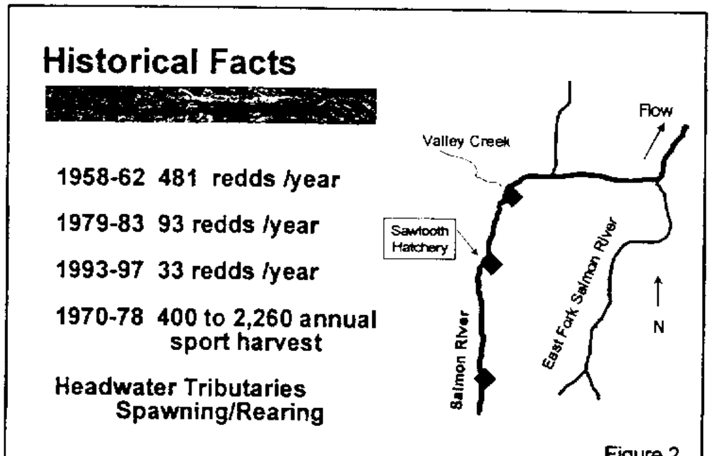

Figure 2.

Brood stock development associated with Sawtooth Hatchery was initiated in 1980 with the release of 168,000 smolts near the current hatchery site, and in 1981 230,550 smolts were released (Fig. 3). Both of these releases were from upper Salmon River stock. These fish were reared at McCall Fish Hatchery (Sawtooth Fish Hatchery was not completed until 1985) before being released into the upper Salmon River. During the late 1970s Rapid River stock juveniles were released into the East Fork Salmon River and upper Salmon River in response to severe declines in adult escapement (Fig. 4). It is not known what adult escapement to the upper Salmon River or East Fork Salmon River resulted from these releases. Since completion of Sawtooth Fish Hatchery and trapping facilities at the hatchery and on the East Fork Salmon River, only local brood stock has been used for the respective programs.

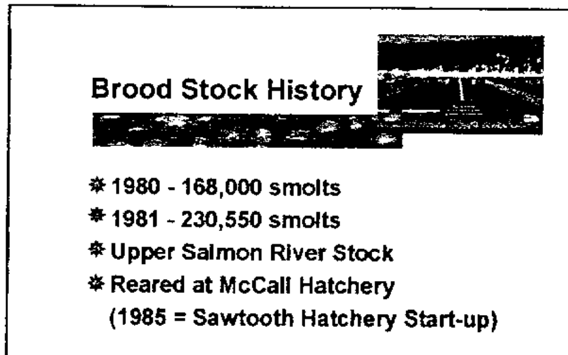

Figure 3.

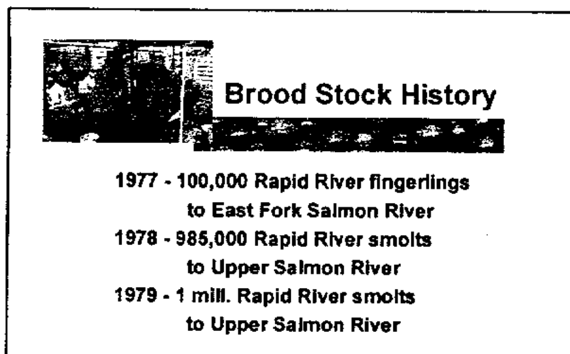

Figure 4.

Green egg to smolt survival rates for salmon reared at Sawtooth Fish Hatchery are shown in Figures 5 and 6. The 70% survival target shown is not a hatchery management goal, but rather is the value used in the original production model to identify facility needs. It is included here for reference. Egg to smolt survival for brood years 1981 through 1984 represents rearing at other facilities prior to completion of Sawtooth Fish Hatchery. Beginning with brood year 1985 rearing of upper Salmon River stock (Fig. 5) and East Fork Salmon River stock (Fig. 6) at the Sawtooth facility, egg to smolt survival has been quite high and stable. The low egg to smolt survival for brood year 1992 was the result of an out break of fuzzy tail disease. Attempts to duplicate this disease outbreak were unsuccessful. The cause of the outbreak remains unknown and the disease has not been observed in subsequent brood years. Hatchery management practices and research activities will continue to seek survival improvements. However, substantial increases are unlikely since survival is continuously high, especially as measured from the green egg stage.

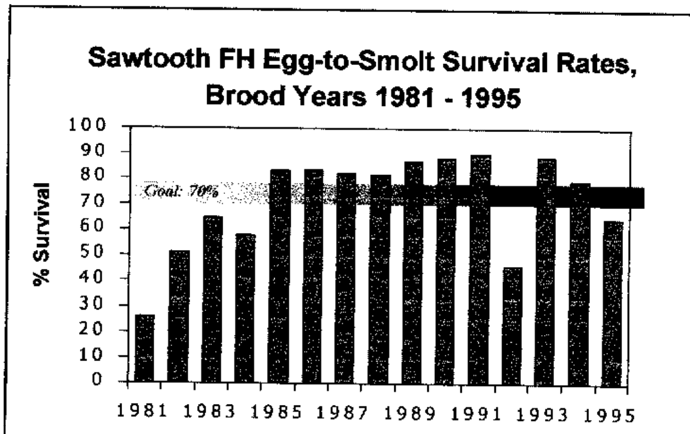

Figure 5.

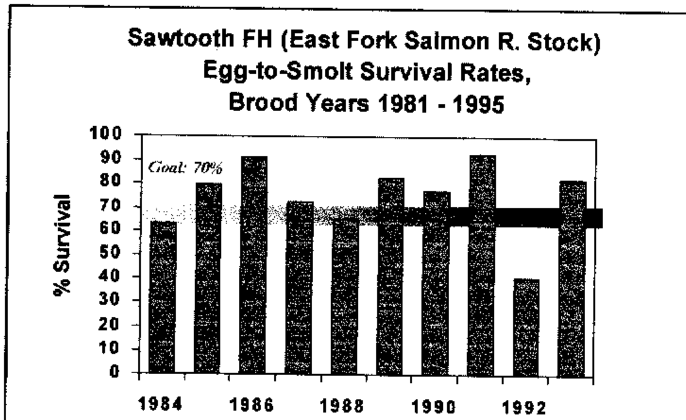

Figure 6.

Smolt releases into the upper Salmon River reached or exceeded the target release number for only three brood years since hatchery start-up (Fig. 7). Releases shown in Figure 7 for brood years prior to 1985 are upper Salmon River stock that were reared at McCall Fish Hatchery.

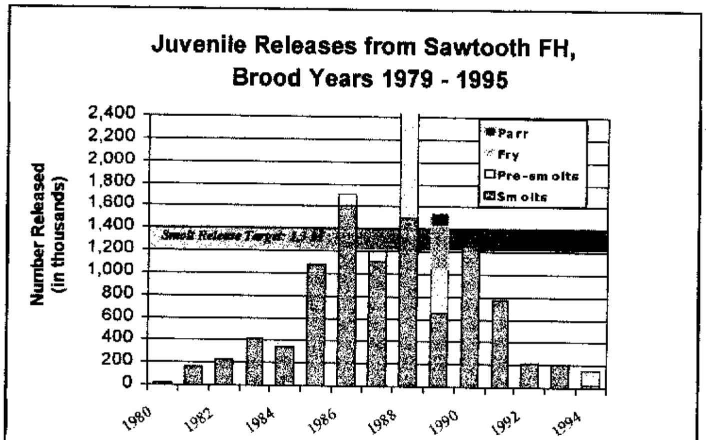

Figure 7.

Initial brood stock management plans, for both upper Salmon River stock and East Fork Salmon River stock, specified using up to one-third of the returning natural origin fish for hatchery brood stock. Since 1991, adult returns have been insufficient to meet hatchery egg-take goals. In 1994 a total of only four females were captured at the hatchery rack; two were hatchery-origin adults that were spawned and produced 4,000 smolts. Smolt releases of East Fork Salmon River stock have never achieved the target release number (Fig. 8). Since the inception of the hatchery program on the East Fork Salmon River, adult returns have been too low to meet the egg-take goal. No fish were trapped for hatchery brood stock from 1994 to the present. A captive rearing program was initiated for the upper East Fork Salmon River natural population in response to the critically depressed status of the population. Naturally produced fish from brood years 1994 and 1996, collected as juveniles, are currently being reared for this program.

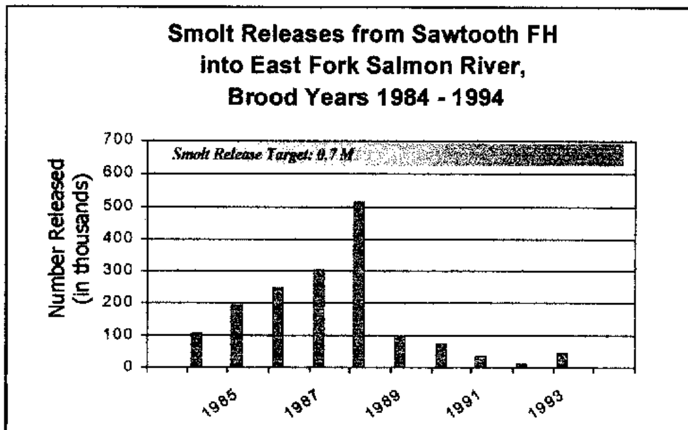

Figure 8.

A relative measure of "performance" of juveniles released is detections of PIT-tagged fish at downstream dams. The data points plotted in Figure 9 represent the cumulative proportion of PIT-tagged fish that were detected. These proportions detected provide an estimate of the minimum proportion of fish released that reached the first dam (Lower Granite).

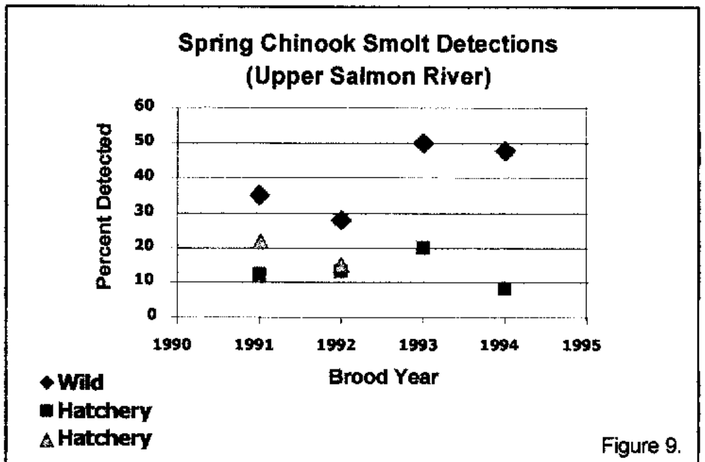

Figure 9.

In Figure 9 cumulative detection rates for one or two groups of hatchery fish (squares and triangles) are shown for four brood years. Also shown are cumulative detections for wild summer chinook salmon juveniles (diamonds) tagged in the upper Salmon River. The detections of wild fish are included for general comparison only, since the detection rates reported have not been adjusted for arrival timing, fish guidance efficiency at the time of arrival, spill at the dams, etc. Therefore, absolute comparisons can not be made between the hatchery and wild fish within any year.

The detection rates shown in Figure 9 do provide year to year relative comparison of smolt quality and performance. It is important to note that to date, no good uniform measure of smolt quality has been developed. However, if we are concerned with the quality of smolts the first indication of a "bad" group of fish would be reduced egg to smolt survival. It was shown in Figures 5 and 6 that green egg to smolt survival has consistently been quite high, indicating good smolt quality.

Adult spring chinook salmon returns to the upper Salmon River weir and East Fork Salmon River weir combined, from hatchery releases, are show in Figure 10. The adult return goal has never been met; in the best years total returns to the two weirs combined were about 20% of the goal. It must be noted that the returns documented here are to the hatchery weirs, and that the compensation goal is to the project area - i.e. above Lower Granite Dam. However, no fisheries have occurred on these fish between Lower Granite Dam and the weirs. In some of the early years natural fish may be included in the estimated return, since they could not be distinguished from fish originating from the hatchery releases. Fallout below the weir, of fish returning from hatchery releases, is not included in the returns shown.

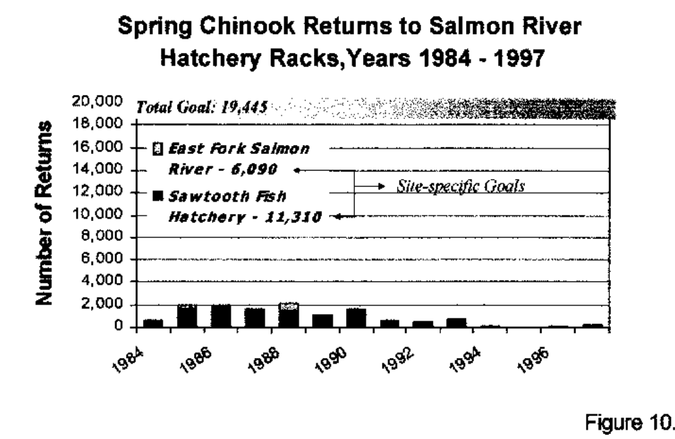

Figure 10.

The same returns shown in Figure 10 are again shown in Figure 11, except the y-axis has been expanded. Returns in the earliest years could not have been expected to achieve the return goal. For example, releases that would have contributed to the age 5 and age 4 returns in 1985 were 168,000 brood year 1980 smolts released in 1982 and 230,550 brood year 1981 smolts released in 1983 (Fig. 7). Releases for brood years 1985 – 1987 were near or exceeded the target number for release into the upper Salmon River (Fig. 7). However, it is clear in Figure 11 that the numbers of adults returning in 1989 – 1992 from these releases were far less than the return goal of more than 11,000 fish. Adult returns from these releases, measured at the hatchery weir, ranged from about 4% to 13% of the upper Salmon River adult return goal.

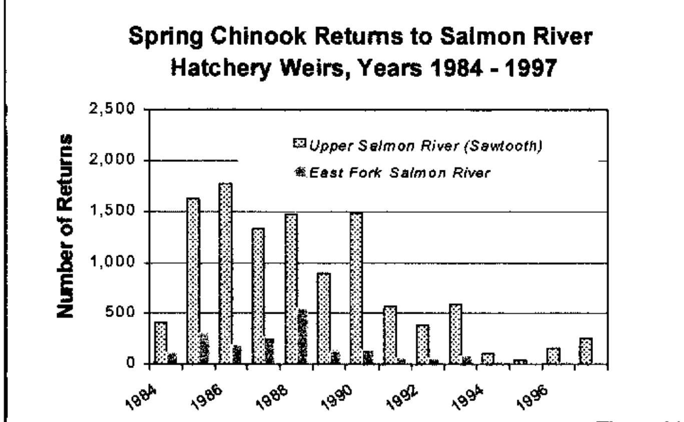

Figure 11.

To complete a performance appraisal for hatchery operation, two other measures are examined. The first of these is smolt-to-adult survival rate (SAR). The original facility development production model SAR was 0.87%. It is apparent in Figure 12 that this SAR has not been achieved (except for brood years 1980 and 1981) for releases into the upper Salmon River. The SAR necessary for replacement of

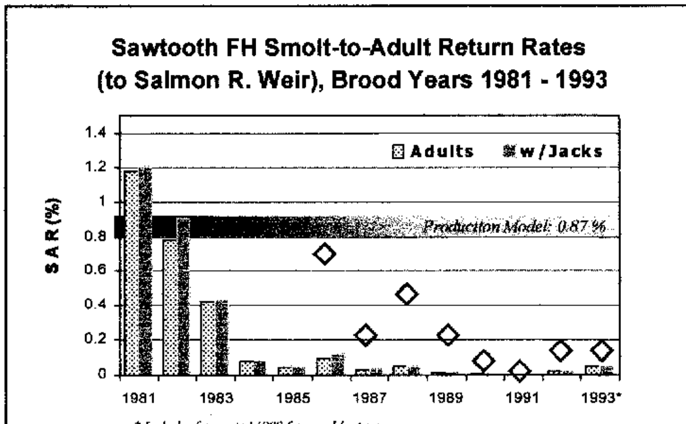

Figure 12.

hatchery brood stock is approximately 0.06%, and is a function of the high egg to smolt survival achieved in a hatchery. For comparison, the SAR necessary for replacement of wild spawners is about 0.6% (at 7% egg to smolt survival). The diamonds in the figure represent SARs for aggregate groups of wild Snake River chinook salmon (Russ Kiefer, IDFG, unpublished data). The SARs for wild fish also have been low and appear to trend in the same direction as SARs for the hatchery released fish. Smolt to adult return rates for releases made into the East Fork Salmon River are displayed in Figure 13. With the exception of brood year 1984, these SARs have consistently been less than the 0.06% necessary to achieve hatchery brood stock replacement.

Sawtooth FH Smolt-to-Adult Return Rates (to East Fork S.R. Weir), Brood Years 1984 - 1993

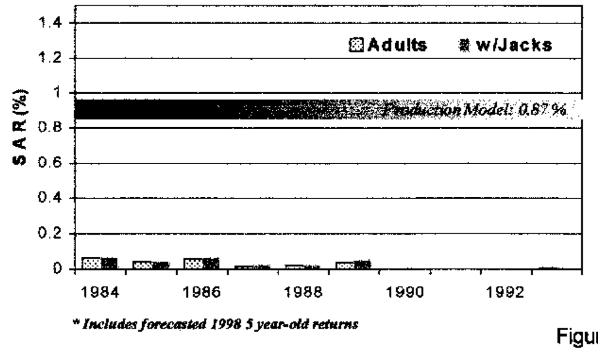

Figure 13.

The last measure in the performance appraisal of hatchery operations is progeny:parent ratios, an expression of the number of females returning for each female spawned to produce juveniles for release. Based on parameters used in the original production model, we estimate a progeny:parent ratio of about 14:1 to 16:1 was anticipated. The progeny:parent ratios incorporate the complete life cycle of events for the fish, which includes both in-hatchery and post-release survival. These progeny:parent ratios directly reflect the SARs shown in the previous figures. Progeny:parent ratios for upper Salmon River stock returning to Sawtooth Fish Hatchery are displayed in Figure 14 (note the divided y-axis). The ratios equaled or exceeded the replacement level for only those cohorts (brood years 1983, 1984, and 1986) when SARs also were above the replacement level. The moderately improved progeny:parent ratios for brood year 1993 are thought to largely be the result of better smolt out migration conditions in 1995 than in previous years. Progeny:parent ratios for East Fork Salmon River stock (Fig. 15) have been below replacement for all years of facility operation except brood year 1984 (note: brood year 1984 progeny had been incubated and reared at McCall Fish Hatchery prior to the completion of the Sawtooth facility).

Sawtooth FH Progeny:Parent Ratios for Female Returns to Upper Salmon R. Weir, Brood Years 1983 - 1993

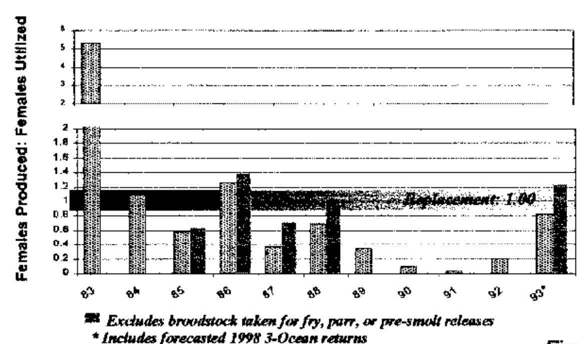

Figure 14.

The last two data slides (Figs. 16 and 17) examine the influence of hatchery weir operations in the upper Salmon River on spawner redd distribution and benefits to natural production. The number of redds observed each year is shown for two stream reaches (Fig. 16); from the mouth of the Yankee Fork Salmon River upstream to the mouth of Redfish Lake Creek (or the hatchery weir beginning in 1985), and from the mouth of Redfish Lake Creek (or the hatchery weir) upstream to the mouth of Alturus Lake Creek (affected by hatchery trapping and release operations).

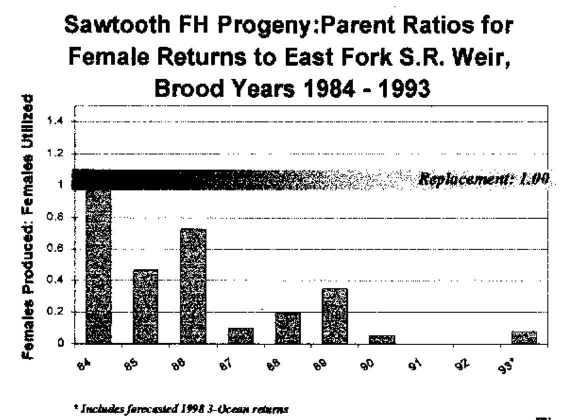

Figure 15.

The combined number of redds observed in these two index areas was generally stable from 1958 through the late 1960s. In the 1970s considerable inter-annual variation was seen in the number of redds observed. Also, the number of redds observed in the down stream of the two index areas, and the proportion of the total observed redds in the down stream index area (Fig. 17) declined. This decline occurred prior to the construction of Sawtooth Fish Hatchery and installation of the weir. Although the total number of redds counted annually in the two index areas has decline since the 1960s, it does not appear that annual brood stock management at the hatchery weir has affected spawner distribution, or caused the decline in the number of spawners passed above the weir. Resolution of the data in Figures 16 and 17 is not fine enough to show impact of hatchery fallout below the weir. Fish returning from hatchery releases that do not recruit back to the weir are more likely to spawn within one mile of the weir.

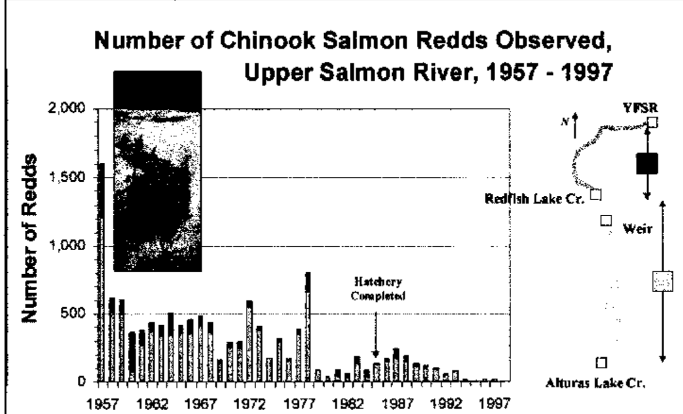

Figure 16.

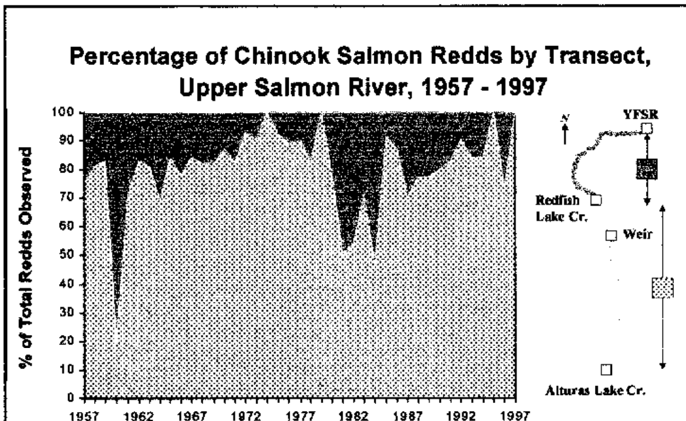

Figure 17.

A performance report card for the upper Salmon River spring chinook salmon compensation program was prepared. Performance in five areas is reported (Fig. 18). In-hatchery egg to smolt survival for both upper Salmon River stock and East Fork Salmon River stock has been consistently high. Smolt release targets have not been met, except for a few releases in the 1980s when sufficient adults were available to satisfy brood stock needs

Smolt survival from release to Lower Granite Dam is difficult to evaluate, since there are no targets or historical reference points. In, relation to wild fish (and based on detections of PIT-tagged fish), fish released from the hatchery are probably surviving to the first dam as well as can be expected. We will continue to monitor this performance measure.

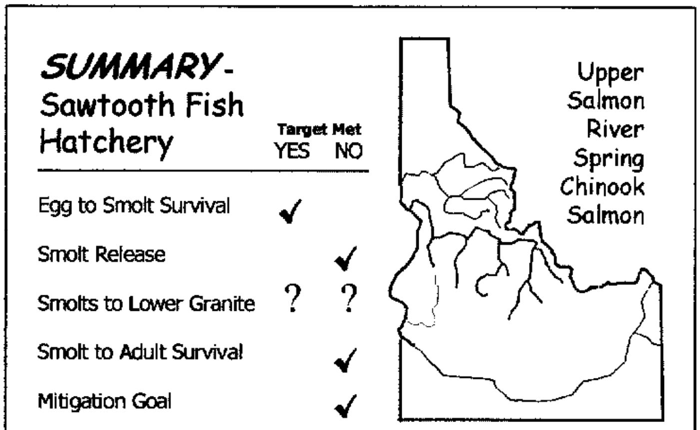

Figure 18.

Smolt-to-adult returns rates have consistently failed to achieve the production model target of 0.87%, and have been below the level needed for replacement in most years. There are no indications that this performance is due to hatchery operations or poor quality of the fish released. Similarly poor SARs have been documented for wild fish. Factors affecting SARs for these fish most likely operate outside of the upper Salmon River basin and hatchery environment. Poor survival through the lower Snake and Columbia rivers hydrosystem is considered to be the primary factor affecting fish survival.

The adult return compensation goal of 19,445 fish has never been met, and is most directly the result of the poor SARs exhibited. IDFG will continue efforts to improve in-hatchery performance. However, only small improvements can be expected, since in-hatchery survival and smolt quality is typically very good. These small improvements will not offset or overcome the extremely low SARs.

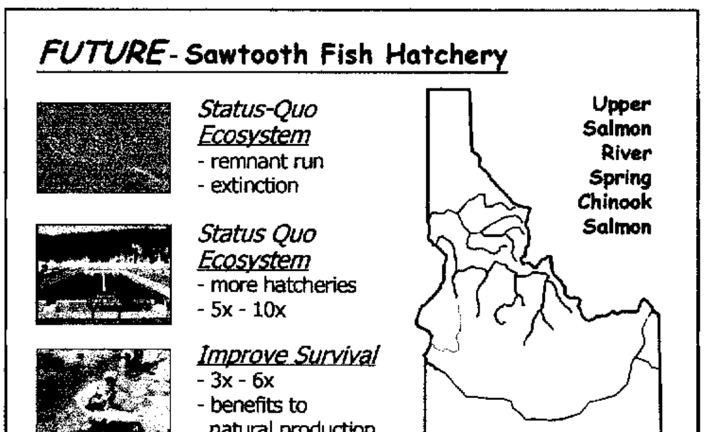

Figure 19.

Three possible avenues are seen for the future of this spring chinook salmon compensation program (Fig. 19). The first avenue - status quo ecosystem - assumes no changes to be made in hatchery operations or ecosystem management (e.g. hydrosystem operations). Under this scenario we can only expect that a remnant run would persist, or the wild and hatchery stocks may go extinct.

If changes necessary to improve smolt-to-adult survivals are not made and the desire is to achieve the compensation goal of 19,445 adults, seven (at 0.1% SAR) to 40 (at 0.02% SAR) additional 'Sawtooth hatcheries' could be constructed to provide for the release of another 19 to 97 million smolts. A major problem with this avenue is that more hatcheries will not stop wild stock extinction or ease restrictions or management under the Endangered Species Act. Also, insufficient numbers of adults return at the present time to provide eggs for these "new" hatcheries.

The third avenue is to implement changes that would improve smolt to adult survival to a level of 2% to 6%. Any survival increases will be realized by both wild and hatchery populations, benefiting both. The Idaho Fish and Game Commission believes that a normative river is the best biological route to meeting this survival level. The Commission and the Idaho Department of Fish and Game do not desire to manage remnant populations that provide no fishery benefits.

It is important to review these future management options to establish the current management framework (Fig. 20). The Idaho Department of Fish and Game's management focus is conservation and rebuilding of wild spring chinook salmon in the upper Salmon River basin. We are currently investigating, through a Bonneville Power Administration funded study, supplementation as a tool to rebuild the natural spawning population. While not meeting its compensation plan goal, the LSRCP-funded hatchery program plays an important role in management of upper Salmon River salmon. Adaptive hatchery management actions are implemented to respond to management needs of naturally produced fish in the upper basin. The supplementation research program utilizes some natural-origin adults as brood stock to produce juveniles for release, and the juveniles are reared in the hatchery. In addition to the supplementation fish, the general production (compensation program) brood stock is maintained to achieve the goal of the LSRCP program and provide fishing opportunity in the future. The general production fish are managed to provide a safety net or reserve should natural-origin returns become so critically depressed that recovery without intervention actions is unlikely. Operations planning and management of the hatchery program acknowledges the Idaho Department of Fish and Game's highest priority -- wild/natural stock conservation and rebuilding -- while continuing to support the facilities objective of compensating for reduced fish survival due to hydroelectric development and providing fishing opportunity.

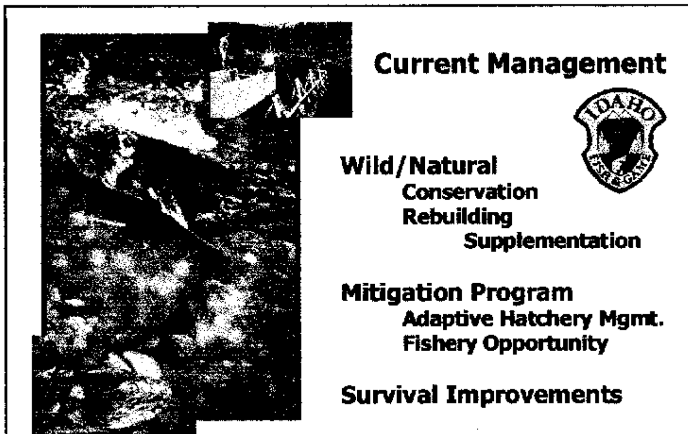

Figure 20.

Questions and comments

Mike Delarm of NMFS asked about the progeny replacement rates for the hatchery and wild stocks included in this program -- can you comment on whether or not you feel that the Sawtooth program has been a benefit, or a detriment, in terms of the total numbers of fish returning to your facility? It is very difficult to come to any conclusions about the benefit or detriment the Sawtooth Hatchery's activities may have had in that area, Hassemer replied. What I used for guidance was the wild production areas adjacent to Sawtooth Hatchery in the upper Salmon River basin, he said -- we have seen identical declines in wild fish abundance in those wild production areas that we have seen in the hatchery-influenced area above Sawtooth. In other words, Hassemer said, even in areas with no hatchery effect, we have seen the same decline. The survival benefit is manifested in higher numbers of fish coming back to the facility, he added.

Bowles said that, in the course of its permit application process in the early 1990s, IDFG did some analysis which showed that the number of adults returning to the Upper Salmon River is probably slightly higher as a result of the hatchery program than it would be if the hatchery program did not exist. It hasn't been possible to transfer that benefit into the natural production area above the weir due to lack of numbers, and because the program has never really gotten off the ground. He added that Sawtooth Hatchery is now being operated purely in a conservation, rather than in a production, mode.

STATUS REVIEW OF THE CHINOOK SALMON HATCHERY PROGRAM IN THE IMNAHA RIVER BASIN, OREGON

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INTRODUCTION

This paper summarizes a presentation given at the Lower Snake River Compensation Plan Status Review Symposium, February 4, 1998. We review the chinook salmon management program in the Imnaha River Basin for the period of time since the hatchery program was initiated in 1982 until the present. In addition, we provide an overview of our outlook for the future.

PROGRAM BACKGROUND

Historically the basin supported a healthy run of summer chinook salmon. Populations in the Imnaha River Basin have declined precipitously through the last three decades (Figure 1). Imnaha River chinook salmon were listed as threatened under the Endangered Species Act (ESA) in 1992. In the past, the basin supported tribal and recreational fisheries. The recreational fishery was closed in the mid 1970's and has yet to be reopened. The tribal fisheries have been severely curtailed or eliminated altogether in recent years.

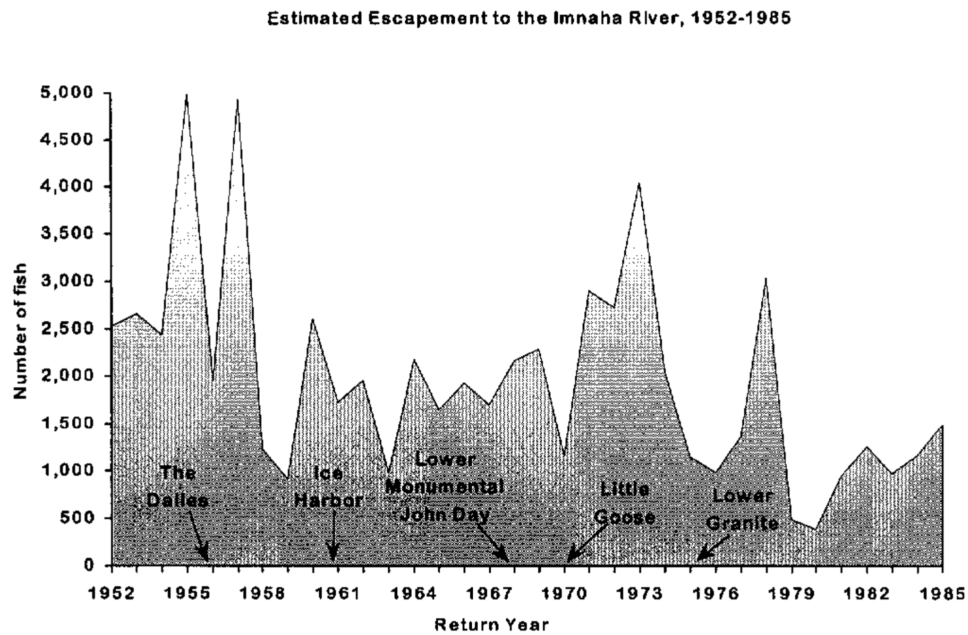


Figure 1. Estimated escapement of chinook salmon in the Imnaha River Basin, 1952-1985. Estimated number of fish based on redd counts from India Crossing to Mac's Mine expanded for variation in spawning in time and space.

The Imnaha River basin is located in the northeastern corner of Oregon (Figure 2). The basin drains 2,461 km^2 of the eastern Wallowa Mountains and the plateau between the Wallowa river drainage and Hell's Canyon of the Snake River. The watershed undergoes a change from alpine mountains at the headwaters to semiarid plateau in the lower river. The Imnaha River enters the Snake River at km 309.3. Eight dams reside between the Imnaha River and the ocean.

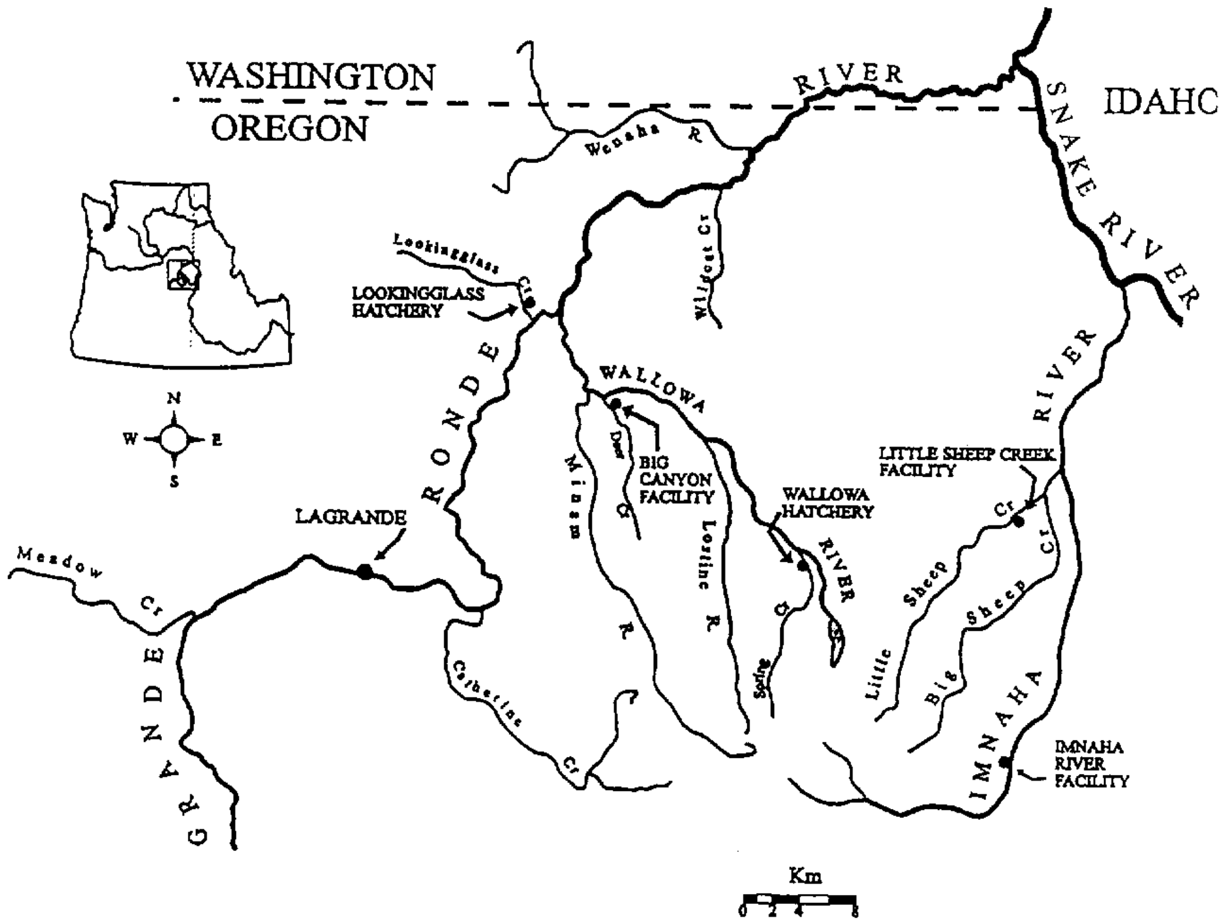


Figure 2. Map of the Imnaha River basin.

Historically chinook salmon spawned in Lick Creek, Big Sheep Creek, and the mainstem Imnaha River. In recent years, few fish have returned to Big Sheep or Lick creeks and spawning distribution is concentrated in 29 km of the mainstem Imnaha River from the Blue Hole downstream.

Four dams (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) were constructed in the Lower Snake River from 1961-1975. Following closure of the last dam, Imnaha chinook numbers declined rapidly. In response to the depressed status and steady declines, the Lower Snake River Compensation Plan (LSRCP) was initiated in Oregon. Compensation and production goals were established to compensate for the estimated annual loss of 48% of adult production (Figure 3).

Mitigation and Production Goals

Spring Chinook Salmon
Imnaha River Basin

490,000 Smolts

24,500 Lbs.

3,210 Adults

0.65% Smolt-to-Adult Survival

Figure 3. Lower Snake River Compensation Plan goals for spring chinook salmon in the Imnaha River Basin.

The implementation of the LSRCP Imnaha chinook salmon program has been guided by five primary management objectives (Figure 4).

Management Objectives

- **Establish an annual supply of broodstock capable of meeting production goals.**
- **Restore and maintain natural spawning populations.**
- **Re-establish historic tribal and recreational fisheries.**
- **Establish a total return number of spring chinook salmon that meets the LSRCP compensation goal.**
- **Operate the hatchery program so that the genetic and life history characteristics of hatchery fish mimic those of the wild fish, while achieving management objectives.**

Figure 4. Management objectives for spring chinook salmon in the Imnaha River Basin developed to guide implementation of the Lower Snake River Compensation Plan.

The Imnaha River facility is operated as a satellite of Lookingglass Hatchery, which serves as the primary production facility. A temporary adult collection and juvenile acclimation facility was operated in the Imnaha River from 1982-1988, and a permanent facility was constructed in 1989. The permanent facility utilizes a floating weir (since 1997) that directs fish up a stepped ladder into a trap. The juvenile acclimation pond is a rectangular concrete raceway that is supplied with Imnaha River water. Typically, adults are collected and transported to Lookingglass Hatchery where they are held and spawned. Lookingglass Hatchery serves as the incubation and rearing facility. Following rearing for about 14 months, smolts are transported back to the acclimation facility where they are held for one month prior to release. Direct stream releases have been made in some years for experimental purposes or when production levels exceeded acclimation pond capacity.

A comprehensive research, monitoring, and evaluation program has been underway since 1984. The program is designed to provide the essential information (Figure 5) needed to implement adaptive management to ensure achievement of management objectives and compensation goals.

Research and Evaluation Objectives

- **Estimate annual adult return, smolt migration characteristics, and smolt-to-adult survival.**
- **Evaluate the influence of various rearing strategies (size, acclimation, density) on smolt migration characteristics, smolt-to-adult survival, and age composition.**
- **Compare life history characteristics (age structure, run timing, sex ratios, smolt migration, fecundity) of natural and hatchery fish.**
- **Determine progeny-to-parent ratios of natural and hatchery origin fish to assess program effectiveness.**
- **Compare genetic characteristics of natural and hatchery origin fish (NMFS).**

Figure 5. Research and evaluation objectives for the Imnaha River Basin spring chinook salmon hatchery program.

STATUS REVIEW

The uniqueness of Imnaha River chinook salmon was recognized long before the hatchery program was started. This recognition led to a decision to use only the endemic stock as a broodstock source for the hatchery program. Wild adults were collected for broodstock beginning in 1982. Wild fish comprised a majority of the broodstock until 1989, when significant numbers of hatchery fish returned to the river. In recent years, the percent of fish spawned that were wild origin has been highly variable (Figure 6). The percentage of fish released above the weir to spawn naturally that were hatchery origin was low during the initial years of the program because of low abundance of hatchery fish and the emphasis on retaining fish for broodstock. Since 1990, the percentage has ranged from 31% to 77% (Figure 7). The percentage of wild fish captured that were retained for broodstock has varied considerably from a low of 17% in 1993 to 100% during the first three years of collection (Figure 7). During the first few years of trapping, the weir was installed late in the migration and therefore only late returning fish were obtained for broodstock. Currently, the weir is installed as early as physically possible; however, fish pass above the weir before installation.

Hatchery Broodstock History
Imnaha Spring Chinook Salmon

Brood year	Origin	# females spawned	% wild spawned (M&F)
1982	wild	10	100%
1983	wild	31	100%
1984	wild	11	100%
1985	wild	32	97%
1986	mix	59	98%
1987	mix	39	87%
1988	mix	92	82%
1989	mix	54	62%
1990	mix	74	43%
1991	mix	39	51%
1992	mix	114	18%
1993	mix	88	34%
1994	mix	22	35%
1995	mix	15	59%
1996	mix	24	71%
1997	mix	57	14%

Figure 6. Broodstock history for the Imnaha River spring chinook salmon hatchery program.

Natural Broodstock History
Imnaha Spring Chinook Salmon

Brood year	% hatchery above weir	% wild kept
1982	--	100%
1983	--	100%
1984	--	100%
1985	10%	79%
1986	6%	100%
1987	10%	50%
1988	15%	39%
1989	4%	41%
1990	47%	44%
1991	63%	39%
1992	77%	33%
1993	64%	17%
1994	54%	28%
1995	44%	100%
1996	31%	50%
1997	61%	30%

Figure 7. History of releases of hatchery fish above the Imnaha River weir and retention of wild fish for broodstock for the Imnaha River spring chinook salmon hatchery program.

Adult prespawn mortality and egg-to-smolt survival has been highly variable and relatively poor in some years (Figure 8).

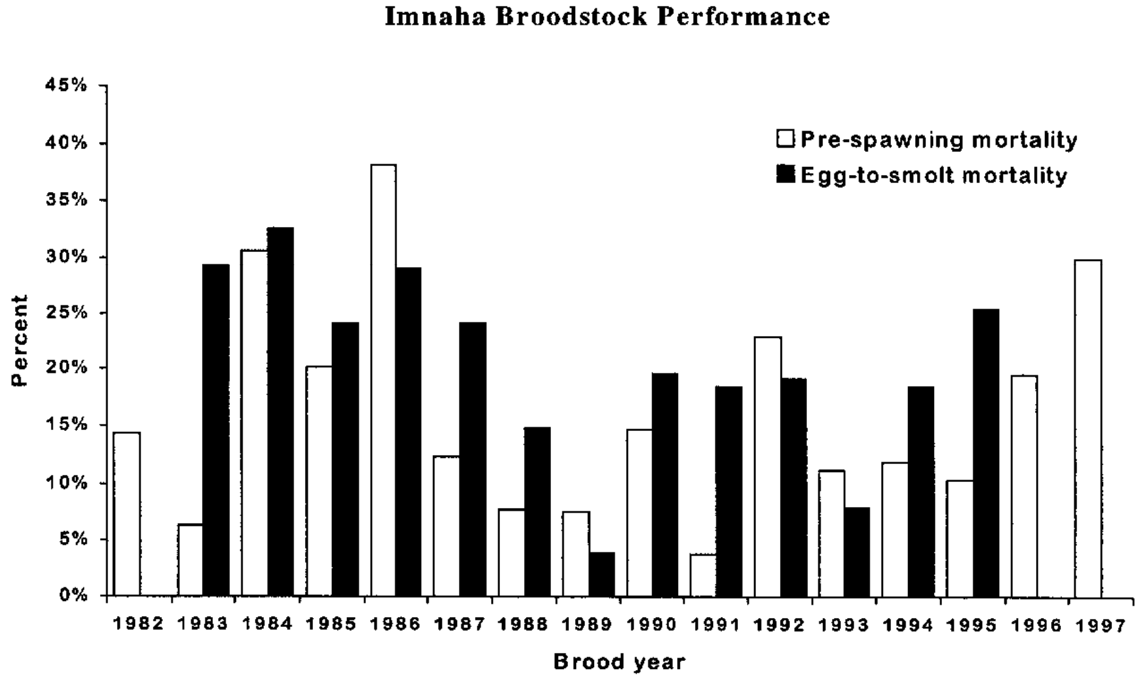


Figure 8. Pre-spawning mortality and egg-to-smolt mortality of Imnaha River spring chinook salmon.

Smolt production goals were not achieved in most years because of inadequate numbers of broodstock (Figure 9).

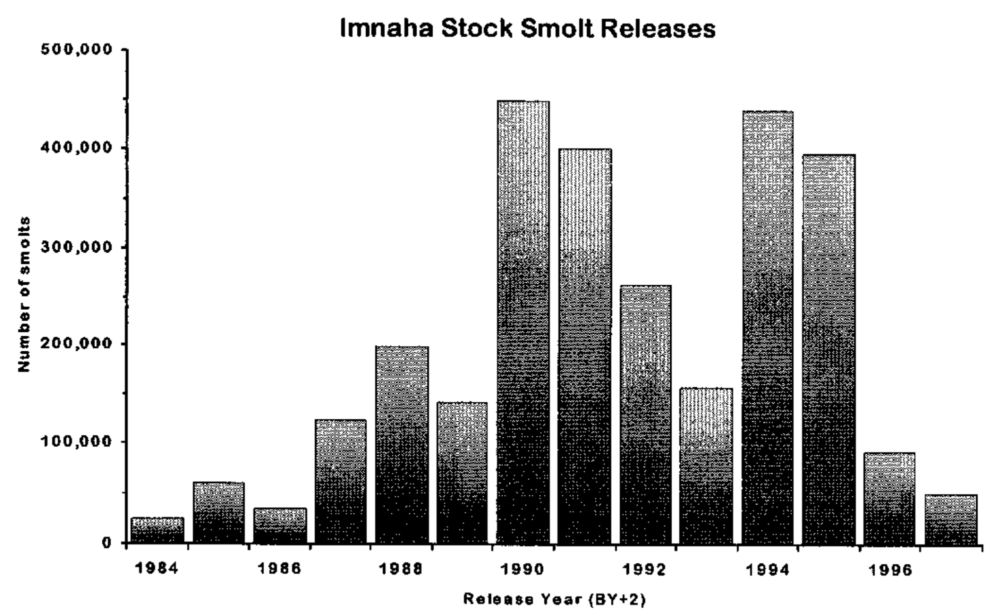


Figure 9. Summary of spring chinook salmon smolt releases in the Imnaha River Basin, broodyears 1982-1997.

Smolt-to-adult survival rates have been well below the goal of 0.65% in all years except for the 1988 broodyear (Figure 10). Imnaha chinook contribute little to ocean or in-river fisheries, as illustrated in the catch distribution profile (Figure 11).

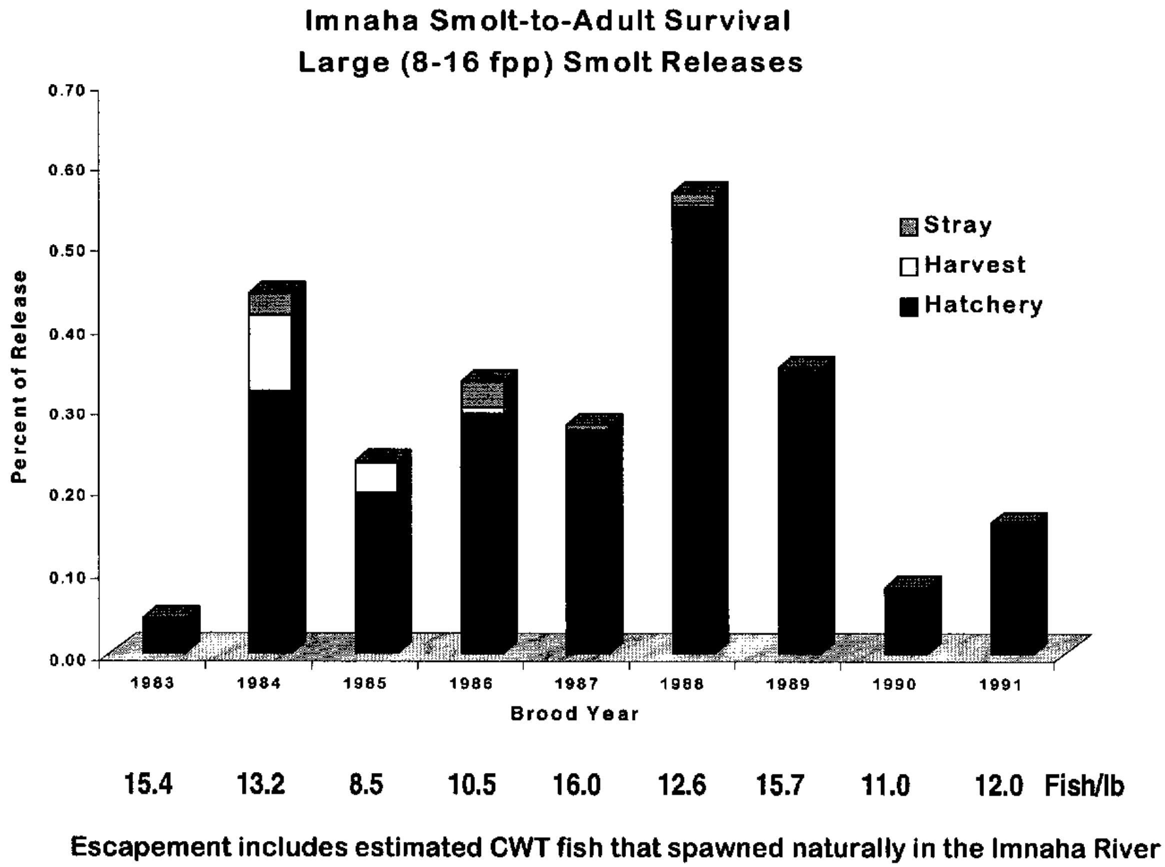


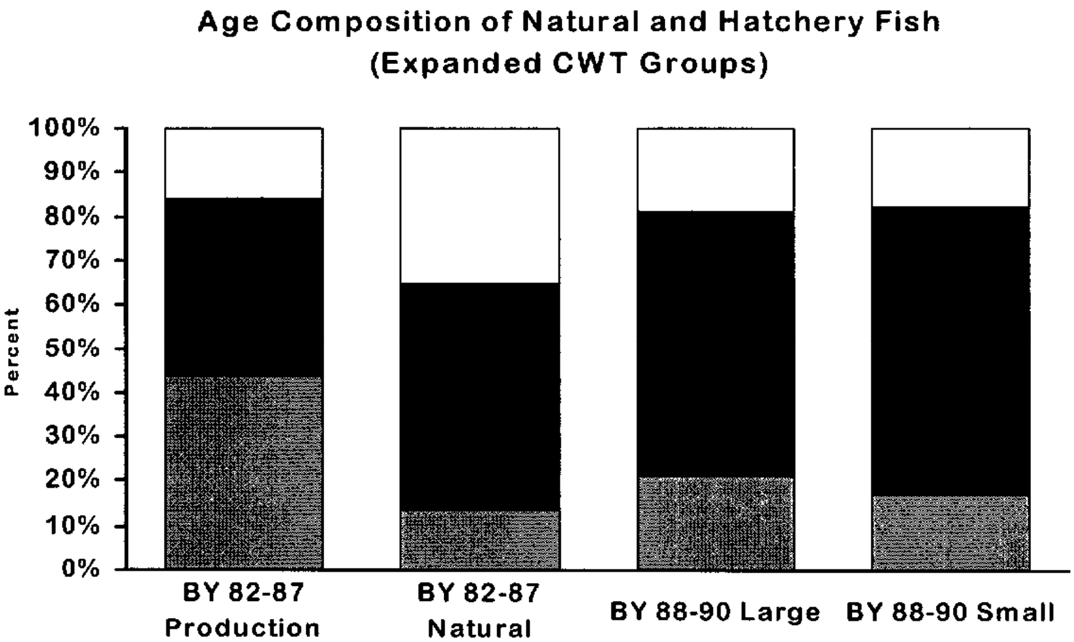
Figure 10. Smolt-to-adult survival rates of Imnaha stock spring chinook salmon smolts, broodyears 1983-1991.

Catch and Escapement (%) of Spring Chinook Salmon Released in the Imnaha River Basin

	Brood year			
	1988	1989	1990	1991
Ocean	0.7	0	0	0
Columbia River				
Treaty Net	0	0	0	0
Non Treaty Net	0.1	0	1.0	0
Sport	0	0	0	0
C and S	0	0	0	0
Test Fishery	0	0	0	0
Deschutes River				
Sport	0.3	0	0	0
Treaty	0	0	0	0
Strays				
Out Basin	1.7	0.8	3.8	0.9
In Basin	4.0	0.4	0	0
Escapement	93.3	98.9	95.2	99.1

Figure 11. Catch and escapement profile for Imnaha River spring chinook salmon produced at Lookingglass Hatchery, broodyears 1988-1991.

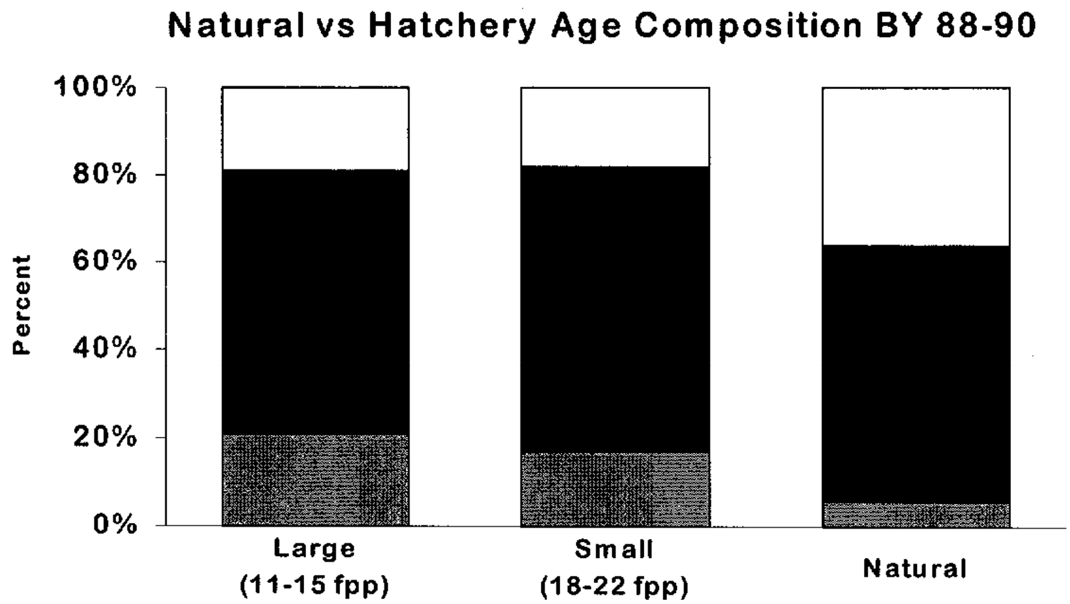
During the early years of production, hatchery smolts were released at a large size in comparison to the original target of 20 fish per pound and relative to the size of naturally produced smolts (≈35 f/lb). Age composition at return of adults produced from the 1982-1987 broodyears was substantially different than that of natural fish for the same broodyears. For the hatchery fish, age 3 males were the dominant component with few age 5 fish. In contrast, age 5 fish comprised an average of 35% of the returns by broodyear for the natural fish and the age 3 fish represented only 14% (Figure 12). Beginning with the 1988 broodyear, we began releasing smolts at a smaller size to evaluate the influence of size at release on survival and age at return.



	BY 82-87 Production	BY 82-87 Natural	BY 88-90 Large	BY 88-90 Small
□Age 5	16%	35%	19%	18%
■Age 4	40%	51%	60%	65%
▩Age 3	44%	14%	21%	17%

Figure 12. Age composition of hatchery and natural Imnaha River spring chinook salmon.

For smolts released at a smaller size in recent years, age-composition was more similar to age-composition of natural fish than were the earlier hatchery broodyears (Figure 13). Adult run timing to the weir hatchery fish was significantly later for hatchery fish than for natural fish during the mid 1980's. This was likely a result of collecting broodstock from the latest part of the return for the first few years of broodstock collection. Run timing of hatchery fish for the 1994-1997 return years was similar for hatchery and natural fish (Figure 14).



	Large (11-15 fpp)	Small (18-22 fpp)	Natural
□Age 5	19%	18%	36%
■Age 4	60%	65%	58%
▩Age 3	21%	17%	6%

Figure 13. Age-composition of natural and hatchery origin Imnaha River spring chinook salmon, broodyears 1988-1990.

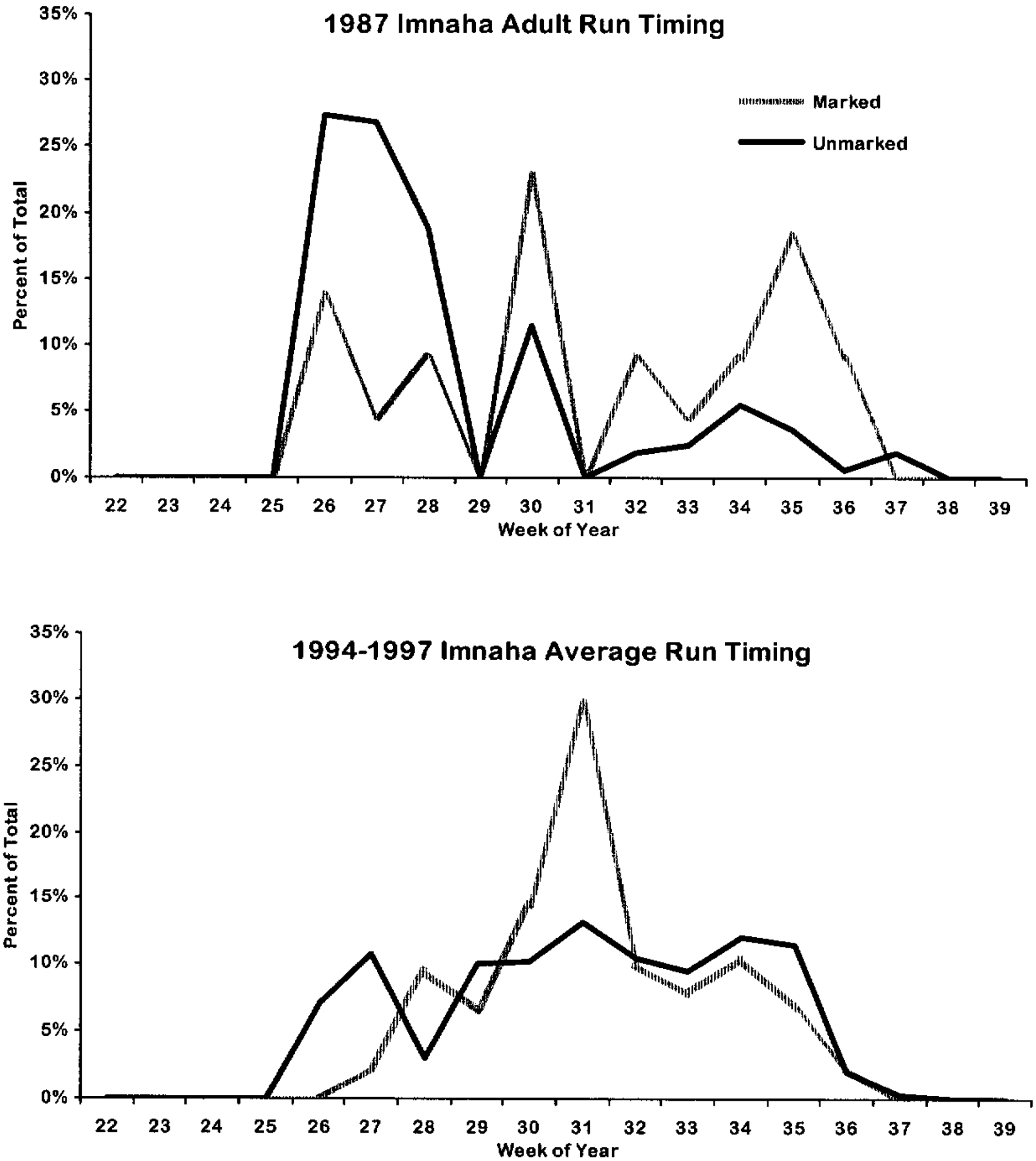


Figure 14. Adult run timing of Imnaha River spring chinook salmon at the Imnaha River weir, 1987 and 1994-1997 average.

One of the most important performance measures and comparisons we use to assess the effectiveness of our hatchery program is the progeny-to-parent ratios relative to replacement (1.0) and to the ratios for the natural spawning population in the Imnaha River. Progeny-to-parent ratios for the natural population have been well below 1.0 since 1983 and have been as poor as 0.2. In contrast, the hatchery progeny-to-parent ratios have been above 1.0 for all broodyears except 1990-1992. The average for the hatchery population is near 4.0, while the average for the natural population is less than 0.5 (Figure 15).

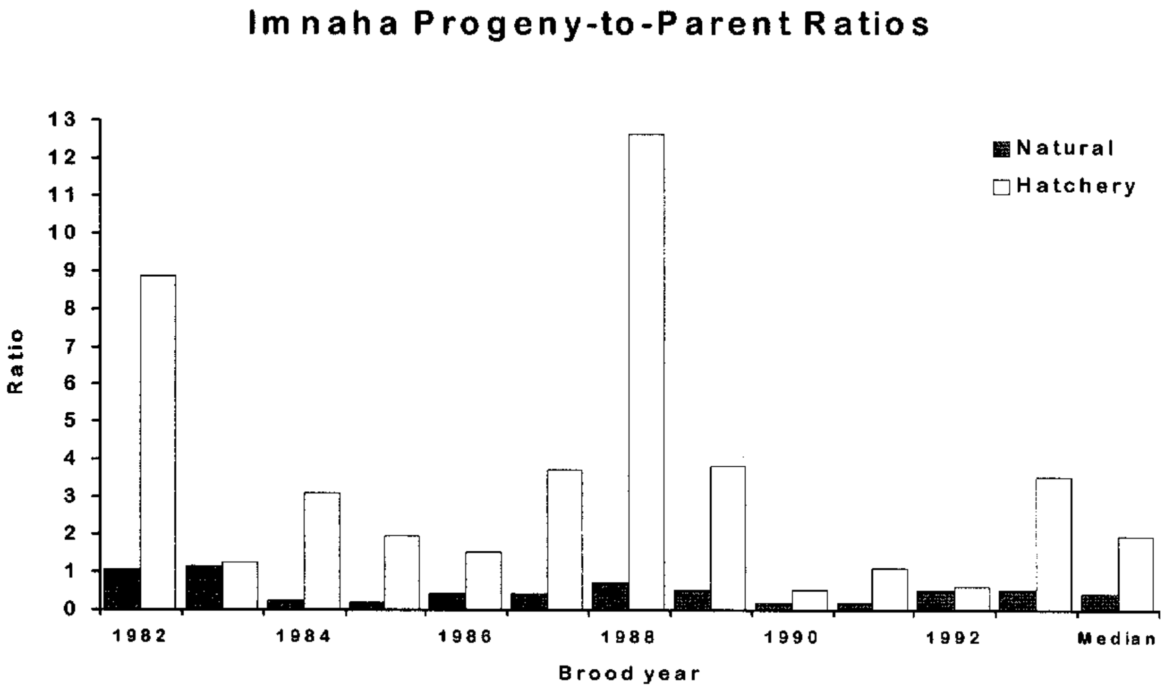


Figure 15. Progeny-to-parent ratios for natural and hatchery Imnaha River spring chinook salmon, broodyears 1982-1992.

Using the natural progeny-to-parent ratios, we conducted a without-hatchery simulation to estimate total escapement and natural escapement as if the hatchery program had never been operated. Our assessment indicates that there are far more fish returning to the basin with the hatchery program than there would have been without the hatchery (Figure 16). In recent years, there were substantially more natural spawners with the hatchery than there would have been without the hatchery (Figure 17).

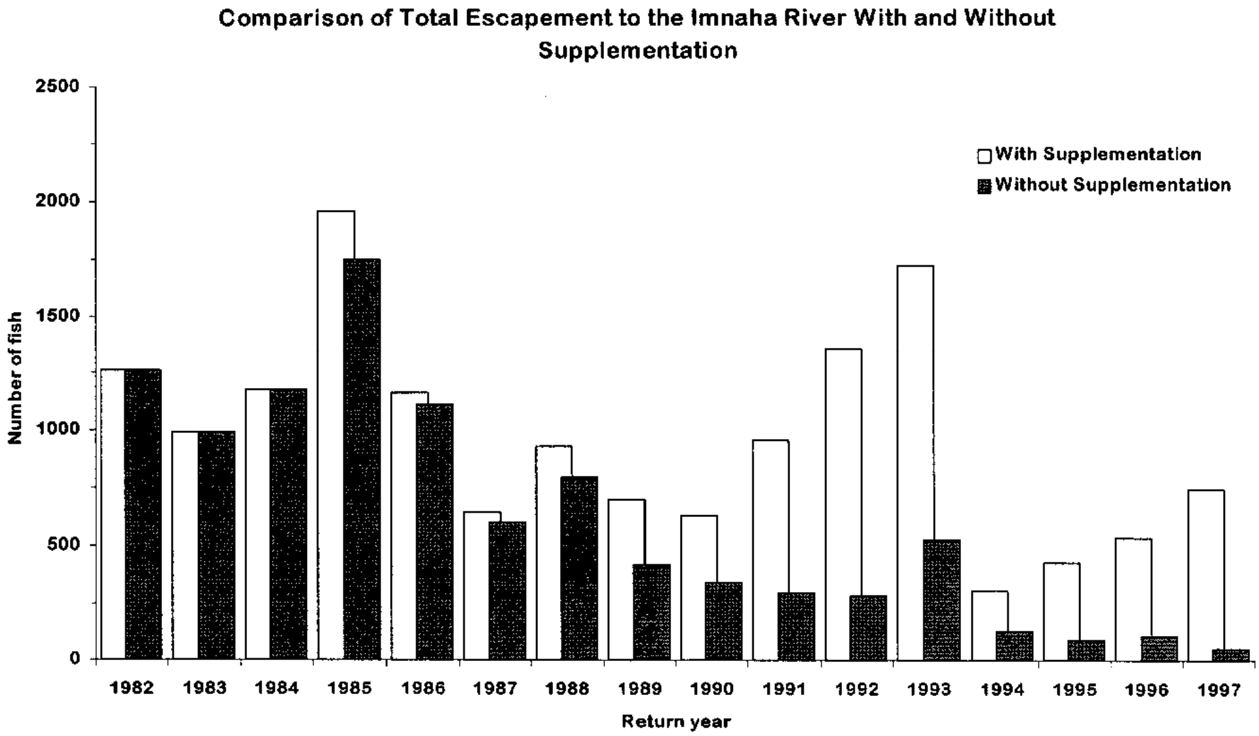


Figure 16. Comparison of actual total escapement to the Imnaha River with estimated escapement assuming the hatchery program had not beein in existence, return years 1982-1997.

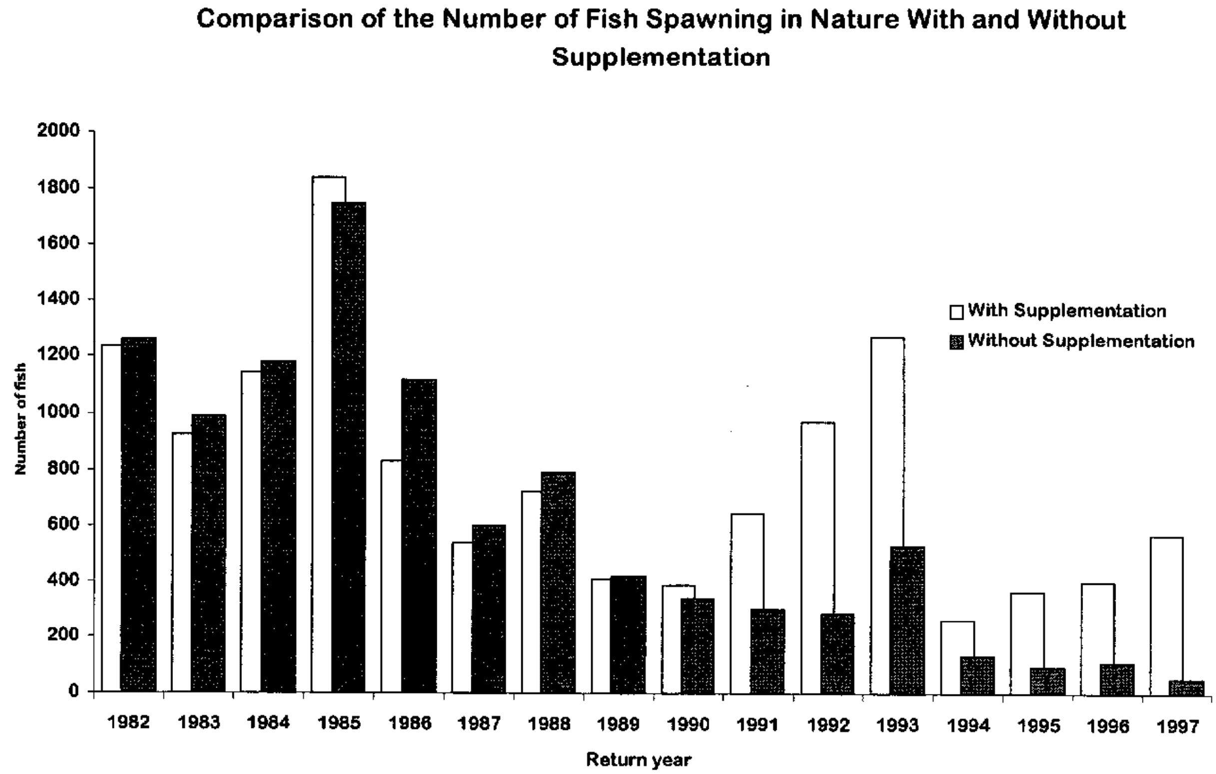


Figure 17. Comparison of actual number of natural spawners in the Imnaha River with estimated number of natural spawners assuming the hatchery program had not been in existence, return years 1982-1997.

We examined spawner distribution to assess whether there has been any trend toward increased spawning in areas directly above and below the weir. The proportion of total redds in river reaches directly above and below the weir has been highly variable since 1986. There does not appear to be any consistent increasing or decreasing trend in either reach. (Figure 18).

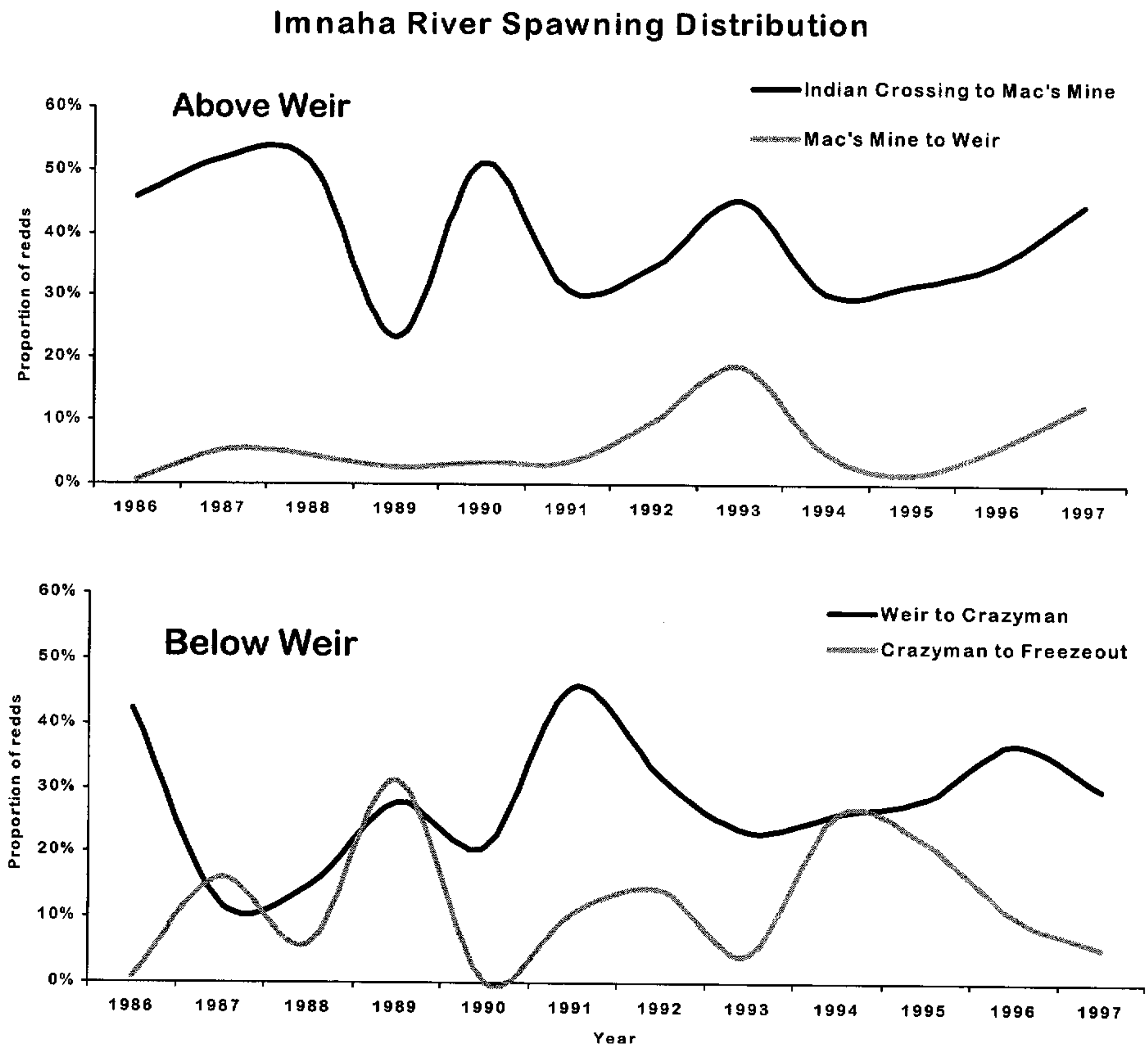


Figure 18. Distribution of spring chinook salmon redds in the Imnaha River above and below the Imnaha weir, years 1986-1997.

The monitoring and evaluation findings can be summarized as follows:

- High prespawning mortality and egg loss have influenced hatchery effectiveness for many broodyears, especially during the early years of operation, when temporary facilities were used on the Imnaha River.
- Poor smolt-to-adult survival for most broodyears has limited success. We have not achieved the original goal of 0.65% for any broodyear.

- We have not seen significant differences in life history characteristics between natural and hatchery fish, except in adult age-composition. Age-composition for the most recently completed hatchery broodyears is more like the natural age-composition than early hatchery broodyears.

- We have not seen any significant differences in genetic characteristics between natural and hatchery fish.

- Natural progeny-to-parent ratios have been consistently below replacement since the 1983 broodyear, while hatchery ratios have been above replacement for most years. Progeny-to-parent ratios of natural and hatchery fish for the three most recent completed broodyears were very poor.

- Although we have not seen a consistent increase in population size or number of natural spawners, we have seen a substantial hatchery benefit in reducing the rate of decline.

- Natural spawning distribution above and below the weir has been highly variable; however, there does not appear to be a shift toward more spawning near or below the weir.

The program has been successful in developing and implementing a viable broodstock management program using wild fish, maintaining life history characteristics, and providing a survival advantage which will result in a longer period of persistence for the Imnaha population. However, we have been unsuccessful in recovering the natural population to historic levels and restoring fisheries. The hatchery program has undergone a number of changes as a result of utilizing the adaptive management approach (Figure 19). We believe that the Imnaha program serves as a good example of how a hatchery program can be managed effectively under the adaptive management philosophy.

Adaptive Management

Program area	Original program	Present program
Production goals	490,000	Based on available broodstock and sliding scale up to 490,000 smolts.
Management objectives	Emphasized meeting hatchery mitigation smolt goal. We assumed we could have it all.	Balance the risk of hatchery and natural production. Emphasize genetic conservation and recovery.
Hatchery broodstock management	Kept most fish.	Keep a maximum of 50% of natural fish.
	Collected late in the run.	Attempt to collect across the entire run with new weir.
	Pooled gamete spawning.	Complex matrix spawning, maximize HxW crosses, use all broodstock.
	Limited disease treatment.	Aggressive BKD and fungus treatment.
Natural escapement above weir	Few fish passed above. No guidelines for % hatchery.	Pass 50% or more above the weir. Regulate % hatchery with escapement > 700 and above.
Rearing and release strategies	Reared at standard high densities	Low density rearing.
	Released large smolts	Medium and natural size smolts.

Figure 19. Synopsis of adaptive management changes made in the Imnaha spring chinook salmon hatchery program. Figure summarizes transition of objectives, guidelines, and operations from the original program to the present program.

OUTLOOK FOR THE FUTURE

Our outlook for the future contains both optimistic as well as pessimistic visions. It is clear that the greatest challenge for this hatchery program rests in the future.

- If hydro system survival improvements are not achieved, natural productivity will remain low and we will be unable to meet any long term management objectives. Only hatchery fish will return to spawn.

- We plan to implement a captive broodstock program if escapement levels to the river mouth drop below 300 for two consecutive years.

- We will begin evaluating Nature's type rearing at Lookingglass Hatchery and look for other ways to produce more natural like smolts and improve smolt-to-adult survival.

- We need better understanding of why natural productivity is so low and what level of improvement can be expected when passage improvement measures are implemented.

- We need to develop more precise and accurate methods to estimate returns. Better estimates are essential for effectively implementing the sliding scale management approach.

- Natural production, life history, hatchery effectiveness and genetics monitoring and evaluation must continue to provide information needed to assess program effectiveness and implement adaptive management.

- We need to design a better approach to evaluate the performance of hatchery fish in nature and the influence of hatchery fish on natural productivity.

- The Imnaha sliding scale management plan will serve as the guiding principle for hatchery and natural production management for Imnaha River chinook salmon (Figures 20 and 21).

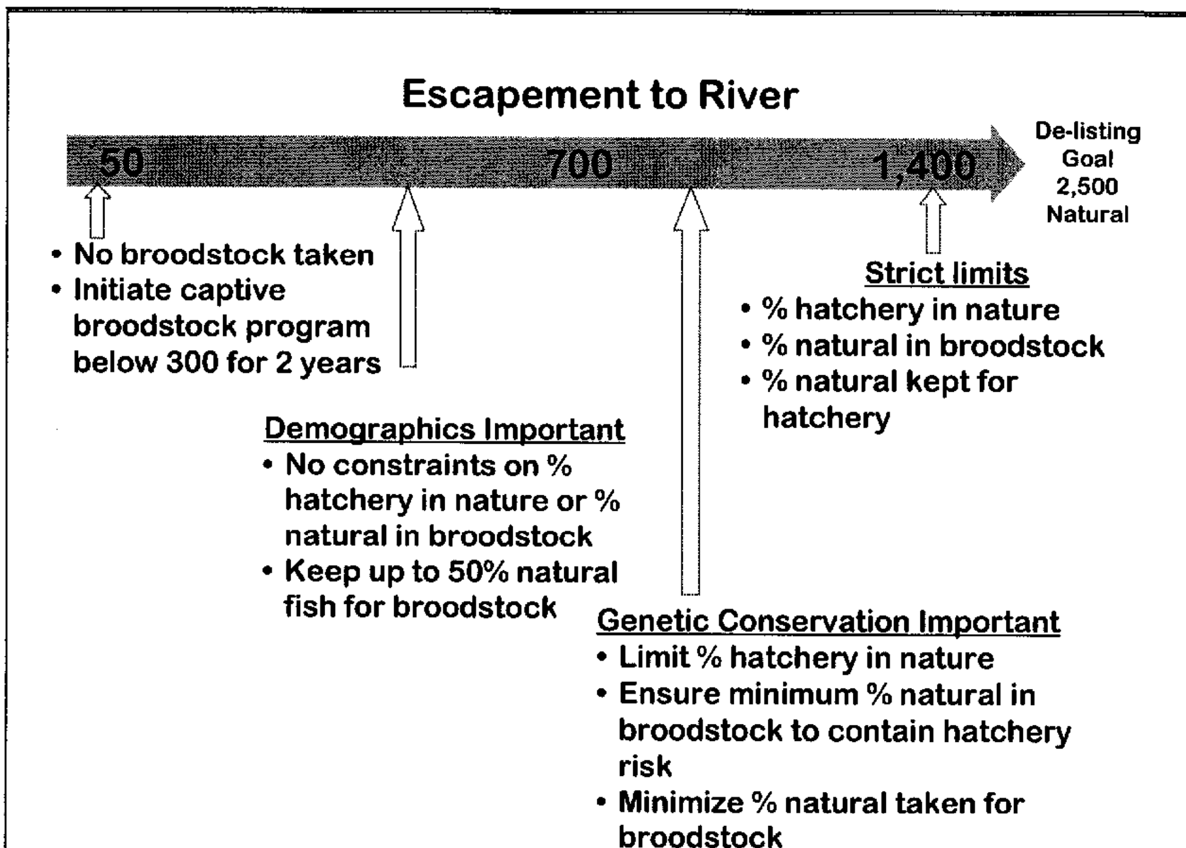


Figure 20. Sliding scale management framework for use of the hatchery program in the management and recovery of Imnaha River spring chinook salmon.

Imnaha Sliding Scale Management Plan

Escapement level	Maximum % retained for broodstock Natural	Maximum % retained for broodstock Hatchery	% hatchery above weir	Minimum % broodstock of natural origin
< 50	0	0	*a*	NA
51 - 700	50	50	*a*	*a*
701 - 1000	40	*a*	70	20
1001 - 1400	40	*a*	60	25
> 1,400	30	*a*	50	30

a A result of implementing other criteria.

Figure 21. Essential criteria for implementaion of the sliding scale management framework for Imnaha River spring chinook salmon.

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Questions and comments

Rich Lincoln asked about the statement that release sizes in this program were being managed to mimic natural phenotypic patterns – I guess I didn't really get a clear sense about the tradeoffs between managing for those characteristics vs. the demographic advantages of survival inherent in larger release sizes, he said. The targets we've established for our most recent size-at-release experiment include fish in the 25-per-pound range – within the natural range, Carmichael replied. The data we have to date on our 15-to-the-pound fish – our normal production size – suggests that it's a wash – the larger fish appear to survive at about the same rate as the smaller fish. However, survival for the two release groups isn't equal every year, Carmichael said -- we've seen considerable variability between years. In some years, the smaller fish survive better; in others, the larger fish survive better. At this point, our recommendation is to continue with both release strategies, because we don't know which will do better in any given year.

Emigration of Hatchery and Natural Chinook Salmon From the Imnaha River

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Introduction

This paper provides a synopsis of the presentation given at the Lower Snake River Compensation Plan Status Review Symposium held on February 3-5, 1998. We present information relating to the emigration characteristics and estimated survival of natural and hatchery chinook salmon.

Hatchery reared chinook salmon raised in an artificial hatchery environment obtain an early life history survival advantage over naturally produced juveniles that must incubate and rear in natal streams prior to smoltification. The estimated egg to smolt survival of hatchery reared chinook salmon is usually greater than 70%, compared to an estimated egg to smolt survival of 7.4% for naturally produced Imnaha River chinook salmon (Kucera - unpublished data). Once this early survival advantage is conferred upon the hatchery reared conspecific, we examined how do the smolts perform (emigrate and survive) in the natural environment.

The Nez Perce Tribe has been conducting emigration studies in the Imnaha River subbasin since 1992 to examine a number of project objectives relating to natural and hatchery chinook salmon and steelhead smolt performance, emigration characteristics and relative survival. More specifically, two of the project objectives have been to: 1) Determine the post-release survival and emigration timing of hatchery reared chinook salmon smolts in the Imnaha River, and 2) Estimate the survival and emigration characteristics of natural and hatchery chinook salmon from the Imnaha River to Lower Granite Dam and other Snake River dams.

Description of Study Area

The Imnaha River chinook smolt acclimation facility is located at river kilometer (rkm) 73 (Figure 1). Hatchery reared chinook salmon smolts are transported to the acclimation facility from Lookingglass Hatchery and acclimated for a four to six week period before release. Smolts that are direct stream released are generally released the same day and location as the acclimated smolts. The Imnaha River outmigrant trap is located 66 km downstream from the smolt acclimation facility at rkm 6.6. Lower Granite Dam (LGR), the first dam emigrating smolts encounter on the Snake River, is located 142 km downstream of the Imnaha River trap site and 208 km from the smolt acclimation facility. Stream reach distance from LGR to Little Goose Dam (LGO) is 60 km, and LGO to Lower Monumental Dam (LMO) is 46 km. Lower Monumental Dam (Figure 2), the third dam smolts encounter in their seaward migration, is situated 314 km downstream of the Imnaha River chinook acclimation facility.

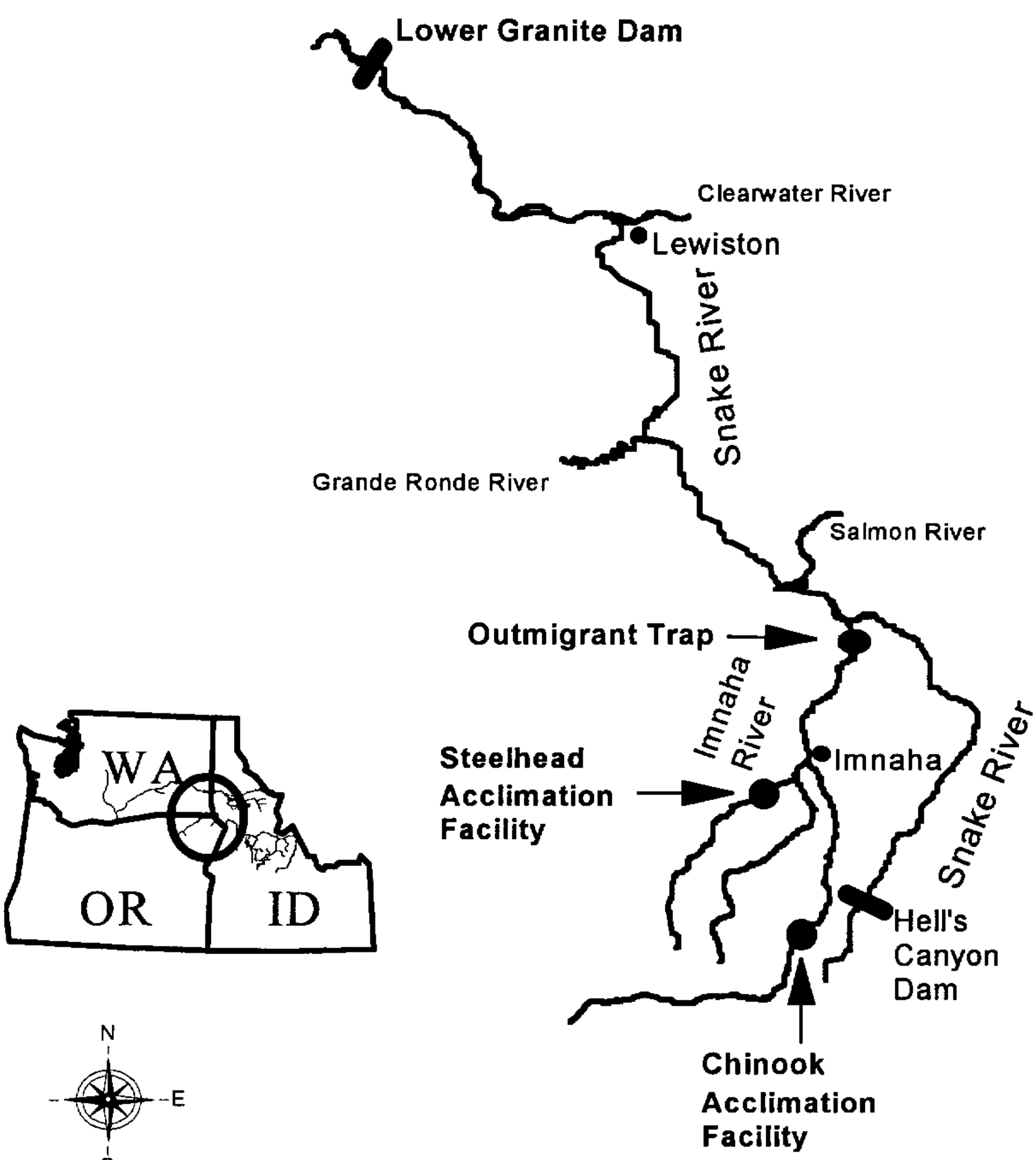

Figure 1. Map of study area including the Imnaha River, chinook salmon smolt acclimation facility, outmigrant trap site, and Lower Granite Dam.

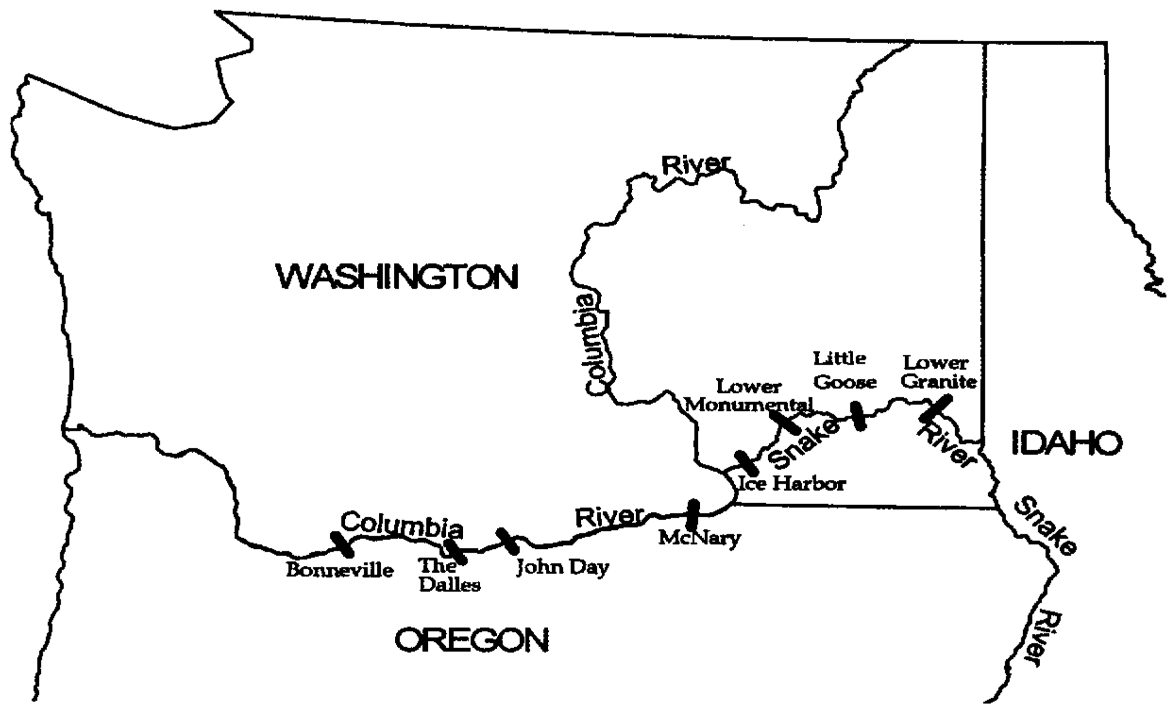

Figure 2. Location of Lower Monumental Dam in the lower Snake River, and dams on the Snake and Columbia River.

Methods

A seven foot rotary screw trap was used to capture migrating fish in the lower Imnaha River. Post-release survival of hatchery reared chinook salmon smolts in the Imnaha River was estimated through a 66 km stream reach from release at the acclimation facility (rkm 73) to the trap site at rkm 6.6. Two methods were utilized to estimate post-release survival. First, we used a bootstrap method which requires trap efficiencies to determine total smolt yield (Efron and Tibshirani 1986, Murphy et al. in prep.). Smolt yield was estimated by dividing the unmarked fish catch by the trap efficiency. This estimate of smolt yield was divided by the number of hatchery chinook salmon smolts released and multiplied by 100 to provide a point estimate of survival from release to the trap site. The second method estimated post-release survival through use of passive integrated transponder (PIT) tagged smolts from the production release group at the Imnaha River chinook salmon acclimation facility, and applying the Survival Using Proportional Hazards (SURPH.1) model (Smith et al. 1994). The SURPH model was also utilized to estimate PIT tagged natural and hatchery chinook salmon survival from the Imnaha River trap site to Lower Granite Dam, and to estimate survival of hatchery reared chinook salmon released from the smolt acclimation facility to Lower Monumental Dam. Survival estimates from Smith et al. (1998) were used to evaluate survival of hatchery reared chinook salmon smolts released from the acclimation facility to Lower Monumental Dam.

Results and Discussion

Hatchery Reared Chinook Salmon Smolts

Estimated post-release survival of hatchery reared chinook salmon smolts from release to the outmigrant trap site, 66 km downstream, ranged from 88.1 to 102% from 1992-1994 and in 1996 (Figure 3) (bootstrap method). These bootstrap derived point estimates had 95% confidence intervals that ranged from 12 to 26% of the estimate. SURPH model estimated survival ranged from 89 to 101% from release at the acclimation facility to the trap site from 1994 to 1997 (Figure 3). Survival calculated by the two methods provided fairly consistent and comparable estimates across years. Comparatively, the SURPH model survival estimates were 12% higher than bootstrap in 1994 and were 7% lower in 1996. In-river post-release mortality of hatchery reared chinook salmon smolts in the Imnaha River was not severe and ranged between 0 to 12% depending on the year.

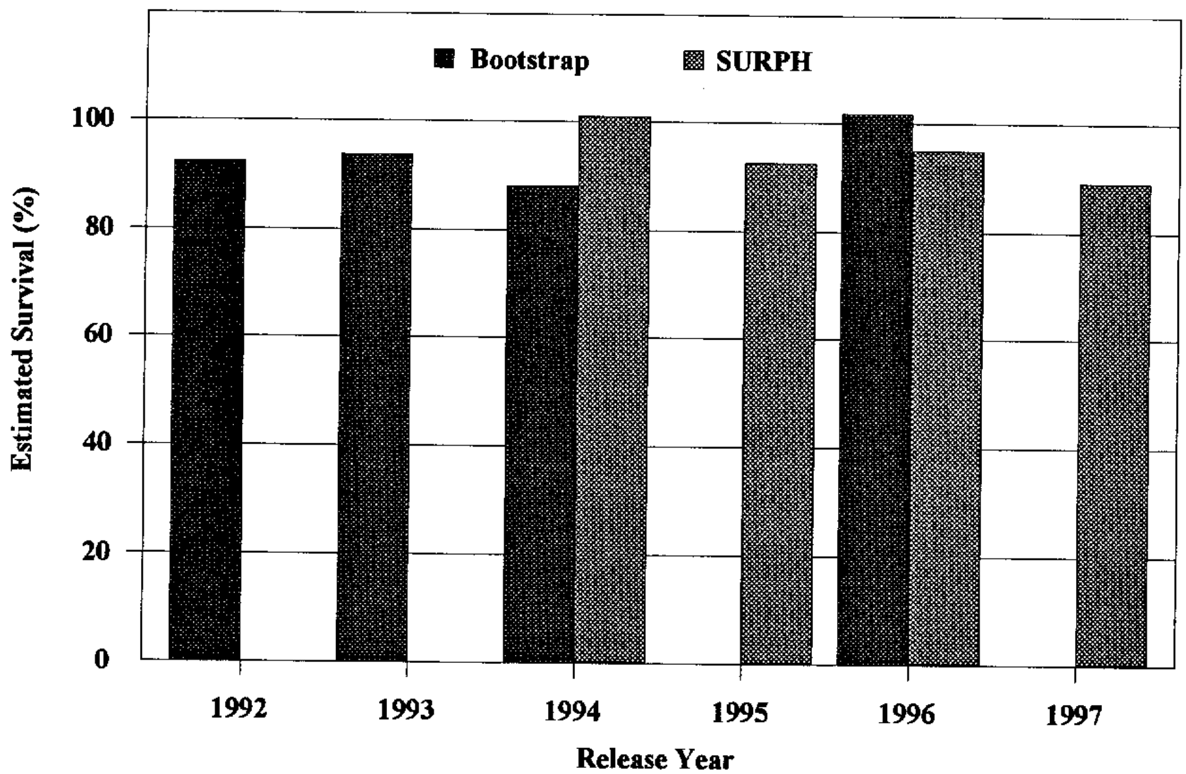

Figure 3. Estimated post-release survival of hatchery reared chinook salmon smolts from release at the acclimation pond to the lower Imnaha River trap site using the bootstrap method and SURPH model method from 1992 to 1997.

Emigration of hatchery reared chinook salmon smolts from the Imnaha River occurred fairly rapidly after release from the acclimation facility. Approximately 90% of the hatchery chinook salmon smolts emigrated from the Imnaha River within eight days after release, from 1992 to 1997, based on cumulative catch at the outmigrant trap site (Figure 4). Ninety percent passage ranged from four to eight days after release during the study period (Table 1). The longest period for 90% passage to have occurred was in 1992 (eight days) which was a historic low flow spring runoff condition. Some fish were captured up to 36 days after release, but this represented only a small proportion of the fish catch. Hatchery chinook salmon smolt release time has occurred from March 30 to April 12 over the five years of study. Smolt releases occurred during the day from 1992 to 1996 and smolts were released at night in 1997. Cumulative catch was used rather than total estimated emigration because such a large proportion of the total catch was obtained in a short period of time. Imnaha River hatchery chinook salmon smolts do not exhibit any substantial delay in emigration after release.

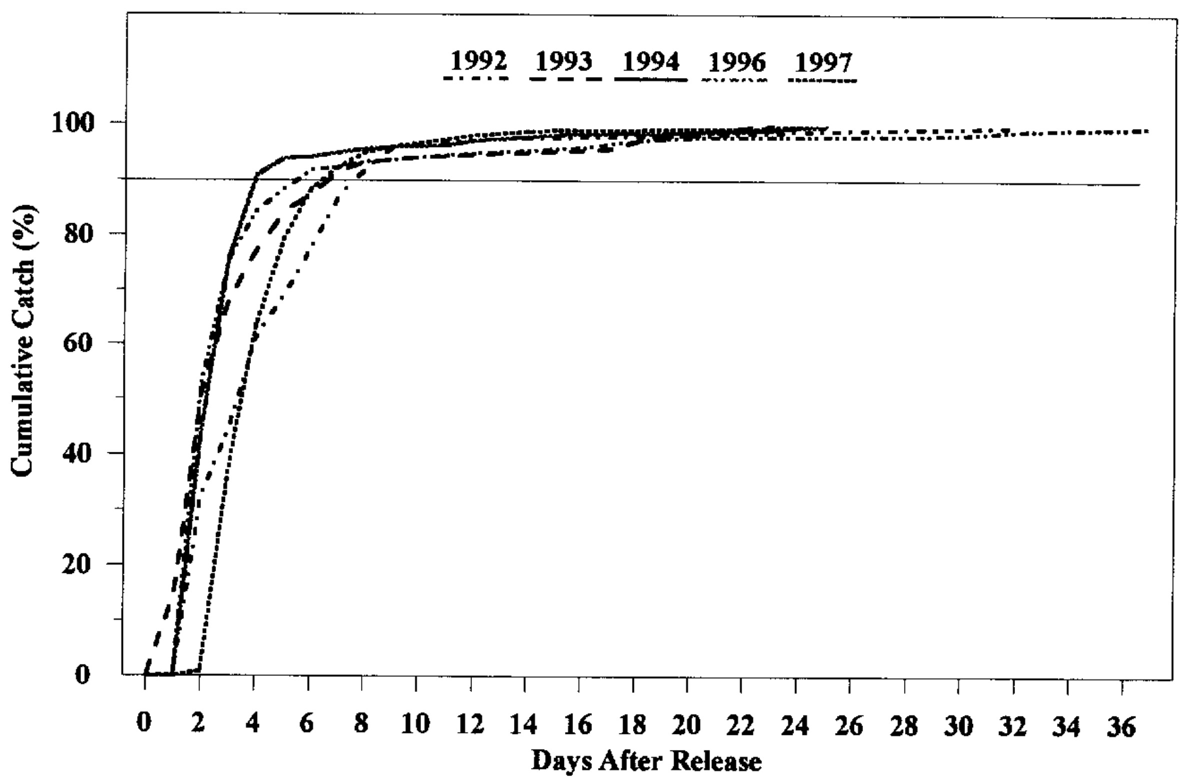

Figure 4. Cumulative percent of hatchery reared chinook salmon smolts sampled at the Imnaha River trap site after release at the acclimation facility.

Table 1. Median and 90 % passage dates of Imnaha River hatchery reared chinook salmon smolts at the outmigrant trap site from 1992 to 1997.

Year	Number of Smolts Released	Release Date	Median Passage (date)	90% Passage (date)
1992	262,500	March 30	April 3	April 7
1993	157,659	April 12	April 14	April 19
1994	438,699	April 11	April 14	April 15
1996	91,240	April 2	April 4	April 7
1997	52,000	April 7[1]	April 11	April 14

[1] Hatchery reared chinook smolts volitionally released over night and forced out the next night.

The estimated survival of hatchery reared chinook salmon smolts from the outmigrant trap site to Lower Granite Dam (Figure 5) ranged from 65-80.4% in 1994, 1996 and 1997. PIT tag sample sizes used to generate these estimates were not large, ranging from 298 to 937 fish (Table 2), and the standard errors ranged from 4.8-10.6 %. Estimated survival of the hatchery chinook salmon smolt production group from releases at the acclimation facility to Lower Monumental Dam (LMO) ranged from 46.3 to 51.9% from 1993-1997 (Figure 6) (Smith et al. 1998). Substantial mortality of hatchery chinook smolts occurs between release at the smolt acclimation facility in the Imnaha River downstream to LMO; which is the third dam emigrating smolts encounter in the Snake River (Figure 2). This estimated loss of listed hatchery chinook smolts represents a severe program constraint in smolt to adult survival and eventual adult return and recovery of the Imnaha River chinook salmon population. It is of special concern since in-river emigrating smolts must migrate past five more hydroelectric dams, after Lower Monumental Dam, to successfully reach the estuary and ocean environment. Estimates of survival of hatchery chinook smolts to LMO dam had relatively large PIT tag release sample sizes ranging from 1,991 to 13,378 fish over the study period (Table 3). The larger PIT tag release group sample sizes (1996 and 1997) provided survival estimates that were of the same magnitude as survival estimated in 1993-1995, which allowed greater confidence in the earlier estimates. Estimated mortality of hatchery reared chinook salmon smolts was examined in four specific stream reaches from release to Lower Monumental Dam from 1994 to 1997 (Figure 7) by following the same group of PIT tagged fish over 314 km of river. Mortality observed from release at the Imnaha River acclimation facility 66 km downstream to the outmigrant trap site ranged from 0-10.8% over the four year period. The largest portion of mortality was estimated to occur in the 142 km stream reach from the Imnaha River outmigrant trap site to Lower Granite Dam (Figure 7). Mortality values in this reach ranged from 26.1 to 38.6%. Estimated mortality in the 60 km stream reach between LGR and Little Goose Dam (LGO) ranged from 2.6 to 10.8% (Figure 7). Mortality from LGO to LMO, in a 46 km stream reach, was estimated to be between 4.4 to 13% from 1994-1997. It is unknown what effect cumulative stress would have on survival of this same group of hatchery chinook salmon smolts as emigration continued past the remaining five hydroelectric dams.

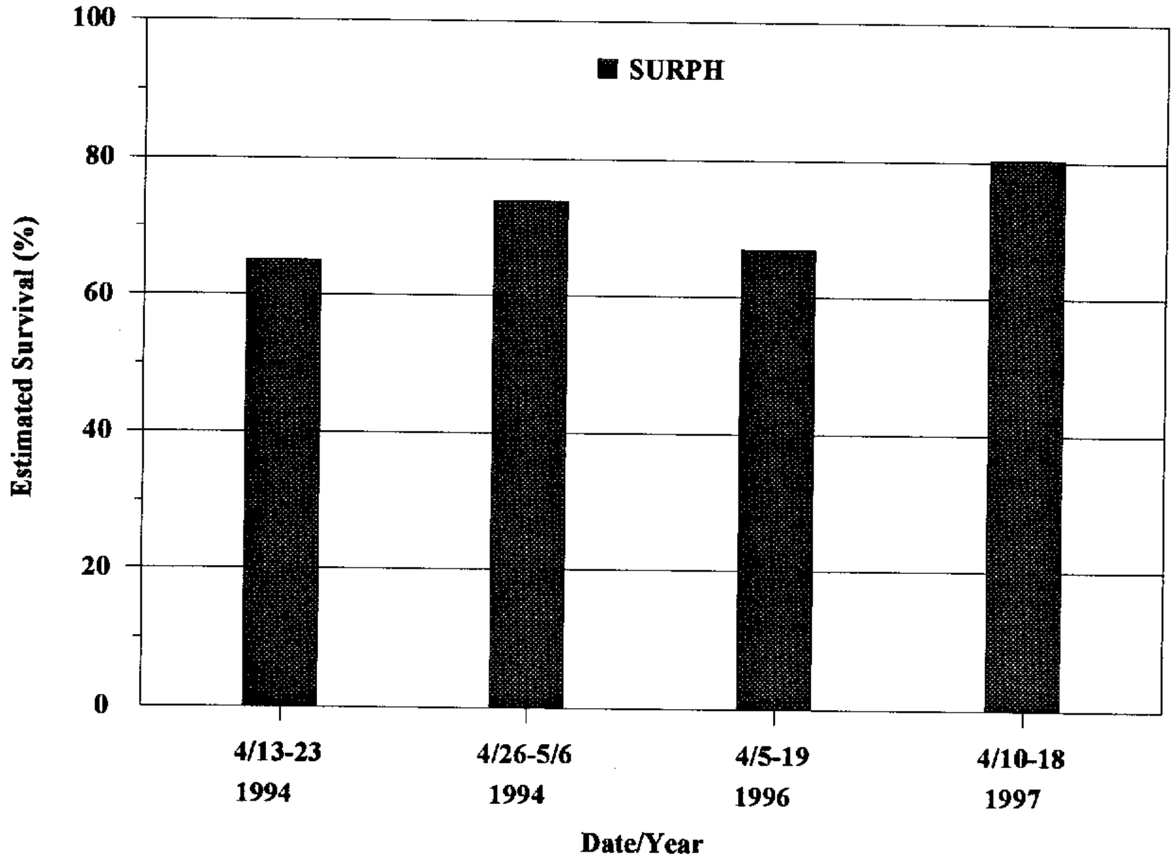

Figure 5. Estimated survival of hatchery reared chinook salmon smolts from the Imnaha River trap site to Lower Granite Dam in 1994, 1996, and 1997 using the SURPH model.

Table 2. Estimated survival of PIT tagged hatchery reared chinook salmon smolts, by year and release date, from the Imnaha River outmigrant trap to Lower Granite Dam in 1994, 1996 and 1997.

Year	Date	PIT Tag Release Size	Survival Estimate	Standard Error
1994	Apr. 13-23	352	0.650	0.060
1994	Apr. 26-May6	298	0.738	0.106
1996	Apr. 5-19	502	0.670	0.054
1997	Apr. 10-18	937	0.804	0.048

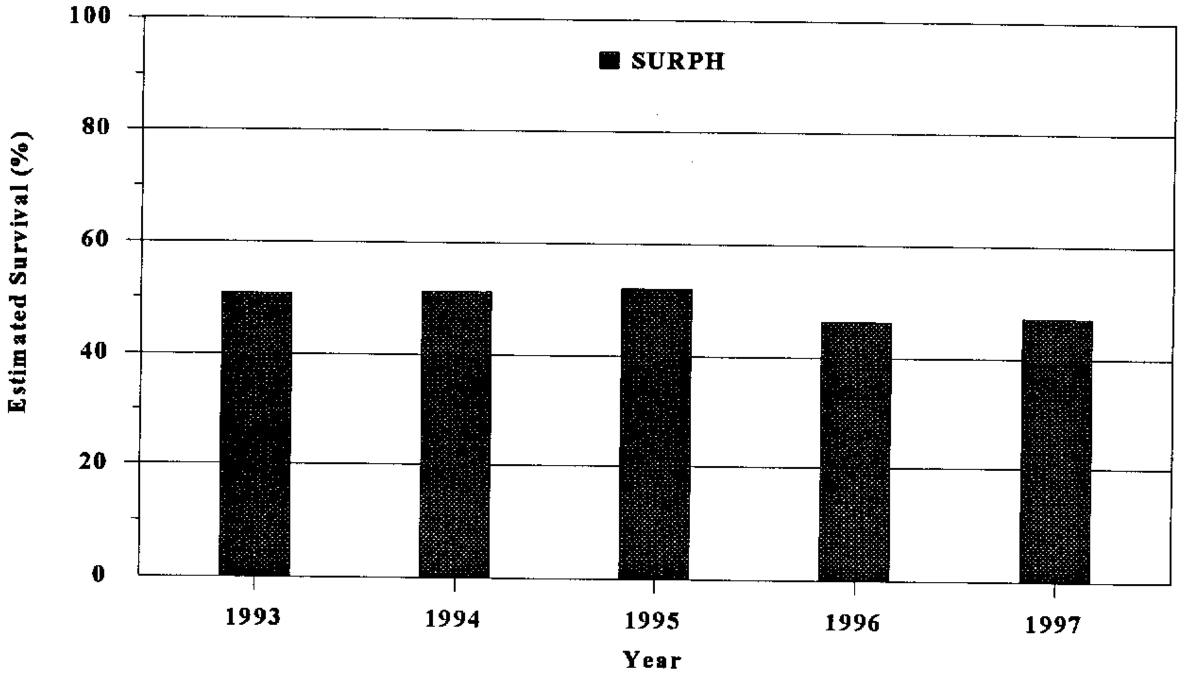

Figure 6. Estimated survival of hatchery reared chinook salmon smolts from release at the Imnaha River acclimation pond to Lower Monumental Dam using the SURPH model from 1993 to 1997 (after Smith et al. 1998).

Table 3. Estimated survival of hatchery reared chinook salmon smolts, by year and release date, from the Imnaha River acclimation facility to Lower Granite Dam (LGR), Lower Granite Dam to Little Goose Dam (LGO), Little Goose Dam to Lower Monumental Dam (LMO), and from release to Lower Monumental Dam (after Smith et al. 1998). Standard error in parenthesis.

Year	Date	PIT Tag Release	Release to LGR	LGR to LGO	LGO to LMO	Release to LMO
1993	Apr. 12	1,991	0.660 (0.025)	0.767 (0.048)		0.507[1] (0.025)
1994	Apr. 11	2,973	0.685 (0.021)	0.851 (0.049)	0.876 (0.065)	0.511 (0.029)
1995	Mar. 28	2,494	0.618 (0.015)	0.926 (0.037)	0.908 (0.059)	0.519 (0.029)
1996	Apr. 2	4,714	0.568 (0.014)	0.894 (0.037)	0.912 (0.061)	0.463 (0.028)
1997	Apr. 7	13,378	0.616 (0.017)	0.987 (0.042)	0.775 (0.042)	0.471 (NA)

[1] Estimated survival from release to Little Goose Dam.

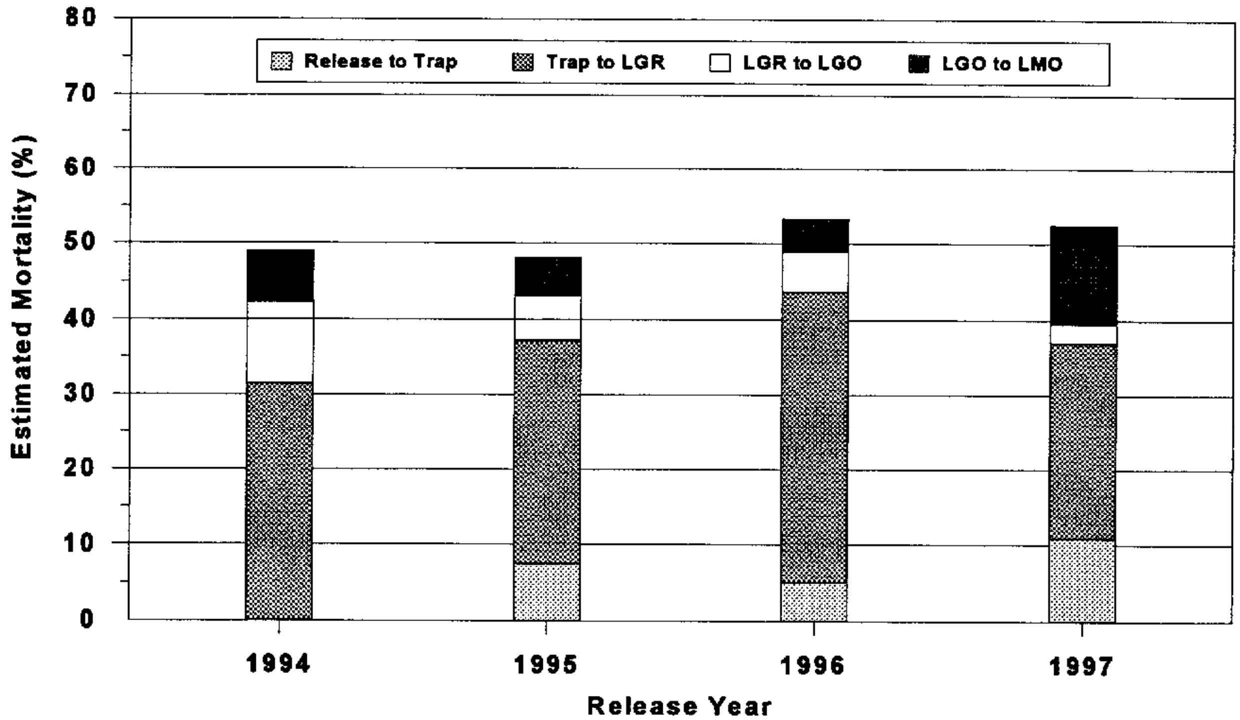

Figure 7. Estimated mortality of hatchery reared chinook salmon smolts, by stream reach, from release at the Imnaha River acclimation facility to Lower Monumental Dam from 1994 to 1997 (after Smith et al. 1998).

Natural Chinook Salmon Juveniles

We believe that it is important for fisheries managers to understand the life history characteristics that naturally produced chinook salmon express in their adaptation to the environment. Understanding life history characteristics may well assist in the conservation actions we select to move toward species recovery and in implementing the hatchery supplementation program in the Imnaha River. In this regard the Nez Perce Tribe began an investigation into the emigration characteristics and relative survival of natural chinook salmon in the Imnaha River.

The supplementation program for the Imnaha River has produced hatchery reared chinook salmon smolts that are significantly larger than their natural counterparts (Figure 8). The upper fish in Figure 8 depicts an 11 fish/lb. hatchery reared chinook that is approximately 250 mm in length (top photo), and the middle fish illustrates another hatchery chinook that represents a 20 fish/lb. smolt that is about 135 mm in fork length. The bottom fish in the photograph (Figure 8) is a natural sized spring emigrating chinook salmon smolt that is approximately 105 mm in fork length and 38 fish/lb . Mimicking the size, growth and development of naturally produced spring migrating chinook, in the hatchery environment may be one tool to improve program effectiveness.

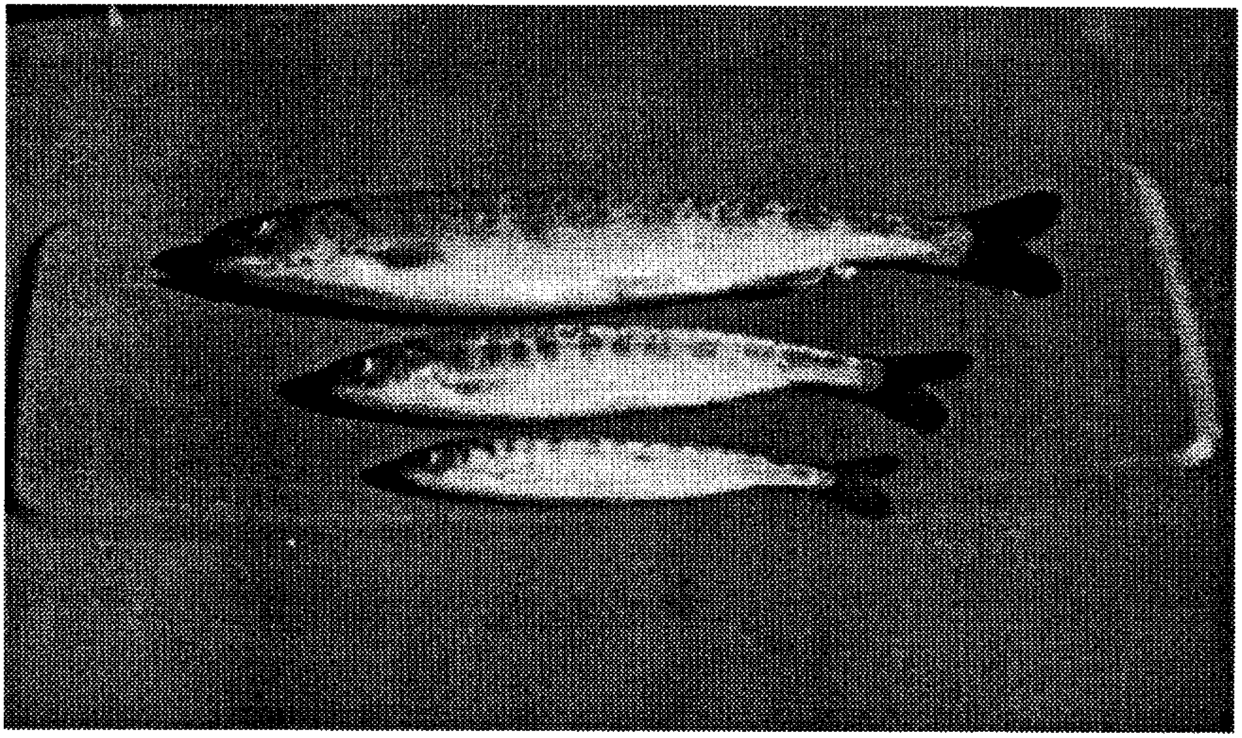

Figure 8. Size comparison of hatchery reared chinook salmon smolts at 11 fish/lb. (top fish), 20 fish/lb. (middle fish) with a natural spring emigrating chinook salmon smolt (bottom fish) from the Imnaha River.

Naturally produced juvenile chinook salmon in the Imnaha River exhibit both fall and spring juvenile movement patterns. Up to 28% of the juvenile chinook salmon, from a given brood years production, have been observed to migrate out of the Imnaha River during the fall period. Gaumer (1968) also reported a fall movement behavior of juvenile chinook from the Imnaha River. An estimated 37,422 natural chinook salmon parr (brood year 1992) moved downstream out of the Imnaha River during the fall of 1993. Fall movement occurred from September through December and at water temperatures as low as 0 degrees centigrade. The remaining 97,683 fish (72%) were estimated to have been spring emigrating smolts in 1994. Fall migrating juveniles either take up residence and overwinter in the mainstem Snake River or continue to move downstream during the fall and winter. The mainstem Snake River environment, therefore, provides a important rearing habitat component in the freshwater life history and survival of Imnaha River chinook salmon, and should be managed with that in mind. Fall moving juvenile chinook salmon collected from 1992-1996 have average fork length and weights that range from 79-97 mm and 5.2-9.5 g, and have condition factors that range from 0.99-1.08 (Table 4).

The majority of the juvenile Imnaha River chinook population (up to 72%) emigrates during the spring time. Spring moving smolts exhibit a protracted emigration period that lasts from mid February through mid June. Spring migrating chinook smolts also migrate almost entirely at night. Average fork length, weight and condition factor of spring emigrating smolts, from1992-

1996, ranged from 99-107 mm, 10.9-14.3 g and 1.07-1.12 (Table 4). In comparison, hatchery reared chinook salmon smolts emigrate after a pre-determined acclimation period and release date (Table 1). Hatchery fish are force-released into the Imnaha River, usually during the first week of April, and release is independent of water temperature, stream discharge, time of day, or other physical habitat variables. A volitional release of hatchery reared chinook smolts would allow the opportunity for fish to emigrate when they were ready, and would more closely mimic the protracted emigration period that natural chinook smolts exhibit. It would also allow for night emigration, which is when both natural and hatchery chinook salmon smolts emigrate. An important consideration would be design of the hatchery smolt acclimation facility to allow for suitable volitional release.

Estimated survival of natural spring emigrating chinook salmon smolts from the Imnaha River to Lower Granite Dam ranged from 80.6 to 92.3% from 1993 to 1997 (Blenden et al. - in press) (Figure 9). PIT tag release group sample size for spring emigrating smolts ranged from 259 to 450 fish for each period (Table 5). Fall PIT tagged juvenile chinook had an estimated survival that ranged from 25 to 34.2% from the outmigrant trap to Lower Granite Dam from 1993 to 1995. This is considered a minimum survival estimate because it is unknown if fall PIT tagged chinook continue to migrate downstream past the dams during fall and winter before PIT tag interrogation systems are operational in the spring of the year.

Table 4. Average fork length, weight and condition factor of spring and fall migrating juvenile chinook salmon from the Imnaha River from 1992 to 1996.

	Spring Emigrants			Fall Emigrants		
Year	Fork Length (mm)	Weight (g)	Condition Factor	Fork Length (mm)	Weight (g)	Condition Factor
1992	107	14.3	1.12	87	7.3	1.01
1993	102	10.9	1.10	92	8.3	1.07
1994	102	11.7	1.07	79	5.2	0.99
1995	99	10.7	1.07	90	8.1	1.08
1996	101	11.4	1.10	97	9.5	1.02

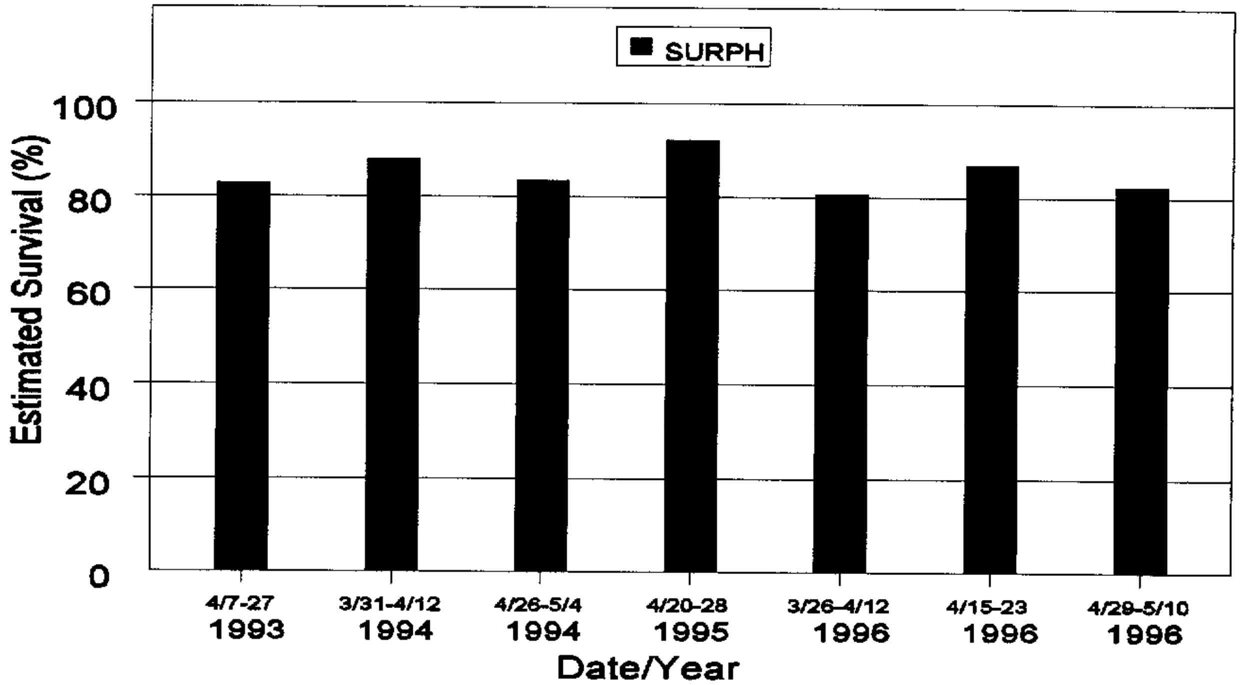

Figure 9. Estimated survival of natural chinook salmon smolts from the Imnaha River trap site to Lower Granite Dam using the SURPH model method from 1993 to 1996.

Table 5. Estimated survival of spring and fall PIT tagged juvenile natural chinook salmon, by year and release date, from the Imnaha River trap site to Lower Granite Dam, from 1993 to 1996.

Year	Date	PIT Tag Release Size	Survival Estimate	Standard Error
Spring Emigrants				
1993	Apr.7-27	234	0.828	0.063
1994	Mar.31-Apr.12	450	0.880	0.031
1994	Apr. 26-May 4	259	0.835	0.097
1995	Apr. 20-28	284	0.923	0.043
1996	Mar. 26-Apr. 12	330	0.806	0.052
1996	Apr. 15-23	269	0.870	0.056
1996	Apr. 29-May 10	415	0.824	0.050
Fall Migrants				
1993	Oct. 26-Nov. 16	749	0.342	0.026
1994	Nov. 8-Dec. 20	760	0.250	0.027
1995	Oct. 19-Nov. 14	998	0.327	0.031

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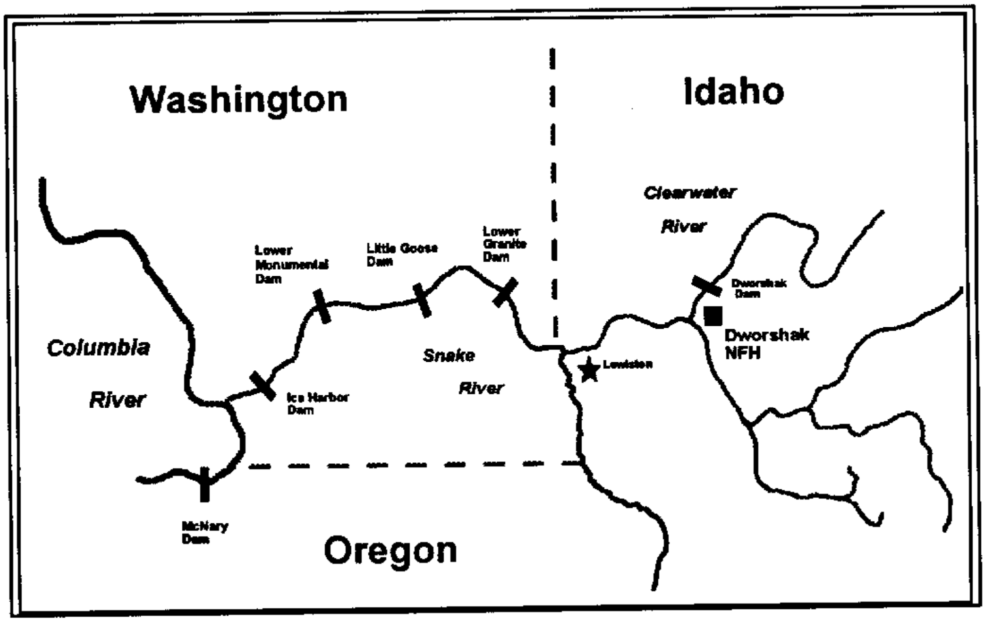

Introduction - Dworshak National Fish Hatchery (NFH) is located at the confluence of the main stem and North Fork Clearwater rivers in North-central Idaho. The Clearwater River is a tributary to the Snake River and enters the Snake at Lewiston, Idaho approximately 40 miles downstream of the Hatchery. Lower Granite Dam is the first lower Snake dam that fish released from Dworshak NFH encounter and is located approximately 70 miles downstream of the hatchery.

Facility Description - Dworshak NFH was originally built in 1969 to mitigate for steelhead lost as result of Dworshak Dam construction on the North Fork Clearwater River. In 1982 Dworshak was expanded to include spring chinook trapping, spawning, and rearing. Thirty raceways were added to Dworshak NFH as part of the LSRCP. These raceways were designed to rear approximately 45k spring chinook smolts each or a total of about 1.4 million which is what was estimated to meet our adult return goal.

Objectives - The original objectives for the program were: 1) an adult return goal of 9,135 to the river above Lower Granite Dam; 2) a production release of 1.4 million 20/lb. smolts which was based on an expected 0.65% smolt-to-adult return rate; and 3) to provide a sport and tribal chinook fishery in the Clearwater River

Genetics - Lewiston Dam, which was located on the Clearwater River just above Lewiston from 1929 to 1972, extirpated the historic spring chinook run to the Clearwater River. Therefore when the spring chinook program was initiated at Dworshak, fish were obtained from a number of sources, including: Little White Salmon (1983 & 85), Leavenworth (1983-86), and Rapid River (1987-88) hatcheries. Since 1989 we have primarily utilized fish that return to Dworshak as our source of broodstock, with the exception of 1995 when approximately a third of the production lot was from Kooskia NFH stock. It was the extirpation and subsequent reintroduction of non-endemic stock that prompted NMFS's decision to not include the Clearwater spring chinook salmon in their listing package.

Characteristics - On average, adults that presently return to Dworshak NFH have the following characteristics: approximately 65% returning adults are 2-ocean, 50:50 sex ratio of males to females, and the average size of a 2-ocean adult is ~ 740mm.
Spring chinook salmon arrive at Dworshak NFH from June to August, they are held until spawning occurs in late August to early September, incubation and rearing lasts approximately 20 months, and then the fish are released in early April.

Results - Releases of spring chinook from Dworshak NFH since 1983 are shown in Figure 1, the production goal of 1.4 mil is designated. As the Figure 1 shows six out of 15 years the release goal was met or exceed. The graph also shows the off-site releases that were to help start up the Clearwater State Hatchery satellite facilities. Figure 2 shows the adult returns since 1984 with the mitigation goal of 9,135 designated. Sport (1990 & 97) and tribal harvest is also shown. The average smolt-to-adult is 0.11% (range 0.0047% - 0.2947%) well below the predicted 0.65% smolt-to-adult return rate.

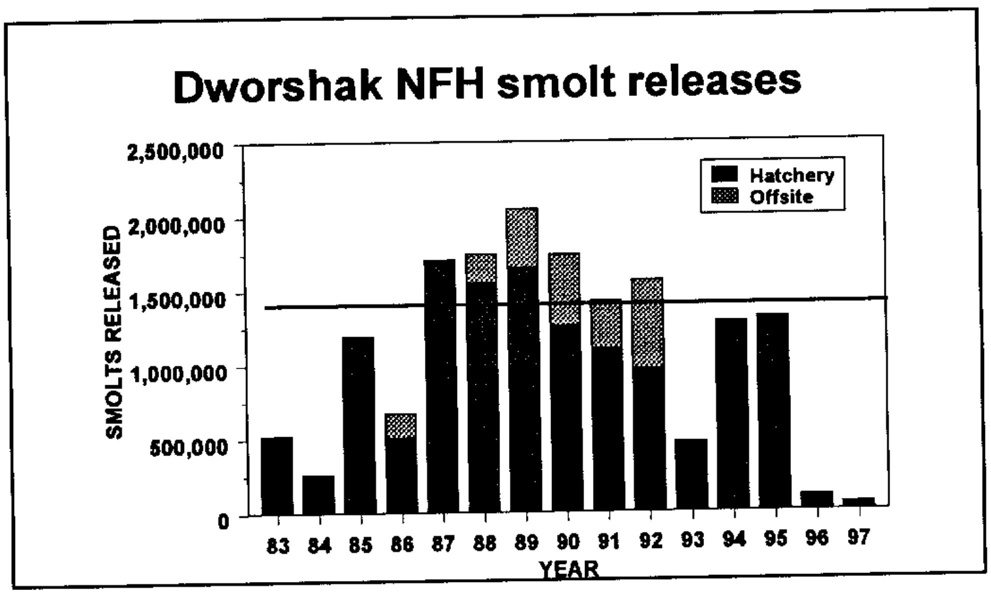

Figure1. Direct and off-site releases of spring chinook salmon smolts from Dworshak NFH, 1983-97, horizontal line indicates production release goal of 1.4 million.

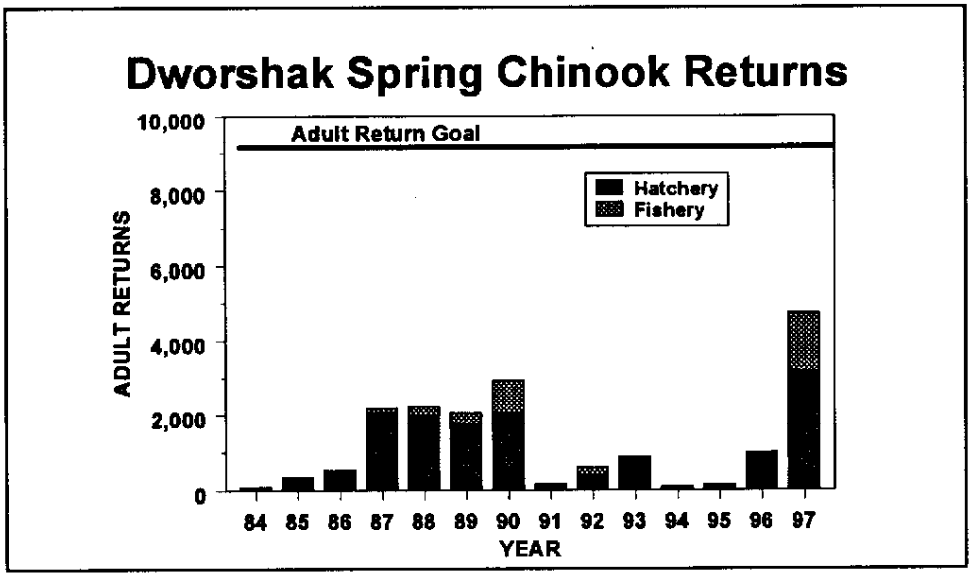

Figure 2. Returns to the hatchery and fisheries of Dworshak NFH spring chinook salmon adults, 1984-97, adult return goal of 9,135 is indicated by the horizontal line.

It should be noted that these returns are what returned to the hatchery or fishery and does not account for approximately 20% fish that are un-counted, however, even when these are factored in we are still far short of out adult return goal (Figure 3).

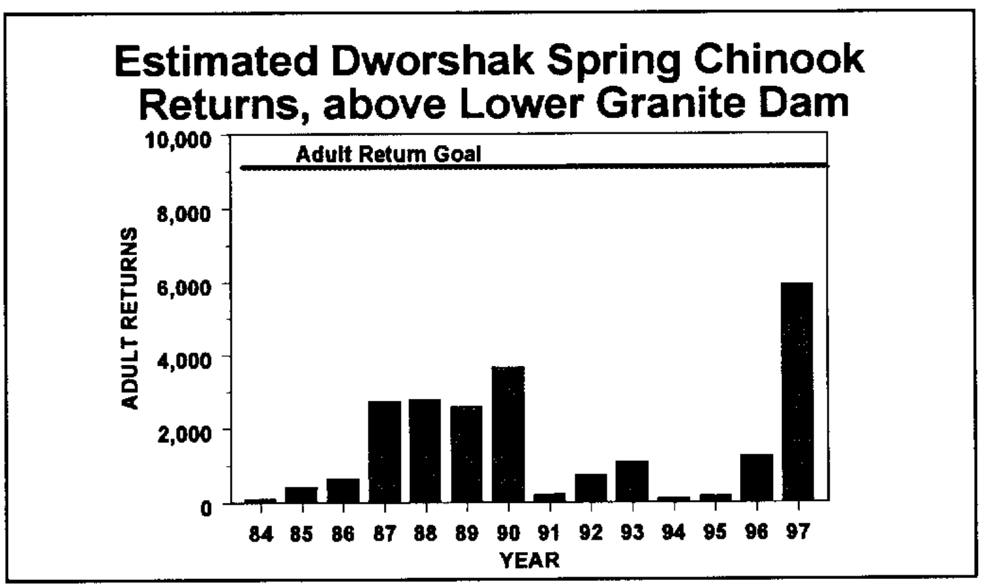

Figure 3. Estimated total returns of Dworshak NFH spring chinook salmon adults to the river above Lower Granite Dam, 1984-97, adult return goal of 9,135 is indicated by the horizontal line.

Changes - We have made many changes to attempt to improve adults returns to Dworshak NFH. These have included changes to improve smolt quality such as, BKD segregation since the late 1980s and, based on studies conducted at Dworshak and elsewhere, reducing rearing densities from ~45,000 to ~35,000 per raceway, which thereby reduced the total release numbers to ~ 1.05 million. Also to release fish from Dworshak at 20/lb. we had to hold fish back, this has been shown to be detrimental to smoltification, especially just before release, so we now release spring chinook at approximately 15-18/lb.

We have also made improvements to our release strategies. Based on studies we conducted at Dworshak and Kooskia NFHs we found that chinook released in early April return better than fish released in late April or early May. We also try to release on an increasing hydrograph, have moved to evening/nighttime releases, and additionally try to time releases on a new moon phase.

Program Considerations - When looking at the Dworshak spring chinook program there are several things to keep in mind: 1) on average we are only returning 1/5 of our mitigation goal, 2) the program is not rebuilding or restoring an endemic run, 3) the Dworshak spring chinook stock is not essential for recovery of a listed stock, and 4) it is unlikely that any changes we make will produce significant improvements towards meeting our adult return goal of 9,135.

So that leads to the question of, what is the value of the Dworshak NFH Program? **FISHING!** In 1997 good chinook salmon returns allowed a sport and tribal fishery, with over 1,600 spring chinook salmon caught in the fisheries in the Clearwater River around Dworshak NFH. This fishery was extremely popular with local and out of area fishermen.

Fishery values - There are several values that directly attributable to providing a sport and tribal fishery: 1) it is part of our tribal trust responsibility, 2) it returns something to the public and tribal members who essential pay for the program, 3) it helps generate public and tribal support for the Dworshak NFH program, and 4) it helps build and foster support for other chinook programs that because of ESA restrictions cannot permit a fishery until recovery is met. So that leads to the next question of, How often can Dworshak NFH provide a fishery? We believe that in most years some sort of fishery can be provided, even in low return years some type of controlled fishery could be allowed, this could include shortened seasons, reduced creel limit, limited permits, limited fishing area, trophy fishery, or some other restriction or combination of restrictions. To accept we could provide a fishery in most years one first has to accept that it's not critical to the program to meet broodstock goals. As shown in Figure 4 there is very low correlation between release numbers and return numbers (1983 - 95 release years has an $r^2 = 0.203$). There are so many factors that are out of our control such as dam and reservoir passage, good or bad water year, transportation vs. non-transportation, ocean conditions, predation, etc. that just releasing large numbers of chinook does not guarantee good returns. There also remains the option to back fill the program from other egg sources.

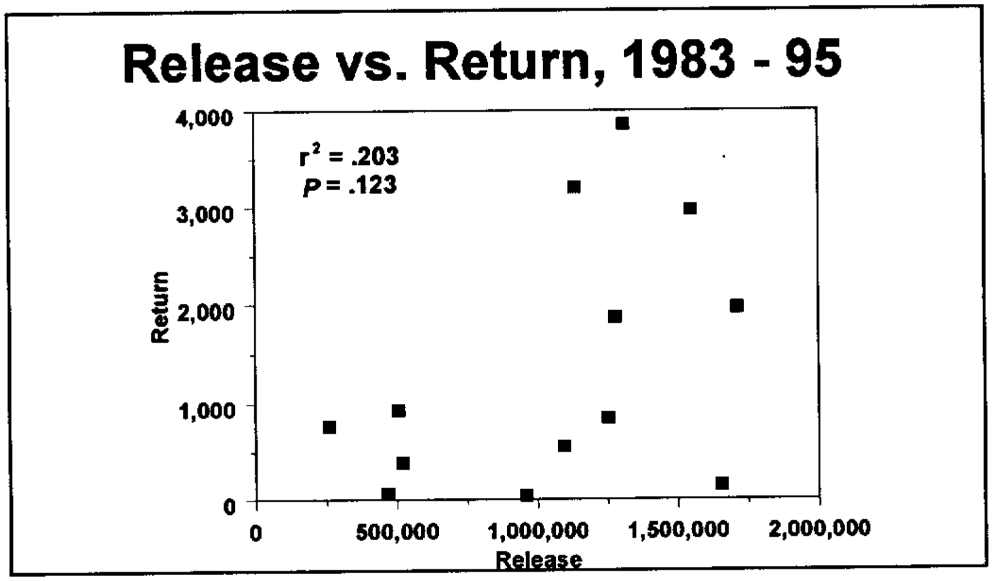

Figure 4. Release versus return plot for spring chinook salmon at Dworshak NFH, 1983-95.

Future - So what do we see for the future for the Dworshak NFH spring chinook program? Hopefully more spring chinook fishing seasons, we firmly believe that the salmon recovery effort needs to build support for programs occurring throughout the Snake River basin and the Dworshak program could assist in that effort. We will continue to make fish cultural improvements where and when appropriate. This could include incorporating natural rearing strategies, changes in feeds, etc.. We also need to conduct a size at release study to determine optimum release size. Additionally, we will continue to provide fish for basin-wide studies as they occur (ie. transported vs non-transported).

Finally, there remains the question of what is critical to the success of the Dworshak NFH chinook program? Since there is little we can do at the hatchery to meet our adult return goal, meeting our goal of providing a fishery, which is the primary intent of the Dworshak NFH spring chinook program, would go a long way towards making the program a success.

Questions and comments

Mike Delarm asked whether any estimates of the parent/progeny ratios among naturally-produced fish in the Clearwater are available. We're just starting to pull those numbers together as part of the ongoing supplementation evaluation, Hassemer replied – we're just completing a five-year, redd-to-redd evaluation of the Upper Lochsa, Red River and other Clearwater tributaries. Based on what we've seen in the natural populations, Hassemer said, I doubt those parent/progeny ratios are at the replacement level.

Clearwater River Spring Chinook Salmon And Clearwater Anadromous Fish Hatchery

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Clearwater Anadromous Fish Hatchery is the most recent addition to the LSRCP program in the Snake River basin. The hatchery was completed and became operational in 1990, and serves only incubation and early rearing functions. Adult spring chinook salmon trapping and spawning, and juvenile fish final rearing and release are conducted at the hatchery's three satellite facilities (Fig. 1). The Powell satellite, located on the Lochsa River was completed in 1989. Red River (completed in 1986) and Crooked River (Completed in 1990) satellites are located in the South Fork Clearwater River basin. Juvenile-fish pond capacities at each of the sites are; Powell – 334,000, Red River – 334,000, and Crooked River – 700,000.

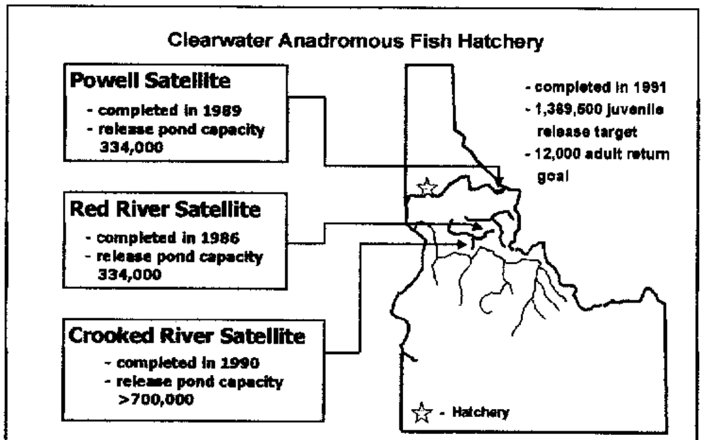

Figure 1.

The total juvenile release target of 1.3695 million fish was intended to return about 12,000 adult spring chinook salmon back to the project area. The juvenile release number was determined from the adult compensation goal for the facility, assuming a smolt to adult return rate (SAR) of 0.87% in the compensation program-planning model.

Little information is available, due to the relatively recent start-up of the facility, to adequately evaluate facility performance as related to return goals of the LCRSP program. Beginning with the rearing of brood year 1992 spring chinook salmon, egg to smolt survival has consistently been very good (Fig. 2). The 70% survival target shown in Figure 2 is not a hatchery management goal, but rather is the value used in the original production model to identify facility needs. It is included here for reference.

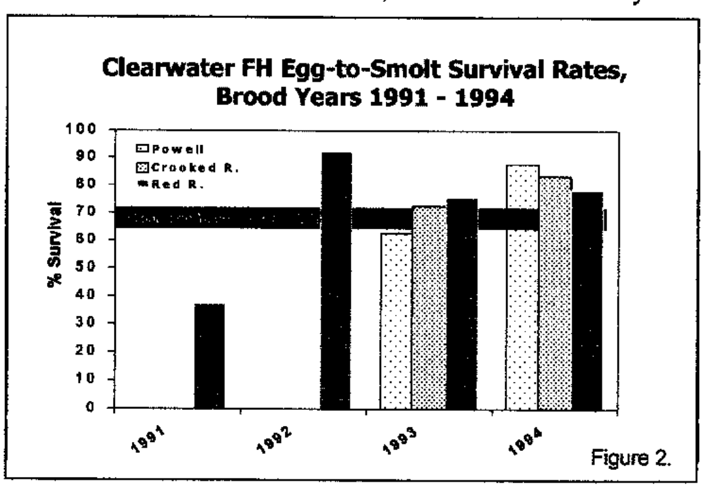

Figure 2.

Juvenile fish releases made at the three satellite facility sites cover two management-program periods. Releases of progeny from brood years 1977 through 1989 spawnings represent releases made under the Columbia Basin Development Program. Brood years 1991 through

1993 releases represent fish that had been incubated and/or reared at Clearwater Anadromous Fish Hatchery. Brood year 1990 releases had been reared at Dworshak Fish Hatchery (operated by the U.S. Fish and Wildlife Service) pending completion of Clearwater Anadromous Fish Hatchery.

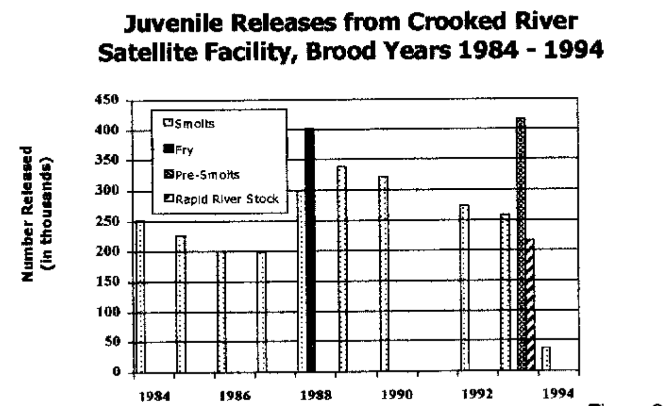

Figure 3.

Juvenile releases at the Crooked River satellite are displayed in Figure 3 for brood years 1984 through 1994. Smolt release numbers range from 200,000 to 340,00 each year, excluding brood years 1991 and 1994. Adult returns in 1991 and 1994 were too low to meet hatchery egg take targets. The strong brood year 1993 return allowed for the release of an additional 400,000 presmolts in the fall of 1995 and the release of about 216,000 Rapid River stock juveniles.

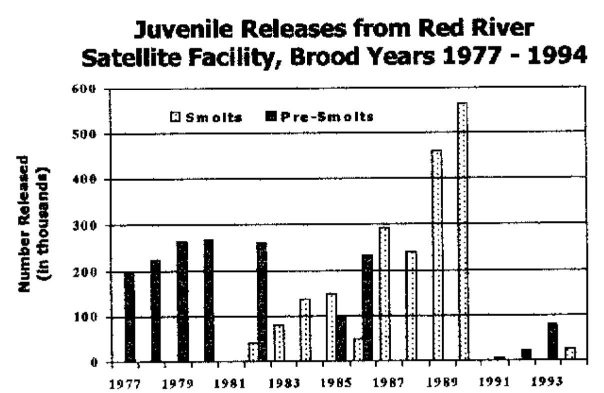

Figure 4.

Rearing pond improvements at the Red River satellite, for the LSRCP program, were completed in 1986. Very few juveniles have been released at the Red River satellite, beginning with brood year 1990, because of extremely low adult returns to the facility (Fig. 4). The progeny of brood years 1991 – 1993 adult returns were released as presmolts to support supplementation research activities. The release strategy was changed to a smolt release for brood year 1994 to take advantage of greater in-hatchery survival to release, in response to the low adult returns. The brood year 1998 release was from Dworshak Fish Hatchery stock, not Red River stock.

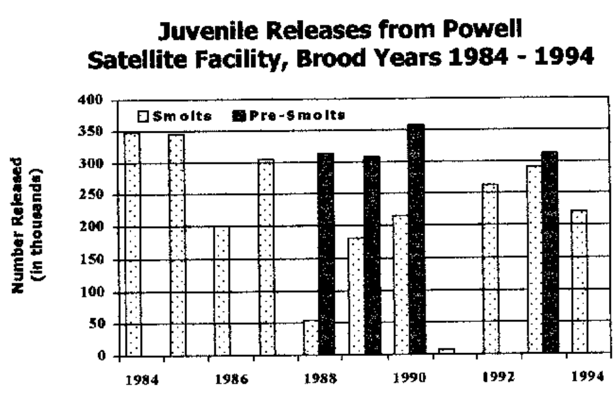

Figure 5.

The Powell satellite trapping and rearing facilities were completed in 1989. Smolt releases at the Powell satellite, for brood years 1984 – 1994, ranged from 50,000 to 350,000 fish annually (Fig. 5). The brood year 1988 release included an additional 200,000 Dworshak Fish Hatchery smolts that are not included in Figure 5. Extremely poor adult returns in 1991 resulted in the release of only about 8,000 smolts from that cohort. Fall presmolt releases from the Powell site have been made in some years; numbers of fish released in those years ranged from 307,000 to 358,000.

A relative measure of "performance" of juveniles released is detections of PIT-tagged fish at downstream dams. The data points plotted in Figures 6 and 7 represent the cumulative proportion of PIT-tagged fish that were detected. These proportions detected provide an estimate of the minimum proportion of fish released that reached the first dam (Lower Granite).

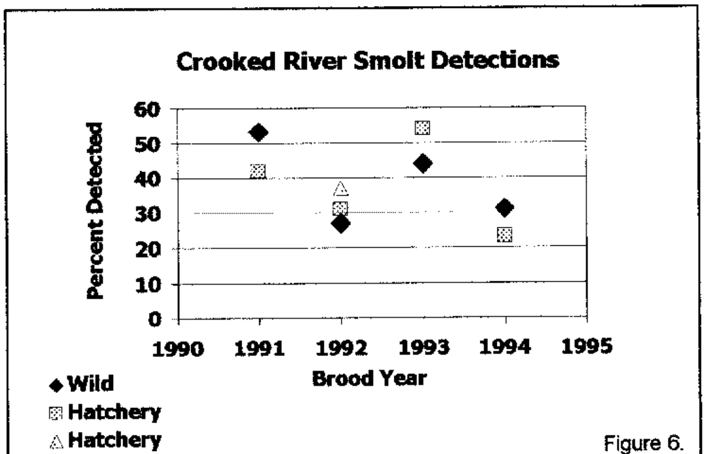

Figure 6.

In Figure 6 cumulative detection rates for one or two groups of hatchery fish (squares and triangles) are shown for four brood years Crooked River smolt releases. Also shown are cumulative detections for naturally produced spring chinook salmon juveniles (diamonds) tagged in Crooked River. The detections of naturally produced fish are included for general comparison only, since the detection rates reported have not been adjusted for arrival timing, fish guidance efficiency at the time of arrival, spill at the dams, etc. Detection rates for hatchery reared fish are similar to the rates for naturally produced fish each year.

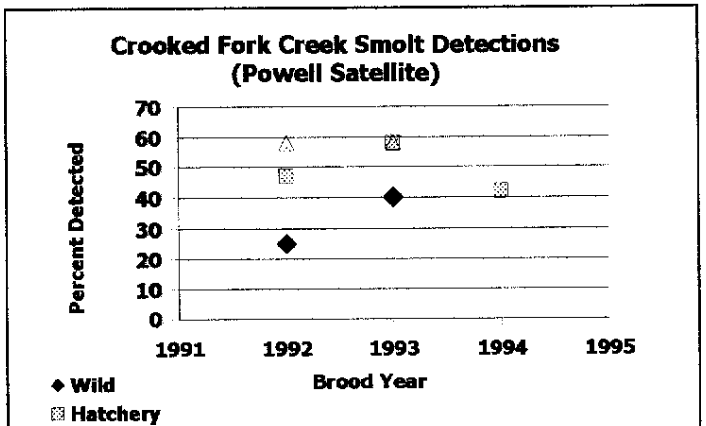

Figure 7.

Detection rates of hatchery reared fish released at the Powell satellite are displayed with detection rates of naturally produced fish tagged in Crooked Fork Creek in Figure 7. Crooked Fork Creek enters the Lochsa River about 100 meters upstream of the Powell satellite, and the juvenile trapping/tagging site is less than two kilometers upstream of the mouth. For three brood years where data is available, detection rates of hatchery reared fish released from the Powell site have ranged from 40% to 60%.

A general conclusion that might be made is that there are no apparent problems with fish survival from the time of release to arrival at the first dam. As a side note, it is important to note that to date, no good uniform measure of smolt quality has been developed. However, if we are concerned with the quality of smolts the first indication of a "bad" group of fish would be reduced egg to smolt survival. It was shown in Figure 2 that green egg to smolt survival has consistently been quite high, indicating good smolt quality.

The combined adult returns to the three hatchery weirs to date have not achieved the LSRCP compensation goal of 12,000 fish (Fig. 8). The largest return to date (1997) consisted of mostly 4-year-old fish, the progeny of brood year 1993 spawners that had migrated to the ocean in 1995. Juvenile releases have never achieved their numeric targets; hence, it is unrealistic to expect adult returns to meet the goal for each facility.

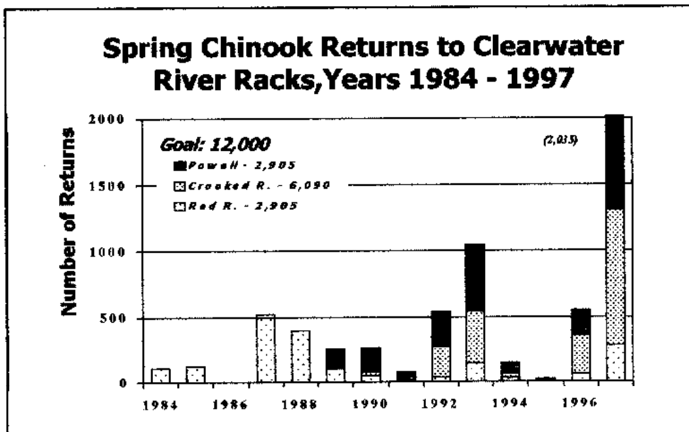

Figure 8.

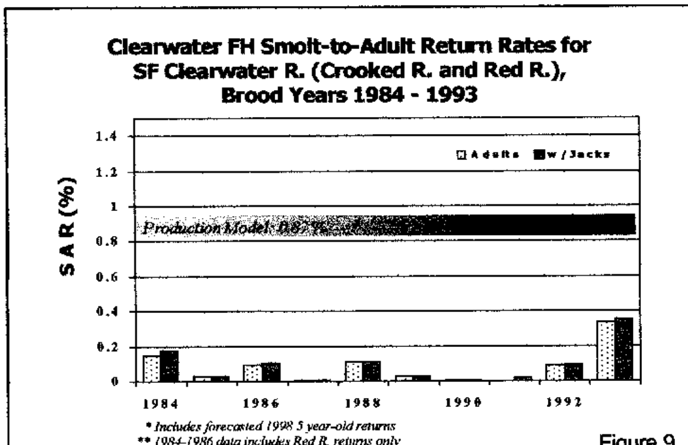

Figure 9.

To complete a performance appraisal for hatchery operation, two other measures are examined. The first of these is smolt-to-adult survival rate (SAR) (Figs. 9 and 10). The original facility development production model SAR was 0.87%. It is apparent in the figures that this SAR has never been achieved. The SAR necessary for replacement of hatchery brood stock is approximately 0.06%, and is a function of the high egg to smolt survival achieved in a hatchery. For comparison, the SAR necessary for replacement of wild spawners is about 0.6% (at 7% egg to smolt survival).

The last measure in the performance appraisal of hatchery operations is progeny:parent ratios, an expression of the number of females returning for each female spawned to produce juveniles for release (Figs. 11 and 12). Based on parameters used in the original production model, we estimate a progeny:parent ratio of about 18:1 was anticipated. The progeny:parent ratios incorporate the complete life cycle of events for the fish, which includes both in-hatchery and post-release

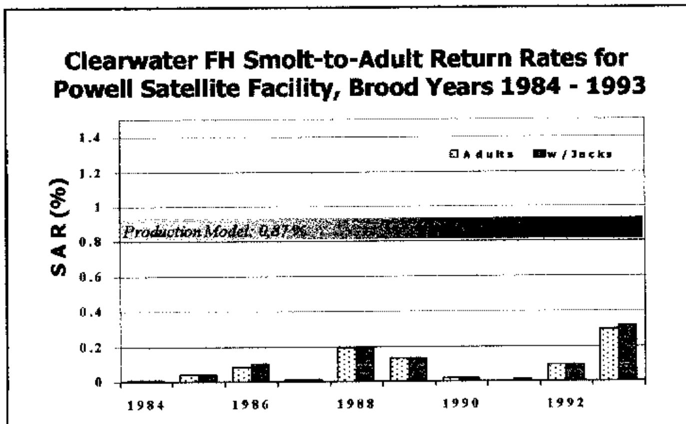

Figure 10.

survival. The figures show that adult-to-adult replacement, incorporating forecasted 1998 returns or five-year-old fish (and excluding jacks) will be exceeded only for brood year 1993 for the Powell facility (Fig. 11) and combined Crooked River and Red River facilities (Fig. 12). These progeny:parent ratios directly reflect the SARs shown in the previous figures. For example, brood years 1990 and 1991 experienced extremely low SARs, and progeny:parent also were extremely low. On the other hand brood year1992, that experienced better SARs (but not high SARs) had slightly greater progeny:parent ratios than brood years 1990 and 1991. The moderately good progeny:parent ratios for brood year 1993 resulted in some limited fisheries on these fish in 1997.

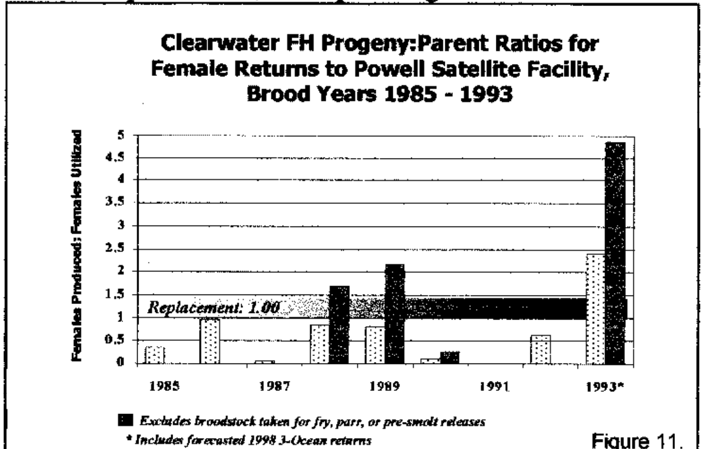

Figure 11.

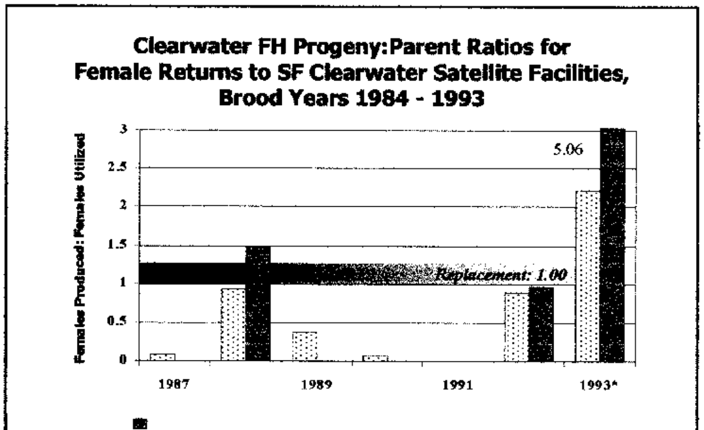

Figure 12.

A performance report card for the Clearwater Anadromous Fish Hatchery chinook salmon compensation program was prepared. Performance in five areas is reported (Fig. 13). In-hatchery egg to smolt survival is consistently high. Smolt release targets have been met when sufficient adults returned to satisfy brood stock needs.

Smolt survival from release to Lower Granite Dam is difficult to evaluate, since there are no targets or historical reference points. In, relation to wild fish (and based on detections of PIT-tagged fish), fish released from the hatchery are surviving to the first dam as well as can be expected. We will continue to monitor this performance measure.

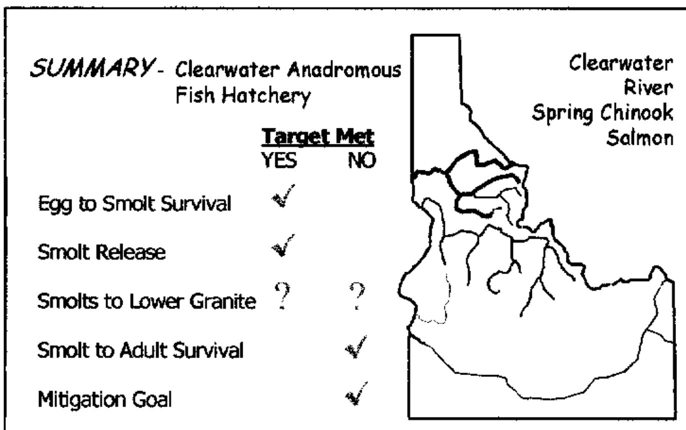

Figure 13.

Smolt-to-adult returns rates have consistently failed to achieve the production model target of 0.87%, and have been below the level needed for replacement in many years. There are no indications that this performance is due to hatchery operations or poor quality of the fish released. Similarly, poor SARs have been documented for wild fish. Factors affecting SARs for these fish most likely operate outside of the Clearwater River basin and hatchery environment. Poor survival through the lower Snake and Columbia rivers hydrosystem is considered the primary factor affecting fish survival.

The adult return compensation goal of 12,000 fish has never been met, as a result of both juvenile releases not meeting their numeric targets and consistently poor SARs. IDFG will continue efforts to improve in-hatchery performance. However, only small improvements can be expected, since in-hatchery survival and smolt quality are typically very good. These small improvements will not offset or overcome the extremely low SARs.

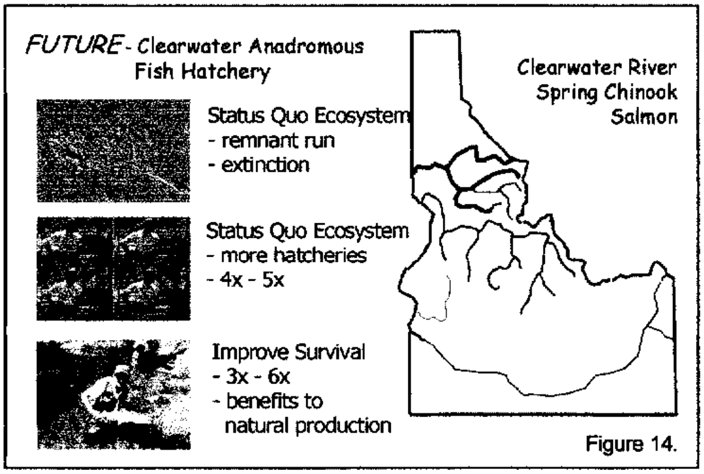

Figure 14.

Three possible avenues are seen for the future of this spring chinook salmon compensation program (Fig. 14). The first avenue - status quo ecosystem - assumes no changes to be made in hatchery operations or ecosystem management (e.g. hydrosystem operations). Under this scenario, we can only expect that remnant runs would persist, or the wild and hatchery stocks may go extinct.

If changes necessary to improve smolt-to-adult survival are not made and the desire is to achieve the compensation goal of 12,000 adults, four or five additional 'Clearwater hatcheries' could be constructed to provide for the release of another five to six million smolts. A major problem with this avenue is that more hatcheries will not halt the decline of naturally reproducing populations. In addition, insufficient numbers of adults return at the present time to provide eggs for these 'new' hatcheries.

The third avenue is to implement changes that would improve smolt to adult survival to a level of 2% to 6%. Any survival increases will be realized by both wild and hatchery populations, benefiting both. The Idaho Fish and Game Commission believes that a normative river is the best biological route to meeting this survival level. The Commission and the Idaho Department of Fish and Game do not desire to manage remnant populations that provide no fishery benefits.

It is important to review these three future management options to establish the current management framework (Fig. 15). The Idaho Department of Fish and Game's management focus is conservation and rebuilding of naturally spawning spring chinook salmon populations in the Clearwater River drainage, while also providing fishing opportunity on fish produced through the compensation program. We are currently investigating, through a

Bonneville Power Administration funded study, supplementation as a tool to rebuild the natural spawning populations. While not meeting its compensation plan goal, the LSRCP-funded hatchery program plays an important role in management of Clearwater River salmon. Adaptive hatchery management actions are implemented to respond to management needs of naturally produced fish in the basin. The supplementation research program utilizes some natural-origin adults as brood stock to produce juveniles for release, and the juveniles are reared in the hatchery. In addition to the supplementation fish, the general production (compensation program) brood stock is maintained to achieve the goal of the LSRCP program and provide fishing opportunity in the future. The general production fish are managed to provide a safety net or reserve should natural-origin returns become so critically depressed that recovery without intervention actions is unlikely. Operations planning and management of the hatchery program acknowledges the Idaho Department of Fish and Game's highest priority – wild/natural stock conservation and rebuilding – while continuing to support the facilities objective of compensating for reduced fish survival due to hydroelectric development and providing fishing opportunity.

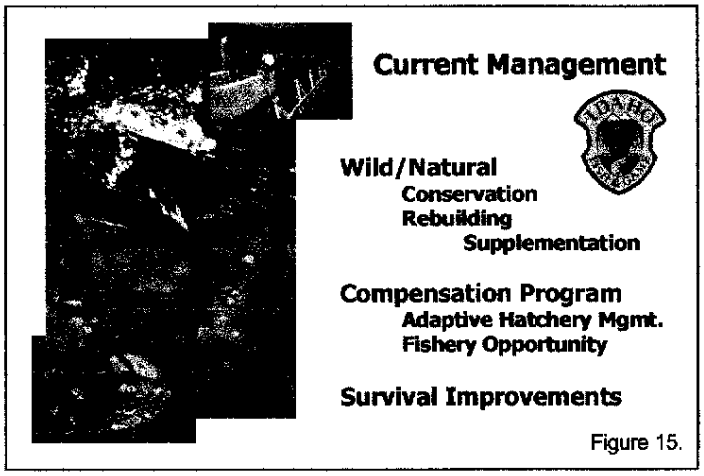

Figure 15.

Upper South Fork Salmon River Summer Chinook Salmon

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The upper South Fork Salmon River program is the only summer chinook salmon program operated within the LSRCP. Historically the South Fork Salmon River produced 60% to 70% of the annual adult summer chinook salmon return to Idaho. The McCall Fish Hatchery facility, completed in 1980, is located in McCall, Idaho, in the Payette River basin (Fig. 1). Juvenile fish rearing is performed out of the basin and fish are trucked back to the South Fork Salmon River for release. This LSRCP program provides in-kind compensation for summer chinook salmon losses associated with the four lower Snake River dams.

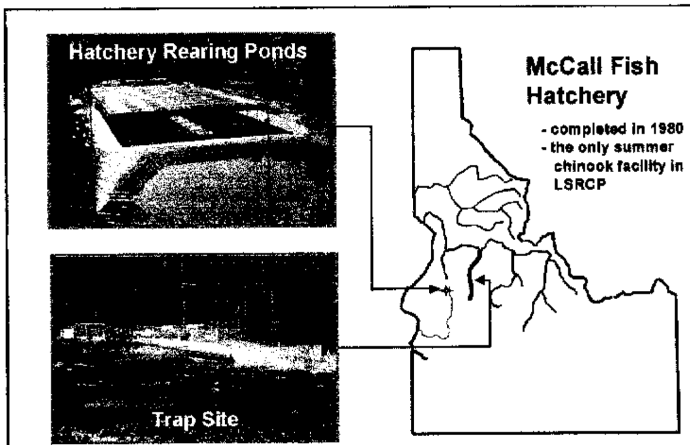

Figure 1.

The hatchery consists of typical incubation and early rearing facilities and 2 large covered ponds for final rearing. Production models used to identify facility needs included an assumed smolt-to-adult (SAR) survival rate of 0.87%, which was applied to the annual adult return goal of 8,000 adults to determine needed juvenile rearing capacity. Smolt production capacity at McCall Fish Hatchery is one million smolts. Adult brood stock trapping and spawning operations occur at the South Fork Salmon River satellite facility, located downstream of the "headwaters" natural production area of Stolle Meadows.

About 500 miles of stream habitat are accessible to chinook salmon in the entire South Fork Salmon River basin. This accessible habitat includes both spawning and rearing habitat. The section of the South Fork Salmon River used for an index of historical abundance is from the mouth of the East Fork South Fork Salmon River upstream to the mouth of Rice Creek (about the upper limit of spawning habitat). Average annual index counts of spawner redds are noted in Figure 2. In addition to substantial adult spawner escapements in the 1960s, harvest was occurring in the South Fork Salmon River until the early 1970s. Sport harvest between 1960 and 1964 ranged from

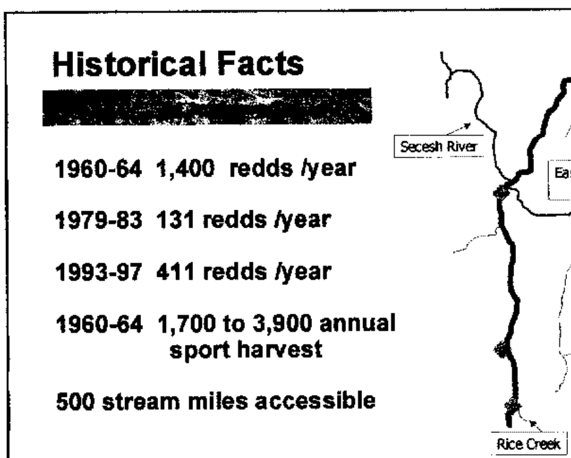

Figure 2.

1,700 to 3,900 fish annually. Estimates of harvest in tribal fisheries during this time period are not available.

Numbers of redds counted in index areas from 1979 through 1983 declined to less than one-tenth the number counted in the early 1960s. The actual number of fish returning to the basin declined by an even greater amount since fisheries were severely restricted beginning in the early 1970s. (No sport harvest occurred from the early 1970s through 1996.) Based on current indices of spawner redds (1993-1997), natural spawning has rebounded to about one-fourth the level observed in the early 1960s.

Adults for brood stock in the program were initially collected in 1978 at Little Goose Dam and in 1979 at both Little Goose and Lower Granite dams (Fig. 3). Adults were taken from the summer run period at the dams, in an attempt to collect fish that were "locally-adapted" to the South Fork Salmon River. The collections in 1978 and 1979 were done to establish an egg bank program prior to the completion of McCall Fish Hatchery. Managers were concerned that at the rate of decline in summer chinook salmon observed at that time (prior to the completion of the hatchery), there would be insufficient fish to meet egg-take objectives when the hatchery was completed. Since 1981, all adults for brood stock were collected at the trapping facility on the South Fork Salmon River.

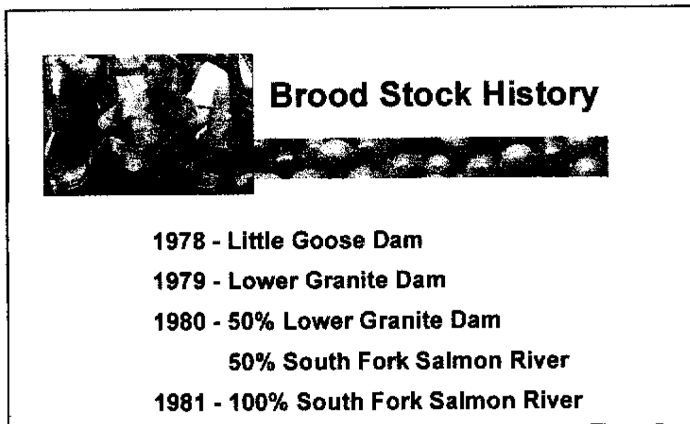

Figure 3.

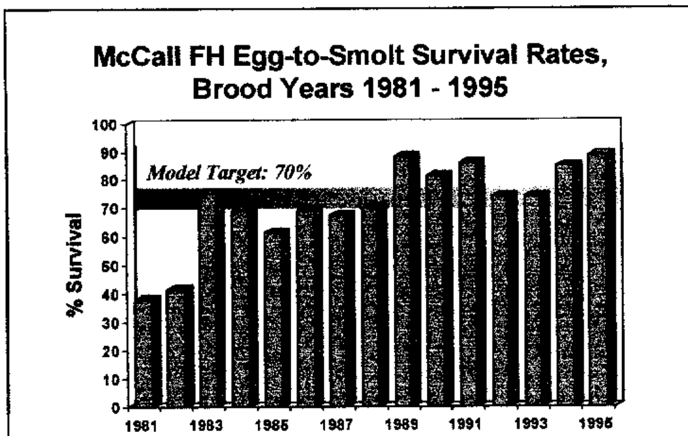

Figure 4.

Green egg to smolt survival rates for McCall Fish Hatchery is shown in Figure 4. The 70% survival target shown is not a hatchery management goal, but rather is the value used in the original production model to identify facility needs. It is included here for reference. Egg to smolt survival was relatively low for brood years 1981 and 1982. Since these were the first two years of operation of the new hatchery, the low survivals may have been related to the newness of the facility and start-up operations. Since 1983 egg to smolt survival has been quite high and stable. Hatchery management practices and research activities will continue to seek survival improvements. However, substantial increases are unlikely since survival is continuously high, especially as measured from the green egg stage.

Smolt releases into the South Fork Salmon River generally have reached the release target of one million smolts (Fig. 5). Small releases were expected in the first years of operation (1978-1984) as brood stock for future egg takes was being developed. Also, annual adult returns in these years were severely depressed and restricted the opportunity to collect sufficient numbers of eggs for the program. In 1982 the first mature four-year-old fish from the initial releases returned to the trapping facility and contributed to the egg take. As mature adults began to return from the earliest releases, these fish and some naturally produced fish were incorporated into the brood stock. More recently (brood years 1989-91, 1994, 1995) adult returns from hatchery releases were insufficient to meet egg take targets.

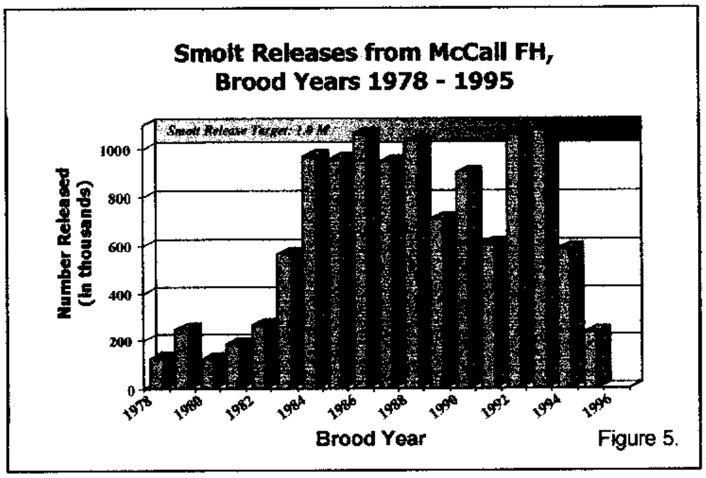

Figure 5.

A relative measure of "performance" of juveniles released is detections of PIT-tagged fish at downstream dams. The data points plotted in Figure 6 represent the cumulative proportion of PIT-tagged fish that were detected. These proportions detected provide an estimate of the minimum proportion of fish released that reached the first dam (Lower Granite).

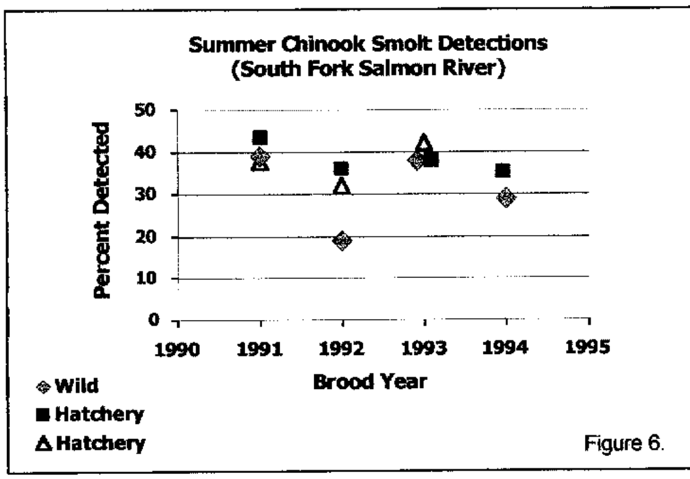

Figure 6.

In Figure 6 cumulative detection rates for one or two groups of hatchery fish (squares and triangles) are shown for four brood years. Also shown are cumulative detections for wild summer chinook salmon juveniles (diamonds) tagged in the upper South Fork Salmon River. The detections of wild fish are included for general comparison only, since the detection rates reported have not been adjusted for arrival timing, fish guidance efficiency at the time of arrival, spill at the dams, etc.

A general conclusion that might be made is that there are no apparent problems with fish survival from the time of release to arrival at the first dam. As a side note, it is important to note that to date, no good uniform measure of smolt quality has been developed. However, if we are concerned with the quality of smolts the first indication of a "bad" group of fish would be reduced egg to smolt survival. It was shown in Figure 4 that green egg to smolt survival has consistently been quite high, indicating good smolt quality.

Adult summer chinook salmon returns to the South Fork Salmon River weir, from hatchery releases, are show in Figure 7. The adult return goal has never been met; in the best year returns were 50% of the goal. It must be noted that the returns documented here are to the South Fork Salmon River weir, and that the compensation goal is to the project area - i.e. above Lower Granite Dam. However, no fisheries have occurred on these fish between Lower Granite Dam and the weir (except in 1997). In some of the early years natural fish may be included in the estimated return, since they could not be distinguished from fish originating from the hatchery releases. Fallout below the weir, of fish returning from hatchery releases, is not included in the returns shown.

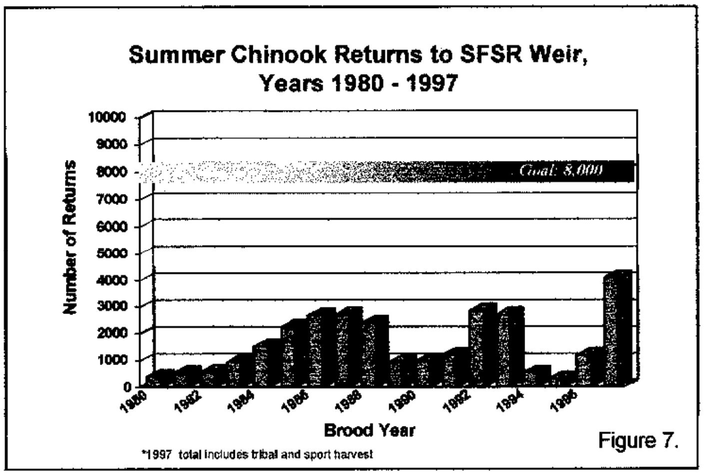

Figure 7.

The same returns shown in Figure 7 are again shown in Figure 8, except the y-axis has been expanded. Returns in the earliest years could not have been expected to achieve the return goal. No hatchery releases were made that could have contributed to the 1980 return. Fish would first begin returning from hatchery releases in 1983. This would include jacks returning from the brood year 1980 release of 100,000 smolts, four year olds returning from the brood year 1979 release of about 200,000 smolts, and five year olds returning from the brood year 1978 release of about 100,000 smolts (Fig. 5).

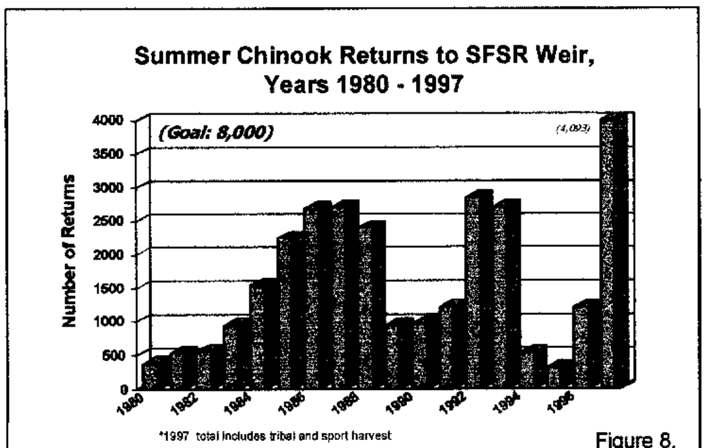

Figure 8.

The years 1988 through 1992 represent returns from releases that met the target of one million smolts. Even though the release target had been met, returns from these releases ranged from 13% to 34% of the adult return goal. In 1989, 1990, and 1991 insufficient adults returned to meet the hatchery egg take target.

To complete a performance appraisal for hatchery operation, two other measures are examined. The first of these is smolt-to-adult survival rate (SAR) (Fig. 9). The original facility development production model SAR was 0.87%. It is apparent in the figure that this SAR has not been achieved (except for brood years 1980 and 1981 if jacks are included). The SAR necessary for replacement of hatchery brood stock is approximately 0.06%, and is a function of the high egg to smolt survival achieved in a hatchery. For comparison, the SAR necessary for replacement of wild spawners is about 0.6% (at 7% egg to smolt survival). The diamonds in the figure represent SARs for aggregate groups of wild Snake River chinook salmon (Russ Kiefer, IDFG, unpublished data). The SARs for wild fish also have been low and appear to trend in the same direction as SARs for the hatchery released fish.

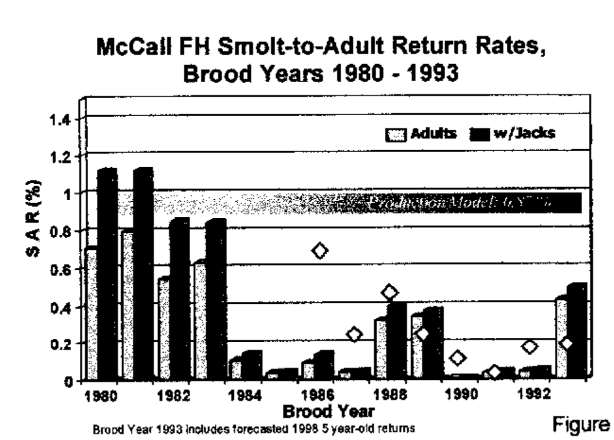

Figure 9.

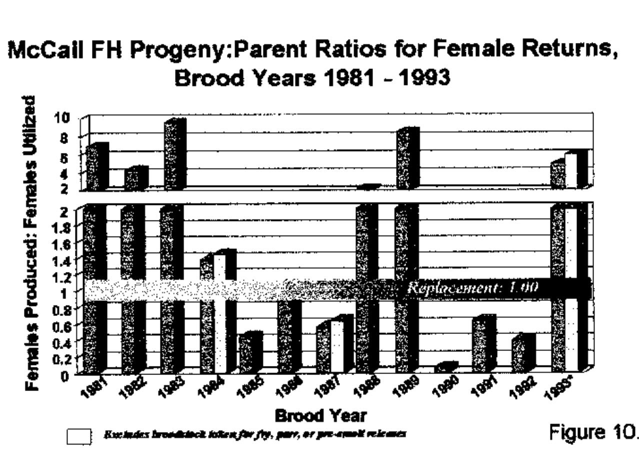

Figure 10.

The last measure in the performance appraisal of hatchery operations is progeny:parent ratios, an expression of the number of females returning for each female spawned to produce juveniles for release (Fig. 10, note the two scales on the y-axis). Based on parameters used in the original production model, we estimate a progeny:parent ratio of about 18:1 was anticipated. The progeny:parent ratios incorporate the complete life cycle of events for the fish, which includes both in-hatchery and post-release survival. These progeny:parent ratios directly reflect the SARs shown in the previous figures. For example, brood years 1985, 1986, and 1987 experienced very low SARs and progeny:parent ratios were below or just at replacement. On the other hand brood years 1988 and 1989, that experienced better SARs (but not high SARs) had progeny:parent ratios above the replacement level. The moderately good progeny:parent ratios for brood year 1993 resulted in some limited fisheries on these fish in 1997.

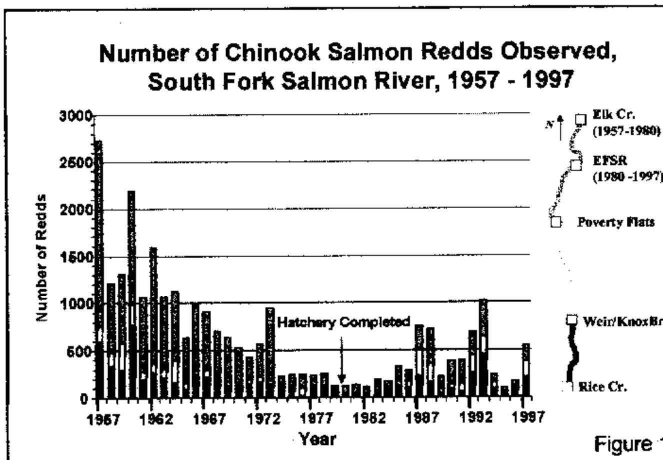

Figure 11.

The last two data slides (Figs. 11 and 12) examine the influence of hatchery weir operations on spawner redd distribution and benefits to natural production. The number of redds observed each year is shown for three stream reaches (Fig. 11); 1) from the mouth of Elk Creek upstream to the Poverty Flats Pack Bridge (assumed to be unaffected by hatchery operations), 2) Poverty Flats Pack Bridge upstream to the hatchery weir (or to Knox bridge prior to construction of the weir; an area potentially affected by fallout of hatchery fish below the weir), and 3) from the hatchery weir (or Knox Bridge) upstream to the mouth of Rice Creek (affected by hatchery trapping and release operations).

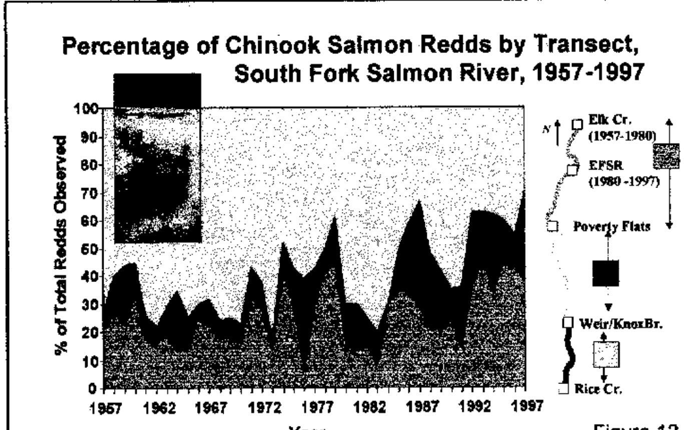

Figure 12.

The number of redds observed in all areas generally declined from 1957 through the early 1970s. Sediment impacts to the South Fork Salmon River in 1964 are thought to have impacted chinook salmon production. Increases in the number of redds in the upper two stream sections have been observed since about 1985. Some of this increase is thought to be a result of hatchery supplementation efforts.

In the 1960s about 20% of the total redds observed upstream of Elk Creek were in the upper most section previously described (Fig. 12). After hatchery operations were initiated in 1980, a higher proportion of redds have been observed in the upstream two sections. Resolution of the data in Figure 12 is not fine enough to show the area of greatest hatchery fallout below the weir. Fish returning from hatchery releases that do not recruit back to the weir are more commonly observed within one to two miles of the weir. Productivity in the lower most stream section may still be depressed as a result of sediment impacts in the 1960s. In general, it appears there has been a net hatchery benefit to the natural spawning population in the upper spawning areas, especially above the hatchery weir.

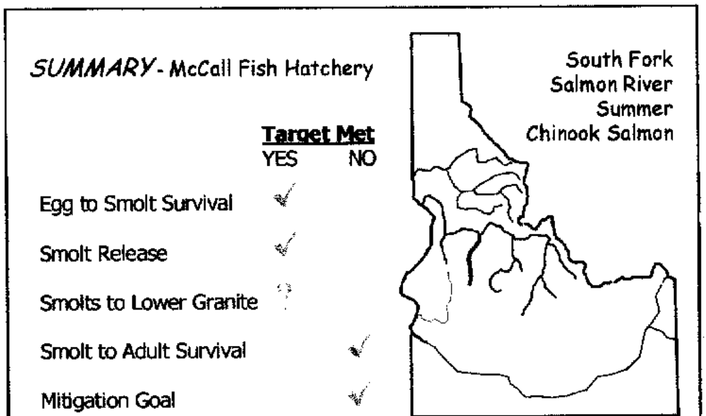

Figure 13.

A performance report card for the South Fork Salmon River summer chinook salmon compensation program was prepared. Performance in five areas is reported (Fig. 13). In-hatchery egg to smolt survival is consistently high. Smolt release targets have been met when sufficient adults returned to satisfy brood stock needs.

Smolt survival from release to Lower Granite Dam is difficult to evaluate, since there are no targets or historical reference points. In, relation to wild fish (and based on detections of PIT-tagged fish), fish released from the hatchery are surviving to the first dam as well as can be expected. We will continue to monitor this performance measure.

Smolt-to-adult returns rates have consistently failed to achieve the production model target of 0.87%, and have been below the level needed for replacement in many years. There are no indications that this performance is due to hatchery operations or poor quality of the fish released. Similarly poor SARs have been documented for wild fish. Factors affecting SARs for these fish most likely operate outside of the South Fork Salmon River basin and hatchery environment. Poor survival through the lower Snake and Columbia rivers hydrosystem is considered to be the primary factor affecting fish survival.

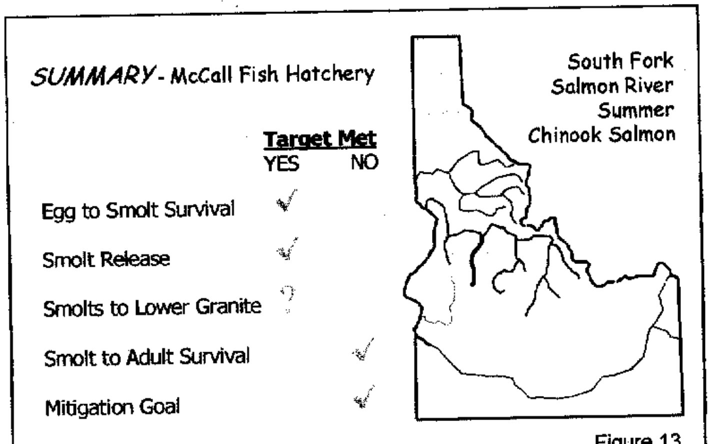

Figure 13.

The adult return compensation goal of 8,000 fish has never been met, and is most directly the result of the poor SARs exhibited. IDFG will continue efforts to improve in-hatchery performance. However, only small improvements can be expected, since in-hatchery survival and smolt quality are typically very good. These small improvements will not offset or overcome the extremely low SARs.

Three possible avenues are seen for the future of this summer chinook salmon compensation program (Fig. 14). The first avenue - status quo ecosystem - assumes no changes to be made in hatchery operations or ecosystem management (e.g. hydrosystem operations). Under this scenario we can only expect that a remnant run would persist, or the wild and hatchery stocks may go extinct.

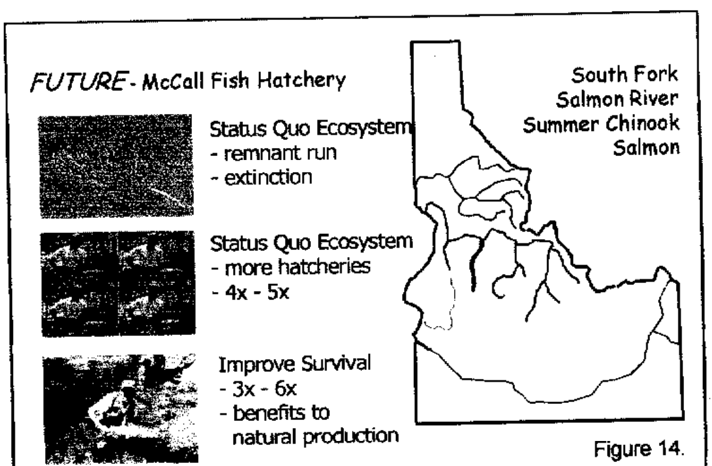

Figure 14.

If changes necessary to improve smolt-to-adult survival are not made and the desire is to achieve the compensation goal of 8,000 adults, four or five additional 'McCall hatcheries' could be constructed to provide for the release of another four to five million smolts. A major problem with this avenue is that more hatcheries will not stop wild stock extinction or ease restrictions or management under the Endangered Species Act. Also, insufficient numbers of adults return at the present time to provide eggs for these 'new' hatcheries.

The third avenue is to implement changes that would improve smolt to adult survival to a level of 2% to 6%. Any survival increases will be realized by both wild and hatchery populations, benefiting both. The Idaho Fish and Game Commission believes that a normative river is the best biological route to meeting this survival level. The Commission and the Idaho Department of Fish and Game do not desire to manage remnant populations that provide no fishery benefits.

It is important to review these three future management options to establish the current management framework (Fig. 15). The Idaho Department of Fish and Game's management focus is conservation and rebuilding of wild summer chinook salmon in the upper South Fork Salmon River. We are currently investigating, through a Bonneville Power Administration funded study, supplementation as a tool to rebuild the natural spawning population. While not meeting its compensation plan goal, the LSRCP-funded hatchery program plays an important role in management of upper South Fork Salmon River salmon. Adaptive hatchery management actions are implemented to respond to management needs of naturally produced fish in the upper basin. The supplementation research program utilizes some natural-origin adults as brood stock to produce juveniles for release, and the juveniles are reared in the hatchery. In addition to the supplementation fish, the general production (compensation program) brood stock is maintained to achieve the goal of the LSRCP program and provide fishing opportunity in the future. The general production fish are managed to provide a safety net or reserve should natural-origin returns become so critically depressed that recovery without intervention actions is unlikely. Operations planning and management of the hatchery program acknowledges the Idaho Department of Fish and Game's highest priority – wild/natural stock conservation and rebuilding – while continuing to support the facilities objective of compensating for reduced fish survival due to hydroelectric development and providing fishing opportunity.

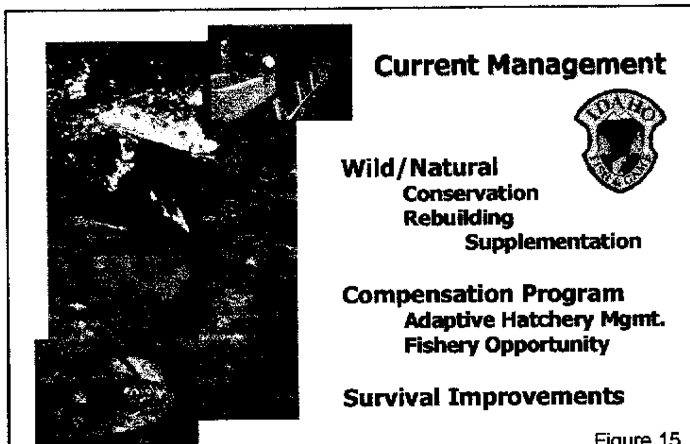

Figure 15.

Questions and comments

Rich Carmichael observed that, at a couple of points in his presentation, Hassemer had expressed the opinion that smolt migration to Lower Granite probably could not be improved. I wonder if you could clarify that, Carmichael said – is that under existing conditions, or would you expect migration success to Lower Granite to improve if we can restore a normative river? In terms of detection to Lower Granite, Hassemer replied, under a normative river, I would expect some improvement, but it would probably be very small. Unfortunately, we have little information on which to base an analysis of historic migration success, he continued – PIT-tag information is all very recent, and frankly, no one has much knowledge about what the survival target should be. The reason I say the improvement would likely be small under normative river conditions is that there is little slack water above Lower Granite Dam, Hassemer continued – if normative river conditions were restored, I expect that the survival improvement to Lewiston would be much more dramatic than the improvement in survival to Lower Granite.

Bowles added the clarification that the comparison uses as its benchmark the performance of wild fish – the implication is, are there any improvements we can make in the hatchery to enhance post-release migration success? If you use the natural fish as a benchmark, Bowles said, there doesn't appear to be a lot we can do.

One thing I didn't touch on in my presentations, said Hassemer, is the magnitude of the hatchery evaluations we've done – we've looked at time of release, size at release, rearing density, mark type, natural rearing, feeding regime... it's a very lengthy list. In the process of evaluating all of those factors, we've come to the conclusion that the hatcheries are doing a good job, he said – they are producing high-quality smolts, which, unfortunately, don't return as adults at nearly the rate we would like to see.

Did the resumption of the sport fishery in 1997 create any problems for your program? asked one participant. None that I'm aware of, beyond the fact that I didn't have a chance to get out there and fish, Hassemer replied. It was a fairly short season for the sport fishery; there was a tribal fishery as well, but as far as I know, it didn't cause any problems for our program. It was a year when progeny-parent ratios were above the replacement value; we were seeing adult returns in excess of the hatchery's needs, so the decision was made to allow the fishery to resume. If anything, he said, the fact that we weren't able to harvest all of the non-listed hatchery fish in excess of hatchery needs may cause some problems in the future. In response to another question, Hassemer said the 1997 Salmon River chinook fishery employed extremely conservative incidental take assumptions with regard to assumed catch-and-release mortality; the fishery was closed when a very low assumption of fishery-related incidental take mortality was reached. My feeling, based on my review of the literature, is that there were no detrimental affects on the natural population, he said.

One of the things that has jumped out at me today is the fact that, in terms of both smolt-to-adult survival and progeny/parent ratio, the South Fork and Imnaha programs are performing better than the other programs that have been reviewed during today's session, said Rich Carmichael. The two things those programs have in common is that they are both local broodstocks, and the fact that the South Fork fish are truly summer chinook, and the Imnaha fish are more summer than spring chinook, if you look at migration timing and other factors. Any thoughts on why those two factors may be contributing to better performance for those two programs? Carmichael asked. Every hatchery is different, Hassemer replied – there may be some stock characteristics that cause these populations to perform better, or it could be something we're doing in the hatchery. For example, McCall is the only hatchery in Idaho that uses larger, covered, outdoor ponds or raceways, and rears the fish out of basin.

Bowles added that, for whatever reason, in the South Fork Salmon, the wild fish are also doing better than their counterparts elsewhere in the basin – I'm not so sure it's a hatchery artifact so much as a stock artifact, he said.

Nez Perce Tribe Vision of the Future for Chinook Salmon Management in the South Fork Salmon River

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Introduction

This paper summarizes a presentation given at the Lower Snake River Compensation Plan Status Review Symposium held on February 3-5, 1998. We present the Nez Perce Tribe vision of the future for chinook salmon management in the South Fork Salmon River

It is difficult to have a positive vision of the future for chinook salmon in the South Fork Salmon River since adult salmon escapement has declined to historic low levels (Figure 1). The simple linear model of annual redd counts over time indicated a population trend in significant decline ($p< 0.01$) between 1957 and 1996. Annual chinook salmon redd counts on the upper mainstem South Fork Salmon River to the Knox bridge, have ranged from 2,145 redds observed in 1957 to just 55 chinook salmon redds counted in 1995. There are 18 other chinook salmon spawning aggregates in Idaho that exhibit similar characteristics of population trend undergoing significant decline ($p<0.01$) in abundance over the same time period (Kucera - unpublished data). Recruit per spawner functions from three chinook salmon spawning aggregates in the Middle Fork Salmon River, calculated by Plan for Analyzing and Testing Hypothesis (PATH) scientists, have been below replacement for seven consecutive brood years (Table 1). Chinook salmon in Johnson Creek, a tributary in the South Fork Salmon River, have experienced four consecutive years of recruit per spawner performance below replacement as well. Currently, chinook salmon are in continued decline and not able to replace themselves (one adult returning for every adult spawner) in their native habitat.

The Lower Snake River Compensation Plan hatchery supplementation program has intervened to attempt to compensate for losses cause by the construction and operation of the four lower Snake River hydroelectric dams. The current program appears to be slowing the decline in salmon population abundance in the South Fork Salmon River (Hassemer 1998) as the proportion of hatchery reared adult returns are comprising a higher proportion of the run in recent years.

Importance of Salmon

Chinook salmon are important for cultural, ecological and economic reasons. Culturally, they were historically important to native Americans and more recently to European man in the Pacific northwest. The Nee Mee Poo (Nez Perce Tribe) utilized salmon as a mainstay in their diet over the past 10-15,000 years. Salmon were a food source that allowed for survival, and became interwoven with Tribal culture, tradition and religious ceremonies.

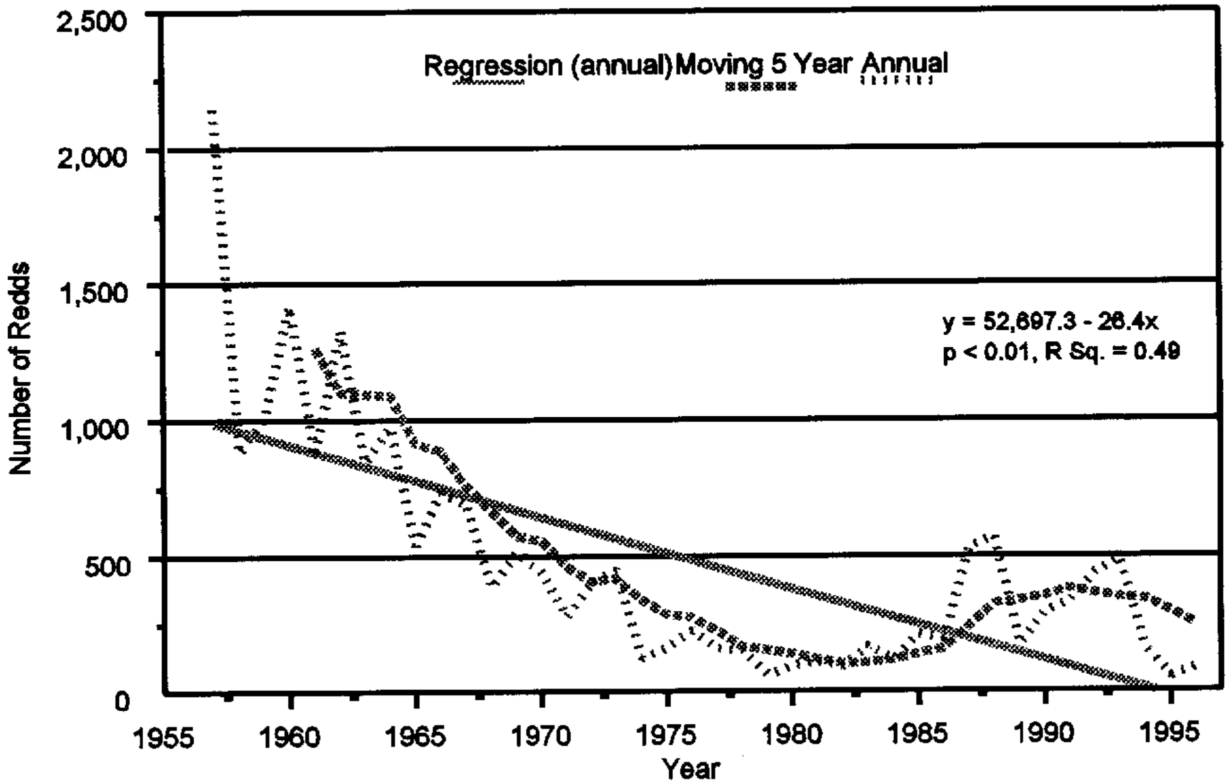

Figure 1. Annual chinook salmon redd counts, moving five year average and regression on annual redd counts in the South Fork Salmon River up to Knox Bridge from 1957 to 1996.

Several excerpts from the Wy-Kan-Ush-Mi Wa-Kish-Wit, Spirit of the Salmon, (1995) places the importance of salmon in this way. "Their very existence (Tribes) depends on the respectful enjoyment of the Columbia River Basin's vast land and water resources. Indeed their very souls and spirits were and are inextricably tied to the natural world and its myriad inhabitants. Among those inhabitants, none were more important than the teeming millions of anadromous fish enriching the basin's rivers. Salmon is important and necessary for physical health and for spiritual well being. The four Columbia River treaty tribes, who are keepers of ancient truths and laws of nature, employ the depths of their hearts and the expanse of their minds to save the salmon. Respect and reverence for this perfect creation are the foundation for this plan".

Ecologically, Pacific salmon are a keystone species integral to continued ecosystem health and species biodiversity. Adult salmon provide an important nutrient payload, mainly derived in the marine environment, into infertile streams that they return to and spawn in. Nutrients from salmon carcasses provide a major source of energy in the aquatic food chain and also provide nutrients to riparian areas. Nutrients from these carcasses may result in greater primary production, heterotrophic production and enhanced decomposition of leaf detritus (Durbin et al. 1979, Richey et al. 1975, Spencer et al. 1991). Piorkowski (in press) reported macroinvertebrate taxa richness and diversity both increase with nutrient enrichment from salmon carcasses. Carcasses are utilized by a great diversity of organisms ranging from decay microbes to bears. At least 22 species of birds and mammals consume salmon carcasses (Cederholm et al. 1989). Live salmon have been important to the survival and proliferation of the human species as well.

Table 1. Recruit per spawner functions calculated on the spawning grounds for Sulphur Creek, Marsh Creek, Bear Valley/Elk Creek, and Johnson Creek for brood years 1957 to 1992 (after PATH analysis).

Brood Year	Sulphur Creek	Marsh Creek	Bear Valley/ Elk Creek	Johnson Creek
1957	0.674	0.834	0.972	0.485
1958	2.830	1.586	1.869	2.687
1959	1.380	7.139	1.025	0.973
1960	0.788	1.535	0.966	0.565
1961	1.005	0.696	0.734	0.576
1962	2.020	2.024	1.139	0.857
1963	0.923	0.998	0.660	0.652
1964	4.715	0.536	0.862	0.542
1965	7.125	1.066	1.667	2.124
1966	0.537	0.760	0.321	1.375
1967	0.546	0.472	0.434	0.786
1968	0.670	1.196	0.845	2.472
1969	0.234	0.816	0.300	0.474
1970	0.605	0.563	0.676	0.944
1971	0.246	0.170	0.504	0.360
1972	0.063	0.140	0.197	0.134
1973	0.869	0.647	0.723	0.638
1974	0.505	0.241	0.498	0.296
1975	0.049	0.046	0.075	0.131
1976	0.288	0.646	0.308	0.721
1977	1.222	0.664	0.370	0.551
1978	0.119	0.143	0.245	0.615
1979	0.086	0.856	0.524	0.431
1980	3.600	10.862	6.219	2.253
1981	6.938	1.735	1.644	1.396
1982	8.094	3.130	4.729	1.458
1983	12.450	8.068	7.080	2.472
1984	NA	0.551	0.598	2.647
1985	1.888	0.439	0.494	0.497
1986	0.627	0.555	0.978	1.560
1987	0.617	0.205	0.336	0.586
1988	0.430	0.694	0.641	1.285
1989	0.392	0.309	0.830	0.854
1990	0.025	0.036	0.096	0.119
1991	0.004	NA	0.025	0.055
1992	0.019	NA	0.004	0.013

Economically, salmon have been cornerstone of the economy in the Pacific northwest for tribal, commercial and sport fisherman both in the ocean and freshwater environments. Salmon are also a part of the Northwest's quality of life. The net value of the Northwest's salmon fishing in 1990 was estimated to be $279 million (American Sportfishing Association 1994). Other speakers from sport, tribal and commercial fishing stake holders have addressed this aspect of salmon importance during the symposium so we will not duplicate their efforts.

Subbasin Management

Four aspects of current chinook salmon management exist in the South Fork Salmon River that should be addressed immediately. Adult salmon returning to the South Fork Salmon River need to be managed as one group of fish. Current management practices have created two groups of fish, one listed under the Endangered Species Act (ESA) and one unlisted reserve group, from one original broodstock source. The listed group currently represents natural by hatchery crossed adult matings in the spawning protocol, and the unlisted group are comprised of hatchery by hatchery crossed fish. All of these fish have some degree of wild or natural parentage and represent important genetic diversity that should be maintained within the supplementation program. Genetic diversity within the artificially propagated population should mimic the natural population as much as possible. The practice of land filling adult hatchery returned salmon viewed as surplus to program needs must cease. Two sub-populations of chinook salmon are currently recognized in the mainstem South Fork Salmon River. One subpopulation exists from the mouth to Poverty Flats, and the other from Blackmare Creek to Stolle Meadows (headwaters). Blackmare Creek is the boundary on Poverty Flats and the spawning locations are located within a continuous stream reach separated by an artificial boundary. Therefore we see no rationale in splitting the upper mainstem spawning aggregates into two groups. We suggest managing the spawning aggregate of salmon from the confluence of the East Fork South Fork Salmon River upstream to Stolle Meadows as one spawning aggregate. Broodstock for the McCall Hatchery supplementation program should be collected from that area.

Secondly, salmon in the upper mainstem South Fork Salmon River should be managed based on a minimum adult spawner escapement goal. This adult escapement number has yet to be calculated and agreed upon by the salmon managers. Recent historic redd counts in the upper mainstem South Fork Salmon have been as high as 2,732 redds (1957). The minimum adult chinook salmon spawner escapement goal agreed to by the Nez Perce Tribe and Oregon Department of Fish and Wildlife, for the Imnaha River, was 700 adults. Below the minimum escapement goal there is no constraint placed on the number of hatchery adults released to spawn naturally or used in the hatchery broodstock. Every adult salmon is considered important to build the population size and move toward recovery. The main concern below the minimum adult spawner escapement is demographic risk of extirpation.

We further believe it important for managers to implement a no-net decline management approach for South Fork Salmon River chinook salmon. By this we mean that populations must remain at replacement or above, and not continue to decline with recruit per spawner functions below one (Table 1). All management activities during the freshwater and marine portions of the salmon life cycle should be directed at this objective.

Finally, the South Fork Salmon River chinook salmon supplementation program should attempt to mimic the life history characteristics exhibited by naturally reproducing salmon. By this we mean such things as rearing a hatchery chinook salmon smolt to a size that will return an age structure of adults that mimics the natural population. We also recommend development of acclimation facilities and allowing volitional release of hatchery reared smolts. Volitional release would allow the fish to emigrate when they were ready, and would more closely mimic the protracted emigration period that natural chinook smolts exhibit. Fish size at release, time of release and release locations should attempt to mimic the natural fish (if possible) and return adults to desired spawning locations. Similarly, spawning protocols should ensure adequate mixing of natural and hatchery reared fish to mimic the genetic diversity of the natural chinook salmon population.

Mainstem Management

Management concern exists relative to mainstem passage smolt survival and adult survival through the eight hydroelectric dams on the Snake River and Columbia River system. Estimated survival of hatchery reared chinook salmon smolts from direct stream release in the South Fork Salmon River to Lower Monumental Dam ranged from 35 to 50% between 1993-1997 (Figure 2) (Smith et al. 1998). These survival rates are of special concern since in-river emigrating smolts must migrate past an additional five dams to successfully reach the estuary.

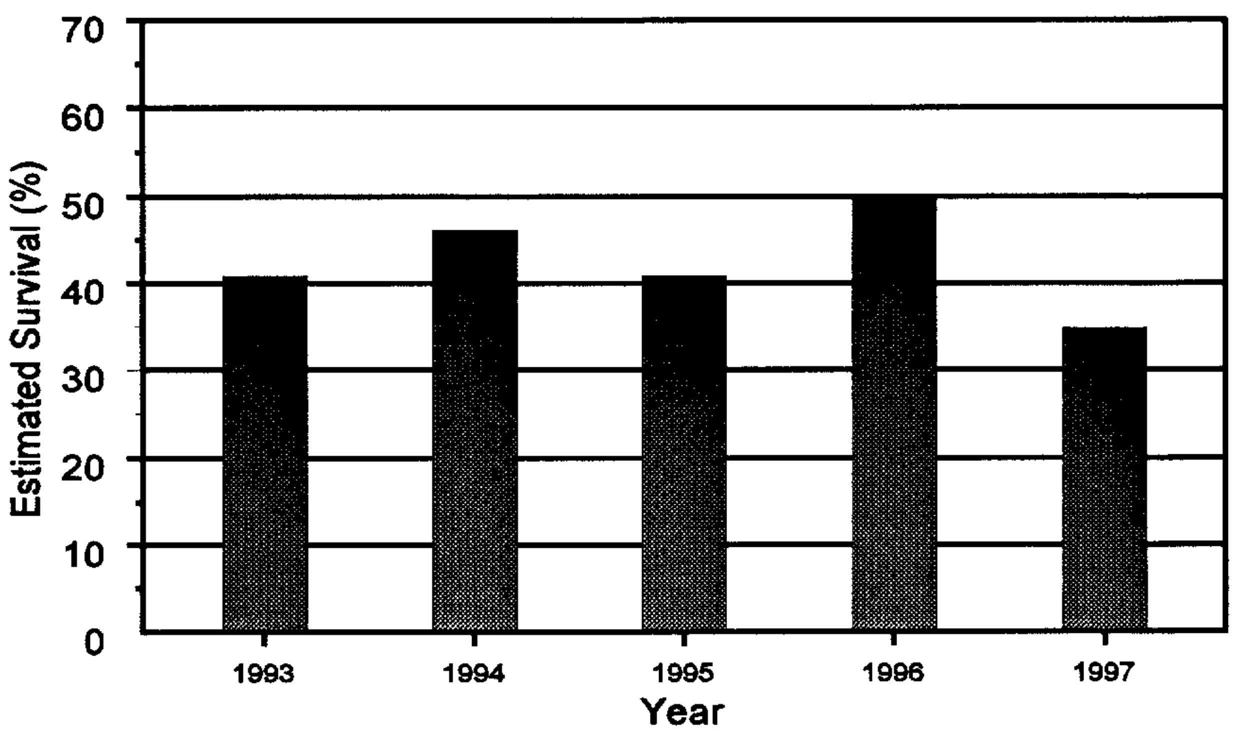

Figure 2. Estimated survival of hatchery reared chinook salmon smolts from the South Fork Salmon River to Lower Monumental Dam from 1993 to 1997 (after Smith et al. 1998).

Estimated survival of adult chinook salmon from the tailrace of Ice Harbor Dam, in the lower Snake River, through Lower Granite Dam ranged from 74 to 84% from 1991-1993 (Figure 3) (Ted Bjornn - personal communication). This estimated loss, of 16 to 26% of the radio transmittered adults in the lower Snake River stream reach, represents a significant loss of adults. The survival of adult salmon through the four lower Columbia River hydroelectric dams is currently unknown and needs further investigation.

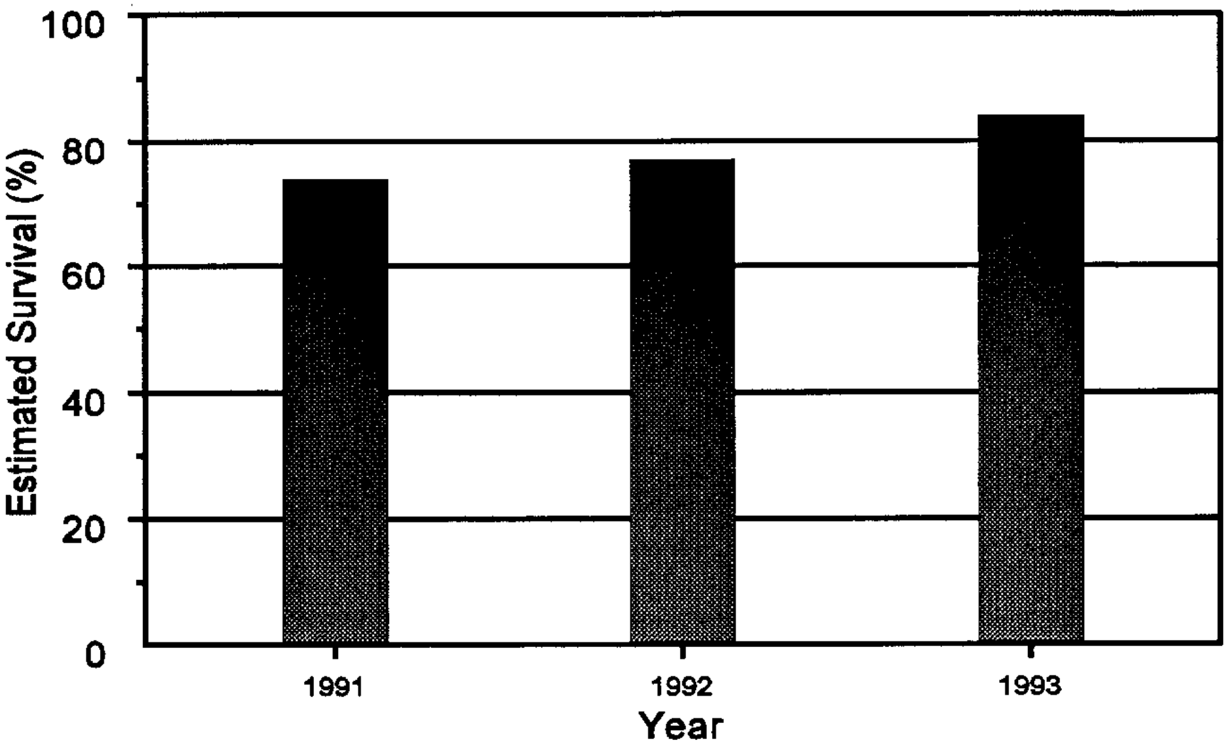

Figure 3. Estimated survival of radio transmittered adult chinook salmon through the four lower Snake River dams from 1991 to 1993 (Ted Bjornn - personal communication).

Mainstem flow and passage improvements are needed in the lower Snake River and Columbia River in light of juvenile and adult survival problems along with fish health and condition concerns relative to current management in the system. Short term measures recommended in the Wy-Kan-Ush-Mi Wa-Kish-Wit (1995) to improve flow and passage conditions included: controlled spill to achieve an 80% fish passage efficiency (fish passing by non-turbine routes), drawdown of Lower Granite reservoir with agreed to mitigation measures, minimum operating seasonal pool drawdown of Little Goose, Lower Monumental and Ice Harbor dams with agreed to mitigation measures, not operating turbines outside of 1% of peak efficiency, and halting mass transportation smolts. Longer term options included several alternatives of natural river drawdown of Snake River reservoirs and John Day Dam, 90% passage efficiency of the controlled spill program, and turbine retrofit.

The Nez Perce Tribe believes that significant juvenile and adult salmon mortality exists due to the mainstem Snake River and Columbia River dams (Figure 4). This mortality constrains chinook salmon smolt to adult survival and effectiveness of the Lower Snake River Compensation Plan hatchery program. Current smolt to adult survival (SAR) for the South Fork Salmon River hatchery chinook supplementation program is approximately 0.20%. PATH scientists estimate that SAR's must be increased to 2-6% for full recovery of Snake River basin salmon populations to occur.

One of the alternatives to improve salmon survival is to move toward normative river conditions (Independent Scientific Group 1996). Normative was defined as an ecosystem where specific functional norms or standards that are essential to maintain diverse and productive populations are provided. The Independent Scientific Group (1996) further reported that important to conditions defined as normative was the availability of a continuum of high quality habitat throughout the salmon life cycle. Development of the Columbia River for hydropower and other purposes has led to a reduction in the quality and quantity of salmon habitat and the disruption in the continuum of that habitat. Consequently, the most promising way to restore salmon populations is to reduce or remove conditions that limit restoration of high quality salmon habitat.

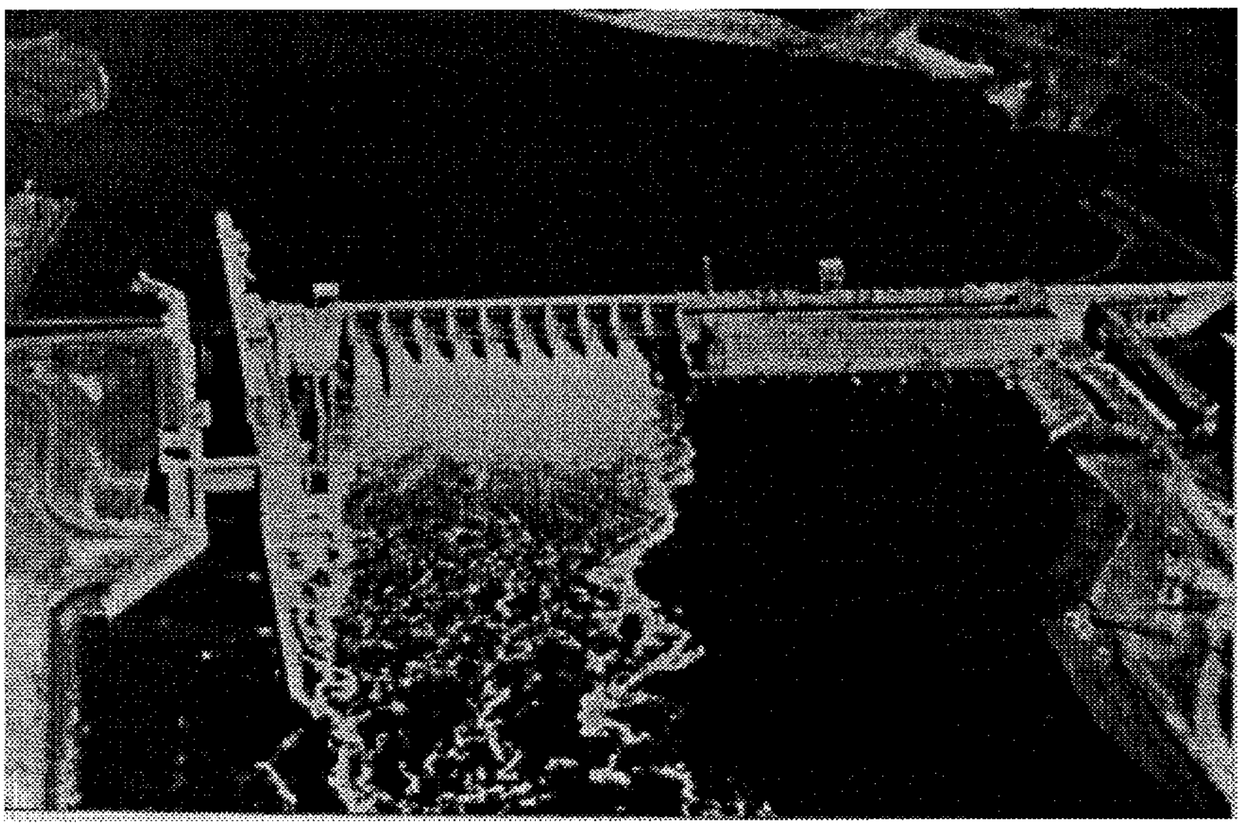

Figure 4. Photograph of a hydroelectric dam that juvenile and adult salmon must negotiate during their life cycle.

Finally, we believe it important to implement adult PIT tag interrogation capabilities at Bonneville Dam immediately. This will allow salmon managers the ability to more effectively evaluate survival questions relating to the ocean environment and mainstem Columbia River and Snake River system.

Vision of the Future

The Nez Perce Tribe's vision of the future in the short term is to preserve Pacific salmon in the Snake River basin. This is a daunting task in the face of salmon populations that are in significant decline, at low levels of abundance, with recruit per spawner functions below replacement and mortalities that are causing localized extirpations of some salmon spawning aggregates. To preserve salmon we must change the way in which we manage salmon. Immediate short-term measures are required to meet a no-net decline approach for Snake River basin spring and summer chinook salmon. Smolt to adult survivals need to be increased to 2-6% in the long term to realize self-sustaining salmon populations and improved ecosystem health and species biodiversity. Improvements in hydroelectric system survival are necessary or natural productivity will remain low and localized extirpations of salmon spawning aggregates will most likely continue to occur. Delisting of Pacific salmon under the ESA also will not occur. Lower Snake River Compensation Plan adult salmon mitigation goals still exist, although we are now reacting in a preservation mode. Mitigation goals should be met for Tribal, sport and commercial fisherman. Finally, program success depends on improved smolt to adult survival in the mainstem hydroelectric system. We need to move toward normative river conditions if we are to fully recover salmon populations (Figure 5). A full array of alternatives must remain on the table for complete examination and discussion including dam breaching options.

Figure 5. Spawning chinook salmon in their native habitat.

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Questions and comments

The fair adult returns we saw in 1997 led to some fairly intense discussions between the co-managers -- the states, tribes and federal management agencies -- about how to allocate those "excess" returning hatchery adults, said Mike Delarm. Early in a your talk, you discussed the need to keep the threshold levels for escapement, utilizing these hatchery fish for natural reproduction when they return in some excess to hatchery production needs. Can you give us the tribal perspective on what the threshold level might be in terms of returns above the hatchery weir, as well as other areas of the McCall/South Fork Basin in which the Tribe feels the surplus might be useful?

I think that is something we need to work with the states on, Paul Kucera replied. It's one of the reasons we say we would manage the populations as one, and not discriminate between hatchery and wild fish -- we view every fish as valuable, given the current situation. I think we need to get a better understanding of how we should use fish that are derived from a local broodstock, in terms of their potential adverse effects on natural populations.

Can you clarify the role of the Tribe in the management of the summer chinook program in the South Fork Salmon? Rick Williams asked. Do you manage a separate facility, or are the data Pete Hassemer presented the data for the South Fork? If you do have a separate facility and separate data, do they show the same trends we saw in Pete's data? The Nez Perce Tribe is viewed as a co-manager of the resource, which extends over 14 million acres in three states, Kucera replied. The Nez Perce Tribe does not manage any hatchery facilities under the LSRCP, although we do manage three of the fall chinook sites. The data Pete presented are the data for all hatchery solutions, Kucera said. The Nez Perce do have an evaluation program, which it is collecting some additional data for the states on the effects of hatcheries, Bowles added.

Summary of Spring/Summer Chinook Session

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In terms of a short summary of the LSRCP spring/summer chinook program, we have heard that there are a number of similarities between the programs. Those similarities aren't necessarily driven by a cookie-cutter approach to chinook salmon production; in fact, we have heard about a number of innovative approaches within the constraints of the concrete that was laid down early in the program. In spite of that, with some exceptions, we have heard fairly consistent results across the board.

Overall, I think it is fair to characterize what we have heard today as a bleak picture, with respect to the goals of the program. There isn't much we can hang our hats on, in terms of program results to be proud of. However, in terms of the innovation and effort that has gone into making the Lower Snake Compensation Plan program successful, there is much to hang our hats on. There is plenty more that can be done, but I'm not sure it will be enough to achieve our spring/summer chinook program goals.

It may be useful for us to consider the question of why these hatcheries are here. There are some extremely important legislative and court-sanctioned and mandated promises that were made. Those promises relate to the LSRCP, U.S. v Oregon and Idaho Power settlement agreement; they aren't going to go away. Those promises all resulted from construction and operation of dams, and they all chose hatcheries as the primary tool to mitigate for those effects. Based on the presentations we have heard today, it may be time to take a step back and ask ourselves whether we, as a society, have chosen the right tool for this job. Additionally, are we expecting too much from the tool that was chosen? If we depend on hatcheries as the only tool for the recovery of Snake River chinook stocks, we may be setting ourselves up for failure.

Given that context, perhaps it would be more productive to evaluate the LSRCP in terms of its two-pronged objective. The first objective is production -- how well are we doing in terms of producing adults to provide fishery opportunities? The second objective has to do with conservation -- how well are we protecting the wild natural fish, and how are we doing in terms of recovering those stocks through supplementation?

From the standpoint of production, and whether or not this is the right tool to be using, I think it is important to keep in mind that this is a survival game, not a numbers game -- you don't harvest based on numbers, you harvest based on survival. You are harvesting surpluses above the level necessary to keep the program going. The key, in terms of harvest opportunities, is productivity -- survival, not just numbers. And in the recent history of our program, he said, fisheries opportunities are coming all too infrequently.

In the hatcheries, almost all of the programs are finding that they are successful in providing the egg-to-smolt survival necessary to meet their targets; however, that is being limited by access to the adults necessary to provide the eggs. Even if we were able to obtain the necessary number of adults to provide the eggs, and we were meeting the target of 8 million smolts, he said, is that the vision we want for the future?

Post-release survival is where we are really hurting in all of these programs. What can we do in the hatchery to enhance post-release survival? We have heard about some innovative approaches today; but is it realistic to expect those approaches to even make the radar screen in terms of providing the survival improvements we need to meet our adult production goals? I consider that very unlikely.

Even if we were successful in meeting the Lower Snake Compensation Plan's adult hatchery return goal of 125,000 chinook returning above Lower Granite Dam, is that the vision of the future we want? What is happening to the wild fish in the interim? My concern is that we may be forgetting about the genetic engine that is going to make these hatchery programs sustainable. If we continue to focus on hatchery production, we will be widening the chasm between the hatchery and wild fish. The key to our future success is going to be our ability to close that chasm, by increasing the production of wild fish.

That leads into the question of whether or not hatcheries can be useful in a supplementation program. In fact, many of the chinook programs now on line are really not production-oriented -- particularly in Oregon and Idaho, many of our programs are actually supplementation-oriented. How well are those supplementation programs doing? The results to date are mixed, but overall, I think it is fair to say that there is little indication that they are providing adequate benefit to the natural populations, within acceptable limits of risk to those populations, to warrant a program-wide implementation of a supplementation approach. That doesn't mean we should discontinue our supplementation efforts; I think we have to do everything we can to hold onto our remaining natural populations.

One thing we have to bear in mind is that supplementation, if it works, can increase the number of naturally-spawning fish. However, it can't increase the survival of those fish in the wild. Given that fact, unless the problems that originally drove those naturally-spawning populations down are fixed, we're going to be stuck with supplementation for an indefinite period. And the longer we're stuck with supplementation, the higher the risk of adversely affecting the very populations we're trying to help.

So while we move toward more conservation-type approaches, those efforts must be closely linked to a commitment to fixing the problems that caused the declines in the first place -- in my view, the main stem migration corridor and the dams. Otherwise, we're doomed in the long haul. Supplementation programs are necessary to preserve and maintain the genetic integrity of these stocks until those fixes can occur, but they are not enough, in and of themselves, to bring about recovery, based on what we've heard today.

My final point is that the key, from both a supplementation and a production standpoint, is to reduce the chasm between our hatchery fish and our wild fish -- both in terms of fish numbers and performance. We need to think seriously about the best way to do that -- whether it's through modification of our hatchery practices, or by removing the limiting factor that caused the chasm in the first place.

Audience Questions on Spring/Summer Chinook Session.

Cindy Deacon-Williams observed that, based on what she had heard today, it is clear that, in essentially all of the LSRCP chinook operations, we are trending toward extinction in our wild populations, and in many cases, trending toward extinction in our hatchery populations. Since we are clearly not meeting our mitigation goals, and often not meeting our replacement goals, what sort of a time-frame are we dealing with in terms of dates of extinction for those wild and hatchery population? What, if anything, can we do to change hatchery operations, in order to push those dates of extinction farther into the future, to give us a chance to make the modifications to the mainstem migration corridor that are necessary to allow recovery?

We have recently completed some planning work on our Grande Ronde broodstock programs, Carmichael replied; in our modeling work in support of that effort, we found that, no matter what range you put on your values or assumptions for survival rates or progeny-to-parent ratios, populations go extinct between 2025 and 2050. I would also observe that, based on what we have heard today, it isn't necessarily accurate to assume that all of our hatchery programs are headed toward extinction -- some programs are definitely in better shape than others, and could persist for a considerable period into the future.

Paul Kucera said that, from the standpoint of some of the Idaho chinook populations, what is alarming to him is the fact that, in the Middle Fork Salmon drainage, which is being managed as a genetic refuge, there are at least three populations that have experienced three consecutive years of cohort collapse. In my view, the wheels are coming off, and wild populations are winking out even as we speak. There are many, many populations that are at very low levels of abundance, that are at high levels of demographic risk of extirpation.

For all practical purposes, the East Fork Salmon chinook population probably went extinct last year, Hassemer added. We have taken that stock into a captive propagation program, to try to conserve what remains, but whether or not that will be successful remains to be seen. Overall, we are in the middle of an evolutionary process, in which the hatcheries are moving away from a production mode and toward a conservation mode, Hassemer said; we need to be very adaptive, and work together to solve these problems as they arise.

David Arthaud asked how many of the 30+ individual stocks in the Snake River system are in immediate danger of extinction, and where does supplementation come in as far as maintaining that entire stock structure? In the Clearwater system, from a hatchery standpoint, I think we could continue for quite awhile, replied Howard Burge. Absent immediate changes to the mainstem migration corridor, what would help would be to get several good water years in a row. In terms of our wild populations, he added, I think 2025 may be optimistic -- I would be surprised to see many of them last that long, unless big changes are made.

Carmichael added that the fact that supplementation is currently focused on only a small number of at-risk populations is primarily a function of logistics -- it's an extremely labor intensive process. It would be useful to have a regional dialogue about which populations are at the greatest risk, he said, as well as which populations are the most valuable, genetically.

Perhaps the time has come to question whether the original mandates and authorizations for the mitigation component of the LSRCP should still be driving where we're going today, observed Rick Williams. Based on what we've heard today, it doesn't sound as though there is a very good fit between those original mitigation objectives and what we're trying to do today, relative to collapsing runs and the danger of extinction for wild populations. It may be time to rethink our entire approach to the Lower Snake Compensation Plan program, he said.

Another question has to do with the fact that one of the options that is very much on the table for the 1999 system configuration decision is the removal of the four Lower Snake dams, Williams continued. The Lower Snake Compensation Plan was created to mitigate for the effects of those dams, and if they are in fact removed, how does that change the mandate for this program?

It obviously would change, Crateau replied -- in fact, if the four Lower Snake dams are removed, I would suspect that this program will cease to exist. And I would be glad to be the one to turn off the lights and lock the doors, if that does come to pass.

However, I think it may be a mistake to assume that if the dams are breached, the mitigation component of this program will disappear, said Deacon-Williams -- it is only once the dams are breached that the mitigation component of this program will truly be able to function. If the dams are removed, then this program becomes the right tool to help restore these populations -- it would finally have a chance to work the way it was intended.

It probably would be a good idea to inform Congress that the original design and objectives of the Lower Snake Compensation Plan are incompatible with the situation we're faced with now, Carmichael said. However, I don't think it's appropriate for us to use that as an excuse for not modified our programs to meet the challenges we have before us today.

Phil Mundy made the point that, based on his experience as a marine fisheries manager, it may be a mistake to assume that the Snake River dams are the primary source of mortality for Snake River chinook stocks -- ocean harvest, marine mammal predation and hooking injuries probably have much more of an impact. Bowles replied that one of the major conclusions in PATH's spring/summer chinook report was that the Snake River chinook indicator populations are performing anywhere from two times to five times worse then down river chinook stocks with comparable life histories. I don't disagree that ocean-related sources of mortality have a major impact on upriver chinook stocks, Bowles said -- however, there is an additional source of mortality consistently at work on those fish.

Mitch Sanchotena observed that the primary intent of the applicable federal laws was to mitigate for fisheries lost due to construction of the Lower Snake dams, not to conserve genetic resources until such a time that mainstem passage conditions improve. I would be curious about how the panel members intend to provide those fisheries in the future, he said. If we're now considering pulling the plug on those mitigation programs, and instead going to a museum-piece conservation program, maybe that's something that needs to be made public, Sanchotena said.

I don't think anyone in this room is happy about the fact that we have been unable to meet our mitigation goals, Deacon-Williams replied. What I've heard today is that the hatchery programs have done their utmost to try to meet those mitigation goals, but have found that, given current conditions in the system, they are incapable of doing so. Furthermore, we are in danger of losing many stocks to extinction, and losing all option for future mitigation. To me, all we can do with the hatcheries at this point is attempt to postpone the date of extinction far enough into the future to give us time to improve mainstem passage conditions and spawning and rearing habitat. Once those changes are made, we can once again use the hatcheries as a mitigation tool, Deacon-Williams said.

Given the uncertainties we're dealing with in the chinook program, said Tim Whitesel, do the panel members feel that, from the standpoint of scientific rigor, we are appropriately considering the risks associated with those uncertainties? I don't think we have in the past, or are now, dealing with the implementation and evaluation of these programs with enough scientific rigor, Carmichael replied. Personally, I think it may be too late, because these programs are now so far along. It's too bad, but it's something we should have thought about 20 years ago.

Science Panel Comments on Spring/Summer Chinook Session

Rick Williams commended Rich Carmichael's remarks on how production-oriented hatchery facilities can be changed over to conservation-oriented facilities; I think what Rich and his co-workers have done is of paramount importance to the region, and a very high priority should be placed on getting it into the literature, out for peer review and out for basin wide recognition, Williams said. It's a nice model, based on a sliding scale, that addresses the risks inherent in dealing with populations at a high risk of demographic extinction. Yet as recovery begins and numbers increase, it also addresses concerns about selection, population size, genetic drift and other factors -- it strikes me as a very useful tool.

During today's session, we have heard about many instances in which the small production goals are being met, but the SARs and parent/progeny ratios are not, said Pete Bisson. As we move toward incorporating more conservation goals into our hatchery strategies, what is being done to conserve the diversity within the natural stocks? My concern is the trend toward homogeneity in our wild populations, he said. I think it is safe to assume two things, Bisson said -- first, that changes will occur in the freshwater habitat, and second, that changes will occur in ocean productivity. Given those assumptions, the question we need to ask ourselves is, are we creating a legacy that will be unable to fully capitalize on those changes once they occur?

Building on this concept of maintaining genetic diversity, said Deacon-Williams, I would note that only seven of the 83 local chinook populations are currently the subject of a broodstock effort. It is obvious to me that the hatcheries will not be able to recover, and in many cases, will be unable to maintain, those local populations, unless the improvements in the migration corridor and spawning habitats occur fairly rapidly. Given that, I would suggest that that is the message we need to disseminate to the region, she continued. It's an ugly dilemma, and we need to decide how we want to present it.

With the exception of Lower Snake drawdown, I don't see anything currently under consideration in the 1999 decision process that is going to bring about the five-fold increase in SARs needed to restore many of these populations, Deacon-Williams continued. After 17 years of LSRCP operation, I think we can safely come to the conclusion that, if we really want to maintain and recover these stocks to fishable levels, then some major rethinking is needed about what we are doing in the Lower Snake, and about the mission of the Lower Snake Compensation Plan. That means we need to do some thinking about how our existing facilities and programs can be reconfigured to provide support for those local populations, so that, when changes occur in the migration corridor and in ocean conditions, we are in the best possible position to take advantage.

In response to a question from Jack McIntyre, Crateau said it would probably take an act of Congress for major changes in the LSRCP program correction to occur. We're talking about a fairly major change if we go from pure mitigation to mitigation plus conservation, McIntrye replied; and if that is that direction in which we are headed, it seems to me that we need to change tomorrow. You're probably right, Crateau agreed -- it may be too late for some of the populations. We've heard estimates that extinction will occur for many of our at-risk populations within 25 to 50 years unless dramatic improvements in smolt-to-adult survival are made; personally, I'm not sure we have that long, Crateau said.

Dan Goodman touched on the subject of the uncertainties associated with some of the big-picture questions the Lower Snake Compensation Plan program now faces -- those uncertainties take on additional importance because the stakes are escalating in a very dramatic way, he said. The extinction of major listed stocks is a very serious matter. It should also be pointed out that the removal of the Lower Snake dams is a very expensive proposition, Goodman said -- as one of my bosses once said to me, "you'd better be right." In that context, we had better be sure we know as much as it is possible to know about system and life-cycle survival and the causes of mortality. Given our current PIT-tag technology, we are in a position to know what mortality rate is associated with passage through the four Lower Snake projects, he said. Additionally, I think there are some very pressing genetic questions about the hatchery populations; the message I've come away with from today's discussion is that, in the Snake River Basin, at least, the wild, naturally-spawning populations are toast. If that is the case, the only populations we will have to work with will be hatchery populations, and we need a much better handle on their genetics. The numbers of fish that are contributing genetically to each generation are not large, Goodman said, which means we're looking at a fairly severe inbreeding situation. Given that likely scenario, the wild populations are a crucial source of genetic variability for sustaining the hatchery populations.

Final Comments on Spring/Summer Chinook Session

Bowles asked the stakeholders panel for their thoughts on today's session. We've touched on some fairly major policy issues today, said Steve Smith -- one thing we can do here is to be aware of how people are interpreting what the scientists are telling us. As most of you are aware, there are many, both inside and outside the region, who feel that hatcheries are not working. This in turn leads to pressure to cut hatchery budgets, Smith said, and shift those hatchery funds to other, more effective, recovery programs. What I have heard today is that hatcheries, operated in a conservation mode, can help us postpone extinction for at least some of these populations; they can also help maintain genetic variability until some of the bigger issues are resolved. I think it is important for us to the extremely aware of the terminology we use in describing the scientific information associated with this program, and how that terminology may be picked up by the press, Smith said.

Silas Whitman observed that, in his opinion, it is arrogant to make the assumption that supplementation is not a good idea. He expressed anger at the number of wild chinook populations that have already been forced to extinction; the only tool we now have available to us, under current management practices, is supplementation in concert with a captive rearing program, he said. We have asked for three years running for some form of intervention in the Middle Fork Salmon, Whitman said; we are now to the point where those flagship natural populations are probably irretrievable. He added that, from his tribal perspective, it is vital to preserve the mitigation component of the LSRCP program, if future legal action is to be avoided.

David Arthaud added that it is worth reminding all of the participants in this workshop that the tribes knew the dams would kill the salmon, even before they were built. It was common knowledge, he said, that there would be no salmon above the Hells Canyon complex. It is interesting that one of the strongest hatchery stocks remaining is from above Hells Canyon -- the Rapid River stock. The tribes did not support the construction of the dams; they did not support the mitigation program that has been put in place to compensate for dam-induced fish loss; they are not signatory to the LSRCP. However, Arthaud said, the tribes are at the table now because there have been some problems -- the mitigation promises have not been fulfilled; harvests have been minimal. The tribes are willing to take a positive approach to the future, and to support the use of hatcheries for the re-introduction of salmon to their former habitat.

At the same time, he continued, the tribes have little patience with calls for further research -- we've been studying this problem for decades, and nothing we have learned has halted the decline. That is one of the factors driving the 1999 decision, he said -- the tribes simply don't want to the waste any more time on study; they want to see solutions implemented. Because somebody has to draw the line, Arthaud said, before all of our wild populations are lost.

Fall Chinook Salmon in the Snake River Basin

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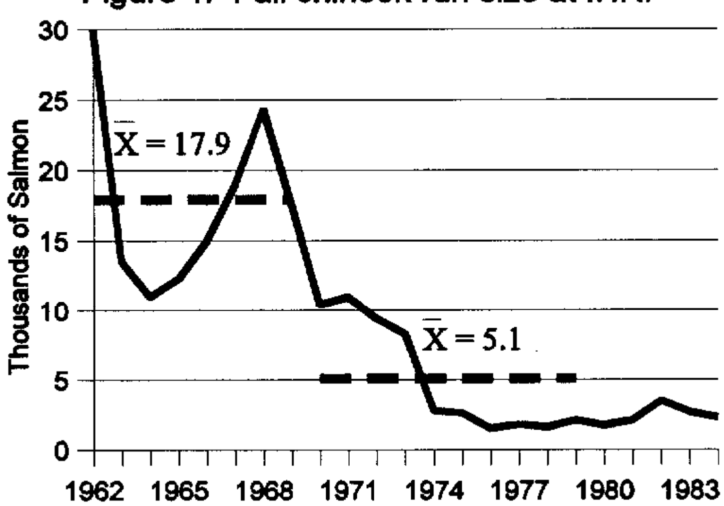
Fall chinook were once widely distributed in the Snake River from the confluence with the Columbia River upstream to Shoshone Falls, 615 miles. Snake River Fall Chinook are an "Ocean type" chinook which migrate within 6-8 months after emergence. They spend 2-5 years in the ocean with most returning to spawn at age 4. Adults arrive at Bonneville Dam after 31 July and spawn in upper Columbia Basin mainstem rivers and the lower portions of larger tributaries from mid-October through early December. Snake River fall chinook are part of the "upriver bright" run but are physiologically and genetically distinct from spring/summer chinook, upper Columbia River "brights" and lower Columbia River "tule" fall chinook. Historical run size according to Irving and Bjornn (1981) averaged 72,000 fish between 1938-1949 and 29,000 during the 1950s.

Construction of the Hells Canyon Complex (1958-1967) and the Lower Snake River Dams (1961-1975) eliminated or severely degraded 530 miles of spawning habitat. Currently fall chinook spawn from Asotin to Hells Canyon Dam and in the tail races below the four Snake dams, and in the lower Clearwater, Grande Ronde, Imnaha and Tucannon rivers. Fall chinook were particularly susceptible to the effects of hydroelectric development because of inundation of its preferred spawning and rearing habitats in mainstem rivers and because juveniles migrate to the ocean in late spring, summer and fall during low summer flows and high water temperatures.

As cumulative habitat loss steadily increased during the 1960s and 1970s, Snake River fall chinook declined, with an abrupt decline occurring in the early 1970s. Mean escapement at Ice Harbor Dam declined over three fold (Fig. 1). During this period of severe population decline, the Lower Snake River Compensation Plan (LSRCP) was being developed and negotiated. The Plan was approved by Congress in 1976. The intent for fall chinook was for hatchery compensation / mitigation for juvenile passage mortality, and loss of spawning habitat for 5,000 chinook caused by the four lower Snake River dams. An adult compensation goal of 18,300 adults/yr, "in place and in kind," was established and the plan identified the need to maintain the genetic integrity of the stock.

While planning and designing the LSRCP facilities in the 1970s, the steep fall chinook decline caused concern that these fish might become extinct before mitigation facilities could be completed to maintain and enhance the run. A fall chinook egg bank program was conceived and initiated. The egg bank program was begun in 1976 by the NMFS trapping at Little Goose Dam. Trapping was conducted at Ice Harbor Dam in subsequent years. The program involved many agencies and hatcheries in the Columbia Basin. By 1978 both Snake River and lower Columbia

Figure 1. Fall chinook run size at IHR.



River (to avoid dam passage related mortality) juvenile releases were occurring. This continued until 1983 when all releases were in the Snake River. Lyons Ferry Hatchery (LFH) was operational and incorporated into the program in 1984. LFH conducted the trapping, rearing, and release programs in 1985 (Bugert et al. 1995). Annual production from LFH to return 18,300 adults was planned to be 9.16 million subyearling smolts (101,880 lbs) at about 90 fpp (80 mm). Expected smolt to adult return rate was 0.2%. In addition to the LSRCP program, Idaho Power Company paid a portion of the construction costs for LFH in return for a promise of 1.3 million eyed eggs/yr as soon as LFH reached 12 million eggs/year. These eyed eggs would produce fish for Idaho Power's Hells Canyon fall chinook mitigation requirement.

As a supplement to the eggbank program, NMFS operated a captive brood program (1980-1985) to try and increase the number of fall chinook available. Using both freshwater and marine rearing phases, they reared fish from 15,000 eyed eggs/yr for three years. The program was discontinued in 1985 because of difficulties with fall chinook seawater tolerance and bacterial kidney disease.

Completed in 1984, LFH is situated downstream of Little Goose Dam. It was the only facility originally planned and constructed under the LSRCP for fall chinook. It included a well water system from the Marmes Cave site, adult trapping and spawning facilities, incubators, 28 raceways and a barge loading dock, as well as administration and support buildings. The eggbank program provided immediate production eggs for LFH, with the primary sources of adults shifting from Kalama Fish Hatchery (KFH) and Ice Harbor Dam (IHR) in 1984 and 1985 to LFH by 1987 (Fig 2). This approach provided broodstock from the desired Snake River population to meet the genetic integrity goal. However during 1987-1989 an increasing number of stray fall chinook began appearing at LFH (Fig. 3). By 1989 strays were a serious concern, with fish from the Umatilla River and Rock Cr. (Near Bonneville Dam) contributing 32% and 11%, respectively,

Figure 2. LFH broodstock sources.

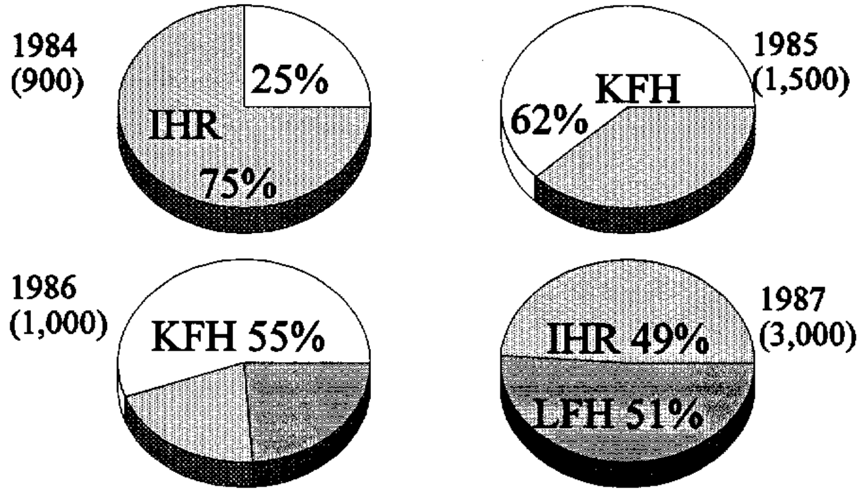
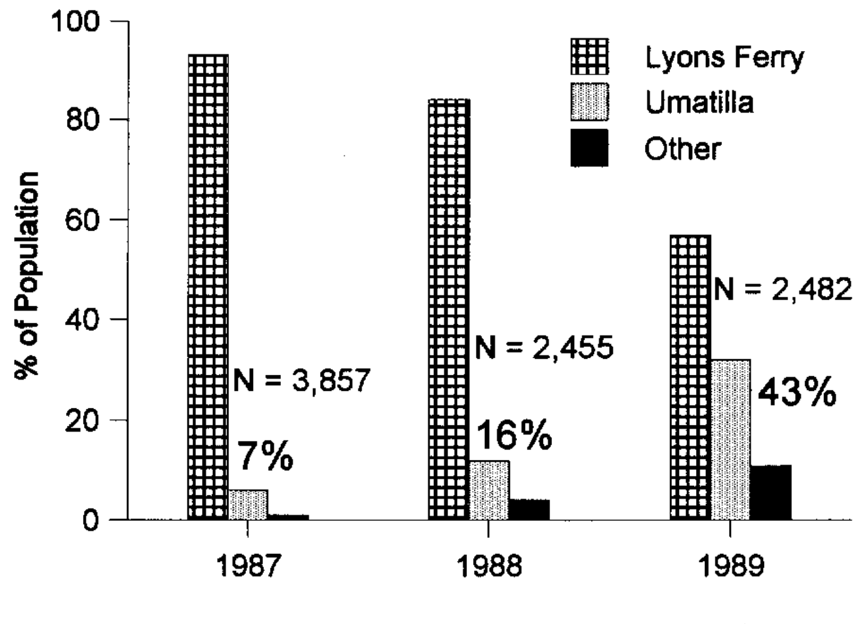


Figure 3. Early stock Composition at LFH



to total escapement at LFH. The high stray rate detected in broodstock after spawning in 1989 prompted several management changes in an effort to maintain the genetic integrity of this stock:

- All 1989 brood juveniles were marked with coded wire or blank wire (CWT : BWT) tags and released as subyearlings,
- All subsequent broods were 100% marked with CWTs,
- Returning 1989 brood were not used as broodstock at LFH,
- No more incorporation of wild (unmarked) fish into the broodstock,
- Matings procedures were changed to 1 x 1 after CWTs were read, and semen from known LFH males was cryogenically preserved for future use.

Progeny from the unknown origin and known stray origin fish were shipped to Klickitat Hatchery on the lower Columbia River for release. Other management changes were also adopted to help maintain the genetic integrity of Snake River fall chinook:

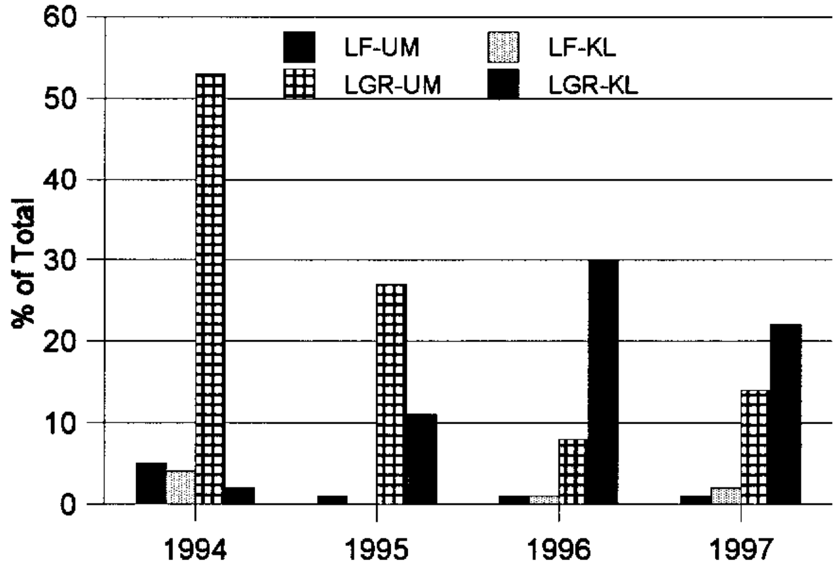
- Trapped only adipose clipped fish at IHR for LFH during 1991-1993,
- Began at Lower Granite Dam (LGR) in 1990 to:
  1. Reduce strays spawning naturally
  2. Estimate stray rate at LGR
  3. Supplement broodstock for LFH
- Umatilla Hatchery marked all fall chinook before release in 1991 (RV)- by 1994 all were wire tagged for removal at LGR Dam and LFH.

WDFW began comparing available genetic information to see if changes had occurred in the stock. WDFW and NMFS had collected genetic samples from IHR, LFH and the mid Columbia River from as early as 1977. Some results of these genetic comparisons include that:

- In 1990, untagged fall chinook adults at LFH appeared more similar to mid Columbia R. fish than known LFH salmon
- Known LFH origin fish showed some genetic shifts towards mid Columbia R. fall chinook
- These shifts were apparent before the Umatilla releases began, indicating the possible capture of "dip in" Columbia R. fall chinook at IHR in the past.
- The genetic distinction between LFH fall chinook and mid Columbia R. chinook remains

Because of the apparent stray problem at LFH and the genetic implications of samples collected over time, we conducted a radio telemetry study in the Columbia and Snake river in 1991-1993. Results from the study tended to confirm the genetic information suggesting that Columbia R. hatchery salmon were "dipping in" to the Snake River, crossing IHR and then returning downstream. This activity made them available to our broodstock trapping actions at IHR. Another goal of the study was to determine why up to 50% of the fall chinook over IHR could not be accounted for at LGR, LFH or spawning in the Tucannon and Palouse rivers. We found that as much as 85% of the loss could be accounted for by fall chinook falling back at IHR Dam and returning to the Hanford reach of the Columbia R., the Yakima R. or elsewhere (Mendel and Milks 1997). This was confirmed by comparing dam counts at IHR and Lower Monumental (LMO) dams. So, although the eggbank program and LFH used trapping at IHR Dam as a source of broodstock for many years, it was now apparent that these fish may have included "dip ins" from the mid Columbia River. Therefore, in 1993 we terminated trapping at IHR Dam.

Figure 4. Fall Chinook Strays at LFH and LGR



Recently we have concentrated our trapping effort at LGR. With fall chinook determined to be "Threatened" under the Endangered Species Act (ESA), we began a cooperative effort with the NMFS to trap and remove marked hatchery salmon at LGR to try and reduce the number of stray hatchery fish that spawned upstream of LGR Dam. Wild chinook escapement to above LGR Dam has increased from a low of 78 fish in 1990 to between 400-700 fish annually in recent years. This increase is likely the result of several conservation actions taken by management agencies. Interestingly, the stray rate of fish that voluntarily return to LFH is quite low (<5%). Conversely the stray rate of fish from Umatilla and Klickitat hatcheries is higher at LGR. And, although the number of Umatilla strays is declining, Klickitat strays are increasing (Fig. 4).

Production releases from LFH started in 1985 and were a mixture of subyearling (50-100 fish/lb) and yearling (6-10 fish/lb) releases (Fig. 5). Because of limited broodstock and extra space at the hatchery, WDFW used a combination of subyearling and yearling releases in a 2x2 factorial experiment to compare the two ages of release and to look at the potential benefits of barging salmon directly from the hatchery to below Ice Harbor Dam. While there were no consistent differences in rates of escapement or contribution to fisheries between barged and on-station releases for either age class, there were significant differences in survival and returns among years for both age classes (Bugert et al. 1997). For all release years, yearlings returned at a mean smolt-to-adult return (SAR) that was 11 times higher than subyearlings (Fig. 6). Also, transported salmon strayed to freshwater areas outside the Snake River more than those released on-station. The experiment was terminated after 1990 because of the high number of stray hatchery fish in the broodstock, and the expected construction of juvenile fish passage facilities at Lower Monumental Dam.

After 1991, production at LFH operated under a new goal for all yearling releases (Fig. 5). We still fell short of the 900,000 yearling goal because of broodstock shortages. This resulted from excluding strays and the 1989 LFH brood fish from the broodstock, and from severely depressed upriver bright escapement. Recent releases have included outplants at acclimation ponds in Idaho as part of a cooperative effort with the Nez Perce Tribe to increase spawning escapement to LGR.

Progress toward meeting LSRCP goals has been slow. Adult returns have not reached 18,300 per year, although actual Snake River escapement is difficult to determine because of Columbia R. strays. Fall chinook at IHR have averaged only 4,000 - 6,000 fish, far short of the goal. Hatchery production has never approached the level needed to return 18,300 adults (>9.2 million subyearling smolts, or 3.1 million yearlings) because of broodstock shortages, strays and lack of hatchery space to produce a full yearling program. Further, SARs for subyearlings have been well below the 0.2% goal, although yearling SAR averages 0.6%. Also, to date no mitigation production for Hells Canyon Complex has occurred from LFH, again due to lack of broodstock and poor SARs. Genetic stock integrity is likely still intact even though some hatchery introgression has occurred.

Current management objectives for LFH are driven by ESA and the Columbia River Fish Management Plan (part of the US v OR process). Those objective are:

- Maintain genetic integrity of LFH / Snake River stock

- Produce 900,000 yearling smolts annually
  1. 450,000 for on-station release
  2. 450,000 for release at 3 acclimation sites above Lower Granite Dam
  3. Produce subyearlings as possible and release above Lower Granite Dam

- Reduce stray hatchery fish escaping above Lower Granite Dam

Figure 5. LFH Fall Chinook Releases

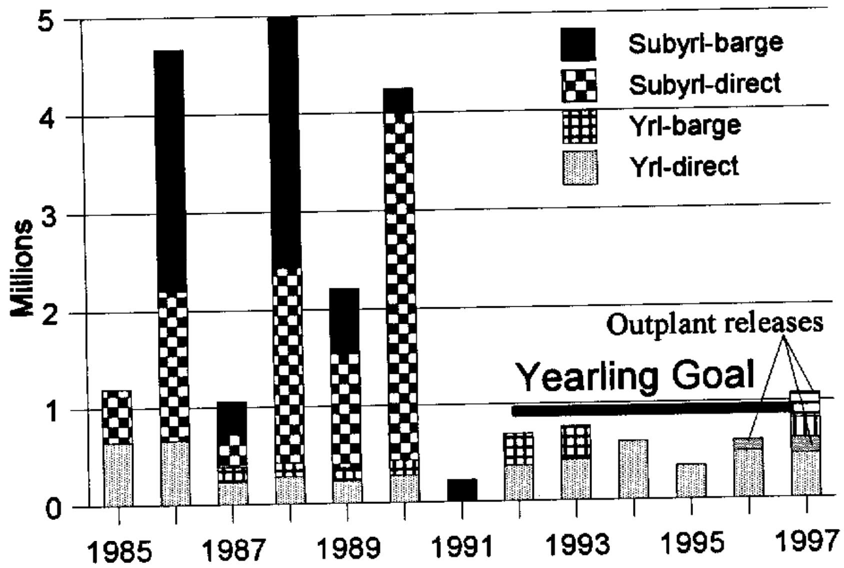
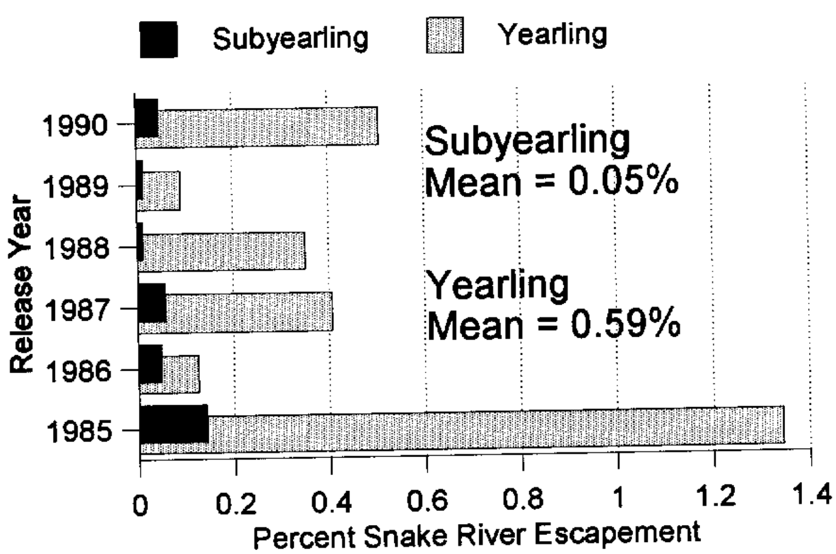


Figure 6. Survival Rate Comparisons



The future success of the fall chinook program depends on several critical factors. It is crucial to establish common goals (or the resolution of several different sets of goals) in forums such as the renegotiation of the Columbia River Fish Management Plan, ESA, Hells Canyon Complex and LSRCP mitigation. Clear goals for emerging programs such as the Nez Perce Tribal Hatchery and the Northeast Oregon Hatchery Program, and demands by numerous research groups, are needed as most target Snake River fall chinook are part of their management emphasis. Improved survivals of subyearlings or increased releases of yearlings (currently broodstock and space limited at LFH) are needed to provide increased adult escapement (hatchery & wild) and will determine whether identified needs will be met. Straying hatchery fall chinook salmon from out-of -basin must be reduced so that wild Snake River fall chinook can be incorporated into the broodstock once again. We must conduct size and time of release studies to improve SAR from subyearlings before phasing into subyearling releases under the NMFS proposed Recovery Plan. Additionally, we need improved marking methods and reduced costs of the marking program (external ID for subyearlings and acceptable tag retention/ detection).

To accomplish these tasks we recommend the following:

- Release more smolts from LFH to increase broodstock and eggs available for the various enhancement plans within the basin
- Reduce Klickitat River fall chinook releases (or mark more of them, so they can be removed at LGR and LFH)
- Begin conducting size and time of release SAR studies to improve survival of subyearlings before "phase-in" under ESA recovery plan

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Questions and Comments

What was the source of your original broodstock? asked David Arthaud. Trapping at Ice Harbor and Little Goose, Mendel replied. What was the composition of the runs you trapped at Ice Harbor and Little Goose? Arthaud asked. Genetically, it was the upper river run, Mendel said. You provided some information showing that straying rates have increased over time, said Tim Whitesel -- is that related at all to sampling accuracy, and the possibility that, because we're looking harder, we're finding more fish? Also, how concerned are you about domestication effects? In response to your second question, we are absolutely concerned about domestication effects, Mendel replied. In response to your first question, our sampling effort has definitely increased; however, we examine every fish we take at Lower Granite for fin clips, tags and other marks.

Why, in your opinion, is your subyearling survival so low? asked Pete Bisson. Our fish go out when they are quite small; they are released at a time when the hydrograph is declining and water temperatures are increasing, Mendel replied. Some of the information Billy Connor has generated indicates that fall chinook outmigrate all summer long, and our thinking is that, if we can get these fish to a larger size earlier, and release them when flow conditions are better, they should do better. However, we have not yet had an opportunity to test that.

Within the 450,000-fish target that was selected for release above Lower Granite dam, did anyone try to estimate what the eventual natural/hatchery composition would be on the spawning grounds upstream of Lower Granite dam? asked Billy Connor. We made some estimates of what we would expect back from the hatchery releases, Mendel replied. However, I don't think anyone did exactly what you are asking, he said.

Summary of Fall Chinook Session

Mark Schuck
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I think it should be obvious to most of you here today that the fall chinook program is somewhat unique -- it is centered primarily in a single part of the Lower Snake area; it does not involve multiple agencies, as both the steelhead and spring/summer components of the Lower Snake Compensation Plan program do. However, it has experienced much the same adaptive management we have seen in those other components; and it has been beset by many of the same problems -- poor survival and lower-than-expected SARs. In recent years, we have seen an increasing level of involvement from the tribe; they have been extremely pro-active in seeking congressional sponsorship for this program, and in pushing their vision of what they want this program to accomplish. Though the program continues to change, I think everyone involved shares a common goal -- increasing the escapement of adult fall chinook.

In short, this is a concerted, sincere, driven effort to ensure that the Snake River fall chinook do not go extinct. There are many contentious issues that remain to be addressed; I expect an intensive effort to hammer out programs and common directions among the co-managers to continue, to ensure that the program is successful into the future, Schuck said.

Audience Questions on Fall Chinook Session

Cindy Deacon-Williams asked whether any genetic analysis has been done to provide an indication of the degree of straying. The radio telemetry program was part of a larger project, which also includes the collection of carcasses for genetic analysis above Lower Granite, Mendel replied. We have found strays throughout the spawning area. The reason I ask, Deacon-Williams said, is that, obviously, there is an interest in trying to incorporate wild fish into this broodstock. It is it possible that you might increase your likelihood of finding the right fish if you trap higher in the system? I'm not sure we have the information necessary to make that call, Mendel said; there are also some logistical problems associated with that type of effort.

What kind of harvest rate is there on these fish, and what is their survival rate to the mouth of the Columbia? asked Bill Miller. The harvest rate on our early broods was quite high, Mendel replied -- at times, as high as 80% exploitation in the ocean and the Columbia River. Currently, however, harvest is substantially constrained. The goal under the Columbia River Fish Management Plan is to have an in-river harvest rate of no more than 25% on these fish. In response to your first question, in 1985, the total recovery for yearling fish was 7.6%, and somewhere in the 3-%-4% range for all recoveries, Mendel said.

If you raise these fall chinook to yearlings, what effect does that have on the age at return for your adults? asked Kent Ball. We've had a lot of questions about that, Mendel replied; interestingly enough, when we look at the data, we tend to get more jacks from our subyearling releases. If we release yearlings, and we don't carefully control how big they are, we get a tremendous number of jacks returning. As long as we keep them in the 10-per-pound range, we don't have that problem, Mendel said. He added that some of the fish in the program have been as old as seven years when they return.

Science Panel Comments on Fall Chinook Session.

I would observe that naturally-spawning fall chinook escapement above Lower Granite dam has increased during the life of this program, from a low of 78 fish to around 600 today, said Mike Matylewich – I think that is a very positive result, especially considering the limited resources you had to work with. I would add that, due to concerns that many of the fish that have been outplanted above Lower Granite Dam were of non-Snake River origin, there are many biologists who feel that the fish in this hatchery program are actually much more similar genetically to what historically spawned above Lower Granite than what is currently on the spawning grounds, he said. From a genetic standpoint, the feeling seems to be that it would be more beneficial to do any future outplanting using the hatchery stock.

From an economist's standpoint, said Dan Huppert, I see a great deal of general support in the region for the idea of recovering salmon. In economics, we refer to that as an existence or a non-use value -- what people are willing to pay to preserve a unique non-commercial resource. We don't have hard numbers that we can apply to that equation, but we do know that households in the Northwest are willing to pay somewhere in the neighborhood of $60 per year for salmon recovery -- roughly $200 million per year total. In other words, Huppert said, there is a fairly large economic value associated with this recovery program, although specifics are lacking because nobody is really doing the research necessary to provide a higher level of accuracy.

Other studies have looked at the economic value of the Idaho steelhead fishery, and have concluded that factors like location and the quality of the experience are as important as fish numbers, he continued. It strikes me that, at least from an economics standpoint, it might be worthwhile to consider which portions of the Snake River basin are most accessible and valuable from a recreational standpoint in deciding on your release strategies and overall program goals, Huppert said. While these types of economics may be a secondary concern at this point, they are something you might want to consider where possible.

There is an existence values survey included in the Corps' EIS for the Lower Snake drawdown, said Bert Bowler -- some of the work to which you refer is ongoing at this time; it should give us some idea, from an economic perspective, of what the recreational values are in the Lower Snake under drawdown. I would add that there are also legal issues and trust responsibilities to the tribes which have to be factored into the economic equation, along with these recreational issues, Arthaud said.

I think it's fairly obvious, from everything that has been said over the last three days, that the Lower Snake River Compensation Plan Program is one area where the biological and social aspects of salmon recovery have really come together, Schuck said. Both will have to be dealt with in a very careful manner if we are to ensure that we give the fish the best possible chance of recovery, while still meeting the region's diverse social needs.

Jeff Abrams of IDFG commented that, in his view, the time has come for the scientists involved in the salmon recovery effort, including many of those in attendance today, to take more of a leadership role in pushing their own agencies, and others, to take the hard steps necessary to bring about salmon recovery. How many more East Fork Salmon Rivers have to happen before we start to push our agencies to do whatever has to the done to stop the bleeding? he asked.

I think it is our responsibility, both as individuals and as members of professional societies such as the American Fisheries Society, to make very clear what is and is not possible, as we evaluate the technical and scientific capabilities of the tools that are available to us, said Cindy Deacon-Williams. My own conclusion, based on what I've heard over the past three days, is that, no matter what improvements we make, or how well we run our hatchery programs, we are not going to be able to maintain even limited populations of wild salmon and steelhead into the future without substantial changes elsewhere in the system, she said. In connection with the LSRCP, I think that is something we need to ensure that we are very clear on, and very aggressive in conveying -- that in spite of 17 years of improvements in our hatchery programs, we will lose these salmon and steelhead populations if we don't make substantial changes elsewhere in the system, Deacon-Williams said. You would be amazed at the decision-makers in this region who don't realize that yet, she said; it is up to us to get that message out.

The symposium goal, printed on the cover of the agenda, states "To inform the regional decision makers, the public and scientists of the purpose, status and options of the Lower Snake River Compensation Program, to promote informed decisions on the future program direction," Schuck said. A major component of the information we need to convey to the regional decision-makers, the public and scientists is the fact that we are headed down the path of extinction for many of the populations we need to protect, he said. That isn't necessarily going to make pleasant hearing, he said, but it is a message that needs to be heard.

In response to Huppert's earlier comment that it is important to keep in mind the needs of those in the region who value salmon, Doug Dompier of CRITFC observed that that, in fact, is what has driven the LSRCP management strategy to date -- our programs are designed with the needs of our constituencies in mind, rather than the needs of the fish. If you continue to think of the needs of your constituents first, and the needs of the fish second, then you will fail, and the fish will continue to be the losers, Dompier said.

If we are going to try to communicate the seriousness of the problem that has emerged over the last three days, said Courtland Smith, it might behoove us to try to develop a one- or two-sentence summary of what we have heard during this workshop. If it's going to get through, we have to distill the message into something that anyone can understand, he said.

Summary and Wrap-up of Species Sessions

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In general, said Bowles, based on what I've heard over the last three days at the steelhead, spring/summer chinook and fall chinook sessions, and in my years of involvement with the LSRCP program, while the situation is grim, it isn't totally bleak. There are many bright spots remaining, particularly if you look at the program in the context of where we would be without it. Those bright spots include the fact that we have had relatively consistent steelhead fisheries, a fact that probably would not be true if the Lower Snake Compensation Program did not exist. In the chinook program, fishing opportunities have been few and far between; however, we have been able to demonstrate, in certain key watersheds, the ability to use our hatchery programs to at least slow the decline in escapement. Obviously, though, that is limited to only a small part of the overall chinook population structure in the Snake River basin, Bowles said.

In the fall chinook arena, and also, to a limited to degree, in the steelhead arena, we have also begun to gain a great deal of information, Bowles continued. That in and of itself is not all that meaningful, unless that information can be translated into management actions and, through public education, policy actions. However, information is being generated at a feverish pace.

That said, Bowles continued, what are our major areas of concern at this point? Obviously, we are not meeting our mitigation goals consistently. Another concern is the fact that the chasm between wild and hatchery fish is growing wider by the year, both for steelhead and chinook. The fundamental genetic material that is crucial to recovery is slipping away, Bowles said. Another concern is that the program is shifting from a pure mitigation focus to a conservation/supplementation focus; in shifting its focus, the program is expanding into areas that it wasn't originally designed for. However, given the direction these stocks are currently headed, I think that process is inevitable, said Bowles.

What we need to ask ourselves -- in looking at this summary of what has been done -- is, what more can we do? he continued. In the hatcheries, survivals are high, and most of the bugs have now been ironed out. The quality of our hatchery product appears to be high, said Bowles; however, based on what we've been hearing, I'm not sure we completely understand how to measure quality. There are still mysteries associated with which qualities are needed to maximize the post-release survival of the fish, their ability to play a role in rebuilding natural populations, and with minimizing the negative interactions of our fish with other at-risk populations. There is still some research that needs to be done in all of these areas, Bowles said -- it may not be enough to simply release large numbers of healthy, disease-free smolts; there may be other, more subtle things we can be doing that are just as important, or more important, to the ultimate success of these fish.

Based on everything we've heard, probably the single most important factor we need to focus on it is, how can we improve post-release survival? Bowles said. Also based on everything we've heard, it doesn't sound like there is much we can do to bring that about through our hatchery program. However, that doesn't mean we have the luxury of simply throwing up our hands in defeat. It is the hatchery program's mandate to mitigate for fish loss at the Lower Snake dams, and to meet the adult return goals contained in the Lower Snake Compensation Plan. If we have to step outside the pure hatchery program to do that, said Bowles, so be it.

Another concern that has been voiced in the past three days is whether or not our hatchery mitigation program is having a negative impact on the very naturally-spawning populations it is intended to protect, he continued. In general, I don't see a lot of major red flags out there, Bowles said. In fact, given the large number of smolts we are compelled to release, I'm a little surprised that those red flags aren't somewhat larger. We haven't detected large-scale genetic divergence; straying effects have been only moderately problematic; the extent of disease impacts is unknown at this point; while some problems have been identified with age structure shifts and spawn timing, those have been compensated for.

A tougher question has to do with the fact that, given the reality that many of our hatchery steelhead populations are not locally-derived, how should we use those populations to supplement? Bowles said. Another general conclusion I've drawn from our discussions over the last three days is that there is a lot of interest in reducing the size of our smolt releases, he continued -- that is one obvious way to reduce the potential for negative interactions between populations.

The LSRCP is no longer in its infancy, said Bowles. Obviously, we have a lot more to learn, and there is a lot more we can do. However, I think we need to be honest with ourselves, and with the public, in making an assessment of what we feel the potentials of the program are, and what its limitations are. We also need to make an honest assessment of the ability of this program to adapt to the new demands with which it is faced, particularly the conservation demands. I don't think we need to wait another seven years before we begin making those assessments available to the public, and to decision-makers, Bowles said.

Science Panel Wrap-up Session.

Rick Williams said the science panel members have agreed to provide a written summary of their interpretation of the information presented over the last three days, as well as their recommendations about the future directions that information indicates for the LSRCP. In terms of general observations, said Cindy Deacon-Williams, there are four main conclusions that seem apparent. **First, it is clear that the hatcheries cannot solve the problem on their own.** Furthermore, if we continue to expect the hatcheries to shoulder that burden on their own, a very rapid result will be the complete loss of Snake River basin wild populations.

The science panel's **second general observation is that, even an optimistic conclusion forces us to acknowledge that, for many of the natural populations, extinction will take place by about 2025**, Deacon-Williams said. **Another general observation is that a very large magnitude of improvement is necessary outside the hatchery system -- for many of these populations, a 5-to 10-fold increase in SARs will be required to avoid extinction and bring about recovery. Finally,** said Deacon-Williams, **in order to bring about the kind of system wide changes needed to produce that level of improvement in SARs, it is crucial to build political will and societal will in support of those changes**. To do that, we need to very clearly let people know what is going on, and what the implications of that information are.

In terms of **more specific recommendations**, Deacon-Williams continued, for steelhead, we think it is prudent to **aggressively explore the development of locally-adapted broodstocks. Second,** we think that **all of the steelhead programs need to invest energy and effort in the development of management criteria and targets that will allow them to know when to shift their operations from responding to demographic concerns to responding to genetic concerns**. This recommendation **also applies to the spring/summary and fall chinook programs, she added**. For the **fall chinook program managers**, we would add that you **need to re-introduce wild fish into the broodstock**, despite the challenges that will entail.

In terms of overall comments about the LSRCP hatchery programs, said Deacon-Williams, **first**, we **need to evaluate the differentials in facilities success, identify, to the best of our ability, why those differentials exist, and make appropriate changes**. **Second,** we **need to integrate conservation goals system wide, and make assignments to individual facilities that make sense, without departing from the commitment to mitigate for the 48% fish loss at dams. Third, it would be prudent for the program managers to begin strategic planning, so that the LSRCP is ready for any of the multitude of decisions that could be made in 1999. Fourth, the monitoring and evaluation program is one of the strengths of this program, and needs to be maintained.**

Finally, said Deacon-Williams, there is a **clear need for comprehensive, integrated, realistic planning for all of the aspects that are affecting conservation, recovery and, ultimately, harvestable populations of salmon and steelhead in the Lower Snake River**. Until that comprehensive, integrated, realistic planning takes place, the hatchery program will be unable to accomplish the tasks it was originally created to do, she said.

Dan Goodman highlighted some of the passage survival and egg-to-smolt survival numbers presented over the past three days, and observed that even a worst-case reading of these data indicates that the current hatchery production in the Lower Snake should be providing a four-fold increase in the number of adult returns per adult spawner than would be the case if all of the production in the basin was from natural spawning. Despite this exercise in logic, he said, it should be fairly obvious to everyone here that we are not drowning in returning adults; in fact, many of these hatcheries are struggling just to meet progeny-to-parent replacement. Given the fact that additional studies have shown that the original per-project mortality figure of 15% included in the original LSRCP authorization is accurate, that means that something else has changed, Goodman said. It is a hemorrhage that is leaking salmon, and we need to find out what it is.

Mike Matylewich observed that most of what needs to be done boils down to a question of vision -- what kind of future do we want to see? Currently, I see a program which is basically trying to save the pieces of Humpty Dumpty -- the question is, can you put them back together, and if so, how? The vision I've heard over the last three days is one where we have fish flourishing in their natural habitat, in harvestable numbers, throughout the basin, Matylewich said. It isn't going to be easy to achieve that goal, he added. But while I see some serious problems ahead, and don't really have any concrete suggestions to offer, I do see some opportunities for change, and some opportunity to put Humpty Dumpty back together, Matylewich said. As Yogi Berra once said, "When you come to a fork in the road, take it."

Rick Williams commended the presenters for the clarity of their presentations, and for their obvious willingness to change their programs in the face of system wide realities. However, I think it has become clear that there are still some improvements that can be made in our hatchery programs, he said. Many of them are at the interface between what happens inside the hatchery, and what happens outside the hatchery, in the immediate tributaries. I think it's clear that more attention needs to be paid to how the smolts we're releasing interact with their environment -- there are levels of mortality there that we do not fully understand. There are also indications in things like run timing that there may be remnant levels of biological, behavioral and ecological diversity in some of these stocks that the hatchery programs, if they are run with too narrow a focus, will constrain. The key to re-establishing some of these populations may be to allow more diversity within them.

It is also clear to me, said Williams, that we are on the verge of extinction for many stocks, so some of the debate we've heard about mitigation vs conservation disturbed me. We must first be concerned with the simple persistence of these stocks -- once they are stabilized through conservation, we can begin to discuss rebuilding them to sustainable, harvestable levels.

In response to Dan Goodman's comments regarding passage survival and egg-to-smolt survival numbers, Ed Bowles commented that a snap-shot approach does not capture the cumulative effects of multiple dam and reservoir migration and problems with ocean entry (timing, stress, disease, etc).

Dan Herrig asked each of the science panel members to talk for a moment about how they felt about hatchery programs prior to this symposium, and how those opinions have -- or have not -- changed as a result of what they have heard. Pete Bisson said that his opinion of hatcheries has not necessarily been altered as a result of his participation here; however, he said, I have been encouraged by how much I have heard about their relative success rate in meeting their goals. If what you are asking it is, is there a role for hatcheries in the Snake River basin, my guess it is that there definitely has to be, at least for the foreseeable future, Bisson said.

Rick Williams pointed out one or two personal misconceptions that had been dispelled over the past three days, one of which was the idea that there were major improvements that could be made in the operation of the hatcheries themselves. It has become clear to me that that isn't really the problem, he said; the unfortunate corollary is that, apparently, there isn't much the hatcheries can do that they aren't already doing to bring the runs back. I agree that hatcheries will be needed in the Snake River basin for the foreseeable future, Williams said; however, I think many here share the hope that, at some point in the future, hatcheries will no longer be needed.

I guess that on a philosophical level, said Cindy Deacon-Williams, I disliked the fact that hatcheries existed to assist the societal delusion that we could build the dams without any negative effects. If hatchery technology had not existed, I think we would have been forced, as a society, to confront more honestly the effects of those dams on the ecosystem. I was glad to hear, in the course of this symposium, that many of the LSRCP hatcheries are placing an emphasis on the development of local broodstocks, she said, particularly given the fact that, based on what we have heard, hatcheries are going to be a critical component of recovery. I still think habitat and hydro are more critical to recovery, she added, but we are now that a point where our populations are at such a low ebb that we are going to have to rely on hatcheries to conserve them until habitat and hydro improvements can be made.

Stakeholders Panel Session

The first member of the stakeholders panel to speak was David Arthaud, representing the Shoshone-Bannock Tribes. As most of you are aware, he said, the Sho-Ban Tribes have always opposed the four Lower Snake dams. They correctly, in my opinion, identified these dams as the final straw to break the back of the Columbia River migration corridor. The Lower Snake River Compensation Plan promised fish with dams; it identified mitigation numbers of anadromous fish, none of which have been met. In 1997, in the entire Upper Salmon River, the Shoshone-Bannock Tribes harvested a total of six chinook salmon, in a run year considered good by current standards. All stocks of Snake River anadromous fish are now listed under the ESA; Snake River coho and lamprey are now extinct, yet NMFS still says that dams are most likely not limiting the recovery of salmon. The bottom line is that the U.S. is not fulfilling its trust responsibilities to the tribes, Arthaud said.

The LSRCP has changed, and further changes are being proposed, he continued. Despite the best efforts and extensive talents of the many managers and biologists who have proven that anadromous fish culture can be done, and done well, there must be a migration corridor to the ocean if anadromous fish are to continue to survive in the Columbia River basin.

The Lower Snake Compensation Program is now being thrust into a native species recovery mode, Arthaud continued. This new direction is in line with Sho-Ban tribal policy, and the tribes can help. However, the proposed changes are not yet authorized by Congress, the tribes or the public. The Fish and Wildlife Service needs to tell Congress that mitigation for the Lower Snake River dams will never be realized, he said. They need to tell Congress the LSRCP was designed to do something it couldn't do -- that hatcheries cannot mitigate for the dams, and that fish are the only acceptable mitigation. In the interim, the Shoshone-Bannock tribes will redouble their efforts to breach the four Lower Snake dams, Arthaud said.

Fred Christianson, representing the conservation stakeholders, spoke next. I heard one of the managers say that the chinook run in the East Fork Salmon River went extinct this year, Christianson begin. Personally, that statement got my attention. And personally, I feel a very high sense of frustration, which I sense is shared by many in this group. I agree with the previous speaker that the time has come to go public and admit that we are losing the fish. Because I don't think many people in the Northwest want to lose these runs, and quite frankly, that could be our ace in the hole, Christianson said.

Time is our enemy, he continued. We don't need any more science -- we need action, and the action we need is the removal of the four Lower Snake dams. Unfortunately, he said, that decision will not be based on science -- it will be based on politics. I think the best we can hope for is that it will be based on bio-politics, he added.

We have heard a lot about economics recently, both within this symposium and in the editorial pages of our newspapers, Christianson continued. Having studied the numbers at some length, I can tell you with confidence that the figures being used by dam proponents to justify the continued operation of the four Lower Snake dams are misleading at best. What really makes sense, from an economic standpoint, is to return a viable commercial, sport and tribal fishery to the river, then use the revenues generated by that fishery to mitigate for any losses sustained by irrigators or navigators, and for lost power revenues.

There is a tremendous amount of brainpower in this room, Christianson said. Frankly, the public is asleep on this issue, and it is up to us to wake them up. If we can generate enough public support, we still have a chance to turn this situation around. But it as going to take a tremendous effort, on our part, to make that happen.

Next up was Rich Lincoln, representing the state agencies. I was extremely impressed by the dedication of many of you who are working on Snake River fishery issues, he began, particularly in the face of the dismal prognosis for the continued survival of many of these populations. The fact that you continue to do everything you can is inspiring, he said.

I was also glad to hear that many of the programs are being re-focused on conservation, Lincoln continued. While true mitigation will depend upon recovery, I think we also have to rely on some creative approaches to provide some fishery benefits wherever possible, he said. Those fishing opportunities may not be exactly what everyone wants to see, but that doesn't mean we shouldn't continue to press for those opportunities as we move forward into a conservation mode.

As the previous speaker noted, I think the major policy challenge we face it is public education, with the goal of obtaining adequate support for true recovery, he continued. I agree that we all have a responsibility to do whatever we can to ensure that the necessary changes are made; it's a natural tendency to want to point fingers, but in the end, everyone will have to share the pain.

Next to speak was Mitch Sanchotena, representing Northwest anglers. From the anglers' standpoint, Sanchotena began, the Lower Snake Compensation Plan was intended as compensation for lost fishing opportunity -- it was never intended to be the Lower Snake Conservation Plan. Of course, we were never supposed to be in this genetic situation, either -- we were supposed to have 52% of our wild runs remaining.

In spite of the rather grim picture we've heard over the last three days, he continued, salmon continue to be an extremely valuable resource, even economically -- in 1997, Idaho sold 38,000 steelhead tags, and the steelhead fishery continues to contribute $90 million to the state's economy. The value that all of those anglers share is a desire for a consumption harvest in Idaho; they are the first to pay the bills to perpetuate that resource, and are often the first to write letters advocating the restoration of the runs. If anything, he added, the value of the fish that remain is enhanced by their listing under the ESA.

Should the objectives of the Lower Snake Compensation Plan change? Sanchotena asked. I don't think so, he said -- I think the LSRCP objective should still be to provide fish in harvestable surplus numbers over and above escapement. Many of the scientists in this room are trying to figure out how to build the ultimate clock, while most members of the public simply want to know what time it is, Sanchotena said. I am frequently asked why we don't simply seed the available habitat with whenever stocks are most appropriate, he added. While ISSU doesn't necessarily advocate doing that, we do feel that all of the exhaustive study you are engaged in is putting the public to sleep -- people are starting to become disinterested.

We have yet to come to grips with the major barriers to salmon recovery, Sanchotena said -- particularly harvest and hydro operations. If the scientific community continues to press for more study while doing nothing, you will be in the same position as the guy who blows the whistle on a train -- he doesn't get to do any driving, but if a wreck occurs, he's the one who gets blamed. At some point, you have to forget who is writing your paycheck, and face the fact that these salmon are going extinct.

I disagree with Cindy Deacon-Williams' statement that hatcheries have contributed to the notion that we could have both dams and fish, Sanchotena continued. It is my honest opinion that, if society had had to make a choice at the time the dams were built between saving salmon and having cheap hydropower, we would not have salmon in the river today. I think the hatcheries have bought us the time that was needed to bring about a change in societal attitudes, so that we can have some meaningful discussion today about how we are going to save the fish, he said.

I would like to leave you with the observation that the one thing I will take away from this symposium is that the problem is not hatcheries, it's not about habitat, it's not about harvest -- harvests today are 5% of what they were during the 1960s, Sanchotena said. The problem is the hydrosystem, pure and simple. You either have to stand up and admit that the Lower Snake dams have to go, or you need to tell the public not to buy any more fishing rods, he said.

Next up was Steve Smith, representing the federal stakeholders. He expressed agreement and many of the points made by the previous stakeholders; however, he said, I think it has now become necessary to set some minimum conservation goals for the program, without losing sight of the LSRCP's mitigation responsibilities. I think it is possible to do that, while still maintaining a fishery, said Smith. It is crucial to maintain as much genetic diversity as possible until the factors that are limiting survival can be addressed. I don't believe it will be necessary to seek congressional legislation before retooling the goals of this program, Smith added -- I think we should get on with it as soon as possible.

Steve Fick, representing lower river commercial and recreational interests, presented some information on the economic importance of salmon to communities near the mouth of the Columbia. He made the point that, due to harvest restrictions, commercial fishermen are no longer impacting Snake River spring/summer chinook or steelhead, and have not done so for more than three decades in some cases. I disagree with Mitch's comment that the people in this room are responsible for that decline in harvest, or for the extinctions that have occurred, said Fick – I think you have done the best job you could with the tools you were given, and that the real problems began once the fish leave the hatchery.

He touched on another possible factor in the decline of the upper river runs which received limited discussion during the symposium -- water temperature. The fact of the matter is, salmon do not do well in 73-degree water, said Fick. We're losing up to 40% of the adult return to the Snake River due to heat mortality at the dams, and that has to be corrected -- otherwise, the best hatchery practices in the world aren't going to the successful.

We also have a flow problem, he added -- there is a direct correlation between Snake River smolt survival and flow levels. Part of the equation is turbidity -- those migrating smolts need turbid water in the lower river to help them avoid predators, yet in the last few years, the water I see flowing past my office window in Astoria during the spring is often clear, because the freshet upstream is being held back. Avian predation alone accounted for 11 million smolt mortalities in the Columbia mainstem in 1997, Fick said -- I would say that's a major reason you're not being more successful. Also, only 50% of the irrigation diversions in the system are currently screened, he added -- if they are all screened, that would make a huge difference in the smolt and adult survival.

In terms of immediate goals for the LSRCP program, Fick said, we would like to see reasonable levels of harvest in the mainstem Columbia River, without adverse impacts to the recovery of the Snake River populations. We would like you to stabilize wild fish production, and increase hatchery production to a point that would allow some commercial fishery and incidental take of healthy stocks in the lower river. We are willing to work with anyone, at any time, to try to resolve this problem, Fick said -- if there is anything else the commercial fishing industry could be doing, please let us know. And again, we urge you to do everything in your power to bring about the necessary changes in mainstem fish passage -- unless those changes are made, all of your efforts will ultimately be in vain.

The next speaker was Silas Whitman, representing the Treaty Tribes of the Columbia Basin. In the course of the last three days, Whitman began, we have not heard a lot about the issue of fish health. In the tribes' view, fish health needs to be an integral part of the mitigation discussion; a full discourse is also needed on application impacts, and how they effect use and access to the sport and tribal harvest, as well as the acquisition of broodstock.

In the tribes' view, habitat impacts also become a big question mark when you consider the high levels of mortality experienced by juvenile migrants in the Snake River system -- sometimes as high as 90% for some populations by the time they reach Lower Granite dam, Whitman continued. We have been asking for two years now for an explanation of what is causing this mortality to Lower Granite, and the best answer we've been able to get is that it is something in the habitat, he said -- it is mining activities, or logging activities, or irrigation activities. I think it is clear that, whenever sources of mortality may exist in the upper river, Whitman said, they are only exacerbated by the problems in the mainstem migration corridor -- passage down and passage back.

On the subject of propagation tools, Whitman said that, often, production is painted with the hatchery brush. That isn't necessarily accurate, he said -- we have portable rearing and acclimation and stream side incubators, as well as other improvements designed to improve imprinting. Production can also include captive rearing, if appropriate, he continued. In the tribes' view, using a metapopulation template is absolutely crucial if we are to succeed in the business of salmon recovery and restoration.

Moving on to conservation management, Whitman said it is crucial for the state and federal management agencies return to this issue within a very short time, and voice their intentions in terms of how they plan to make the transition from a mitigation mode to a mitigation/conservation mode. There is no need to research in this question to death, Whitman said -- we need to get on with our business.

On the subject of genetics, Whitman said he is troubled by what he characterized as a prevailing narrow-mindedness -- almost an "Aryan nation" mentality in terms of its insistence on a monoculture – in the current thinking on this issue. We have driven the vitality and natural survival instincts out of these populations, and often take these poor creatures to task for straying, when all they're trying to do is survive, he said. Straying is a natural occurrence, and we need to think about how we can make something positive out of it. With regard to the continuing debate over hatchery vs. wild populations, Whitman said the time has come to reach some conclusions about how we intend to implement and use these programs.

When I was a child, Whitman said, I was approached by a group of university researchers who wanted to question me and take physical measurements -- to study me, in other words, because my tribe was considered to be a dying people. How ironic it is that, today, we are doing the same to salmon -- and as we treat those fish, so we treat ourselves. It is incumbent on us to ensure that mitigation, under the Lower Snake Compensation Program, truly meets the needs of all the stakeholders, Whitman said.

In summary, he continued, there is no longer any middle ground in the Nez Perce vision of the universe -- you either do what has to be done to restore the salmon, or you don't. The genetic connections between the various populations in the Columbia basin make intervention an absolute must, Whitman said -- a necessity if salmon and steelhead populations are to survive in the basin. If effective intervention does not take place soon, we will witness the extirpation of these magnificent animals -- as, indeed, we are all ready doing. Someone earlier was talking about scientific rigor, he added -- the only rigor I've seen in this effort to date is rigor mortis. It is incumbent on you to take an aggressive role and make some effective and workable recommendations -- otherwise, you will find that the politicians have made your decisions for you, Whitman said. I would end my remarks by saying that I have cleared this discussion with my superiors; if they were here today, they would probably have expressed themselves much more harshly than I have, he added.

Rick Williams observed that many of the stakeholders panel members had advocated the removal of the Lower Snake dams. I think many of us in this room would like to see that happen, he said, and hope that the 1999 decision is not simply an exercise in rhetoric -- we hope that it has a direct and positive impact on Idaho salmon and steelhead stocks.

However, I would caution that it may be unrealistic to expect the removal of the Lower Snake dams to solve all of our problems, he continued. The analyses surrounding the normative river concept lead us to believe that the salmon will probably respond positively to the removal of the dams, but the scientific evidence to support that conclusion is incomplete. We expect that drawdown of the Lower Snake projects will reduce passage-related mortality through the upper part of the hydrosystem, but it is naive and, perhaps, dangerous to assume that that alone will be enough to bring the Idaho stocks back from the edge of extinction, Williams said. Even as we continue to push for dam removal, we also need to continue to push for habitat reform and improvements in passage conditions in the lower part of the hydrosystem; it is also fair to say that we know very little about causes of mortality in the estuary or the ocean, he added.

The success of whatever major system configuration changes are made as a result of the 1999 decision will depend, in large part, on what kind of expectations we create in the public and in the decision-makers, Williams said. If we create the expectation that the Idaho salmon and steelhead runs are going to respond to drawdown in a dramatically positive fashion within a year or two, then we predispose our own actions to failure. On the other hand, if we scale those expectations appropriately, we may find ourselves on the road to success.

I don't think it is fair to assume that the advocates of dam removal believe that that step alone will bring about a five-fold improvement in SARs, replied Mitch Sanchotena. However, we do believe that, if we continue to operate the system as it is currently configured, the Idaho salmon and steelhead runs will in short order be reduced either to museum piece status or to extinction.

The scientists have to hold us that, under current conditions, less than one-tenth of 1% of the smolts leaving the Snake River will eventually make it back to Lower Granite as adults, Whitman said. When I was listening to the Harza report at a recent meeting in Spokane, I heard someone say that we are looking at an additional five life-cycles of research -- another 25 years of the status quo. What that tells me, said Whitman, is that the people in control are saying that they are willing to bet on attaining a two-fold to four-fold increase in smolt-to-adult returns, in the hopes of improving SARs from their current one-tenth of 1% to something closer to 1%.

From the standpoint of the tribes, we have said that 2001 is a magic date, by which we will determine among ourselves whether or not we have been successful in getting restored populations, Whitman continued. Those populations are the ones we are hoping will feed our continued access to direct management and harvest, he said. We have also said that 2010 is the magic date for recovery populations -- those natural/wild populations that still remain. If we are successful in bringing about recovery of those stocks by 2010, then the real work begins, Whitman said. We have talked, at this symposium, about constituencies -- my constituency is my war society, and they are very aggressive about wanting to have fish for the ceremonies of their clans. My stakeholders are continually nipping at my heels about providing them something, Whitman said -- some sort of sustenance. The ability to fish for salmon is directly linked to the survivability of my people, for a variety of health reasons, he said -- it isn't just a ceremonial thing for us, it is pure survival.

In response to a question, Smith said the short take-home message he had written down from this symposium was the fact that we are far too close to wild run extinction; we don't have much time. The problem cannot be solved with the Lower Snake River Compensation Program alone. In the near-term, we need to expand the Lower Snake Compensation Program to preserve some semblance of population diversity until the other issues can be resolved. Even if the 1999 decision is made on schedule, and that decision is to remove the four Lower Snake dams, it might be ten years before we actually have restored the Snake to a free-flowing condition, Smith said. Frankly, based on what I've heard over the last three days, I don't think some of the populations have that much time, and we need to do whatever we can to buy them more time.

Final Comments

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Most anything I could say at this time is anti-climatic to what has already been said over the past 3 days. First, I would like to commend you all for your participation. I think we accomplished what we set out to do. The presenters have provided good sound data and information on the status of the LSRCP production program. They have pointed out factors that prevent us from attaining our goals while describing their plan to get us closer to attaining our goal and at the same time balancing all of our obligations under Endangered Species Act, Columbia River Fish Management Plan and LSRCP program.

The message that came out loud and clear to me during the past three days is that if the survival of listed salmon doesn't change soon:

- Hatchery compensation programs will not be able to rely on natural populations to maintain diversity.
- Hatchery compensation efforts may fail.
- Some natural populations will go extinct.
- All natural populations could go extinct due to low numbers and loss of diversity.

Before we leave I'd like to give a special thanks to Dan Herrig for all the effort he put into the organization of this meeting and his attention to details that made this a success. I also like to thank Joe Krakker for his assistance anywhere we needed help. Joe was also responsible for putting the LSRCP exhibit together.

And without the guidance of the Symposium steering team members:

Paul Kucera, NPT
Peter Lofy, CTUIR
Rich Carmicheal, ODFW
Bruce Eddy, ODFW
Bill Hutchinson, IDFG
Al Van Vooren, IDFG
Pete Hassemer, IDFG
Mark Schuck, WDFW
Howard Burge, FWS
Chris Reighn, SBT
David Arthurd, SBT
Joe Krakker, FWS
Dan Herrig, FWS

we couldn't have pulled this meeting off anywhere near as effectively as we did.

Finally, I thank you all of you for attending and contributing your attention, your comments, and your thoughtful questions.

With that said I'd like to close this meeting.

Poster Session Papers

Poster Session Goal: Provide results of research studies and monitoring efforts in an informal atmosphere with authors present and available for questions and comments.

Spring and summer chinook salmon poster titles and authors

Fall Chinook poster titles and authors

Fish health poster titles and authors

LSRCP Program Goals, Activities, and Status

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The Lower Snake River Compensation Plan (LSRCP) Program was authorized by Congress to offset losses caused by construction and operation the four Lower Snake River dam and navigation lock projects. The Plan called for the construction of adequate facilities to produce enough juveniles to replace lost salmon and steelhead adults in-kind and in-place.

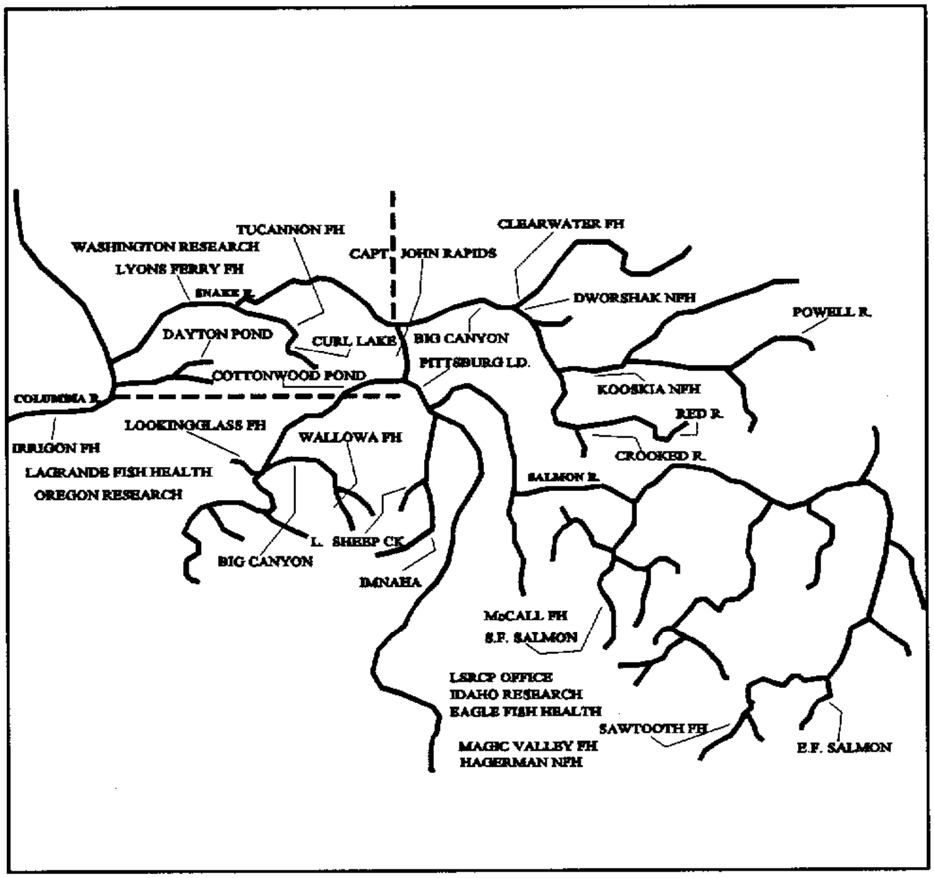
AUTHORIZATION

- Authorized by the Water Resources Development Act of 1976 (90 Stat. 2917)
- To replace fish and wildlife losses caused by the construction and operation of the four lower Snake River dam projects
- Compensation costs are allocated to power project costs and are reimbursed to the U.S. Treasury by Bonneville Power Administration from power revenues

LOWER SNAKE RIVER COMPENSATION GOALS

- **Adult goals are to return 18,300 fall chinook, 58,700 spring/summer chinook, and 55,100 steelhead back to the project area**
- **Produce 86,000 pounds of rainbow trout to replace resident sport fisheries in Washington and Idaho**
- **Required the expansion or construction of 12 hatcheries and 14 satellite facilities in Idaho, Washington, and Oregon**

The LSRCP Program is administered by the U.S. Fish and Wildlife Service with costs reimbursed to the U.S. Treasury by Bonneville Power Administration from power revenues. Twelve hatcheries and 14 trapping and acclimation facilities along with monitoring and evaluation and fish health offices are operated by the fisheries agencies of Idaho, Washington, Oregon, U.S. Fish and Wildlife Service, Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, and Shoshone-Bannock Tribes.



LOWER SNAKE RIVER COMPENSATION PLAN

COOPERATORS:

- **IDAHO DEPARTMENT OF FISH AND GAME**
- **OREGON DEPARTMENT OF FISH AND WILDLIFE**
- **WASHINGTON DEPARTMENT OF FISH AND WILDLIFE**
- **SHOSHONE BANNOCK TRIBE**
- **CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION**
- **NEZ PERCE TRIBE**
- **U.S. FISH AND WILDLIFE SERVICE**

The LSRCP Program continues to work with its co-managers to find solutions to issues resulting from trying to meet Tribal Trust, Endangered Species Act, and compensation responsibilities. As natural production continues to decline in the Snake River Basin, it has becomes more difficult to balance the all of the mandates without conflict.

ENDANGERED SPECIES ACT

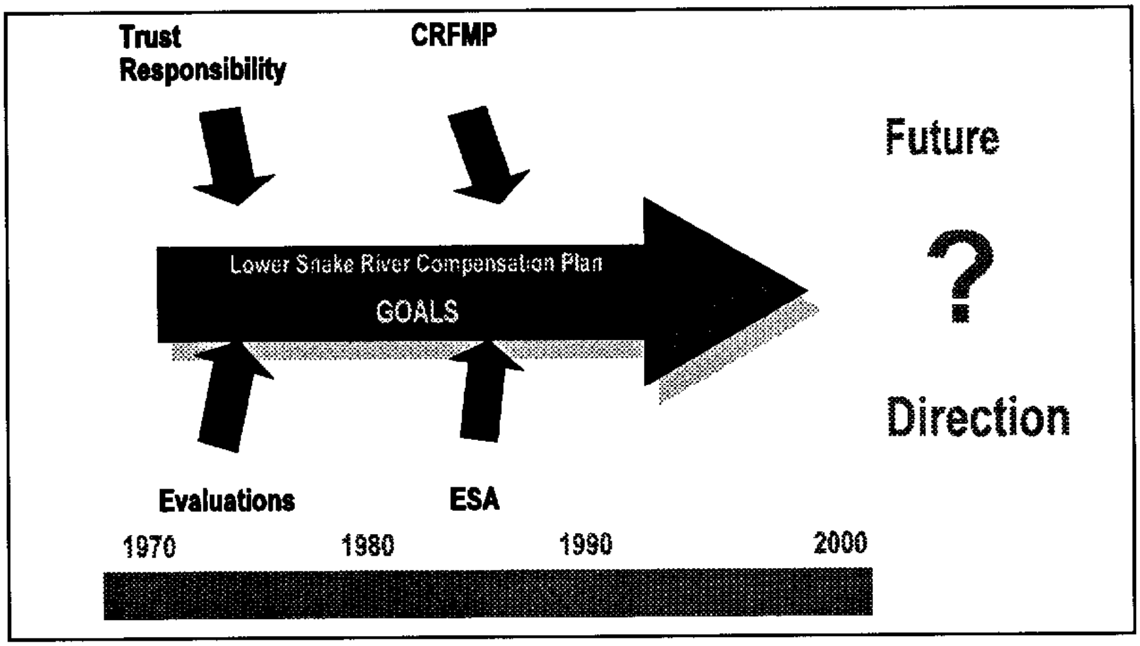
- **Provide a means whereby the ecosystem upon which endangered species and threatened species may be conserved**
- **Ensure that any action authorized, funded, or carried out by the LSRCP is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species**
- **Use authorities for conservation of listed species for scientific purposes or to enhance the propagation or survival of any listed species**
- **Listed or proposed species that may be affected by the Lower Snake River Compensation Plan Program**

  Snake River sockeye salmon
  Snake River fall chinook salmon
  Snake River spring/summer chinook salmon
  Snake River steelhead
  upper Columbia River steelhead
  Columbia River bull trout

TRIBAL TRUST RESPONSIBILITY

- **Provide technical assistance**
- **Consult with Tribes as co-managers**
- **Fulfill fish restoration or mitigation needs as determined by co-managers**
- **Recognize Tribal management decisions on resources under their jurisdiction**

The LSRCP Program will continue to work with its co-managers to determine the future direction of the program.



A Method to Reduce the Abundance of Residual Hatchery Steelhead in Rivers

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We developed and tested a release strategy designed to reduce the number of hatchery reared steelhead Onchorynchus mykiss that fail to migrate out of the Tucannon River (i.e., residualize) in Southeast Washington and described the characteristics of those fish that fail to emigrate. Hatchery reared steelhead that residualize may negatively impact naturally produced salmonids through competition for food, space, predation, and the spread of disease. Steelhead residualism was reduced by retaining fish in Curl Lake acclimation pond after volitional emigration had ceased. Remaining fish in the pond had a sex ratio of 4:1 (male/female) and 90% of these fish were composed of a combination of transitional, parr and precocious male stages. This method resulted in 2,022 residualized fish in the Tucannon River; 3.1% of the fish planted in Curl Lake. During the same year 4,186 (14.0%) fish residualized in the Tucannon river from direct river releases. The 3.1% residualism of the fish planted in Curl Lake in 1993 was significantly lower than the 14.0% residualisim that occurred in 1993 from direct river releases and the 17.7% and 10.3% percent residualism that occurred from fish planted into Curl Lake in 1991 and 1992. By retaining about 14,000 probable residual fish in Curl Lake in 1993, potential negative interactions in the natural river environment were substantially reduced. These fish were harvested by sport anglers from Curl Lake after June 1 1993 when the lake opened for sport fishing.

Increasing Returns of LSRCP Steelhead While Protecting ESA Listed Salmonids in the Tucannon River

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Each year, during 1991-1993, WDFW released juvenile hatchery steelhead Onchorynchus mykiss into the Tucannon River using 3 different methods: 1) 5.0 fish /lb. steelhead acclimated for 6 weeks and released from Curl Acclimation Pond, in the upper reach of the river; 2) 3.8 fish/lb. liberated directly into the river adjacent to Curl Acclimation Pond; 3) 3.8 fish /lb steelhead released directly into the lower river at Marengo, 26.1 km down river from Curl acclimation Pond. Smolt to adult returns from each of the 3 release methods were compared. We discuss the relationship between each release method and Endangered Species Act (ESA) listed spring chinook salmon Onchorynchus tshawytscha and wild steelhead. Direct river releases of larger (3.8 fish/lb) returned 200-300 % more adult steelhead to the Tucannon River than acclimated releases in all three years. Improved smolt to adult survival of direct river released fish will allow us to release fewer hatchery fish and still meet LSRCP adult steelhead return goals. Because releasing fewer fish will decrease the abundance of residual hatchery steelhead in the Tucannon River and because most ESA listed juvenile fish reside up river of our lower release site at Marengo. We advocate that if fewer fish are released down river at Marengo we will greatly reduce the incidence of negative interactions among residual hatchery fish and ESA listed juvenile salmonids. In 1998 WDFW will discontinue releases of steelhead from Curl Acclimation Pond and release all LSRCP steelhead directly into the river at a down river location. Because of it's location water temperatures in Curl Acclimation Pond have been to cold for successful imprinting and/or emigration. The results of this study are specific to the Tucannon River and Curl Acclimation Pond and dose not indicate that all acclimation ponds are ineffective.

Migration Success of PIT-tagged Juvenile Steelhead Released From an Acclimation Pond into the Tucannon River, WA.

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After chinook salmon were listed under the ESA in 1992, Washington Department of Fish and Wildlife (WDFW) took steps to decrease the abundance of residual hatchery steelhead in streams. Acclimation pond (AP) management techniques developed by Viola and Schuck (1995), significantly reduced residual hatchery steelhead in the Tucannon River. However we wanted to know if potential residuals which had been retained in the AP would have out-migrated if released. We also wanted to describe the physical characteristics of, and behavior of, migrant and non-migrant steelhead from the pond; and determine if precocious male steelhead could smolt and out-migrate. WDFW's Snake River Lab. conducted a study during 1994-1997 to determine if non-migrant juvenile steelhead would smolt and successfully out-migrate if released from Curl Lake AP into the Tucannon River, and characterize a successful smolt. We passive integrated transponder (PIT) tagged three groups of juvenile steelhead from Curl Lake AP:

> *Voluntary Migrants* - steelhead which migrated from the pond voluntarily. Comprised of three sub-groups: (**Early, Middle** and **Late**) corresponding to periods of out-migration from the pond within each year.
>
> *Non-migrants* - steelhead which did not migrate from the pond.
>
> *Precocious males* - sexually mature male juvenile steelhead (includes both migrants and non-migrants).

Each fish tagged was anesthetized with MS-222, weighed, measured and classified as a smolt, transitional smolt, parr or precocious male, and released immediately into the Tucannon River. PIT tag detections were summarized from all dams on the Snake and Columbia rivers downstream of the Tucannon River through September of each year. We compared PIT tag detections among migrant, non-migrant and precocious male groups, and among early, middle and late migrant sub-groups, and characterized successful migrants (we considered a smolt successful if detected at one or more downstream dams). We found that: 1) voluntary migrants were detected at dams (successful) much more often than non-migrants (Table 1); 2) successful migrants from both groups were either smolts or transitional smolts at time of release (Figure 1); 3) no parr or precocious males were detected at any downstream dam, and; 4) more early out-migrants from the pond were detected than later migrants.

Pond management techniques developed by WDFW effectively separated smolts from non-smolts in Curl Lake AP. Although some juvenile steelhead would have smolted and out-migrated, they were prevented from leaving the pond; however the number was small.

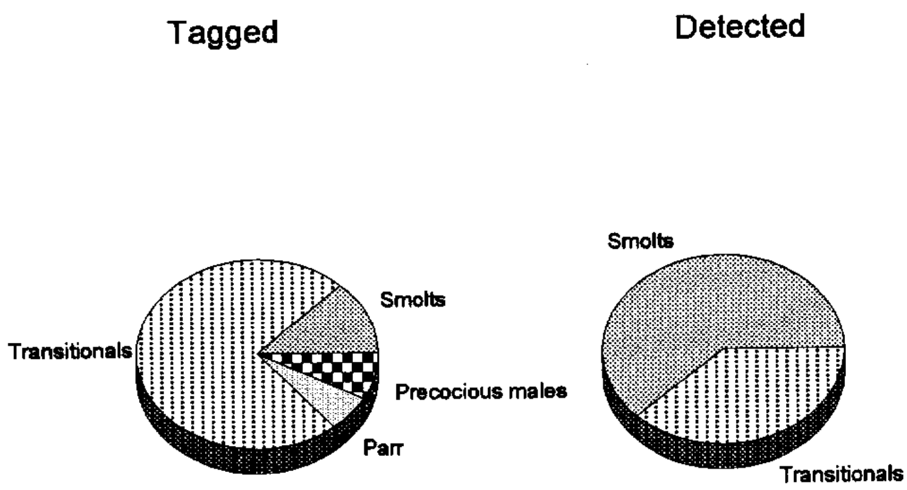

Figure 1

Table 1. Percent of pit tags detected* for three study groups released from curl lake acclimation pond.

	VOLUNTARY	NON-MIGRANT	PRECOCIOUS
1994	33.5	3.5	0
1995	27.5	6.8	0
1996	28.9	3.4	0
1997	33.7	7.9	0

* Represents unique detections at all dams below point of release

Smolt Performance Characteristics of Natural and Hatchery Steelhead Trout From the Imnaha River

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The Nez Perce Tribe has operated a rotary screw trap on the lower Imnaha River to evaluate hatchery smolt performance and biological characteristics of hatchery and natural steelhead trout smolts under the Lower Snake River Compensation Plan since 1992. This project has operated in conjunction with the Fish Passage Center's smolt monitoring program since 1994. Survival estimates of PIT tagged fish from the Imnaha River trap to lower Snake River dams were calculated using the Survival Under Proportional Hazards (SURPH) model (Skalski et al 1994). Hatchery reared steelhead trout smolts emigrate from the Imnaha River within days of release followed by a protracted outmigration, typically through June. Natural steelhead trout smolt emigration commences about mid-April and curtails by about the end of May. A multiple release strategy for hatchery reared steelhead trout may result in emigration timing patterns more similar to those of natural steelhead smolts. From 1994 through 1997, hatchery steelhead trout smolt median and 90% arrival timing to Lower Granite Dam ranged from May 23 to May 31 and June 13 to July 15, respectively. Natural steelhead smolt median and 90% arrival timing to Lower Granite Dam ranged from May 2 to May 9 and May 9 to June 4, respectively. Estimated survival of PIT tagged hatchery steelhead smolts from the Imnaha River trap to Lower Granite Dam ranged from 37.0-89.1% between 1993 and 1997. Estimated survival of PIT tagged natural steelhead trout smolts from the Imnaha River trap to Lower Granite Dam ranged from 73.1-93.1% between 1994 and 1997. Estimated survival of PIT tagged steelhead trout smolts from the Imnaha River trap to Lower Monumental Dam was 64.3% for hatchery steelhead and 74.1% for natural steelhead smolts in 1997.

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Acclimation of summer steelhead hatchery smolts: influence on juvenile migration performance and smolt-to-adult survival

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We evaluated the use of three acclimation facilities in Northeast Oregon to increase survival of hatchery juvenile summer steelhead to adulthood. Juvenile steelhead about 90 grams were held at least 30 days in facilities, then released in early April as yearlings. Results were compared to fish released directly into the streams near the facilities. At the Wallowa Facility acclimated steelhead survived at significantly higher rates ($\bar{x} \approx 1.3$ times) than non-acclimated fish, as indicated by coded-wire tag data for the 1986-1989 brood years. Data from the 1991 to 1994 brood years that were released at Big Canyon and Little Sheep Creek facilities were not yet complete, but suggested that any survival advantage for acclimated fish is likely to be much less than 1.3.

The mechanism for increased survival of acclimated fish at the Wallowa Facility was unclear. Acclimated fish from the Wallowa Facility arrived at Lower Granite Dam similar to or slightly later than non-acclimated fish, peaking in May, as indicated by expanded recovery of branded fish and detections of PIT-tagged fish. Similar arrival trends were observed at the Big Canyon and Little Sheep facilities. At the Big Canyon and Little Sheep facilities the 1991 brood of both acclimated and non-acclimated fish reacted similarly to standardized stressors, with plasma cortisol concentrations increasing from baselines around 50 to post-stress levels about 250 ng/ml. Progress toward recovery from stressors was more advanced for the acclimated group than the non-acclimated group after 48 hours at the Big Canyon Facility but not at the Little Sheep Creek Facility. Acclimated fish did not seem to exhibit increased smoltification over the acclimation periods compared to non-acclimated fish, both treatments having similar ATPase activities (~7-12 μmole$P_i$mg protein^{-1}h^{-1}) and skin guanine concentrations (~0.35-0.45 mg/mm^2). The use of large vertical-sided, concrete ponds to acclimate fish appeared to have increased survival at the Wallowa Facility.

Large differences between acclimated and non-acclimated steelhead juveniles in reactions to stressors, stress recovery and smoltification were not evident for the 1991 brood at the Big Canyon or Little Sheep facilities. Unfortunately survival rates for the 1991 brood were too small to statistically test for differences in survival between acclimated and non-acclimated groups. Therefore it was not possible to infer anything about a relationship between differences in survival rate and any relationship to differences in physiological indices between treatments.
Differences in survival between facilities may reflect differences between years, between facilities, or between stocks. This suggested that the use of acclimation may not always result in a consistent outcome at every facility.

Although not part of the original "hatchery complex" design, operation of the acclimation facilities in Northeast Oregon has given managers a place to put fish in the springtime during unanticipated well water shortages at Irrigon Hatchery.

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Restoration of Summer Steelhead Recreational Fisheries in the Grande Ronde and Imnaha River Basins

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In 1974, recreational steelhead fisheries in the Grande Ronde and Imnaha river basins in NE Oregon were closed due to low escapement, as indicated by low redd counts in index streams and low fish counts at Ice Harbor Dam. In 1976, Congress initiated the Lower Snake River Compensation Plan (LSRCP) program to compensate for losses of anadromous salmonids caused by construction of the four lower Snake River Dams. Program goals for NE Oregon, under the LSRCP program are 9,184 adult steelhead for the Grande Ronde Basin and 2,000 adult steelhead for the Imnaha Basin. To achieve these compensation goals, we released 1,350,000 juvenile steelhead into the Grande Ronde Basin and 330,000 juvenile steelhead into the Imnaha Basin each year. Since the LSRCP program began, consumptive recreational fisheries re-opened in 1986, primarily due to increases in adult returns of hatchery reared steelhead to both basins. Harvest on returning adults occurs primarily in the Columbia River sport and net fisheries, Snake River sport fisheries, and within-basin sport fisheries. One primary objective under the LSRCP program was to reestablish sport and tribal fisheries in the mainstem Snake River and tributaries. Our study objectives were to 1) compare historic to current estimates of angler effort, catch rate, and harvest of steelhead on the Grande Ronde, Wallowa, and Imnaha rivers, 2) compare historic harvest to current harvest in time and place, 3) determine the proportion of hatchery and wild fish in the catch, 4) establish a total return of summer steelhead that meets compensation goals in Oregon, and 5) minimize impacts of hatchery programs on resident stocks of game fish. We conducted statistical angler surveys (roving surveys and check stations) on the Grande Ronde, Wallowa, and Imnaha rivers beginning in the fall of 1985 during the steelhead season. We summarized all available historic and current data for the Grande Ronde, Wallowa, and Imnaha rivers from district annual reports, punch cards, and creel surveys. We used these data to 1) compare historic and current fisheries, 2) compare the proportion of harvest in time and place, and 3) estimate the proportion of hatchery and wild fish caught in current fisheries. Over the past 10 years anglers have spent less time to catch a steelhead, have spent more time fishing than they did historically, and have harvested (only adipose-clipped fish) the same number of fish as they did historically. The contribution of hatchery fish to the total catch typically increases throughout the fall fishery and hatchery fish have dominated the catch during most spring fisheries. Historically, 55% of the harvest occurred during the fall, whereas currently, only 15% of the harvest occurs during the fall. In addition, historical harvest was greatest on the Grande Ronde River and lowest on the Wallowa River, whereas currently, harvest is greatest on the Wallowa River and lowest on the Imnaha River. In conclusion, we need to determine whether restoring fisheries in time and place is important, and to develop broodstock collection strategies that will increase the contribution of hatchery fish to the early fall fishery.

Evaluation of the influence of size-at-release on juvenile migration performance and smolt-to-adult survival of summer steelhead

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Little is known about steelhead production in NE Oregon and what the best rearing and release strategies are for our hatchery steelhead program in the Grande Ronde and Imnaha river basins. Our goal was to begin developing optimum rearing and release strategies to maximize smolt-to-adult survival. The hatchery system in NE Oregon has the capability to produce fish larger than the standard program target size of 91g. We therefore examined whether fish released at a target size of 113 g (4 fish/lb) would have higher survival than fish released at a target size of 91 g (5 fish/lb). Our study objectives were to 1) examine juvenile migration characteristics and relative survival to Lower Granite Dam, 2) compare catch contribution patterns and age composition at return, and 3) determine differences in smolt-to-adult survival and adult production effectiveness. We used Wallowa stock steelhead from the 1985-1990 brood years. Returning adults were trapped and spawned at Wallowa Fish Hatchery. Eggs were incubated and juveniles were reared at Irrigon Fish Hatchery, a constant temperature well water facility. Target sizes were achieved with temperature, feeding, and grading. Replicate groups were freeze-branded (30,000-50,000/group) to determine juvenile migration characteristics and passage indices (relative survival) at Lower Granite Dam, and were coded-wire-tagged (25,000/group) to determine smolt-to-adult survival rates. Juveniles were transferred back to Wallowa Fish Hatchery for acclimation prior to release. The 91 g and 113 g release groups did not necessarily reach target sizes for each brood year. Fish targeted for 113 g survived at a higher rate than fish targeted for 91 g. The number of adults produced per kg of smolts released for the 113 g target release groups were equal to or greater than the 91 g target release groups. There was no consistent trend in migration timing or passage indices (relative survival) to Lower Granite Dam for the 91 g and 113 g target release groups. There was no difference in mean age composition or catch distribution patterns between 91 g and 113 g target release groups. There are numerous benefits of increasing target size at release from 91g to 113 g. Fewer smolt release numbers would result in equal or greater numbers of returning adults. Broodstock needs could be reduced from 672 to 537 adults, resulting in fewer eggs taken, incubated, and picked. Fewer residual fish may result from fewer smolt release numbers and a larger size at release, because other studies have shown that smaller fish tend to residualize. Thus, we recommend switching the target size of juvenile summer steelhead in NE Oregon from 91 to 113 g.

Steelhead survival and adult returns to Idaho - the effects of fish size at release

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Over 200,000 steelhead (*Oncorhynchus mykiss*) were reared to two different sizes, tagged with coded wire tags and passive integrated transponder (PIT) tags, and released into the Salmon River in 1991 and 1992. In 1991 (brood year 1990), large and normal size steelhead averaged 241 mm fork length (FL) and 204 mm FL, respectively. In 1992 (brood year 1991), large and normal size steelhead averaged 234 and 205 mm FL, respectively. A total of 53,245 large size and 61,431 normal size steelhead, were released in 1991. In 1992, 53,463 large size and 61,431 normal size steelhead were released. Approximately 500 steelhead from each size group were released with PIT tags each year.

For brood year 1990, 70.1% of the large and 63.5% of the normal size PIT tagged steelhead were interrogated at downstream dams. Significantly ($\chi^2 = 4.59$, $P = 0.032$) more large size steelhead were interrogated than normal size steelhead. Travel time to Lower Granite Dam was not significantly different ($P = 0.40$) between groups.

For the 1991 brood, 47.1% of the large and 48.6% of the normal size steelhead were interrogated at downstream dams. The number of fish interrogated was not significantly different ($\chi^2 = 0.154$, $P = 0.694$) between size groups. Travel time to Lower Granite Dam was not significantly different ($P = 0.068$) between groups.

For brood year 1990, 129 adults from large size smolts and 93 adults from normal size smolts returned to Idaho. Large size steelhead smolts returned as adults at a significantly higher rate than normal size smolts ($\chi^2 = 11.73$, $P = 0.001$). Smolt-to-adult survival rate (SAR) for large size smolts was 0.24%; SAR for normal size smolts was 0.15%. Sex composition of the adult return was independent of smolt size ($\chi^2 = 2.23$, $P = 0.136$). Age at return was independent of smolt size ($\chi^2 = 0.271$, $P = 0.602$).

For the 1991 brood, 26 adults from large size smolts and 15 adults from normal size smolts returned to Idaho. There was no significant difference in return rates between groups ($\chi^2 = 1.12$, $P = 0.289$). Large size smolts had a SAR of 0.05%; SAR for normal size smolts was 0.03%. Sex composition of the adult return was independent of smolt size ($\chi^2 = 1.01$, $P = 0.314$). Age at return was independent of smolt size ($\chi^2 = 0.001$, $P = 1.000$).

Results suggest that releasing larger smolts may improve adult return rates if spring discharge is of normal volume. Snake River flows in 1992 were below normal and believed responsible for the low interrogation and return rates observed for the 1991 brood. Releasing larger smolts did not adversely affect adult return rates, sex ratios, or age composition even under poor migratory conditions.

Residual Hatchery Steelhead: Characteristics and Potential Interactions with Spring Chinook Salmon in Northeast Oregon

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Each year in NE Oregon 1.5-1.7 million hatchery steelhead smolts are released into the Grande Ronde and Imnaha river basins under the Lower Snake River Compensation Plan. Some of these hatchery reared steelhead residualize (i.e., they do not migrate to the ocean during the smolt migration season after they are released) and have the potential to interact with juvenile spring chinook salmon. We examined the characteristics of residual steelhead and evaluated the potential for these fish to interact with juvenile spring chinook salmon. We found 80-90% of the residual steelhead to be males, and significantly smaller than the average size fish that was released. We found residual steelhead near all the release sites during summer, and near acclimation facilities in Deer and Little Sheep creeks during summer, fall, winter and spring. The highest densities of residuals occurred at release sites, and densities were very low upstream of and decreased downstream of release sites. Residual steelhead and juvenile chinook salmon likely interact in the lower Wallowa, Grande Ronde, and Imnaha rivers where both are present and densities of one or both are relatively high. During controlled predation trials, we found that prey less than 30% of the length of a residual steelhead predator were eaten at a higher rate than their availability, and the largest prey eaten were 44% of the fork length of a residual steelhead predator. Predation may be a concern in the lower Grande Ronde River during August, as we found that 42% of the residual steelhead we sampled there were large enough to prey on the average size juvenile chinook salmon in the area. Current release locations of hatchery steelhead help to minimize the impacts of residual steelhead on juvenile chinook salmon. We may be able to reduce the number of residual steelhead found in local streams by culling small males from our releases.

Steelhead survival and adult returns to Idaho - the effects of release site acclimation

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Juvenile emigration and adult recovery rates were used to test the effects of a two week acclimation period on steelhead trout (*Oncorhynchus mykiss*) smolts reared at Hagerman National Fish Hatchery and subsequently transported and released into the Salmon River at Sawtooth Fish Hatchery. Acclimated steelhead were reared at Sawtooth Fish Hatchery for two weeks prior to being released where as non-acclimated steelhead were transported from Hagerman National Fish Hatchery and released directly into the Salmon River. Between 1992 and 1997, 370,908 acclimated and 356,881 non-acclimated steelhead were released with coded wire tags. A total of 2,579 of the acclimated and 2,000 of the non-acclimated steelhead were released with passive integrated transponder (PIT) tags.

Interrogation rates at downstream dams for PIT tagged acclimated steelhead ranged from 33.9% in 1994 (brood year 1993) to 62.7% in 1993 (brood year 1992). Interrogation rates for steelhead from the non-acclimated groups ranged from 42.7% in 1994 (brood year 1993) to 69.6% in 1997 (brood year 1996). Non-acclimated steelhead from the 1991, 1993, and 1996 broods were interrogated at significantly ($P<0.05$) higher rates than acclimated fish. For the 1992 brood, acclimated steelhead were interrogated at a significantly ($P<0.05$) higher rate. For the 1994 and 1995 broods, PIT tag interrogation rates were not significantly different. Non-acclimated steelhead from the 1991, 1994, 1995, and 1996 broods had significantly ($P<0.05$) shorter travel time to Lower Granite Dam than fish from the acclimated group. For the 1992 and 1993 broods, travel time to Lower Granite Dam was not significantly different between groups.

Adult steelhead return data are complete for only the 1991 and 1992 broods. For brood year 1991, 13 adults from the acclimated group and 15 adults from the non-acclimated group were recovered in Idaho. Recovery rates were not significantly different ($\chi^2 = 0.51$, $P = 0.475$) between groups. Sex and age composition of the adults recovered did not differ between the acclimated and non-acclimated groups ($\chi^2 < 0.001$, $P = 1.000$; $\chi^2 = 0.57$, $P = 0.449$, respectively). For brood year 1992, 80 adults from the acclimated group and 46 adults from the non-acclimated group were recovered in Idaho. Acclimated steelhead smolts returned as adults at a significantly higher rate than non-acclimated smolts ($\chi^2 = 5.79$, $P = 0.016$). Sex and age composition of the adults recovered did not differ between the acclimated and non-acclimated groups ($\chi^2 = 0.24$, $P = 0.626$);.$\chi^2 = 1.04$, $P = 0.309$, respectively)

Wild vs Hatchery Survival and Life History of Tucannon Spring Chinook

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Hatchery supplementation in Tucannon River began in 1985 with first collection of wild salmon for the hatchery broodstock. Since that time, WDFW has closely monitored the returning wild and hatchery spring chinook to the river. One goal of the monitoring and evaluation program is to document differences (survival and life history traits) between the wild and hatchery populations. By doing this we can identify potential problems within and outside of the hatchery program, and recommend the necessary changes which will benefit the spring chinook population in the river.

The first task was to compare survival rates from Egg-to-Smolt, Smolt-to-Adult, and Parent-to-Progeny (see Tucannon Spring Chinook Program Presentation for graphs) between the wild and hatchery fish. From egg-to-smolt hatchery fish survive considerably better (8:1 advantage), but wild fish survive better from smolt-to-adult (4:1 advantage). For parent-to-progeny, wild fish are below the replacement level, but the hatchery fish are generally above. The hatchery population is therefore critical to maintaining the Tucannon River population at healthy genetic levels. Factors identified that are limiting the wild population from succeeding are loss of habitat in the Tucannon River and loss of the natural migration corridor because of the Columbia and Snake River dams. Limiting factors need to be addressed and corrected to sustain the population into the future.

The second task was to examine life history traits (age composition and fecundity) of returning wild and hatchery adults. Age composition of wild and hatchery fish is not the same. Hatchery fish are younger in age than wild fish, though by changing the release size of the hatchery smolts (10 fish/lb to 15 fish/lb), the age composition has shifted to more closely mimic the wild population (Figure 1). Fecundity of hatchery females has also been less than wild females; about 500 eggs/female in Age 4 and about 1000 eggs/female in Age 5. However, by releasing smaller hatchery smolts (15 fish/lb), fecundity in Age 4 hatchery females has increased to more closely mimic the wild population. No Age 5 hatchery females have been included in the broodstock of yet for a comparison.

By changing the release size of hatchery smolts, we have successfully altered the life history traits to more closely mimic the wild population. Since returns of fish released at 15 fish/lb are few at this point, we may see either an increase or decrease in survival of the hatchery population. More complete returns in the next few years will provide a more definitive answer. Mimicking the wild population may become secondary if the spring chinook population continues to decline, as it may be more desirable to have better survival (more returning fish), than similar traits.

Figure 1- Age Composition

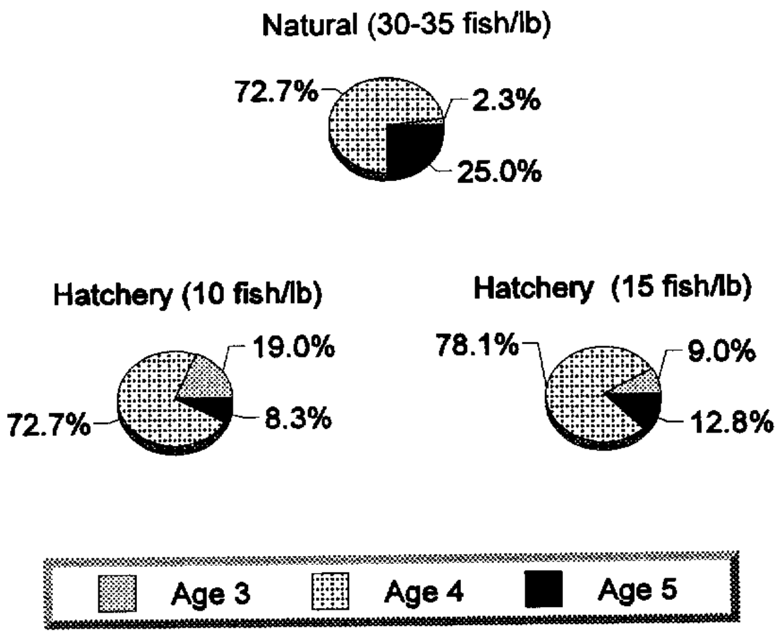
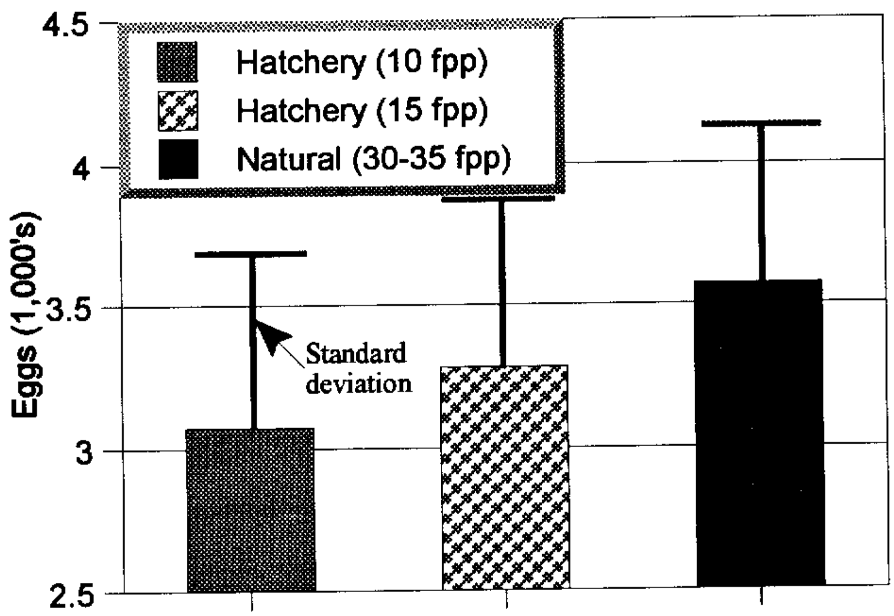


Figure 2 - Age 4 Fecundity



Post-release Survival of Hatchery Chinook Salmon Smolts and Emigration Characteristics of Natural and Hatchery Chinook Salmon from the Imnaha River

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A rotary screw trap was operated at rkm 7 on the lower Imnaha River (67 rkm downstream of the Imnaha River Chinook Acclimation Pond) since 1992 to evaluate emigration characteristics and survival of natural and hatchery reared chinook salmon. Post-release survival estimates of hatchery chinook salmon smolts to the lower Imnaha River screw trap were derived by estimating smolt yield by the bootstrap method from 1992 to 1994 and 1996 and by the SURPH.1 model (SURvival with Proportional Hazards) from 1994 to 1997. Estimated hatchery chinook smolt post-release survival ranged from 88.1 to 101.7% in the Imnaha River from 1992 to 1994 and 1996 (bootstrap method). Estimated hatchery chinook smolt post-release survival ranged from 89.2 to 100.9% in the Imnaha River from 1994 to 1997 (SURPH model). The majority of hatchery reared chinook salmon smolts (>90%) emigrate from the Imnaha River within eight days after release. Estimated survival of hatchery chinook from the lower Imnaha River trap to Lower Granite Dam ranged from 65 to 80.4% for the years 1994 and 1996 to 1997 (SURPH model). Cumulative interrogations to Lower Granite Dam for the same groups of fish ranged from 43.3 to 53.4%. Estimated survival (SURPH) of hatchery reared chinook salmon smolts from release at the Imnaha River Acclimation Pond to Lower Monumental Dam was 46.3 to 51.9% from 1993 to 1997. Arrival timing at Lower Granite Dam (1994 to 1997) for Imnaha River hatchery chinook smolts occurred from April 13 to June 7 with median arrival from May 2-12 and 90% arrival from May 12-16. Natural chinook smolts exhibit a more protracted emigration from the Imnaha River with spring emigration occurring from February through June. Substantial numbers of naturally produced juvenile chinook leave the Imnaha River in fall as age 0+ pre-smolts. Both hatchery and natural chinook smolt movement occurred almost exclusively at night. Hatchery reared chinook are significantly larger than their natural spring emigrating counterparts. Spring emigrating natural chinook salmon smolts had an estimated survival of 80.6 to 92.3% (SURPH) from the Imnaha River trap to Lower Granite Dam from 1993 to 1996. Cumulative interrogations to Lower Granite Dam for these same groups of natural chinook smolts ranged from 52.9 to 76.2%. Fall emigrating natural chinook salmon juveniles, PIT tagged in the fall of 1993 and 1995, had a minimum estimated survival (SURPH) of 34.2% and 32.7% to Lower Granite Dam. Arrival timing at Lower Granite Dam (1993 to 1997) for natural Imnaha River chinook smolts occurred from April 6 to July 11 with median arrival from April 22 to May 4 and 90% arrival timing from May 11-18. Mean travel time to Lower Granite Dam from the lower Imnaha River trap (142 rkm) for natural and hatchery chinook salmon smolts tagged in the spring ranged from 7.6 to 53 and 8.1 to 27.3 days, respectively, in 1994 and 1996. Mean travel time to Lower Granite Dam was always faster for natural chinook smolts compared to hatchery chinook smolts released during the same week at the lower Imnaha River trap (1994 and 1996).

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Cryopreservation of Adult Male Spring and Summer Chinook Salmon Gametes

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Many salmon populations in the Northwest are decreasing in number. Detrimental conditions causing these decreases can be improved in some cases, but time is required. With the constant threat of losing genetic diversity in specific native fish stocks, the establishment of a program for the long-term storage of fish germ plasm would serve as back-up insurance for ongoing conservation programs. The best way to ensure availability of a representative genetic sample of the original population is to establish a germ plasm repository while the population is relatively healthy. Cryopreservation of semen is the simplest and most economical means by which to meet this endpoint. Cryopreservation is a genetic repository and not a cure for decreasing fish stock problems. The Nez Perce Tribe was funded in 1997 by the Bonneville Power Administration to coordinate and initiate gene banking of adult male gametes from ESA listed spring/summer chinook salmon in the Snake River basin. In 1997, 198 viable cryopreservation samples were taken from Lostine River, Big, Johnson, Lake, Marsh and Capehorn creeks, the South Fork Salmon River weir, and Sawtooth (upper Salmon River stocks) and Lookingglass (Imnaha River stock) hatcheries. A total of 278 cryopreserved samples from the Snake River basin, from as early as 1992, are in storage, in duplicate, at the University of Idaho and Washington State University.

Wild:Hatchery Composition of Adult Chinook Salmon on Spawning Grounds in the South Fork Salmon River

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The percentage of naturally spawning chinook salmon of hatchery origin spawning in two adjacent stream reaches downstream of the South Fork Salmon River adult weir was estimated using scale pattern analysis (SPA) in 1992 to 1995, and using known marked hatchery fish in 1996 and 1997. Classification accuracy of the SPA method ranged from 81 to 100% for the known hatchery adult salmon group which was comprised of marked hatchery fish collected at the South Fork Salmon River adult weir. SPA classification accuracy ranged from 77 to 100% for the known wild adult salmon group, comprised of fish collected on the Secesh River, a tributary of the South Fork Salmon River. Substantial between-year variation existed in freshwater growth zones of the known wild adult salmon group scales, preventing pooling of the known wild group between years. Ninety three percent of 31 known hatchery adult salmon carcasses collected on the spawning grounds (unknowns) were correctly classified by the SPA. The SPA method estimated hatchery adult composition in the 11.3 km area directly downstream of the adult weir to range from 60 to 100% from 1992 to 1995. Known marked hatchery adult composition in this same area was 53% in 1996 and 88% in 1997. Hatchery adults that spawn in the 11.3 km stream reach downstream of the adult weir represent a significant portion of all naturally reproducing salmon in this area. A total of 3 to 130 chinook salmon redds have been observed in this area from 1991 to 1997. The SPA method estimated hatchery composition in the second stream reach, Poverty Flat/Lodgepole Camp (7.8 km), to range from 19 to 75% between 1992 and 1995. Known marked hatchery adult composition in this stream reach was 6% in 1996 and 37% in 1997. Hatchery adults represented the majority (53%) of all spawners on Poverty Flat in 1997. The percent composition of hatchery origin adults on the spawning grounds in the South Fork Salmon River generally decreased with distance downstream of the adult weir. The Poverty Flat/Lodgepole Camp section was located 25 to 30 km downstream of the direct stream smolt release location. SPA methodology tended to over-estimate the percentage of hatchery fish on the spawning grounds in 1996 and 1997 compared to the known marked hatchery fish method. It was not possible to examine whether this discrepancy occurred from 1992 to 1995.

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Emigration Rates Versus Adult Returns For Sequentially Released Spring Chinook Salmon From Dworshak and Kooskia National Fish Hatcheries

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A number of physiological, morphological, and behavioral characteristics are involved with the parr-smolt transformation process (Wedemeyer et al. 1980; Folmar and Dickhoff 1980). More fully developed smolts tend to move offshore to faster mid-river waters, resulting in faster migration rates (Zaugg and Mahnken 1991). A faster migration rate can contribute to increased survival by reducing exposure of fish to predation and competition for food.

The goal of this study was to improve the post-release performance and adult returns of spring chinook salmon at Dworshak and Kooskia NFHs by determining the optimum release time during smoltification. The study was initiated at Kooskia NFH in 1992 and was continued at Dworshak NFH in 1993 and 1994. The objectives of the study were to determine if release time had a significant effect on:

1) Smolt development prior to and during smolt emigration;
2) Downstream emigration time to Lower Snake River and Columbia River dams;
3) Smolt interrogation rates at Lower Snake River and Columbia River dams; and
4) Adult returns to Dworshak and Kooskia NFHs.

Three releases, early, mid, and late were scheduled at two-week intervals during April and May for all three years. Starting in March of each year, smolt development was determined by measuring gill (Na+K+) ATPase at bi-weekly intervals prior to release. Additionally, fish released from Kooskia NFH in 1992 were collected at Lower Granite and McNary dams and fish released from Dworshak NFH in 1994 were collected at Lower Granite Dam to measure changes in gill ATP-ase. Smolt migration times to Lower Granite, Little Goose, and McNary dams were determined using PIT tags. At Kooskia NFH in 1992, about 400 fish were PIT tagged in each release group. At Dworshak NFH in 1993 and 1994, about 1,500 and 6,000 fish in each release group, respectively, were PIT tagged. The sum of unique interrogations at Lower Granite, Little Goose, and McNary dams were used as a minimum estimate of survival to Lower Granite Dam. Coded-wire tags were used to evaluate adult returns. At Kooskia NFH, two groups of about 60,000 fish each were coded-wire tagged and freeze branded in each release group. At Dworshak NFH in 1993, two groups of about 64,000 fish each were marked in each release group with different tag codes. In 1994, one tag code of about 64,000 fish each were marked in each release group and all the fish were freeze-branded.

ATPase levels generally increased over time prior to release at Kooskia NFH in 1992 and at Dworshak NFH in 1994. ATPase levels did not increase prior to release at Dworshak NFH in 1993. In 1992, the early release group was the only group that showed signs that ATPase was continuing to increase by the time they reached McNary Dam. Data could not be collect at McNary Dam in 1993 or 1994.

Later release groups traveled significantly ($P<0.05$) faster than earlier release groups all three years. Differences between release groups were greater in 1993 and 1994 than in 1992. PIT-tag interrogation rates were variable at each of the dams from year to year. The early and mid release groups had higher cumulative PIT-tag interrogation rates than the late release groups in all three years. However, differences were statistically significant only for 1993 and 1994. Adult returns for the early release groups were higher than for the mid or late release groups in all three years based on code-wire tag returns (Table 1).

In conclusion, we found that later releases resulted in faster emigration but that this did not result in higher cumulative PIT-tag interrogations at downriver dams. Earlier releases consistently produced higher adult returns. The results may be related to ATPase development. ATPase levels of the mid and late release groups at McNary Dam in 1992 exhibited signs of decreasing, which may have negatively influenced their ability to make the transition from fresh to salt water by the time they entered the estuary. Attempts to use indices of smoltification in the development of hatchery release strategies in the upper reaches of the Columbia River Basin, such as in the Clearwater River, need to consider the time required for fish to reach the estuary so that the development of smoltification peaks at the optimum time.

Table 1. Coded-wire tag return rates for sequentially released spring chinook salmon.

Year	Release Date	Tags Released	Tags Returned	Percent
1992	April 7	111,879	22	.02
	April 21	113,423	5	.004
	May 5	97,637	1	.001
1993	April 8	121,929	17	.01
	April 22	119,297	7	.006
	May 6	105,988	4	.004
1994[1]	April 8	66,014	48	.07
	April 22	61,840	28	.05
	May 6	68,211	28	.04

[1] Tags recovered for 1994 do not include the III-Ocean returns.

Improving chinook smolt quality: Exercise experiments in production raceways

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Rigorous exercise (flows of 1-4 BLs^{-1}) has been shown to stimulate growth, increase food conversion and swimming ability, and enhance survival to adulthood in a number fishes in culture (Woodward and Smith, 1985; Leon, 1986; Houlihan and Laurent, 1987; Christiansen et al. 1992; Young and Cech, 1993). Some of these benefits may be indirect results of exposing the fish to a current, which encourages changes in social behavior (aggression, schooling and less uncontrolled activity) compared to counterparts in more quiescent waters (Kiessling *et al.*, 1994).

We used elevated flows to attempt to separate the physiological effects of exercise from the behavioral changes that occur when hatchery-reared salmon are exposed to moderate, though sub-exercise flows. Rapid River stock spring chinook salmon (*Oncorhynchus tshawytscha*) juveniles were reared in raceways under a modified pattern of water flow to induce light exercise compared to normal hatchery practices or to more rigorous exercise.

Beginning when 8 month old parr (2 g) were transferred to outdoor raceways in May, those in exercise groups experienced currents requiring them to swim at 0.18 to 0.75 BLs^{-1} following a cyclic annual pattern in flow, while control groups swam at 0.20 BLs^{-1} through the entire period. Raceways measured 30.5m x 3.5m x 1.22m and contained 35,000 to 40,000 juveniles targeted for 22.7 g at release. Representative portions of fish in each raceway were PIT tagged the following February to evaluate their success during downstream migration when released in April. In the months preceding the release of smolts, fish were sampled periodically to determine if the exercise treatment influenced body morphology, energy reserves, smoltification indices, or their cortisol response to a standard handling stress.

No differences were observed between exercise and control groups in morphological or physiological measurements throughout the sampling period in either brood year 1993 or 1994 smolts. Pre-release mortality in exercise groups was higher (3.3% and 2.8%) than in control groups (1.1% and 2.2%), but the cumulative percent PIT tag detection during migration was the same for each group in 1996 and 1997. This study suggests that chronic light exercise does not have the same effect on smolt physiology that more rigorous exercise programs have reported and that the exercise treatment was also to light to induce the behavioral changes postulated by Kiessling *et al.* (1994). In addition, many hatchery facilities may not have the water or distribution facilities to provide meaningful exercise flows. The maximum discharge possible at Lookingglass Fish Hatchery was 6,823 lpm; equivalent to 7 cm/s or 0.75 BL/s maximum. Thus, although more vigorous exercise may be valuable to the fish, the high discharge required at a production scale must be considered and may be beyond the capabilities of many hatchery facilities.

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Assessment of Reestablishing Natural Production of Spring Chinook Salmon (*Oncorhynchus tshawytscha*) in Lookingglass Creek, Oregon

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Hatchery-produced adult Rapid River stock spring chinook salmon that returned to Lookingglass Hatchery were used to restore natural production in Lookingglass Creek. To quantify the success of the restoration effort, we compared performance and life history characteristics of the hatchery adults and their naturally-produced progeny in Lookingglass Creek with those of the extinct Lookingglass Creek natural population and other extant natural populations in Columbia River basin tributaries.

We released 133 adult Rapid River stock spring chinook salmon above the Lookingglass Hatchery weir in 1993, 99 in 1993, and 112 in 1994. Additional fish escaped above the weir. We estimated the total adult spring chinook salmon population above the hatchery weir to have been 220 in 1992, 297 in 1993, and 121 in 1994.

There was no significant difference in the mean adult-per-redd estimate among years for populations of the Rapid River hatchery stock (3.3), the extinct Lookingglass Creek natural population (2.4), or other natural populations in the Columbia and Snake River basins, (range 3.1 to 2.4). The estimated juveniles-per-adult for the 1993 and 1994 broods of naturally-produced Rapid River stock were about 400 and 60 respectively, while the mean was 130 for the 1965 to 1969 broods of the extinct Lookingglass Creek natural population. Monthly median fork lengths from April to October of naturally-produced Rapid River stock juveniles from the 1993 and 1994 broods in Lookingglass Creek were similar to or significantly greater than the maximum of median fork lengths observed from the 1964 to 1969 broods of the extinct Lookingglass Creek natural population. Migration timing of naturally-produced Rapid River stock juvenile spring chinook salmon past our trap in Lookingglass Creek for the 1993 and 1994 broods peaked 1 to 2 months later in the fall than that observed for the 1965 to 1969 broods of the extinct Lookingglass Creek natural population. Both the naturally-produced Rapid River stock and the extinct Lookingglass Creek natural population, however, migrated past the trap site predominantly as subyearlings. Arrival timing at Lower Granite Dam of the juvenile spring chinook salmon from the 1992 to 1994 broods of naturally-produced Rapid River stock that were PIT-tagged in Lookingglass Creek peaked in mid- to late-April, generally earlier than most, but within the range of 5 other Grande Ronde River tributaries. Minimum survival rates to Lower Granite Dam for Lookingglass Creek fish ranged from about 13 to 17 %, within the ranges for other Grande Ronde River tributaries (~9-21%).

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Monitoring spawning escapement in northeast Oregon; It's not just a walk in the park anymore

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Initially, spawning ground surveys for spring chinook salmon were conducted to provide a relative annual index of natural escapement. With the advent of population restoration programs these objectives have changed. Contemporary surveys have become an essential component for the monitoring and evaluation of hatchery supplementation programs. These programs require detailed information on population size, redd location, carcass recoveries, and the origin of natural and hatchery adults.

Historical surveys, instituted in 1948, examined stream sections with the highest densities of spawning salmon. These "Index" surveys were conducted on specific days of the year coinciding with peak spawning, and the number of redds and fish were enumerated. As salmon populations declined, this method did not provide the quantitative information needed to make management decisions.

In 1986, we added two components to spawning ground surveys to increase the accuracy of population estimates and to recover more carcasses to estimate straying of hatchery produced salmon. First, in addition to the historical index survey sections, we surveyed the majority of salmon spawning habitat on the same day as the index survey (termed "extensive" surveys). Second, we repeated surveys of the Index section(s) one and two weeks later to observe spawning that occurred after the Index survey (termed "supplemental" surveys). These techniques allowed us to estimate the total number of fish spawning in each system, though still with limited accuracy.

Beginning in 1996 we implemented another change to obtain the most accurate estimates possible of spawning escapement, and to boost carcass recoveries. We now conduct three weekly surveys covering the majority of known spawning habitat. The first survey is conducted on the same day as the Index survey, and is followed by two weekly surveys that include all survey sections. This latest survey design enables us to obtain an accurate population estimate, including the age, sex and origin structure of the population spawning in nature. These data can then be used to calculate progeny-to-parent ratios, providing a method to evaluate the status of the natural population over time, as well as the effectiveness of our hatchery supplementation programs. In addition, this design adds to the number of carcasses collected thereby increasing the precision of the population estimates and raising the probability of finding hatchery strays in small populations. The negative aspects of this design include an increase in survey effort and expense, complex data tracking and analysis, and although progeny-to-parent ratios can be calculated, there is no mechanism available to determine the associated error with each term.

Though intensive and logistically difficult, using this new design enables us to account for a majority of spawning activity in each system and to collect an increased number of carcasses. So in addition to calculating an annual natural population size, we can now evaluate many critical aspects of hatchery supplementation programs and their influence on the populations they are intended to benefit. Therefore, these surveys enable managers to have the best possible data available when making complex restoration decisions.

Straying of hatchery spring chinook salmon and hatchery:wild composition of naturally spawning adults in the Grande Ronde River basin

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We estimated the percentage of adult spring chinook salmon that were of hatchery origin for returns to six Grande Ronde River tributaries during 1986 to 1997. Fin clips were used, when available, to identify hatchery fish. Discriminant analysis was also used to categorize unmarked salmon as hatchery or naturally-produced using scale patterns from 1986 to 1994. We used scales collected from 1976 to 1984 (before major hatchery releases returned to the basin) to represent naturally-produced fish, and coded-wire tagged fish returning to the basin each year to represent hatchery fish.

In order to apply the information from analysis to the population, our main assumptions were: 1) our ability to identify the origin of each fish was relatively accurate, 2) scale patterns of the naturally-produced fish from 1976-1984 returns were similar to those during recent years, and 3) carcasses recovered represented the spawning population in both space and time.

Jackknife analysis of our models resulted in greater than 95% accuracy in distinguishing known hatchery (coded-wire tagged from 1986 to 1994) from known natural fish (unmarked fish from 1976 to 1984). However, recent data from Lookingglass Creek suggested that current growth rates (1993 and later broods) of natural fish were greater than historically (1965-1969). If similar patterns held true in other tributaries of the Grande Ronde River, current growth patterns of natural fish may be faster than indicated from scales recovered from fish from 1976 to 1984. Higher growth rates would make scale patterns of recently returning natural fish appear more similar to hatchery fish, increasing the likelihood of naturally-produced fish from 1986 to 1994 being misidentified by discriminant analysis as being of hatchery origin. This error may have caused us to overestimate the percentage of hatchery fish in spawning areas before 1995. At the present we have no technique for evaluating assumption 3.

From 1986 to 1994, the percentage of the carcasses that were of hatchery origin in tributaries targeted for supplementation with smolts or adults (Catherine Creek and Lostine and Grande Ronde rivers) generally ranged from about 20 to 80 %. Tributaries not targeted for supplementation (Hurricane Creek, and Minam and Wenaha rivers) had similar ranges but did not exhibit the higher percentages as frequently. After 1994, our estimates of the percentages of hatchery fish generally decreased. This was attributable, in large part, to interception and removal of hatchery fish at Lower Granite Dam, estimated to be as great as 90% effective. However, concomitant with this procedure, after 1994 we relied solely on fin clips to determine origin, rather than using discriminant analysis to identify hatchery fish (because we marked 100% of 1990 and later broods). Therefore, using fin clips may have reduced potential overestimation of the percentage of hatchery fish which could occur when relying mainly on discriminant analysis to identify unmarked hatchery fish.

Early Life History Study of Naturally-Produced Spring Chinook Salmon in the Grande Ronde River Basin

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We have documented two general life history strategies utilized by juvenile spring chinook salmon in the Grande Ronde River basin: (1) juveniles migrate downstream out of summer rearing areas in the fall, overwinter in river valley habitats, and begin their seaward migration in the spring, and (2) juveniles remain in summer rearing areas through the winter and begin seaward migration in the spring. Although the migration patterns were similar for all populations, the proportion of fish exhibiting a fall migration was reduced for the upper Grande Ronde River population compared to both Catherine Creek and the Lostine River populations. Data from PIT tag detections at traps and mainstem dams, has shown that fish that overwintered in valley habitats leave as smolts and arrive at Lower Granite Dam earlier than fish that overwinter upstream. Furthermore, fall migrant fish that overwinter in valley habitats, have been detected at the dams at consistently higher rates than fish that overwintered upstream. Abundance estimates ranged from 70 (MY 96-97) to 32,567 (MY 94-95) for the upper Grande Ronde, 4,316 (MY 96-97) to 18,780 (MY 94-95) for Catherine Creek, and 4,323 (MY 96-97) for the Lostine River populations. Recommendations to managers include protection and enhancement of valley habitats in the Grande Ronde River and Catherine Creek and priority restoration and protection of rearing habitat in the upper Grande Ronde River where a majority of juvenile chinook produced from the upper Grande Ronde River population spend their freshwater residency.

Innovative Hatchery Spawning Strategies for Threatened Salmonids

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Choosing an appropriate spawning protocol is an important aspect of any fish culture program. Traditionally, spawning protocols were developed to select for specific traits or for convenience. However, as many programs move toward management of natural populations, it is desirable to avoid artificial selection in the hatchery. The Oregon Department of Fish and Wildlife and the Nez Perce Tribe manage the Imnaha River stock of spring chinook, an endangered species, using a hatchery supplementation program. Key to our success is the ability to preserve the genetic variability of this population. Since genetic material is collected and combined during spawning, the choice of a spawning protocol can have tremendous effect on the genetic resources of a population.

Our primary goal is to maintain the genetic diversity of this unique population. Given this goal, a number of principles govern our spawning practices. The following principles and associated rationale are used to guide our program. We use all available broodstock over the course of the spawning season; none of the fish we collect are considered surplus. The Endangered Species Act mandates that all fish taken are done so with a purpose. We spawn at least 100 of each sex when possible. In theory, this is the number of successfully reproducing adults at which most rare gene combinations are maintained. We attempt to avoid artificial or intentional selection. Minimizing all types of selection lessens adaptation to hatchery conditions or domestication, which could interfere with a population's ability to reproduce in nature. We give each individual the opportunity to make an equal contribution to the next generation and no spawner is given an advantage over any other. This aids in maintaining genetic variability by avoiding giving any advantage to specific genotypes or phenotypes and preserving the frequency of various alleles. Finally, we avoid pooling milt from multiple males. Since there are large differences among the capabilities of males to fertilize females, pooling males removes the opportunity for each male to contribute equally to the next generation. Using our five guiding principles, an optimum spawning protocol can be determined for any combination of available spawners. In the case of northeast Oregon chinook, we are usually working with small broodstocks (under 100 of each sex) and unequal sex ratios. We compared the advantages and disadvantages of different spawning protocols and determined that a matrix protocol would provide the best result for our program.

A matrix protocol can be developed for any given broodstock population. For example, assume a broodstock population consists of 62 females and 87 males. We would spawn using the same matrix throughout the season as often as practical, adjusting the matrix minimally as necessary to use all spawners. Our sex ratio is approximately 2 **E** to 3 **G**, so we would select a 2 **E** x 3 **G** matrix. We would attempt to use this matrix as many times as possible, 28 times, leaving 6 females and 3 males to be spawned. Because of the time and effort required to spawn using large matrices, we prefer to limit our matrix to 1 **E** x 4 **G** or 4 **E**x 1 **G**. We would complete spawning our broodstock population with one 4 **E** x 2 **G** and one 2 **E** x 1**G** matrix. Minor adjustments would be needed if additional fish were collected or if mortalities occurred.

A matrix protocol allows us to utilize all available broodstock. Reproductive failure of one spawner does not result in the loss of all gametes from any other spawner. Also, use of this protocol increases the number of possible gene combinations derived from the same number of spawners versus one-by-one matings. A major advantage of using a matrix protocol is the promotion of equal parent contribution. For small broodstocks it is prudent to select the optimum spawning matrix at the onset of spawning by considering the number of available spawners and their sex ratio. The goal is to follow the same matrix throughout the season, adjusting only if necessary to use the ripe broodfish at each spawning event. This will ensure, for example, that the number of eggs paired with each male will have minimal deviation. Equal parent contribution lessens intentional selection. Sustainable populations of salmonids are more likely to endure if the genetic resources required for all present and future needs are retained and passed on. Our goal is to maintain the greatest possible number of these genetic resources. In response to this challenge, we have developed a practical method to spawn fish that also preserves genetic variability.

Opercle tags - a Brood Stock Management Tool for Tracking Individual Fish

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In 1995, we researched external tags for adult chinook salmon (*Oncorhynchus tshawytscha*). Tagging chinook salmon with individually numbered tags when they return to the hatchery can provide useful information on run timing in addition to providing opportunities for brood stock management initiatives such as selective breeding. Due to the low number of chinook salmon returning to Idaho, potential tags were first tested on rainbow trout.

We tested 11 external tags on rainbow trout in 1995. Tags were applied to fish for a period of two months and were rated based on ease of application, durability, loss rate, and effects to fish health. Of the tags tested, the operculum staple tag ranked highest.

Tags were applied to hatchery chinook in 1995. Tag loss on chinook was unexpectedly high. Initially, operculum staple tags performed well, but tag loss increased as the spawning season progressed. The primary reason for the tag loss was attributed to the rigidity of the plastic tags. In 1996 we modified the operculum staple tag by using a flexible material called TYVEK. Fewer tags were lost in 1996, however, tag loss was still unacceptable. Tag loss was attributed to handling and the continued deterioration of the salmon. Tag loss was higher on males than females because males were not killed after spawning. Tag loss was highest on 1-ocean males.

We are still searching for an external tag for adult salmon and would like your ideas. Tagging individual fish facilitates hatchery operations by tracking fish inventories, identifying stocks, tracking disease samples, and fish dispositions.

Comparison of Smolt-to-Adult Returns of Hatchery Yearling and Subyearling Fall Chinook

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Objectives:
- Compare smolt-to-adult returns (SAR) rates for Lyons Ferry Hatchery yearling and subyearling fall chinook released on-station or barged and released downstream of Ice Harbor Dam.
- Evaluate homing abilities and recovery distribution of treatment groups: 1) yearling/on-station release
  2) yearling/barged release
  3) subyearling/0n-station release
  4) subyearling/barged release

Methods: Treatment groups were reared similarly at Lyons Ferry Hatchery. All salmon in each treatment group were coded-wire tagged and all treatment groups were represented in releases each year after 1986 (Figure 1). Salmon released on-station were crowded in raceways and either pumped, or gravity released, to the river, or barged below Ice Harbor Dam and released. Recoveries were summarized from the Regional Mark Information System (PSMFC). We used a 2X2 factorial statistical design and recoveries were expanded by sample rate.

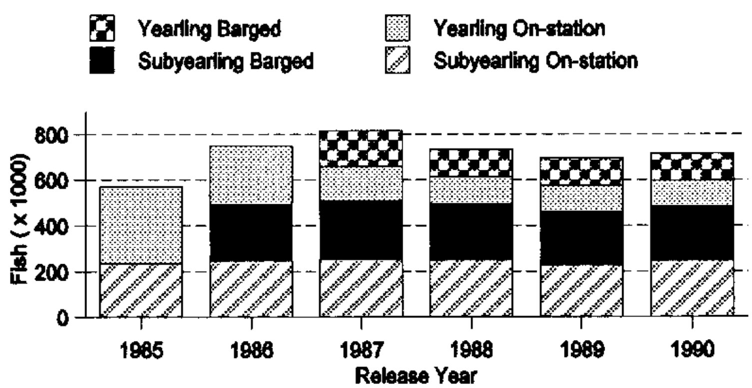

Figure 1. Salmon released by treatment group (age and location).

Results: Chinook salmon may have benefitted by barging below Ice Harbor Dam only during 1987 for subyearlings and 1989 for yearlings. Salmon released as yearlings were recovered at higher rates each year than subyearlings, regardless of release location or method (Figure 2) - but high annual variation existed for both groups. More barged salmon strayed than those released on-station, but stray rates were low (<2%). Subyearling releases showed a slightly higher proportion of recoveries in the Columbia Basin and along the north coast than yearlings (Figure 3).

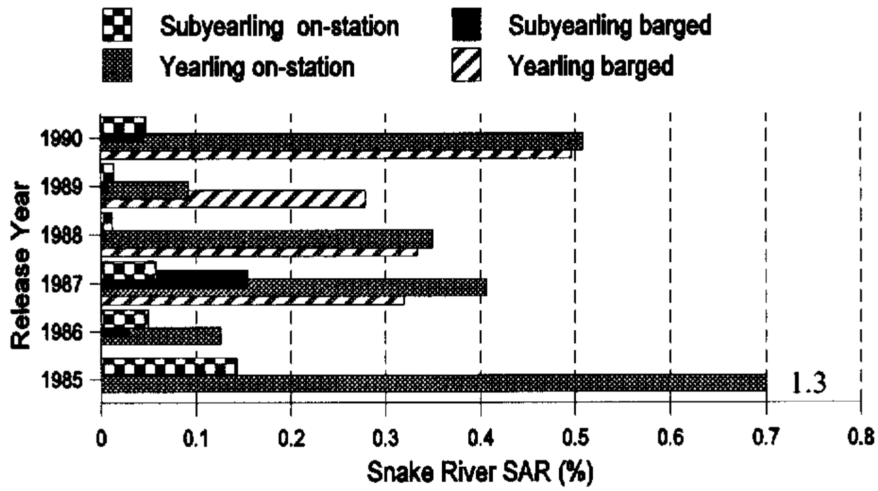

Figure 2. Smolt-to-adult return rates (%) to the Snake River.

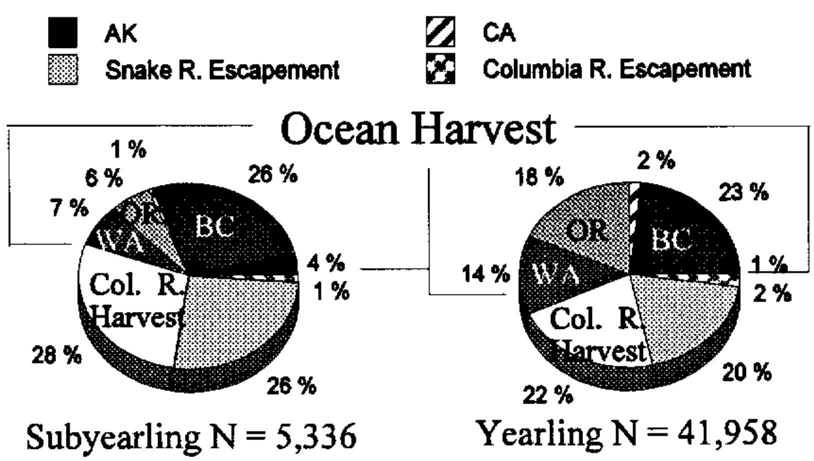

Figure 3. Harvest and escapement for yearlings and subyearlings.

Conclusions: The distance barged may not have been sufficient to generally affect adult return rates. Yearling releases may have three advantages over subyearling releases:

1) larger size at release (168 mm vs 88 mm FL)
2) higher main-stem flows in April/May vs low flow in June when subyearlings were released.
3) possible foraging advantage during migration

Therefore, releasing larger subyearlings in April or May could possibly increase survivals. Annual variation in recovery rates may be a reflection of variable survival rates down-river or in the ocean.

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Dam Count Discrepancies of Adult Fall Chinook in the Snake River in 1993

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Washington Department of Fish and Wildlife annually monitors returns of threatened fall chinook salmon to the Snake River. For several years, 30-50% of fall chinook over Ice Harbor Dam (IHR) could not be accounted for above Lower Granite Dam (LGR) based on redd counts. Fall chinook counts at IHR (RK 16.1) and LGR (RK 173.0) do not account for fallbacks or recrosses. Fall chinook counted at IHR are assumed to become Lyons Ferry Hatchery broodstock, spawn in the Tucannon or Palouse rivers, or cross LGR. In 1991 we began a radio telemetry study which continued through 1993 to address these issues. The following information was derived from work done in 1993 (Mendel et al. 1997).

We radio tagged 200 fall chinook at Charbonneau Park (RK 18.3) above IHR and another 20 fall chinook at the Lower Granite adult trap (RK 173.0). We monitored fish movements by vehicle, airplane, helicopter, and boat. There were also fixed site receivers at dams and along rivers.

Through our data analysis we determined that 37% (72 of 190) of the radio tagged fish that crossed IHR were not counted for at LGR. We discovered that radio tagged fall chinook moved extensively between dams often falling back and recrossing dams multiple times. For example, at IHR, 76 fish fell back a total of 81 times, while at LGR, 36 fish fell back a total of 41 times. Fallback at IHR accounted for 83.3% of the unaccounted for fish between IHR and LGR.

In relation to spawning escapement above IHR and LGR, we determined that fish counts at IHR over estimate the number of fall chinook available to spawn upstream of IHR by 64.3%. We also determined that fish counts at LGR over estimate the number of fall chinook available to spawn upstream of LGR by 31.4%.

In conclusion, most of the discrepancy between IHR and LGR fall chinook counts can be attributed to fallback at IHR. Fallbacks are occurring at all Snake River dams from IHR to LGR, contributing to over estimates of threatened fall chinook in the Snake River. Fish management entities need to consider these over estimates when determining management schemes regarding fall chinook in the Snake River.

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Monitoring and Evaluation of Yearling Snake River Fall Chinook Salmon Outplanted Upstream of Lower Granite Dam

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Supplementation of Lyons Ferry Hatchery fall chinook salmon (Snake River stock) began as yearling releases above Lower Granite Dam at the Pittsburg Landing Acclimation Facility in 1996, the Big Canyon Creek Facility on the Clearwater River in 1997, and Captain John Rapids Facility on the Snake River in 1998. Preliminary results of a cooperative monitoring and evaluation effort between the Nez Perce Tribe, U.S. Fish and Wildlife Service, and Washington Department of Fish and Wildlife are summarized. A representative sample of about 10,000 fish were PIT tagged out of approximately 150,000 fish released at each acclimation facility in 1997. Estimated survival of yearling fall chinook salmon smolts from release to Lower Granite Dam was 90-98% and 91-95% for Big Canyon and Pittsburg Landing, respectively. A total of 195 radio tags were gastric implanted in fish prior to release to monitor movement patterns and migration rates in the rivers and through Lower Granite Reservoir. Smolts traveled seven to eight times faster in the free-flowing river sections as compared to Lower Granite Reservoir, ranging between 109-159 km/d and 12-22 km/d, respectively. Future monitoring of smolt-to-adult survival will be important in determining the success of the yearling supplementation program upstream of Lower Granite Dam.

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Monitoring and Evaluation of Snake River Fall Chinook Salmon Supplementation Emphasizing Juvenile Survival

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This poster included preliminary findings from an ongoing study of juvenile fall chinook salmon early life history and survival. The study was founded on the premise that a thorough understanding of natural Snake River fall chinook salmon production is required for supplementation planning, monitoring, and evaluation. Natural subyearling chinook salmon were collected and PIT tagged from 1992 to 1997 in the Snake River and from 1993 to 1995 in the Clearwater River. Experimental releases of PIT-tagged Lyons Ferry Hatchery subyearling fall chinook salmon of three fork lengths (means = 71 mm, 85 mm, and 92 mm) were made at Pittsburg Landing on the Snake River in June, 1997 to compare to survival of supplementation releases of 156-mm Lyons Ferry Hatchery yearling fall chinook salmon released in April, 1997. Survival probability estimates from release to the tailrace of Lower Granite Dam were made using a release-recapture approach. The poster was arranged in a question and answer (Q&A) format. Q&A: Is the emergence timing of naturally produced fall chinook salmon fry related to smolt survival? Yes, date of fry emergence is significantly related to survival to the tail race of Lower Granite Dam with earlier emerging fry surviving better than later emerging fry. Q&A: Do any naturally produced fall chinook salmon migrate seaward as yearlings? Yes, a small percentage of fall chinook salmon residualize during summer then emigrate the following spring as yearlings. However, analyzing available data is a process complicated by race of subyearlings tagged, environmental factors, and shut-down of bypass facilities from December to April each year. Q&A: Is there a release strategy that could be adopted at Lyons Ferry Hatchery to increase the survival of subyearling smolts, thereby fostering a more natural emigration pattern in hatchery fish? In 1997, survival to the tailrace of Lower Granite Dam increased significantly as the fork length of Lyons Ferry Hatchery fall chinook salmon at release increased. The rate of change in survival decreased markedly between 92-mm subyearlings released in June and 156-mm yearlings released in April. Releasing large subyearling smolts early in the spring might be a step towards reducing the difference in smolt-to-adult returns between Lyons Ferry Hatchery subyearling and yearling fall chinook salmon smolts. The United States Fish and Wildlife Service Lower Snake River Compensation Plan provided initial funding for this study in 1991. Continued funding has been provided by the Bonneville Power Administration since 1991 (Project 9102900). Appreciation is extended to my cooperators at the Idaho Fishery Resource Office, University of Idaho, United States Geological Survey, National Marine Fisheries Service, Nez Perce Tribe, and Washington Department of Fish and Wildlife.

Use of radio-telemetry to determine the spawning distribution of fall chinook salmon released as yearlings upstream of Lower Granite Dam

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In 1996, we began a 5-year study designed to document the spawning distribution of fall chinook salmon released as yearlings upstream of Lower Granite Dam, and determine if there is a difference in spawning location for fish released at three release sites: (1) in the Snake River at Pittsburg Landing, 1996-1998; (2) in the Clearwater River near Big Canyon Creek, 1997-1998; and (3) in the Snake River between the Grande Ronde River and Asotin, 1998. Our approach is to radio-tag returning adult fish at Lower Granite Dam, and track each fish to its spawning location using fixed telemetry receivers (operated by the USFWS/BRD, and UI), and mobile surveys using fixed-wing aircraft (conducted by NPT), boats (USFWS), automobiles (WDFW), and helicopter (USFWS, NPT, IPC). To test this approach, and collect information on the migration patterns of one-ocean fish (jacks), NMFS radio-tagged 16 fall chinook salmon returning from the first release upstream of Lower Granite Dam (Pittsburg Landing in 1996) in 1997 using radio tags provided by UI. Based on a cursory analysis of the data we collected, the tracking system worked as designed. Fish were detected as they passed each of four newly installed fixed telemetry receivers, and mobile tracking was used determine exact locations of radio-tagged fish. Based on the current release schedule, and projected return rates, we will obtain enough data to determine if there is a statistically significant difference in spawning distribution between fish released at the three release sites in 2001. This determination is critical for assessing the current release strategy, which was designed to distribute spawning in specific river reaches. In the process of our work we will also collect needed information on the spawning distribution of fish released as subyearlings, and natural fish, and document redd distribution in the Snake, Grande Ronde, and Imnaha rivers.

Integrated Management of Bacterial Kidney Disease at IDFG Lower Snake River Compensation Fish Hatcheries

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IDFG's program to limit BKD prevalence includes:

1. Intraperitoneal injection of erythromycin (20 mg/kg body weight)
2. Iodophor disinfection of eggs.
3. 100 % elisa testing of female brood stock.
4. Elisa-based segregation to limit horizontal transmission
5. Prophylactic feeding of erythromycin medicated feed
6. Segregated release of smolts.

Conclusion

Idaho Department of Fish and Game operated LSRCP hatcheries have the capability to control bacterial kidney disease. This capability also limits horizontal transmission of *Renibacterium* to healthy hatchery fish and probably wild fish as well, thus enhancing the chances of smolt survival and adult returns. There has not been an epizootic of BKD in low BKD segregation groups in any LSRCP or Idaho Power chinook hatchery since 1993.

In 1993 IDFG implemented 100 % ELISA sampling of chinook brood

Historical BKD incidence data for McCall Hatchery

	Brood	Juvenile	Preliberation
BY'87	44/187	37/288	28/60
BY'88	27/236	4/181	0/60
BY'89	4/60	0/131	0/60
BY'90	0/60	0/100	13/60
BY'91	19/60	0/50	0/60
BY'92	7/60	15/44	3/60
BY'93	136/515	1/89	0/20
BY'94	22/141	0/44	0/20
BY'95	37/58	0/40	0/40
BY'96	1/12	0/30	------

BY'87: Adult injections only.
BY'88 through BY'92: Adult injections and 2X prophylactic erythromycin medicated feedings
BY'93 to present: Adult injections, 2X erythromycin medicated feedings and segregated rearing or culling.

Historical BKD prevalence data for Rapid River Hatchery

	Brood	Juveniles	Preliberation
BY'87	---------	27/174	24/120
BY'88	24/60	24/106	0/60
BY'89	18/60	0/112	0/60
BY'90	31/60	0/101	3/60
BY'91	10/60	0/32	18/180
BY'92	132/232	0/72	5/60
BY'93	685/1590 1/95	0/20	
BY'94	57/120	0/68	0/20
BY'95	32/36	0/65	0/20
BY'96	288/327	0/20	------

BY'87: Adult injections only.
BY'88 Through BY'92: Adult injections plus 2X prophylactic erythromycin medicated feedings.
BY'93 to present: Adult injections, 2X prophylactic medicated feedings and segregated rearing or culling.

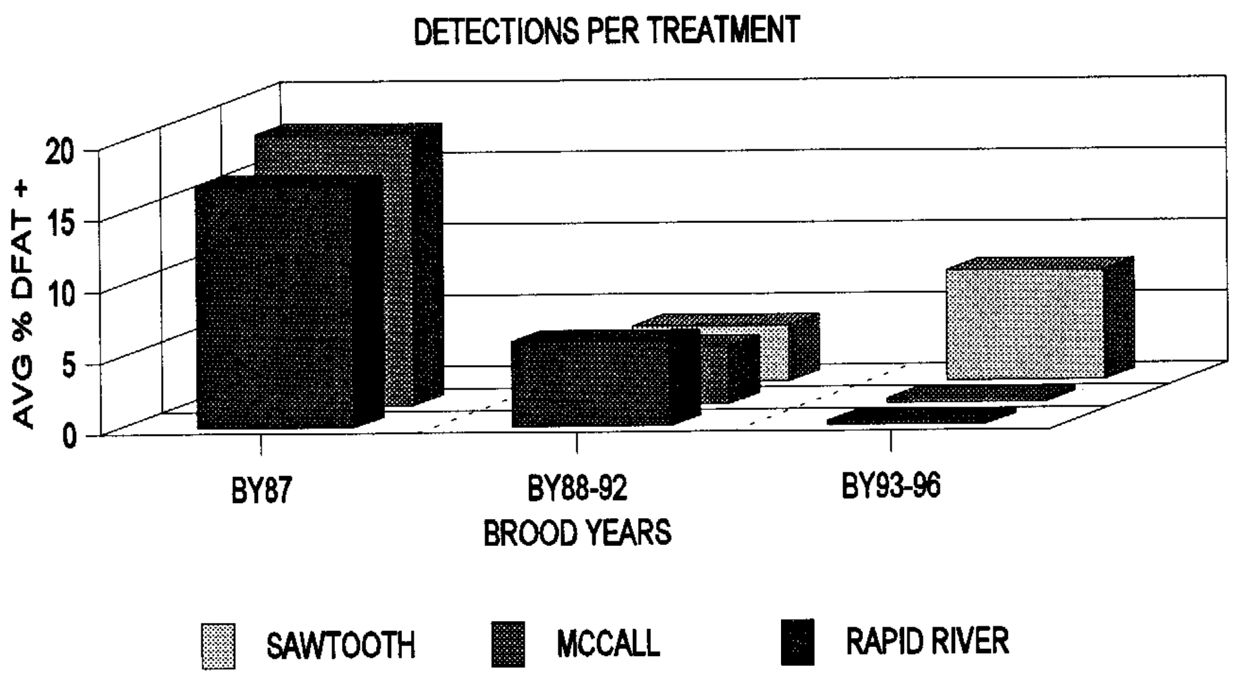
Historical data for Sawtooth Hatchery

	Brood	Juveniles	Preliberation
BY'89	2/5	4/235	0/80
BY'90	119/497	28/154	3/120
BY'91	63/203	2/117	0/80
BY'92	95/272	1/142	0/55
BY'93	35/89	20/90*	3/40*
BY'94	9/12	0/35	0/40
BY'95	3/5	0/13	0/80
BY'96	9/15	------	------

* These DFAT positives represent the last epizootic of BKD in IDFG hatchery production fish. IDFG has had only two epizootics in high bkd segregation groups.
BY'87 and BY'88: No data.
BY'89 to BY'92: Adult injections and 2X prophylactic erythromycin medicated feedings.
BY'93 to present: Adult injections, 2X medicated feedings and segregated rearing or culling.

Prior to 1993 all results were via direct fluorescent antibody (DFAT) technology. Brood testing results from 1993 to 1996 were elisa optical densities, while juvenile and preliberation testing continued to use DFAT.

DFAT DETECTION OF RENIBACTERIUM



BY87 ERY INJECTION ONLY
BY88-92 INJECTION + 2 ERY FEEDINGS
BY93-96 INJECTION + FEEDINGS + SEGREGATION

Oregon Department of Fish and Wildlife Fish Health Program

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The Oregon Department of Fish and Wildlife La Grande Fish Pathology Laboratory serves fish health needs for Lower Snake River Compensation Plan programs and facilities in northeastern Oregon including: 1) Lookingglass Hatchery spring chinook salmon conventional mitigation, 2) Lookingglass Creek spring chinook salmon natural production, 3) Grande Ronde River basin spring chinook salmon captive broodstock supplementation, 4) Grande Ronde River basin endemic broodstock supplementation, 5) Imnaha river spring chinook salmon and summer steelhead supplementation, and 6) Wallowa River summer steelhead conventional mitigation. The spring chinook salmon supplementation programs for the Grande Ronde River basin and the Imnaha River are three separate Endangered Species Act (ESA) programs.

Fish health activities for these programs include: 1) conducting monthly and preliberation examinations of juvenile fish; 2) conducting annual inspections of broodstock; 3) providing on-call diagnostic services; 4) making recommendations for prophylactic and therapeutic treatments; 5) conducting examinations of fish from the natural environment; 6) identifying fish culture, fisheries or human activities which jeopardize fish health; 7) conducting research projects that target problems or needs that arise; 8) providing services and support to other projects and investigations; 9) providing fisheries managers with relevant scientific data; and 10) developing and implementing fish health management protocols for the ESA programs.

Several important salmonid pathogens have been identified in spring chinook salmon and steelhead during fish health monitoring and disease outbreak investigations. Infectious hematopoietic necrosis (IHN) virus is enzootic in both species in the Grande Ronde and Imnaha river basins. An epizootic of IHN occurred in the Imnaha stock of spring chinook salmon smolts at Lookingglass Hatchery during the spring of 1995. *Renibacterium salmoninarum,* the agent of bacterial kidney disease (BKD), is also present in populations of spring chinook salmon in the Imnaha and Grande Ronde river basins. The frequency of detection of *R. salmoninarum* among both adult and juvenile spring chinook salmon has increased in recent years. An epizootic of BKD occurred in the Rapid River stock of spring chinook salmon at Lookingglass Hatchery over most of the rearing cycle of the 96 brood year fish during 1997-98. *Aeromonas salmonicida,* the bacterial agent of furunculosis, has also been more frequently isolated from adult spring chinook salmon in the past two years. The enteric redmouth bacterium, *Yersinia ruckeri,* has often been isolated from adult and juvenile spring chinook salmon since 1990. Other agents detected and of concern are *Flavobacterium psychrophilus* (bacterial cold water disease), erythrocytic inclusion body syndrome (EIBS) virus, *Saprolegnia* (fungus), and *Myxobolus cerebralis* (the whirling disease parastie). A condition of unknown etiology, referred to as headburn, was prevalent on adult spring chinook salmon in 1996 and 1997.

The presence of a variety of serious pathogens among populations of fish in the diverse programs in northeastern Oregon poses a continual challenge. Disease prevention is a critical strategy for allowing the needs of programs to move forward and for protecting the sensitive species and stocks involved.