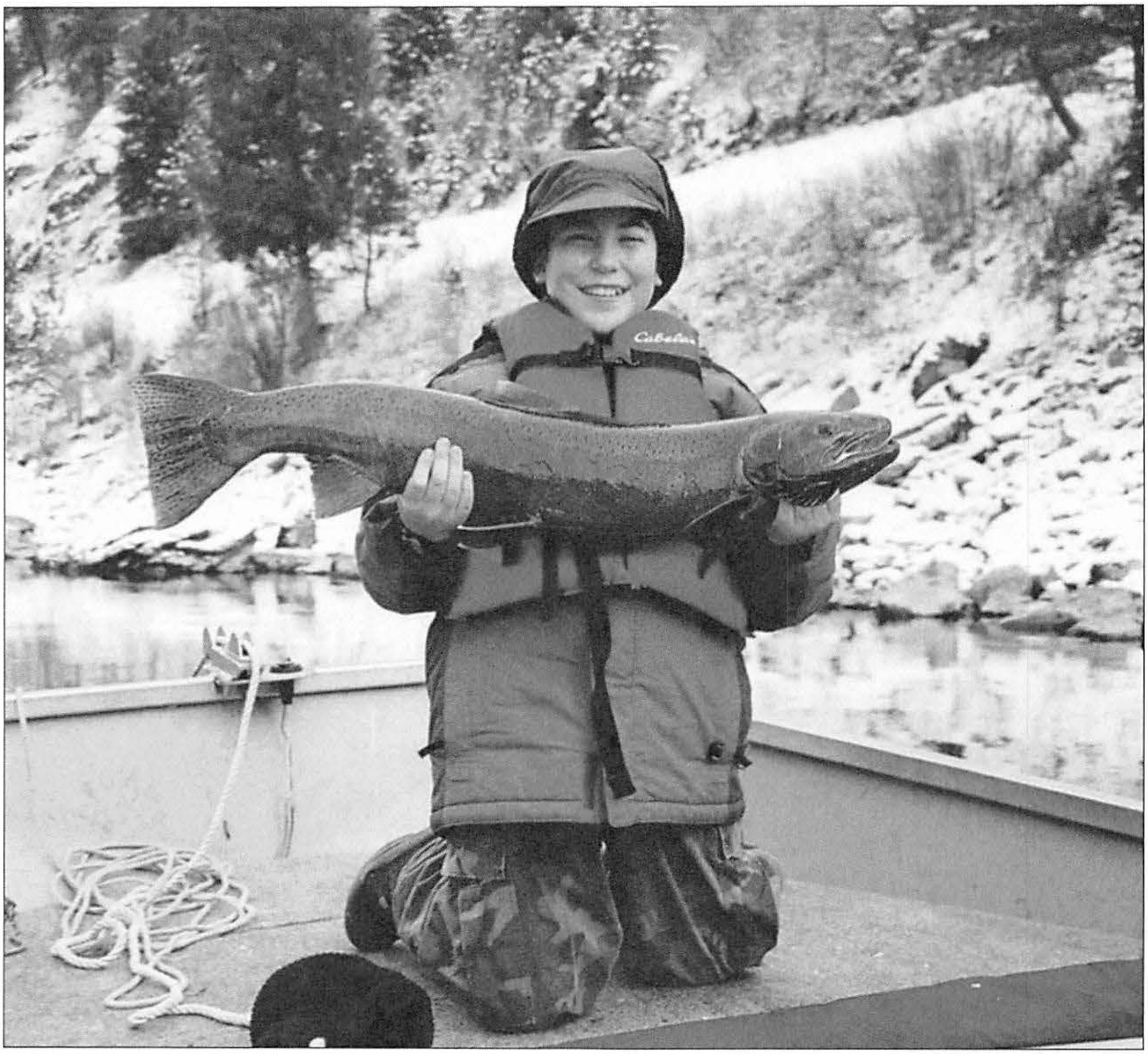
Summer Steelhead Program Review

Lower Snake River Compensation Plan
June 20, 21, 2012
Clarkston, WA



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A Brief History of the Lower Snake River Compensation Plan Hatchery Program for Steelhead

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Abstract

The Lower Snake River Compensation Plan (LSRCP) hatchery program for anadromous fish was designed to replace lost adult salmon & steelhead caused as a consequence of construction and operation of four hydroelectric dams on the Lower Snake River in Washington. For steelhead, an adult return goal back to the project area, post-harvest below the project area of 55,100 was established. It was anticipated that after the hatcheries were built and achieved full production that some 37,000 adults would be caught in commercial fisheries and 73,200 in recreational fisheries below the project area and this would generate 130,000 days of recreational fishing. Other than assuming that enough broodstock would return to the hatcheries to perpetuate further generations, no other beneficial use for retuning adults was identified in the plan. Congress authorized the U.S. Army Corps of Engineers to build five hatcheries in 1976 capable of producing 11 million smolts. The hatcheries were distributed in the Snake River Basin to reflect a desire to mitigate for the estimated losses "in kind and in place". Construction of the first steelhead facility was completed in 1983 and the last facility was completed in 1991. Since the program was authorized three factors have impacted the LSRCP program. First, the smolt to adult survival rate has been less than expected. Second, Snake River steelhead were listed as threatened under the Endangered Species Act. The need to reduce harvest rates in mainstem fisheries to protect natural-origin fish resulted in a much higher proportion of the annual runs to escape mainstem fisheries and return to the project area than expected at the time the program was authorized. Third, states and tribes through the U.S. v. Oregon court stipulated Fishery Management Plan have established specific hatchery production agreements between the states, tribes and federal government. This agreement has substantially diversified the steelhead hatchery program by adding new off station releases sites and stocks designed to meet short term conservation objectives. The presentations by the LSRCP cooperators over the next two days will review the successes and challenges we have faced to implement the LSRCP steelhead program.

Introduction[1]

The Lower Snake River Compensation Plan (LSRCP) for anadromous fish was designed to replace lost adult salmon & steelhead caused as a consequence of construction and operation of four hydroelectric dams on the Lower Snake River in Washington. Specifically the plan is to

> *"..... provide the number of salmon and steelhead trout needed in the Snake River system to help maintain commercial and sport fisheries for anadromous species on a sustaining basis in the Columbia River system and Pacific Ocean" (NMFS & BSF&W 1972 pg. 14).*

The LSRCP was authorized by the Water Resources Development Act of 1976, Public Law 94-587. The Act implementing the LSRCP simply states;

[1] This paper draws liberally from a history written on the LSRCP program by Herrig in 1990.

"...Fish and Wildlife Compensation Plan for the Lower Snake River, Washington and Idaho, substantially in accordance with a report on file with the Chief of Engineers, at an estimated cost of $58,400,000."

The "report on file with the Chief of Engineers" referred to in the Act is the Special Report, Lower Snake River Fish and Wildlife Compensation Plan, Lower Snake River, Washington and Idaho, June 1975 (US Army Corps of Engineers 1975 (COE)).

The four lower Snake River projects (dams, power plants, and locks) were authorized by P.L. 74, 79th Congress, in March 1945, but no funds for construction were authorized. Congressional authorization absent funding set up a major political battle in the Northwest between those advocating for construction and those opposed. A history of this political battle can be found in (Petersen and Reed 1994 and Petersen 1995). Highlights of the struggle included:

- In 1950 the COE requested $2 million for funding construction of Ice Harbor Dam. The request was denied because of concerns over fish, runaway government spending, the cost in relation to other options for generating power, and the proposition that such new projects should be undertaken by a consortium of government and private capital.
- In 1953 President Truman requested $5 million for construction in his final year as president, but after newly elected President Eisenhower was inaugurated he cut the funding stating that there would be "no new starts on dams". He cited a need to curb federal spending and cost share with states and private enterprise for his decision to eliminating funding in the project.
- The deadlock over construction was broken in 1955 when Senator Warren Magnuson of Washington "slipped" $1.0 million into an omnibus spending bill for construction, and once construction had started, there was no stopping future appropriations.

The four dam & locks projects took almost 20 years to complete. The lower-most dam, Ice Harbor, was completed in 1961; moving upstream, Lower Monumental was completed in 1969, Little Goose was completed in 1970 and Lower Granite was completed in 1975. Each dam is approximately 100 feet high. These dams create a total of approximately 140 miles of reservoir from about 10 miles above the mouth of the Snake River to its confluence with the Clearwater River. The series of locks allow for barge traffic to travel inland to Lewiston, Idaho.

In 1959, four years after the initial appropriation for construction of Ice Harbor Dam & Locks, the U.S. Fish and Wildlife Service (Service) started to evaluate the impact of these hydroelectric projects on fish and wildlife resources. The limited engineering and biological data available at the time resulted in the Service making only general recommendations regarding fish passage and artificial propagation. In 1966, some seven years into developing recommendations on a by-project basis the COE District Engineer in Walla Walla requested that the Service produce a single report, rather than four separate reports, that would cover all the Lower Snake River projects, including the yet to be constructed Lower Granite Dam and Locks.

Over the next 6 years, the Service, National Marine Fisheries Service (NMFS) and the state wildlife agencies of Oregon, Washington, and Idaho collaborated to evaluate the effects of the four projects. A final Fish and Wildlife Coordination Act Report was produced by the NMFS and the Service in September 1972 and submitted to the COE.

The COE questioned several of 1972 report's findings and it was not until 1975 that these issues were resolved and the COE submitted its final report to Congress. By September 1976 the COE had finalized an Environmental Impact Assessment of the LSRCP and in that year Congress authorized the COE to design and construct the LSRCP "substantially in accordance" with their June 1975 Special Report.

LSRCP Goal

Specific mitigation goals for the LSRCP were established in a three step process. First the adult escapement that occurred prior to construction of the four dams was estimated. Second an estimate was made of the reduction in adult escapement (loss) caused by construction and operation of the dams (e.g. direct mortality of smolt). Last, a catch to escapement ratio was used to estimate the future production that was forgone in commercial and recreational fisheries as result of the reduced spawning escapement and habitat loss. Assuming that the fisheries below the project area would continue to be prosecuted into the future as they had in the past, LSRCP adult return goals were expressed in terms of the adult escapement back to, or above the project area. Other than recognizing that the escapements back to the project area would be used for hatchery broodstock, no other specific priorities or goals were established in the enabling legislation or supporting documents regarding how these fish might be used.

For steelhead, the escapement above Lower Granite Dam prior to construction of these dams was estimated at 114,800. . Based on a 15% mortality rate for smolts transiting each of the four dams (48% total mortality), the expected reduction in adults subsequently returning to the area above Lower Granite Dam was 55,100. This number established the LSRCP escapement mitigation goal back to the project area. This reduction in natural spawning escapement was estimated to result in a reduction in the coast wide commercial/tribal harvest of 37,000, and a reduction in the recreational fishery harvest of 73,200 below the project area. In summary the total number of adults that was expected to be produced was 165,300.

Component	Number of Adults
Escapement above Lower Granite Dam	55,100
Commercial Harvest (below project area)	37,000
Recreational Harvest (below project area)	73,200
Total	165,300

Hatchery Development Plan

Historical distribution and abundance data were used by a hatchery subcommittee of the Columbia Basin Fisheries Technical Committee to recommend release sites for the future hatcheries (Tollefson, 1974). Table 1 outlines the recommended distribution of returning LSRCP produced steelhead by state and river basin.

Once the adult return goals were established the subcommittee calculated the number of smolts that would have to be released to achieve the desired adult run size (Table 2). The model made assumptions about each life history stage of the fish, including eggs per female, survival of eggs to smolt, and survival of smolt to returning adult (after passing thru fisheries below the project area) (Table 3). The most important and difficult part was the smolt-to-returning adult rate, because this part is highly variable and subject to many uncontrollable natural factors.

Table 1. Recommended distribution of returning LSRCP produced adult steelhead

Drainage	Washington	Oregon	Idaho
Tucannon	1,632		
Snake River Lewiston to Hells Canyon Dam	2,208	1,368	1,368
Asotin Creek	816		
Clearwater River			20,736
Grande Ronde River		7,632	
Imnaha River		1,920	
Salmon River			16,896
Small tributaries		264	264
Total by State	4,656	11,184	39,264
Percent of Program	8.5%	20.3%	71.2%

Funding the LSRCP

The Special Report states that "...Operations and maintenance would be funded through future appropriations to the U.S. Fish and Wildlife Service or National Marine Fisheries Service." In 1977 an agreement was signed by the COE, NMFS, and the Service stating that the Service would budget for and administer the operation and maintenance of the LSRCP Program. When funding mitigation programs the COE must decide how to partition the flow of benefits of these dam & lock projects as a way to distribute cost. Electric power benefits were generally considered the largest benefit from COE dam projects in the Columbia Basin and the benefactors, the electric rate payers are required to pay that portion of the cost. Bonneville Power Administration (BPA) is the marketer of the generated power by these projects and was required to pay the share of costs commensurate with the benefits ascribed to power generation. Whatever benefits are ascribed to flood control, irrigation, transportation etc. are borne by Congress through annual appropriations to the COE. The Lower Snake River program is unique among mitigation programs in the Columbia basin because the COE determined that 100% of the benefits of these projects were for power generation. As such BPA pays all the costs.

From the LSRCP's beginning through FY 2001, the Service requested funding from Congress each year through the President's Budget Request to Congress. Congressional appropriations were reimbursed to the treasury at the end of each fiscal year by BPA as well as capitalized construct costs of the LSRCP facilities. When the Service and BPA signed a direct funding agreement in July 2001 a new business oriented atmosphere developed that allows the Service and BPA to work in a business oriented manner to meet short and long term mitigation responsibilities.

Table 2. Smolt production goals (in pounds) for the five LSRCP hatcheries that rear steelhead and dates of completion.

Primary Rearing Hatchery (Operator)	Pounds of smolt	Associated Facilities	Date of Completion
Irrigon	279.600		October 1985
		Wallowa	May 1985
		Big Canyon	August 1987
		Little Sheep Cr	August 1987
Lyons Ferry (WDFW)	116,400		November 1983
		Tucannon Hatchery	November 1984
		Dayton Pond	October 1986
		Cottonwood	February 1985
		Curl Lake	February 1985
Hagerman National (FWS)	340,000		April 1984
		E.Fk. Salmon R.	November 1983
		Sawtooth Hatchery	January 1985
Magic Valley (IDFG)	291,500		August 1987
Clearwater (IDFG)	350,000		December 1991
		Red River	November 1986
		Crooked River	May 1990

FWS, U.S. Fish and Wildlife Service; ; IDFG, Idaho Department of Fish and Game; ODFW, Oregon Department of Fish and Wildlife ; WDFW, Washington Department of Fish and Wildlife

Table 3. The estimated hatchery production necessary to return the required number of adult steelhead to meet LSRCP escapement goals, post harvest below project area (COE, 1975).

Adult loss level for basing hatchery size rounded)	
Estimated smolt to adult survival rate back to Lower Granite Dam after harvest below project area	0.50
Estimated number of smolts that would have to be produced	11,020,000
Target size of smolts in fish per pound	8
Target number of pounds of smolts to be produced	1,377,500
Estimated percent survival from eggs to smolt	65%
Estimated number of eggs needed	16,950,000
Estimated number of females needed for broodstock	3,390

Important Changes since the LSRCP was Authorized

Since 1976 when the LSRCP was authorized, many of the parameters and assumptions used to size the hatchery program and estimate the magnitude and flow of benefits have changed. These changes will become evident as during the presentations by our cooperators.

- The smolt to adult survival rate has in many years been less than expected and this has resulted in fewer adults retuning than planned.
- The listing of spring Snake River steelhead under the Endangered Species Act has resulted in significant curtailment of commercial, recreational and tribal fisheries throughout the mainstem Columbia River. This has resulted in a higher percentage of the annual run returning to the project area than was expected.
- States and tribes through the U.S. v. Oregon court stipulated Fishery Management Plan have established specific hatchery production agreements. This agreement has substantially diversified the steelhead hatchery program by adding new off station releases sites and stocks designed to meet short term conservation objectives, in partnership with the Northwest Power and Conservation Council' Fish and Wildlife program.

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LSRCP Steelhead Hatchery Mitigation Program Salmon River, Idaho

Brian Leth and Carl Stiefel, IDFG

This report describes the steelhead hatchery mitigation program in the Salmon River, Idaho that is part of the Lower Snake River Compensation Program (LSRCP). Information includes: a description of Idaho Department of Fish and Game (IDFG) management objectives, description and status of natural populations, background and history of the hatchery program, description of how successful the hatchery program has been in achieving objectives, and a description of the current and future management focus. While not part of this program review, the hatchery steelhead mitigation program for the Hells Canyon hydroelectric complex funded by the Idaho Power Company (IPC) is introduced to provide context and scope for the entire steelhead hatchery mitigation effort within the Salmon River drainage.

Management Objectives and Framework for the Salmon River

The Salmon River is one of the largest tributaries in the Snake River and encompasses approximately 14,100 square miles along its 425 mile route and 7,000 ft. elevation change between the mouth and headwaters. Major tributaries of the Salmon River include the East Fork, Pahsimeroi, Lemhi, North Fork, Middle Fork, South Fork, and Little Salmon rivers (Figure 1). The Salmon River and its tributaries once supported robust wild populations of steelhead. In 1974, fisheries targeting wild steelhead in the Salmon River were terminated due to dwindling returns of wild steelhead. In 1997, the Snake River steelhead DPS was listed as threatened under the ESA.

The Idaho Department of Fish and Game (IDFG) statewide management objectives include restoring and maintaining natural populations of steelhead in the Salmon River. Objectives for the hatchery steelhead program are to meet the LSRCP adult mitigation objectives, to restore and maintain recreational and tribal steelhead fisheries, to minimize impacts of the hatchery program on natural populations, and to evaluate the use of hatchery supplementation as a tool to aid in the recovery of natural populations. The primary objective of the steelhead hatchery program is to meet harvest mitigation objectives. As such, the hatchery program is managed as a segregated program intended to maximize smolt to adult survival rates while at the same time minimize interaction with natural populations.

The IDFG management framework for steelhead includes confining the release of hatchery production to areas it is likely to have the least impact on natural populations. Within the Salmon River sub-basin, hatchery releases of summer steelhead are confined to sections of the Salmon River upstream of North Fork Salmon River (upper Salmon River) and to the Little Salmon River (Figure 2). There are no hatchery releases in the North Fork Salmon, Middle Fork Salmon, South Fork Salmon, and mainstem Salmon River downstream of the North Fork Salmon River. IDFG managers have maintained this strategy throughout the history of the hatchery program. Approximately one half of the LSRCP steelhead mitigation for the entire Snake River and approximately 70% of the Hells Canyon hatchery mitigation occurs within the Salmon River drainage. Managers realize that with a hatchery program this large it is impossible to completely isolate hatchery steelhead from natural populations in areas adjacent to hatchery release sites. Given these conditions, managers have chosen to operate the hatchery program in locations selected to minimize impacts to natural populations. The Little Salmon River, a tributary to the Salmon River near the town of Riggins, ID, is an example of a terminal area hatchery release site that provides good angler accessibility to adult returns. The upper Salmon River (upstream of North Fork Salmon River) receives the remaining LSRCP hatchery smolt releases (Figure2). Little information is available regarding the historic abundance of wild steelhead in the upper Salmon River but based on elevation and habitat characteristic, it is likely that the upper Salmon River never supported large populations of wild steelhead. The upper Salmon River provides excellent angler access and fishing opportunity from October through April.

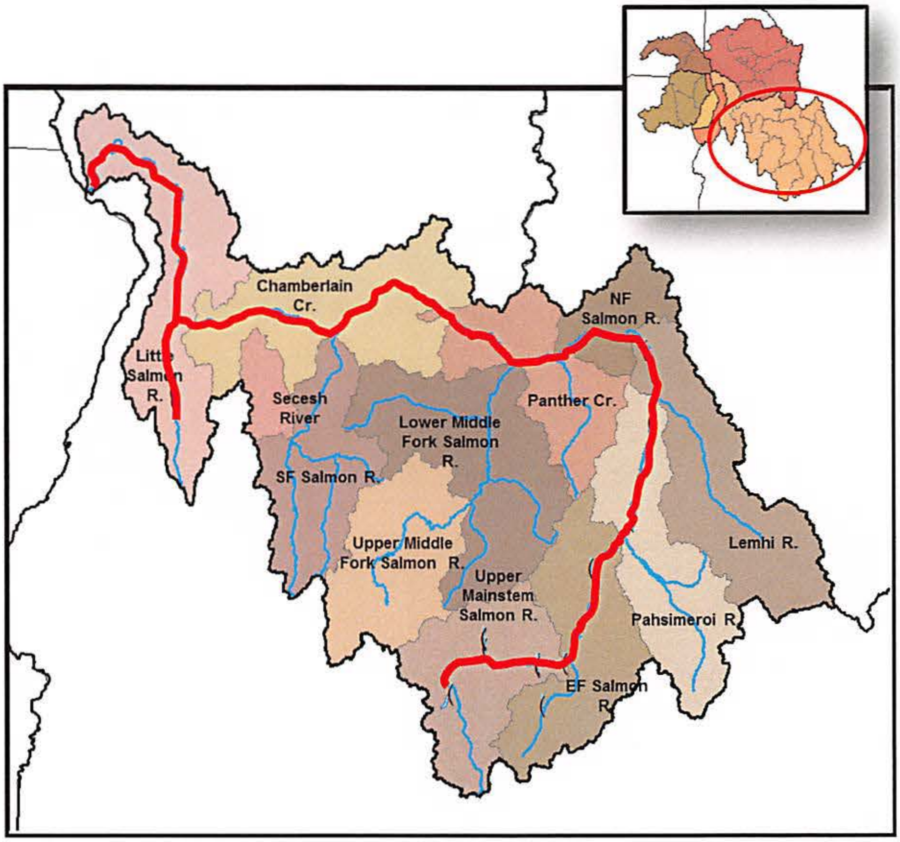

Figure 1. Map of the Salmon River steelhead Major Population Group (MPG) and twelve independent populations and major tributaries.

Status of Natural Populations

Steelhead in the Salmon River basin have been classified into twelve demographically independent populations (Figure 1) (ICTRT 2003). Currently, all twelve populations of steelhead in the Salmon River Major Population Group (MPG) fail to meet the viability criteria established by the Interior Columbia Technical Recovery Team (ICTRT). All populations are currently classified at moderate to high risk for abundance and productivity measures. This is partially due to the lack of population specific abundance and productivity data. The twelve populations are rated at low to moderate risk for spatial structure and diversity measures. While population specific abundance and productivity data is currently lacking, managers are focusing effort to estimate these parameters though the use of genetic analysis and PIT tagging technologies.

Mitigation Goals and Hatchery Program Background

The LSRCP steelhead hatchery mitigation program was established to provide in-kind and in-place mitigation for lost harvest opportunity resulting from the construction and operation of the four lower Snake River hydroelectric dams. Total mitigation expected for the LSRCP is 165,300 adults to be produced annually. This is based on an assumed 2:1 ratio of catch (downstream of project area; Lower Granite Dam) to escapement (upstream of the project area) (Corps of Engineers, 1975). During the program development, it was anticipated that the majority of the harvest mitigation benefits would be distributed downstream of the project area. However, less than expected returns of hatchery fish produced within the program and the depressed status of natural-origin fish influenced Columbia River fisheries management programs. The anticipated 2:1 distribution of harvest benefits downstream: upstream of Lower Granite Dam has not been realized. Regardless of the actual distribution of harvest benefits, it was anticipated that the Salmon River steelhead hatchery program would contribute 75,780 (46% of total) adults annually towards the total LSRCP mitigation goal (Table 1). To achieve the adult goals, smolt to adult survival rates (SARs) were modeled and used to size the hatchery facilities.

For the LSRCP hatchery program operated within the Salmon River drainage, two primary hatchery facilities are operated; Magic Valley Fish Hatchery (MVFH) and Hagerman National Fish Hatchery (HNFH). Smolt to adult survival rates (SARs) used to size the program specified the need for a release of approximately 3.45 million smolts to produce 75,780 adults annually. Currently, 2.9 million smolts are released in the Salmon River. A reduction in spring flows at both MVFH and HNFH currently limits the smolt production. Managers are exploring options to mitigate for the loss of spring water to bring the facilities back to the original production capacity specification

While not part of this hatchery review, another hatchery mitigation program is also operated within the Salmon River and is funded by the Idaho Power Company (IPC). This program is operated to mitigate for the loss of anadromous steelhead resulting from the construction and operation of the Hells Canyon hydroelectric complex (Brownlee, Oxbow, and Hells Canyon dams) on the Snake River. In addition to the 2.9 million smolts released as part of the LSRCP program, 1.275 million smolts from the Hells Canyon mitigation are also released within the Salmon River basin for a total of 4.175 million smolts (Table 1).

Hatchery Steelhead Broodstock History in the Salmon River

Hatchery steelhead broodstocks used in the Salmon River include both A-run and B-run stocks. These run type designations were originally established by managers of fisheries in the Columbia River to manage stock groups in two modes of a bimodal temporal distribution of migrating adult summer steelhead but for the purpose of this report, the A-run and B-run designations are used to describe the predominant life history exhibited by each stock. Stocks that are referred to as A-Run return predominantly as one-ocean adults and those referred to as B-run return predominantly as larger two–ocean adults. Both life history types occur naturally in the Salmon River. Since the beginning of steelhead hatchery program in the Salmon River, managers have desired to maintain both run types for the harvest mitigation program.

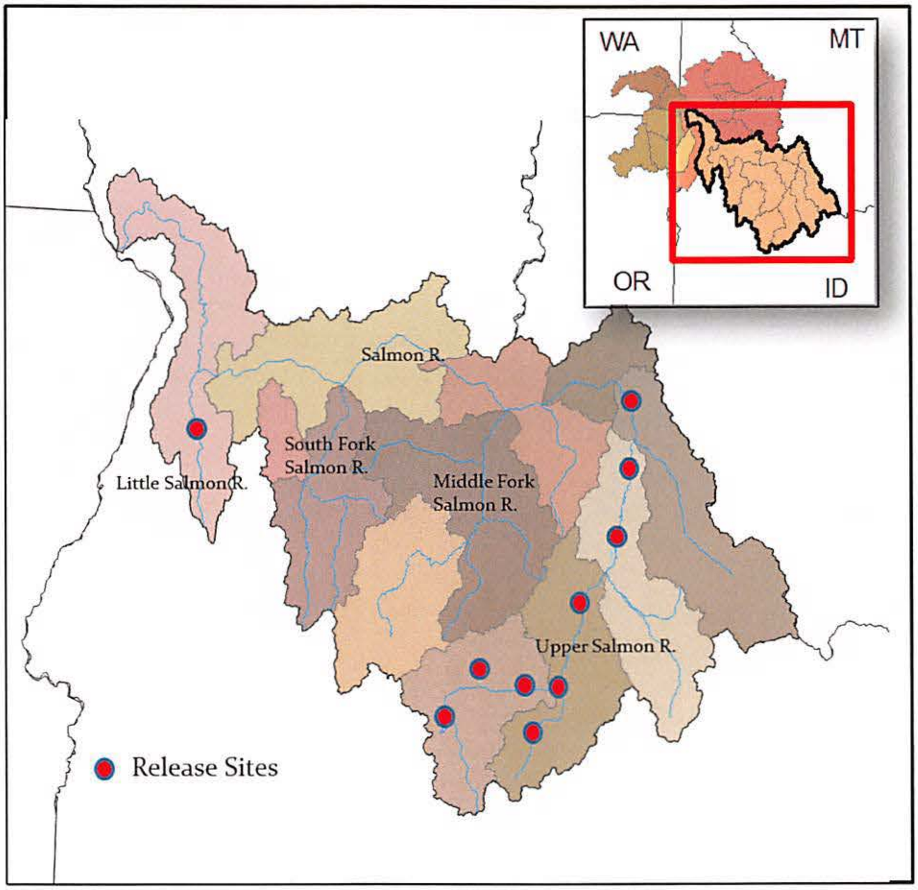

Figure 2. Release Sites for hatchery steelhead that are part of the LSRCP hatchery mitigation program.

Table 1. Mitigation goals and smolt releases for the LSRCP hatchery steelhead program in the Salmon River, ID.

	Magic Valley Fish Hatchery	Hagerman National Fish Hatchery	Total
Adult Goal- Project Area	11,660	13,600	25,260
Adult Goal- Downstream of Project Area	23,320	27,200	50,520
Total Adult Mitigation Goal	**34,980**	**40,800**	**75,780**
Smolt Release Target	1,749,000	1,700,000	3,449,000
Actual Smolts Released	**1,540,000**	**1,360,000**	**2,900,000**
IPC smolts Released in Salmon R			1,275,000
Total Steelhead Smolts Released in the Salmon River			**4,175,000**

A-Run Broodstock Development

Snake River steelhead trapped below Hells Canyon Dam were first transferred to the upper Salmon River at Pahsimeroi Fish Hatchery in 1966 as part of the Hells Canyon steelhead mitigation program funded by IPC. When the Sawtooth Fish Hatchery was constructed in 1985 as part of the LSRCP mitigation program, steelhead broodstock from Pahsimeroi Fish Hatchery were used to found the broodstock for this program. Since 2000, steelhead broodstock at Sawtooth Fish Hatchery has been sourced exclusively from adults returning to Sawtooth Fish Hatchery.

B-Run Broodstock Development

Broodstock from Dworshak National Fish Hatchery (DNFH) in the Clearwater River was first transferred to the Salmon River in 1973 at Pahsimeroi Fish Hatchery in an effort to develop a hatchery B-run program in the Salmon River. Later, the broodstock was moved to the E.F. Salmon River and more recently has been shifted to Squaw Creek in the upper Salmon River. Increased efforts are currently underway to expand the development of the locally adapted Salmon River B-run hatchery broodstock and phase out the use of DNFH broodstock in the Salmon River.

Description of the Hatchery Steelhead Program in the Salmon River

The hatchery steelhead program within the Salmon River basin is composed of four primary components (Table 2). Fish culture associated with this program includes several hatcheries at some part of the life stage but final rearing for all Salmon River smolt releases that are part of the LSRCP program occurs at Magic Valley Fish Hatchery (MVFH) and at Hagerman National Fish Hatchery (HNFH). Both of these hatchery facilities are located on the Snake River near the town of Hagerman, ID. Within the Salmon River, a combined 2.9 million smolts are released from HNFH and MVFH across the four hatchery components (Table 2). Additionally, 1.275 million smolts are released from Niagara Springs Fish Hatchery (NSFH) as part of the hatchery mitigation program funded by IPC. The following section provides background information for each of the four LSRCP funded hatchery components in the Salmon River.

Table 2. Hatchery steelhead smolt releases in the Salmon River that are part of the LSRCP and IPC hatchery mitigation programs.

Salmon River Hatchery Program Component	LSRCP Hatchery Steelhead Smolt Releases	IPC Hatchery Steelhead Smolt Releases	Total Release
Little Salmon R. A and B-Run	415,000	445,000	860,000
Upper Salmon R. A-Run	1,580,000	830,000	2,410,000
Upper Salmon River B-Run	735,000	0	735,000
East Fork Salmon R.	170,000	0	170,000
Total Release	**2,900,000**	**1,275,000**	**4,175,000**

Little Salmon River

The ICTRT defined Little Salmon River steelhead population includes the Little Salmon River, its tributaries, and the mainstem Salmon River and its tributaries downstream of the Little Salmon River to the mouth of the Salmon River (Figure 3). Production and productivity data for natural steelhead within the Little Salmon population is limited. An adult trap located on Rapid

River, a major tributary to the Little Salmon River, is operated as part of the IPC spring Chinook salmon hatchery program and is operated during the steelhead run to monitor natural steelhead escapement. All natural steelhead trapped in Rapid River are passed upstream to spawn naturally. No hatchery-origin steelhead are passed upstream of the trap. All hatchery releases (both LSRCP and IPC) within the Little Salmon population occur on the mainstem of the Little Salmon River upstream of the confluence with Rapid River (Figure 3).

Little Salmon River A-Run and B-Run Component

The hatchery steelhead program operated in the Little Salmon River is managed strictly for harvest mitigation. There is no adult trapping facility on the Little Salmon River and all 415,000 hatchery smolts released into the Little Salmon River are part of the LSRCP program originating from A-run program based on adults trapped at Pahsimeroi Fish Hatchery and a B-run program based on adults trapped at Dworshak National Fish Hatchery. Managers are planning to phase out the releases of B-run smolts from DNFH and replace them with a B-run that is locally adapted to the Salmon River (see Upper Salmon B-Run Component below)

In addition to the LSRCP funded hatchery program in the Little Salmon River, 445,000 smolts that are part of the Hells Canyon mitigation program funded by IPC are also released into the Little Salmon River. These smolts are progeny of adults trapped at Pahsimeroi Fish Hatchery on the Salmon River and at the Hells Canyon trap on the Snake River.

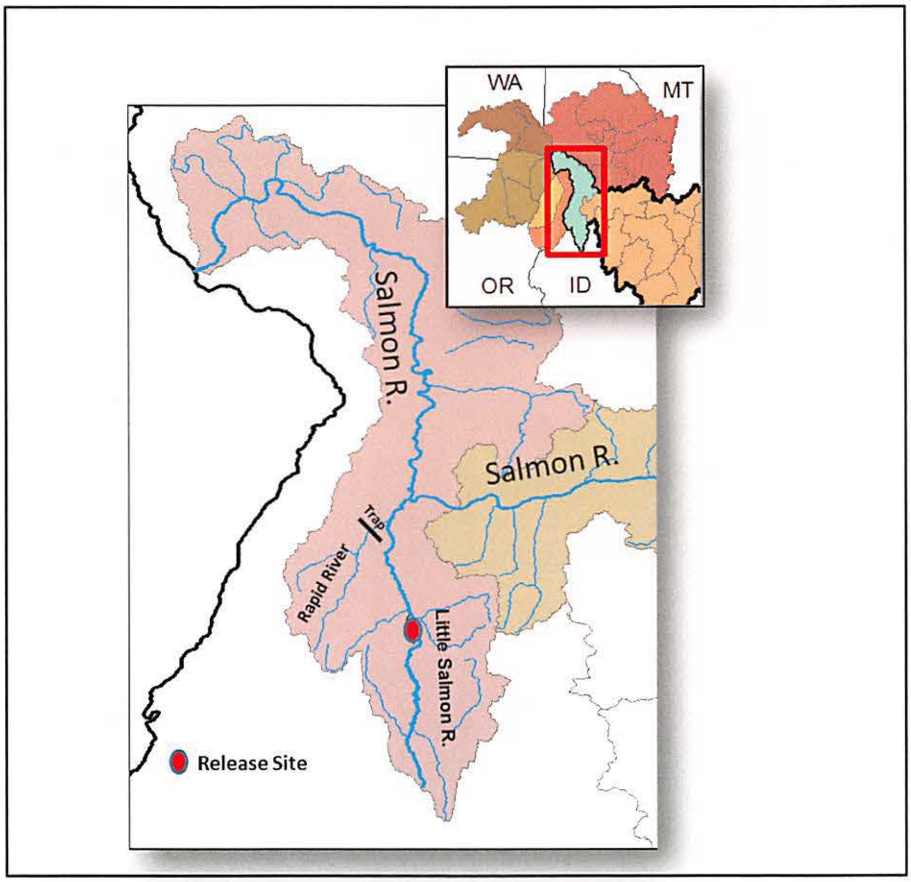

Figure 3. Little Salmon River steelhead TRT population and hatchery steelhead smolt release site.

Upper Salmon River

The ICTRT identified four independent steelhead populations (Lemhi River, Pahsimeroi River, East Fork Salmon River, and upper Salmon River mainstem) upstream from the North Fork Salmon River (Figure 4). Historic abundance and productivity data for natural steelhead within these populations are limited but managers are working to build programs to collect more abundance and productivity data for natural populations within the upper Salmon River. In the Lemhi River, in-stream PIT tag arrays are in operation and, in conjunction with adult steelhead PIT tagging at Lower Granite Dam, are used to estimate of the number of natural steelhead escaping into the Lemhi River. Similarly, newly installed PIT tag arrays in the mainstem Salmon River near the town of Salmon will also provide information to estimate the number of natural steelhead in aggregate that are destined for natural production areas upstream of the Lemhi River. A hatchery trap operated on the Pahsimeroi River is used to enumerate the number of natural-origin adults in the Pahsimeroi River. A hatchery trap operated in the East Fork Salmon River is used to enumerate the number of natural-origin steelhead arriving at the trap. A PIT tag array in the Yankee Fork Salmon River in conjunction with PIT tagging of adult steelhead at Lower Granite Dam is used to estimate the escapement of natural steelhead into the Yankee Fork. The Sawtooth Fish Hatchery adult trap near the headwaters of the Salmon River is used to enumerate the escapement of natural steelhead upstream of the hatchery facility.

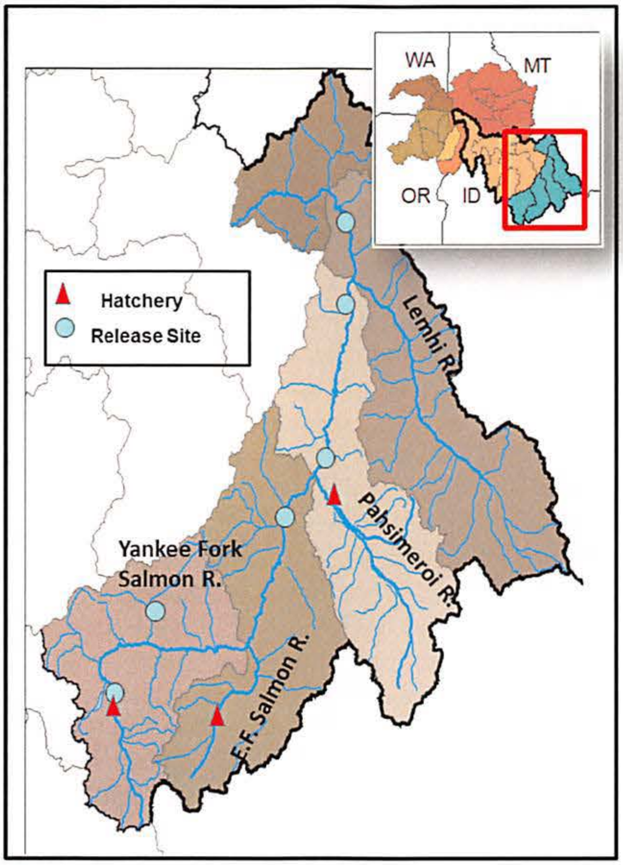

Figure 4. Upper Salmon River hatchery steelhead release locations

Upper Salmon River A-Run Component

The A-run hatchery program in the upper Salmon River that is part of the LSRCP program utilizes hatchery broodstock from both Pahsimeroi and Sawtooth fish hatcheries for a total release of 1.58 million smolts (Table 2). Historically, release sites have been distributed from the North Fork Salmon River to the Sawtooth Fish Hatchery with as many as ten release sites annually. More recently, the release locations have been consolidated to six sites. These releases include 750,000 at Sawtooth Fish Hatchery, 440,000 in the Yankee Fork Salmon River, and 390,000 across four locations in the mainstem Salmon River downstream of the East Fork Salmon River (Figure 4).

Smolts released in the Yankee Fork Salmon River are part of the 2008-2017 US v. OR Management Agreement and represent a cooperative effort between the IDFG and the Shoshone-Bannock Tribe (SBT). Previously this production had been released into other tributaries of the upper Salmon River including Slate Cr., Valley Cr., and the Lemhi River. In 2010, releases from these tributaries were consolidated into the Yankee Fork Salmon River. The lack of adequate trapping facilities in the Yankee Fork has prevented the collection of local broodstock and the monitoring of escapement back to the Yankee Fork. A more recent effort to develop trapping facilities in the Yankee Fork has prompted managers to reconsider how the Yankee Fork is managed. Future management of steelhead in the Yankee Fork Salmon River is discussed in more detail in the description of the Upper Salmon B-run component below.

In addition to the 1.58M A-run smolts released as part of the LSRCP program, 830,000 A-run hatchery smolts are released from Pahsimeroi Fish hatchery as part of the IPC hatchery mitigation (Table 2).

Upper Salmon B-Run Component

Wild populations of steelhead in the Middle Fork Salmon and South Fork Salmon rivers are classified as B-run. Both the Middle Fork and South Fork Salmon rivers are managed for wild populations and no sport harvest opportunity is available. However, it is the desire of managers to provide in-kind harvest opportunity for B-run steelhead in the Salmon River. In the late 1990s, an increased effort to build a locally adapted broodstock of Salmon River B-run hatchery steelhead was initiated. Since then it has been observed that locally adapted adults return at a significantly higher rate compared to first generation releases from Dworshak National Fish Hatchery. Even with higher return rates of the locally adapted fish, the lack of an adequate trapping facility has continually hampered the ability of managers to perpetuate and expand a locally adapted B-run broodstock in the Salmon River. As an interim measure, the locally adapted B-run broodstock was transferred to Pahsimeroi Fish Hatchery in 2009. Managers felt that this would provide the best short term solution by providing an adequate trapping facility. In the spring of 2010, approximately 120,000 B-run smolts were released at the Pahsimeroi Fish hatchery. Smolts were released with their adipose fins intact and all were tagged with coded wire tags (CWTs). This will allow the fish to be differentiated from the Pahsimeroi A-run returns and also allow them to bypass all mark selective fisheries. Returns in 2013 at Pahsimeroi Fish Hatchery from that first smolt release in 2010 are expected to produce at least 500,000 smolts. This would be a substantial increase of smolts compared to all previous years of the B-run program.

Plans initiated by the SBT to develop a permanent adult trapping infrastructure in the Yankee Fork Salmon River are currently underway. It is the intent of managers to transfer the Salmon River B-run broodstock program to the Yankee Fork Salmon River. This will provide an adequate adult collection facility necessary to expand the program. Expansion of the program will allow managers to phase out the use of DNFH broodstock in the Salmon River. As this program develops, managers also intend to replace the DNFH B-run smolt releases in the Little Salmon River with the locally adapted Salmon River B-run stock. The A-run production that is currently located in the Yankee Fork will be incorporated into existing onsite releases at Sawtooth Fish Hatchery.

East Fork Salmon River Component

The hatchery steelhead program in the East Fork Salmon River (EFSR) represents the only integrated hatchery steelhead program operated by IDFG. In 2001, an effort was initiated to develop a small conservation program in the EFSR with the intent to use a hatchery program to increase the number of natural adults in the EFSR. A permanent trapping facility exists in the East Fork Salmon River but is located approximately 18 miles upstream of the mouth and also upstream of much of the spawning and rearing habitat in the EFSR. This severely constrains our ability to manage the hatchery fraction on the spawning grounds and to evaluate the production and productivity of the integrated program in the EFSR. In the 2008 FCRPS Biological Opinion, RPA #42 identified the need to develop the necessary infrastructure to manage the program in the EFSR. Additionally, independent regional hatchery reviews conducted by the US Fish and Wildlife Service Hatchery Review Team (HRT) (USFWS 2011) and by the Hatchery Scientific Review Group (HSRG) of the Congressionally mandated Pacific Northwest Hatchery Reform Project (HSRG 2009). Both reviews indicated that developing adequate trapping facilities near the mouth of the EFSR is required to properly manage the integrated program.

Current production objectives in the EFSR include releasing 170,000 smolts immediately below the trapping facility. In the past few years, the number of hatchery returns to the East Fork trap has vastly outnumbered the natural-origin returns (Figure 5). Based on this observation, it is presumed that a significant proportion of fish spawning naturally below the trap are also of hatchery-origin. Because the majority of fish spawning both naturally and in the hatchery are hatchery-origin, the proportional natural influence (PNI) in the EFSR is low. To decrease the amount of influence the hatchery program has in the EFSR, managers have initiated changes to the hatchery program. Beginning in brood year 2013, the hatchery production will be reduced to a 60,000 smolt target with the broodstock consisting of 100% natural-origin adults. If insufficient natural-origin adults are available to produce 60,000 smolts (approx. 15 pairs) a minimum of 40,000 smolts will be produced including the use of hatchery-origin adults if necessary. When hatchery-origin adults return to the EFSR, there will be no restriction on the numbers released to spawn naturally. Managers feel that this strategy will provide the best opportunity to both maintain at least a minimum number of returning adults to the EFSR to perpetuate the hatchery broodstock and still maintain some naturally produced fish spawning in the natural environment.

Hatchery Production and Survival

The following section describes the production and survival metrics associated with the hatchery program and compares the observed performance with the anticipated program mitigation benefits. Information includes in-hatchery and post release survival and contribution to fisheries for the combined LSRCP steelhead mitigation program in the Salmon River. Metrics are summarized for the combined production at each of the Magic Valley and Hagerman National fish hatcheries.

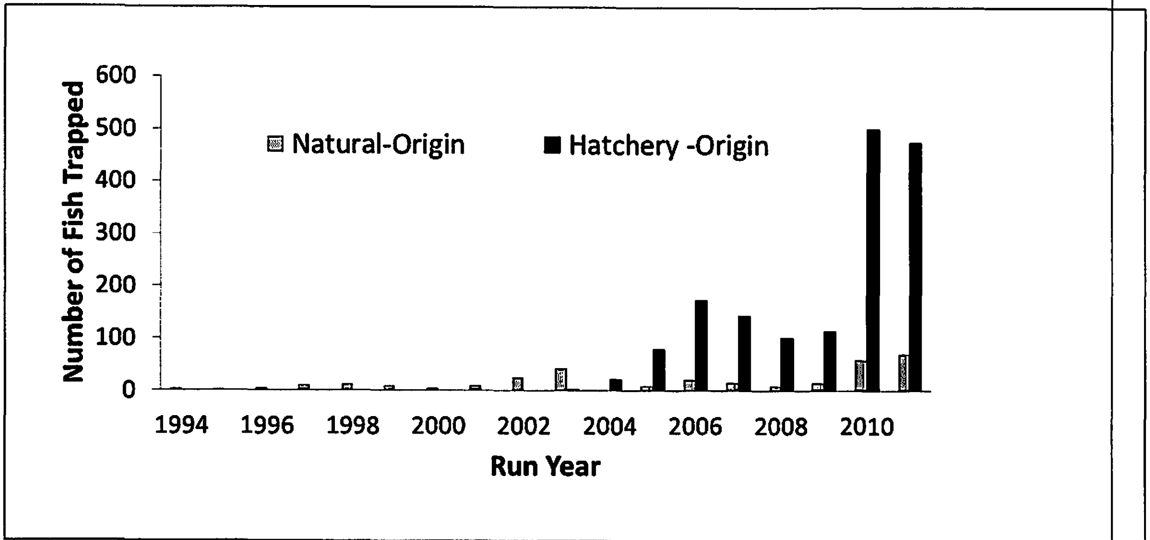

Figure 5. Hatchery- and natural-origin steelhead trapped at the East Fork Salmon River adult fish trap 1994-2011.

With few exceptions, egg to release survival rates for both hatcheries have remained consistently high over the time series and have not limited the ability of either hatchery facility to reach production targets (Figure 6).

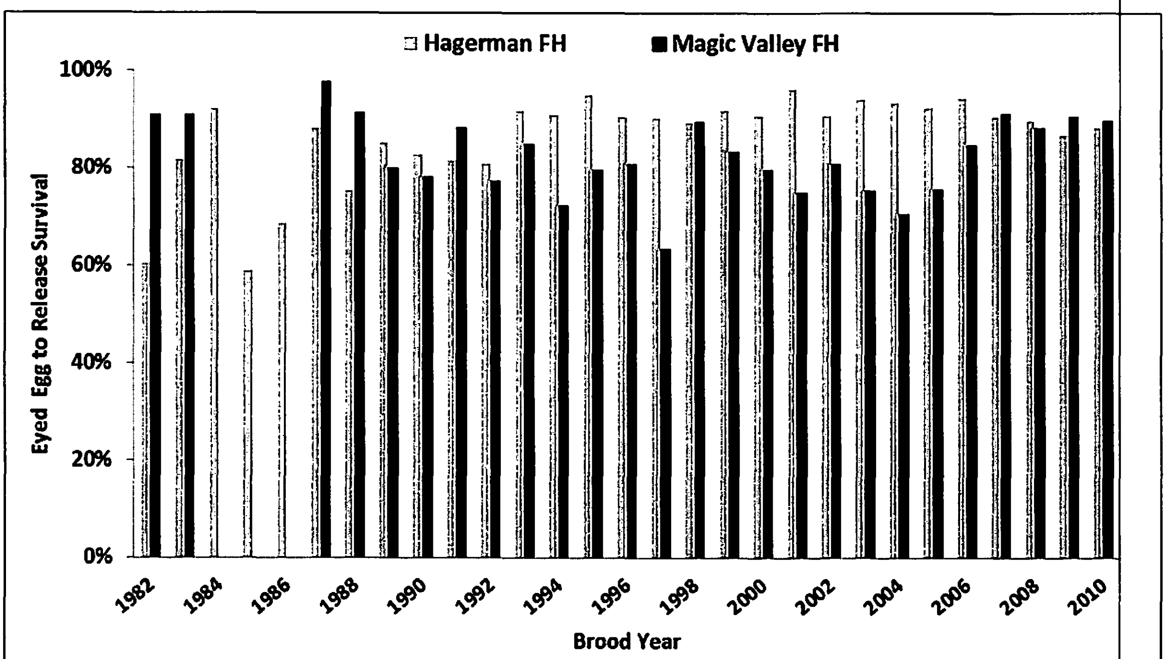

Figure 6. Eyed egg to release survival rates for steelhead reared at Magic Valley Fish Hatchery and Hagerman National Fish Hatchery.

Magic Valley Fish Hatchery consistently met smolt release targets through 2004 (Figure 7). Declines in spring water since then has limited the ability of the program to meet the smolt release target of 1.75 million. Currently the maximum rearing capacity is 1.54 million full term smolts at 4.5 fish per pound. Hagerman National Fish Hatchery has consistently failed to meet the release target of 1.7 million full term smolts and the failure is attributed to reduced spring flows (Figure 7). Managers are looking into alternatives to increase smolt capacity at the hatcheries given the limited water supply.

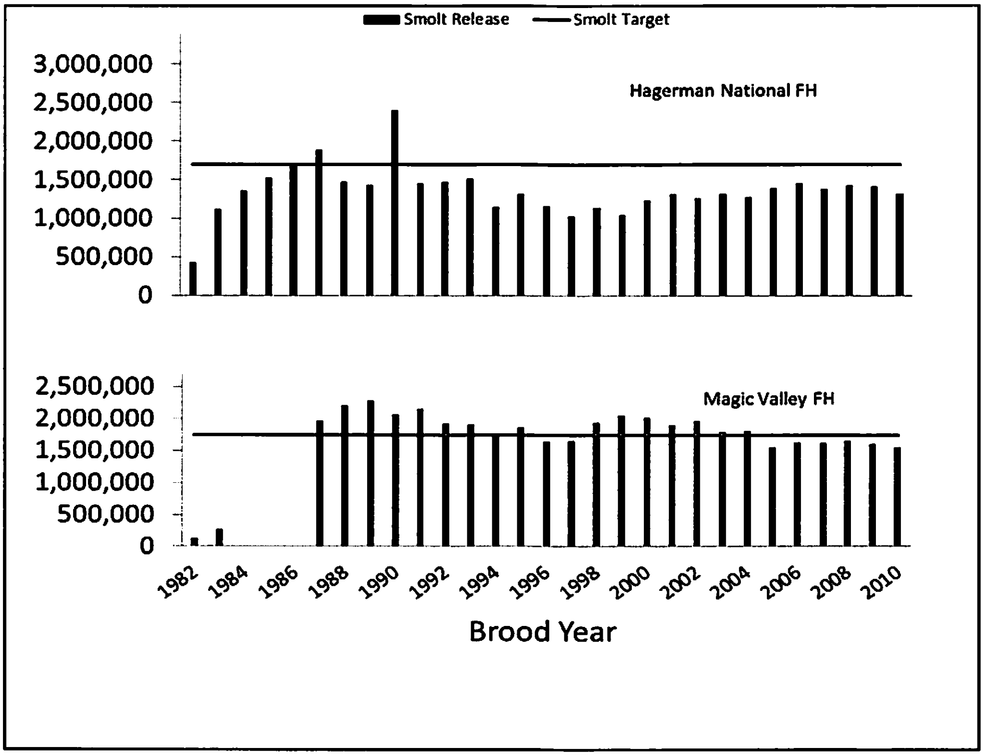

Figure 7. Number of yearling steelhead smolts released from Hagerman National Fish Hatchery and Magic Valley Fish Hatchery 1982-2010.

Survivals of smolts from release sites to Lower Granite Dam are estimated using PIT tagged smolts. For migration years 1993-2011 estimated survival rates have remained stable and have averaged 73.7% and 73.4% for MVFH and HNFH respectively (Figure 8). While there really is not a benchmark or goal for juvenile survival to Lower Granite Dam for hatchery steelhead, survival rates observed from MVFH and HNFH are comparable to other facilities in the Snake River basin.

The number of total adults produced annually from each hatchery is estimated by summing hatchery rack returns, harvest estimates, and the fish recovered as strays. As described earlier in this document, the total combined adult mitigation for the LSRCP Salmon River program is 75,800 adults produced annually (34,980 from MVFH and 40,800 from HNFH). Since 1989, the average annual number of adults produced at MVFH and HNFH is 17,470 (range: 4,600-40,100) and 16,022 (range: 2,960-50,590) respectively (Figure 9). This represents approximately 50% and 40% of the adult goals respectively. Over the history of the program, the total mitigation goal has been achieved in three years at MVFH and two years at HNFH. Despite the fact that the total goal has only been achieved a few times, this program has helped to maintain robust fisheries every year.

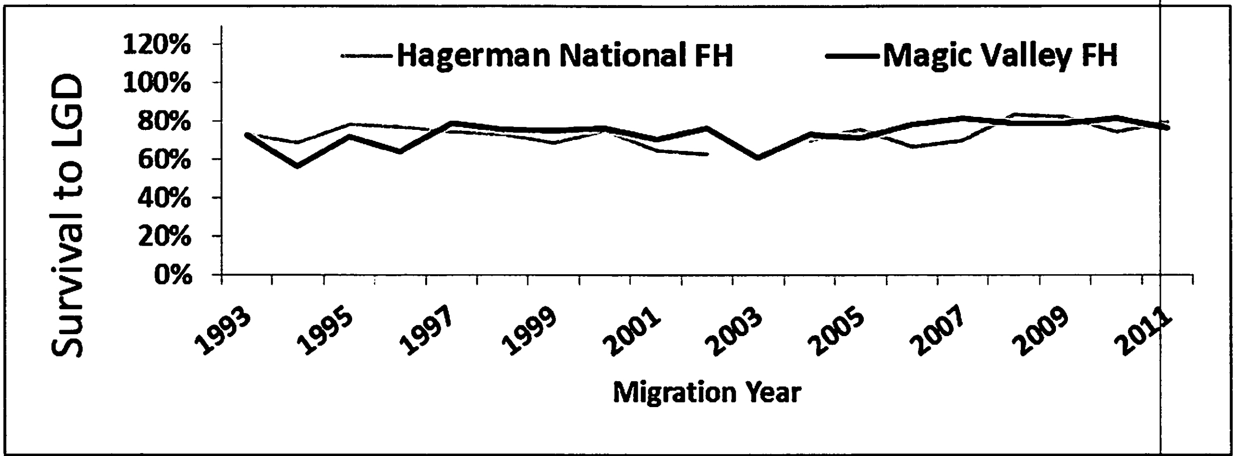

Figure 8. Estimated steelhead smolt survival from release site to Lower Granite Dam from Magic Valley and Hagerman National fish hatcheries 1993-2011.

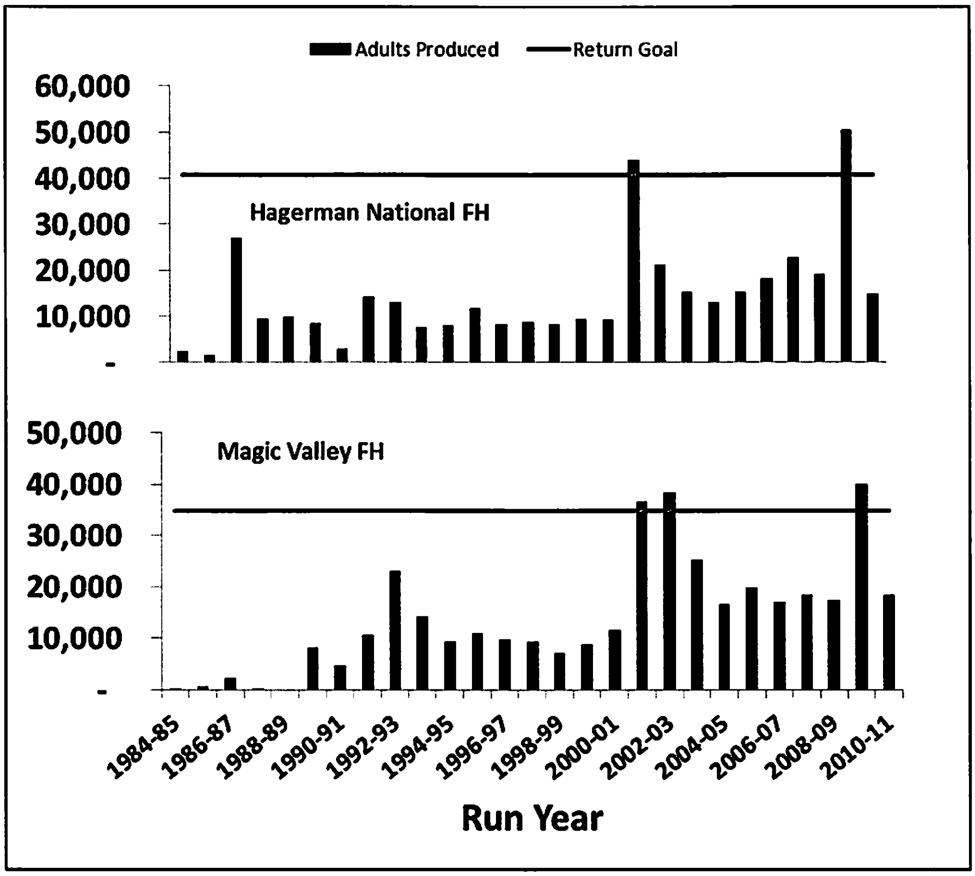

Figure 9. Total hatchery steelhead produced from Magic Valley and Hagerman National fish hatcheries 1985-2011.

Assumptions that were initially used to size the LSRCP hatchery programs included smolt to adult survival (SAS) rates of 2.0% and 2.4% necessary to achieve adult mitigation objectives for MVFH and HNFH respectively). For brood years 1982-2006 average SAS rates were 0.95%

(range: 0.27-2.56%) and 1.19% (range: 0.27-4.98%) for MVFH and HNFH respectively (Figure 10).

Stray Rates

Adult steelhead recovered (fisheries, hatchery traps, spawning grounds etc.) anywhere outside of the direct path to the release location are considered strays. It is possible that fish harvested

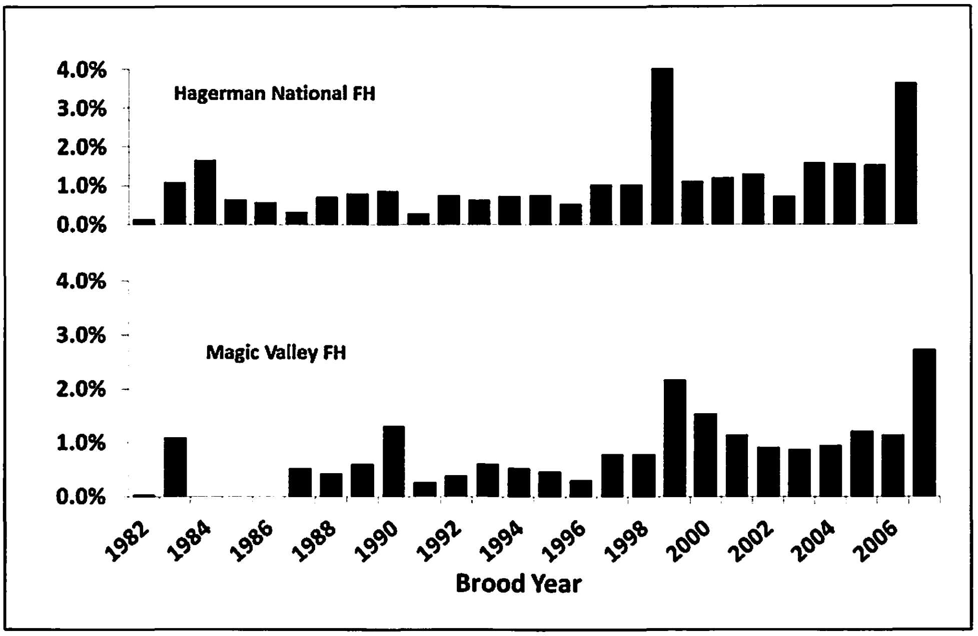

Figure 10. Estimated smolt to adult survival (SAS) rates for hatchery steelhead produced at Magic Valley and Hagerman National fish hatcheries for brood years 1982-2007.

outside of the direct path to the release site during the summer and fall months may have ended up back on the direct path had they not been harvested but there is not a good method to estimate this parameter. It should also be noted that these stray rate estimates are based strictly on fish that are recovered as strays in fisheries and natural spawning areas where sampling programs are in place. Because not all fisheries and natural spawning populations are sampled, reported stray rates are likely underestimates. IDFG has historically used the Left Ventral (LV) fin clip as a flag for the presence of CWT in steelhead but that clip was discontinued in brood year 2002 for A-run steelhead and in brood year 2006 for B-run steelhead. Any current recovery programs that are restricted to visual scanning for the presence of CWT will miss the CWT tagged fish and the stray rate will be underestimated. For brood years 1982-2007 estimated stray rates averaged 4.3% (range: 0-19%) and 3.5% (range: 0.1-15%) for MVFH and HNFH respectively. The majority of fish recovered as strays from MVFH and HNFH were recovered upstream of Lower Granite Dam (65% and 64% respectively). Many of the recoveries upstream of Lower Granite dam were in fisheries located immediately upstream of the direct path to the release location but based on the strict definition were included in stray rate estimation.

Contribution to Harvest

Harvest Downstream of Lower Granite Dam

As previously mentioned, the primary focus of the LSRCP hatchery program in the Salmon River is harvest mitigation. Since the inception of the program, both MVFH and HNFH have produced numbers of adult steelhead sufficient to maintain robust sport and tribal fisheries in Idaho and have also supported fisheries downstream of the project area. While the distribution of harvest benefits has changed over the program history, the contribution to overall adult production has remained relatively stable through time with a few notable extremes (Figure 9).

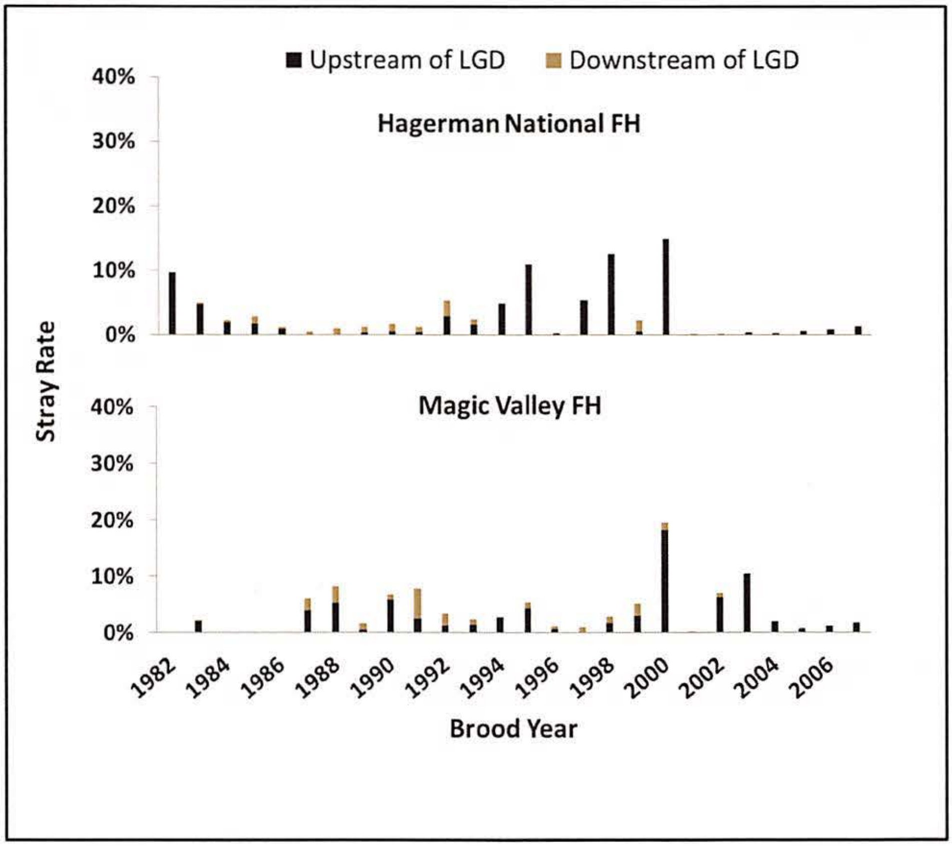

Figure 11. Estimated stray rates of hatchery steelhead produced at Magic Valley and Hagerman National fish hatcheries for brood years 1982-2007. Estimated stray rates are differentiated for the areas upstream and downstream of Lower Granite Dam.

Prior to 1999, estimated harvest rates in areas downstream the project area ranged from 16-53%. Since 1999, the estimated harvest rates in fisheries downstream of the project area have ranged from 3-8% percent. This reduction in harvest rate is primarily related to changes in harvest management in the Columbia River since the mid-1990s. However, when these harvest rate estimates are compared with the cumulative harvest information for A-run index stocks reported by the US v. OR Technical Advisory Committee (TAC) for the Columbia River downstream from McNary Dam, it appears that the harvest rates based on CWT expansions for MVFH and HNFH underestimate the actual harvest assuming that the MVFH and HNFH releases are harvested at a similar rate as the aggregate A-run index stocks used by TAC (Figure 12).

If the MVFH and HNFH releases are actually harvested at a similar rate, there are a couple of possible explanations for why the harvest rates reported for these stocks are underestimated. First, there could be an insufficient number of fish marked with CWTs to accurately represent the stock composition of the harvest. Over the history of the MVFH and HNFH programs, the major release components from each hatchery have been tagged with CWT (usually 60-100K CWTs). However, in some years, some or all of the offsite releases were not marked with CWT. In these situations, the CW tagged groups were used as surrogates to represent the untagged releases. If the untagged release groups survive at a different rate, or behave differently in the fisheries, a harvest rate estimate based on data from a tagged surrogate group would be biased. Given that the tagged and untagged release groups are the same stocks reared at the same facility, it is unlikely that a significant bias would result. A second possible explanation is that escapement estimates at LGD are overestimated for MVFH and HNFH. An overestimate of the escapement would artificially decrease the harvest rate downstream of LGD. To examine this, we have taken a preliminary look at the escapement data and summarized the total

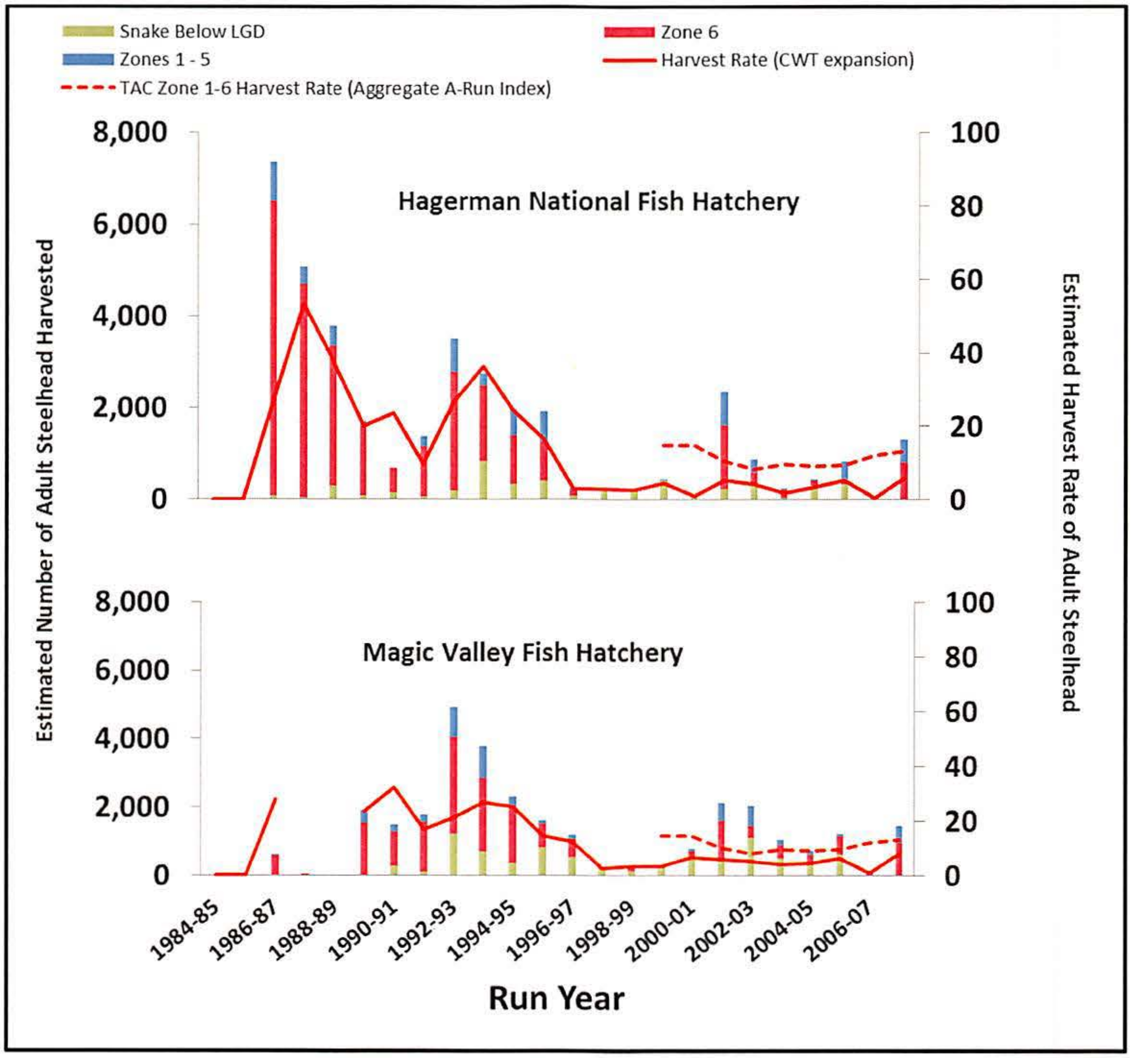

Figure 12. Estimated harvest rates of hatchery steelhead in the Columbia and Snake rivers downstream of Lower Granite Dam for return years 1985-2008. All fish were produced at Magic Valley and Hagerman National fish hatcheries.

estimated escapement to Lower Granite Dam across all programs (Oregon, Idaho and Washington) located upstream of Lower Granite Dam and compared those totals to the window counts at Lower Granite Dam (Figure 13). For every year, the summed escapement estimates are less than the total window counts for hatchery fish. Given this, it is unlikely that we are overestimating the escapement at Lower Granite Dam. A third possible explanation is that CWTs from MVFH and HNFH are not being sampled representatively in the observed catch. We have no information to indicate this is happening but we are going to work with agency staff from Oregon, Washington and CRITFC to try and determine if this issue exists. We are also going to do a more thorough review of the historic CWT recovery data to try and resolve this discrepancy.

The IDFG is in the process of shifting the steelhead marking program to a genetic technology whereby essentially all progeny are tagged via Parental Based Tagging (PBT). This is accomplished by taking tissue samples from all adults that contribute to hatchery broodstocks. When any of their progeny are sampled (as juveniles or adults), the parents can be identified thus revealing the hatchery, stock, age, gender, and release site. Beginning in 2011, with cooperation from CRITFC and WDFW, tissue samples from the observed harvest both above and below Bonneville Dam are being collected and analyzed to estimate the harvest contribution of Snake River steelhead in the Zones 1-6 fisheries. We will compare the results of the PBT stock composition analysis alongside that of the CWT analysis to help identify if the CWT data is biased.

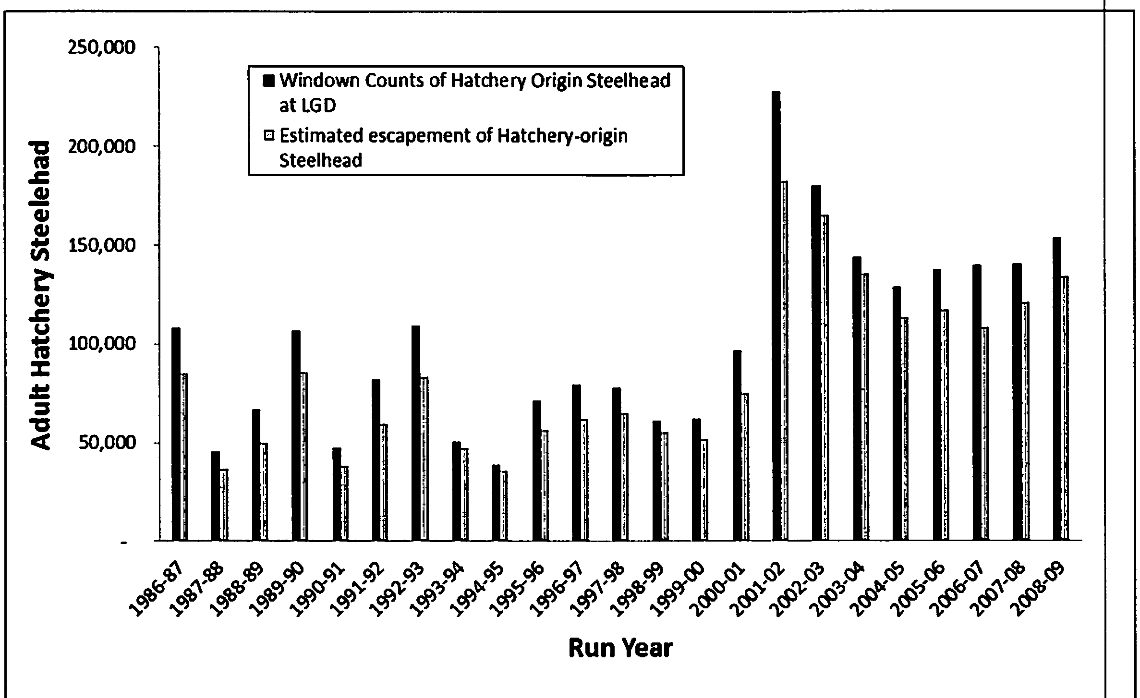

Figure 13. Comparison of the total estimated escapement of hatchery steelhead produced upstream of Lower Granite Dam to the window counts at Lower Granite Dam 1986-2009

Harvest Upstream of Lower Granite Dam

Over the history of the LSRCP program, Idaho has maintained consistent and robust steelhead fisheries in the Snake and Salmon rivers providing anglers with abundant opportunity in both in time and space. The total number of adult steelhead from MVFH and HNFH harvested upstream of Lower Granite Dam annually between 1987 and 2011 averaged 16,628 (range: 2,677-52,043) (Figure 14). More recently (since 2000) the number of fish harvested annually above Lower Granite Dam has averaged 24,974 (range: 13,418-52,043%). Harvest rates over these two periods averaged 68% (range: 41-85%) and 66% (range: 59-77%) respectively.

There are currently 410 river miles open to steelhead fishing in the Salmon and Little Salmon rivers combined and a total of 289 days open to steelhead fishing in some river zones with a minimum of 260 days open in all river zones (Figure 15). Total annual angler effort in the Salmon River since 1984 has averaged 219,200 angler days (range: 136,000-382,000 days) (Figure 16). This fishery provides unique opportunity for anglers to spread out and achieve the angling experience they desire in a variety of riverine habitats and conditions throughout the majority of the year.

When comparing harvest and angler effort over the program time series in the Salmon River including the period prior to hatchery mitigation, the current harvest and angler effort estimates are considerably higher than the pre-mitigation period. It is important to note that the catch and effort displayed in Figure 16 represents the combined harvest and effort information for both the LSRCP and IPC programs. To show the relationship with harvest and effort it was necessary to combine them since effort cannot be attributed to a single program due to the significant spatial and temporal overlap of the programs (LSRCP and IPC). The primary purpose of the figure is to convey that the hatchery mitigation program is maintaining sport fisheries relative to the pre-mitigation period.

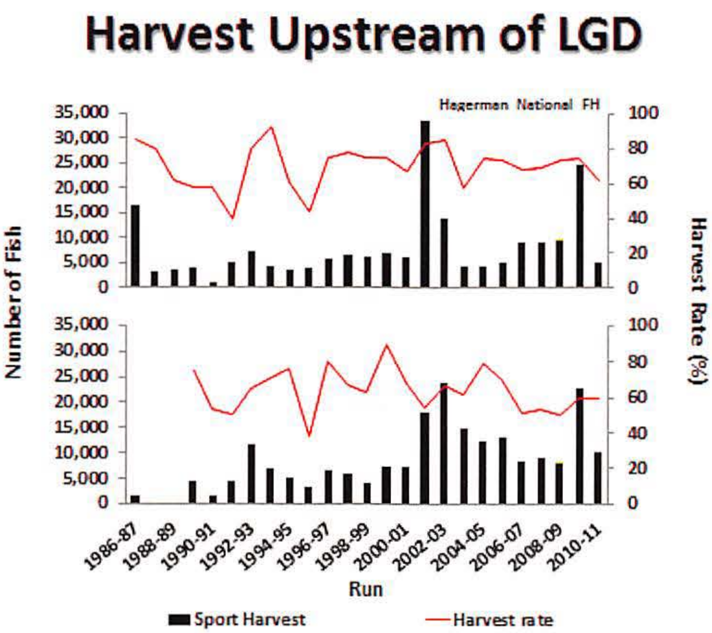

Figure 14. Estimated number of hatchery steelhead harvested upstream of Lower Granite Dam 1986-2011. All fish were produced from Magic Valley and Hagerman National fish hatcheries.

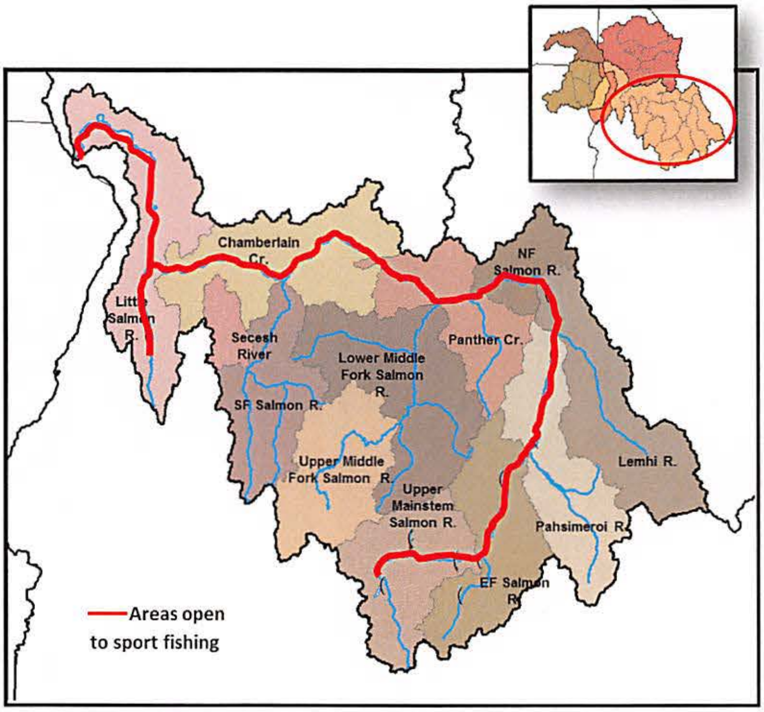

Figure 15. Hatchery steelhead fishing boundaries in the Salmon River, ID.

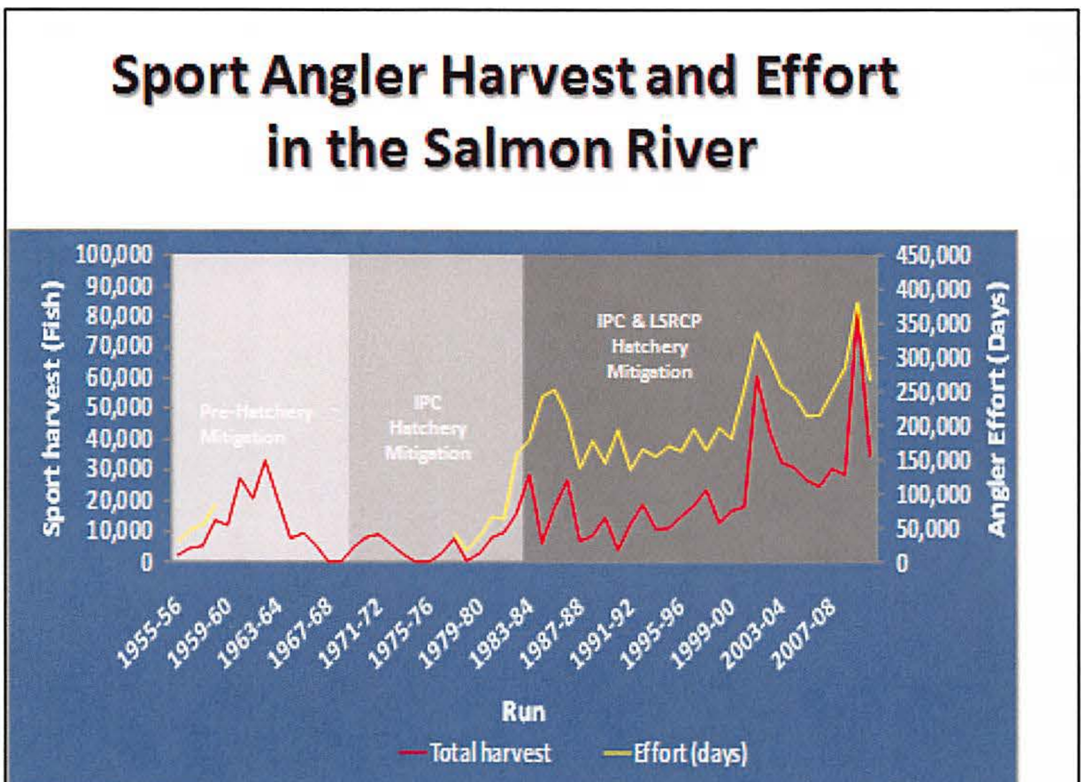

Figure 16. Estimated harvest and angler effort for the hatchery steelhead fisheries in the Salmon and Little Salmon rivers 1956-2010.

Summary and Moving Forward

Since the inception of the LSRCP hatchery mitigation program in Idaho, IDFG has prioritized harvest mitigation as the primary function of the hatchery program and has focused efforts to maximize SARs, provide anglers with abundant harvest opportunity, and to meet adult mitigation objectives. During this period, hatchery practices have been refined and with few exceptions, broodstock collection and in-hatchery survival has not limited the ability of managers to meet smolt production objectives. Hatchery adult returns from HNFH and MVFH have consistently provided robust fisheries upstream of the project area and have also contributed to fisheries downstream of the project area. While the total adult mitigation objective has only been reached in a few years, MVFH and HNFH have annually produced on average 50% and 40% to the total mitigation goal respectively since 1989.

The Salmon River represents a significant portion of the habitat in the Snake River that historically produced wild steelhead. Likewise, the Salmon River hatchery steelhead program is the largest hatchery steelhead program in the Snake River. In addition to the LSRCP hatchery mitigation, approximately 70% of the IPC hatchery mitigation for the Hells Canyon hydroelectric complex is also operated within the Salmon River in the same general proximity to the LSRCP program. Managers realize that operating a hatchery mitigation program this large is not without some risk to natural populations. Since the inception of hatchery mitigation efforts in the Salmon River, IDFG has maintained a management framework that emphasizes reducing interactions between hatchery-origin and natural-origin fish by confining hatchery releases to areas that managers feel will have the least impact on natural populations. Within the Salmon River sub-basin, there are no hatchery steelhead releases in the South Fork Salmon River, Middle Fork Salmon River, North Fork Salmon River, or in the mainstem Salmon River downstream of the North Fork Salmon River.

Over the history of the program, IDFG has been adaptively managing the hatchery program to both increase adult returns and to reduce impacts to natural populations. Changes have included consolidating release sites to areas away from natural populations and emphasizing the use of locally adapted broodstocks. In an effort to provide in-kind mitigation, managers are committed to maintaining both A-run and B-run hatchery stocks in the Salmon River mitigation program. This includes a recently expanded effort to increase the development of a locally adapted B-run hatchery stock in the Salmon River. This change is expected to increase the survival rate, provide more opportunity to harvest B-run steelhead, and allow managers to phase out the use of the Dworshak National Fish Hatchery stock in the Salmon River.
While IDFG has prioritized the use of the hatchery program to mitigate for lost harvest opportunity, evaluating the use of hatchery supplementation to aid in the maintenance and recovery of natural populations has also been prioritized. A small hatchery program within the EFSR is operated to evaluate the use of an integrated broodstock to supplement the natural population. Current trapping infrastructure in the EFSR is insufficient to properly manage an integrated program due to its location high up in the drainage. The RPA #42 listed in the 2008 FCRPS Biological Opinion identified the need for infrastructure development to operate this program. Additionally, two independent regional hatchery reviews (HRT and HSRG) both recommended developing adult trapping infrastructure near the mouth of the EFSR to properly operate the integrated program.

The IDFG views the LSRCP hatchery steelhead mitigation program as a success story in that it has made significant progress towards achieving the targeted management objectives. This program has provided consistent and robust steelhead fisheries throughout the program history and has maintained the ability of managers to provide abundant angling and harvest opportunity over a vast landscape during the majority of each year. These fisheries have not only provided significant economic impacts to the region and state, but have also helped to maintain a connection between citizens and our natural resources.

The IDFG is fully committed to maintain and restore ESA listed populations of steelhead. At the same time we are also committed to continue the operation of the hatchery mitigation program. To address this, we have developed a management framework that incorporates both objectives. Hatchery and Genetic Management Plans (HGMPs) have been developed to describe the management goals, program plans, monitoring and evaluation plans, and plans for addressing risks associated with each of the programs. We view these plans as guidance documents and understand the need to remain flexible as new information becomes available to help guide and improve the programs in such a way to better achieve the stated IDFG management objectives.

Acknowledgements

The list of people directly involved with the Salmon River steelhead program is extensive. We would like to begin by extending our sincere appreciation to the many hatchery staffs that are involved with this program. They include: Magic Valley Fish Hatchery, Hagerman National Fish Hatchery, Sawtooth Fish Hatchery, Clearwater Fish Hatchery, Pahsimeroi Fish Hatchery and Dworshak National Fish Hatchery. They all make significant contributions to the highly coordinated and successful program in the Salmon River. We would also like to thank the many cooperators in the basin including staff at the IDFG regional office in Salmon, Idaho Power Company, Pacific States Marine Fisheries Commission, IDFG harvest monitoring crews, and the staffs from the Shoshone-Bannock Tribe, the Nez Perce Tribe, and the US Fish and Wildlife Service. Lastly, we would like to thank the staff at the LSRCP office in Boise, ID for providing funding and support to maintain and improve the program.

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LSRCP Steelhead Hatchery Mitigation Program Clearwater River, Idaho

Carl Stiefel and Brian Leth, IDFG

This report describes the steelhead hatchery mitigation program in the Clearwater, Idaho that is part of the Lower Snake River Compensation Program (LSRCP). Information includes: a description of Idaho Department of Fish and Game (IDFG) management objectives, description and status of natural populations, background and history of the hatchery program, description of how successful the hatchery program has been in achieving objectives, and a description of the current and future management focus. While not part of this program review, the hatchery steelhead mitigation program for the Dworshak hydroelectric dam funded by the US Army Corps of Engineers (USACOE) is introduced to provide context and scope for the entire steelhead hatchery mitigation effort within the Clearwater River drainage.

Management Objectives and Framework for the Clearwater River

The Clearwater River is a tributary of the Snake River encompassing approximately 9,600 square miles. Major tributaries of the Clearwater River include the Selway, Lochsa, North Fork Clearwater, South Fork Clearwater, Middle Fork Clearwater, and Potlatch rivers (Figure 1). The Clearwater River and its tributaries once supported robust wild populations of steelhead. In 1997, the Snake River steelhead DPS was listed as threatened under the ESA.

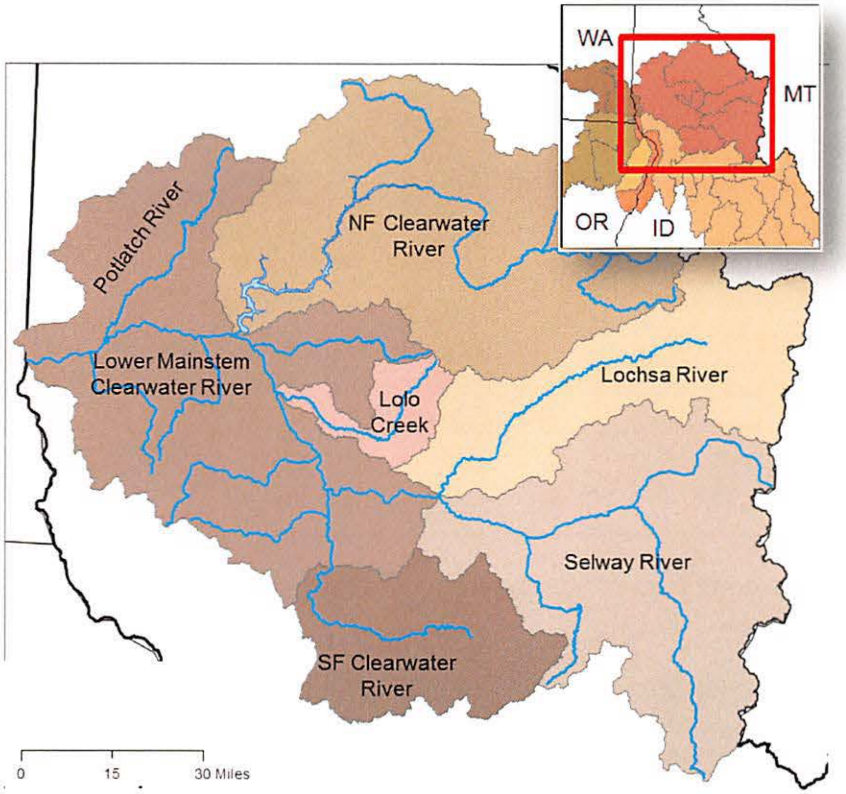

Figure 1. Map of the Clearwater River steelhead Major Population Group (MPG) and six independent populations and major tributaries.

The Idaho Department of Fish and Game (IDFG) statewide management objectives include restoring and maintaining natural populations of steelhead in the Clearwater drainage. Objectives for the hatchery steelhead program are to meet the LSRCP adult mitigation objectives, to restore and maintain recreational and tribal steelhead fisheries, and to minimize impacts of the hatchery program on natural populations. The primary objective of the steelhead hatchery program is to meet harvest mitigation objectives. As such, the hatchery program is managed as a segregated program intended to maximize smolt to adult survival rates while at the same time to minimize interaction with natural populations.

The IDFG management framework for steelhead includes confining the release of hatchery production to areas likely to have the least impact on natural populations. Within the Clearwater River sub-basin, hatchery releases of summer steelhead that are part of the LSRCP mitigation program are confined to the South Fork Clearwater River (Figure 2).

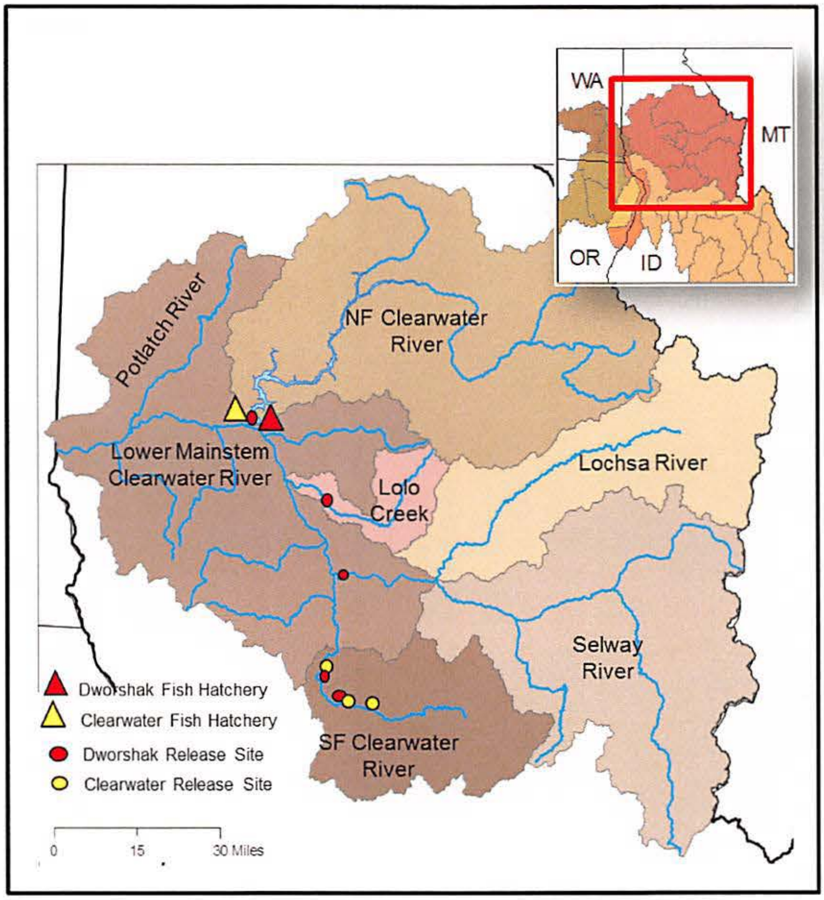

Figure 2. Release Sites for hatchery steelhead reared at Clearwater and Dworshak fish hatcheries.

Harpster Dam was constructed on the South Fork Clearwater River (SFCR) in 1910, approximately 20 miles upstream of the mouth, and had significant impacts to wild steelhead during the years it was operated. Between 1910 and 1935, no fish passage facilities existed at the dam and all upstream passage of wild steelhead was blocked. In 1935, fish passage facilities were constructed at the dam and operated until 1949 when high water damaged the passage facilities rendering them unusable. Between 1949 and 1963, all upstream migration of adult steelhead was once again blocked. The dam was finally removed in 1963. Efforts to reestablish wild steelhead in the SFCR began in 1961 as part of the Columbia River Fisheries Development Program. As part of this effort, wild adult steelhead collected at the Lewiston Dam, on the Clearwater River, were transported upstream of Harpster Dam and released for natural spawning. Additionally, beginning in 1962, eyed eggs from wild adults collected at Lewiston Dam were placed into hatching channels annually in tributaries of the SFCR upstream from the dam. In 1969, the egg source for steelhead mitigation in the SFCR changed to the North Fork Clearwater River at Dworshak National Fish Hatchery (DNFH).

The focus of the LSRCP hatchery mitigation in the Clearwater River has remained in the SFCR. Annually, 843,000 steelhead smolts reared at Clearwater Fish Hatchery (CFH) that are part of the LSRCP steelhead mitigation program are released in the SF Clearwater River (Figure 2). There are no hatchery steelhead smolt releases in the Middle Fork Clearwater River upstream of Clear Creek, or in the Selway or Lochsa rivers. Dworshak Dam, constructed in the late 1960s and early 1970s near the mouth of the North Fork Clearwater River completely blocked steelhead access to the North Fork Clearwater River. Mitigation efforts to compensate of the loss of wild steelhead into the North Fork Clearwater River included the construction of Dworshak National Fish Hatchery in 1969 funded by the USACOE. This mitigation program includes 2.1M yearling smolt releases. The majority of the smolts for the DNFH mitigation are released onsite at DNFH (1.2M) and in the SFCR (600,000) with the remaining smolts released in Lolo Creek and in Clear Creek (Figure 2).

Status of Natural Populations

Steelhead in the Clearwater River Major Population Group (MPG) have been classified into six demographically independent populations including five extant populations and one population where all historic habitat is blocked by the Dworshak Dam (Figure 1) (ICTRT 2003). Currently, all five extant populations of steelhead in the Clearwater MPG fail to meet the established viability criteria. All populations are currently classified at moderate to high risk for abundance and productivity measures. All five extant populations are rated at low to moderate risk for spatial structure and diversity measures. While population specific abundance and productivity data are currently lacking, managers are focusing effort to estimate these parameters though the use of genetic analysis and PIT tagging technologies.

Mitigation Goals and Hatchery Program Background

The LSRCP steelhead hatchery mitigation program was established to provide in-kind and in-place mitigation for lost harvest opportunity resulting from the construction and operation of the four lower Snake River hydroelectric dams. Total mitigation expected for the LSRCP is 165,300 adults to be produced annually. This is based on an assumed 2:1 ratio of catch (downstream of project area; Lower Granite Dam) to escapement (upstream of the project area) (Corps of Engineers, 1975). During the program development, it was anticipated that the majority of the harvest mitigation benefits would be distributed downstream of the project area. However, less than expected returns of hatchery fish produced within the program and the depressed status of natural-origin fish influenced Columbia River fisheries management programs. The anticipated 2:1 distribution of harvest benefits downstream: upstream of Lower Granite Dam has not been realized. Regardless of the actual distribution of harvest benefits, it was anticipated that the Clearwater River steelhead hatchery program would contribute 42,000 (25.4% of total) adults annually towards the total LSRCP mitigation goal (Table 1). To achieve the adult goals, smolt to adult survival rates (SARs) were modeled and used to size the hatchery facilities.

For the LSRCP hatchery program operated within the Clearwater River drainage, the Clearwater Fish Hatchery (CFH) is the primary hatchery facility. All broodstock for the CFH program have historically been collected at DNFH. However, efforts have been initiated to develop a locally adapted broodstock in the SFCR and move away from use of adults returning to DNFH. This effort is discussed in more detail later in this report.

Table 1. Mitigation goals and smolt releases for the LSRCP hatchery steelhead program in the Clearwater River, ID.

	Clearwater Fish Hatchery
Adult Goal- Project Area	14,000
Adult Goal- Downstream of Project Area	28,000
Total Adult Mitigation Goal	**42,000**
Smolt Release Target	1,750,000
Actual Smolts Released	**843,000**
DNFH smolts Released in Clearwater R	2,100,000
Total Steelhead Smolts Released in the Clearwater River	2,943,000

Smolt to adult survival rates (SARs) used to size the CFH program specified the need for a release of approximately 1.75M million smolts to produce 42,000 adults annually. Currently, 843,000 yearling smolts are released in the SFCR representing about one half of the original production target. Limited water availability at CFH and the desire of managers to increase the size of the Chinook salmon program at CFH are the primary reasons for the reduced steelhead production. Despite the current limitations for rearing capacity at CFH, managers do have expectations to increase steelhead production up to the original smolt production target of 1.75M.

While not part of this hatchery review, another hatchery mitigation program is also operated within the Clearwater River at DNFH and is funded by the US Army Corps of Engineers (USACOE). This program is operated to mitigate for the loss of anadromous steelhead resulting from the construction and operation of the Dworshak hydroelectric dam on the North Fork Clearwater River. In addition to the 843,000 smolts released as part of the LSRCP program, 2.1M smolts from the Dworshak Dam mitigation are also released within the Clearwater River basin for a total of 2.943M smolts (Table 1).

Hatchery Steelhead Broodstock History in the Clearwater River

Hatchery steelhead broodstocks currently used in the Clearwater River at CFH and DNFH were founded with wild North Fork Clearwater River steelhead captured at DNFH. Throughout the duration of hatchery mitigation within the Clearwater River basin, no out-of-basin steelhead have been released in the Clearwater River. North Fork Clearwater steelhead are classified as B-run steelhead and return predominantly as 2-ocean adults.

As previously mentioned, all of the 843,000 smolts released in the SFCR as part of the LSRCP steelhead program have been sourced from adults trapped at DNFH (North Fork Clearwater R). Managers have recently initiated efforts to develop a locally adapted broodstock in the SFCR. While currently lacking adequate facilities to trap returning adult steelhead in the SFCR, IDFG has been collecting broodstock in the SFCR through the use of angling techniques since 2010. All broodstock collected in the SFCR are transferred to DNFH for spawning and the resultant eggs are transferred to CFH for final rearing. Plans are currently underway to develop and construct trapping facilities on a tributary of the SFCR to perpetuate and expand the SFCR localized broodstock.

Description of the Hatchery Steelhead Program in the Clearwater River

Clearwater Fish Hatchery (CFH) was constructed in 1991 and is the last of the LSRCP hatcheries to be constructed. CFH includes a satellite facility in the upper Lochsa River, and two satellite facilities in tributaries of the SFCR (Red River and Crooked River). The satellite facility on the upper Lochsa is only utilized for the spring Chinook salmon program. Historically the Red River and Crooked River sites have been used as release sites for the steelhead mitigation program in the SFCR. However, the lack of adults returning to these locations has forced managers to rely on broodstock collected at DNFH to perpetuate the CFH program. It appears that under certain flow conditions, a velocity barrier exists in the mainstem SFCR that impacts upstream passage of adult steelhead. As part of the plan to develop a locally adapted broodstock in the SFCR, managers are moving forward with a plan to develop adult trapping and juvenile acclimation facilities in a tributary of the SFCR downstream of the migration barrier.

The LSRCP hatchery steelhead program within the Clearwater River basin is composed of 843,000 yearling smolts released in the SFCR (Table 2). Of the 843,000 smolts released for this program, 510,000 are adipose clipped and the remaining 333,000 smolts are released with their adipose fin intact. All releases for this program are consistent with the 2008-2017 US v. OR Management Agreement.

In addition to smolts released as part of the LSRCP program, 2.1M million yearling smolts are released from DNFH as part of the hatchery mitigation for Dworshak Dam funded by the USACOE. These two programs contribute to a total release of 2.943M hatchery steelhead smolts in the Clearwater River basin (Table 2, Figure 2).

Table 2. Hatchery steelhead smolt releases in the Clearwater River that are part of the LSRCP and USACOE hatchery mitigation programs.

Clearwater River Hatchery Program Component	LSRCP Hatchery Steelhead Smolt Releases	USACOE Hatchery Steelhead Smolt Releases	Total Release
South Fork Clearwater R. and Tributaries	843,000	540,000	1,383,000
North Fork Clearwater R.		1,200,000	1,200,000
Lolo Creek		60,000	60,000
Clear Creek		300,000	300,000
Total Release	**843,000**	**2,100,000**	**2,943,000**

Hatchery Production and Survival

The following section describes the production and survival metrics associated with the hatchery program and compares the observed performance with the anticipated program mitigation benefits. Information includes in-hatchery and post release survival and contribution to fisheries for the LSRCP steelhead mitigation program in the Clearwater River.

With few exceptions, egg to release survival rates have remained consistently high over the program time series and have not limited the ability of CFH to reach production targets (Figure 4). Under the current management scenario, CFH has insufficient rearing capacity to produce 1.75M yearling steelhead smolts. The interim smolt release target of 843,000 has been consistently met since 2002 (Figure 5).

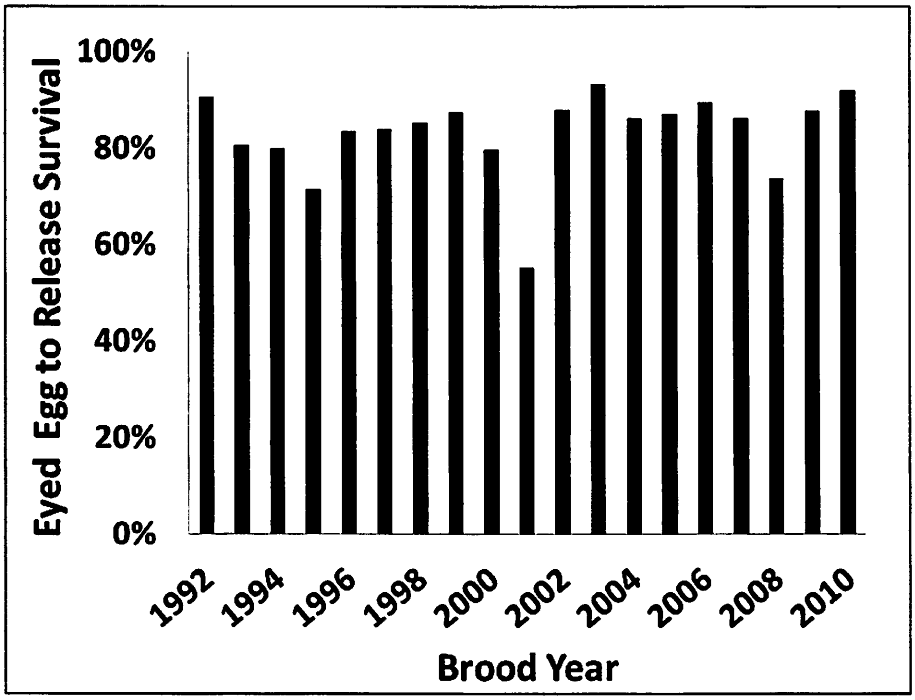

Figure 4. Eyed egg to release survival rates for steelhead reared at Clearwater Fish Hatchery 1992-2010.

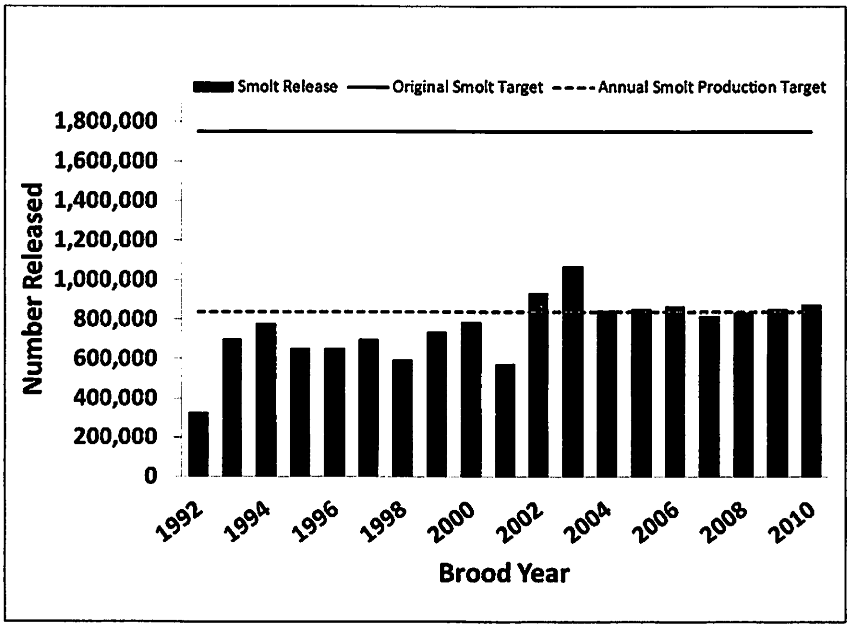

Figure 5. Number of yearling steelhead smolts released from Clearwater Fish Hatchery 1992-2010.

Survival of smolts from release sites to Lower Granite Dam is estimated using PIT tagged smolts. For migration years 1993-2011, estimated survival rates have remained stable and have averaged 75.7% (range: 58-86%) (Figure 6). While there really is not a benchmark or goal for juvenile survival to Lower Granite Dam for hatchery steelhead, survival rates observed from CHF are comparable to other facilities in the Snake River basin.

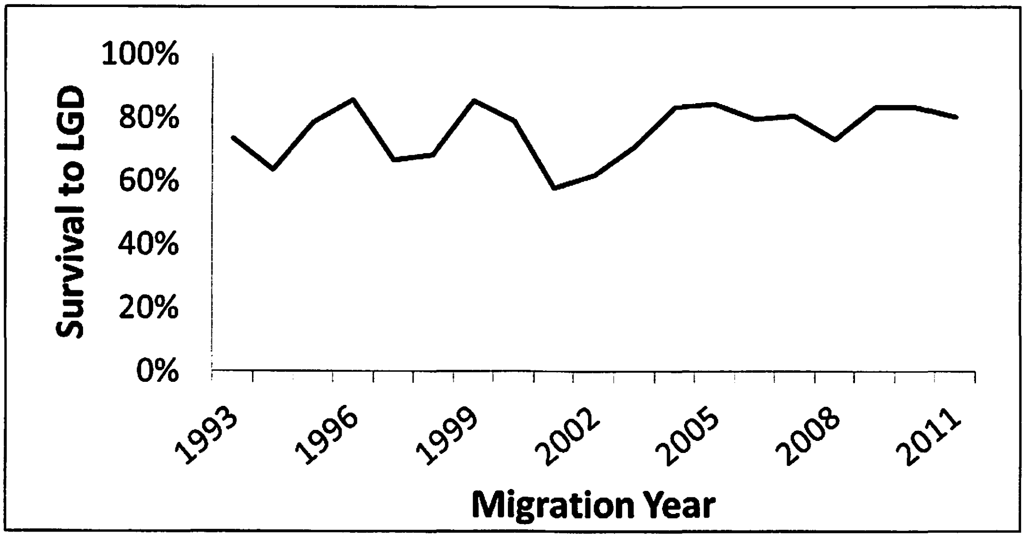

Figure 6. Estimated steelhead smolt survival from release site to Lower Granite Dam from Clearwater Fish Hatchery 1993-2011.

The number of total adults produced annually from CFH is estimated by summing hatchery rack returns, harvest estimates, and the fish recovered as strays. As described earlier is this document, the total adult mitigation goal for the LSRCP Clearwater River program is 42,000 adults produced annually. Since 1996, the average annual number of adults produced from CFH is 13,287 (range: 2,484-24,504) (Figure 7). Since 2003, adult returns have averaged 18,106 annually. Over the history of the CFH program, the total mitigation goal has never been achieved. Given that CFH lacks the rearing capacity to rear the original smolt production target of 1.75M, this is not unexpected. Despite not meeting the mitigation goal, this program has helped to maintain robust fisheries in the Clearwater River.

It should be noted that estimating the total adult returns for CFH steelhead production is problematic in that IDFG has been unable to obtain a full accounting of the unharvested escapement. Managers suspect that under some flow conditions in the South Fork Clearwater River there is a migration impediment preventing adult steelhead from getting back to the release locations at the Red River and Crooked River satellite facilities. In the absence of complete escapement data, we are unable to directly estimate total adult returns. In the absence of a direct estimate we have used the observed SAR rate for steelhead returning to the DNFH trap as a surrogate to estimate adult returns for the CFH releases. By applying the DNFH SAR rate to the smolt releases from CFH we derive a total number of fish produced. All CFH adults recovered in fisheries or as strays are subtracted from the total. The balance represents the unharvested escapement.

In recent years, managers have been working to improve the quality of adult return data. Several changes in technology and infrastructure have been made to improve our ability to monitor the adult returns for the CFH steelhead program.

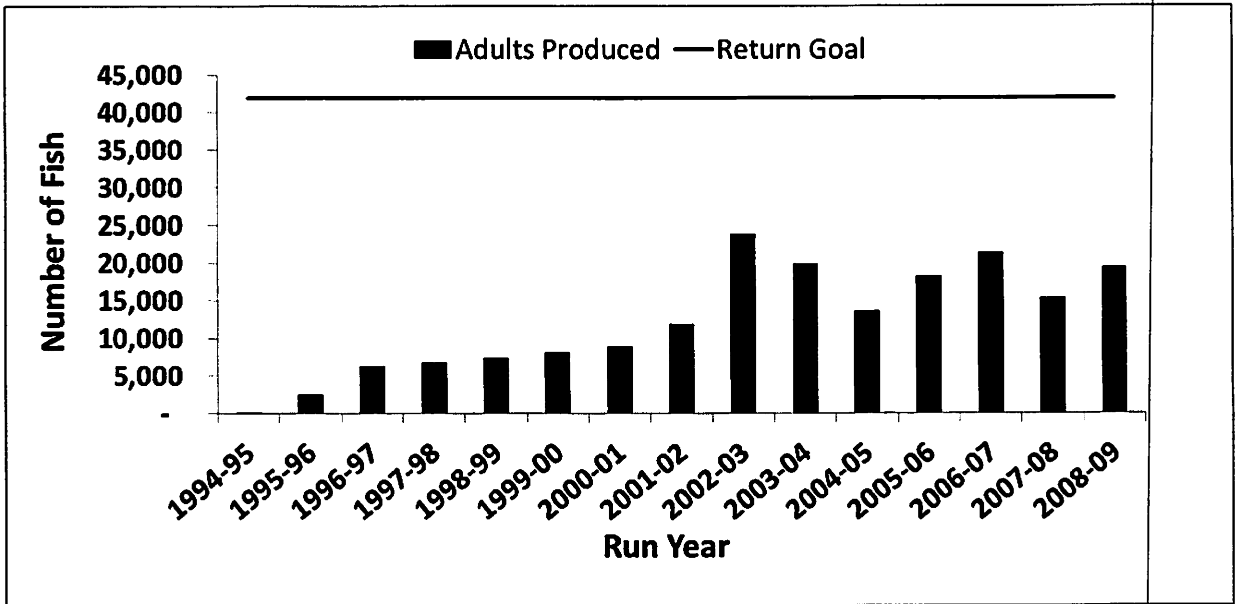

Figure 7. Total hatchery steelhead produced from Clearwater Fish Hatchery 1985-2011.

In brood year 2007, IDFG began tagging larger numbers of CFH steelhead with PIT tags to estimate the adult escapement to Lower Granite Dam. PIT tags provide valuable information related to migration timing, conversions between dams, and return rates. The first two-ocean adults returned to Lower Granite Dam during the 2010-2011 run year for CFH. When we compared the estimated escapement to LGD using the PIT tag method and the method of using the DNFH SAR as a surrogate, it appears that the traditional method overestimated the escapement to LGD for 2011. For the first few years of PIT tag return data, we have observed that PIT tags do underestimate the return due to tag loss and potentially a differential survival of tagged and untagged fish. The rate of underestimation also appears to be variable between facilities and across years. While PIT tags can provide other useful information such as migration timing and conversion rates, the variability associated with tag loss does limit the utility of PIT tags to estimate adult survival rates if the rate of tag loss cannot be estimated. In 2012, an in-stream PIT tag array was installed in the lower SFCR by the Nez Perce Tribe for monitoring both hatchery and natural adult returns to the SFCR. This array will provide valuable information for the hatchery return including timing of tributary entry, fidelity to release locations and conversion rates of fish detected at Lower Granite Dam to the SFCR.

In 2008, IDFG initiated the process of shifting the steelhead marking program to a genetic technology whereby essentially all progeny are tagged via Parental Based Tagging (PBT). This is accomplished by taking tissue samples from all adults that contribute to hatchery broodstocks. When any of their progeny are sampled (as juveniles or adults), the parents can be identified thus revealing the hatchery, stock, age, gender, and release site. When progeny from these adults return they are systematically sampled at Lower Granite Dam to directly estimate the stock and age composition of the hatchery-origin steelhead. Managers feel that this methodology will provide the most reliable return estimates.

In addition to refining monitoring methods for adult returns for the CHF program, IDFG is also working to develop a new trapping facility further downstream in a tributary of the SFCR. It is anticipated that this new location will provide a suitable site to collect the unharvested escapement in the South Fork and enable us to develop a localized SF Clearwater River steelhead broodstock.

Assumptions that were initially used to size the LSRCP hatchery programs included a smolt to adult survival (SAS) rate of 2.4% to achieve adult mitigation objectives for CFH. For brood years 1992-2006 average SAS was 1.78% (range: 0.72-3.01%) (Figure 8). Given that the current rearing capacity at CFH will not support the original smolt release target of 1.75M yearling smolts, SAS is useful to assess performance across programs regardless of the number of smolts released. For CFH, the SAS that was modeled as being necessary to achieve the mitigation objective has been reached in only three years since 1992 and is similar to what has been observed for the steelhead programs in the Salmon River.

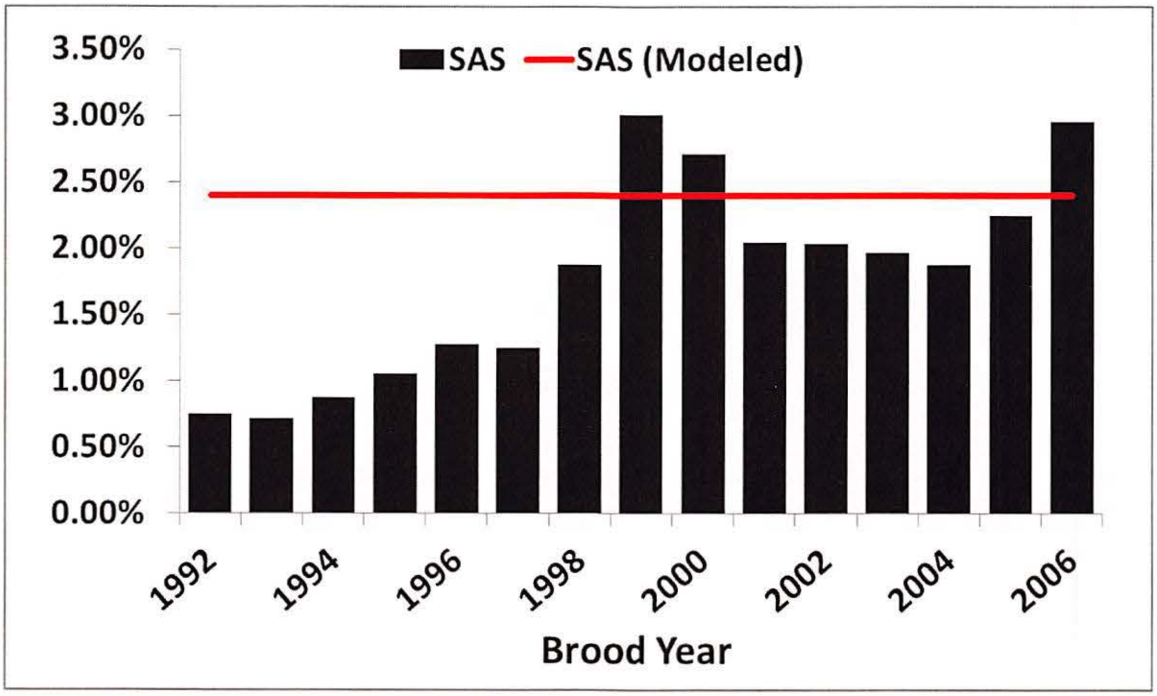

Figure 8. Estimated smolt to adult survival (SAS) rate for hatchery steelhead produced at Clearwater Fish Hatchery for brood years 1992-2006.

Stray Rates

Adult steelhead recovered (fisheries, hatchery traps, spawning grounds etc.) anywhere outside of the direct path to the release location are considered strays. It is possible that fish harvested outside of the direct path to the release site during the summer and fall months may have ended up back on the direct path had they not been harvested but there is not a good method to estimate this parameter. It should also be noted that these stray rate estimates are based strictly on fish that are recovered as strays in fisheries and natural spawning areas where sampling programs are in place. Because not all fisheries and natural spawning populations are sampled, reported stray rates are likely underestimates. IDFG has historically used the Left Ventral (LV) fin clip as a flag for the presence of CWT in steelhead but that clip was discontinued in brood year 2006 for B-run steelhead. Any current recovery programs that are restricted to visual scanning for the presence of CWT will miss the CWT tagged fish and the stray rate will be underestimated. For brood years 1992-2007 estimated stray rate of adults from

CFH averaged 0.8% (range: 0-6.8%) (Figure 9). The majority of fish recovered as strays from CFH were recovered upstream of Lower Granite Dam (90%). Some of the recoveries upstream of Lower Granite dam were in fisheries located immediately upstream of the direct path to the release location but based on the strict definition were included in stray rate estimation.

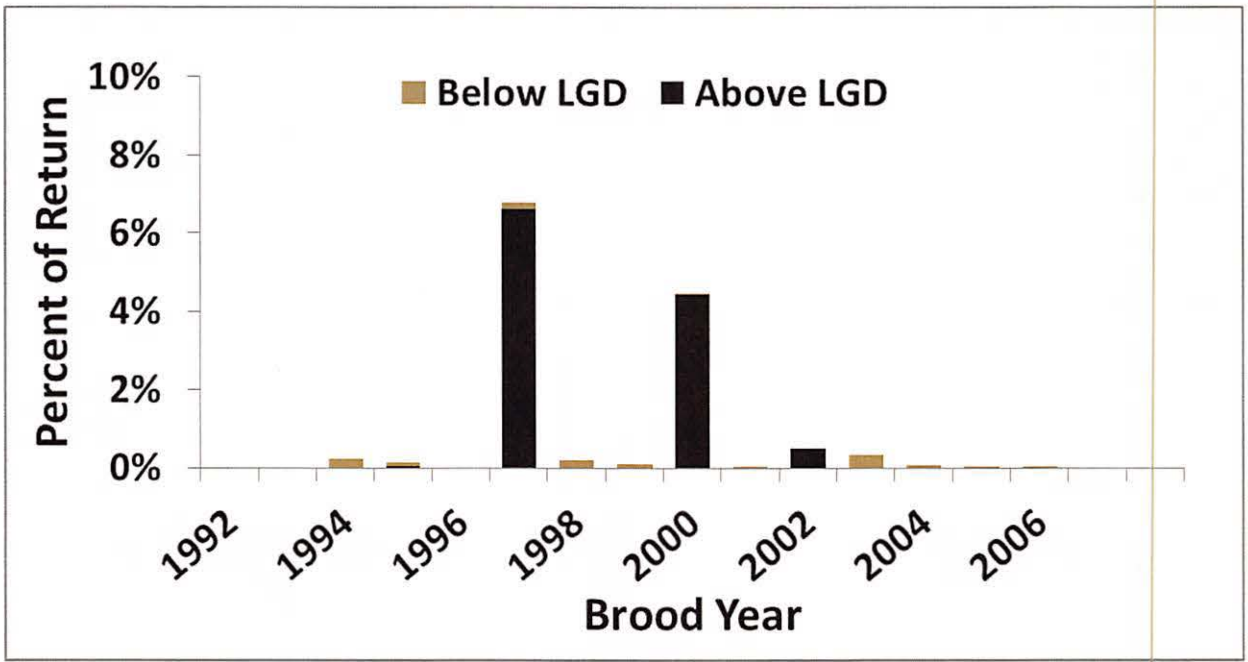

Figure 9. Estimated stray rates of hatchery steelhead produced at Clearwater Fish Hatchery for Brood Years1992-2007. Estimated stray rates are differentiated for the areas upstream and downstream of Lower Granite Dam.

Contribution to Harvest

Harvest Downstream of Lower Granite Dam

As previously mentioned, the primary focus of the LSRCP hatchery program in the Clearwater River is harvest mitigation. Since the inception of the program, CFH has produced numbers of adult steelhead sufficient to maintain robust sport and tribal fisheries in Idaho and have also supported fisheries downstream of the project area (Figure 10). Over the CFH history, the estimated harvest rate in areas downstream from Lower Granite Dam averaged 4% (range: 1-13%). It should be noted however, when these harvest rate estimates are compared with the cumulative harvest information for B-run index stocks reported by the US v. OR Technical Advisory Committee (TAC) for the Columbia River downstream from McNary Dam, it appears that the harvest rates based on CWT expansions for CFH underestimate the actual harvest assuming that the CFH releases are harvested at a similar rate as the aggregate B-run index stocks used by TAC (Figure 10).

If the CFH releases are harvested at a similar rate, there are a couple of possible explanations for why the harvest rates reported for these stocks are underestimated. First, there could be an insufficient number of fish marked with CWTs to accurately represent the stock

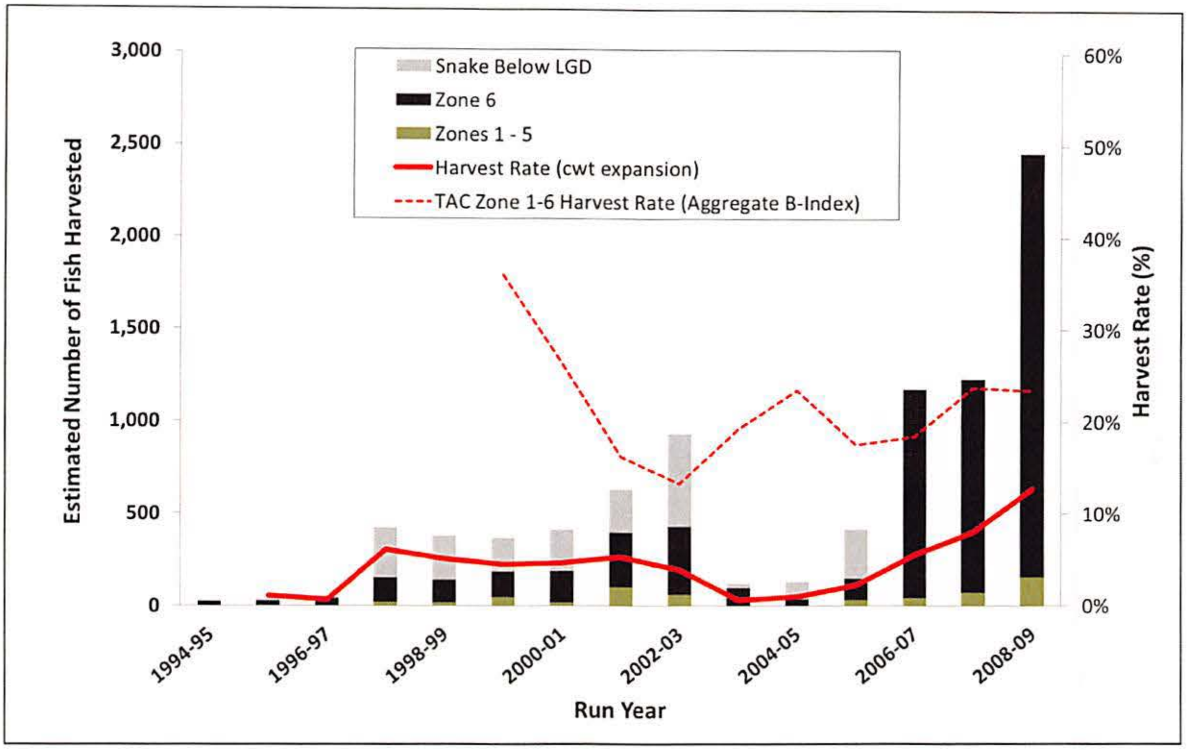

Figure 10. Estimated harvest rates of hatchery steelhead in the Columbia and Snake rivers downstream of Lower Granite Dam for return years 1995-2009. All fish were produced at Clearwater Fish Hatchery.

composition of the harvest. Over the history of the CFH program, the major release groups from Clearwater hatchery have been tagged with CWT (usually 60-80K CWTs). However, in some years, not all of the release groups were tagged with CWT. In these situations, the CW tagged groups were used as surrogates to represent the untagged releases. If the untagged release groups survive at a different rate, or behave differently in the fisheries, a harvest rate estimate based on data from a tagged surrogate group would be biased. Given that the tagged and untagged release groups are the same stocks reared at the same facility, it is unlikely that a significant bias would result. A second possible explanation is that escapement estimates at LGD are overestimated for CFH. An overestimate of the escapement would artificially decrease the harvest rate downstream of LGD. To examine this, we have taken a preliminary look at the escapement data and summarized the total estimated escapement to Lower Granite Dam across all programs (Oregon, Idaho and Washington) located upstream of Lower Granite Dam and compared those totals to the window counts at Lower Granite Dam (Figure 11). For every year, the summed escapement estimates are less than the total window counts for hatchery fish. Given this, it is unlikely that we are overestimating the escapement at Lower Granite Dam. However, as mentioned in the previous section, the one data point we have comparing a PIT tag derived escapement estimate with our traditional escapement estimate method indicated that we overestimated the escapement at Lower Granite Dam so it is possible that this could be contributing to the underestimation of the harvest. A third possible explanation is that CWTs from CFH are not being sampled representatively in the observed catch. We have no information to indicate this is happening but we are going to work with agency staff from Oregon, Washington and CRITFC to try and determine if this issue exists. We are also going to do a more thorough review of the historic CWT recovery data to try and resolve this discrepancy.

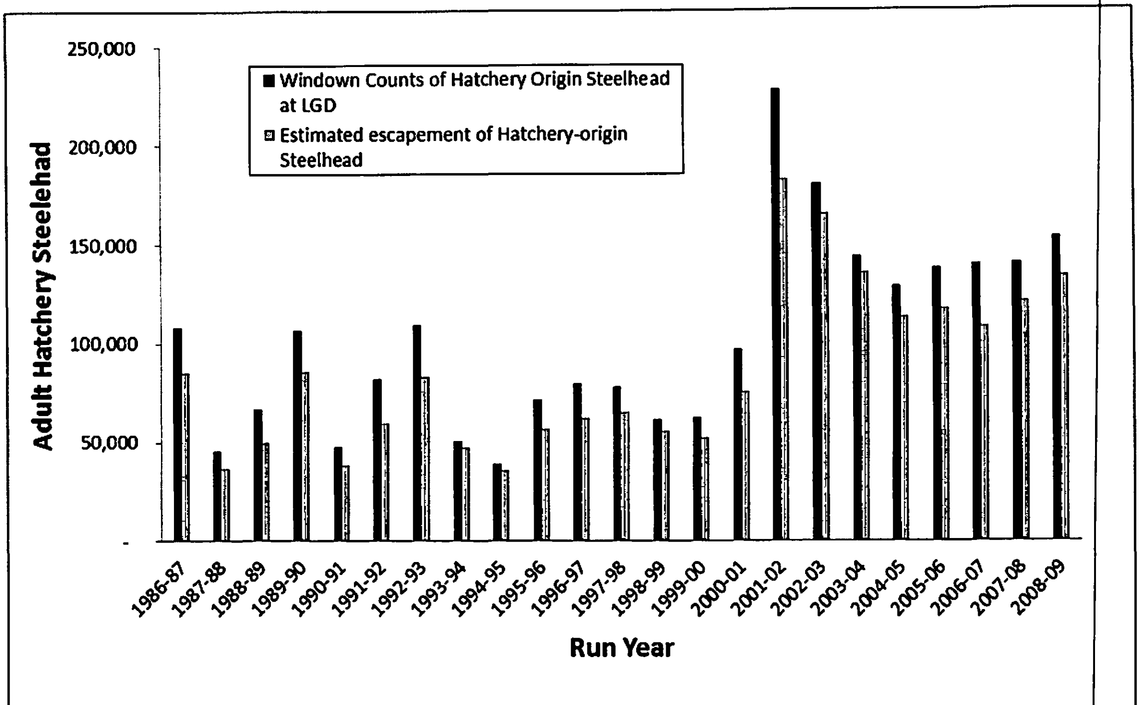

Figure 11. Comparison of the total estimated escapement of hatchery steelhead produced upstream of Lower Granite Dam to the window counts at Lower Granite Dam 1986-2009

Beginning in the fall of 2011, with cooperation from CRITFC and WDFW, tissue samples from the observed harvest both above and below Bonneville Dam are being collected as part of the PBT steelhead tagging program initiated in brood year 2008. Samples will be analyzed to estimate the harvest contribution of Snake River steelhead in the Zones 1-6 fisheries. We will compare the results of the PBT stock composition analysis with the CWT analysis to help identify if the CWT data is biased.

Harvest Upstream of Lower Granite Dam

Over the history of the LSRCP program, Idaho has maintained consistent and robust steelhead fisheries in the Clearwater River providing anglers with abundant opportunity in both time and space. The number of adult steelhead from CFH harvested upstream of Lower Granite Dam annually between 1997 and 2011 averaged 16,628 (range: 608-14,006) (Figure 12). Harvest rates over the same period averaged 60.5% (range: 10.8-95.8%).

There are currently 141 river miles open to steelhead fishing in the Clearwater River basin including 304 days open to steelhead fishing in all river zones with 273 days open to steelhead harvest in some river zones and a minimum of 197 days open to steelhead harvest in all river zones (Figure 13). Total annual angler effort in the Clearwater River since 1984 has averaged 152,800 angler days (range: 69,000-220,000 days) (Figure 14). Steelhead fisheries in the Clearwater River basin provide unique opportunity for anglers to spread out and achieve the angling experience they desire in a variety of riverine habitats and conditions throughout the majority of the year.

When comparing harvest and angler effort over the program time series in the Clearwater River including the period prior to hatchery mitigation, the current harvest and angler effort estimates are considerably higher than the pre-mitigation period. It is important to note that the catch and effort displayed in Figure 14 represents the combined harvest and effort information for both the LSRCP and USACOE programs. To show the relationship with harvest and effort it was necessary to combine them since effort cannot be attributed to a single program due to the significant spatial and temporal overlap of the programs (LSRCP and USACOE). The primary purpose of the figure is to convey that the hatchery mitigation program is maintaining sport fisheries relative to the pre-mitigation period.

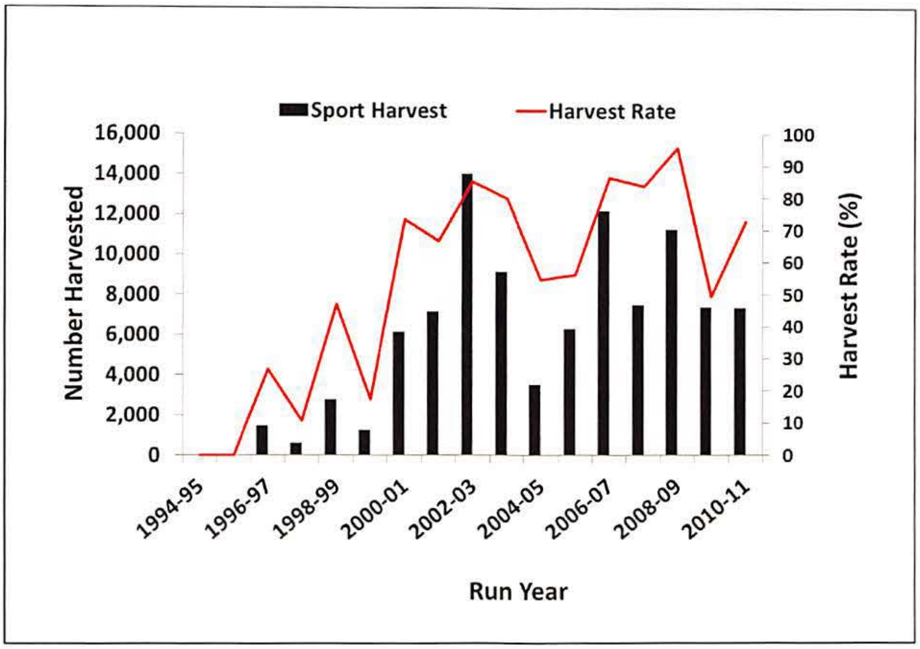

Figure 12. Estimated number of hatchery steelhead harvested upstream of Lower Granite Dam 1995-2011. All fish were produced from Clearwater Fish Hatchery.

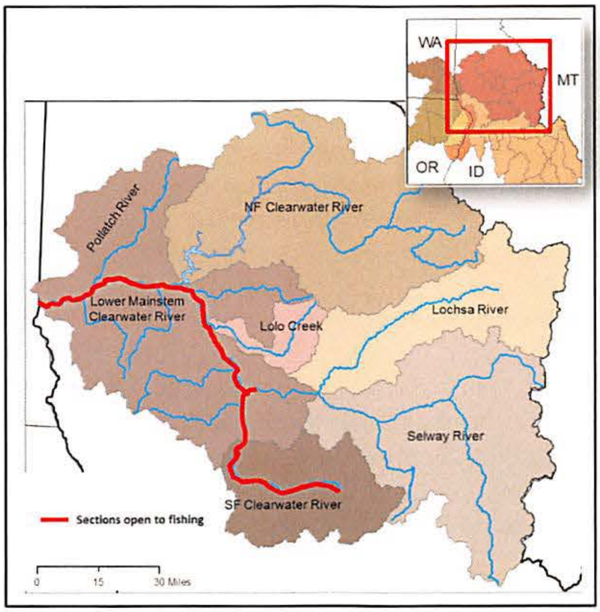

Figure 13. Hatchery steelhead fishing boundaries in the Clearwater River, ID.

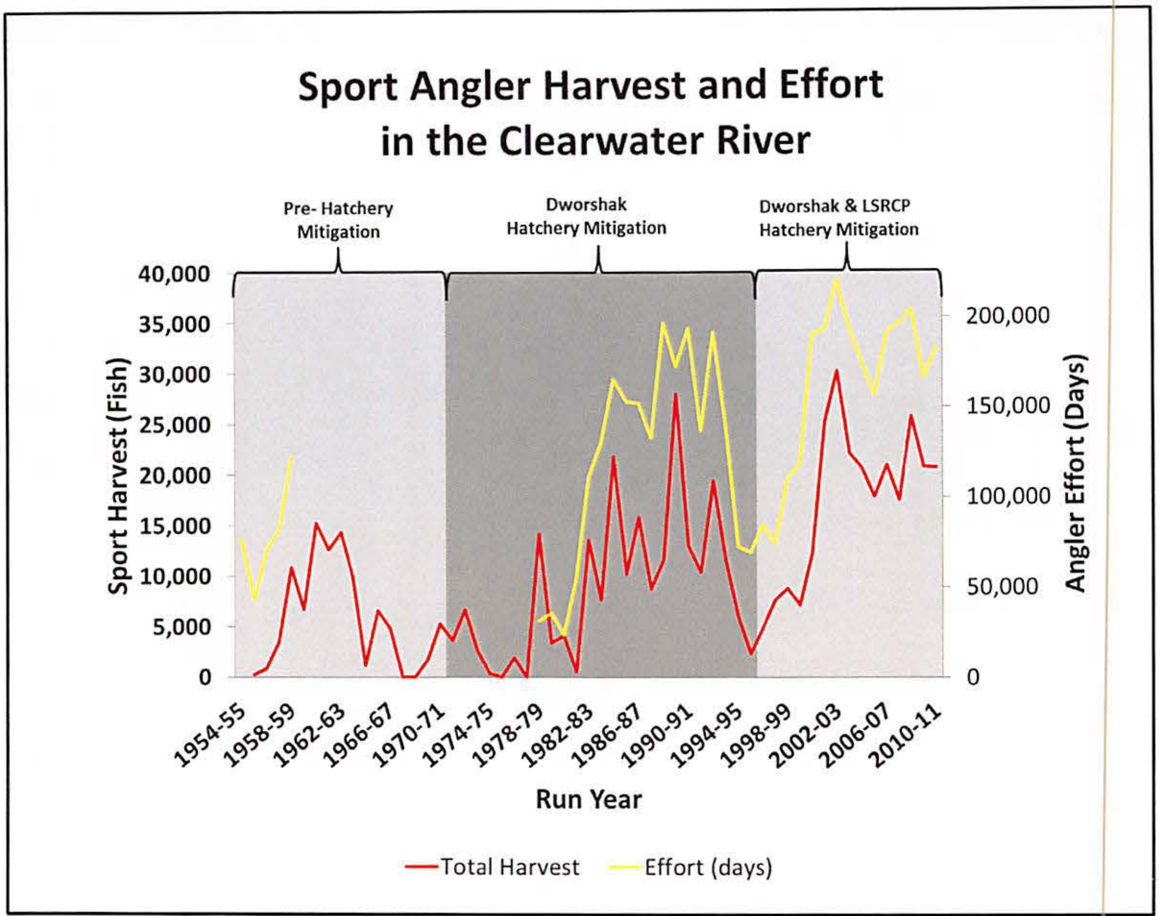

Figure 14. Estimated harvest and angler effort for the hatchery steelhead fisheries in the Clearwater River 1955-2011.

Summary and Moving Forward

Since the inception of the LSRCP hatchery mitigation program in Idaho, IDFG has prioritized harvest mitigation as the primary function of the hatchery program and has focused efforts to maximize SARs, provide anglers with abundant harvest opportunity, and to meet adult mitigation objectives. During this period, hatchery practices have been refined and with few exceptions, broodstock collection and in-hatchery survival has not limited the ability of managers to meet smolt production objectives. Hatchery adult returns from CFH have consistently provided robust fisheries upstream of the project area and have also contributed to fisheries downstream of the project area. While the total adult mitigation objective has never been reached, CFH has produced on average 33% of the total mitigation goal since 1997 even though the rearing capacity at CFH is limited to approximately half of the original intended smolt production. Managers do have expectations to increase steelhead smolt production in the Clearwater River to meet mitigation objectives.

The Clearwater River represents a significant portion of the habitat in the Snake River that historically produced wild steelhead. Likewise, the Clearwater River hatchery steelhead program is the second largest hatchery steelhead program in the Snake River. In addition to the LSRCP hatchery mitigation, 2.1 million steelhead smolts that are part of the hatchery mitigation for Dworshak Dam is also operated within the Clearwater River in the same general proximity to the

LSRCP program. Managers realize that operating a hatchery mitigation program this large is not without some risk to natural populations. Since the inception of hatchery mitigation efforts in the Clearwater, IDFG has maintained a management framework that emphasizes reducing interactions between hatchery-origin and natural-origin fish by confining hatchery releases to areas likely to have the least impact on natural populations.

The IDFG views the LSRCP hatchery steelhead mitigation program as a success story in that it has made significant progress towards achieving the targeted management objectives. This program has provided consistent and robust steelhead fisheries throughout the program history and has maintained the ability of managers to provide abundant angling and harvest opportunity over a vast landscape during the majority of each year. These fisheries have not only provided significant economic impacts to the state, but have also helped to maintain a connection between citizens and our natural resources.

The IDFG is fully committed to maintain and restore ESA listed populations of steelhead. At the same time we are also committed to continue the operation of the hatchery mitigation program. To address this, we have developed a management framework that incorporates both objectives. Hatchery and Genetic Management Plans (HGMPs) have been developed to describe the management goals, program plans, monitoring and evaluation plans, and plans for addressing risks associated with each of the programs. We view these plans as guidance documents and understand the need to remain flexible as new information becomes available to help guide and improve the programs in such a way to better achieve the stated IDFG management objectives.

Acknowledgements

We would like to extend our sincere appreciation to the dedicated staffs at the Clearwater Fish Hatchery and Dworshak National Fish Hatchery for their efforts in maintaining high quality fish culture operations in the Clearwater River. We would also like to thank the many cooperators in the basin that help to make this a successful program including staff at the IDFG regional office in Lewiston, Pacific States Marine Fisheries Commission, harvest monitoring crews, and the staffs from the Nez Perce Tribe and the US Fish and Wildlife Service. Lastly, we would like to thank the staff at the LSRCP office in Boise, ID for providing funding and support to maintain and improve the program.

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Summer Steelhead Releases into the Grande Ronde River: Wallowa Stock - Hatchery Program Review 1982-2012

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This program is a cooperative effort of the Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife, the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation. The program is funded by the Bonneville Power Administration and administered by the United States Fish and Wildlife Service under the Lower Snake River Compensation Plan.

INTRODUCTION and BACKGROUND

This paper provides background information, program development history, and an assessment of program performance for the Washington Department of Fish and Wildlife's (WDFW) Wallowa stock summer steelhead (*Oncorhynchus mykiss)* hatchery program. The coverage period is from program initiation in 1982 to the present (spring of 2012).

A precipitous decline in numbers of Snake River steelhead (Figure 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.

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 was constructed as the core of the mitigation program and an existing state facility, the Tucannon Hatchery was renovated. Three acclimation ponds for steelhead were also constructed: Curl Lake on the Tucannon River; Cottonwood Pond on the Grande Ronde River; and Dayton Pond on the Touchet River (Figure 2).

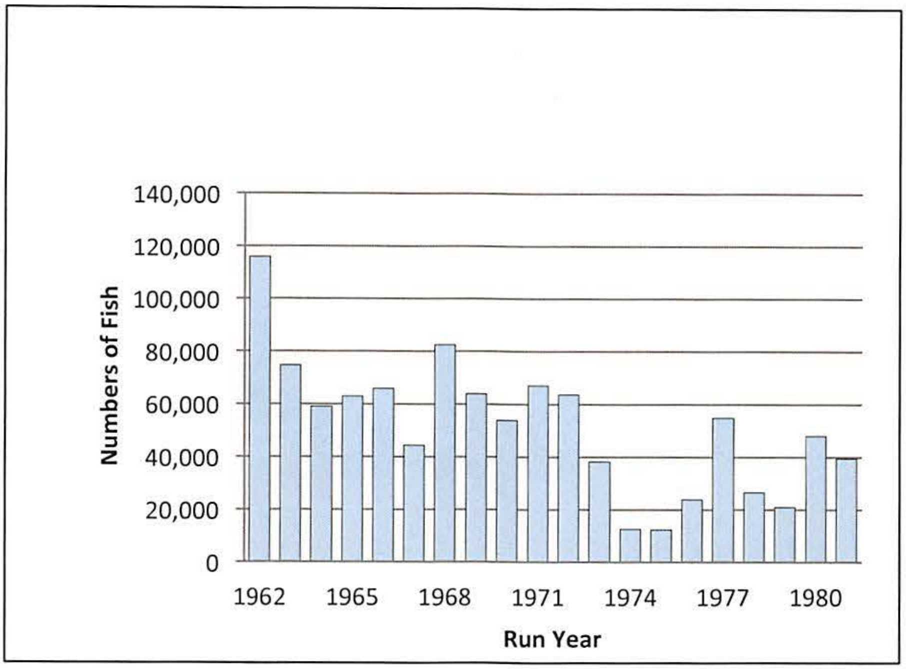


Figure 1. Counts of summer steelhead at Ice Harbor Dam, 1962-1981 Run Years.

The Cottonwood Acclimation Pond is located at river kilometer 46 on the mainstem of the Grande Ronde River (Figure 2). The acclimation site is operated as a satellite of Lyons Ferry Hatchery, which serves as the incubation and rearing facility for WDFW's Wallowa stock summer steelhead program. In 1992, an adult trap was constructed on Cottonwood Creek (acclimation pond water supply source) to allow WDFW to trap/spawn the Wallowa stock steelhead returning to Cottonwood Creek. Prior to that time, eyed eggs for the program were provided by Oregon Department of Fish and Wildlife (ODFW).

Under the LSRCP, Washington's entire steelhead program would mitigate for 4,656 summer steelhead to the project area at various locations within SE Washington (Table 1). The project area for the WDFW steelhead program is defined by all areas above Ice Harbor Dam. In the Grande Ronde River, the summer steelhead program was to be accomplished by annual production of 300,000 steelhead smolts @ 8 fish/lb, with the goal to return 1,500 adults (0.5% survival) to the project area, or 4,500 adults (1.5% survival) to the Columbia River Basin, based on an assumed downriver catch to escapement ratio of two-to-one that existed prior to construction of the dams.

Table 1. WDFW LSRCP summer steelhead smolt releases and mitigation goals.

Location	Original Smolt Goals	Current Smolt Goals	Adult Goal to Project Area	Total Adult Goal
Snake R.	126,000	160,000	630	1,890
Tucannon R.	175,000	0	876	2,628
Walla Walla R.	180,000	100,000	900	2,700
Touchet R.	150,000	85,000	750	2,250
Grande Ronde R.	300,000	200,000	1,500	4,500
TOTALS	**931,000**	**545,000**	**4,656**	**13,968**

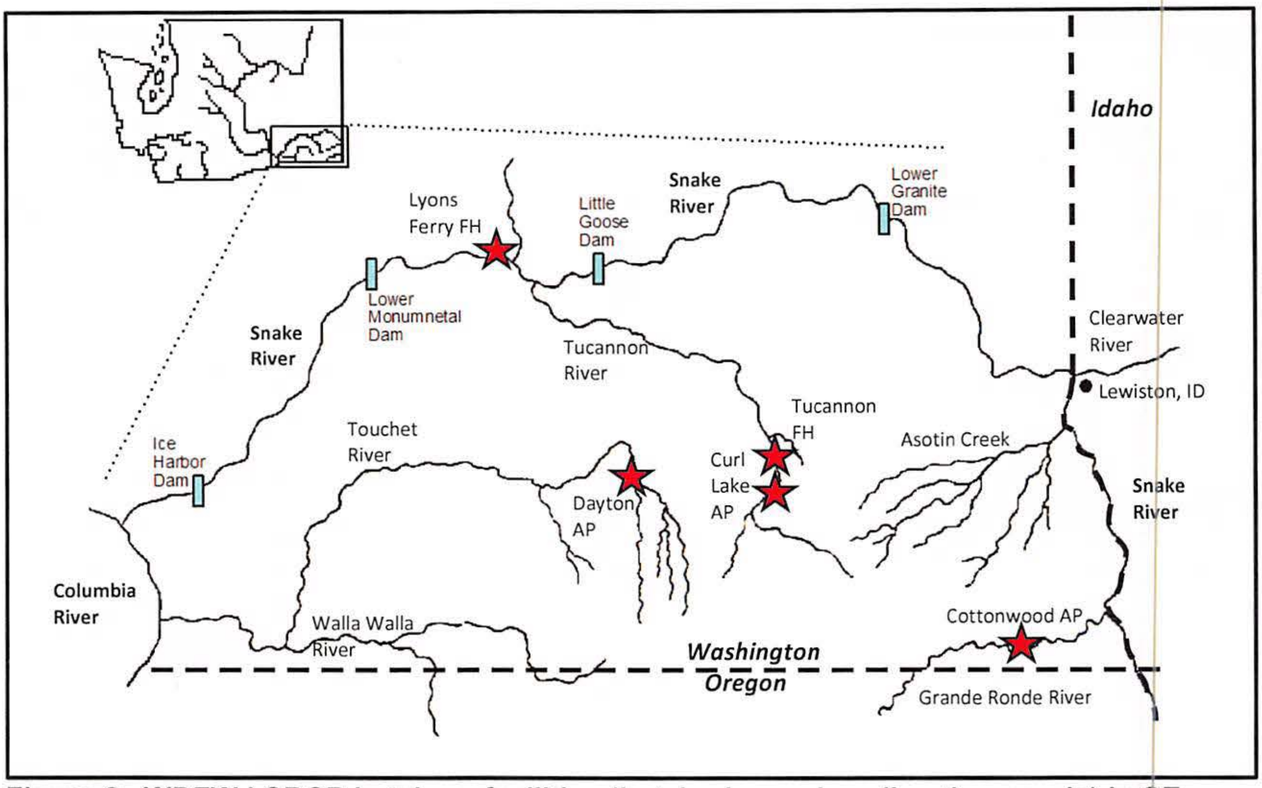


Figure 2. WDFW LSRCP hatchery facilities (hatcheries and acclimation ponds) in SE Washington.

The survival rates of 0.5% and 1.5%, were not goals, but used as a guideline for managers to determine the size of hatchery facilities needed, and should be considered as "design criteria survival goals". Over time, changes in the smolt production have occurred and the current goal is 200,000 smolts @ 4.5 fish/lb to meet the original adult goals. Current smolt-to-adult survival (SAS) and smolt-to-adult return (SAR) expectations needed to meet the adult goals for the program are 2.25% and 0.75%, respectively.

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, and 5) Coordinate actions with other basin managers. These goals have directed actions taken by WDFW to ensure the success of the LSRCP program, and have played a key role in guiding our monitoring and evaluation efforts for the program as needed. In addition to the original goals, as summer steelhead became listed within the Snake River basin, WDFW added additional goals that were more focused on wild steelhead protection: 1) Monitor the status and trends of natural steelhead populations where LSRCP fish might have effects, and 2) Ensure the program is compliant to the greatest extent possible with ESA (HGMP's, FMEP's) and WDFW Policies to protect and recover wild populations. Currently, the WDFW LSRCP program gathers information that is provided and used by LSRCP, US v Oregon Management and ESA, and plays a critical role in the management of the steelhead in SE Washington.

PROGRAM ASSESSMENT

The Wallowa stock of steelhead was developed by ODFW in the late 1970s (Snake River origin fish trapped at Lower Snake dams were used to start the stock) for use in the Wallowa River LSRCP program [Refer to ODFW Wallowa stock summary for more details]. WDFW and ODFW identified the Wallowa stock as the stock of choice for harvest mitigation in the Grand Ronde River, and aided ODFW in building returns of fish for each program. Currently, WDFW requires about 60 full-spawned females to meet program needs, though 1/2 –spawned females are also used to increase/maintain genetic diversity within the stock. Crosses with males are generally 1:1. Run timing of adults to the trap in Cottonwood Creek varies annually depending on how much water is available during the spring (Figure 3A). In low water years nearly all the water is siphoned off from Cottonwood Creek for the acclimation pond, which limits the ability of adults to swim up Cottonwood Creek and enter the trap. Since 1992, there have been two years where eggs had to be provided by ODFW due a lack of returning adults to the trap. Spawning of broodstock generally occurs from the third week in March to the second week in April. The number of adults returning to Cottonwood Creek varies annually, and very few natural origin adults are observed (Figure 3B).

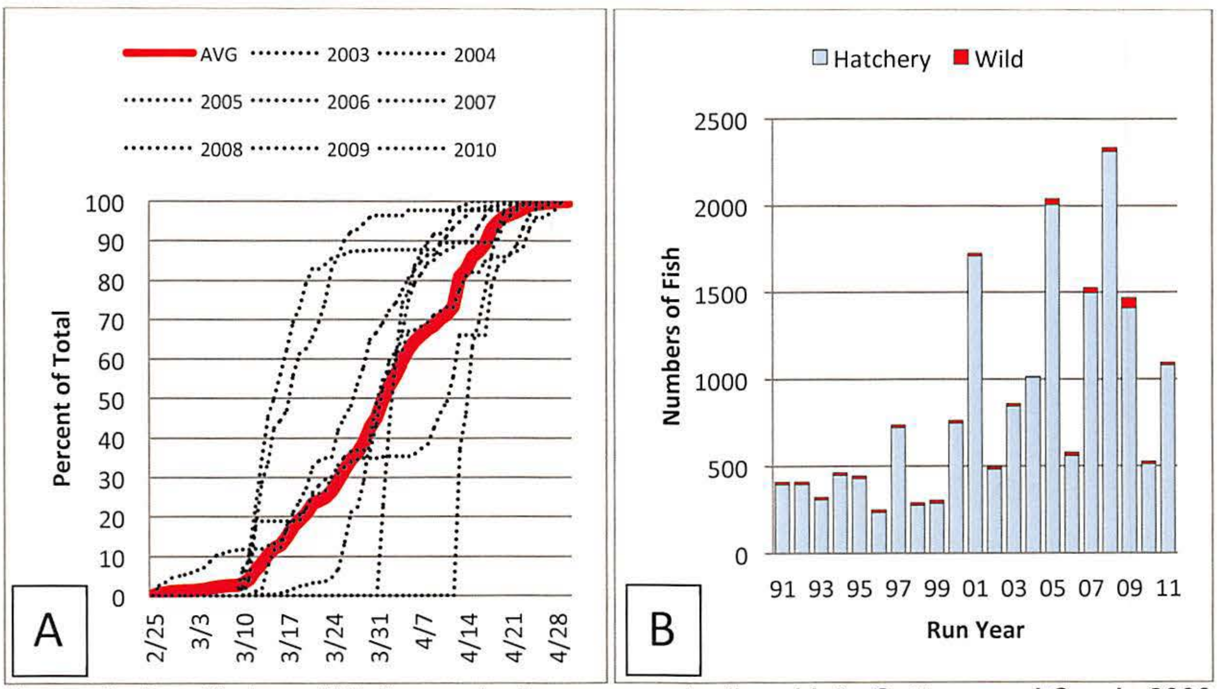


Figure 3. Run timing of Wallowa stock summer steelhead into Cottonwood Creek, 2003-2010 (A), and the number of hatchery and wild origin summer steelhead captured at the Cottonwood Creek adult trap from 1991-2011 run years (B).

Between 1994 and 2008, management of hatchery origin adults in Cottonwood Creek was as follows: 19% were spawned, 15% were killed out-right for data (coded-wire tags, etc...), 2% were pre-spawn mortalities, and the remaining 64% were passed upstream for natural spawning in Cottonwood Creek. In 2009, management of adults was changed (IHNV concerns to juveniles and broodstock adults) and is as follows: 14% spawned, 70% killed out-right for data (coded-wire tags, etc...) or euthanized to prevent straying and spawning, 6% pre-spawn mortalities, and 10% provided to food banks. Pre-spawn mortality has increased slightly, but this is likely due to holding of fish which become over-ripe and die – in the past these fish would have been passed upstream. Of the coded-wire tags recovered in Cottonwood Creek since

1992, 99.8% have been WDFW Wallowa stock releases; no ODFW Wallowa stock steelhead have ever been recovered in Cottonwood Creek.

For each steelhead program at Lyons Ferry Hatchery, counts or estimates of production are made at various life stages. Over the years, the number of green eggs and eyed-eggs have been estimated through either volumetric or weight sampling methods, or mechanical egg counters. Eyed egg-to-smolt survival has been consistent for the entire program, and green egg-to-smolt survival has increased in recent years due to a change in green egg handling at Cottonwood (Figure 4A). Disease incidence in the Wallowa stock at Lyons Ferry has been low, with no outbreaks of INHV and although bacterial coldwater disease is sometimes present, it has not affected overall smolt production. Production of Wallowa stock steelhead since 1983 has achieved or closely approached the goal of number of fish to be released (Figure 4B). Each release group is currently 100% adipose fin clipped for selective harvest fisheries, and coded-wire tagged (20,000) and PIT tagged (4,000) for estimating adult returns and assessing straying. During adipose fin clip marking, a complete count of the stock is provided, with any mortality subtracted from that point forward to estimate total smolt release numbers. Adjustments are made as necessary to account for predation loss at the hatchery while the fish are in the large rearing lakes. At release, a minimum of 200 smolts are sampled (length/weight) and multiple pound-counts from each steelhead release group produced at Lyons Ferry (either from Acclimation Ponds or raceways at the hatchery) to estimate smolt size (length, weight, CV, fish/lb, and K-factors). Smolt survival to Lower Granite Dam has generally been high (>60%), and is comparable to survivals seen from ODFW and IDFG releases of steelhead from the Grande Ronde, Imnaha, and Salmon river basins.

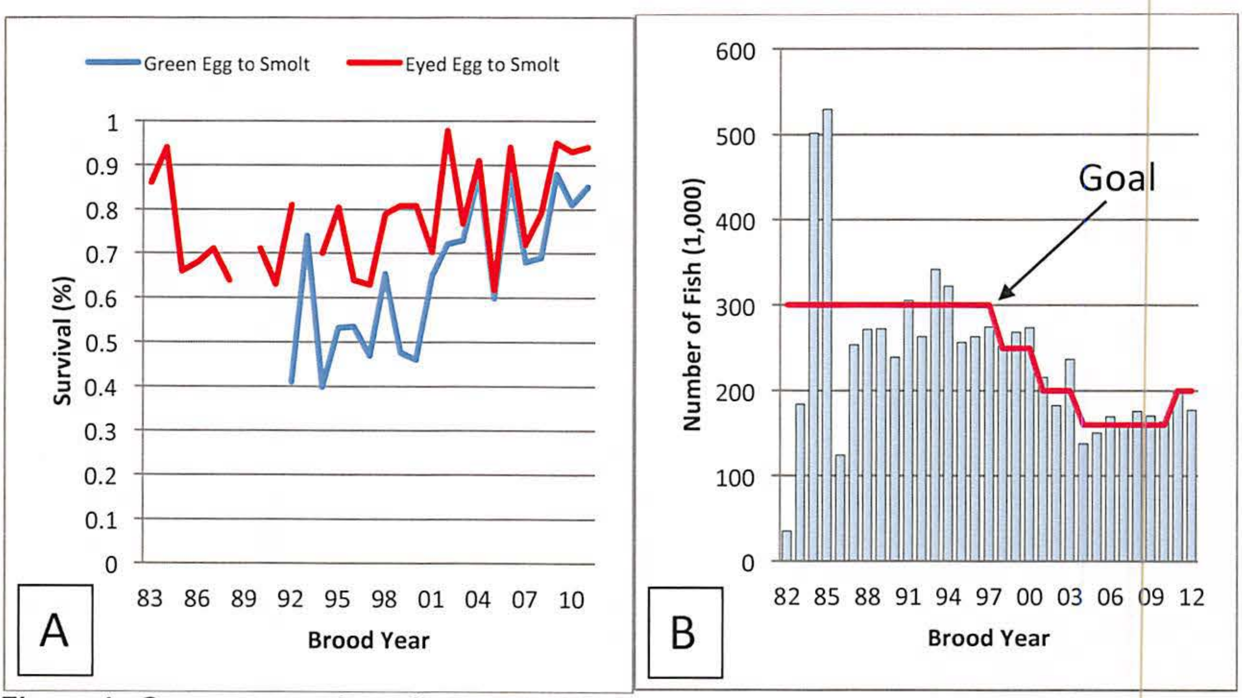


Figure 4. Green-egg and eyed-egg to smolt survival of Wallowa stock fish reared at Lyons Ferry Hatchery (A), and smolt production of Wallowa stock steelhead released into the Grande Ronde Basin by WDFW (B).

The primary function of the Wallowa stock steelhead program has been to return fish for harvest, and broodstock needs. Run timing of Wallowa stock adults to the Columbia and Snake rivers coincide well with established sport, commercial and tribal fisheries in the basins (Figure

5). Washington's Wallowa stock steelhead program has been highly successful in returning adults to the project area above Ice Harbor Dam (1,500 adult goal has been met or exceeded every year) (Figure 6A), and has met the downriver adult goal about 50% of the time (Figure 6B). The SAS and SAR survivals have also met expectations (Figure 7). Progeny:Parent ratios for the Wallowa stock program since trapping/spawning has occurred at Cottonwood Creek (1992) has average 30, another indicator of the program's success.

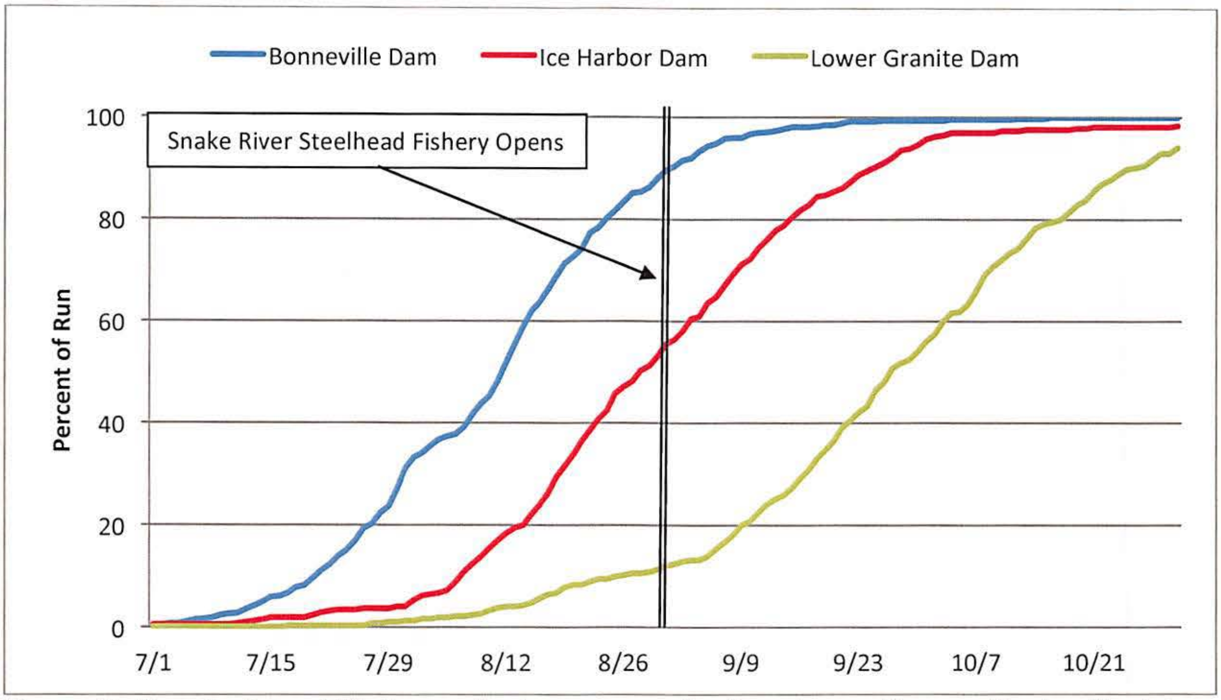


Figure 5. Run timing of Wallowa stock summer steelhead over Bonneville, Ice Harbor, and Lower Granite Dams based on PIT Tags, 2009-2011 run years.

Currently, Wallowa stock summer steelhead are exploited at very low rates in the ocean and lower Columbia River, but are harvested heavily in steelhead sport fisheries in the main-stem Snake and Grande Ronde rivers (about 58%), with about 33% escaping the fisheries and returning to Cottonwood Creek (Table 2). Mean exploitation rate taken in all fisheries (including those shown as strays because the fish were captured outside of the juvenile migratory route) is 67%. Average stray rate from 2001-2006 brood years as defined by the juvenile migratory route is 6.5%. However, many of the fish defined as strays for this analysis are captured in sport fisheries (Figure 8), with only a very small percentage (10.1% of the total strays by definition) being found in locations (i.e. hatcheries or weirs) at a place and time where they should be considered strays.

The Wallowa stock steelhead had been identified through previous analysis by ODFW, as having large number of fish straying into the Deschutes River, Oregon. Unfortunately, for many years, WDFW did not have coded-wire tags present in our Wallowa stock releases, and there was not terminal trapping location until 1992, so they were not part of the original ODFW analysis. Since that time, WDFW has consistently coded-wire tagged steelhead released from Cottonwood AP. Based on our results (Figures 8 and 9), the WDFW Wallowa stock releases stray into the Deschutes River at a much lower rate than ODFW Wallowa stock steelhead (refer to ODFW presentation). Differences in survival and stray rates following this review have prompted WDFW and ODFW to propose a study which will begin with the 2013 brood to examine effect of rearing facility (Lyons Ferry and Irrigon hatcheries) and release location (acclimated releases from Cottonwood AP, Wallowa AP, and Big Canyon AP) on survival and straying within the Wallowa stock.

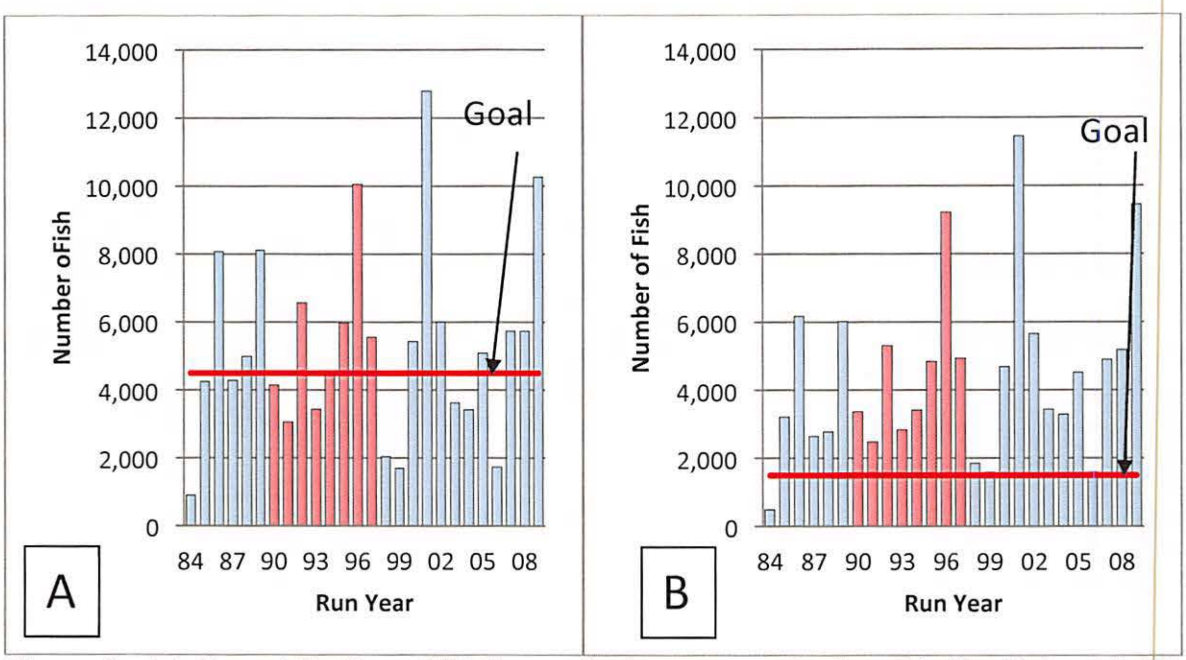


Figure 6. Adult contribution of Wallowa stock summer steelhead to the Columbia River basin (A) or back to the LSRCP project area (B), 1984-2009 run years. Note: years with different color shading during the 1990's are estimated based on Lyons Ferry stock steelhead releases.

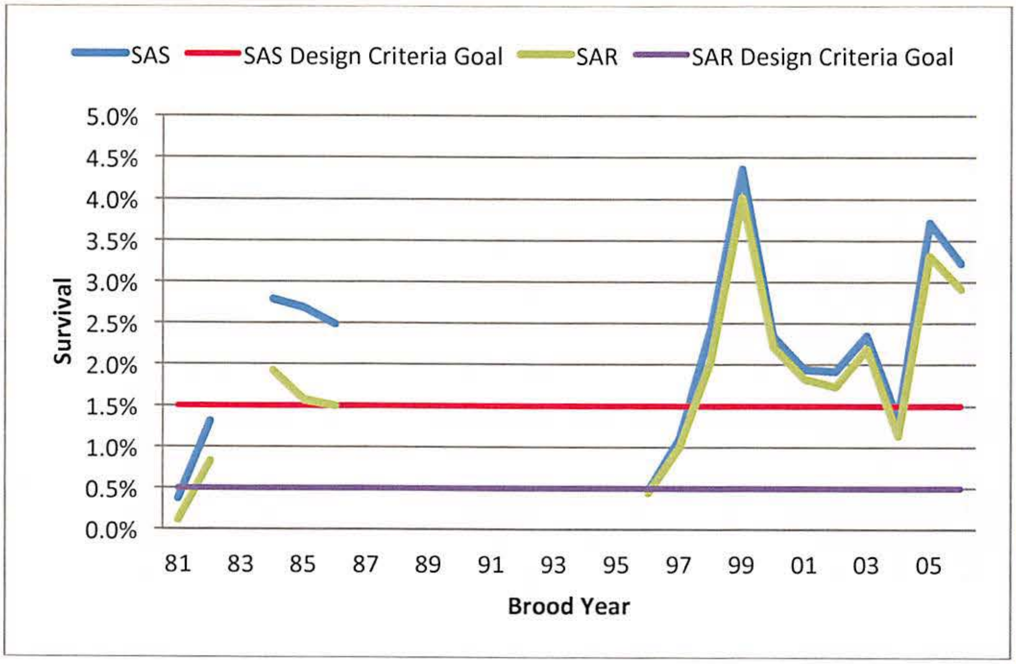


Figure 7. Smolt-to-adult survival (SAS) and smolt-to-adult return (SAR) of WDFW Wallowa stock summer steelhead released into the Grande Ronde Basin.

Table 2. **Catch and escapement of WDFW Wallowa stock summer steelhead, 2001-2006 brood years.**

Location	Sub-Area	Brood Year						Mean
		2001	2002	2003	2004	2005	2006	
Ocean		0.3	0.0	0.0	0.0	0.0	0.0	**0.05%**
Columbia River	Sport	2.6	7.2	2.9	4.0	6.1	5.5	4.7
	Tribal	2.8	2.4	3.5	9.6	4.7	3.5	4.4
	Stray Harvest	0.1	0.0	0.1	0.4	0.0	0.2	0.1
	Stray Rack	0.1	0.0	0.5	0.6	0.1	0.3	0.3
	TOTALS							***9%***
Snake River	Sport (Below LGD)	2.8	1.3	3.3	1.0	4.7	0.7	2.3
	Sport (Above LGD)	20.8	18.8	8.5	19.4	24.9	26.0	19.7
	Tribal	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stray Harvest (Below LGD)	0.6	0.5	0.9	0.5	0.3	0.5	0.6
	Stray Harvest (Above LGD)	0.0	4.0	1.9	3.1	8.5	2.8	3.4
	Stray Rack (Below LGD)	0.3	0.3	0.5	0.2	0.1	0.0	0.2
	Stray Rack (Above LGD)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTALS							***26%***
Grande Ronde	Sport Harvest	43.3	25.0	36.8	29.1	19.8	25.3	29.9
	Stray Harvest	2.3	1.8	1.7	3.3	0.9	0.7	1.8
	Stray Rack	0.0	0.2	0.1	0.0	0.0	0.0	0.1
	TOTALS							***32%***
Escapement to Weir	Cottonwood Creek	24.4	38.5	39.3	28.6	29.9	34.6	***33%***

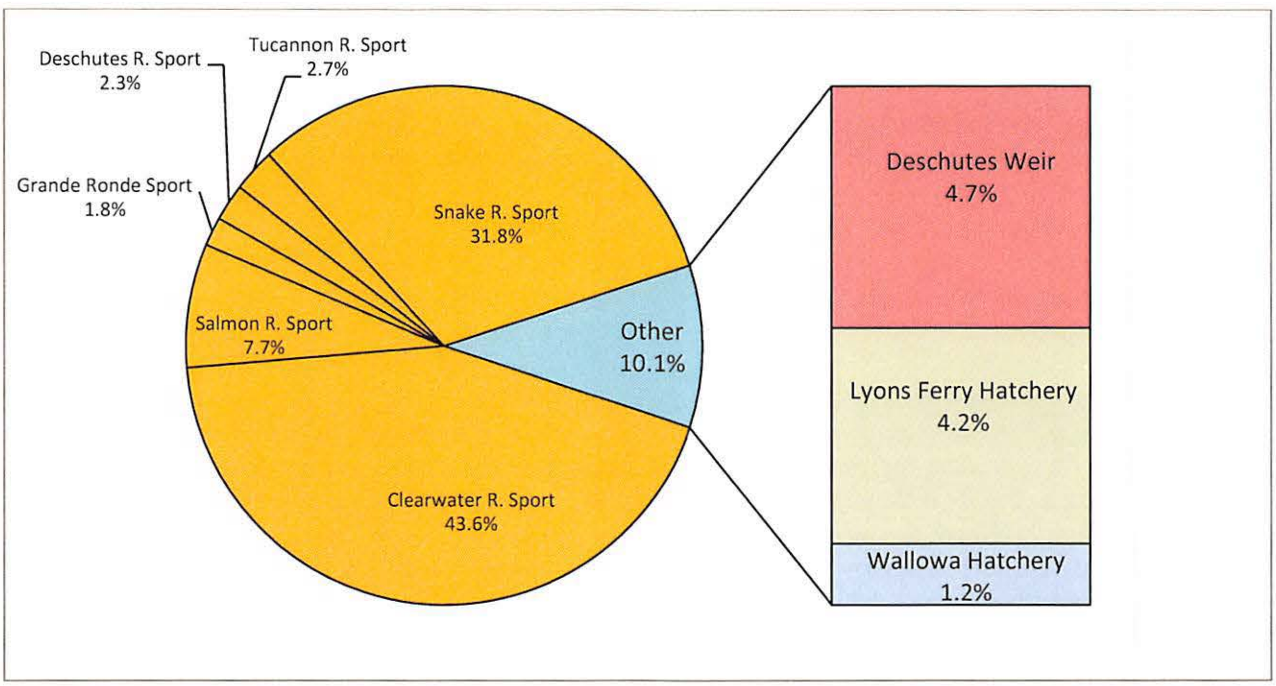


Figure 8. Point of recovery of Wallowa stock summer steelhead (2001-2006 Broods) defined as "strays" in Table 2.

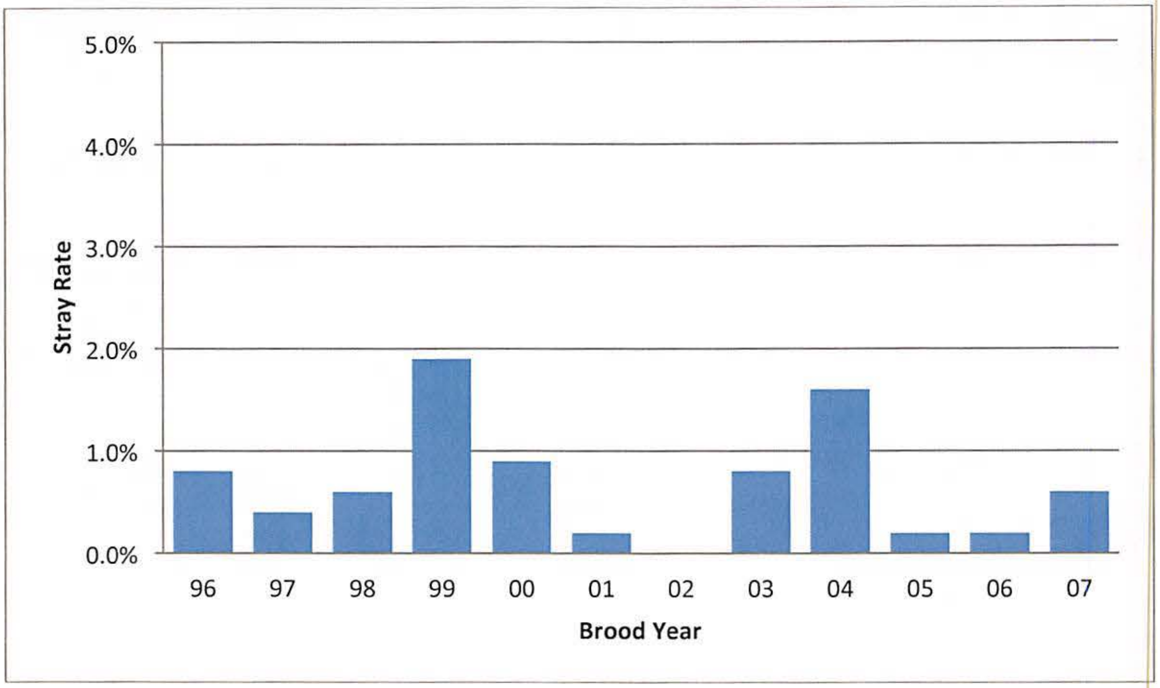
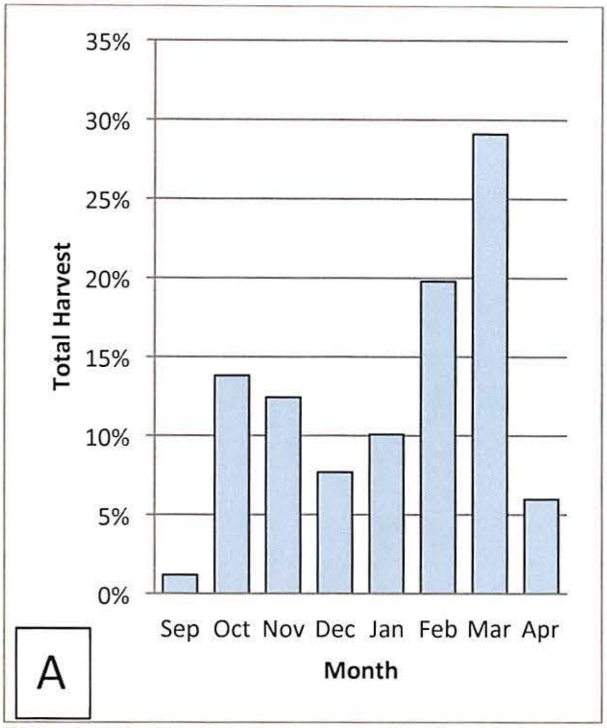


Figure 9. Percent stray rates of WDFW Wallowa Stock summer steelhead into the Deschutes River, Oregon. Percentages based on recoveries within the Deschutes River, and all recoveries upstream in the Columbia and Snake River basins.

The resurgence of sport fisheries in Washington's portion of the Snake and tributary rivers, such as the Grande Ronde River, has been in direct relation to returning large numbers of hatchery fish from the LSRCP program. The steelhead sport fishery in the Grande Ronde River (both Washington and Oregon) is well established and recognized as one of the best in the United States. Within the State of Washington there are 38 river miles open to fishing and steelhead can be retained 319 days of the year. Recent survey information on angler origins indicates that 96% of anglers come from Washington, Oregon, and Idaho, with trip lengths of 1-5 days. Based on a USFWS survey in 2002, we determined a direct cost of ~$1,000 per harvested steelhead, thereby valuing the fishery in the Grande Ronde River (Washington only) between $3-8 million/year (estimates based on harvested steelhead from 2000-2008 Run Years).

The majority of the steelhead harvested within the Washington portion of the Grande Ronde River occurs in the fall and spring (Figure 10A), as winter months can often be too cold, with ice flows in the river limiting fishing opportunities. Based on code-wire tag recoveries from 2008-2009 run years, the ODFW Wallowa stock program contribute the majority of the fish harvested within Washington from September to January (Figure 10B). From February-April, the fishery is dominated by WDFW's Wallowa stock program fish that are returning to the Cottonwood area. Overall, we estimate about 25% of the steelhead harvested within the Grande Ronde River in Washington originated from the WDFW program. From the contribution of both WDFW's and ODFW's Wallowa stock program, the steelhead sport fishery in the Grande Ronde River has greatly increased (Figure 11).

Increased harvest and an increase in number of angler days (fulfilling program goals), also translate into possible negative effects on wild steelhead populations. As required by NOAA Fisheries to operate our steelhead fisheries within SE Washington, WDFW has compiled a



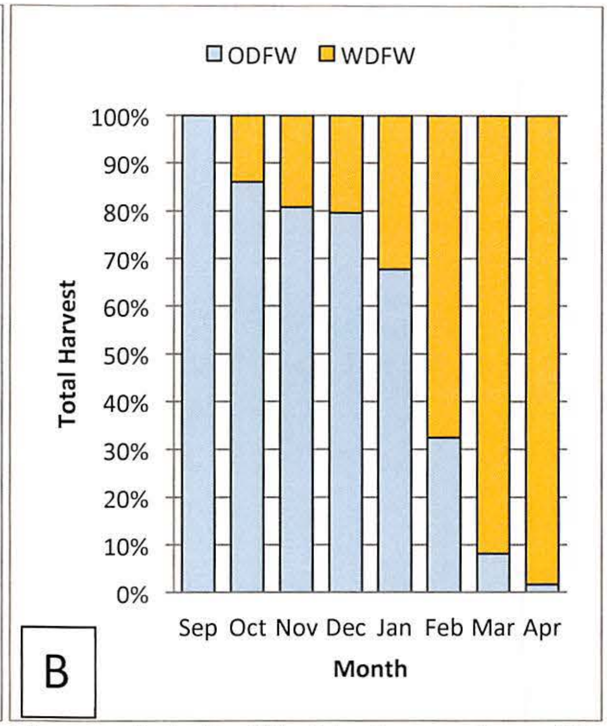


Figure 10. Percent annual steelhead harvest by month in the Washington portion of the Grande Ronde River, 1998-2009 Run Years (A), and contribution of harvested Wallowa stock steelhead by hatchery program, 1998-2009 Run Years (B).

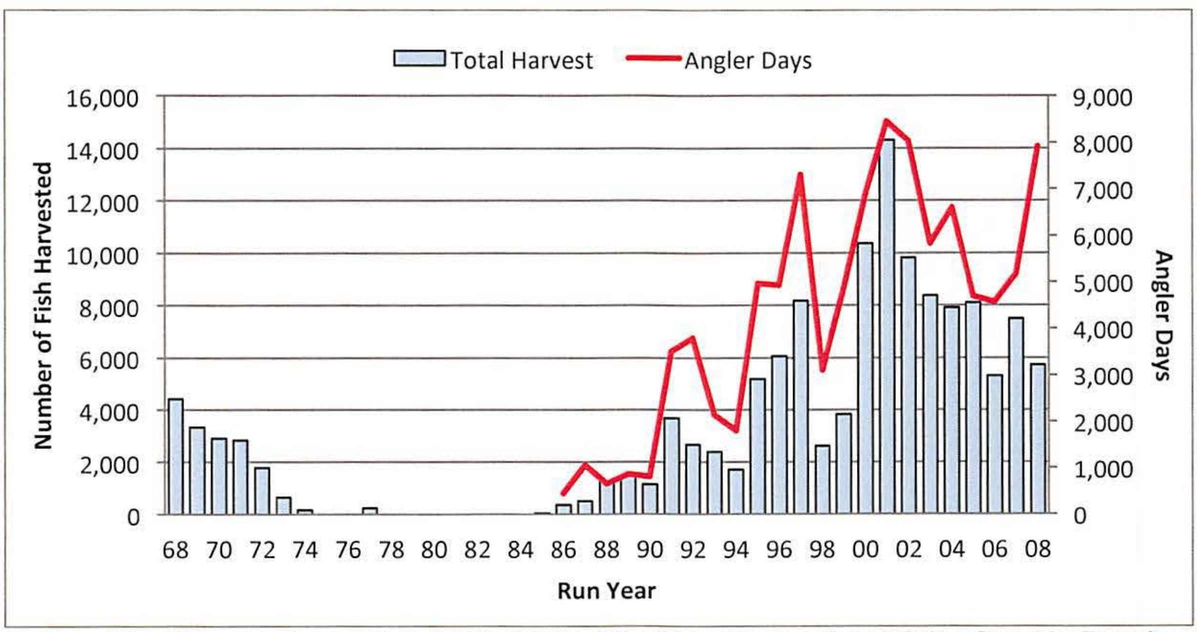


Figure 11. Harvest of steelhead within the Washington portion of the Grande Ronde River (1968-2008), and estimated angler days from 1986-2008.

Fishery Management and Enhancement Plan (FMEP) to estimate impacts of fisheries to listed populations of steelhead during steelhead creel survey on the Grand Ronde River, samplers collect data on the number of wild fish captured and released. Based on the proportions with hatchery fish retained, and applying a hooking mortality rate of 5%, we estimate that on average about 60 (2.3%) wild Grande Ronde River steelhead are inadvertently killed from the fishery on an annual basis in the Grande Ronde River in Washington (Table 3). Based on the relative low estimated impacts to wild fish, WDFW believes that the creel surveys are adequate in their current design.

Table 3. Estimates of impacts to ESA listed summer steelhead in the sport fishery on the Washington portion of the Grande Ronde River, 1988-2007 run years.

Run Year	Wild (W) SH released	Hatchery (H) SH Kept	Proportion of W to H Kept	Catch Record Card Harvest Estimate	Estimated Wild SH caught	Hooking mortality (5%)[1]	Annual wild steelhead run size estimate[2]	Hooking mortality % of Total
1988	393	647	0.61	465	282	14	3,163	0.4
1989	267	1,014	0.26	844	222	11	3,745	0.3
1990	269	754	0.36	484	173	9	1,393	0.6
1991	412	1,413	0.29	2,284	666	33	2,597	1.3
1992	264	678	0.39	1,423	554	28	2,902	1.0
1993	456	1,282	0.36	1,416	504	25	1,103	2.3
1994	224	726	0.31	1,011	312	16	1,128	1.4
1995	267	1,150	0.23	2,673	621	31	1,199	2.6
1996	283	1,155	0.25	3,387	830	41	1,143	3.6
1997	422	1,417	0.30	4,603	1,371	69	1,311	5.2
1998	355	897	0.40	1,578	625	31	1,408	2.2
1999	508	1,095	0.46	2,191	1,016	51	1,656	3.1
2000	921	2,639	0.35	5,390	1,881	94	3,039	3.1
2001	1,508	3,127	0.48	7,792	3,758	188	6,154	3.1
2002	1,023	2,222	0.46	5,842	2,690	134	6,770	2.0
2003	851	2,189	0.39	4,910	1,909	95	4,374	2.2
2004	1,193	2,068	0.58	4,661	2,689	134	3,458	3.9
2005	1,083	2,871	0.38	4,522	1,706	85	2,716	3.1
2006	755	2165	0.35	3,062	1,068	53	1,421	3.8
2007	394	2217	0.18	4,040	718	36	2,088	1.7
All Years Totals/ Average	**11,848**	**31,726**	**0.37**	**62,578**	**23,593**	**1,180**	**52,767**	**2.3**

1 Estimated number of wild steelhead hooking mortalities. Hooking mortality is related to water temperature; as water temperature increases hooking mortality increases (Mongillo 1984; Rawding 2000). A hooking mortality rate of 5% is used because most of the steelhead harvest occurs between October and March when average water temperature in the Snake River was 8.65 ^{0}C, (WDOE – River and Stream Water Quality Monitoring Program – Station#35A150).

2 The estimated annual Snake River wild steelhead run size as counted at Lower Granite Dam (IDFG sampling at Lower Granite Dam). The Grande Ronde River run size was estimated at 15% of that at Lower Granite Dam, as determined in the Lower Snake River Compensation Program (USACE 1975).

WDFW has adapted the Wallowa stock program as needed and has provided a highly successful program; however, a significant objective of the original program remains unmet.

Within the Grande Ronde Basin, the status of many natural steelhead populations remains unknown. While some systems, such as Joseph Creek, have been monitored extensively by ODFW (refer to ODFW presentation for specifics) or more recently the Nez Perce Tribe. Their monitoring efforts would suggest that very few hatchery fish are straying into Joseph Creek. Other major river basins that contain steelhead populations, such as the Wenaha River Basin, have not been monitored at all; mainly due to limited accessibility. In addition, numerous small tributaries that enter the mainstem Grande Ronde River contain steelhead, but are largely unchecked. Limited monitoring of two small tributaries within close proximity to Cottonwood AP (Menatchee Creek, Rattlesnake Creek) would suggest that as high as 80% of the steelhead in those two tributaries are of hatchery origin.

Recognizing that we lack stock status information within the Grande Ronde Basin, and other locations with SE Washington, WDFW has enacted various policies/fishery regulations for protection of wild steelhead. These include: 1) adoption of Wild Steelhead Refuge Areas (Asotin Creek, Joseph Creek, Wenaha River Basin, 2) Restriction of fishing in most headwater areas of streams with wild steelhead present, 3) limitation of directed wild steelhead harvest since 1983, 4) Barbless hooks are required in all Snake River Basin sport fisheries, 5) The daily bag limit of hatchery origin fish was increased from 2 fish/day to three fish/day in 2001, 6) implemented selective gear and closed area regulations for trout/juvenile steelhead and refocused trout fisheries within SE Washington to area lakes stocked with LSRCP fish, 7) Decreased the number of steelhead smolts released and changed their release locations in some rivers to downstream locations to limit their interaction (both as juveniles and returning adults) with wild stocks, and 8) where we operate traps/weirs on tributaries, all mitigation purpose hatchery steelhead are removed upon capture (i.e. Cottonwood Trap, Asotin Creek, Tucannon River, etc.).

SUMMARY AND CONCLUSIONS

Broodstock Development and Management

Originally, ODFW developed the Wallowa stock through trapping of adults at Snake River dams, sharing that stock with WDFW for harvest mitigation within the Grande Ronde. Since 1992, WDFW has generally be able meet its own program needs by trapping adults from Cottonwood Creek. The Wallowa stock (both agencies) remains unchanged.

In-Hatchery Performance

Pre-spawning mortality and egg-to-smolt survival rates have been variable, but within acceptable limits and have not affected overall program performance. Disease incidence within the Wallowa stock has been limited, and has not affected overall program performance. Smolt releases (both target number and size at release) have generally been met, and have not appeared to affect overall program performance.

Survival and Adult Return Performance

Adult return goals (1,500 adults) to the project area have been met in 24 (96%) of the last 25 run years (1984-2009). Total adult returns (4,500 adults) have been met 14 (56%) of the last 25 run years (1984-2009). Smolt-to-adult survival (SAS) and smolt-to-adult return (SAR) has averaged 2.08% (Goal = 2.25%) and 1.72% (Goal=0.75%), respectively. Wallowa stock steelhead returns are exploited in fisheries at high rates (67%), with most of the current harvest occurring in the Snake and Grande Ronde rivers. About 33% of the steelhead returns annually escape back to Cottonwood Creek. Strays to others hatcheries/traps are very low (0.5% of total returns). Recreational fishing opportunity for summer steelhead has been restored in the Grande Ronde Basin.

Wild Steelhead Stock Status and Data Gaps

The status of wild steelhead populations within the Washington portion of the Grande Ronde is largely unknown. In particular, large and small tributaries within close proximity to Cottonwood Creek and the Wenaha Basin are believed to have hatchery steelhead present, but we currently lack the ability (logistically and financially) to monitor/manage these populations to reduce the effects of the hatchery program on wild steelhead. WDFW has enacted policies/regulations to protect wild steelhead populations within SE Washington.

Hatchery Reform Actions

From the beginning, the WDFW Wallowa stock hatchery program has remained flexible to changing needs/directions that have been provided through ongoing monitoring and evaluation studies, WDFW policy changes, Federal Biological Opinions, Hatchery Scientific Review Group and Hatchery Review Team program reviews, and consultation feedback from NOAA Fisheries on submitted Hatchery Genetic Management Plans (HGMP's) . Program changes that have occurred are:

- The numbers of smolts and release locations have been decreased, and smolt size has been increased. WDFW believes these actions have reduced straying, increased emigration success and survival, and reduced competition and predation effects from residuals.
- Implemented removal of excess hatchery adults at traps/weirs. WDFW believes this action has decreased hatchery fish spawning in target locations and other areas, and has reduced the risk of possible disease transmission (i.e. Cottonwood Adult Broodstock or into the acclimation pond juveniles). In addition, excess adults have been provided to local foodbanks.
- Annually coded-wire tag and PIT tag smolts prior to release. For many years, coded wire tags were not designated for each WDFW steelhead release group, greatly limiting our ability to accurately determine adult returns and survival and assess straying. Beginning in 2001 and 2008 release years, all WDFW LSRCP steelhead releases were tagged with representative groups of coded-wire and PIT Tags, respectively.
- Increasing genetic diversity and fitness of the WDFW Wallowa stock by implementing (when possible) ½ spawning of females. The overall size of the Cottonwood program had been reduced, and concerns were raised about the annual number of spawners used to meet program needs.
- Destroy all eggs from IHNV positive females. If the prevalence of IHNV in broodstock females is high, eggs will be provided by the ODFW Wallowa stock program to meet program needs.
- Installation of handrails at the Cottonwood Adult trap for staff safety.

FUTURE PROGRAM CHALLENGES AND NEEDS

Wild steelhead populations in the Snake River Basin remain depressed. The apparent success of the LSRCP program in Washington (see also the Lyons Ferry program review) to return adult steelhead has had little beneficial effect on wild escapement, but it was never directly intended to rebuild those populations. Program goals and actions may need to be revisited in light of ESA and WDFW policies to preserve/protect/rebuild wild steelhead populations. WDFW is currently tasked with development of Steelhead Management Plans for each steelhead population within the State. Hatchery goals and program actions will be a critical part of those plans, as well as coordinating with Snake River Recovery Plans and HGMP's. Management priorities may differ from those originally established under the mitigation program, and could move management agencies to question whether harvest mitigation programs and wild stock recovery can be conducted/achieved concurrently.

Factors critical to the future success of our program include: 1) Establishment of consistent goals among all managers, 2) wild populations characterization (VSP parameters), 3) Identifying the causes of decline or factors that continue to suppress population productivity, 4) correcting the limiting factors where possible, and 5) retaining flexible hatchery programs. We may need to 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 construction and operation 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 populations remain depressed. Correction of survival problems within the basin must occur.

Grande Ronde River Summer Steelhead Hatchery Program Review

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This program is a cooperative effort of the Oregon Department of Fish and Wildlife, the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation. The program is funded by the Bonneville Power Administration and administered by the U.S. Fish and Wildlife Service under the Lower Snake River Compensation Plan.

INTRODUCTION AND BACKGROUND

This paper provides background information, management goals and objectives, program development history, assessment of program performance and future challenges for the Grande Ronde River summer steelhead *Oncorhynchus mykiss* hatchery program. We cover the time period from the program initiation in the late 1970s to the present (2010).

The Grande Ronde River is located in Northeast Oregon. The headwaters originate at high elevation areas in the Wallowa Mountains in the eastern part of the basin and the Blue Mountains from the west. The Grande Ronde River enters the Snake River at river kilometer (rkm) 271. Eight main stem hydroelectric dams and associated reservoirs exist between the Grande Ronde River and the ocean.

The Grande Ronde River historically supported productive and abundant steelhead runs. Steelhead escapement to the Snake River basin and the Grande Ronde River basin declined significantly following the completion of the four lower Snake River dams. The depressed status of the Snake River steelhead populations prompted NOAA Fisheries to list the Snake River steelhead Distinct Population Segment (DPS) as threatened in 1994. Four populations of steelhead (Figure 1) were identified in the Grande Ronde Basin as part of the Grande Ronde steelhead Major Population Group (MPG).

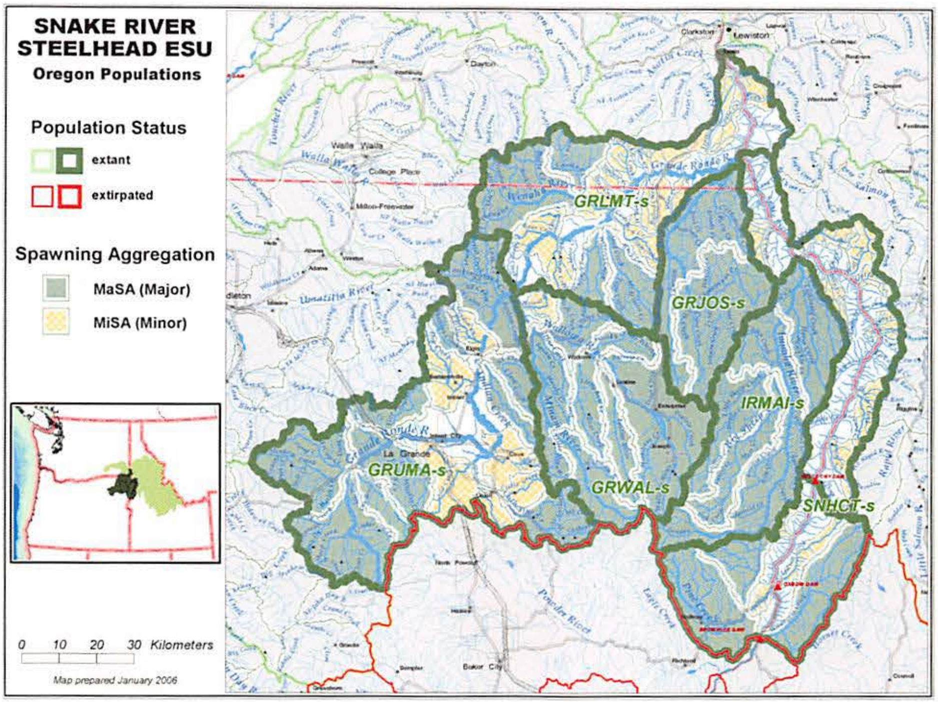

Figure 1. Steelhead populations within the Grande Ronde steelhead Major Population Group: GRLMT=Lower Mainstem, GRJOS=Joseph Creek, GRWAL=Wallowa River, GRUMA= Upper Grande Ronde River.

Viability assessments have been updated through 2009 for Joseph Creek and Upper Grande Ronde River populations. There are no natural abundance estimates for the other two populations so assessments cannot be conducted. Natural-origin spawner abundance estimates over multiple generations were used to assess productivity and abundance (Figures 2 and 3). The Joseph Creek steelhead population has high abundance and productivity and is the only steelhead population in the Snake River DPS that is rated as "highly viable." The recent annual natural-origin abundance geometric mean is greater than 2,000 and the spawner-to-spawner productivity is 2.4 (Figure 4). The probability of persistence over 100 years for this population is greater than 99%. The Upper Grande Ronde River population's current status in considered "maintained" which is below the viable criteria. Productivity is high at 2.9 recruits per spawner; however, the natural-origin abundance geometric mean is 1,340, which is below the minimum abundance threshold of 1,500 (Figure 5).

In 1976, the U.S. Congress authorized the Lower Snake River Compensation Plan (LSRCP). The LSRCP mandated a compensation program to mitigate for losses of anadromous fishes that resulted from construction and operation of the four lower Snake River dams—Ice Harbor, Lower Monumental, Little Goose, and Lower Granite.

The Grande Ronde River steelhead hatchery program was initiated in 1976 in response to the rapid decline in Snake River steelhead abundance. Annual adult mitigation, brood year specific smolt-to-adult return and total smolt-to-adult survival rates, and annual smolt production goals were established to compensate for the estimated annual loss of 48% of adult production (Table 1). Interim production goals that are less than the original goals have been adopted through the adaptive management process.

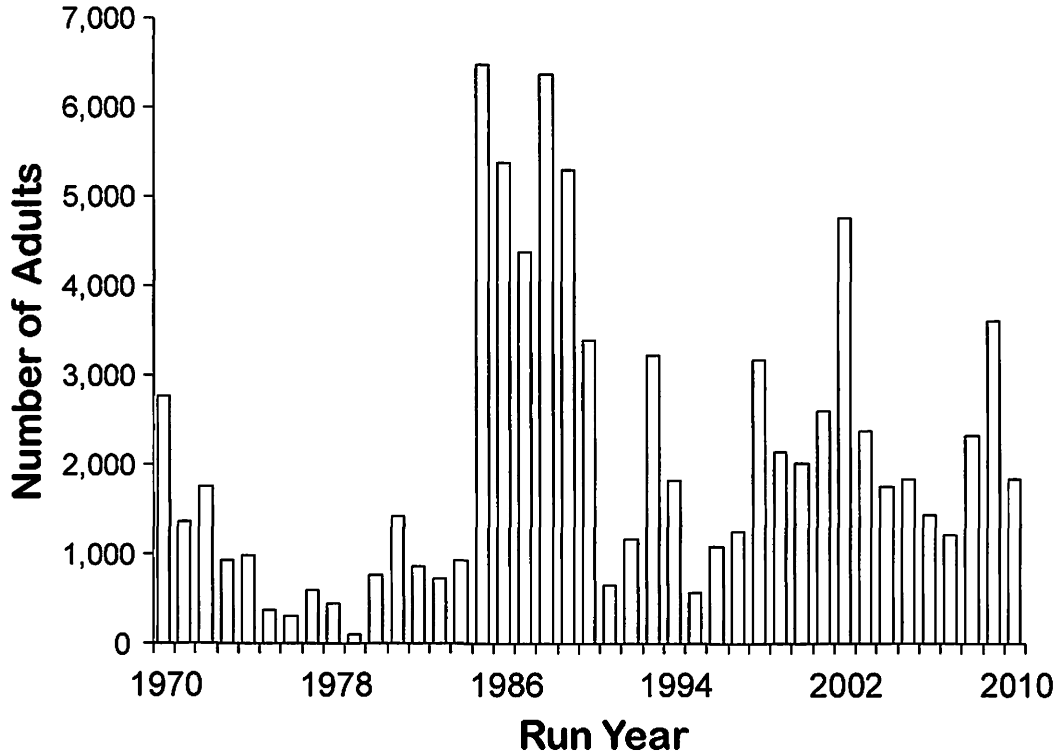

Figure 2. Natural-origin spawner abundance in the Joseph Creek steelhead population.

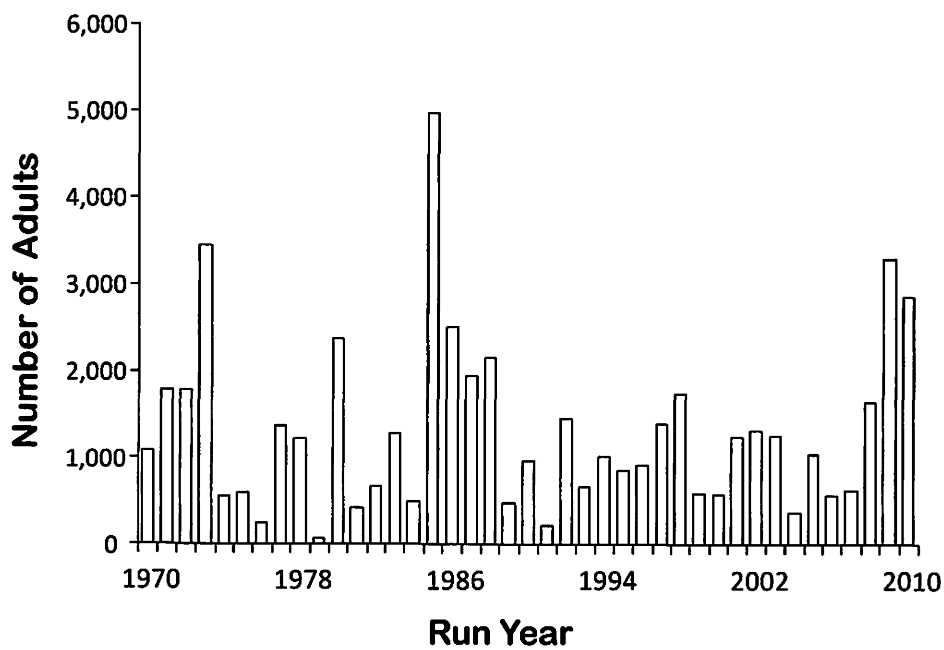

Figure 3. Natural-origin spawner abundance in the Upper Grande Ronde River steelhead population.

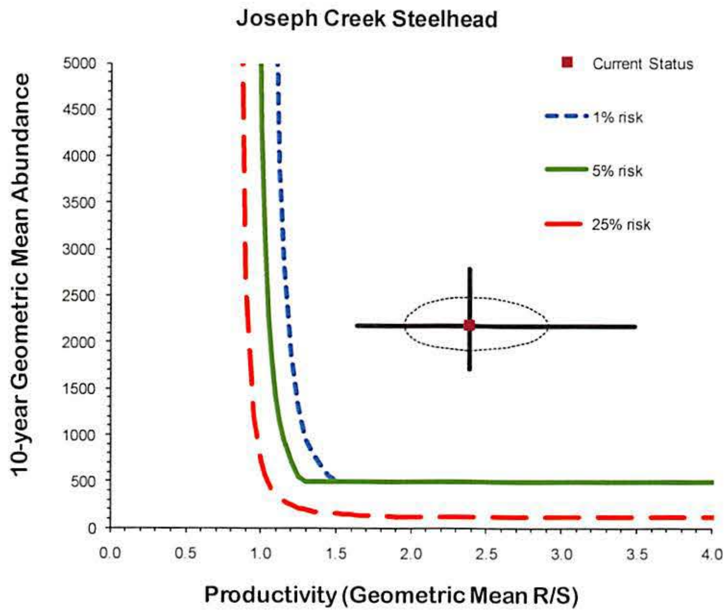

Figure 4. Joseph Creek summer steelhead population current abundance and productivity compared to viability curves.

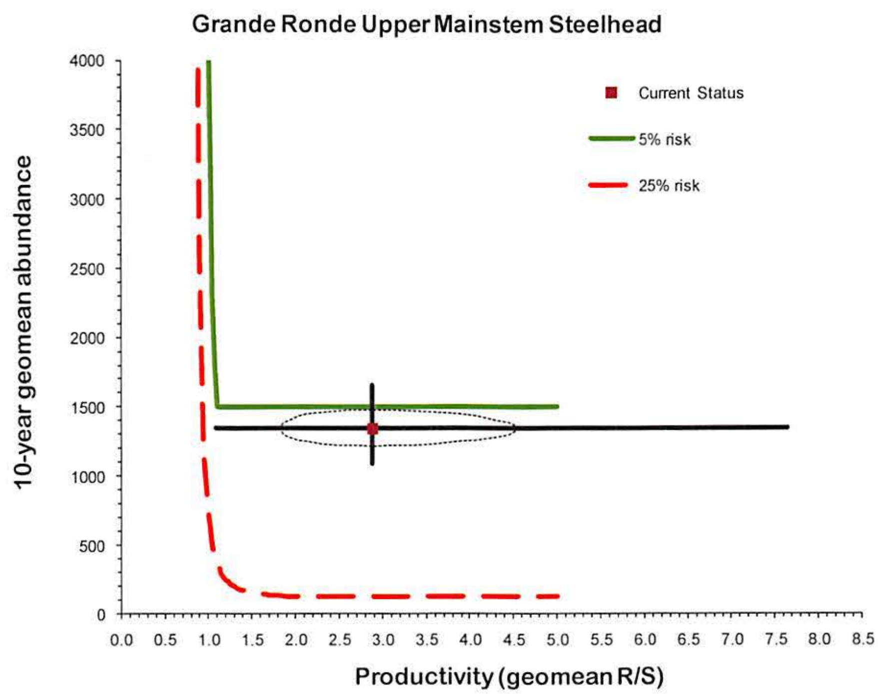

Figure 5. Upper Grande Ronde River steelhead population current abundance and productivity compared to viability curves.

Table 1. Lower Snake River Compensation Plan mitigation goals for Oregon's summer steelhead in the Grande Ronde River. Adult and survival goals are expressed as returns to the compensation area and total catch and escapement.

Category	Goal
Compensation Area	
Annual smolt goal	1,350,000 smolts (800,000 interim)
Annual pounds of production	270,000 lbs
Annual adult goal	9,184 adults
Brood year smolt-to-adult return rate (SAR)	0.68% (1.15% interim SAR)
Total Catch & Escapement	
Annual adult goal	27,552 total adults
Brood year smolt-to-adult survival rate (SAS)	2.04% SAS

The adult return and smolt-to-adult return rates for the compensation area represent the required performance to the area above Lower Granite Dam (LGD). The total adult return and smolt-to-adult survival rate goals were determined based on the LSRCP planning analyses which assumed a downriver harvest below the compensation area of 66.7% prior to construction of the dams.

The implementation of the Grande Ronde steelhead hatchery program has been primarily guided by five priority management objectives: 1) establish an annual supply of broodstock capable of meeting production goals; 2) restore and maintain natural populations; 3) re-establish historical tribal and recreational fisheries; 4) establish a total return number of steelhead that meets the LSRCP goals; and 5) maintain Joseph Creek, Wenaha River, and Minam River as wild fish sanctuaries.

Although the original objectives included "restore and maintain natural populations," this objective has never been a priority objective. The program has been operated as a harvest augmentation segregated program for managing broodstock and minimizing the number of hatchery fish that spawn in nature.

A comprehensive research, monitoring and evaluation (RM&E) program has been underway since 1984. The primary objectives of the RM&E program are: 1) document and assess fish culture and hatchery operation practices and performance; 2) determine optimum rearing and release strategies that will produce maximum survival to adulthood; 3) determine total catch and escapement, smolt survival to LGD, total smolt-to-adult survival (SAS), smolt-to-adult return rate (SAR) to the compensation area, and assess if adult production meets mitigation goals; 4) determine recruits-per-spawner of hatchery-origin fish; 5) assess life history characteristics of hatchery fish (age structure, run timing, sex ratios, smolt migration patterns) and monitor for changes through time; 6) determine the magnitude and patterns of within-basin and out-of-basin straying; and, 7) determine the success in restoring fisheries to historical levels.

The steelhead production program involves three hatchery facilities—Wallowa Hatchery, Irrigon Hatchery, and the Big Canyon Facility. Excluding broodstock collected by anglers for the autumn line, adult broodstock are collected, held, and spawned at the Wallowa Hatchery, which is located in Enterprise, Oregon on Spring Creek, a tributary to the Wallowa River (Figure 6). Embryos are incubated at Wallowa Hatchery on temperature mediated spring water. Once embryos reach the eyed stage they are transferred to Irrigon Hatchery for final incubation, hatching, and final rearing on well water. Ten to 13 months after fertilization smolts are transferred back (March-April) to Wallowa Hatchery and Big Canyon Facility acclimation ponds for final rearing and acclimation. During the early years of program operations direct-stream releases were conducted in the Wallowa River, upper and lower Grande Ronde River, and Catherine Creek.

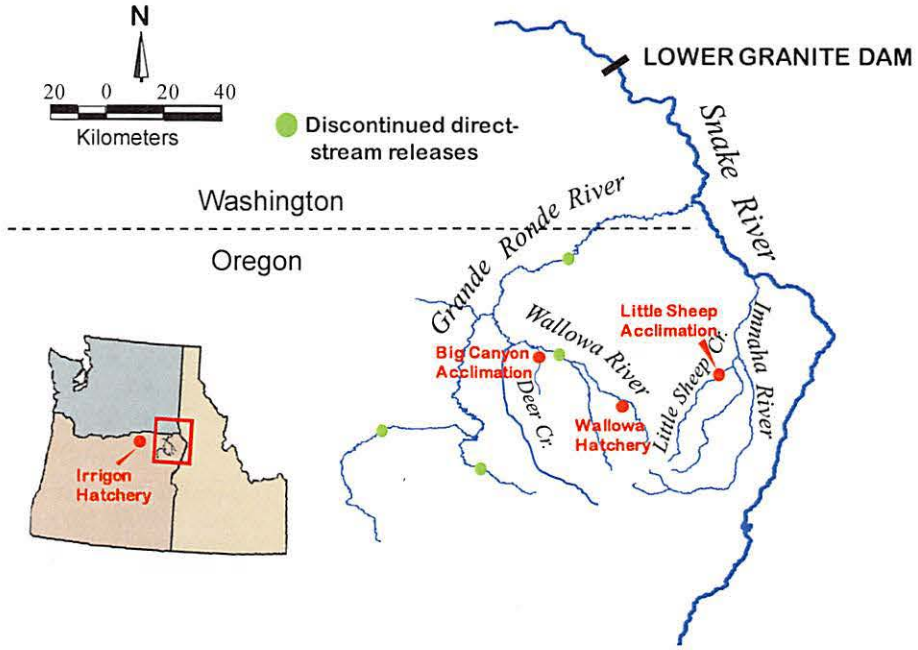

Figure 6. Map showing locations of discontinued direct-stream release sites and current acclimation sites on Deer and Spring creeks in the Grande Ronde River basin and Little Sheep Creek in the Imnaha River basin. Inset shows location of the study area within a three-state region, including the location of Irrigon Fish Hatchery.

PROGRAM ASSESSMENT

Broodstock development was initiated in 1976 and from 1976-1978 natural-origin adults were collected at lower Snake River dams in the springtime (Table 2). In 1979, eggs were obtained from Pahsimeroi Hatchery in Idaho. From 1980 until the present adult broodstock were collected at Wallowa Hatchery (except for autumn line).

We estimate total number of green eggs based on the estimated number of eyed eggs plus the number of eggs that died prior to the eyed egg stage. The number of eyed eggs is estimated at the time of shocking. We count 1,000-2,000 towel dried eyed eggs and weigh the total to get an average number of eggs per gram. The remaining eyed eggs are then towel dried and weighed and total number of eyed eggs are determined. Green-to-eyed egg survival is calculated by dividing the total number of eyed eggs by the total number of green eggs. The number of embryos that are culled, transferred, or are in excess of program needs is recorded and is subtracted out of the total eyed egg inventory when determining embryo-to-smolt survival.

Table 2. History of natural- and hatchery-origin broodstock collection for the Grande Ronde basin steelhead program, spawn years 1976 to 2011.

Stock of Origin	SpawnYears	Number of Females in Broodstock	
		Production	Autumn Line
Snake R, Mixed	1976-1978	35-48	NA
Pahsimeroi, Idaho	1979	33	NA
Wallowa Hatchery	1980-1985	85-384	NA
Wallowa Hatchery	1986-2000	275-812	NA
Wallowa Hatchery	2001-2011	180-242	31-54*

*The first year angler-caught autumn line (Fall Brood) were spawned was in 2004. In 2008, we began using autumn line F_{1s} as brood and discontinued the angler-caught program.

After hatching and ponding in indoor circulars, fry are transported to outside raceways for final rearing. Each month, fish in each raceway are crowded and an average fish per pound is calculated from three separate samples of approximately 20 pounds each. Fish are weighed and then counted. Beginning in late February, fish are loaded onto liberation trucks and hauled to acclimation ponds (or hauled later and direct-stream released) to be acclimated for a 1-6 week period and are then released. The number of fish hauled to acclimation ponds or direct-stream released is calculated during loading. At loading, an average fish/lb for each raceway is again calculated as it was during each previous month during rearing. As fish are loaded into liberation tanks, pounds of fish are estimated using a calibrated displacement gauge on each tank of each truck. To estimate the number of fish in each acclimation pond, we multiply the average fish/lb estimate by total lbs to get the total number of fish on each liberation truck, and then sum the totals. In 2012, the number of fish estimated using the displacement method during grading, when fish from each raceway are loaded into a liberation truck, deviated from a complete count of fish during adipose-fin clipping by only 0.17%, thus indicating that the displacement method accurately estimates the number of steelhead. The total number of smolts released is calculated using the number hauled to the acclimation ponds (or direct-stream released) minus mortality from the acclimation ponds (or observed immediately after the direct-stream release). Embryo-to-smolt survival for production releases is calculated by dividing the number of smolts released by the eyed embryos minus any culled, transferred, or excess embryos.

To determine size at release for each release group, we conduct pre-release sampling at each acclimation pond immediately prior to release (the day before or the day of release). Fish are crowded and a sample of approximately 1,000 fish is held in a live box. We measure fork length (FL) of 100 fish and weigh (g) 50 fish for each production and experimental group (Ad-only, AdLV, and AdRV clipped fish). For direct-stream released fish, we measure FL of 200-250 fish prior to hauling to release sites and use the monthly fish/lb to determine weight.

Prespawning survival of broodstock has been high, consistently above 90% since 1990. Green egg-to-smolt survival has been variable and in some years below 50% (Figure 7). Poor egg-to smolt survival can be attributed to juvenile fish mortality resulting from coldwater disease.

The original smolt production goal of 1,350,000 was consistently achieved beginning in 1987. The reduced interim smolt goals, which were adopted in 2000 and then reduced again in 2007, have been reached in most recent years (Figure 8).

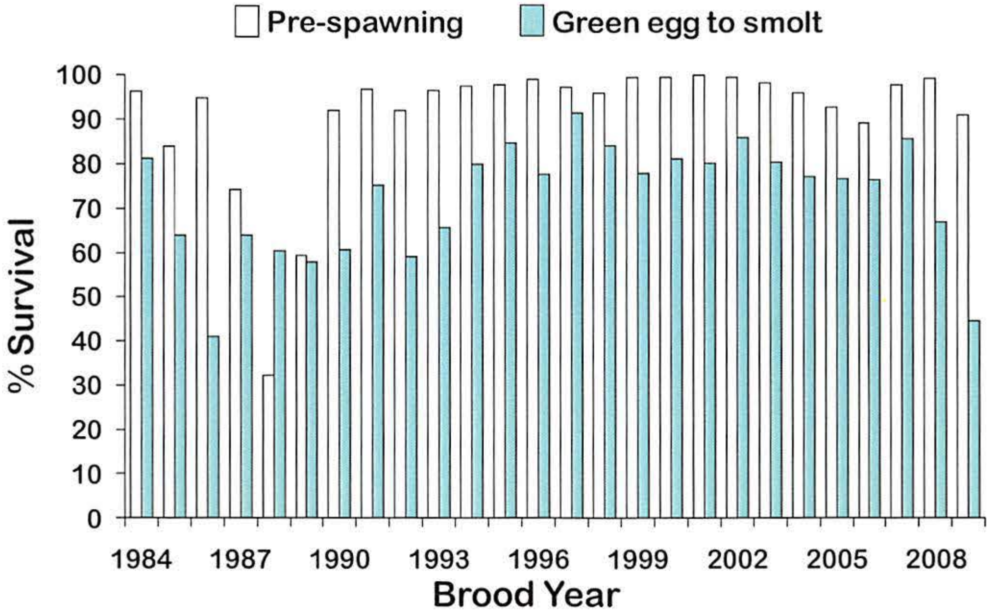

Figure 7. Percentage of Wallowa Hatchery steelhead stock adult pre-spawning survival and green-egg-to-smolt survival from brood years 1984 to 2009.

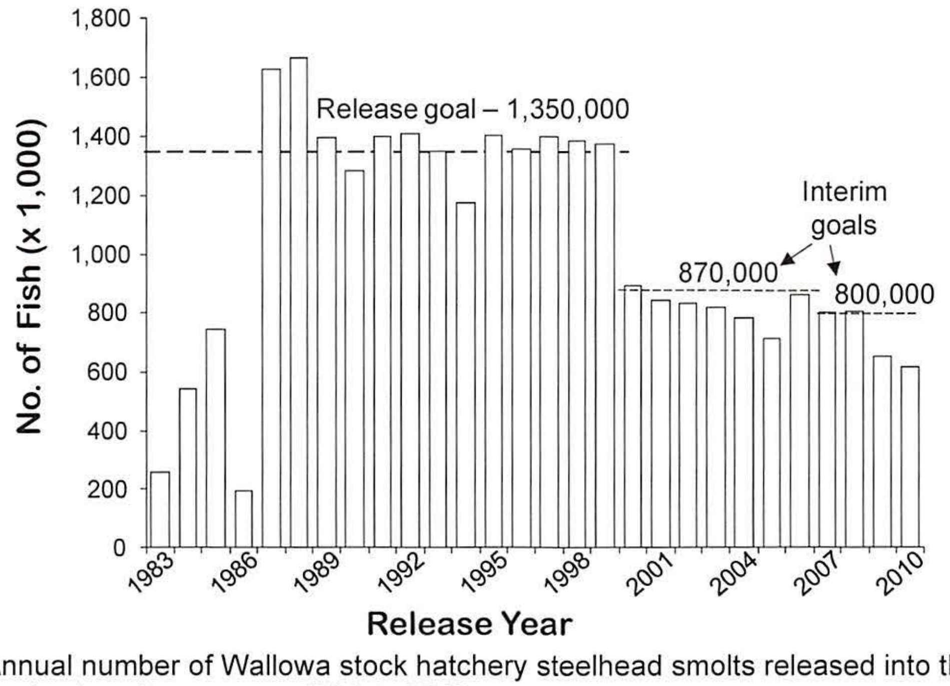

Figure 8. Annual number of Wallowa stock hatchery steelhead smolts released into the Grande Ronde River basin, release years 1983 to 2010.

Smolt survival rates from Wallowa Hatchery and Big Canyon Facility to LGD have been variable. We have observed an increasing trend in survival since 2000, with the highest survival rates in recent years at 80% (Figure 9). Wallowa stock smolt survival has been equal to survival of natural-origin smolts originating from the Lostine River (Figure 10). The smolt migration pattern at LGD for hatchery smolts is nearly identical to the pattern observed for Lostine River natural-origin smolts (Figure 11).

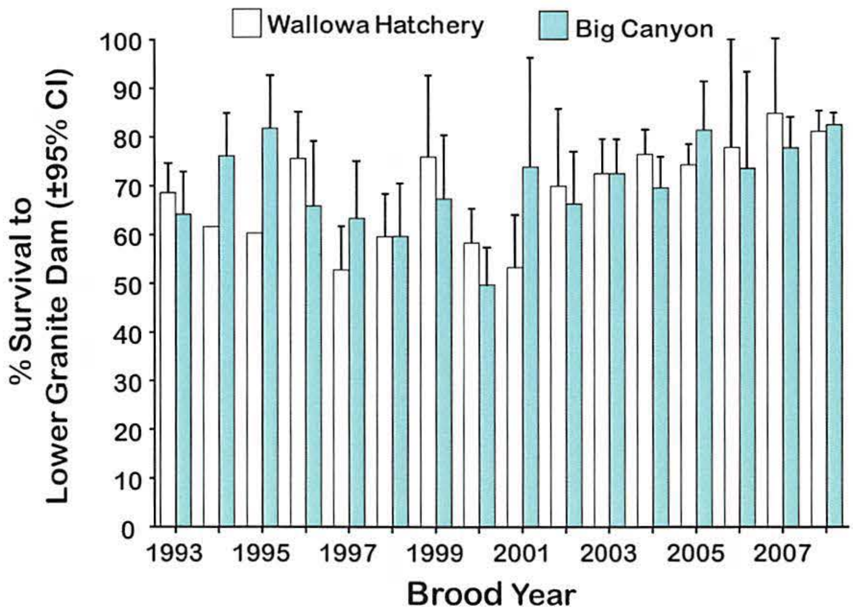

Figure 9. Average annual outmigration survival to Lower Granite Dam of PIT tagged Wallowa stock hatchery steelhead smolts released from Wallowa Hatchery and Big Canyon acclimation facilities, brood years 1993 to 2008.

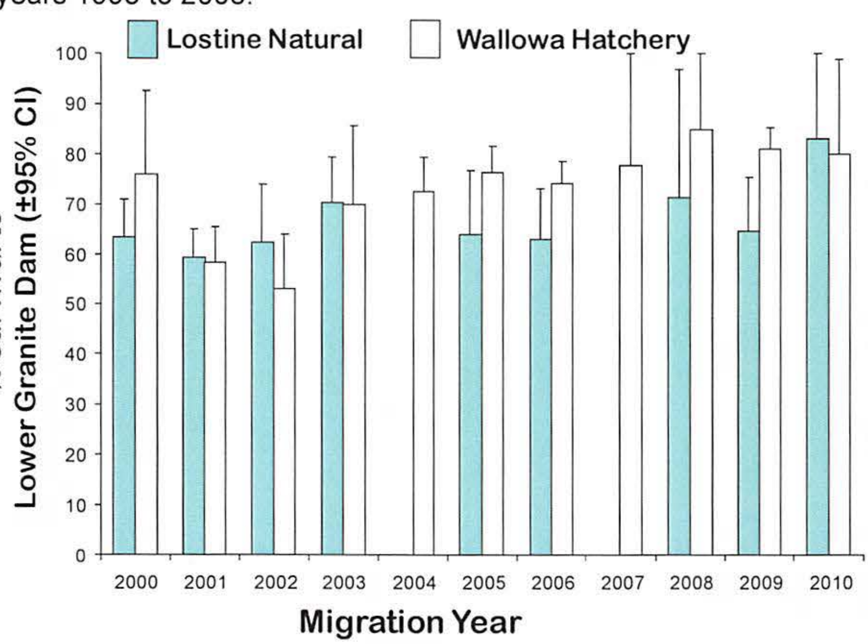

Figure 10. Average annual outmigration survival to Lower Granite Dam of PIT tagged Wallowa stock hatchery steelhead smolts released from Wallowa Hatchery, and natural-origin Lostine River steelhead smolts, brood years 2000 to 2010.

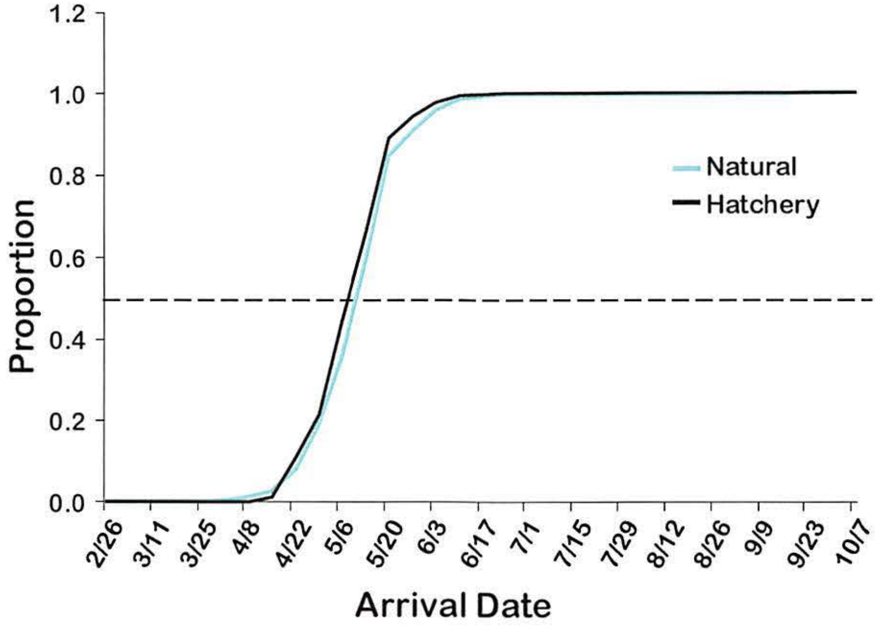

Figure 11. Average migration timing of PIT tagged Wallowa stock hatchery steelhead smolts and natural-origin Lostine River steelhead smolts that arrived at Lower Granite Dam from late February through early October, migration years 2007 to 2011.

Prior to the 2001-02 run year we had only reached the adult return goal to the compensation area in two years. Since the 2001-02 run year the goal has been reached in six years, and in the two years the goal was not reached escapement was close (Figure 12). One of the key measures of performance is SAR relative to the program goal of 0.68%. The program goal had rarely been achieved prior to the 1998 brood year. The SAR ranged from (0.30 to 1.80) over the past 10 years and the goal has been achieved every brood year since 1998 (Figure 13). The SAS goal of 2.04% has only been reached in one brood year, and for most brood years the performance has been well below the goal. The SAS has been much higher on average in the recent 10-year period than it was in the previous 10 years.

Adult recruits per spawner (R/S) has been highly variable throughout the program history; however, on average the rate has been high (Figure 14).

Wallowa stock steelhead have a diverse catch and escapement profile with substantial contribution to commercial, tribal, and recreational fisheries throughout the Columbia basin. We have observed little ocean harvest for recent brood years and the freshwater harvest is distributed into small proportions in many fisheries (Table 3). The overall exploitation rate on Wallowa stock steelhead is consistently high and ranged from 66.5–74.5% for the 2001-04 brood years.

A majority of the escapement into the Oregon portion of the Grande Ronde basin is harvested. Foodbank contributions also comprise a significant proportion of the in-basin disposition (Figure 15).

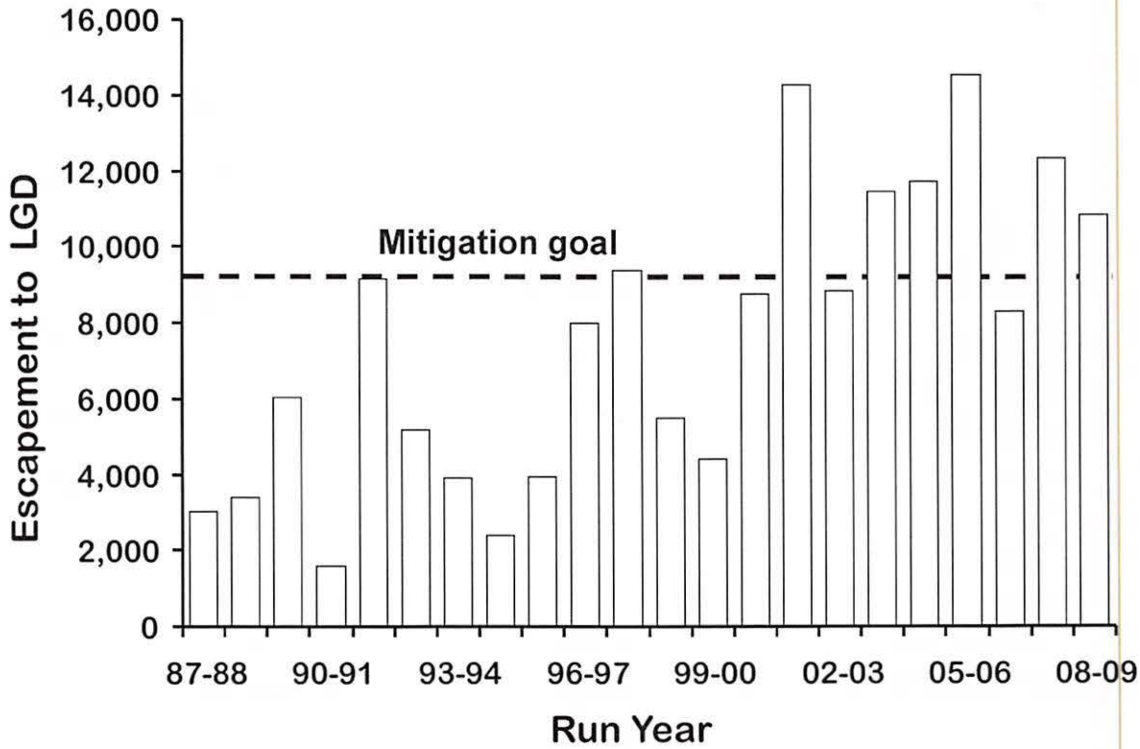

Figure 12. Wallowa stock steelhead adult escapement to the LSRCP Area above Lower Granite Dam, run years 1987-88 to 2008-09.

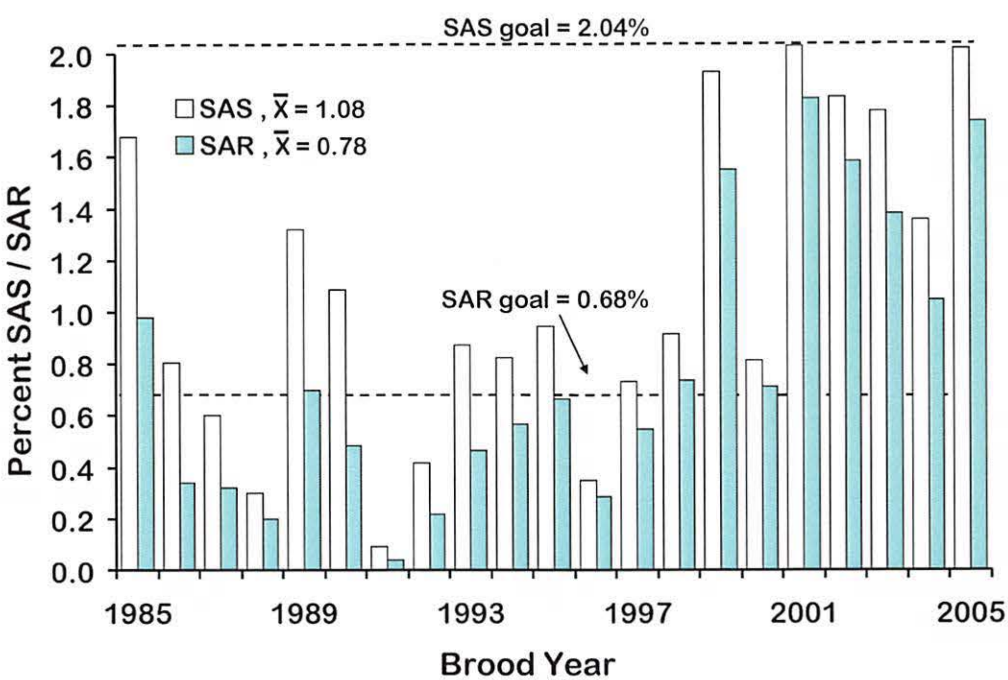

Figure 13. Percent smolt-to-adult survival (SAS) to Bonneville Dam and smolt-to-adult return (SAR) to Lower Granite Dam of Wallowa stock steelhead, brood years 1985-2005.

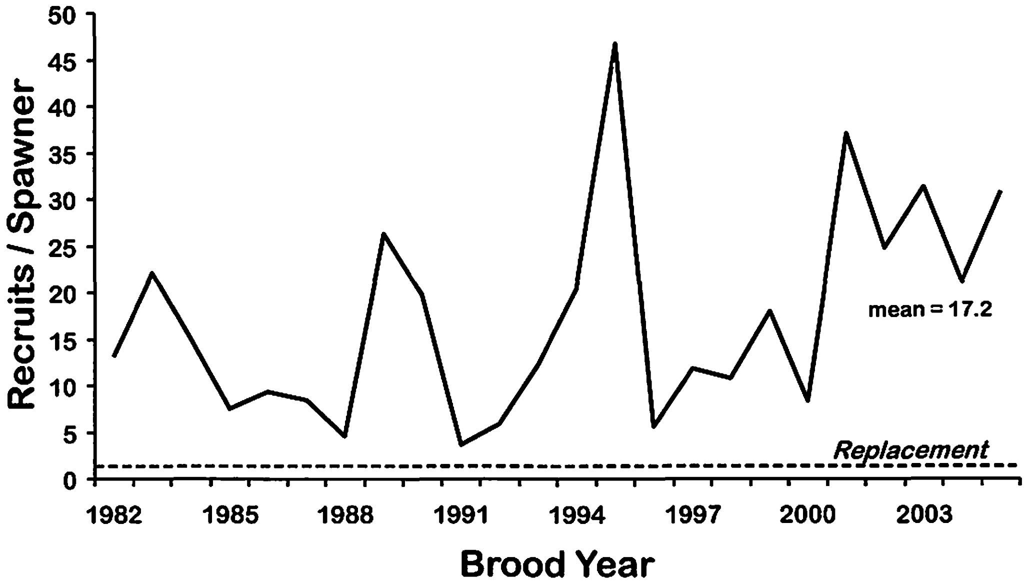

Figure 14. Total adult recruits per spawner for Wallowa stock steelhead, brood years 1982-2005.

Table 3. Catch and escapement distribution (%) of Wallowa stock hatchery steelhead.

Recovery Location	Percent of Total				
	Brood Year				
	2001	2002	2003	2004	Mean
Ocean	0.0	0.0	0.1	0.0	0.0
Columbia River Main Stem					
Sport	3.9	5.4	13.4	7.7	7.6
Tribal	2.1	3.4	1.7	3.1	2.6
Stray Harvest	0.5	0.3	1.3	2.2	1.1
Stray Rack	1.4	0.9	2.2	6.7	2.8
Snake River Basin					
Stray below LGD	0.0	0.0	0.0	0.0	0.0
Stray above LGD Harvest	0.5	1.1	0.0	2.1	0.9
Stray above LGD Rack	0.2	0.3	0.1	0.0	0.2
Sport below LGD	2.1	3.6	3.7	3.1	3.1
Sport above LGD	20.3	15.8	16.1	13.3	16.4
Grande Ronde Sport	37.1	45.0	30.4	30.3	35.7
Escapement to Wallowa Hatchery	31.9	24.3	31.1	31.4	29.7

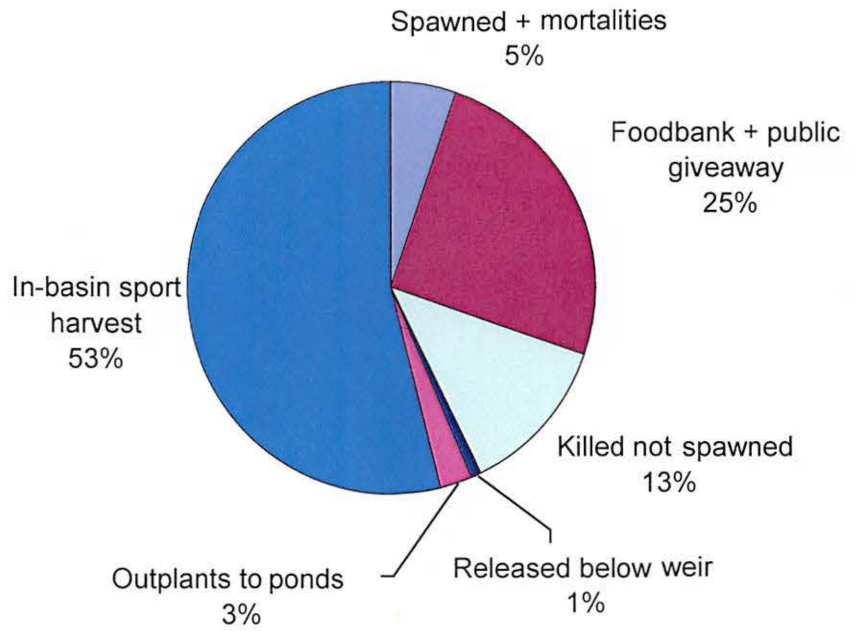

Figure 15. Escapement distribution of Wallowa stock steelhead within the Oregon portion of the Grande Ronde River basin, run years 2003-04 to 2007-08.

Wallowa stock stray rates have been highly variable ranging from less than 3.0–18% (Figure 16). We have observed a decreasing trend in stray rates through time. Over 70% of the strays have been recovered in the Deschutes River basin and minor proportions have been observed in the Salmon River in Idaho (Figure 17). Substantial numbers of Wallowa stock steelhead are recovered during the winter and springtime at Warm Springs Hatchery and Pelton Dam traps high in the Deschutes River basin. The high rate of straying into the Deschutes River basin is one of the primary reasons we are evaluating alternative broodstock sources (autumn line) for the Grande Ronde hatchery program. Within-basin stray rates are low, and hatchery fish comprise a small fraction of total returns to Lookingglass Creek, Catherine Creek, and the upper Grande Ronde River, where strays are monitored with weirs and traps (Table 4).

Table 4. Wallowa stock hatchery steelhead adults captured at weirs on Catherine and Lookingglass creeks and on the upper Grande Ronde River, return years 2001-10.

Weir Location	Avg. Total No. of Adults	Avg. % Hatchery-Origin	Range (%) of Hatchery-Origin
Catherine Creek	207	0.37	0-1.6
Lookingglass Creek	186	1.61	0-2.4
Upper Grande Ronde R.	44	0.67	0-1.4

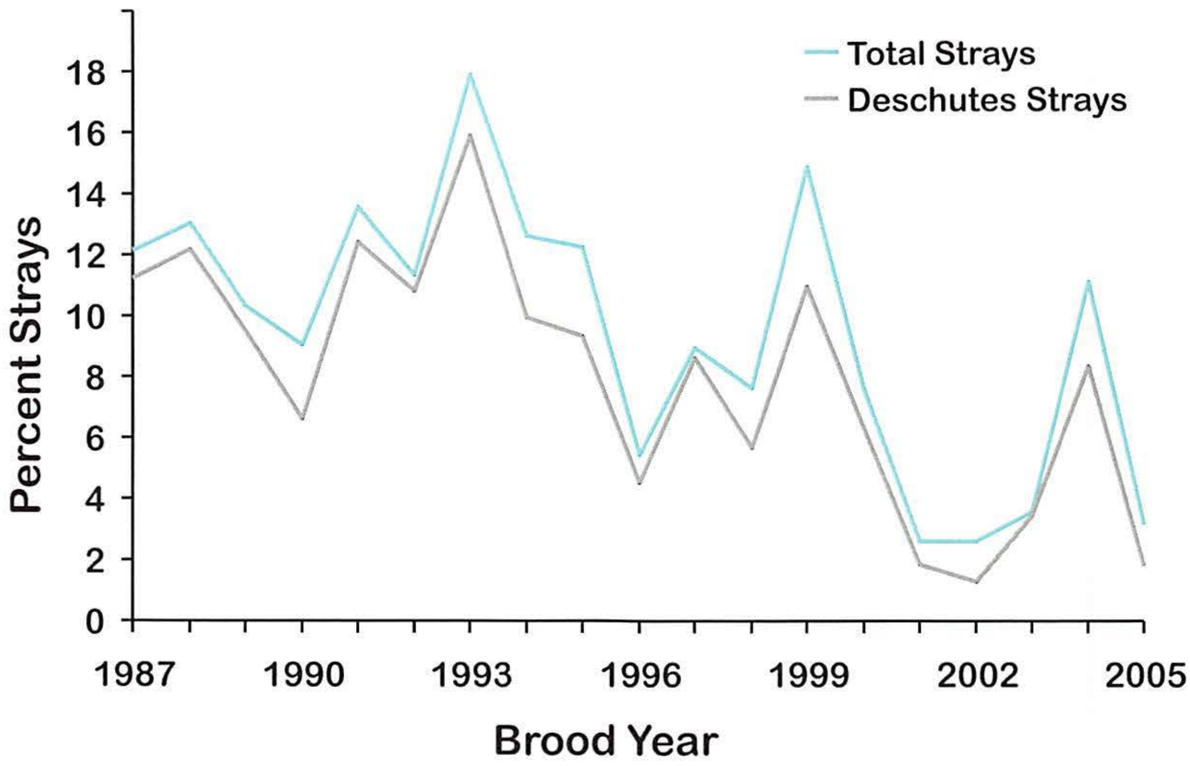

Figure 16. Percentage of Wallowa stock steelhead adult recruits that stray, and the percentage that stray into the Deschutes River, a tributary to the Columbia River, brood years 1987-2005.

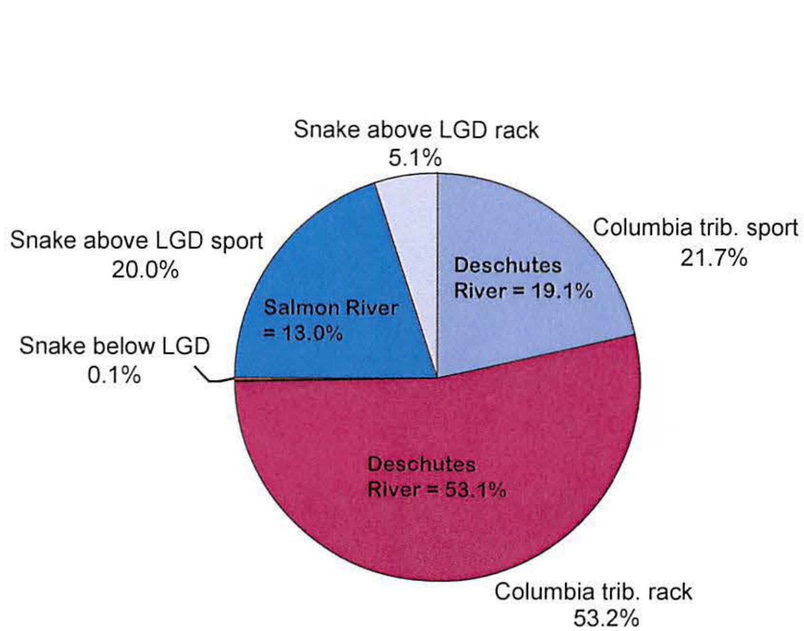

Figure 17. Distribution of adult Wallowa stock steelhead strays, brood years 2001 to 2004.

We observed an increase in the variability of adult return timing to Wallowa Hatchery between the 1991-1995 and 2006-2010 time periods. In recent years adults arrive earlier in the spring, and a greater proportion of the return occurs at the tail end of the distribution (Figure 18). We have not observed any significant change in age structure over time; however, Wallowa Hatchery adults do return at a slightly younger ocean age than natural-origin adults in Deer Creek, a tributary to the Wallowa River (Figure 19). Length at age has not changed over time (Figure 20).

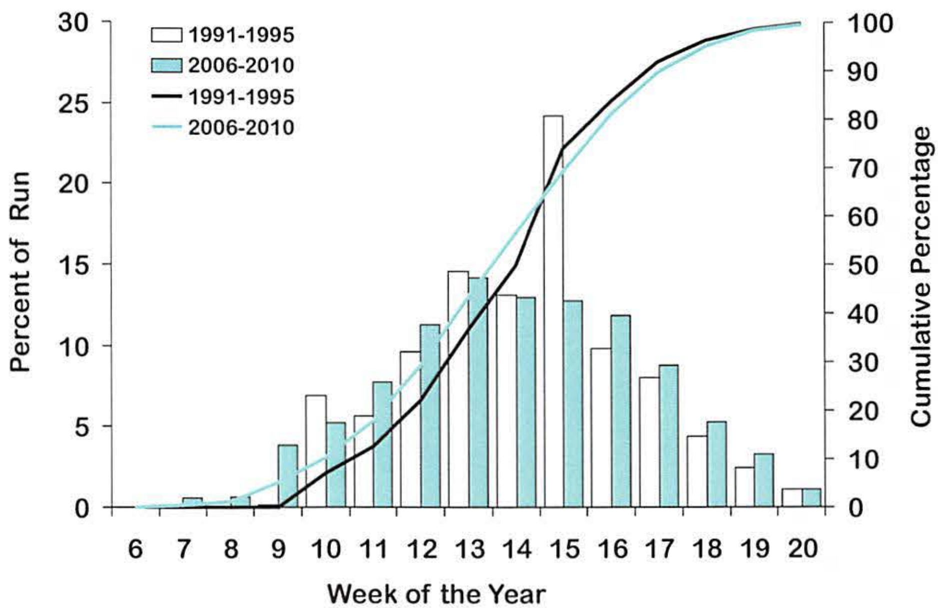

Figure 18. Average historical (1991-1995) and current (2006-2010) return timing of Wallowa stock hatchery steelhead adults to the Wallowa Hatchery weir and cumulative percentage that returned by week of the year.

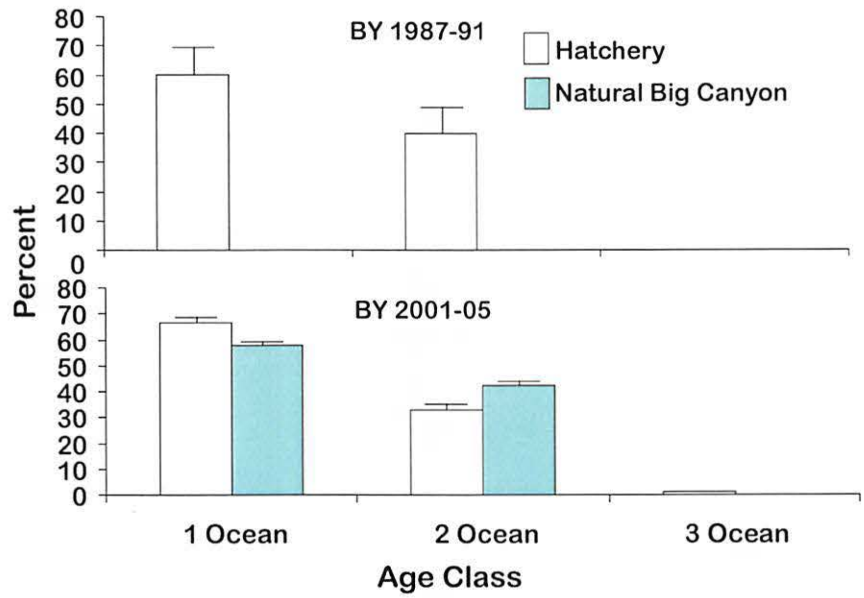

Figure 19. Historical (BY 1987-91) and current (BY 2001-05) age at return of Wallowa stock steelhead adults returning to Wallowa Hatchery and natural-origin steelhead adults returning to the Big Canyon Facility weir on Deer Creek.

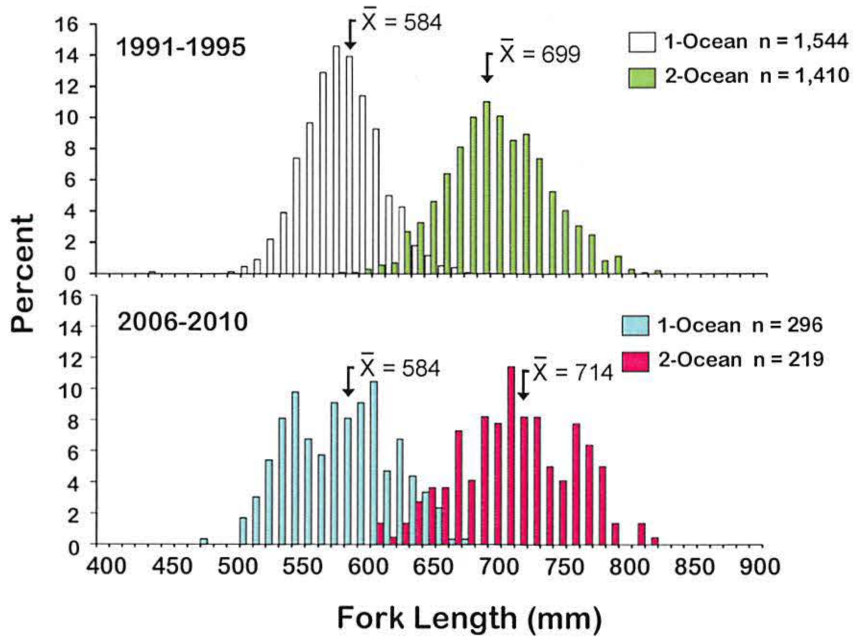

Figure 20. Historical (return years 1991-95) and current (2006-10) fork lengths at ocean age of adult Wallowa stock steelhead.

The primary fish health issue that has influenced the program is cold-water disease caused by *Flavobacterium psychrophilum* (Table 5). Cold-water disease induced mortality has occurred primarily after fry ponding in late June and early July and at the acclimation ponds in the spring following transport from Irrigon Hatchery.

Table 5. Fish health issues in the Wallowa stock steelhead hatchery program.

Disease Issues	Consequences	Fish Health Response
Bacterial cold-water disease (CWD) caused by *Flavobacterium psychrophilum* (Fp)	CWD loss in most brood years after ponding fry into indoor circular tanks at Irrigon Hatchery After hauling to acclimation some smolts develop open sores with CWD bacteria being a contributing factor	Antibiotic treatment with florfenicol for 10 d 2005-2009 used florfenicol at 15 mg/kg. Some repeat treatments necessary Collaborative research with Univ. of Idaho on new broodstock screening methods for Fp
Transfer of smolts to Big Canyon Acclimation Facility in cold weather	Loss from temperature shock and post hauling stress (2001 & 2009) CWD can be a contributing factor causing chronic loss (2012)	Recommend delaying transfers till March Recommend no hauling to acclimation if water temperature is < 35° F

Recreational fisheries in the Grande Ronde River basin were closed from 1974 to 1984. The season was initially reopened in 1985 during the fall for catch and release of both hatchery and natural-origin fish. In 1986, consumptive fisheries were reopened from fall through spring throughout the basin in all of the areas that were open for fishing historically. The fishery has been managed as a mark selective fishery with mandatory release of all natural-origin fish.

Steelhead recreational fishery creel surveys were originally conducted throughout the Grande Ronde basin including Catherine Creek and the upper Grande Ronde River. Hatchery releases were discontinued in Catherine Creek and the upper Grande Ronde River in the mid-1990s and thus we discontinued our creel surveys in these areas. Creel surveys are currently conducted on the lower Grande Ronde River, Rondowa (area at the confluence of the Grande Ronde and Wallowa rivers), and on the Wallowa River (Figure 21).

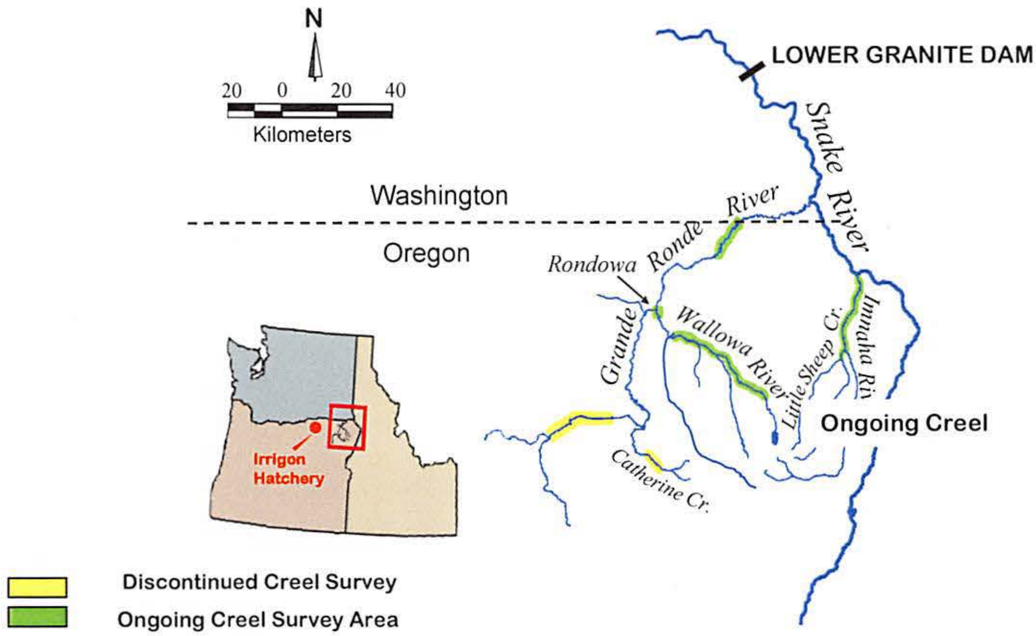

Figure 21. Ongoing (green shaded) and discontinued (yellow shaded) steelhead creel survey areas in the Grande Ronde and Imnaha river basins.

Total catch of hatchery- and natural-origin steelhead in the Oregon section of the lower Grande Ronde River ranged from 600 to greater than 6,500 (Figure 22). Hatchery fish generally comprise 60% or more of the catch. Natural-origin fish represent a high proportion of the catch in the early fall. As the season progresses hatchery-origin fish become a majority of the catch. Annual harvest for all fisheries combined has substantially exceeded the historical average harvest of 764 fish consistently since the 1996-97 run year (Figure 23). Harvest in the springtime fisheries typically exceeds harvest that occurs in the fall on the lower Grande Ronde River. The highest harvest levels have occurred in recent years with the peak of over 5,000 fish in the 2005-06 run year.

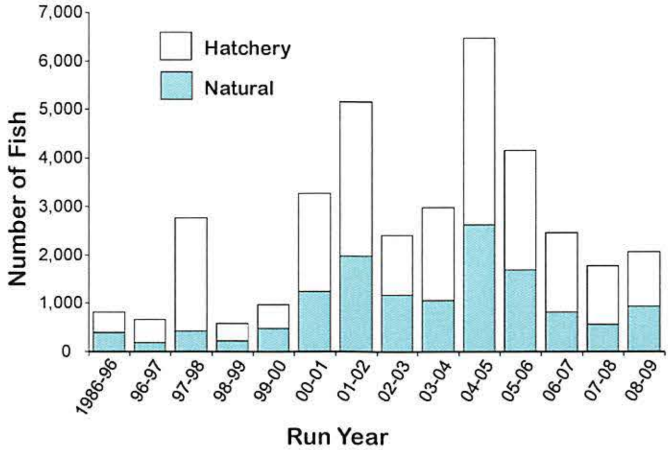

Figure 22. Annual recreational catch of hatchery- and natural-origin steelhead in the Oregon section of the lower Grande Ronde River. Hatchery-origin fish are predominantly Wallowa stock releases. Data from 1986-96 are annual averages.

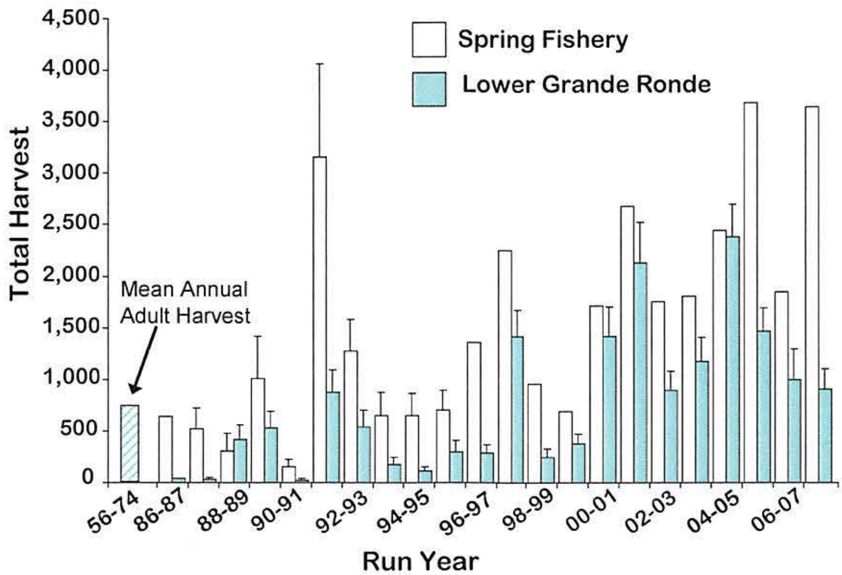

Figure 23. Estimated annual harvest by run year of Wallowa stock steelhead in the lower Grande Ronde River and in spring fishery areas (upper Grande Ronde River, Wallowa River, Catherine Creek, and Rondowa). Data from 1956-74 are annual averages.

Angler effort has been variable with the greatest angler day estimate slightly below 16,000 days (Figure 24). Most of the anglers participating in fisheries originate from Wallowa and Union counties and only a small proportion are from outside Oregon (Figures 25 and 26).

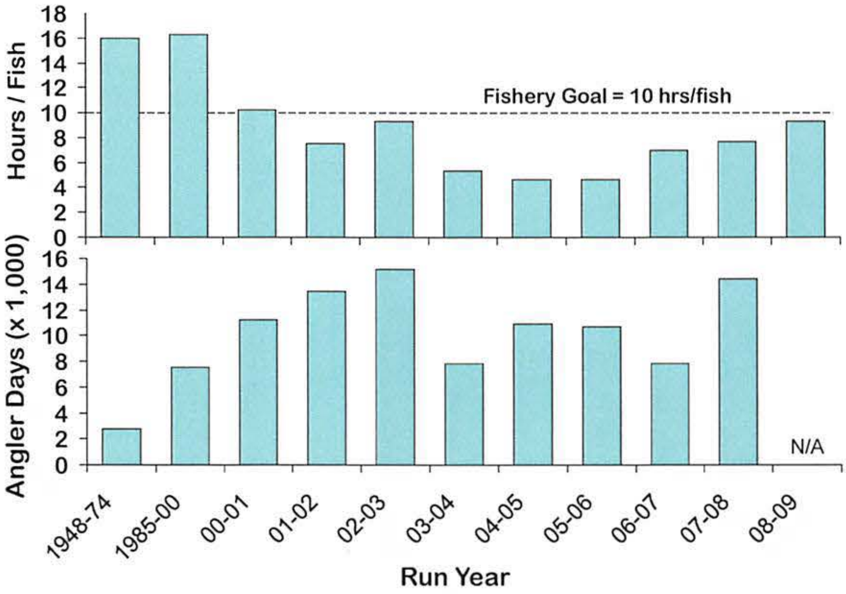

Figure 24. Estimated annual fishing effort (angler days) and catch rate (hours/fish) in the steelhead fishery of the Oregon section of the Grande Ronde River. Data from 1948-74 and 1985-2000 are annual averages.

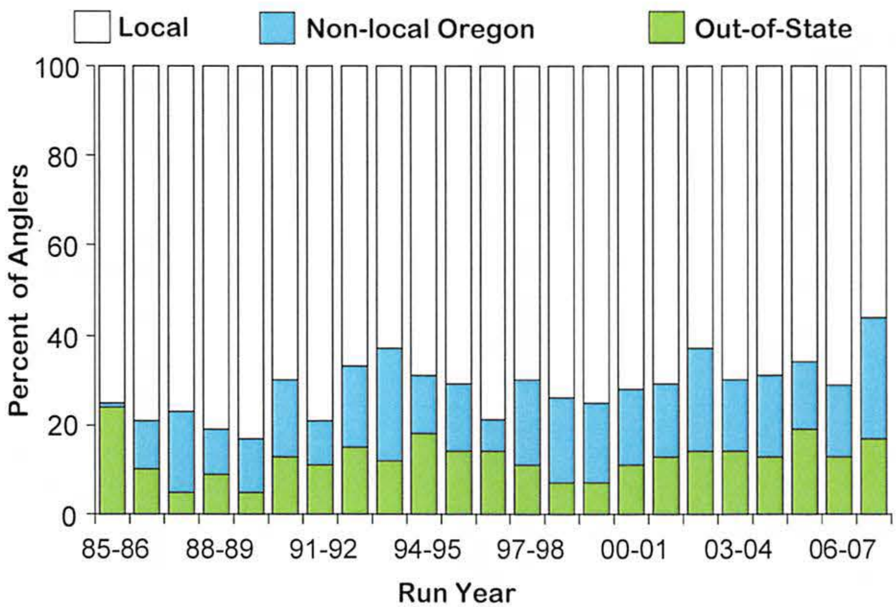

Figure 25. Origin of anglers fishing the Oregon section of the lower Grande Ronde River, run years 1985-86 to 2007-08.

We estimated annual economic value for summer steelhead recreational fisheries in the Grande Ronde, Wallowa, and Imnaha river basins based on total estimated angler days (total hours fished/hours per completed angler), origin of anglers (local = Union and Wallowa counties; non-local = all other Oregon counties; Washington, and other states), and average expenditures of local and non-local angler days. Estimated angler days and origin of anglers were summarized from angler surveys conducted on the lower Grande Ronde, Wallowa, and Imnaha rivers each year from 1999 through 2009.

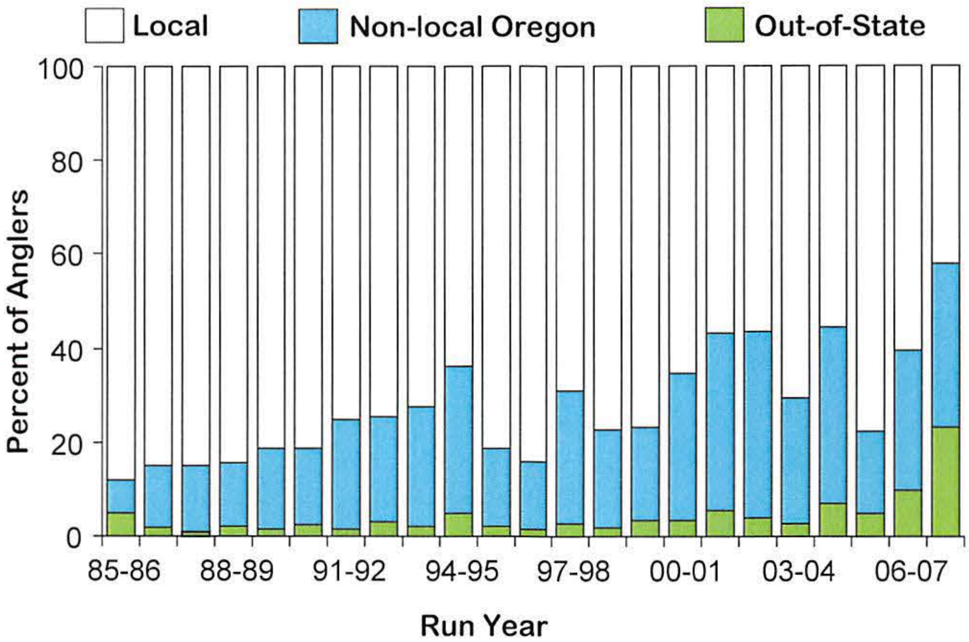

Figure 26. Origin of anglers fishing the spring fishery areas (upper Grande Ronde River, Wallowa River, Catherine Creek, and Rondowa) of the Grande Ronde River, run years 1985-86 to 2007-08.

Average angler day cost for local and non-local anglers was obtained from data reported in *Fishing, Hunting, Wildlife Viewing, and Shellfishing in Oregon, 2008 State and County Expenditure Estimates.* These estimates included expenditures per day for the eastern Oregon travel region that included both "travel expenditures" and "fishing-related equipment expenditures" for freshwater local anglers ($74.31 per angler day) and for non-local anglers ($90.09 per angler day). Travel-related expenditures include accommodations, food services, food stores, ground transportation, outfitter/guide service, and equipment (tackle, clothing, boats, etc.).

Estimated annual expenditures by anglers fishing all Grande Ronde River basin steelhead fisheries ranged from $500,000 to $1,200,000 from the 1999-2000 run year through the 2008-2009 run year (Figure 27).

SUMMARY AND CONCLUSIONS

Broodstock Development and Management

The broodstock development process was slow (10 years) in building up to adequate returns to meet smolt production goals. We have had more than adequate returns since 1987 to meet production goals. The autumn line broodstock are providing substantial returns to Wallowa Hatchery to enable a transition when desired.

In-Hatchery Performance

Adult prespawn mortality is low and egg-to-smolt survival is typically high, except in years when substantial mortality occurs due to cold-water disease.

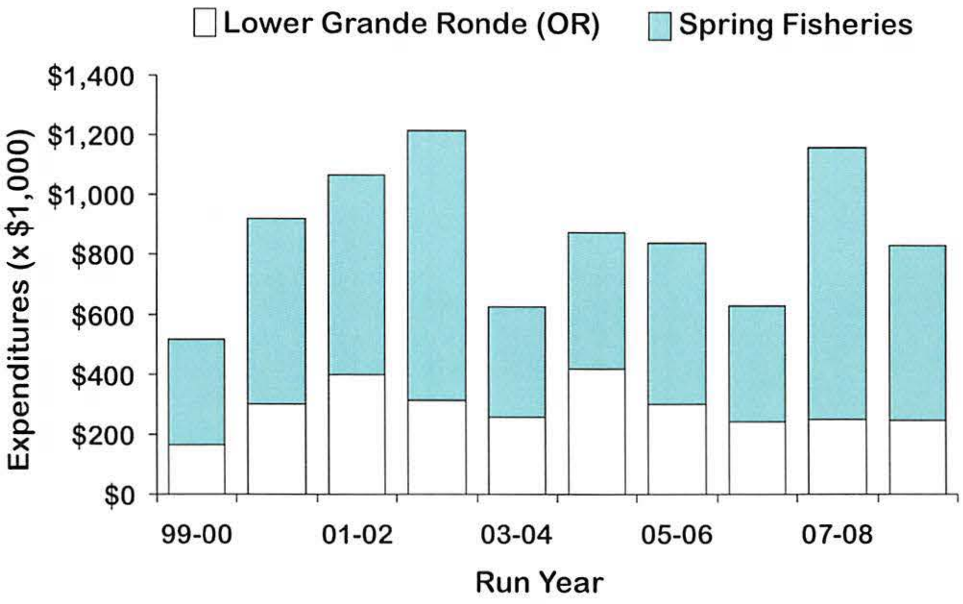

Figure 27. Estimated annual expenditures by anglers fishing the lower Grande Ronde River and spring fishery areas (upper Grande Ronde River, Wallowa River, Catherine Creek, and Rondowa) in run years 1999-00 to 2008-09.

Production, Survival, and Adult Return Performance

Smolt production has generally reached the annual goals and smolt survival to LGD has been high. Adult return numbers have improved compared with the previous decade, and we have reached the compensation goal in six of the past 10 years. SARs have been at or near the goal nearly every year in the past decade; however, we have rarely met the SAS goal. Exploitation rates are high and Wallowa stock steelhead contribute substantially to numerous fisheries through their entire adult migratory path. We have observed high stray rates into the Deschutes River basin; however, the rates have declined recently to relatively low levels. We observed very low stray rates in Snake River tributaries and within the Grande Ronde River basin.

Recreational fisheries have been restored to levels well above historical for catch, harvest and effort. Catch rates are consistently better than our goal of 10 hrs/fish and the recreational fisheries provide substantial local economic value.

Life History Characteristics and Natural Production Monitoring

Adult migration timing has become more variable over time. We have not observed changes in age composition or size at age in the Wallowa stock over time.

Natural population viability status, for populations that are monitored, is relatively good with the Joseph Creek population rated at "highly viable" and the Upper Grande Ronde River population close to "viable" status. Viability monitoring has expanded recently with GRTS-based redd counts, PIT tag adult array estimates, and an extensive habitat monitoring program for the Upper Grande Ronde River population. These efforts will improve abundance/productivity and hatchery fraction estimates.

Grande Ronde Steelhead Hatchery Program Adaptive Management Changes

We have made numerous adaptive changes to improve performance and reduce program impacts on natural populations. The following adaptive activities have been implemented: 1) reduced smolt production numbers to reduce straying impact in the Deschutes basin; 2) eliminated direct stream releases in lower Grande Ronde, upper Grande Ronde and Catherine Creek to reduce natural spawning hatchery fish risks to natural populations; 3) implemented 100% acclimation releases and adult trapping and removal for all production to reduce abundance of natural spawning hatchery fish; 4) implemented volitional release strategies with removal of non-migrants to reduce juvenile ecological interaction risks; 5) implemented 4/lb release size goal over 5/lb to maximize SAS; 6) developing and evaluating alternative broodstocks (autumn line) to reduce straying and improve fishery contributions in Oregon; 7) transitioning to 50% autumn line by 2014; and, 8) developed food bank outlets for surplus hatchery returns.

Grande Ronde Steelhead Program Hatchery Scientific Review Group (HSRG) and Hatchery Review Team (HRT) Recommendations and Responses

HSRG – The HSRG has no specific recommendations to improve this hatchery program.

Response: Great and a much appreciated conclusion.

HRT – Continue to investigate the use of fall-returning (autumn line) adults versus production adults and research different rearing strategies.

Response: The autumn line broodstock investigation continues and includes evaluation of the progeny of returns from the original broodstock. We are scoping out options for alternative rearing/release strategies (comparison of Lyons Ferry reared smolts with Irrigon Hatchery reared smolts).

HRT – Investigate other broodstock sources as alternatives to the current Wallowa stock including endemic and Little Sheep Creek. The team believes control/treatment evaluations should be performed to determine whether these recommendations affect survival and stray rate before large scale changes to the program occur.
Response: Other alternative broodstocks have been discussed and will be further evaluated after completion of the autumn line investigations. Any alternative broodstock will be evaluated with control/treatment design to determine effect on survival and straying, the same as the autumn line investigation. We are transitioning toward 50% autumn line production by 2014.

HRT – Discontinue recycling of Wallowa stock adults returning to Big Canyon.

Response: Recycling continues at a reduced rate of 100 adults.

HRT – Continue to monitor residualism.

Response: Monitoring of residual abundance and characteristics continues in Deer Creek.

HRT – Monitor natural escapement to ensure that less than 5% of natural spawning populations are hatchery-origin Wallowa stock, particularly in Joseph Creek and the Wenaha River.

Response: Extensive monitoring of hatchery fractions in natural spawning areas is underway including trapping on Joseph Creek, Lookingglass Creek, upper Grande Ronde River, Lostine River and Catherine Creek. In addition, extensive GRTS-based spawning surveys are underway in the upper Grande Ronde River and Joseph Creek. Multiple in-stream PIT tag detectors are in place in Joseph Creek and the upper Grande Ronde River, and more are planned for the Grande Ronde and Wallowa rivers.

FUTURE PROGRAM CHALLENGES AND NEEDS

Although the Grande Ronde River basin hatchery steelhead programs are operating effectively and achieving the primary management objectives, there remain challenges that face the program in the future. Complex interrelated challenges are to identify the most effective broodstock source, broodstock management, and rearing and release strategies that maximize SAS, achieve fisheries contributions objectives, and reduce straying to levels that pose acceptable risk to ESA listed Mid-Columbia steelhead populations. Given that we have observed much lower straying rates for in-river migrants versus barge-transported smolts, maintaining a spread-the-risk main stem migration strategy with spill and a significant proportion of smolts as in-river migrants is a prudent approach for reducing stray rates.

We have documented significant residualism of hatchery releases in the Grande Ronde basin. Additional monitoring to better understand the characteristics and ecological impacts of residuals would provide a better foundation for managing hatchery strategies.

Performance of a New Steelhead Line Derived From Hatchery Parents Collected in Autumn in the Grande Ronde River

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This program is a cooperative effort of the Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation. Program funding is from the Bonneville Power Administration administered by the U.S. Fish and Wildlife Service under the Lower Snake River Compensation Plan.

INTRODUCTION and BACKGROUND

This paper provides information about the developmental history and performance assessment of a new line of Wallowa stock steelhead created from Wallowa stock hatchery parents that were collected by angling in autumn in the Grande Ronde River of northeastern Oregon. Our performance assessment is not complete because coded-wire tag reporting from adult tag recoveries from the first generation (brood years 2004-2007) of releases is incomplete and adults have yet to return from all of the second generation releases (brood years 2008-2011).

The Grande Ronde steelhead hatchery program was initiated in the late 1970s as part of the Lower Snake River Compensation Plan (LSRCP) to mitigate for Oregon harvest opportunities lost by construction of the four lower Snake River dams. The founding parents for the Wallowa program were endemic to the Snake basin and the resulting stock is a proven, productive hatchery population that has reestablished a fishery with effort, catch rates, and harvest levels similar to historic, pre-dam levels (Flesher et al. 2011). The LSCRP program goal of returning 9,184 adults to the compensation area was met in 1997-98 and in every year since 2001-02 (Warren et al. 2011).

Prior to closure of the native steelhead fishery in 1974, the majority of harvest opportunity occurred in the lower Grande Ronde River during fall (Carmichael et al. 1990), whereas peak harvest of the current Wallowa hatchery stock typically occurs in the spring (Flesher et al. 2011). This apparent shift in timing of harvest opportunities may be associated with selection of the founding parents. The Wallowa stock was sourced from collections of Snake River steelhead during spring at Ice Harbor and Little Goose dams, and incorporated embryos from Pahsimeroi Fish Hatchery, Idaho. Since 1979, Wallowa stock adults returning to Wallowa Hatchery, Big Canyon, and Cottonwood traps (WA) have been utilized as broodstock.

Most Wallowa stock steelhead migrate through the Columbia River corridor in mid-summer, when water temperatures are warmest; a behavior that may encourage migrants to use relatively cooler mid-Columbia tributaries, particularly the Deschutes River, as thermal refuge. Once they enter the mouth of the Deschutes River, Wallowa stock steelhead are apparently more likely to stray far upriver than are other Snake River basin hatchery stocks (Figure 1). Managers hypothesized that the earliest returning portion of the Wallowa stock run—those adults that traveled through the Columbia River mainstem quickly and arrived in the Grande Ronde River in the fall—would produce progeny that would be less likely to stray. Therefore, in response to straying concerns, co-managers agreed to modify the Wallowa program to reduce impacts of hatchery releases on out-of-basin native stocks.

The desire to increase fall harvest opportunities in the lower Grande Ronde River, combined with efforts to reduce straying of Wallowa stock steelhead in the Deschutes basin, provided impetus for the Wallowa autumn line broodstock experiment. By creating an alternate brood line of Wallowa stock steelhead collected from the lower Grande Ronde River by angling in October, the progeny were expected to contribute to the following objectives: 1) modify run-timing to emphasize fall-entry to the Grande Ronde River, 2) reduce straying of Wallowa stock steelhead in the Deschutes River, 3) enhance fishing opportunities in the lower Grande Ronde River in fall, and 4) maintain the successful performance exhibited by the standard Wallowa stock.

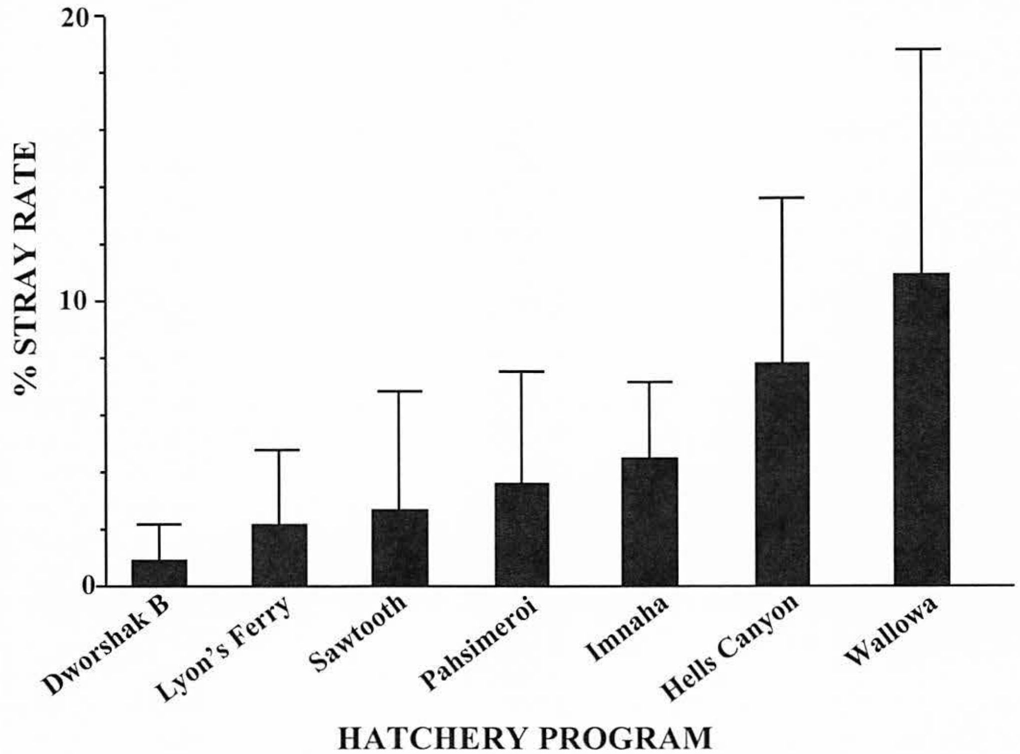

Figure 1. Average (± 1 SE) annual Deschutes River straying rates of hatchery steelhead stocks released into the Snake River. This analysis is based on 11 to 24 years of coded wire tag recovery data (Carmichael and Hoffnagle 2006).

BROODSTOCK COLLECTION and HATCHERY REARING

Broodstock collection for the first generation of the autumn line was by angling in the Grande Ronde River near Troy, Oregon, in October of 2003 through 2006 (for brood years 2004 through 2007; Figure 2). Volunteer anglers from the general public and biologists from ODFW, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation participated in broodstock collection of between 77 and 115 fish annually. Upon landing a hatchery steelhead, anglers placed the fish in a tube and oriented the tube into the flow where it was held until an ODFW biologist could take possession. Fish were then passive integrated transponder (PIT) tagged for future identification and transferred to the Wallowa Hatchery to be held until spring for spawning. Broodstock from the autumn line and the standard Wallowa stock were spawned separately, eggs were incubated to the eyed stage at the Wallowa Hatchery then transferred to the Irrigon Hatchery located near the town of Irrigon, Oregon for final incubation and rearing to the yearling smolt stage. While in the hatchery, eggs and fish from the two broodstock lines were kept separate but rearing was the same, except that the standard Wallowa stock was size-graded as fry whereas the small numbers of autumn line fry did not allow for size grading.

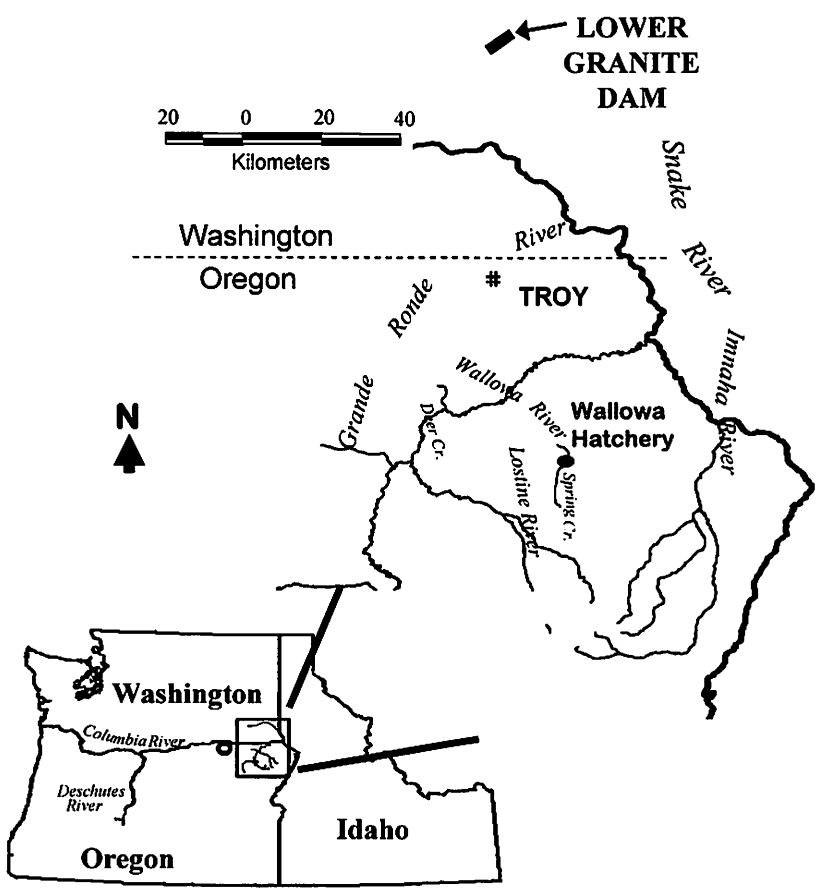

Figure 2. Map of northeast Oregon showing the location of the Wallowa Hatchery on the Wallowa River, and the town of Troy on the lower Grande Ronde River near where autumn line adult broodstock were collected. Inset shows location of study area within a three-state region, with an open circle marking the Irrigon Fish Hatchery's location.

Number of first generation autumn line reared for release ranged between 114,763 and 221,317, whereas the number of standard Wallowa stock ranged between 257,806 and 447,755 (Table 1). Second generation autumn line smolts are the progeny of first generation adult broodstock that returned to Wallowa Hatchery and were trapped temporally across the run. In mid-summer all steelhead were marked with an adipose fin clip and in autumn approximately 100,000 fish each from the autumn line and standard stock groups received a left ventral fin clip and a coded-wire tag (CWT) snout implant that was uniquely coded by release group. To estimate smolt survival and migration timing to Lower Granite Dam, representative samples from each release group were PIT-tagged in November or December. Then in February or early March all fish were transferred to two acclimation ponds at the Wallowa Hatchery, acclimated for no less than 27 d, and released into the river. Prior to release, a representative sample of 50 fish from each acclimation pond were collected for weight (g) and fork length (mm) measurements, from which Fulton's condition factor (K = weight/length^3 x 10^5; Anderson and Neumann 1996) was calculated. To sample fish, water volumes in the ponds were first drawn down, then fish were crowded to one end of the pond using a beach seine, and lastly a large volume dip net was used to collect a sample of fish. Sampled fish were held in a net pen until measurements on anesthetized fish could be made soon thereafter. We used adult PIT tag recoveries at Columbia and Snake River dams to track adult migration timing and to calculate smolt-to-adult survival to Bonneville Dam and smolt-to-adult return to Lower Granite Dam. Coded-wire tag recoveries from out-of-basin locations were used to calculate a stray rate index. We consider our estimate to be an index of straying behavior, rather than a true stray rate, because the intended ultimate destination of steelhead captured in out-of-basin fisheries is unknowable; if un-captured some individuals may have returned to their release location.

Table 1. Numbers of autumn line and standard stock smolt releases by brood year and corresponding numbers of fish that were PIT tagged.

		Number Released		Number PIT tagged	
Brood Year	Generation	Autumn line	Standard stock	Autumn line	Standard stock
2004	F_1	114,763	309,751	3,777	3,769
2005	F_1	138,053	447,755	3,567	3,566
2006	F_1	221,317	257,806	3,567	3,586
2007	F_1	140,082	345,425	3,558	6,914
2008	F_2	241,010	129,447	3,599	5,203
2009	F_2	94,548	230,013	3,425	7,634
2010	F_2	207,535	292,986	5,673	7,773

Irrigon Hatchery personnel were successful at rearing autumn line and standard stock juveniles to a similar size, because the average difference in fork length and condition factor just prior to release was generally small (Figure 3) and judged to be biologically inconsequential.

POST RELEASE PERFORMANCE

Following release to the river, smolts took between 17 and 33 days to arrive at Lower Granite Dam (Table 2). In most release years the difference in arrival timing between autumn line and standard stock adults was less than two days. Because arrival timing was similar it is likely that smolts from the two groups were loaded onto barges and shipped to below Bonneville Dam, or allowed to migrate in-river, at similar rates. Outmigration survival was also similar between the two groups, ranging between 73% and 84%.

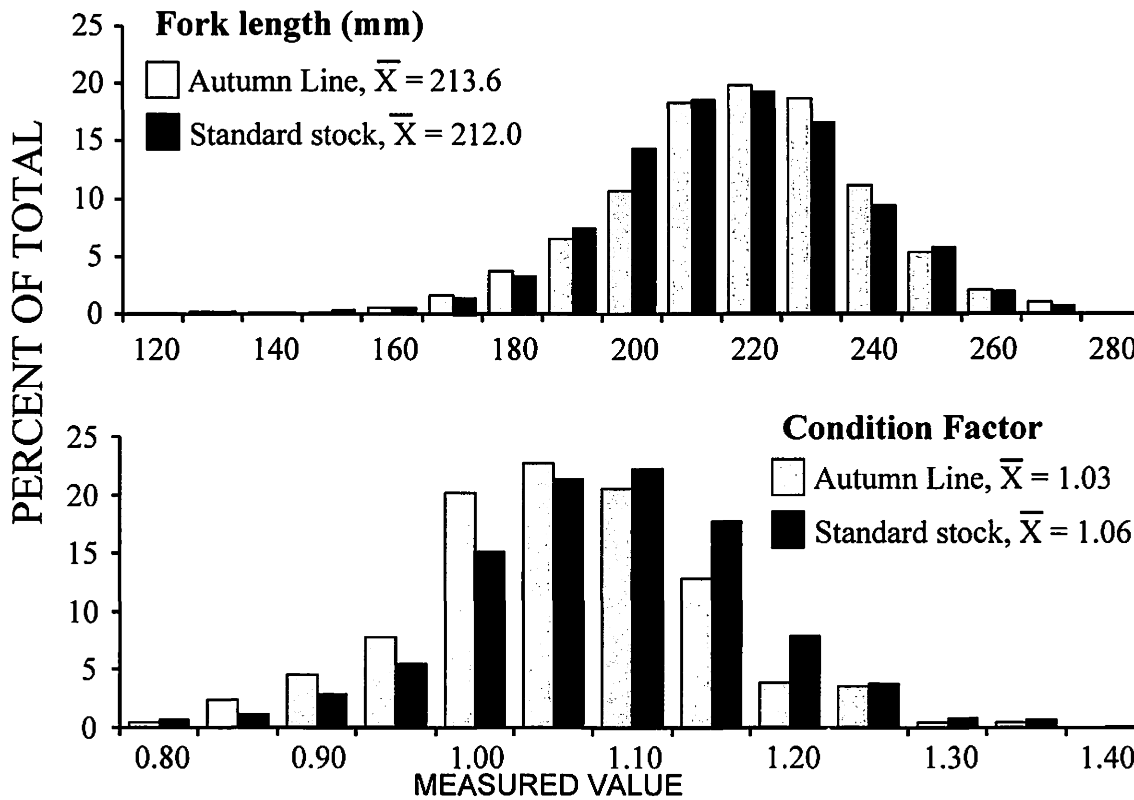

Figure 3. Average fork length (top graph) and condition factor for Wallowa stock autumn line and standard stock for first generation release groups, brood years 2004-2007.

Table 2. Annual average travel time and percent outmigration survival to Lower Granite Dam of Wallowa stock autumn line and standard stock smolts, brood years 2004-2010.

	Travel Time (d; ± SD)		Outmigration Survival (± CI)	
Brood Year	Autumn line	Standard stock	Autumn line	Standard stock
2004	23.5 (7.0)	23.8 (7.6)	77 (2.1)	77 (3.0)
2005	21.6 (11.5)	22.4 (10.8)	73 (6.6)	74 (5.3)
2006	30.8 (6.7)	30.1 (8.7)	71 (22.3)	78 (41.0)
2007	31.3 (11.3)	33.1 (12.9)	84 (19.3)	84 (13.5)
2008	18.3 (9.7)	17.3 (11.2)	82 (4.8)	80 (3.9)
2009	27.1 (11.8)	23.8 (11.9)	80 (29.0)	82 (17.0)
2010	21.9 (12.1)	20.1 (12.9)	77 (8.2)	74 (6.0)
Averages	*24.9*	*24.4*	*77.7%*	*78.4%*

Based on PIT tag detections, adult steelhead progeny from the first generation (brood years 2004-2007) of autumn line releases returned to Bonneville Dam an average of about 9 days earlier than their standard stock counterparts (Figure 4). As the run moved upstream to McNary Dam the difference in return timing widened to 24 days, then to 26 days at Lower Granite Dam. However, second generation adult steelhead from the autumn line may not be displaying a similar early return timing behavior. Based on 1 and 2-ocean adults returning from brood year 2008 and 1-ocean adults returning from brood year 2009, average return timing of the second generation autumn line adults to Bonneville Dam was only 5 days earlier than the standard stock, the difference widened to 13 days at NcNary Dam, then it contracted to 9 days at Lower Granite Dam (Figure 5). We will delay making final determinations about the run timing of second generation autumn line adults until several years more data is obtained.

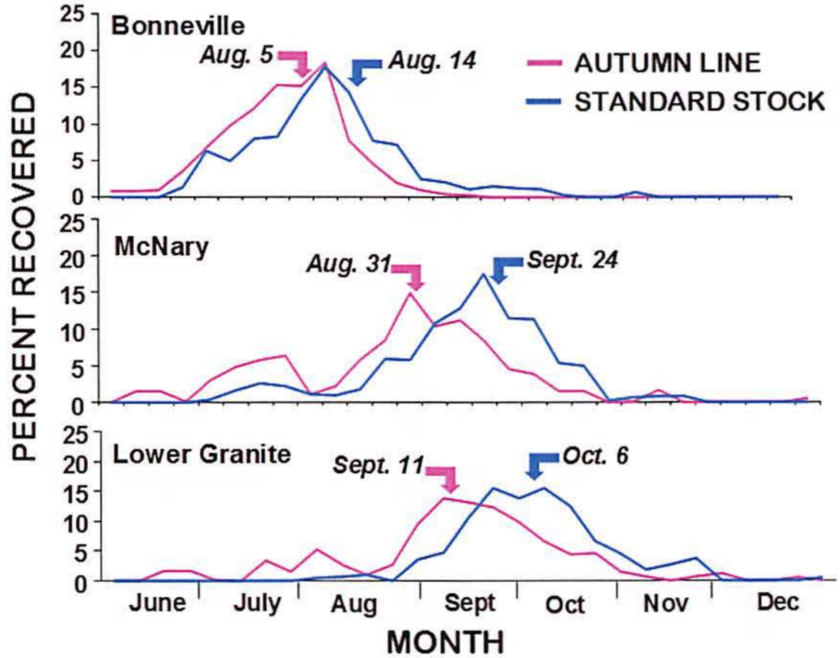

Figure 4. Average adult return timing to Bonneville, McNary, and Lower Granite dams of the first generation (brood years 2004-2007) of the autumn line compared to return timing of the standard Wallowa stock.

At the outset of this experiment we did not hypothesize that adults from the autumn line would exhibit higher post-release survival than the standard Wallowa stock; however, smolt-to-adult survival of the first generation of the autumn line to Bonneville Dam was 32% higher than the standard Wallowa stock, a difference that was statistically significant (Paired *t*-test, $P = 0.004$; Figure 6). For brood year 2008, the one complete year of second generation adult returns, the smolt-to-adult survival advantage of the autumn line narrowed to 23.5%. Smolt-to-adult return to Lower Granite Dam was 35% higher for the autumn line (Figure 7), a difference that was also significant ($P = 0.001$). A potential explanation for the stronger survival of the autumn line lies in the adult age at return data (Figure 8), which shows that a higher portion of the autumn line adult run is composed of 1-ocean individuals compared to the standard Wallowa stock. Since the autumn line returns at a younger age they suffer one less year of ocean mortality.

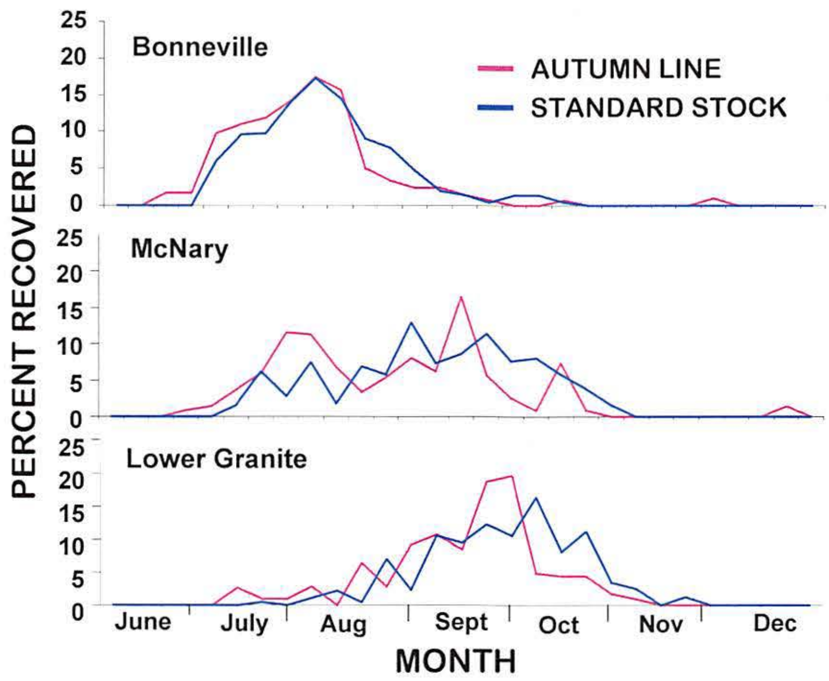

Figure 5. Smolt-to-adult survival to Bonneville Dam based on PIT tag recoveries of autumn line and standard Wallowa stock steelhead. First generation (F_1) autumn line adults are from brood years 2004-2007, whereas 2008 is the only complete brood year in which complete results exist for the second generation. Numbers inside bars are the number of PIT tags detected.

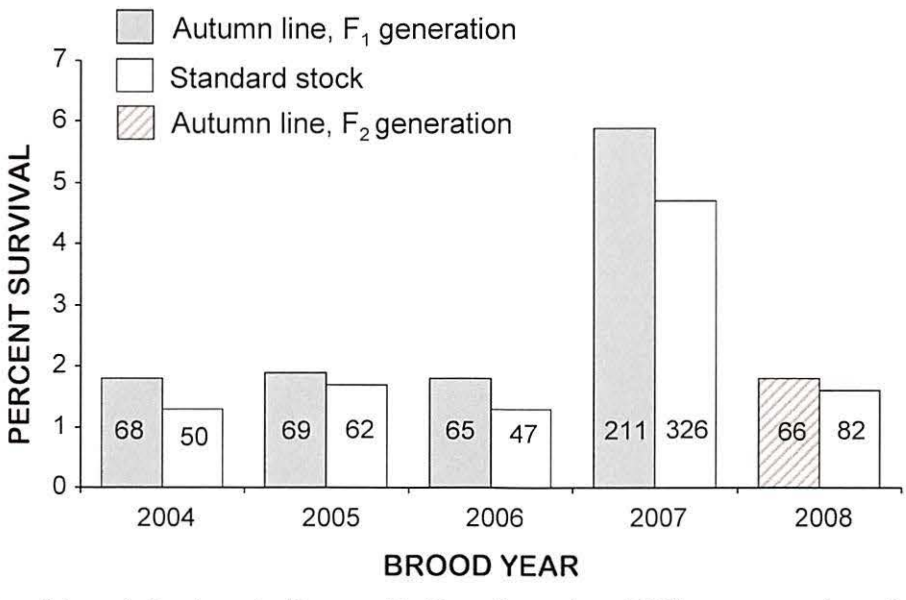

Figure 6. Smolt-to-adult return to Bonneville Dam based on PIT tag recoveries of autumn line and standard Wallowa stock steelhead. First generation (F_1) autumn line adults are from brood years 2004-2007, whereas 2008 is the only complete brood year in which complete results exist for the second generation. Numbers inside bars are the number of PIT tags detected.

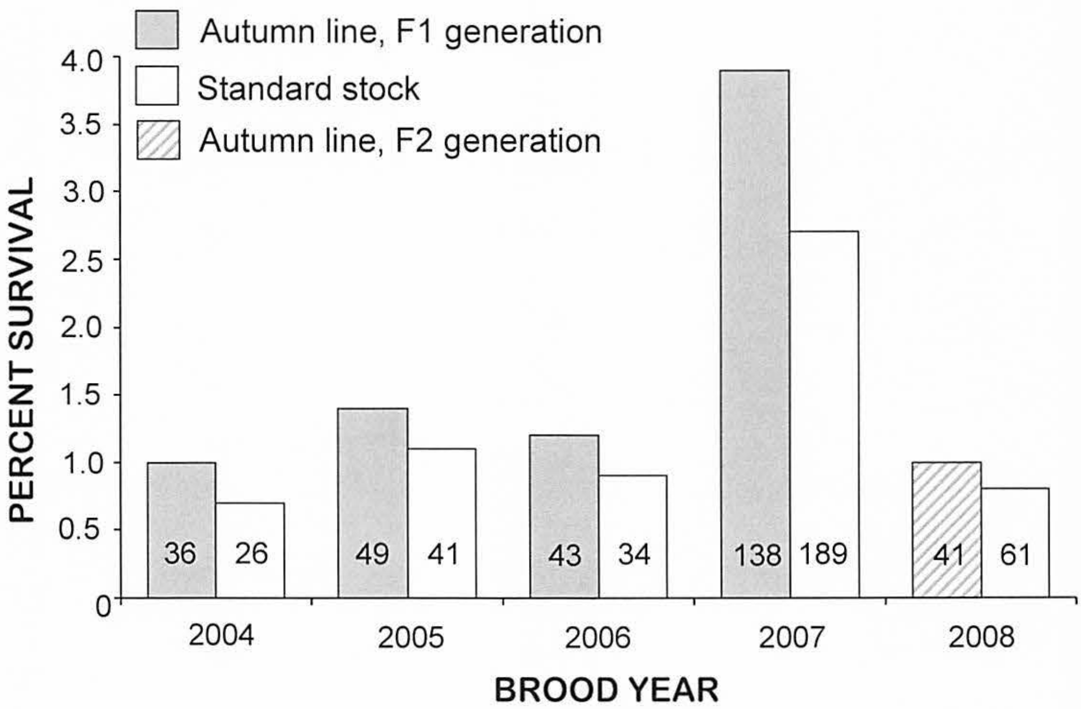

Figure 7. Smolt-to-adult return to Lower Granite Dam based on PIT tag recoveries of autumn line and standard Wallowa stock steelhead. First generation (F_1) autumn line adults are from brood years 2004-2007, whereas 2008 is the only complete brood year in which complete results exist for the second generation. Numbers inside bars are the number of PIT tags detected.

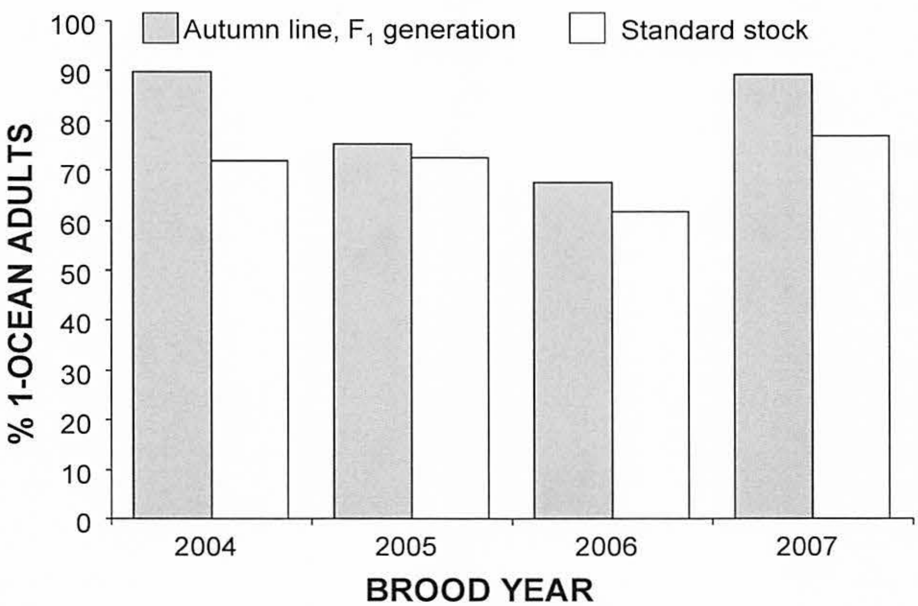

Figure 8. Adult age at return for autumn line and standard Wallowa stock steelhead.

Coded-wire recovery data for the first generation of autumn line releases is not yet complete. Nevertheless, stray rate estimates based on coded-wire recoveries are not encouraging as they suggest that the autumn line is at least as prone to stray as is the standard Wallowa stock (Figure 9). However, we see an interesting pattern in the year-to-year stray rate estimates for both the autumn line and the standard Wallowa stock, which is that stray rates were much higher in 2004 than in subsequent years. This pattern may be attributable to a reduction in the percentage of smolts that were barged, since barged fish are known to stray at higher rates (Fish Passage Center 2007). An estimated 94% of brood year 2004 smolts were barged, but that percentage dropped to 41% for brood year 2007 releases.

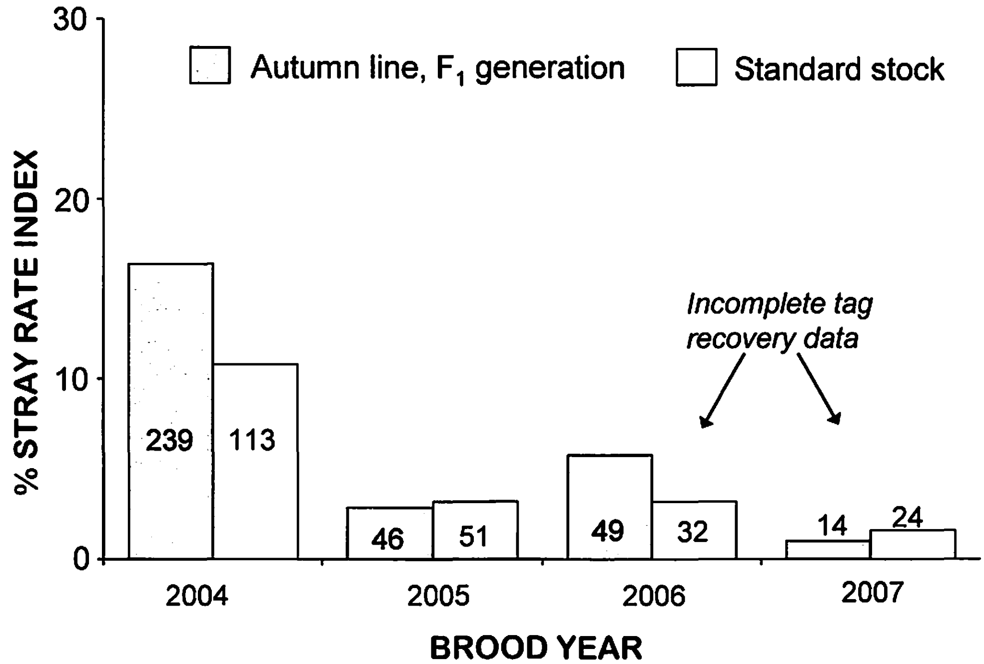

Figure 9. Percent stray rate index for autumn line and standard Wallowa stock steelhead. Coded-wire tag recovery data for brood year 2006 is mostly complete but data for brood year 2007 is mostly incomplete.

In most years over 90% of Wallowa stock stray tag recoveries come from the Deschutes River basin. Therefore, to better understand whether our straying conclusions based on the stray rate index are correct, we also examine tag recovery data in a spatio-temporal context. In the Deschutes basin about 80-85% of tag recoveries for both the autumn line and the standard Wallowa stock are above the lower river fishery, which occurs from the mouth to river kilometer 69 (Figure 10), indicating that the autumn line is just as likely to migrate upstream of the lower river. However, a higher portion of the autumn line adults reach traps located in the upper reaches of the Deschutes basin before 1 February, indicating that autumn line fish stray farther upstream earlier in the season.

Studies show that a portion of Snake River basin steelhead that enter the Deschutes River in summer and become vulnerable to capture will ultimately exit to resume their migration up the Columbia River. To investigate the propensity for Wallowa stock steelhead to demonstrate this pattern we gathered PIT tag detection information at Sherars Falls and at McNary Dam (or at dams farther upstream) on the Columbia River upstream from the Deschutes River for four run years (Table 3). The annual number of Wallowa stock PIT tag detections at Sherars Falls is relatively low, in part because the efficiency of the PIT tag antenna is thought to be low.

However, the data suggests that about 20% of both the autumn line and the standard Wallowa stock that are detected at Sherars Falls will later be detected at McNary Dam or farther upstream.

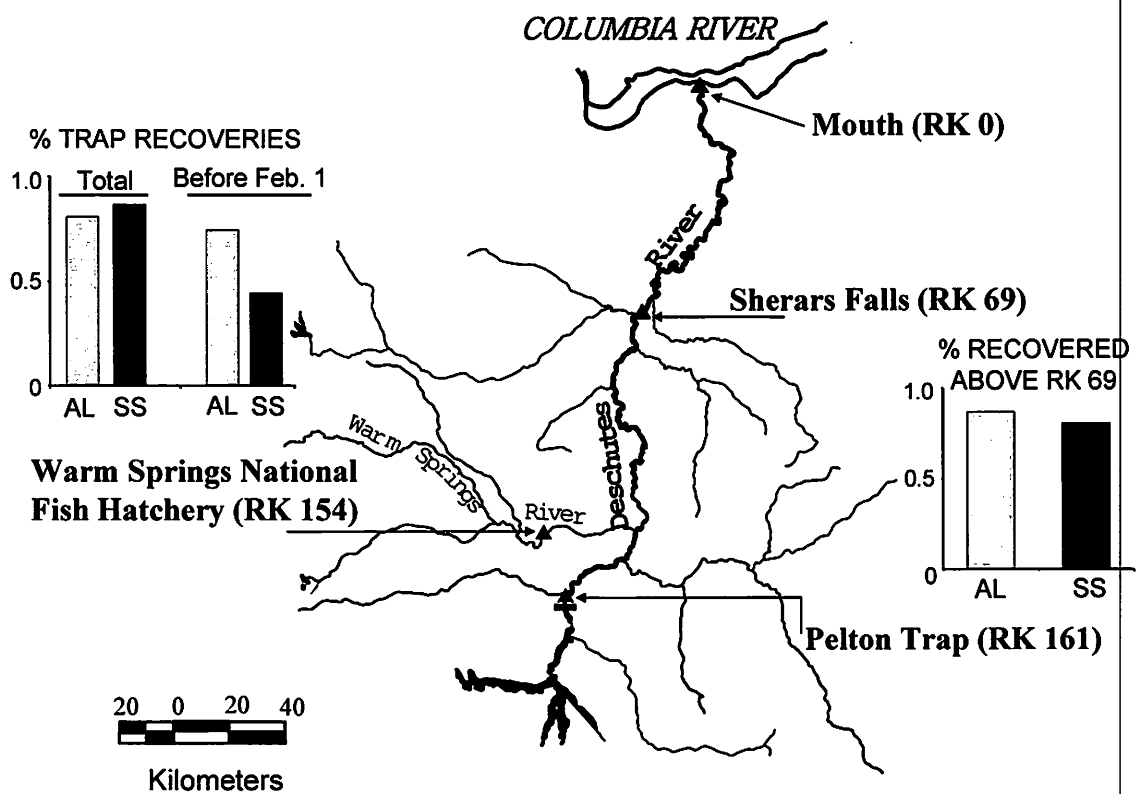

Figure 10. Map of the Deschutes River basin. The lower river fishery takes place from the mouth to Sherars falls, PIT tagged fish are detected at Sherars Falls, and steelhead are trapped at the Pelton Dam trap and at the Warm Springs National Fish Hatchery. Inset graphs show the percentage of autumn line (AL) and standard Wallowa stock (SS) adults recovered above Sherars Falls and the percentage at fish traps. Fish that are trapped after 1 February are believed to be true strays that will not exit the Deschutes River to continue their migration to the Grande Ronde basin.

We conduct steelhead creel surveys in the Grande Ronde basin from September through mid-April; the entire length of the steelhead fishing season. If the creel surveyor encountered an angler that harvested a hatchery steelhead with a ventral fin clip--indicating the presence of a coded-wire tag in the snout—then with permission from the angler the surveyor removed the fish's snout for later processing to determine the numerical tag code, and thus the release group from which the fish originated. Using such fisheries contribution data collected in our creel surveys, as well as data from other creel surveys conducted within the Lower Snake River Compensation Plan area, we can determine if the autumn line has been successful at enhancing autumn fisheries.

Table 3. Detections of PIT-tagged Wallowa stock steelhead at Sherars Falls on the Deschutes River and the percent that subsequently exited the Deschutes and were detected at McNary Dam or sites farther upstream.

Run year	Experimental group	Number detected at Sherars Falls	Number later detected at McNary or upstream	Percent later detected at McNary or upstream
2007-2008	Autumn line	5	0	0
	Standard stock	7	5	71
2008-2009	Autumn line	6	1	17
	Standard stock	3	0	0
2009-2010	Autumn line	19	4	21
	Standard stock	15	2	13
2010-2011	Autumn line	5	2	40
	Standard stock	5	0	0
Total Autumn line		35	7	20
Total Standard stock		30	7	23

Since first generation autumn line adults displayed an earlier average return timing to Lower Granite Dam, we hoped they would contribute more substantially to the autumn fishery. Indeed, coded-wire tag recovery data in the Grande Ronde basin indicates that a greater proportion of the autumn line are harvested in September and October compared to the standard Wallowa stock (Figure 11). Within the Lower Snake River Compensation Plan area, the estimated number of autumn line adults harvested per 1,000 smolts released also shows that autumn line release groups contribute more fish to the September through November fishery than the standard Wallowa stock (Figure 12). Within the compensation plan, a greater portion of autumn line adults are harvested in Oregon than outside Oregon (Figure 13), whereas that pattern is reversed with the standard Wallowa stock.

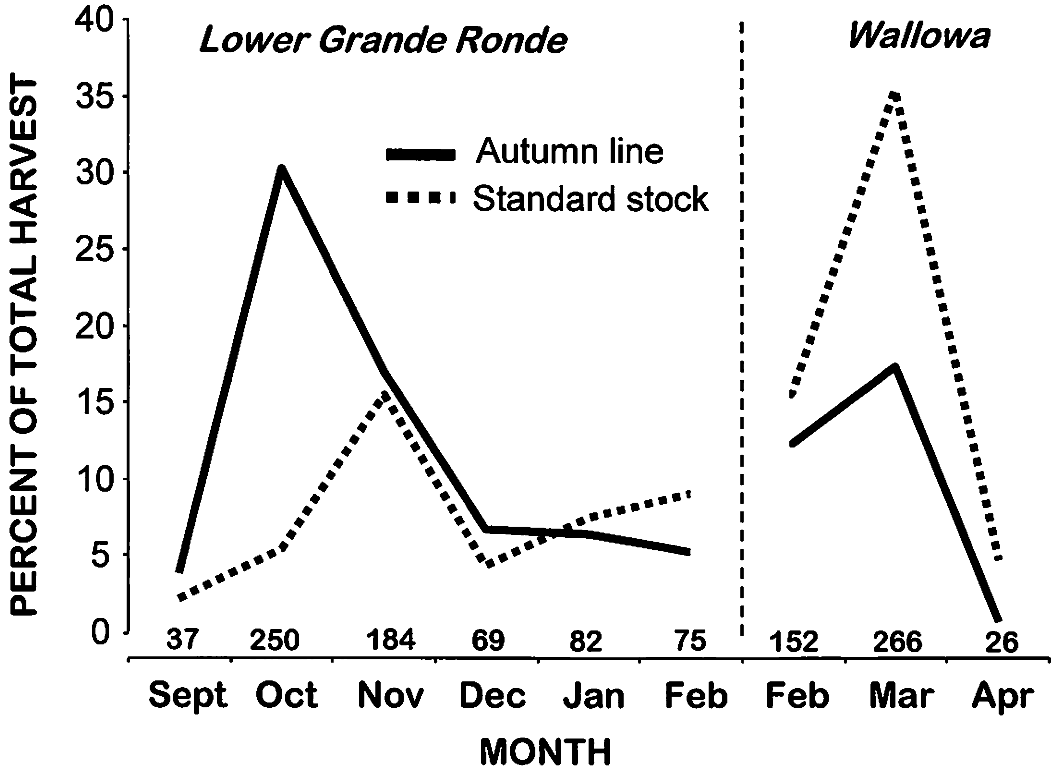

Figure 11. Monthly percent harvest of the total estimated annual harvest of autumn line and standard Wallowa stock in the Grande Ronde River basin, run years 2006-07 to 2008-09. The estimated monthly number of coded-wire tag recoveries on which this analysis is based is shown along the x-axis. Fisheries in the Grande Ronde River occur in the lower river from September through February and from February through April in the Wallowa River, an upstream tributary to the Grande Ronde River.

The data for adult run timing of the first generation autumn line releases is complete, and it is clear that these individuals met the first objective of this project, that is, to modify run-timing to emphasize fall entry into the Grande Ronde River. However, incomplete data from the second generation leads us to suspect that these groups may not return as comparatively early to the Grande Ronde basin as first generation adults. In return year 2008 a PIT tag antenna array was installed in the adult ladder at Wallowa Fish Hatchery. When we compared tag detection dates from that array to tag detection dates for the same fish detected at Lower Granite Dam, we see a possible trend whereby the earliest returning autumn line adults to Wallowa Fish Hatchery were also the earliest to pass Lower Granite Dam. If this is a consistent year to year trend that continues in later generations of the autumn line, then it may be possible to encourage early return timing by collecting all the earliest returning individuals to the Wallowa Fish Hatchery for broodstock rather than collecting temporally from across the run. Otherwise, managers have discussed maintaining early arrival characteristics of the autumn line by periodically "refreshing" the line with new parents collected in the same manner as the first generation broodstock, i.e., via angling in October.

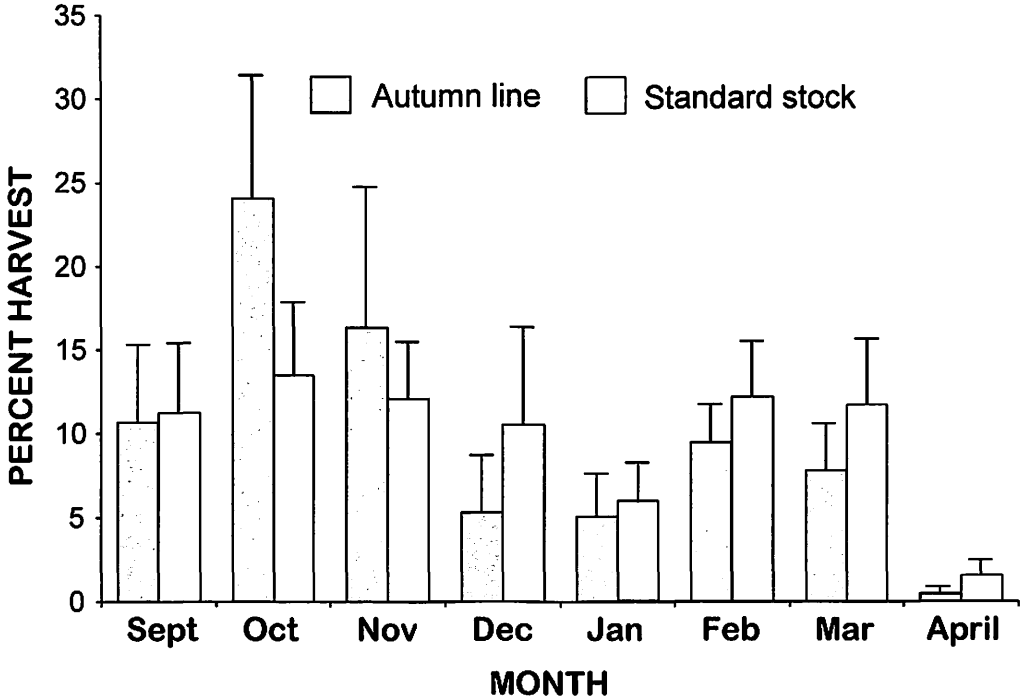

Figure 12. Average monthly autumn line and standard Wallowa stock adults harvested in the Lower Snake River Compensation Plan area per 1,000 smolts released. Data is from run years 2006-07 to 2008-09. Vertical bars = 1 SE.

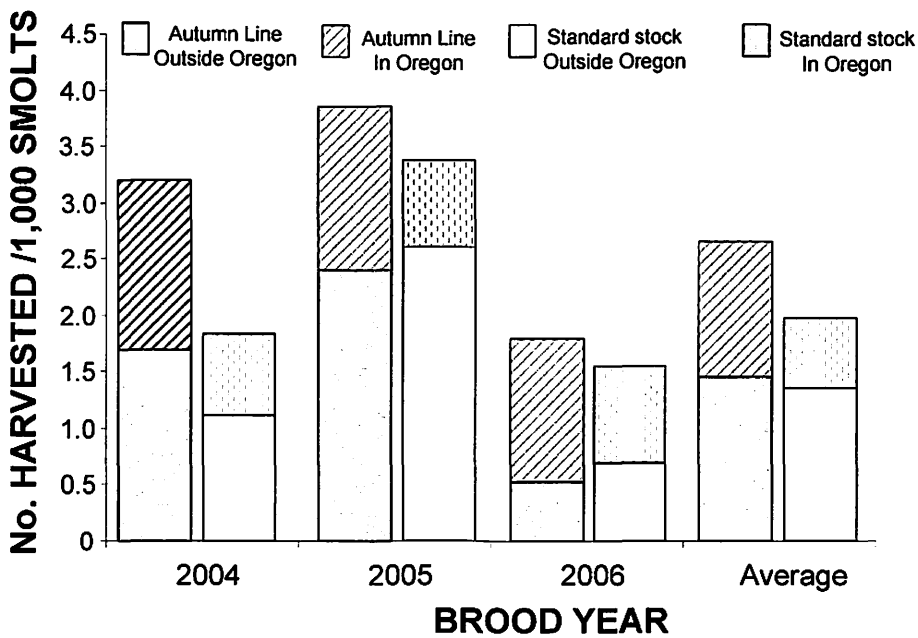

Figure 13. Number of adult autumn line and standard Wallowa stock steelhead harvested in the Lower Snake River Compensation Plan area per 1,000 smolts released. Data is grouped by harvest outside Oregon (solid bars) and harvest in Oregon (diagonal patterned bars).

CONCLUSIONS

We did not expect to see an advantage in survival to adulthood for the autumn line. That advantage may be entirely due to an earlier age at return of the autumn line, or perhaps age at return is just one of several factors responsible for the survival advantage. Angling was used to collect first generation autumn line broodstock, and this technique can be selective for older or younger fish depending on the gear that is used (Hayes et al. 1996). Angling is also selective for fish that are more aggressive to a lure or bait, and these fish may have different metabolisms, and thus different survival rates, than fish that are not caught (Lewin et al. 2006). We will be monitoring adult returns of the second generation autumn line to see if the survival advantage continues.

Unfortunately we did not measure an autumn line straying advantage in the incomplete data we have thus far collected. However, the lower staying rates for both autumn line and standard Wallowa stock adults from the brood year 2005 through 2007 releases is encouraging. Straying of Wallowa stock steelhead may be associated with whether or not smolts are barged from Lower Granite Dam; steelhead smolts that are not barged have displayed a lower straying behavior when they return as adults (Comparative Survival Study 2011). Smolts from brood year 2004 were barged at an estimated 94% rate, whereas that rate declined to 76% for brood year 2005, 47% for brood year 2006, and 41% for brood year 2007 (Fish Passage Center 2011). If barging rates remain low it is possible that overall Wallowa stock stray rates will be acceptably low.

FUTURE OF THE AUTUMN LINE

The last year of second generation autumn line adults were spawned in brood year 2011, which meant that for brood year 2012 a decision had to be made as to how to proceed with the autumn line. This decision was made by ODFW managers and tribal co-managers over the course of several hatchery Annual Operation Plan meetings that occurred in late 2011 and early 2012. The following text is recommendations for the autumn line that appeared as part of Appendix U to the 2012 Annual Operation Plan document.

Recommendations for BY 2012

Brood take / Production: Spawn 72 females to create 240,000 smolts from the fall brood (also known as the autumn line), which is 30% of total Wallowa stock production. Reduce standard Wallowa stock production releases accordingly to maintain total release levels at 800,000 smolts.

Rearing: Continue releasing fall brood production from Wallowa Hatchery to consolidate spawning.

Marking: Maintain current tagging and marking to assess whether the third generation performs similarly to the first generation.

Recommendations for BY 2013 and beyond

Brood take / Production: For brood year 2013, spawn 96 females to create 320,000 smolts from the fall brood line (40% of total production). For brood year 2014, spawn 120 females to produce 400,000 smolts from the fall brood line (50% of total production). Reduce production releases accordingly to maintain total release levels at 800,000 smolts.

Increasing production beyond BY 2014 will depend on our ability to manage the fall brood line in a fashion that: maintains the run timing, stock performance, and harvest benefits consistent with results of the first generation; while offering a size-at-return similar to the production line, and harvest opportunity during both fall and spring periods. In addition, final production goals will need to consider rearing space allocations at both Irrigon Hatchery and acclimation facilities, and feasible broodstock collection protocols for hatchery staff. Long-term management of the fall brood line will likely include occasional 'refreshing' of the broodstock with adults collected via angling in the fall Grande Ronde fishery. We expect refreshing the fall brood line will act to sustain run timing differences observed in the F1 generation, and diversify the genetic makeup of the broodstock. Tentatively, we will plan to refresh the fall brood line during the fall of 2013. Long term strategies may employ a focused one to two-week effort as occurred in 2003-2006, or a dedicated group of volunteer anglers that collect fish throughout the fall period.

Rearing: Long term rearing strategies will ultimately depend on desired production goals for the fall brood line, our ability to differentially mark the fall brood and production lines, and brood take needs.

Marking: Long term tagging and marking strategies will largely be determined when data from the F2 generation is complete. However, to maintain two steelhead lines will require differential marking, which is currently accomplished using left and right ventral clips. Coordination with Washington: The state of Washington currently uses Wallowa-stock steelhead in the Cottonwood program (lower Grande Ronde River) releases. Currently, Washington is considering utilizing the Wallowa fall brood line for the Cottonwood program, depending on results of the current experiment. We will continue to coordinate with the state of Washington, understanding that any desire to use fall brood Wallowa steelhead in Washington programs will affect brood take goals at Wallowa Hatchery.

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Release Strategies to Improve Post-Release Performance of Hatchery Steelhead in Northeast Oregon

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This program is a cooperative effort of the Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation. Program funding is from the Bonneville Power Administration administered by the U.S. Fish and Wildlife Service under the Lower Snake River Compensation Plan.

SUMMARY

This presentation covered recently published information from three journal articles. Most of the slides were from two studies with Wallowa and Imnaha stock steelhead; one that compared the post-release performance of smolts that were either released following an acclimated period or direct-released, and a second study in which smolts were released volitionally following an acclimation period or forced-released from acclimation ponds. The third study was with spring Chinook salmon smolts that were acclimated for either two months or four months before being force released.

In the acclimation versus direct-release study, from years 1987 through 1996 we released 14 paired groups of yearling steelhead smolts into the Grande Ronde River that were either acclimated (AC) for 16 to 57 d in ponds supplied with ambient stream water or trucked from a groundwater-supplied hatchery and directly-released (DR). Upon release we monitored outmigration travel times and survival to Lower Granite Dam (LGD) on the Snake River using freeze brand marks or implanted Passive Integrated Transponder (PIT) tags in a sample of each release group. Across all release groups, travel time was significantly slower for AC groups (34.7 d) than for those that were DR (31.8 d); however, there was no significant difference in outmigration survival probabilities to LGD between AC and DR groups. We used recoveries of coded-wire tags (CWT) to estimate smolt-to-adult survival (SAS) and a stray rate index. Across all release groups, SAS was 33% higher, and straying was 42% lower for AC steelhead.

In the forced versus volitional release study, conducted over 4 release years, we compared the performance of hatchery steelhead groups that were force-released (FR) from acclimation

ponds to those provided a 2-week volitional release (VR). Upon fish release into streams, we monitored smolt outmigration travel times and survival to Lower Granite Dam (LGD) on the Snake River using Passive Integrated Transponder (PIT) tags in a sub-sample of each release group. To better understand the outmigration characteristics of volitionally departing fish, we also captured and PIT-tagged fish as they exited ponds in the first and last 24 h of VR. Across all release groups, travel time was 3% faster for fish that were forced from acclimation ponds than for VR groups; however, average survival of VR groups (65.0%) was significantly higher than FR groups (58.6%). On average, fish that departed acclimation ponds in the first 24 h of VR took 6 d longer to reach LGD and had lower survival (50.3%) than those departing in the last 24 h (56.9%), though these differences were not statistically significant. We estimated smolt-to-adult survival (SAS) and a stray rate index (SRI) for FR and VR groups based on recoveries of coded-wire tagged adults. Across all releases, SAS was not significantly different (FR = 0.63%, VR = 0.59%), nor was the SRI (FR = 10.9%, VR = 10.6%). Our finding that VR provided no post-release survival benefit is consistent with other published studies, but this is the first study to quantify stray rate in relation to VR.

In the study in which hatchery spring Chinook salmon were acclimated either two or four months before release, in release years 2000 through 2005 fish were transferred from a groundwater-supplied hatchery to acclimation ponds supplied with stream water either in November (November transfer; NT) or January (JT) for rearing at ambient water temperatures prior to release into the Umatilla River in early March. After stream release, PIT tag data indicated that median travel time to John Day Dam on the Columbia River was slower for NT groups (51 d) than for JT groups (46 d), with significant differences in five of six release years. Average outmigration survival probabilities were 15% higher for NT groups, though this difference was not significant. Based on CWT recoveries we found that NT groups had a significantly higher SAS than JT groups, with an average difference of 27%. However, little or no straying occurred for both strategies.

Complete information and analysis are in the following papers:

Clarke, L. R., M. W. Flesher, T. A. Whitesel, G. R. Vonderohe, and R. W. Carmichael. 2010. Post- release performance of acclimated and direct-released hatchery summer steelhead into Oregon tributaries of the Snake River. North American Journal of Fisheries Management 30:1098-1109.

Clarke, L. R., M. W. Flesher, S. M. Warren, and R. W. Carmichael. 2011. Survival and straying of hatchery steelhead following forced or volitional release. North American Journal of Fisheries Management 31:116-123.

Clarke, L. R., W. A. Cameron, and R. W. Carmichael. 2012. Performance of spring Chinook salmon reared in acclimation ponds for two and four months before release. North American Journal of Aquaculture 74:65-72.

Summer Steelhead Releases into the Snake, Walla Walla, Touchet and Tucannon Rivers

Lyons Ferry Stock - Hatchery Program Review 1982-2012

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This program is a cooperative effort of the Washington Department of Fish and Wildlife, the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation. The program is funded by the Bonneville Power Administration and administered by the United States Fish and Wildlife Service under the Lower Snake River Compensation Plan.

INTRODUCTION and BACKGROUND

This paper provides background information, program development history and an assessment of program performance for the Washington Department of Fish and Wildlife's (WDFW) Lyons Ferry stock summer steelhead (*Oncorhynchus mykiss)* hatchery program. The coverage period is from program initiation in 1982 to the present (spring 2012).

A precipitous decline in numbers of Snake River steelhead (Figure 1) and other anadromous salmonids 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 and operations of the four lower Snake River power dams.

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 was constructed as the core of the mitigation program. And an existing state facility, the Tucannon Hatchery was renovated, and three acclimation ponds (AP) for steelhead were constructed: Curl Lake on the Tucannon River; Cottonwood Pond on the Grande Ronde River; and Dayton Pond on the Touchet River (Figure 2).

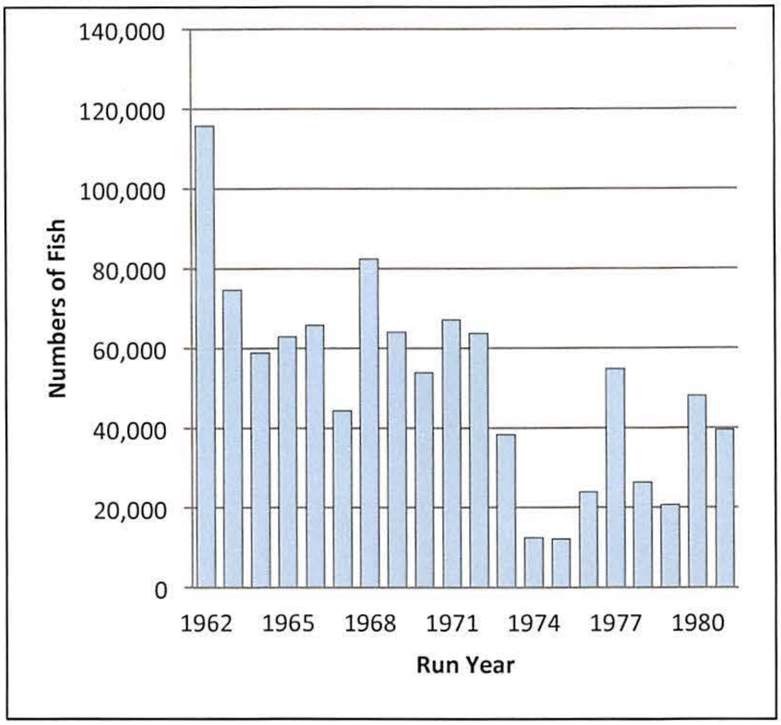

Figure 1. Counts of summer steelhead at Ice Harbor Dam, 1962-1981 Run Years.

The Lyons Ferry Hatchery is located at river kilometer 96 on the mainstem of the Snake River (Figure 2), and serves as the primary rearing facility for the LFH stock program. The Lyons Ferry Hatchery stock steelhead releases have occurred in the mainstem Snake, Tucannon, Walla Walla and Touchet rivers. In the Snake River, releases have been primarily from LFH, but occurred at other locations in the 1980's as the program was getting started. Releases of LFH stock steelhead in the Tucannon River started in the upper watershed as either direct stream releases near Curl Lake, or from Curl Lake AP. Poor survival from smolts released at Curl Lake and concerns about competition/predation on recently ESA listed Tucannon River spring Chinook ESA listings prompted managers to shift releases to lower Tucannon River locations (concerns about competition/predation). With the implementation of the Tucannon River endemic stock steelhead program in 2010, LFH stock steelhead were last released in the Tucannon River in 2010. Releases of LFH stock steelhead in the Walla Walla River Basin (offsite mitigation), have occurred in the Touchet River from Dayton AP, various locations within the Walla Walla River from below the mouth of the Touchet River up to the Oregon Stateline, and lower Mill Creek. With the ESA listings of mid-Columbia River steelhead in the late 1990's, releases of LFH stock steelhead in the Walla Walla Basin have been decreased, and currently are released only from Dayton AP, and in the Walla Walla River near the mouth of the Touchet River.

Under the LSRCP, Washington's entire steelhead program would mitigate (return) 4,656 summer steelhead to the project area at various locations within SE Washington (Table 1). The project area for the WDFW steelhead program is defined by all areas above Ice Harbor Dam, plus the Walla Walla and Touchet rivers. In the Snake, Tucannon, Walla Walla and Touchet rivers, the summer steelhead program was to be accomplished by annual production of 631,000 steelhead smolts @ 8 fish/lb, with the goal to return 3,156 adults (0.5% survival) to the project area, or 9,468 adults (1.5% survival) to the Columbia River Basin, based on an assumed downriver catch to escapement ratio of two-to one that existed prior to construction of the dams. The survival rates of 0.5% and 1.5%, were not goals, rather were used as guidelines for managers to determine the size of hatchery facilities needed. Over time, changes in the smolt production have occurred and the current goal is 345,000 smolts @ 4.5 fish/lb to meet the original adult return goals. Current smolt-to-adult survival (SAS) and smolt-to-adult returns (SAR) expectations needed to meet the adult goals for the program are 2.74% and 0.91%, respectively.

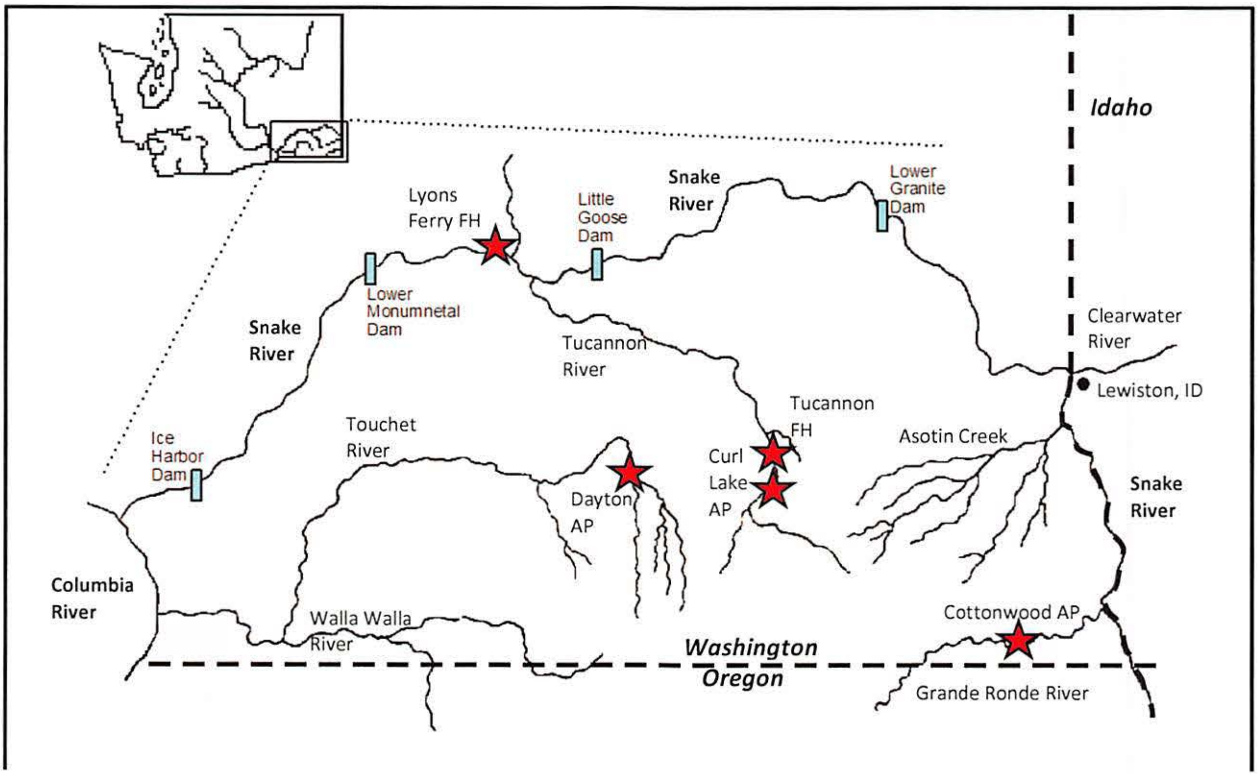

Figure 2. WDFW LSRCP hatchery facilities (hatcheries and acclimation ponds) in SE Washington.

Table 1. WDFW LSRCP summer steelhead smolt releases and mitigation goals.

Location	Original Smolt Goals	Current Smolt Goals	Adult Goal to Project Area	Total Adult Goal
Snake R.	126,000	160,000	630	1,890
Tucannon R.	175,000	0	876	2,628
Walla Walla R.	180,000	100,000	900	2,700
Touchet R.	150,000	85,000	750	2,250
Grande Ronde R.	300,000	200,000	1,500	4,500
TOTALS	**931,000**	**545,000**	**4,656**	**13,968**

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, and 5) Coordinate actions with other basin managers. These goals have directed actions taken by WDFW to ensure the success of the LSRCP program, and have played a key role in guiding our monitoring and evaluation efforts for the program as needed. In addition to the original goals, as summer steelhead became listed within the Snake River basin, WDFW added additional goals that focused on wild steelhead protection: 1) Monitor the status and trends of natural steelhead populations where LSRCP fish might have effects, and 2) Ensure the program is compliant to the greatest extent possible with ESA (HGMP's, FMEP's) and WDFW Policies to protect and recover wild populations. Currently, the WDFW LSRCP program gathers information that is provided and used by LSRCP, US v Oregon Management and for ESA management and implementation, and plays a critical role in the management of the steelhead in SE Washington.

PROGRAM ASSESSMENT

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 funding and oversight responsibilities. WDFW had not specified any remote facilities for broodstock development from LSRCP affected 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 Grande Ronde River LSRCP program (Refer to WDFW and ODFW summaries for more details). 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, Touchet, and Snake rivers between 1983 - 1986. To make LFH self-sufficient, returning Wells and some Wallowa stock fish trapped at LFH were the basis for a new LFH stock. Based on release locations of those two stocks in the early 1980's, and what we currently observe returning to LFH from those release locations, we estimate that the LFH stock was founded from approximately 80-85% Wells stock steelhead.

Currently, about 110 females are needed to meet annual LFH stock program needs. Crosses with males are generally 1:1. Run timing of adults to the trap at Lyons Ferry has not been specifically documented. However, adult steelhead have been trapped as early as July and into mid-December (Figure 3). While not generally trapped, adult steelhead are observed at the ladder entrance to LFH from January through April. Spawning of broodstock was originally in February/March, but over time has shifted to January/February (Figure 3). While the exact cause of this shift is unknown, it is likely due to holding the broodstock in the warmer constant temperature well water at Lyons Ferry (51 °F) and an inadvertent selection for early spawning fish. To halt the continued selection of early spawning fish, early ripening fish are removed from the broodstock during the first week of January, and the first spawn does not occur until mid-January. The number of adults trapped at LFH has varied over the years, mainly due to expected broodstock needs or studies conducted on returning adults, but has leveled off in recent years with steady smolt production goals established for the program (Figure 4). The number of wild-origin steelhead trapped at LFH on any given year is very low, and does not appear to cause undue "take" on listed Snake River steelhead populations. All wild steelhead trapped are returned to the Snake River during broodstock sorting (November).

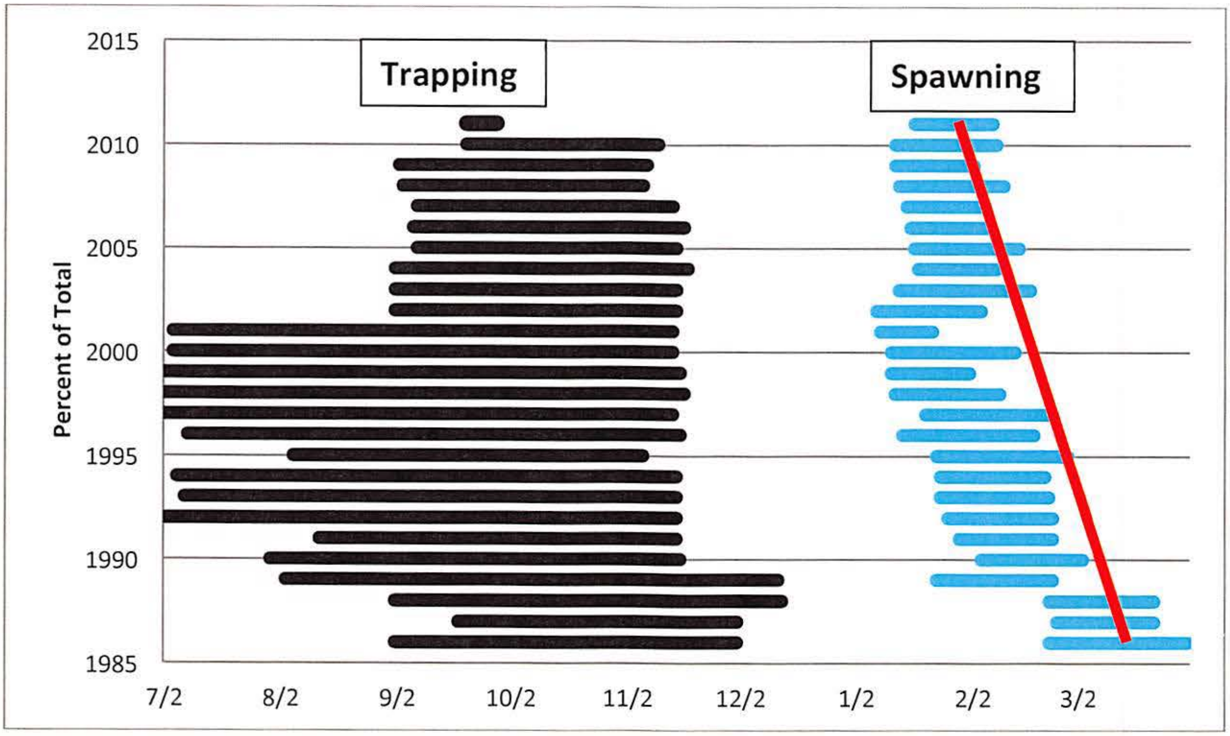

Figure 3. Trap and spawn timing of adult steelhead at LFH (1985-2011 run years).

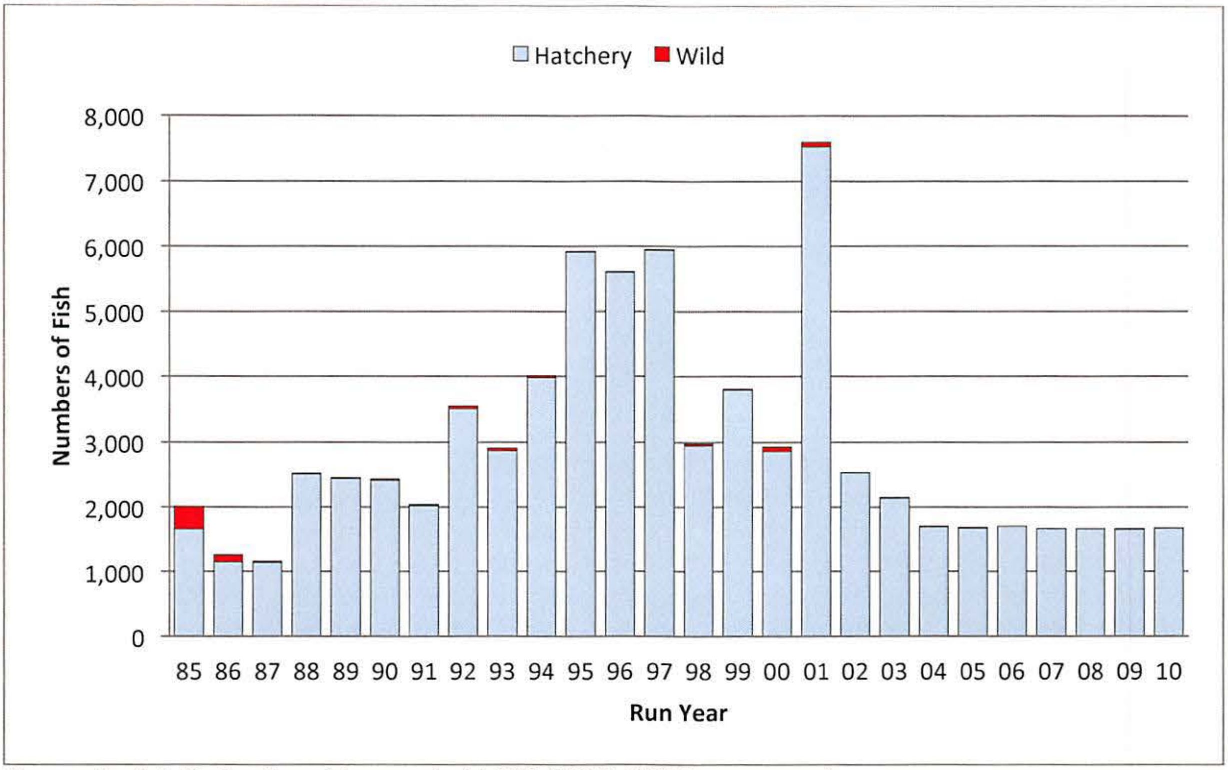

Figure 4. Adult steelhead trapped at LFH (1985-2011 run years).

Between 1996 and 2012, disposition of adult steelhead trapped at LFH was as follows: 12% have been spawned, 7% have been killed out-right for data (coded-wire tags, etc..), 15% were pre-spawn mortalities, and the remaining 66% were returned to the Snake River so they could contribute to the active sport fishery. Pre-spawn mortality is higher than what is observed for many of the other steelhead programs. However, nearly all other steelhead programs in the Snake River Basin trap their broodstock in the spring, much closer to spawning. Of the coded-wire tags recovered at LFH since 1999, 99.1% have been LFH stock releases, 0.4% WDFW Wallowa stock, 0.1% Tucannon endemic stock, 0.3% Idaho stocks, and 0.1% Oregon stocks. For the LFH stock recoveries, 48.4% were from on-station releases at Lyons Ferry, 18.9% and 19.2% were from the Walla Walla and Touchet river releases, respectively, and 12.6% were from the Tucannon River releases.

Based on broodstock collections and coded-wire tag recoveries, a substantial shift in adult age composition has been observed in the LFH stock steelhead (Figure 5). While this shift has not affected overall production, since these fish are primarily directed at harvest, WDFW would prefer to have more of the population represented with 2-salt fish (i.e. anglers like bigger fish) and more similar to the stock's historical age composition. Beginning with the 2011 brood, parent selection is now directed at fish larger than 62cm in fork-length, which translates into about 50% of the parents of 2-salt age, instead of only 10-15% that were included many years prior. It is hoped that over time, the age structure of the population will shift back to historical levels.

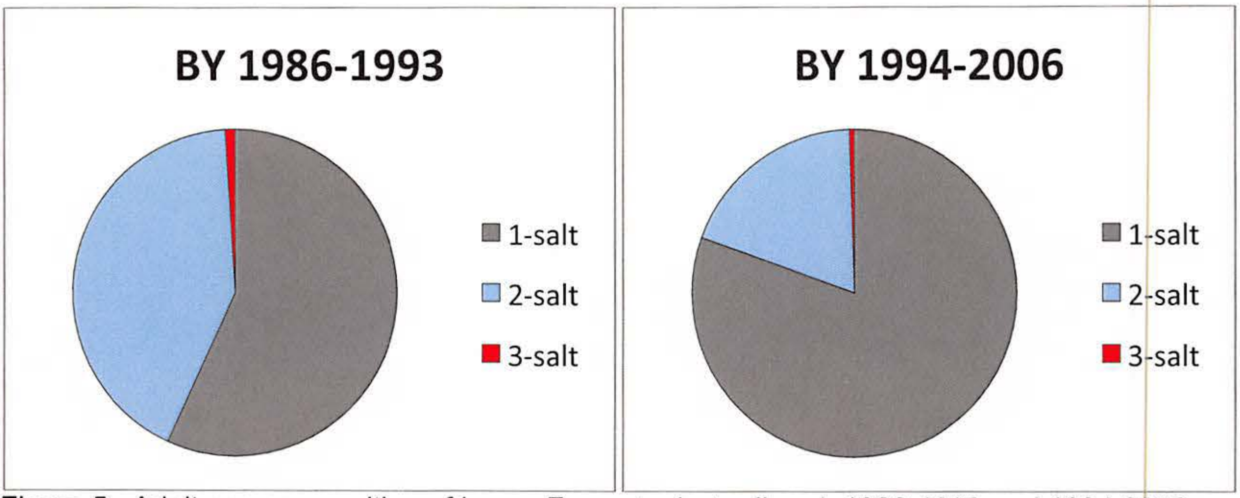

Figure 5. Adult age composition of Lyons Ferry stock steelhead, 1986-1993 and 1994-2006 brood years.

For each steelhead program at LFH, counts or estimates of production are made at various life stages. Over the years, the number of green eggs and eyed-eggs have been estimated through either volumetric, weight sampling, or by mechanical egg counters. Eyed egg-to-smolt survival has been consistent, though highly variable, for the entire program, and green egg-to-smolt survival has increased in recent years due to a change in spawning procedures at LFH (Figure 6). 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. An additional IHN outbreak occurred in the 1992 brood, resulting in the loss or elimination of about 45% of the LFH stock for the brood year. To offset the loss in production, Oxbow stock steelhead from

Idaho were brought in and released as part of the Snake River release group (see smolt production Figure 7D). Since that time, the disastrous effects of the IHN virus have been effectively controlled. While not as disastrous, bacterial coldwater disease is present during the rearing cycle on an annual basis; although the disease has generally not affected overall smolt production of the LFH stock.

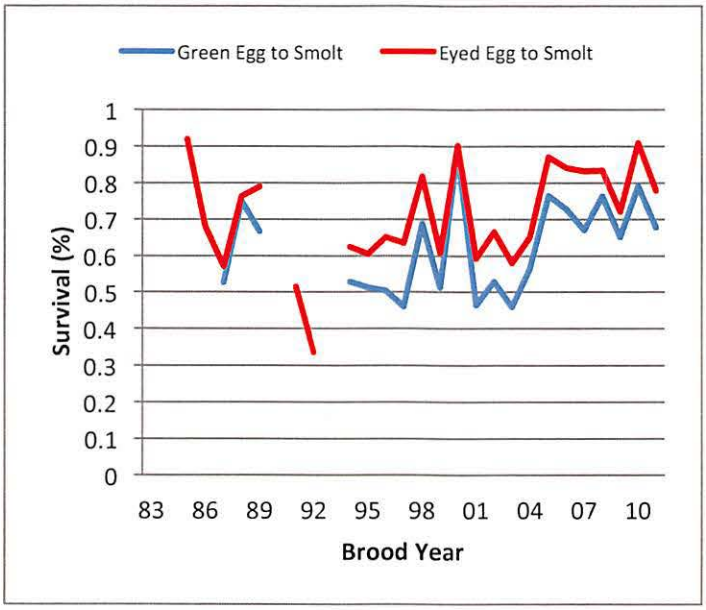

Figure 6. Green-egg and eyed-egg to smolt survival of LFH stock fish at Lyons Ferry hatchery.

Production of LFH stock steelhead since 1983 has achieved or closely approached the goal number of fish to be released in the four major release tributaries (Figure 7). Each release group is currently 100% adipose fin clipped for selective harvest fisheries, and coded-wire tagged (20,000) and PIT tagged (4,000) for estimating adult returns and for assessing straying. During marking, a complete count of the stock is provided, with any mortality subtracted from that point forward to estimate total smolt release numbers. Adjustments are made as necessary to account for predation loss at the hatchery. At release, a minimum of 200 smolts are sampled (length/weight) and multiple pound-counts from each steelhead release group (either from Acclimation Ponds or raceways at the hatchery) are used to estimate smolt size.

Overall, hatchery smolt releases in the Tucannon and Touchet rivers have remained fairly consistent over time, though LFH stock releases in both rivers were reduced, and two new endemic stocks were developed. In the Tucannon River, WDFW has implemented the Tucannon River steelhead supplementation program (2010), but no decision has been reached on whether to implement the Touchet River endemic stock program (see Tucannon and Touchet endemic stock program review). Relatively large production cuts are clearly visible in the Walla Walla and Snake rivers' release groups, although in the last two years smolt releases at Lyons Ferry were increased. This was a temporary management strategy that was adopted in response to the elimination of the LFH stock steelhead in the Tucannon River in 2010. The number of smolts to be released on-station at Lyons Ferry in the future is currently unknown, but will likely decrease. The primary functions of the LFH stock steelhead program has been to return fish for harvest and broodstock needs. Run timing of LFH stock adults to the Columbia and Snake rivers coincide well with established sport, commercial and tribal fisheries in the basins (Figure 8). The LFH stock steelhead program has been highly successful in returning adults to the project area above Ice Harbor Dam (3,156 adult goal has been met or exceeded every year), and has met the downriver adult goal about 50% of the time (Figure 9). The SAS and SAR survivals have also met expectations (Figures 10 and 11). Note that documented survival between the four different release groups follow a consistent pattern and are relatively similar. The one exception is Tucannon River releases during the early part of the program. These were primarily fish released from Curl Lake AP, where poorer survival for steelhead was documented. Progeny:Parent ratios for the LFH stock program since has average 19; another indicator of the program's success.

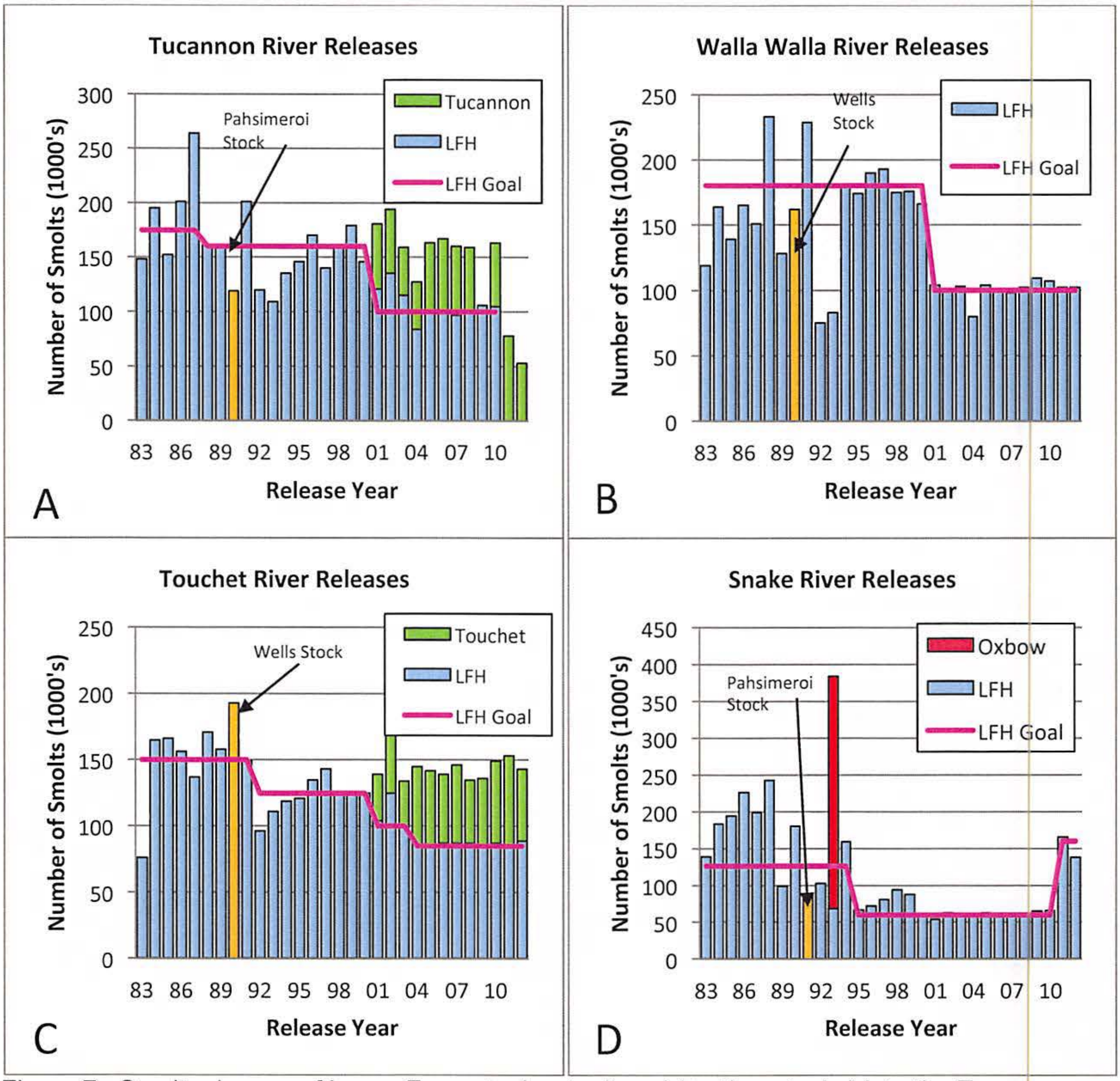

Figure 7. Smolt releases of Lyons Ferry stocks steelhead (+ other stocks) into the Tucannon (A), Walla Walla (B), Touchet (C) and Snake (D) rivers, 1983-2012 release years.

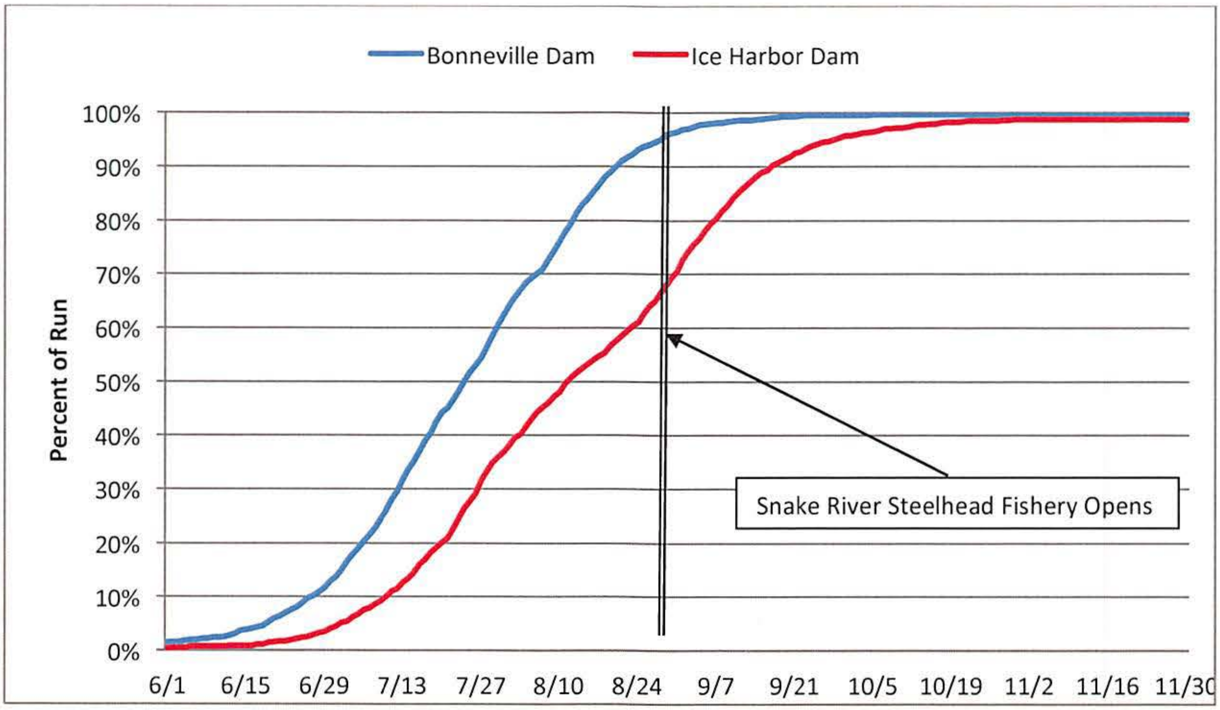

Figure 8. Run timing of LFH stock summer steelhead over Bonneville and Ice Harbor Dams based on PIT Tags, 2009-2011 run years.

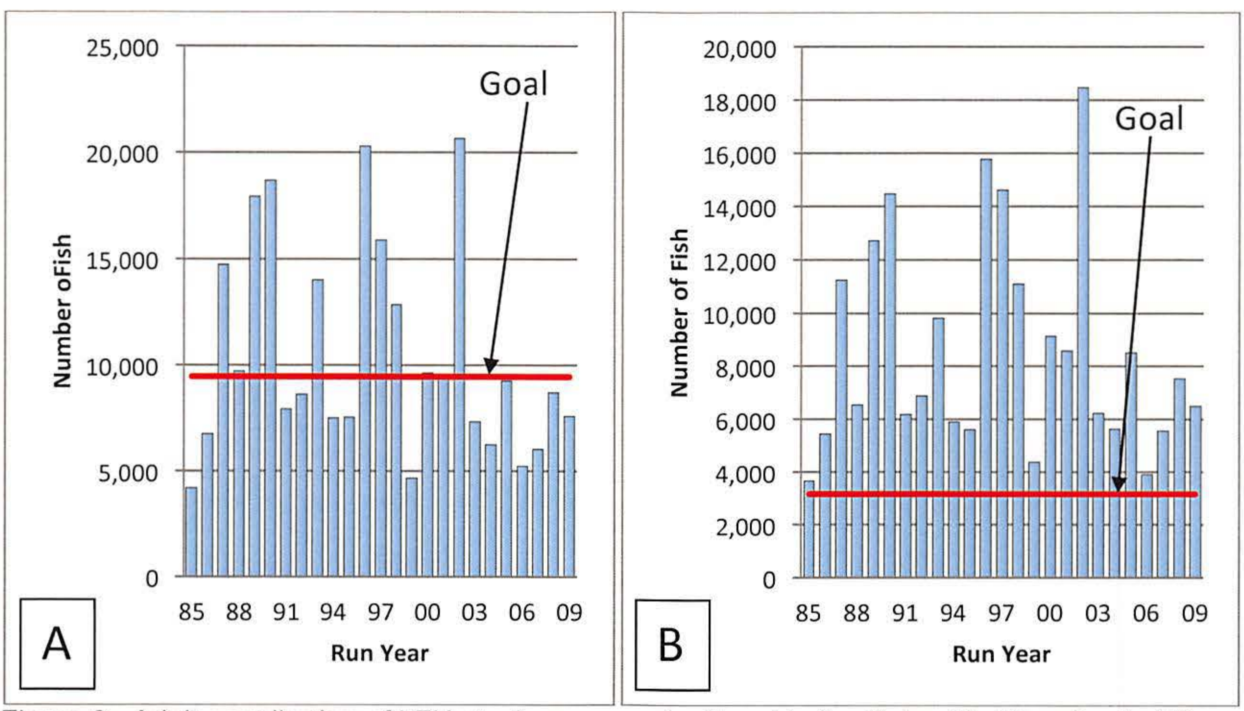

Figure 9. Adult contribution of LFH stock summer steelhead to the Columbia River basin (A) or back to the LSRCP project area (B), 1984-2009 run years.

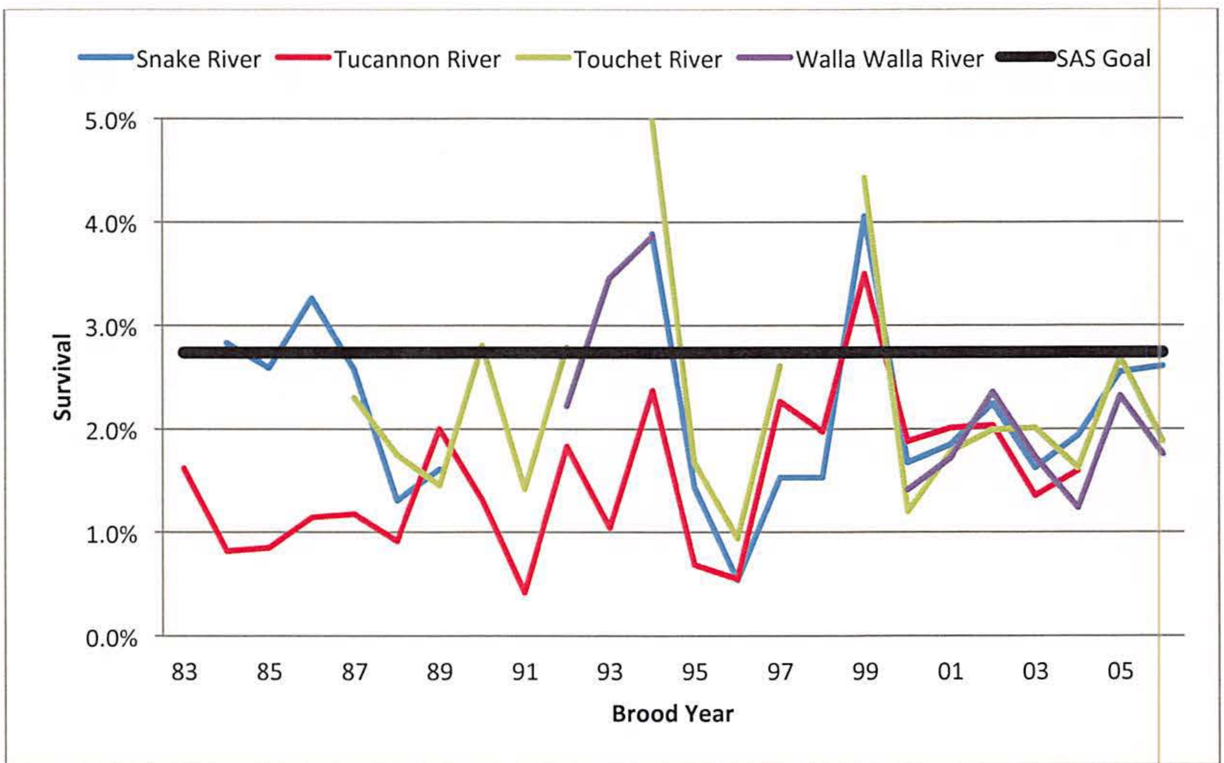

Figure 10. Smolt-to-adult survival (SAS) of WDFW Lyons Ferry stock summer steelhead released into the Tucannon, Walla Walla, Touchet and Snake rivers.

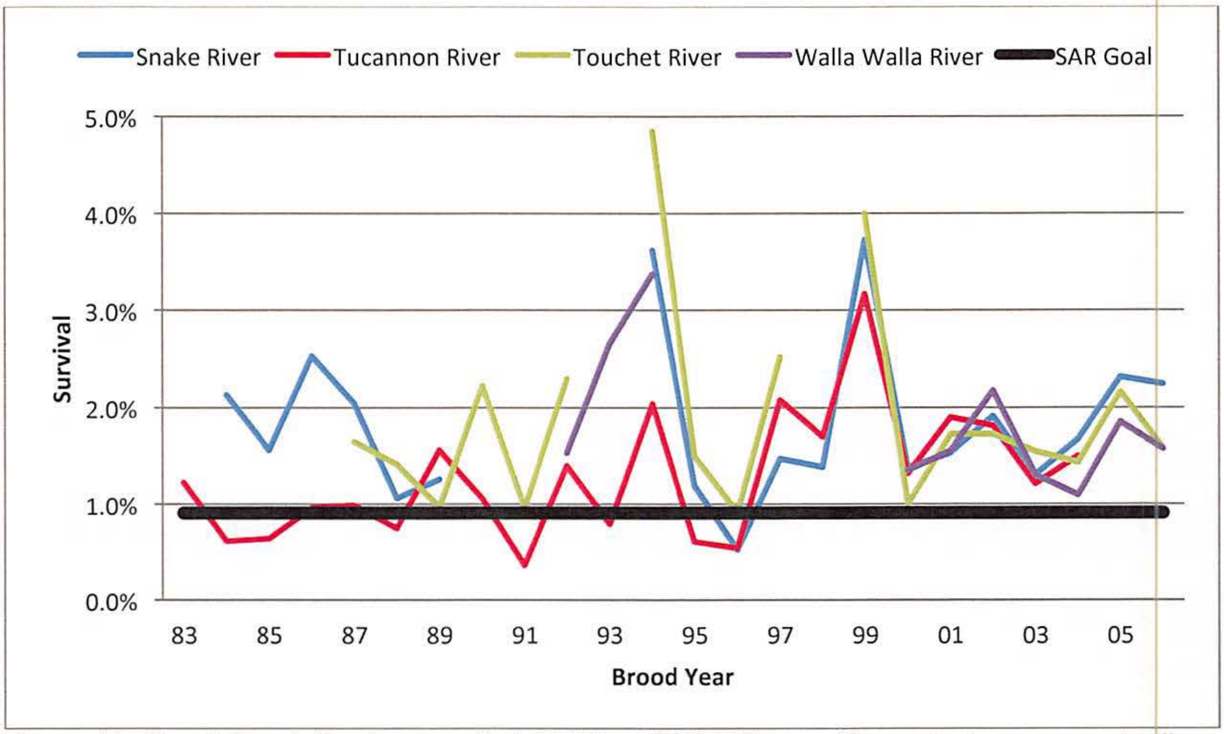

Figure 11. Smolt-to-adult return survival (SAR) of WDFW Lyons Ferry stock summer steelhead released into the Tucannon, Walla Walla, Touchet and Snake rivers.

Consistently among all release locations, LFH stock summer steelhead are exploited at very low rates in the ocean and lower Columbia River, but are harvested heavily in steelhead sport fisheries in the main-stem Snake and their respective tributaries within Washington (Table 2). Tributary harvest in the Tucannon, Walla Walla and Touchet account for 31%, 28.7% and 22%, respectively, of the total returns from those release groups. Mean exploitation rate taken in all fisheries (including those shown as strays because the fish were captured outside of the juvenile migratory route) is 84.5%. Average "stray" rate for all LFH stock release groups as defined by the juvenile migratory route is 49%. However, many of the fish defined as "strays" for this analysis are captured in sport fisheries (Figure 12), with only a very small percentage (2 % of the 49%) being found in other locations (i.e. hatcheries or weirs) at a place and time where they should be considered true strays.

Due to geographic differences in each of the four release locations, the rate of "straying" differs considerably. As such, we present catch and escapement (Tables 3, 4, 5, and 6), and locations of "stray" fish (Figures 13-16) for each of the four release groups independently. Individual "stray" rates for the on-station release at Lyons Ferry, the Tucannon River, the Touchet River, and the Walla Walla River were 22.6%, 40.6%, 54.3%, and 64.4%, respectively, for the brood years shown. The "stray" rates are higher for the Walla Walla River Basin releases. This is likely due to the time of year (August) when LFH stock fish are passing the mouth of the Walla Walla River. Stream flows at the mouth of the Walla Walla River during that time are extremely low, and water temperature can be very high compared to the Snake or Columbia rivers, so bypassing of the Walla Walla River Basin is not surprising. Environmental factors (flow and temperature) and releases between mainstem dams are likely controlling factors that determine overall stray rates in the LFH stock steelhead. For example, releases in the Touchet River are acclimated with a volitional release, yet have overall stray rates higher than Tucannon River releases, which are direct stream (without acclimation) released.

Table 2. Catch and escapement of WDFW LFH stock summer steelhead, 2001-2006 brood years for Lyons Ferry, Touchet, and Walla Walla, and 2001-2004 brood years for the Tucannon River.

Location	Sub-Area	Release Groups				
		Lyons Ferry	Tucannon	Touchet	Walla Walla	Mean Stray
Ocean		0.0	0.1	0.0	0.0	**0.0%**
Columbia River	Sport	9.5	4.0	10.5	12.2	
	Tribal	4.4	0.9	3.5	1.4	
	Stray Harvest	0.6	2.5	0.2	0.1	0.9
	Stray Rack	0.1	1.3	0.2	0.1	0.4
	TOTALS	**14.6%**	**8.7%**	**14.4%**	**13.8%**	***1.3%***
Snake River	Sport (Below LGD)	19.7	4.5	0.0	0.0	
	Sport (Above LGD)	0.0	0.0	0.0	0.0	
	Tribal	0.0	0.0	0.0	0.0	
	Stray Harvest (Below LGD)	6.9	2.0	22.3	24.9	14.0
	Stray Harvest (Above LGD)	14.7	35.0	11.7	16.3	19.4
	Stray Rack (Below LGD)	0.0	12.4	19.8	22.8	13.8
	Stray Rack (Above LGD)	0.3	1.2	0.4	0.2	0.5
	TOTALS	**41.6%**	**55.0%**	**54.2%**	**64.2%**	**47.7%**
Tributary	Sport Harvest	N/A	31.0%	28.7%	22.0%	
	Weir Enumeration	43.7%	5.2%	2.6%	N/A	

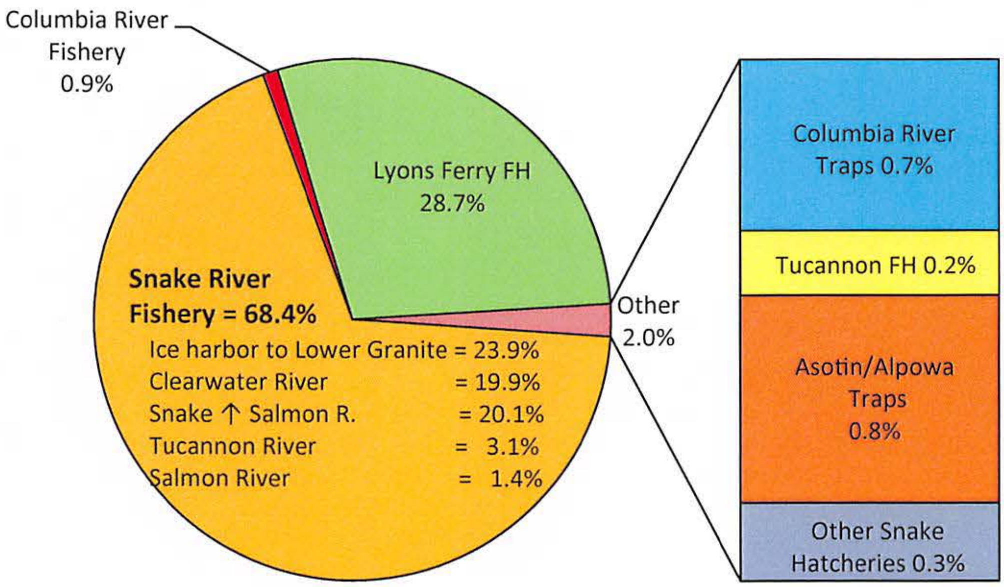

Figure 12. Point of recovery of Lyons Ferry stock summer steelhead (all release groups combined) defined as "strays" in Table 2.

Table 3. Catch and escapement of WDFW LFH stock summer steelhead, 2001-2006 brood years, released from Lyons Ferry Hatchery.

Location	Sub-Area	Brood Year						Mean
		2001	2002	2003	2004	2005	2006	
Ocean		0.0	0.0	0.0	0.0	0.0	0.0	***0.0***
Columbia River	Sport	13.2	12.1	17.8	9.7	3.7	5.0	9.5
	Tribal	3.1	2.5	1.5	3.0	5.2	8.9	4.4
	Stray Harvest	0.8	0.4	0.4	0.3	0.2	0.0	0.6
	Stray Rack	0.0	0.0	0.0	0.8	0.0	0.0	0.1
								14.6
Snake River	Sport (Below LGD)	7.0	21.4	21.8	25.2	20.7	20.8	19.7
	Sport (Above LGD)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tribal	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stray Harvest (Below LGD)	7.1	2.8	9.0	10.2	3.4	6.0	6.9
	Stray Harvest (Above LGD)	15.4	20.7	5.5	4.3	29.6	18.3	14.7
	Stray Rack (Below LGD)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stray Rack (Above LGD)	0.3	0.6	0.0	0.0	0.8	0.2	0.3
								41.6
Escapement to Weir	Lyons Ferry Hatchery	53.1	39.4	44.1	46.7	26.5	40.7	***43.7***

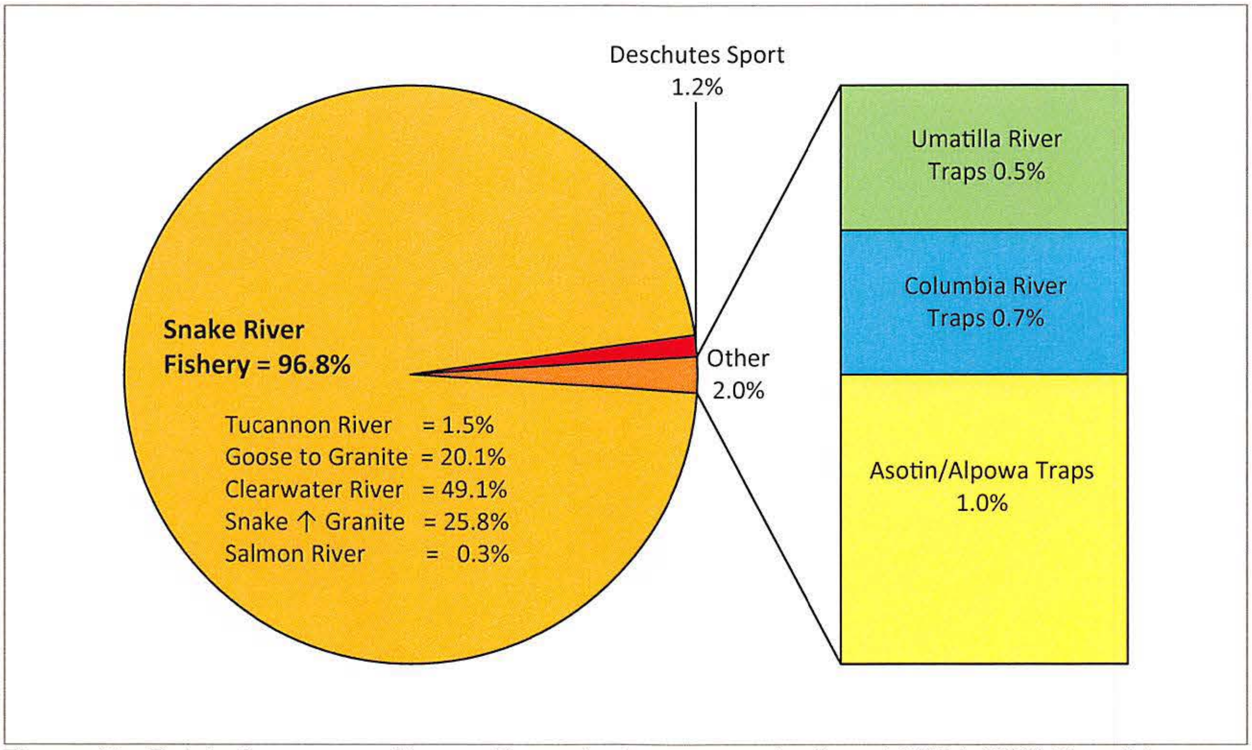

Figure 13. Point of recovery of Lyons Ferry stock summer steelhead (2001-2006 Broods) released from Lyons Ferry Hatchery and defined as "strays" in Table 3.

Table 4. Catch and escapement of WDFW LFH stock summer steelhead, 2001-2006 brood years, released from Lyons Ferry Hatchery.

Location	Sub-Area	Brood Year						Mean
		2001	2002	2003	2004	2005	2006	
Ocean		0.0	0.0	0.0	0.0	0.0	0.0	***0.0***
Columbia River	Sport	13.2	12.1	17.8	9.7	3.7	5.0	9.5
	Tribal	3.1	2.5	1.5	3.0	5.2	8.9	4.4
	Stray Harvest	0.8	0.4	0.4	0.3	0.2	0.0	0.6
	Stray Rack	0.0	0.0	0.0	0.8	0.0	0.0	0.1
								14.6
Snake River	Sport (Below LGD)	7.0	21.4	21.8	25.2	20.7	20.8	19.7
	Sport (Above LGD)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tribal	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stray Harvest (Below LGD)	7.1	2.8	9.0	10.2	3.4	6.0	6.9
	Stray Harvest (Above LGD)	15.4	20.7	5.5	4.3	29.6	18.3	14.7
	Stray Rack (Below LGD)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stray Rack (Above LGD)	0.3	0.6	0.0	0.0	0.8	0.2	0.3
								41.6
Escapement to Weir	Lyons Ferry Hatchery	53.1	39.4	44.1	46.7	26.5	40.7	***43.7***

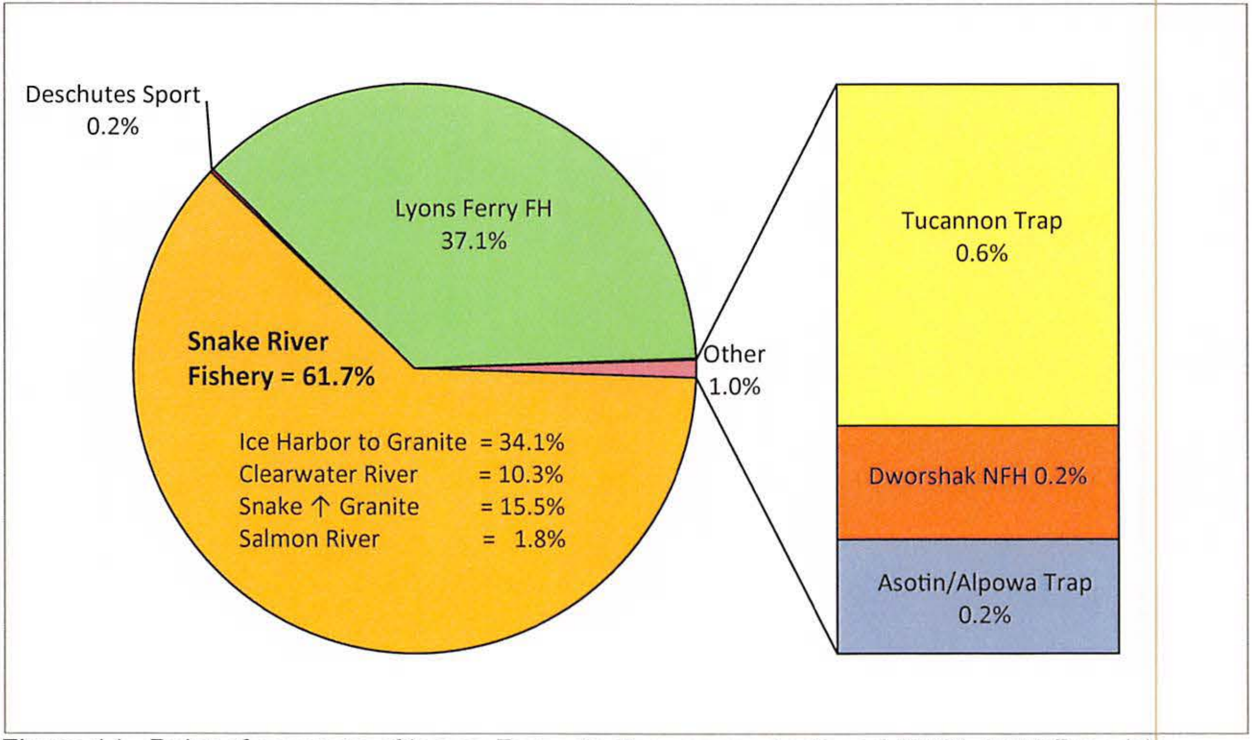

Figure 14. Point of recovery of Lyons Ferry stock summer steelhead (2001-2006 Broods) released into the Walla Walla River and defined as "strays" in Table 4.

Table 5. Catch and escapement of WDFW LFH stock summer steelhead, 2001-2006 brood years, released into the Touchet River.

Location	Sub-Area	Brood Year						Mean
		2001	2002	2003	2004	2005	2006	
Ocean		0.0	0.0	0.0	0.0	0.0	0.0	***0.0***
Columbia River	Sport	0.3	11.0	22.3	8.5	11.9	11.2	10.5
	Tribal	2.8	1.7	0.5	2.9	7.4	4.9	3.5
	Stray Harvest	0.0	0.7	0.0	0.3	0.0	0.0	0.2
	Stray Rack	0.0	0.0	0.3	0.0	0.5	0.0	0.2
								14.4
Snake River	Sport (Below LGD)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sport (Above LGD)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tribal	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stray Harvest (Below LGD)	23.5	17.7	16.8	24.6	28.0	21.6	22.3
	Stray Harvest (Above LGD)	11.3	5.4	11.5	7.5	23.8	5.7	11.7
	Stray Rack (Below LGD)	29.5	18.0	15.3	15.3	16.2	21.6	19.8
	Stray Rack (Above LGD)	0.3	0.0	0.0	0.3	0.5	1.6	0.4
								54.2
Walla Walla /Touchet	Sport Harvest	28.6	41.3	29.4	37.5	10.2	30.5	***28.7***
Escapement to Weir	Touchet River	3.0	4.3	1.0	2.9	1.4	2.9	**2.6**

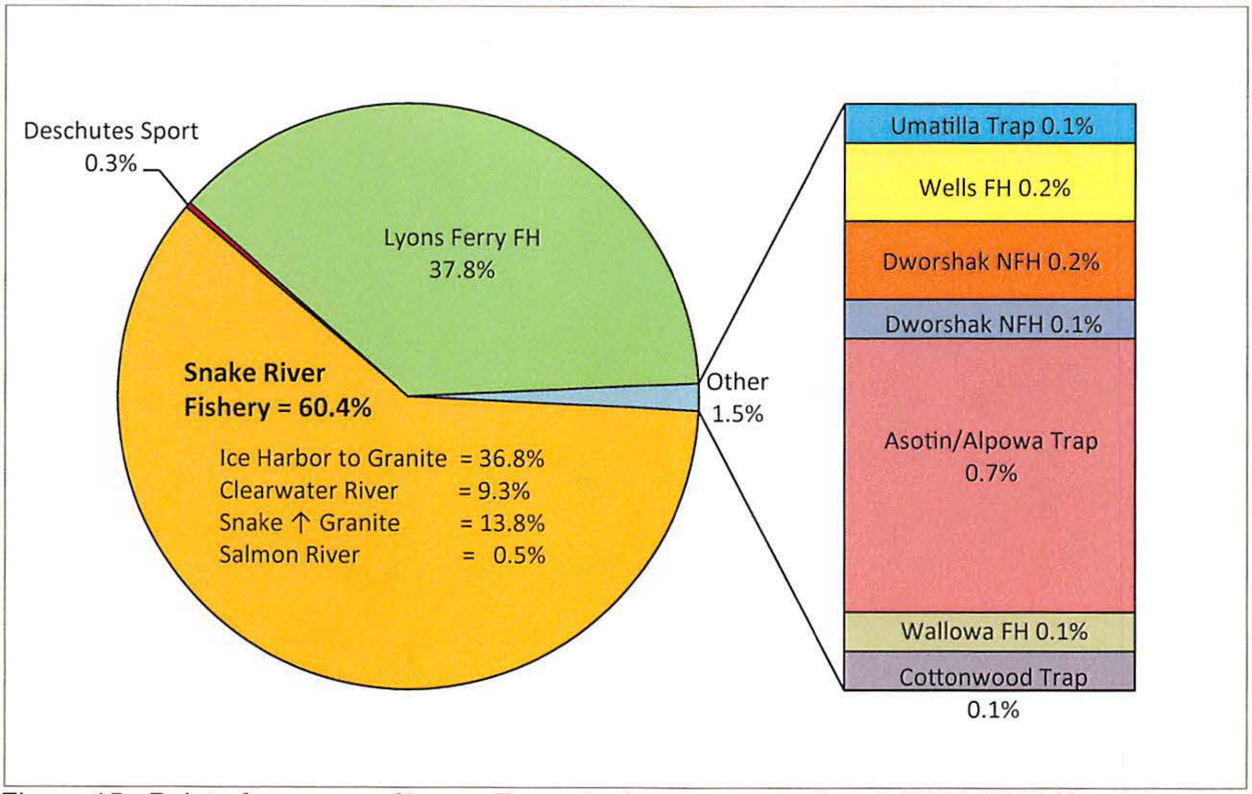

Figure 15. Point of recovery of Lyons Ferry stock summer steelhead (2001-2006 Broods) released from Dayton AP in the Touchet River and defined as "strays" in Table 5.

Table 6. Catch and escapement of WDFW LFH stock summer steelhead, 2001-2004 brood years, released into the Tucannon River.

Location	Sub-Area	Brood Year				Mean
		2001	2002	2003	2004	
Ocean		0.0	0.2	0.4	0.0	***0.1***
Columbia River	Sport	2.2	7.6	4.4	1.7	4.0
	Tribal	0.0	1.9	1.8	0.3	0.9
	Stray Harvest	3.3	1.9	2.7	2.0	2.5
	Stray Rack	0.7	0.5	2.2	3.0	1.3
						8.7
Snake River	Sport (Below LGD)	7.2	1.7	5.5	3.6	4.5
	Sport (Above LGD)	0.0	0.0	0.0	0.0	0.0
	Tribal	0.0	0.0	0.0	0.0	0.0
	Stray Harvest (Below LGD)	0.0	4.9	1.8	1.3	2.0
	Stray Harvest (Above LGD)	39.0	25.0	30.4	45.4	35.0
	Stray Rack (Below LGD)	11.9	11.4	11.3	15.3	12.4
	Stray Rack (Above LGD)	0.7	1.4	0.7	2.0	1.2
						55.0
Tucannon	Sport Harvest	29.5	35.6	35.9	22.8	***31.0***
Escapement to Weir	Tucannon River	5.5	7.9	2.8	2.6	***5.2***

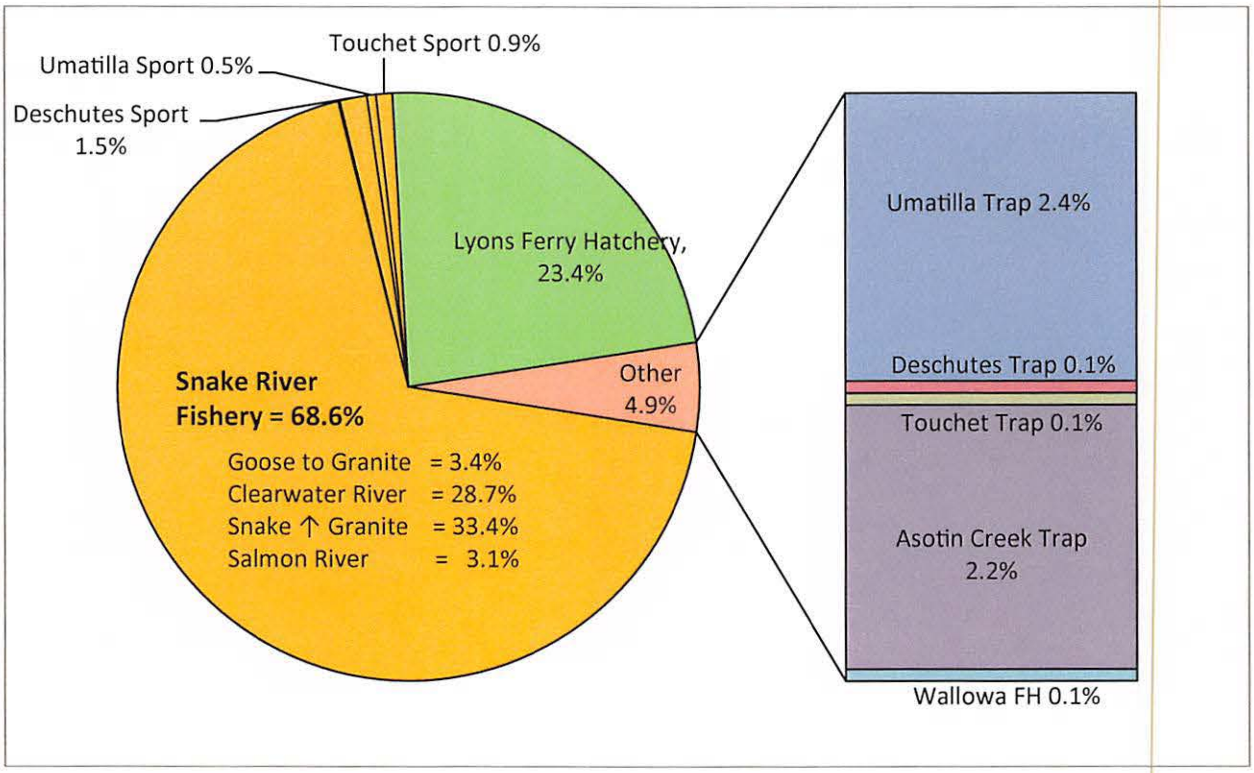

Figure 16. Point of recovery of Lyons Ferry stock summer steelhead (2001-2004 Broods) released in the Tucannon River and defined as "strays" in Table 6.

The resurgence of sport fisheries in Washington's portion of the Snake and tributary rivers in SE Washington, such as the Tucannon, Touchet, and Walla Walla rivers, has been in direct relation to returning large numbers of hatchery fish from the LSRCP program. The steelhead sport fisheries in the Snake, Tucannon, and Walla Walla basins are well established and recognized as prime steelhead fisheries within the Pacific Northwest. Within the State of Washington from the four rivers where LFH stock fish are released, there are 319 river miles open to fishing and steelhead can be retained 212-304 days of the year. Based on a USFWS survey in 2002, we determined a direct cost of ~$1,000 per harvested steelhead, thereby valuing the fishery in these rivers $13-29 million/year (estimates based on harvested steelhead from 2000-2010 Run Years).

Table 7. River miles and days of steelhead seasons, and the estimated direct cost of summer steelhead fisheries in the Snake, Tucannon, Walla Walla and Touchet rivers (2000-2010 run years).

Location	Snake River	Tucannon River	Walla Walla River	Touchet River	**Totals**
River Miles	179	34	51	55	**319**
Days Open	212	304	304	304	**212-304**
Economic Value	$12-25 Million	$0.5-1.2 Million	$0.4-2.0 Million	$0.1-0.9 Million	**$13-29 Million**

The majority of the steelhead harvested in the Snake, Tucannon and Walla Walla rivers occurs in the fall and spring (Figure 17), but the Touchet River is primarily a spring fishery. From the contribution of all LSRCP steelhead programs, the steelhead sport fishery in the Snake River has greatly increased (Figure 18A), and fisheries within the Tucannon, Walla Walla and Touchet river from WDFW's specific programs within those tributaries have also been successful (Figure 18 B, C, and D).

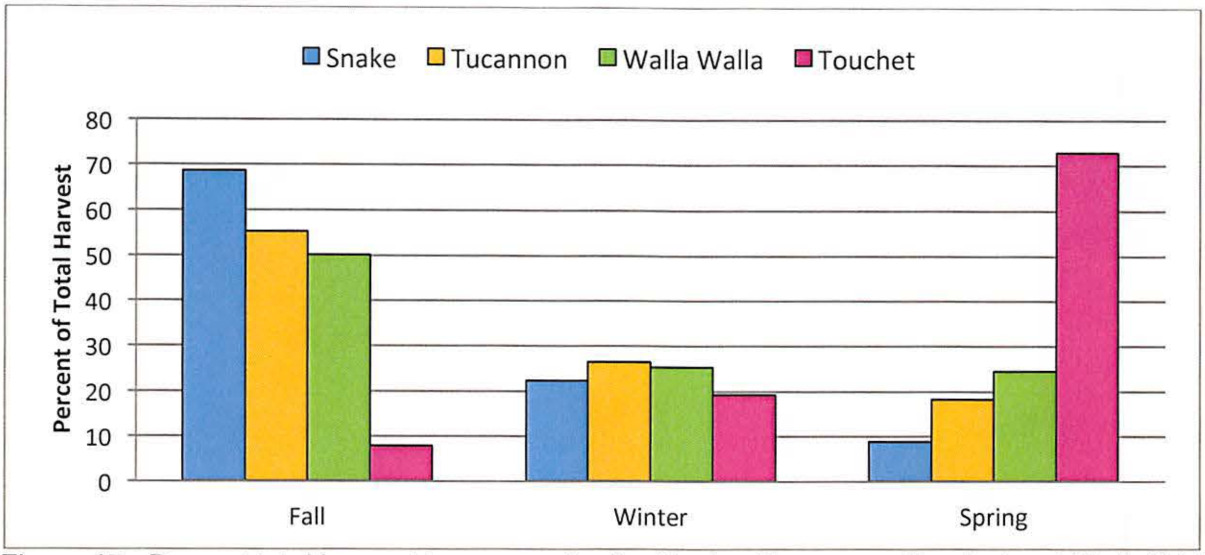

Figure 17. Percent total harvest by season for the Snake, Tucannon, Touchet and Walla Walla rivers, 1985-2009 run years.

Increased harvest and an increase in number of angler days (fulfilling program goals) also translate into possible negative effects on wild steelhead populations. The NOAA Fisheries requires WDFW to operate our steelhead fisheries within SE Washington under a Fishery Management and Enhancement Plan (FMEP) and estimate impacts of fisheries to listed populations of steelhead. During steelhead creel surveys on the mainstem Snake River, samplers collect data on the number of wild fish captured and released. Based on the proportions with hatchery fish retained and wild fish released, and applying a hooking mortality rate of 5%, we estimate that an average of 374 (1.5%) wild Snake River origin summer steelhead are inadvertently killed from the fishery (Table 8). Because of the relative low estimated impacts to wild fish, WDFW believes that the creel surveys are adequate in their current design to adequately describe fishery impacts to wild steelhead on the Snake River.

Similar tables for the Walla Walla, Touchet and Tucannon rivers have also been constructed. Estimates of mortality within the tributaries generally show impacts to be higher (about 10% annually). However, the greatest unknowns in these estimates are the wild steelhead returns to each tributary. Estimates that are available are for index areas only, or not available at all. WDFW believes the creel surveys on the tributaries have been adequate to describe impacts to the wild populations. However, creel surveys have been curtailed/limited in recent years due to lack of financial resources, and the inability to achieve sample target rates (20%) from the tributary fisheries, thereby we've placed a greater emphasis on sampling the mainstem Snake River fishery.

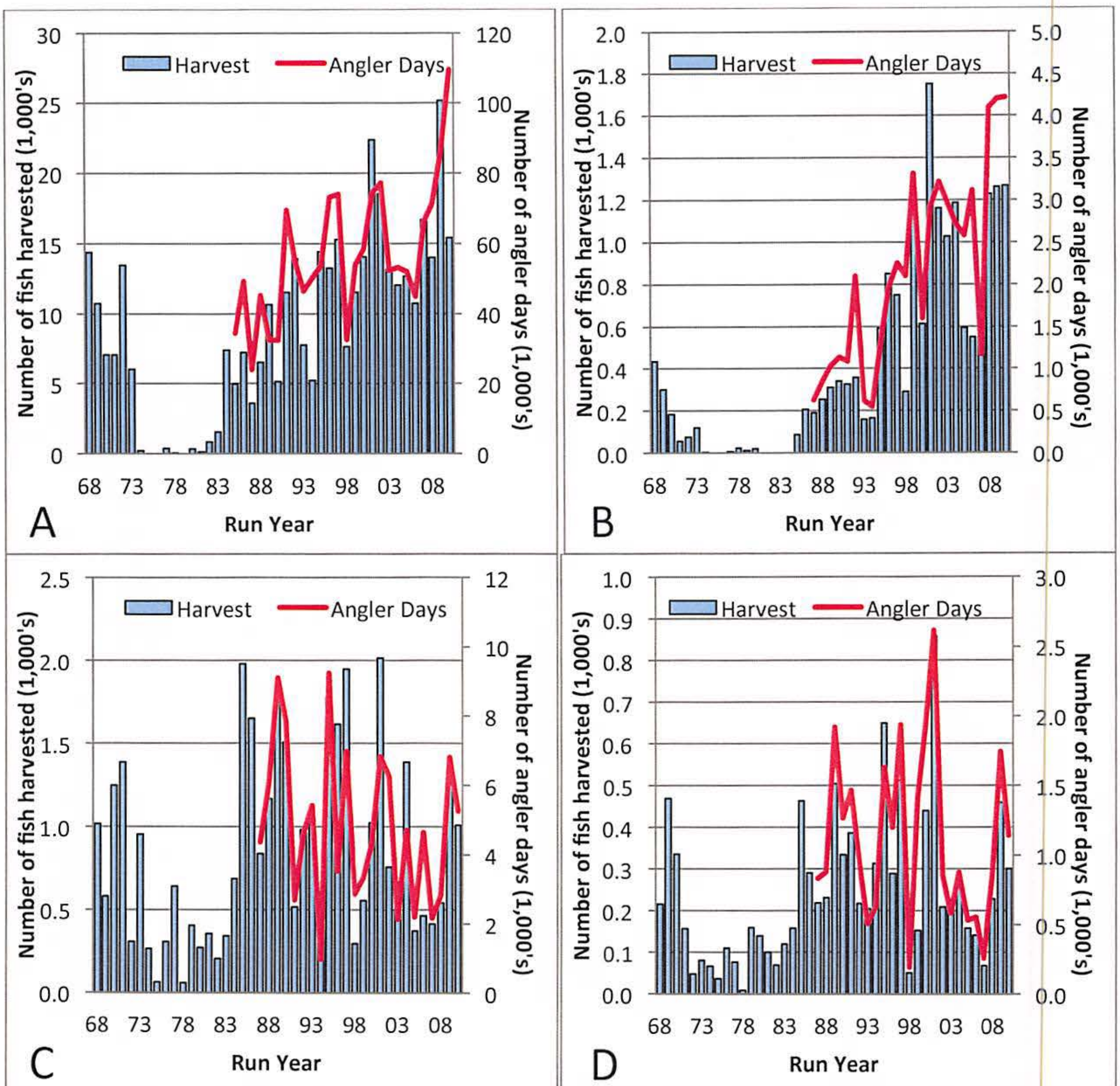

Figure 18. Harvest of steelhead within the Snake River (A), Tucannon River (B), Walla Walla River (C), and Touchet River (D) 1968-2010 run years, and estimated angler days in each from 1986-2010.

When possible , WDFW has adapted the highly successful LFH stock program as needed, although, a significant objective of the original program remains unmet. Within the Snake River Basin in SE Washington, the status of many natural steelhead populations and/or individual streams that contain steelhead remains unknown. While some systems such as the Touchet and Tucannon rivers and Asotin Creek have been monitored consistently (either through index spawning ground surveys or deployment of adult traps), environmental conditions such as high, muddy stream flows often limit our ability to accurately assess total returns or to estimate composition of hatchery and wild steelhead on the spawning grounds. Further, due to environmental conditions, or lack of resources or river access, many areas within these particular streams are not assessed on an annual basis; yet steelhead are likely present. Due to these constraints, WDFW has recently focused their steelhead monitoring efforts on steelhead using PIT tags and PIT tag arrays in these streams to answer many of the status, trend, and composition questions we have.

Table 8. Estimates of impacts to ESA listed summer steelhead in the sport fishery on the mainstem Snake River in Washington, 2000-2007 run years.

Run Year	Wild (W) SH released	Hatchery (H) SH Kept	Proportion of W released to H Kept	Catch Record Card Harvest Estimate	Estimated Wild SH caught	Hooking mortality (5%)[1]	Annual wild steelhead run size estimate[2]	Hooking mortality % of Total
2000	432	1,089	0.40	13,727	5,445	272	20,263	1.3
2001	896	2,169	0.41	22,375	9,243	462	41,024	1.1
2002	1,275	2,010	0.63	18,524	11,750	588	45,135	1.3
2003	958	1,739	0.55	13,122	7,229	361	29,158	1.2
2004	975	1,549	0.63	12,634	7,952	398	23,051	1.7
2005	799	1,499	0.53	12,678	6,758	338	18,107	1.9
2006	755	1,467	0.51	10,714	5,514	276	9,470	2.9
2007	770	2,174	0.35	16,700	5,915	296	13,917	2.1
All Years Totals/ Average	**6,860**	**13,696**	**0.50**	**120,474**	**59,806**	**2,991**	**200,125**	**1.49**

[1] Estimated number of wild steelhead hooking mortalities. Hooking mortality is related to water temperature; as water temperature increases hooking mortality increases (Mongillo 1984; Rawding 2000). A hooking mortality rate of 5% is used because most of the steelhead harvest occurs between October and March when average water temperature in the Snake River was 8.65 ^{0C}, (WDOE – River and Stream Water Quality Monitoring Program – Station#35A150).
[2] The estimated annual Snake River wild steelhead run size as counted at Lower Granite Dam (IDFG Estimates from Sampling at Lower Granite Dam from Lower Columbia River BA).

Other streams such as the Walla Walla River and Mill Creek (Walla Walla tributary), or numerous smaller tributaries to the Snake River, have only recently begun to be monitored (i.e. Almota and Alpowa creeks), or have not been monitored at all (e.g. Penewawa, Alkali Flat, Deadman creeks, etc.); mainly due to limited financial resources and land-ownership accessibility. The limited monitoring that has occurred in Almota Creek (currently defined as part of the Tucannon River population) and Alpowa Creek (currently defined as part of the Asotin Creek population) raises serious concerns about the LFH stock program as it contributed 38% and 32% of the adult steelhead returning to Almota Creek and Alpowa Creek, respectively (Figures 19 and 20), for years that we've sampled. Considering that the Lyons Ferry stock program has been in existence for nearly 30 years, it's likely that these small streams have had hatchery fish present every year; the consequences of which are unknown. Tissue samples collected from the natural fish present in these streams need to be analyzed to determine stock designation. Additional small streams in the area will be sampled in the coming years.

Recognizing that we lack stock status and/or stream status information for all steelhead bearing streams within SE Washington, WDFW has enacted various policies/fishery regulations for protection of wild steelhead. These include: 1) adoption of Wild Steelhead Refuge Areas (Asotin Creek, Joseph Creek, Wenaha River Basin, 2) restriction of fishing in most headwater areas of streams with wild steelhead present, 3) elimination of directed wild steelhead harvest since 1983, 4) Barbless hooks are required in all Snake River Basin sport fisheries, 5) The daily bag limit of hatchery origin steelhead was increased from 2 to 3 fish/day in 2001, 6) implemented selective gear and closed area regulations for trout/juvenile steelhead and refocused trout fisheries within SE Washington to area lakes stocked with LSRCP fish, 7) Decreased the number of steelhead smolts released and changed their release locations in some rivers to downstream locations to limit their interaction (both as juveniles and returning adults) with wild stocks, and 8) where we operate traps/weirs on tributaries, all mitigation purpose hatchery steelhead are removed upon capture (i.e. Cottonwood Trap, Asotin Creek, Tucannon River, etc.).

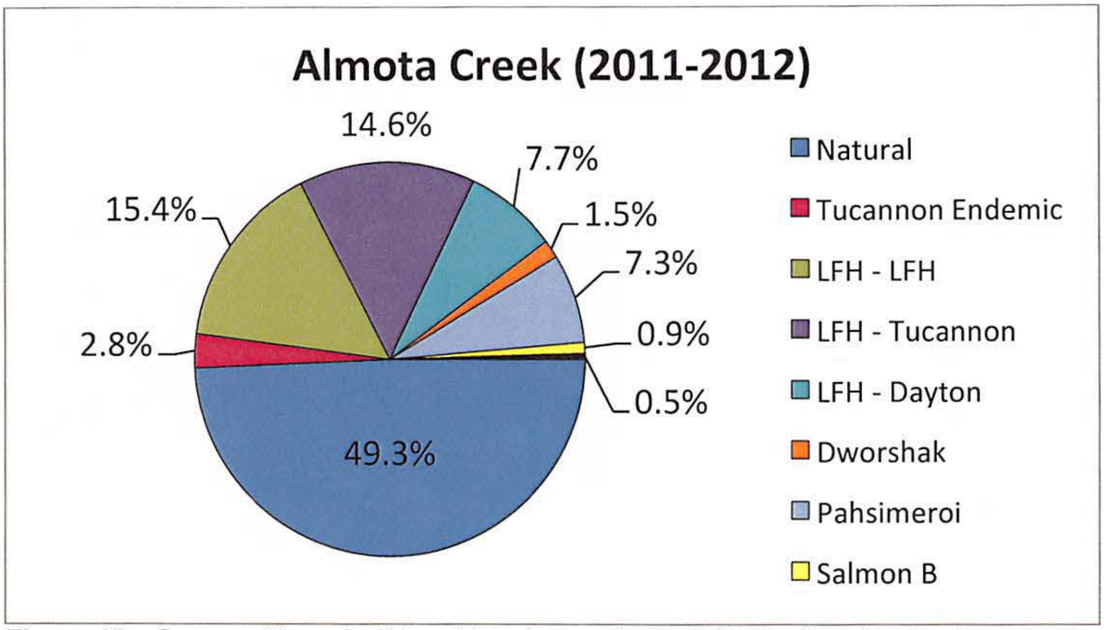

Figure 19. Composition of wild and hatchery-origin adult steelhead returning to Almota Creek, spring of 2011 and 2012.

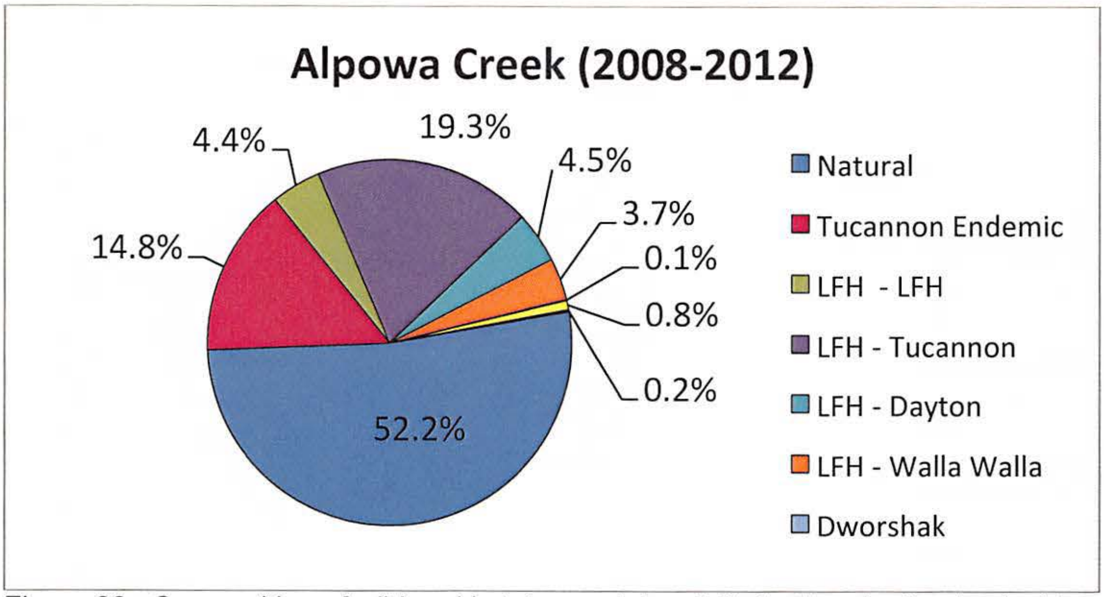

Figure 20. Composition of wild and hatchery-origin adult steelhead returning to Alpowa Creek, spring of 2008 to 2012.

SUMMARY AND CONCLUSIONS

Broodstock Development and Management

WDFW developed the LFH stock through trapping of returning adults of Wells and Wallowa stock origins at Lyons Ferry Hatchery. The LFH stock has been the primary one used for mitigation in the Snake, Tucannon, Walla Walla and Touchet rivers. Broodstock availability has not been a limiting factor for the program .

In-Hatchery Performance

Over the course of the program, spawn timing of the LFH stock has shifted about 1-month earlier, though this has not been considered a detriment to the program. Pre-spawning mortality is higher than noted for other steelhead program with the Snake River basin, but most other programs trap their broodstock in the spring, not in the late summer/early fall as with the LFH stock. Egg-to-smolt survival rates have been variable, but within acceptable limits and have not affected achieving overall program performance/goals. Outbreaks of IHNV caused severe losses in the LFH stock program in two years, but the disease has been controlled with strict disinfection/rearing protocols. Bacterial coldwater disease occurs annually within the LFH stock, but has not prevented the program from achieving smolt release goals. Smolt releases (both target number and size at release) have generally been met.

Survival and Adult Return Performance

Adult return goals (3,156 adults) to the project area have been met in 100% of the time over the last 25 run years (1984-2009), albeit with releases of other Snake basin stock fish in two of those years. Total adult return goals (9,468 adults) have been met about 50% of the time over the last 25 run years (1984-2009). The SAS and SAR survival rates are within expected ranges, but are greater than the survivals used to size hatchery facilities in the origin LSRCP document. Adult returns from the LFH stock steelhead smolts releases are exploited in fisheries at high rates (85% of adults accounted for), with most of the current harvest occurring in the Snake River, and in the tributaries with directed fisheries (Tucannon, Walla Walla, and Touchet rivers). Between 20-25% of the LFH stock steelhead returns annually escape back to Lyons Ferry Hatchery. Strays to others hatcheries/traps are very low (1% of total returns – excluding Lyons Ferry Hatchery returns). Recreational fishing opportunity for summer steelhead has been restored in the Snake, Tucannon, Walla Walla and Touchet rivers.

Wild Steelhead Stock Status and Data Gaps

The status of wild steelhead populations within SE Washington are not completely understood, even though some monitoring has occurred (i.e. Tucannon and Touchet rivers, and Asotin Creek). In particular, small tributaries that enter directly into the mainstem Snake River, appear to have high percentages of hatchery origin steelhead, a cause for concern. Though we currently lack the ability (logistically and financially) to intensively monitor/manage all of these small streams continuously to reduce the effects of the LSRCP hatchery program on wild steelhead, WDFW has enacted policies/regulations to protect wild steelhead populations within SE Washington.

Hatchery Reform Actions

From the beginning, the WDFW LFH stock hatchery program has remained flexible to changing needs/directions that have been provided through ongoing monitoring and evaluation studies, WDFW policy changes, Federal Biological Opinions, Hatchery Scientific Review Group and Hatchery Review Team program reviews, and consultation feedback from NOAA Fisheries on submitted Hatchery Genetic Management Plans (HGMP's). Program changes that have occurred are:

- The numbers of smolts and release locations have been decreased, and smolt size has been increased. WDFW believes these actions have reduced straying, increased emigration success and survival, and reduced competition and predation effects from residuals.
- Implemented removal of excess hatchery adults at traps/weirs. WDFW believes this action has decreased hatchery fish spawning in target locations and other areas, and has reduced the risk of possible disease transmission.
- Annually coded-wire tag and PIT tag smolts prior to release. For many years, coded wire tags were not designated for each WDFW steelhead release group, greatly limiting our ability to accurately determine adult returns and survival and assess straying. Beginning in 2001 and 2008 release years, all WDFW LSRCP steelhead releases were tagged with representative groups of coded-wire and PIT Tags, respectively.
- Development of endemic broodstocks on the Tucannon and Touchet Rivers. While a decision to implement the Touchet endemic stock has not been made, steps to fully implement the Tucannon endemic stock program began in 2010. This decision also included ceasing the release of LFH stock steelhead into the Tucannon River, reducing the effects of out-of-basin hatchery steelhead on the natural population of steelhead in the Tucannon River.

FUTURE PROGRAM CHALLENGES AND NEEDS

Wild steelhead populations in the Snake River Basin remain depressed. The apparent success of the LSRCP program in Washington (see also the Wallowa stock program review) to return adult steelhead has had little beneficial effect on wild escapement, but it was never intended to rebuild those populations. Program goals and actions may need to be revisited in light of ESA and WDFW policies to preserve/protect/rebuild wild steelhead populations. WDFW is currently tasked with development of Steelhead Management Plans for each steelhead population within the State. Hatchery goals and program actions will be a critical part of those plans, as well as coordinating with Snake River Recovery Plans and HGMP's. Management priorities may differ from those originally established under the mitigation program, and could move management agencies to question whether harvest mitigation programs and wild stock recovery can be conducted/achieved concurrently.

Factors critical to the future success of our program include: 1) Establishment of consistent goals among all managers, 2) wild population characterization (VSP parameters), 3) Identifying the causes of decline or factors that continue to suppress population productivity, 4) correcting the limiting factors where possible, and 5) retaining flexible hatchery programs. We may need to redefine success for the LSRCP program and for anadromous salmonids in the Snake River basin. We believe that success must include both <u>recovery</u> of depressed wild stocks, and <u>opportunity</u> for Washington's residents to partake of that resource which was lost to them as a result of the construction and operation 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 populations remain depressed. Correction of survival problems within the basin must occur.

Imnaha River Summer Steelhead Hatchery Program Review

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This program is a cooperative effort of the Oregon Department of Fish and Wildlife, the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation. The program is funded by the Bonneville Power Administration and administered by the U.S. Fish and Wildlife Service under the Lower Snake River Compensation Plan.

INTRODUCTION AND BACKGROUND

This paper provides background information, management goals and objectives, program development history, assessment of program performance and future challenges for the Imnaha River summer steelhead *Oncorhynchus mykiss* hatchery program. We cover the time period from the program initiation in 1982 to the present (2010).

The Imnaha River basin is located in Northeast Oregon. The basin originates in high elevation areas of the eastern Wallowa Mountains and the plateau between the Wallowa River drainage and Hells Canyon. The Imnaha River enters the Snake River at river kilometer (rkm) 308. Eight main stem hydroelectric dams and associated reservoirs exist between the Imnaha River and the ocean.

The Imnaha River historically supported an abundant run of summer steelhead. Recreational fisheries occurred throughout the basin from autumn through late spring. Steelhead escapement to the Snake River declined substantially following the completion of the four lower Snake River dams. Annual index redd counts in the Imnaha River tributaries showed a drastic decline following completion of Lower Granite Dam in 1974.

In 1976, the U.S. Congress authorized the Lower Snake River Compensation Plan (LSRCP). The LSRCP mandated a compensation program to mitigate for the losses of anadromous fishes that resulted from construction and operation of the four lower Snake River dams–Ice Harbor, Lower Monumental, Little Goose, and Lower Granite.

The Imnaha River steelhead hatchery program was initiated in 1982 in response to severe declines of steelhead that occurred throughout the 1970s. Annual adult mitigation, brood year specific smolt-to-adult return rate, total smolt-to-adult survival rate, and annual smolt production goals were established to compensate for the estimated annual loss of 48% of adult production (Table 1). Interim smolt production goals that are less than the original have been adopted through the adaptive management process.

The adult return and smolt-to-adult return rate goals for the compensation area represent the required performance to the area above Lower Granite Dam (LGD). The total adult and smolt-to-adult survival rate goals were determined based on the LSRCP plan analyses which assumed that a downriver harvest to compensation area escapement ratio of two-to-one existed prior to construction of the dams. We recognized that this level of exploitation in downriver areas under current conditions is an unreasonable expectation. Current status of upriver natural steelhead populations that are listed under the Endangered Species Act (ESA) along with the associated limits on harvest take for recovery purposes will preclude, possibly indefinitely, reestablishing downriver fisheries of the magnitude that existed prior to construction of the dams.

Table 1. Lower Snake River Compensation Plan mitigation goals for Oregon's summer steelhead in the Imnaha River basin. Adult and survival goals are expressed for returns to the compensation area and total catch and escapement.

Category	Goal
Compensation Area	
Annual smolt goal	330,000 smolts (215,000 interim)
Annual pounds of production	66,000 lbs.
Annual adult goal	2,000 adults
Brood year smolt-to-adult return rate (SAR)	0.61% (0.93% interim)
Total Catch & Escapement	
Annual adult goal	6,000 adults
Brood year smolt-to-adult survival rate (SAS)	1.83%

Implementation of the LSRCP Imnaha steelhead hatchery program has been guided by five priority management objectives: 1) establish an annual supply of broodstock capable of meeting production goals; 2) maintain and enhance natural production while maintaining long-term fitness of the natural population; 3) re-establish historic tribal and recreational fisheries; 4) establish a total return number of summer steelhead that meets the LSRCP goals; and 5) operate the hatchery program to maintain the genetic and life history characteristics of the natural population and have hatchery fish characteristics mimic those of natural fish, while achieving management objectives.

A comprehensive research, monitoring and evaluation (RM&E) program has been underway since 1984. The primary objectives of the RM&E program are: 1) document and assess fish culture and hatchery operational practices and performance; 2) determine optimum rearing and release strategies that will produce maximum survival to adulthood; 3) determine total catch and escapement, smolt survival to LGD, total smolt-to-adult survival (SAS), smolt-to-adult return rate to the compensation area (SAR), and assess if adult production meets mitigation goals; 4) assess and compare recruits-per-spawner of hatchery reared and natural spawning fish; 5) determine the magnitude and patterns of straying; 6) assess response in natural population abundance and productivity (adult recruits-per-spawner, smolts-per-spawner) to supplementation; 7) assess and compare life history characteristics (age structure, run timing, sex ratios, smolt migration timing, fecundity) of hatchery and natural fish; and, 8) assess success in restoring fisheries to historical levels.

The steelhead production program involves three hatchery facilities. Adult broodstock are collected, held, and spawned at the Little Sheep Creek Facility, which is located at rkm 8.0 on Little Sheep Creek (Figure 1). Embryos are immediately transported to Wallowa Fish Hatchery where they are incubated on temperature mediated spring water. Once embryos reach the eyed stage they are transferred to Irrigon Hatchery for final incubation, hatching, and final rearing on well water. Ten to 12 months after fertilization (March-April) smolts are transferred back to the Little Sheep Creek acclimation pond for final rearing and acclimation. Smolts are released in April or early May as yearlings.

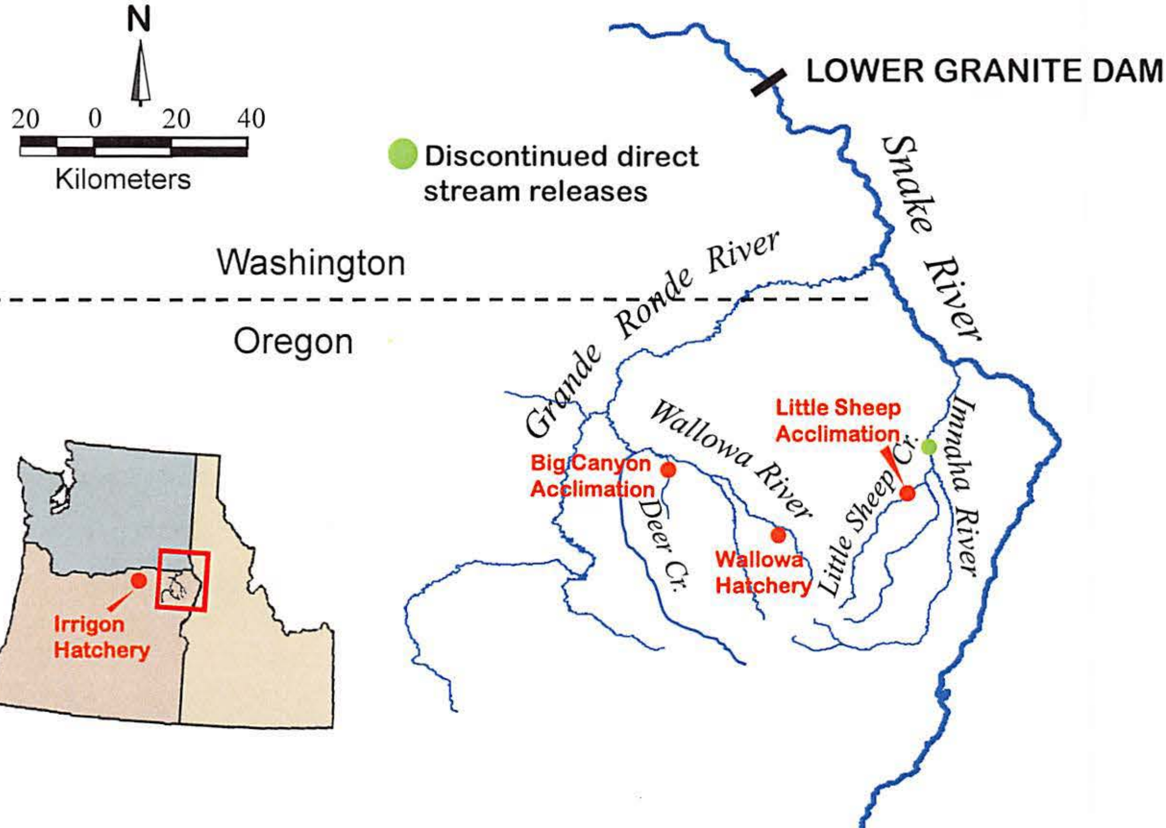

Figure 1. Map showing locations of acclimation sites on Deer and Spring creeks in the Grande Ronde River basin and Little Sheep Creek in the Imnaha River basin and a discontinued direct-stream release site. Inset shows location of study area within a three-state region and the location of Irrigon Fish Hatchery.

PROGRAM ASSESSMENT

Fortuitously, the local biologists recognized the importance of initiating broodstock from a local source. Natural-origin adults were collected from Little Sheep Creek beginning in 1982. Natural-origin adults comprised a majority of the broodstock from 1982-1986. When significant numbers of hatchery fish began to return in 1987 the broodstock was dominated by hatchery-origin fish (Table 2). The proportion of broodstock that were natural origin has only reached 25% in the most recent years.

Table 2. History of natural- and hatchery-origin broodstock collection at Little Sheep Creek, spawn years 1982 to 2011.

Spawn Years	Number of Females in Broodstock		Percent Natural Run Retained for Broodstock
	Natural	Hatchery	
1982-1986	25-75	0-19	63.2-81.6
1987-1994	6-33	94-165	20.8-59.3
1995-2007	2-6	95-346	3.5-54.5
2008-2011	5-16	51-106	4.8-10.0

Spawning escapement above the weir is well regulated with an adult trapping facility that provides nearly 100% collection capability. Few hatchery fish were passed above the weir to spawn naturally in the early years of program development (Table 3). Large numbers of hatchery fish and few natural fish were released above the weir to spawn naturally from 1987-2007. This management strategy resulted in very low proportion natural influence (PNI) for this entire time period (range 0.02-0.18). Beginning in 2008 an alternative sliding scale management framework (Table 4) was implemented to increase the proportion of broodstock that are natural-origin, increase the proportion of fish spawning in nature that are natural origin, and reduce the total number of spawners above the weir. This sliding scale has substantially improved the PNI in recent years (Table 3).

Table 3. History of the spawning disposition of hatchery- and natural-origin Imnaha stock steelhead that returned to the weir on Little Sheep Creek. PNI is the proportion of natural influence and is calculated as [PNOB ÷ (PNOB+PHOS)].

Spawn Years	Total Number Spawning in Nature	% Hatchery-origin Spawning in Nature (PHOS)	% Natural-origin in Brookstock (PNOB)	PNI
1982-1986	0-36	0-8.3	71.0-100	0.90-1.0
1987-1994	55-610	46.8-97.0	4.2-15.3	0.02-0.18
1995-2007	46-1,387	66.0-93.8	1.1-9.7	0.02-0.06
2008-2011	281-346	25.1-52.2	12.4-25.2	0.10-0.50

Prespawning mortality of broodstock has been low with the exception of the first few years when temporary holding facilities were used. Green egg-to-smolt survival has been highly variable and low in some recent years (Figure 2), primarily due to cold-water disease.

Table 4. Sliding scale guidelines and associated percent natural influence (PNI) for hatchery- and natural-origin broodstock collections and passage above the weir at Little Sheep Creek.

No. Natural-origin Fish Returning to Weir	No. Natural-origin Retained for Broodstock*	% Hatchery-origin Fish Above Weir	PNI
≤ 100	10 (≤10%)	Any % hatchery to make 250 fish escapement goal	0.14**
150	30 (20%)	52%	0.30
200	50 (25%)	40%	0.48
250	70 (28%)	32%	0.65
300	90 (30%)	16%	0.81

* When number of natural-origin fish exceeds 100, keep 10 adults plus 40% of the natural run greater than 100.
** Assumes return of 100 natural-origin adults.

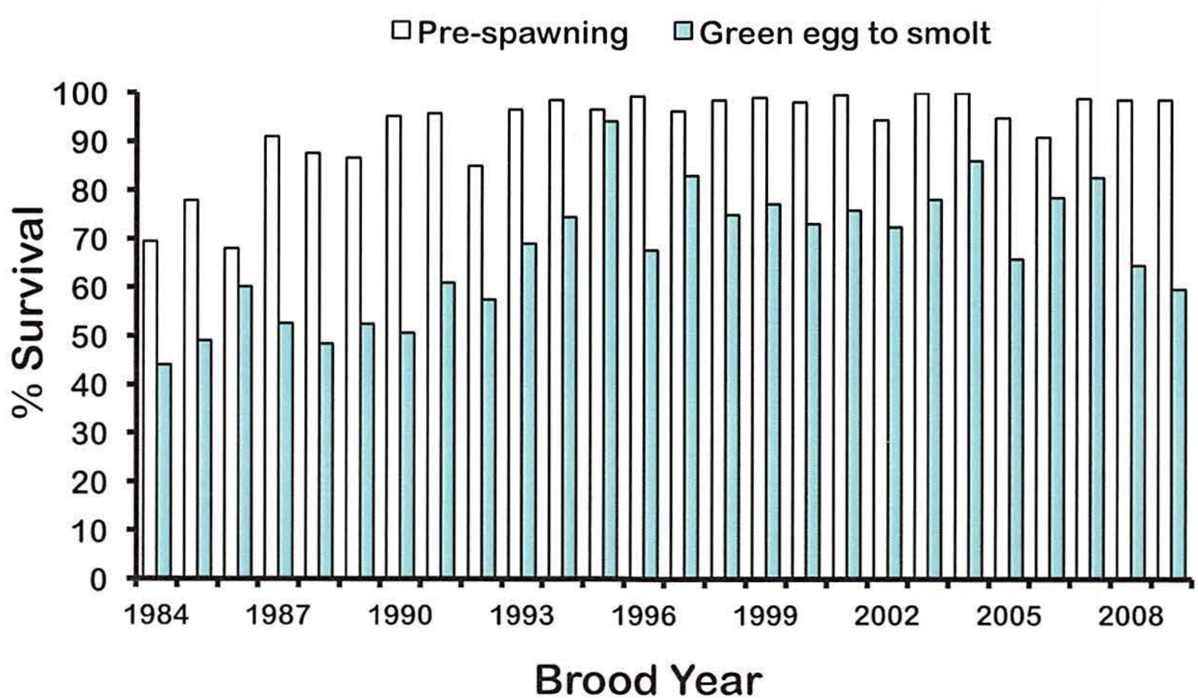

Figure 2. Imnaha stock hatchery steelhead adult pre-spawning survival and green egg-to-smolt survival from brood years 1984 to 2009.

We estimate total number of green eggs based on the estimated number of eyed eggs plus the number of eggs that died prior to the eyed egg stage. The number of eyed eggs are estimated at the time of shocking. We count 1,000-2,000 towel dried eyed eggs and weigh the total to get an average number of eggs per gram. The remaining eyed eggs are then towel dried and weighed and total number of eyed eggs is determined. Green-to-eyed egg survival is calculated by dividing the total number of eyed eggs by the total number of green eggs. The number of embryos that are culled, transferred, or are in excess of program needs is recorded and is subtracted out of the total eyed egg inventory when determining embryo to smolt survival.

After hatching and ponding in indoor circulars, fry are transported to outside raceways for final rearing. Each month, fish in each raceway are crowded and three separate samples of approximately 20 pounds each are weighed and then counted. Average fish per pound is calculated from these samples. Beginning in late February, fish are loaded onto liberation trucks and hauled to acclimation ponds (or hauled later and direct-stream released) to be acclimated for a 1-6 week period and are then released. The number of fish hauled to acclimation ponds or direct-stream released is calculated during loading. At loading, an average fish/lb for each raceway is again calculated as it was during each previous month during rearing. As fish are loaded into liberation tanks, the number of lbs of fish is estimated using a calibrated displacement gauge on each tank of each truck which estimates the number of pounds of fish loaded. To estimate the number of fish in each acclimation pond, we multiply the average fish/lb estimate by total lbs to get the total number of fish on each liberation truck, and then the totals are summed. In 2012, the number of fish estimated using the displacement method during grading when fish from each raceway are loaded into a liberation truck deviated from a complete count of fish during adipose-fin clipping by only 0.17%, thus indicating that the displacement method accurately estimates the number of steelhead. The total number of smolts released is calculated using the number hauled to the acclimation ponds (or direct-stream released) minus mortality from the acclimation ponds (or observed immediately after the direct stream release). Embryo-to-smolt survival for production releases is calculated by dividing the number of smolts released by the eyed embryos minus any culled, transferred, or excess embryos.

To determine size at release for each release group, we conduct pre-release sampling at each acclimation pond immediately prior to release (the day before or the day of release). Fish are crowded and a sample of approximately 1,000 fish is held in a live box. We measure fork length (FL) of 100 fish and weigh (g) 50 fish for each production and experimental group (Ad-only, AdLV, and AdRV clipped fish). For direct-stream released fish, we measure FL of 200-250 fish prior to hauling to release sites and use the monthly fish/pound to determine weight.

The smolt production goal of 330,000 was met in most years once the program reached full implementation. The reduced interim production goals were met in three of the last four years (Figure 3). Smolt survival rates from the Little Sheep Creek Facility to Lower Granite Dam have been highly variable with the highest rates observed (80-90%) in the two most recent years (Figure 4). The smolt migration pattern for hatchery fish is similar to that of natural smolts with initial arrival timing in mid-April and migration completion by mid-June (Figure 5).

Prior to 2001-02 run year, adult returns to the compensation area were well below the mitigation goal of 2,000 in all run years except one (Figure 6). Since the 2001-02 run year the returns have exceeded the goal in every year and have been two times greater than the goal in three of the last eight years. One of the key measures of performance is the SAR relative to the program goal of 0.61%. Over the past 10 brood years, the SAR has ranged from 0.28% to 1.60% (Figure 7). Prior to the recent 10 brood years, the goal was rarely achieved. We have exceeded the SAR goal in eight of the last 10 brood years (Figure 7). The SAS goal has never been achieved; however, SAS was much greater in the most recent 10 brood years than the first 10 brood years.

One of the key indicators of the full life cycle advantage provided by a hatchery supplementation program is the hatchery-to-natural ratio in adult recruits-per-spawner (R/S).

The hatchery R/S has averaged 8.6 times the R/S of naturally spawning fish (Figure 8). In recent years, the ratio has been higher. Natural spawner recruits-per-spawner has been below 1.0 for most years only exceeding 1.0 in five of 18 recent years.

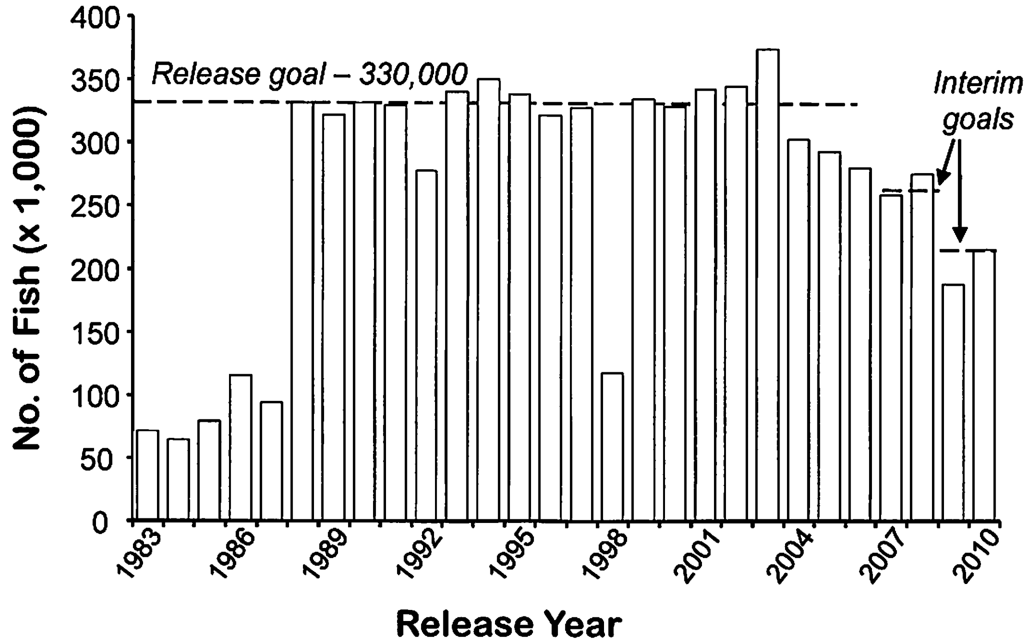

Figure 3. Annual number of Imnaha stock hatchery steelhead smolt releases into the Imnaha River basin, release years 1983 to 2010.

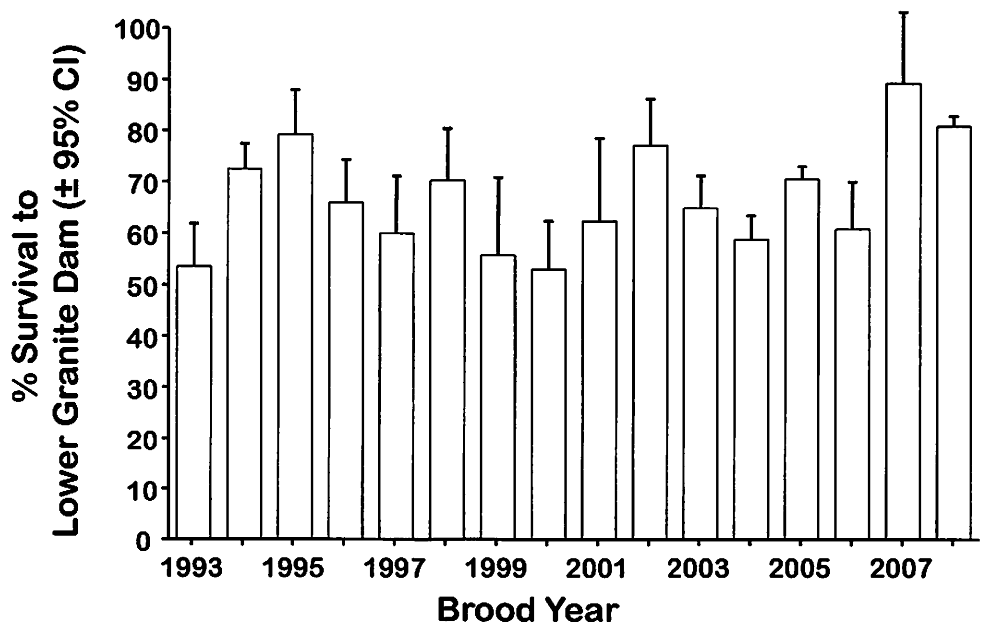

Figure 4. Average annual outmigration survival to Lower Granite Dam of PIT tagged Imnaha stock hatchery steelhead smolts released from the Little Sheep Creek Facility, brood years 1993 to 2008.

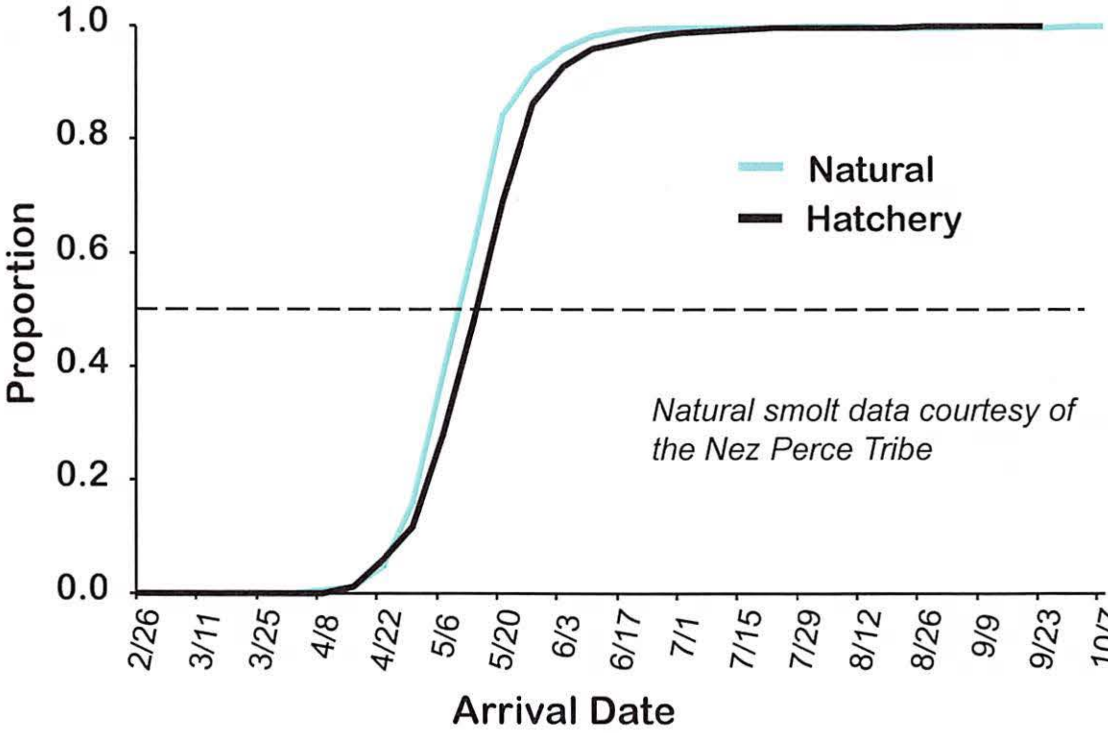

Figure 5. Average proportion of PIT tagged Imnaha stock hatchery steelhead smolts and natural-origin Imnaha River steelhead smolts that arrived at Lower Granite Dam from late February through early October, migration years 1994 to 2011.

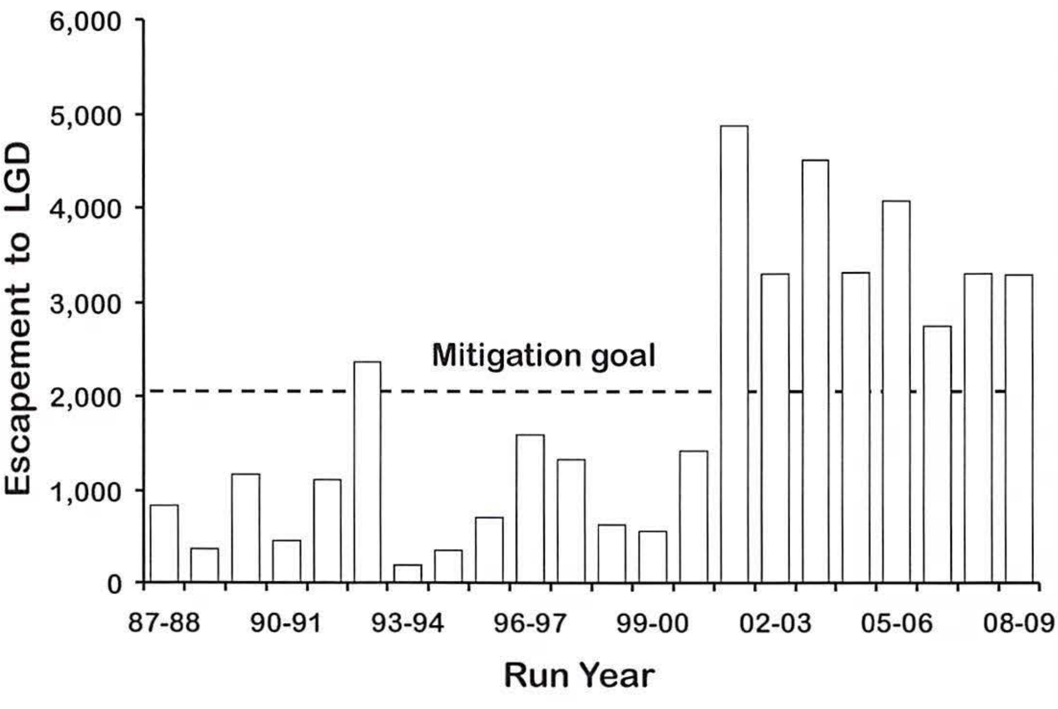

Figure 6. Imnaha stock hatchery steelhead adult escapement to the LSRCP Area above Lower Granite Dam, run years 1987-88 to 2008-09.

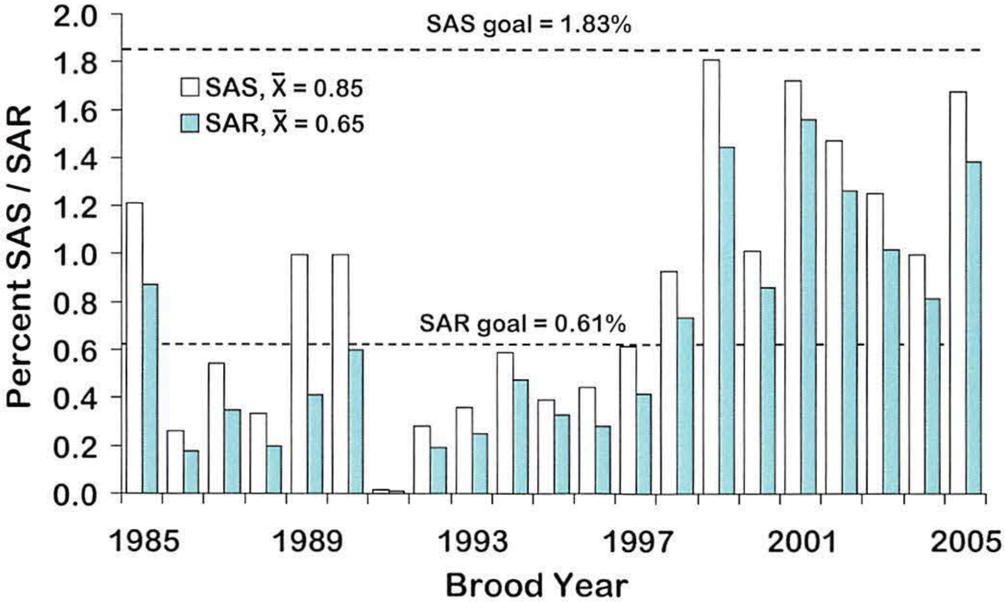

Figure 7. Percent smolt-to-adult survival (SAS) and smolt-to-adult return (SAR) to Lower Granite Dam of Imnaha stock hatchery steelhead, brood years 1985-2005.

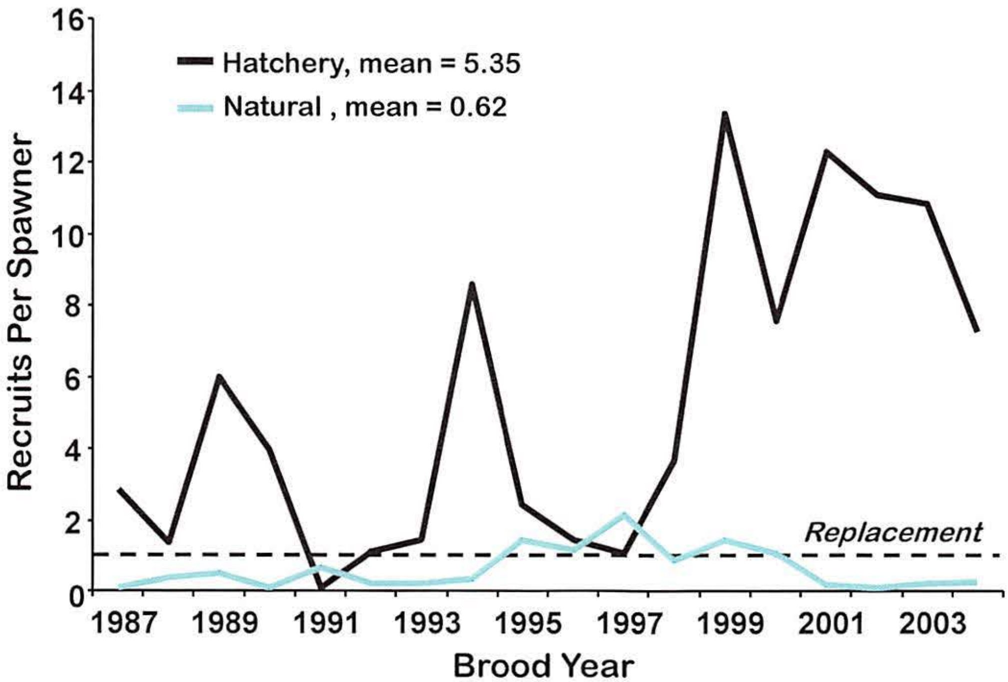

Figure 8. Adult recruits per spawner for natural- and hatchery-origin Imnaha stock steelhead that returned to and were counted at the Little Sheep Creek weir, brood years 1987-2004.

Imnaha River hatchery steelhead have a diverse catch and escapement profile with contributions to fisheries throughout their entire adult freshwater migration path. Few fish are harvested in the ocean and the freshwater harvest is distributed into small proportions across many fisheries (Table 5). Relative to other Snake River hatchery steelhead stocks, the Imnaha hatchery stock has a low overall exploitation rate. This low rate is a primarily due to the low exploitation rate in the Imnaha River recreational fishery. In recent years, a majority (66%) of the escapement to the Imnaha River is collected at the Little Sheep Creek Facility and outplanted into Big Sheep Creek (Figure 9). In addition, harvest and passage above the Little Sheep weir comprise significant proportions of the hatchery fish disposition. A majority of the natural-origin adults that returned to Little Sheep Creek have been passed above the weir to spawn naturally (Figure 10).

Table 5. Catch and escapement distribution (%) of Imnaha stock hatchery steelhead.

Recovery Location	Percent of Total				
	Brood Year				
	2001	2002	2003	2004	Mean
Ocean	0.0	0.0	0.1	0.0	0.0
Columbia River					
Sport	3.5	6.4	11.9	6.1	7.0
Tribal	2.3	2.0	1.3	1.4	1.8
Stray Harvest	1.4	1.4	1.7	3.8	2.1
Stray Rack	.2	0.7	1.7	1.8	1.1
Snake River Basin					
Stray below LGD	0.0	0.0	0.1	0.0	0.0
Stray above LGD Harvest	1.6	0.0	0.0	2.6	1.1
Stray above LGD Rack	0.1	0.0	0.0	0.7	0.2
Sport below LGD	2.0	3.5	2.2	5.1	3.2
Sport above LGD	13.1	13.2	9.8	14.1	12.6
Imnaha Sport	5.2	8.5	7.1	7.9	7.2
Escapement to Weir	70.6	64.3	64.2	56.3	63.9

Stray rates have been highly variable ranging from 3% to 19% (Figure 11). Most of the Imnaha River hatchery strays have been recovered in the Deschutes River recreational fishery or at Warm Springs River and Pelton Dam traps (Figure 12). The number of hatchery and natural adults released above the weir to spawn naturally has been highly variable due to the run size variation and divergent strategies for managing escapement through time. In recent years escapement has been reduced and the fraction of natural-origin spawners has been far greater than earlier years, consistently exceeding 50% (Figure 13).

Adult outplanting from Little Sheep Creek into Big Sheep Creek has been ongoing since the 1999 run year. Number of adults outplanted has been highly variable but has been above 1,000 in most years (Figure 14). A substantial percentage of the adults outplanted to Big Sheep Creek fall back out of Big Sheep Creek and rerun back to Little Sheep Creek.

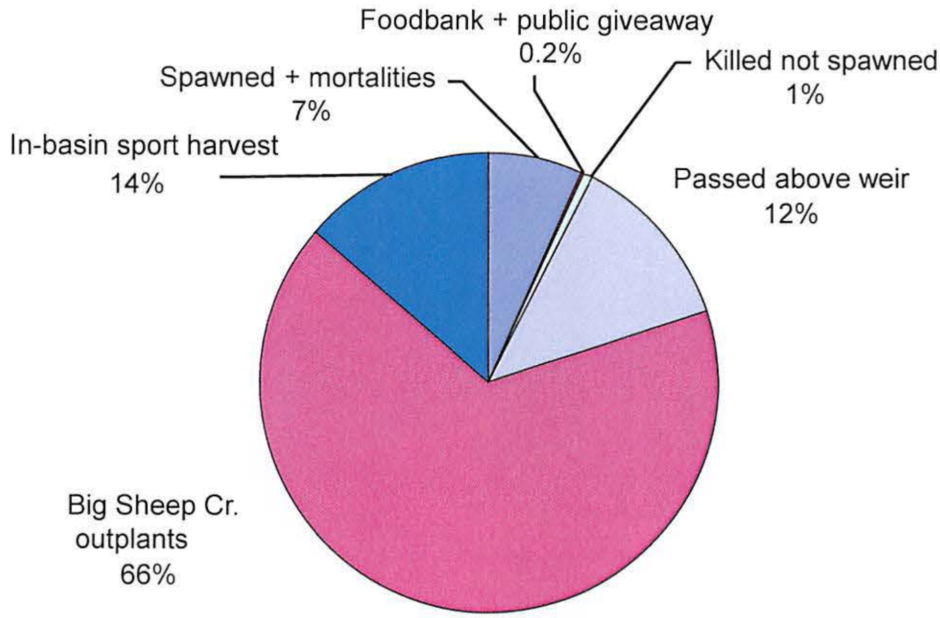

Figure 9. Escapement distribution of Imnaha stock hatchery steelhead within the Imnaha River basin, run years 2003-04 to 2007-08.

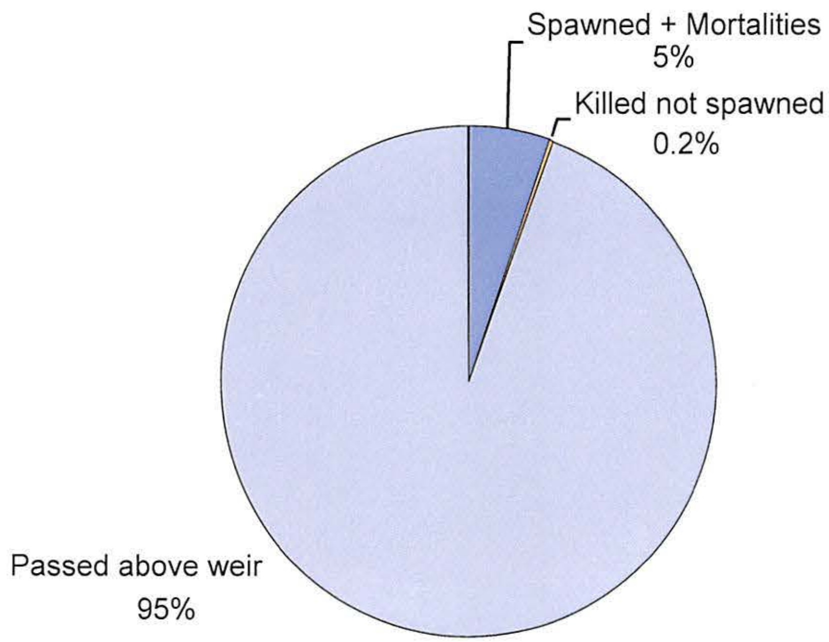

Figure 10. Escapement distribution of natural-origin Imnaha stock steelhead that returned to the Little Sheep Creek weir, return years 2004 to 2008.

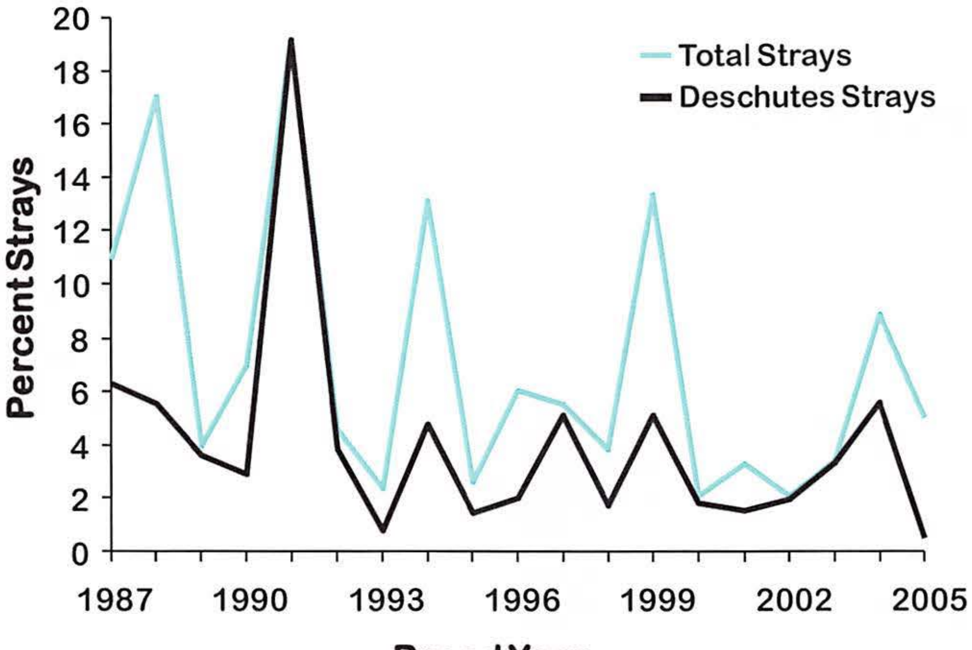

Figure 11. Percentage of Imnaha stock hatchery steelhead adults that stray, and the percentage that stray into the Deschutes River, a tributary to the Columbia River, brood years 1987-2005.

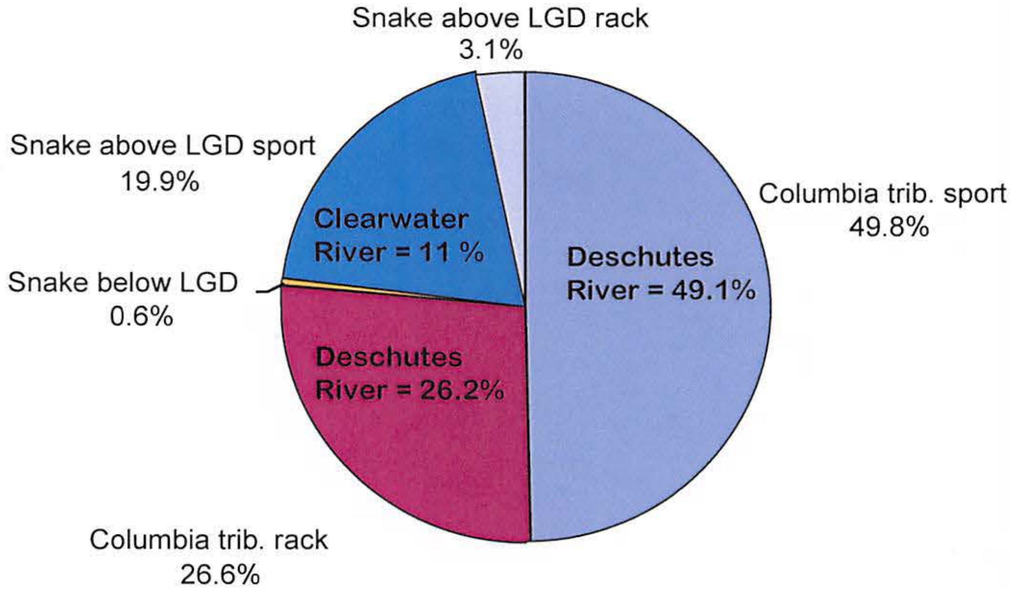

Figure 12. Distribution of adult Imnaha stock steelhead strays in the Columbia River basin, brood years 2001 to 2004.

We have not observed meaningful differences in adult run timing between hatchery- and natural-origin adults, with both exhibiting a broad normal distribution over an 11-week time period in the spring (Figure 15). There is no significant difference ($\alpha = 0.05$) in ocean age at return between hatchery- and natural-origin adults for combined sexes (Figure 16). However, we did observe a significant difference in ocean age at return for males, with hatchery-origin males returning at a younger age (Figure 17). Mean length at age is similar for natural and hatchery adults (Figure 18). Fecundity of 2-ocean females is significantly greater than 1-ocean females for both hatchery- and natural- origin fish. We found no significant difference in ocean age-specific fecundity between hatchery and natural females (Figure 19).

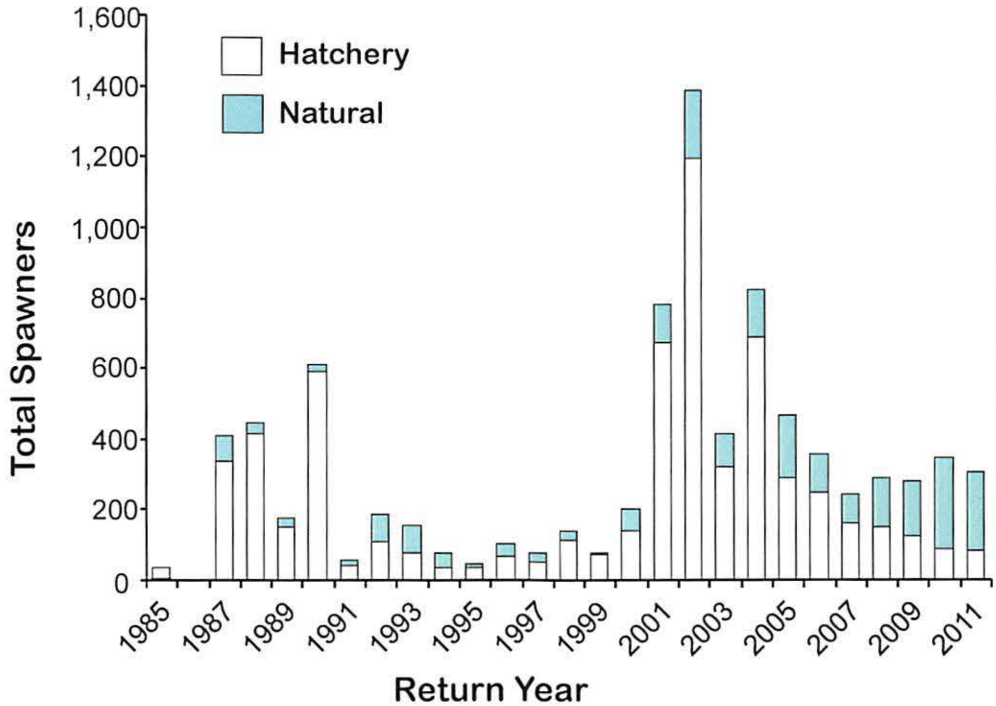

Figure 13. Annual number of hatchery- and natural-origin Imnaha stock steelhead passed above the Little Sheep Creek weir, return years 1985 to 2011.

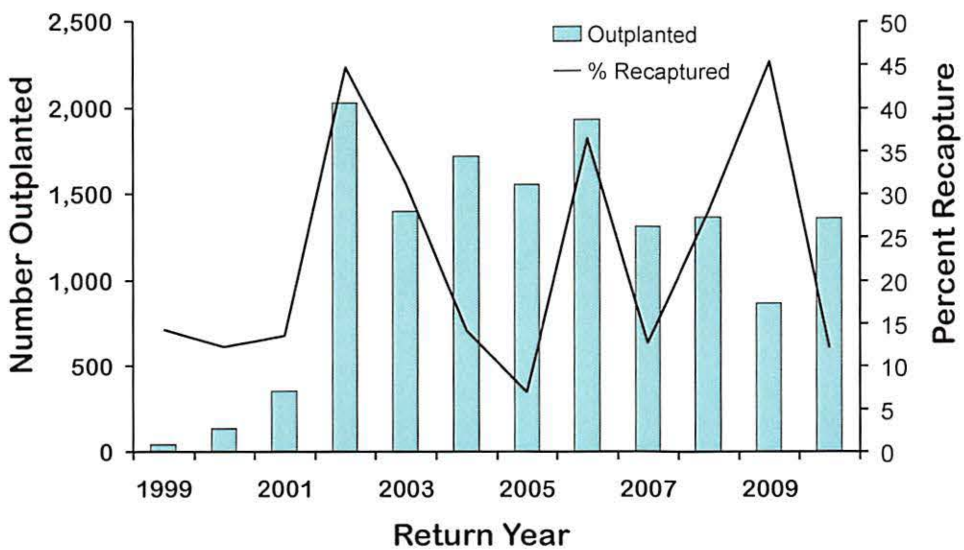

Figure 14. Number of adult Imnaha stock hatchery steelhead that were captured at the Little Sheep Creek weir and then outplanted into Big Sheep Creek, and the percentage that subsequently returned to the trap at Little Sheep Creek, return years 1999 to 2010.

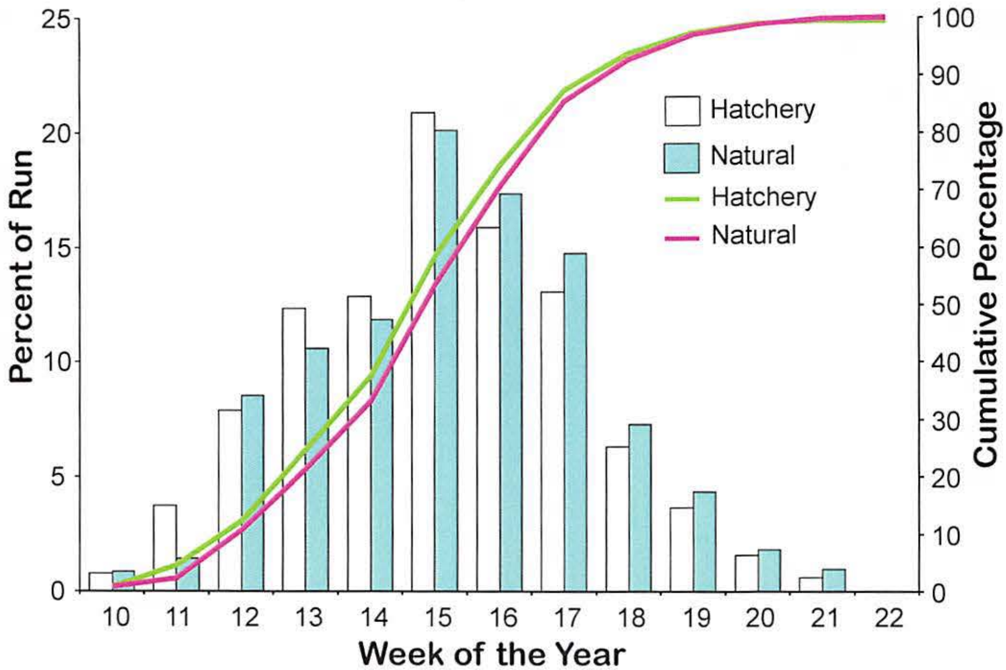

Figure 15. Average hatchery- and natural-origin return timing of Imnaha stock steelhead adults to the Little Sheep Creek weir and cumulative percentage that returned by week of the year. Data are from return years 2006 to 2010.

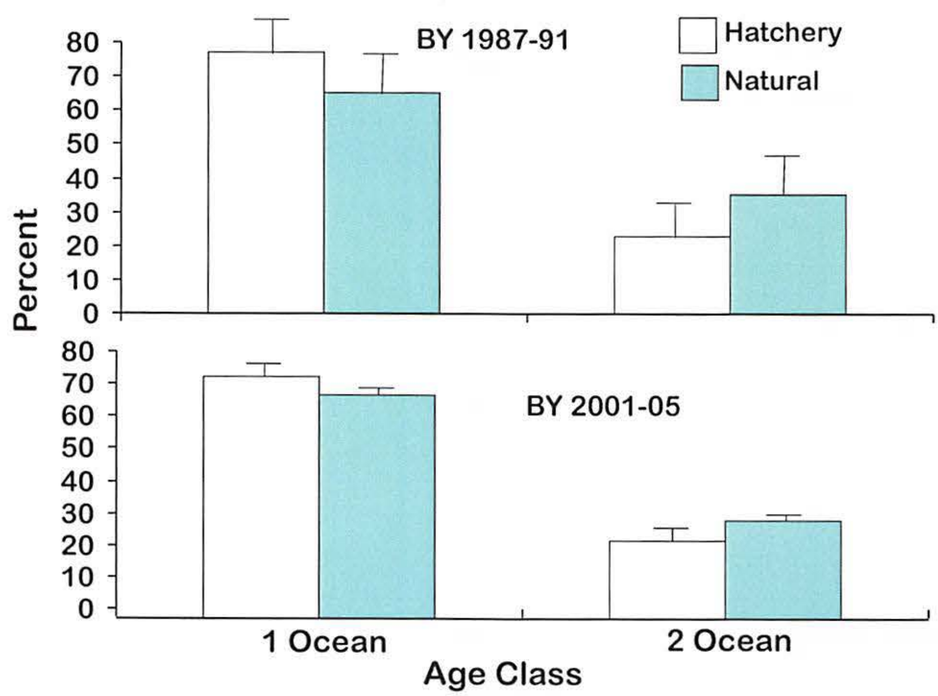

Figure 16. Percentage of 1-ocean and 2-ocean adult Imnaha stock hatchery- and natural-origin steelhead that returned to the Little Sheep Creek weir. Data are averages for early years (brood years 1987-91) and current (brood years 2001-05) time periods.

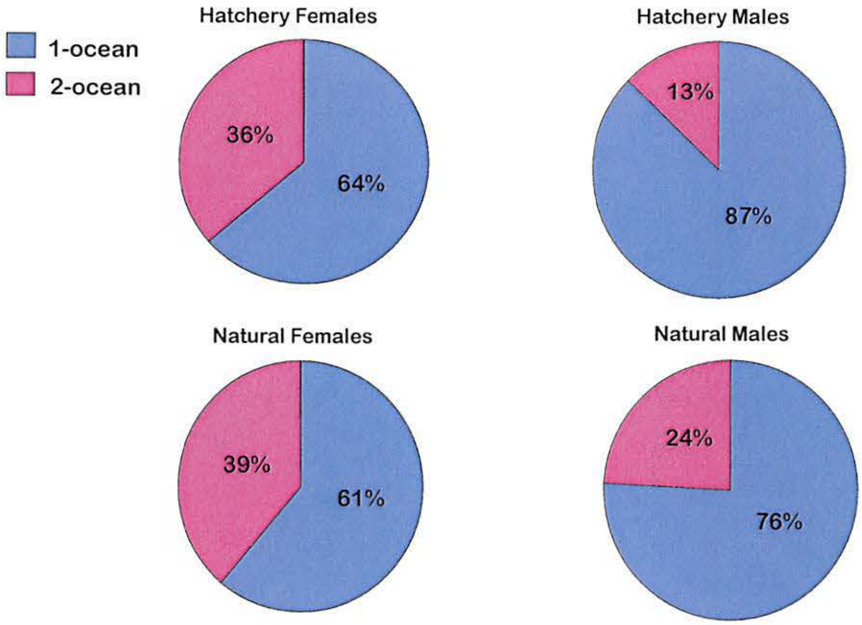

Figure 17. Average ocean age of hatchery- and natural-origin Imnaha stock steelhead females and males, brood years 1986 to 2004.

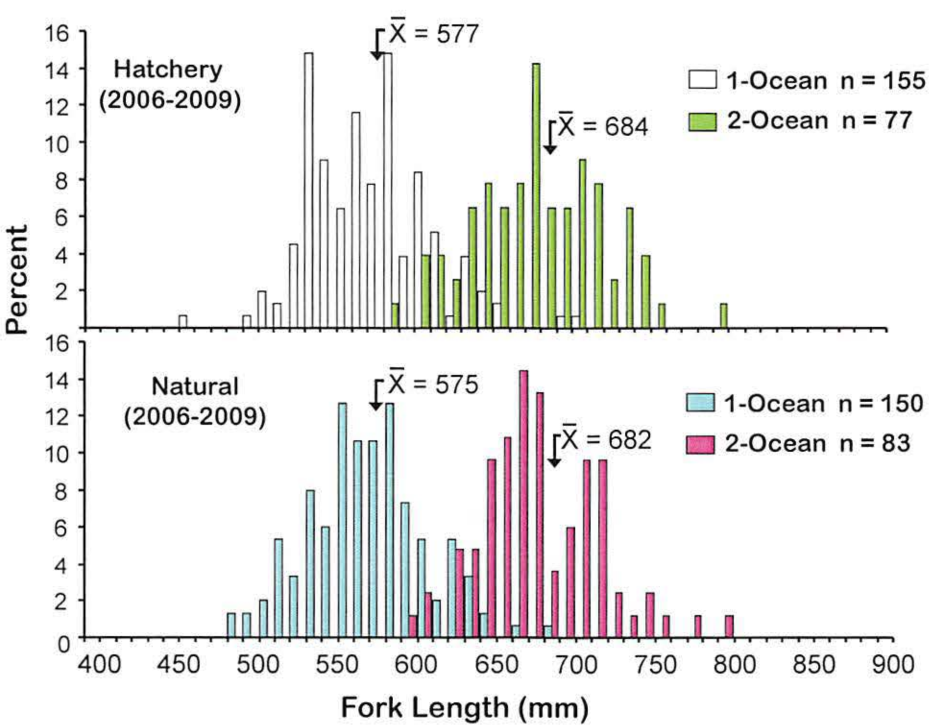

Figure 18. Length-frequency histograms showing average fork lengths of 1- and 2-ocean adult Imnaha stock hatchery- and natural-origin steelhead that returned to Little Sheep Creek in return years 2006 to 2009.

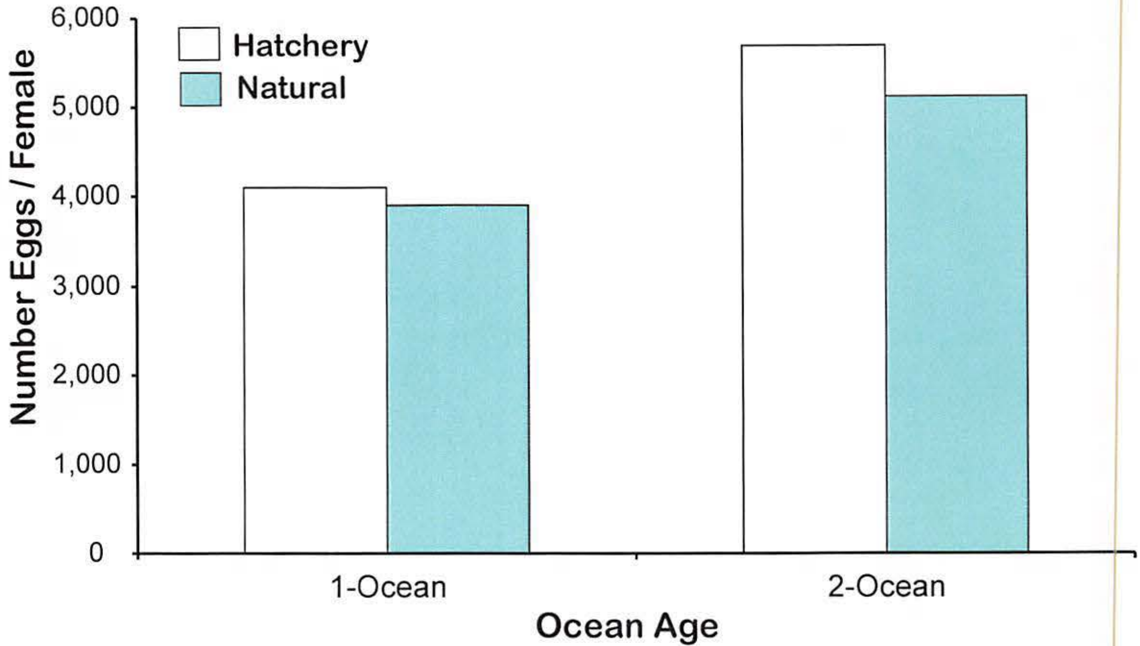

Figure 19. Mean age-specific fecundity of hatchery- and natural-origin Imnaha steelhead females.

The Imnaha River steelhead hatchery supplementation program was initiated in Little Sheep Creek prior to development of any experimental design to evaluate response. There were no pre-treatment data collected nor were there any reference/control streams established and monitored. Without pre-treatment data or reference streams we are forced to use alternative post-hoc approaches to assess natural abundance and productivity supplementation response in Little Sheep Creek. We compared natural-origin abundance of the Snake River population aggregate assessed at Lower Granite Dam with natural-origin abundance in Little Sheep Creek. If productivity of the natural-hatchery spawning aggregate in Little Sheep Creek is declining over time we would expect an asymptotic relationship or a distribution of residuals around the regression line to be skewed negatively for recent years. We found a highly significant linear relationship between run year specific natural-origin abundance at Lower Granite Dam and natural-origin abundance in Little Sheep Creek (Figure 20). There was no trend in residuals through time. Although this analysis does not adequately address the critical questions of whether supplementation has enhanced natural production or altered productivity, it does demonstrate that recent year natural-origin adult abundance in Little Sheep Creek during supplementation has maintained a consistent relationship to the Snake River aggregate returns.

We conducted adult-to-adult stock recruitment analyses for Little Sheep Creek to investigate the extent of density dependence and to assess our escapement goal relative to the maximum recruitment estimate. We found a significant relationship between adult spawners and recruits and a strong signal of density dependence (Figure 21). The maximum recruitment estimate of 410 adult spawners is greater than our escapement target of 250 adults (Figure 21). However, there are a number of years prior to implementation of the new sliding scale when escapement was at or above the maximum recruitment level.

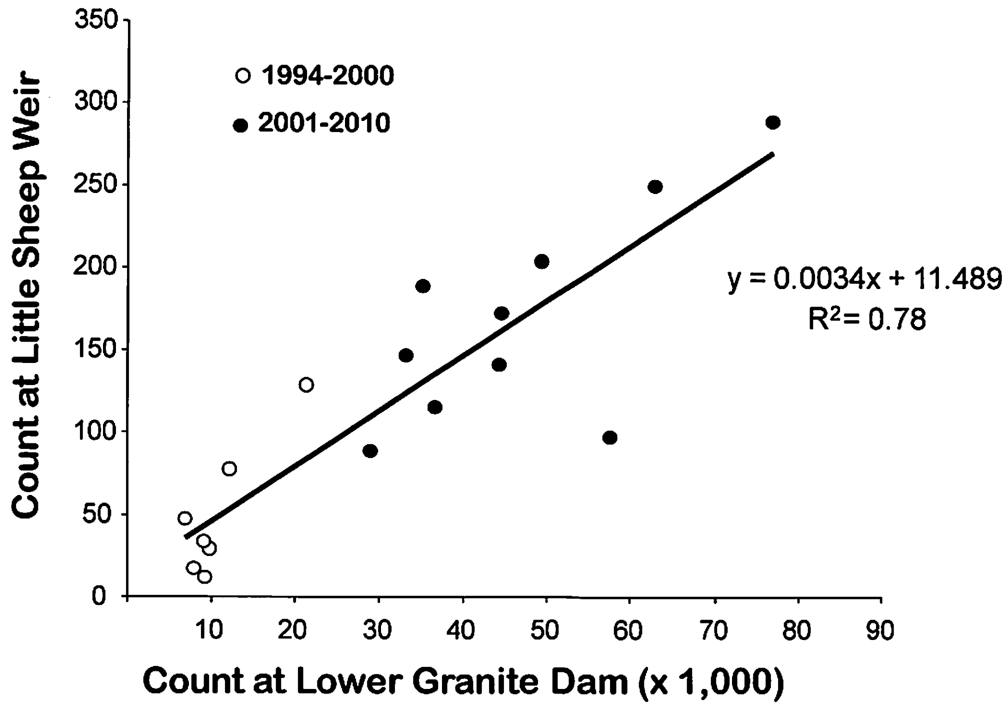

Figure 20. Number of natural-origin Imnaha stock steelhead adults returning to the Little Sheep Creek weir plotted against the number of natural-origin steelhead counted at Lower Granite Dam. Open circles are data from run years 1994 to 2000 and closed circles are from 2001 to 2010.

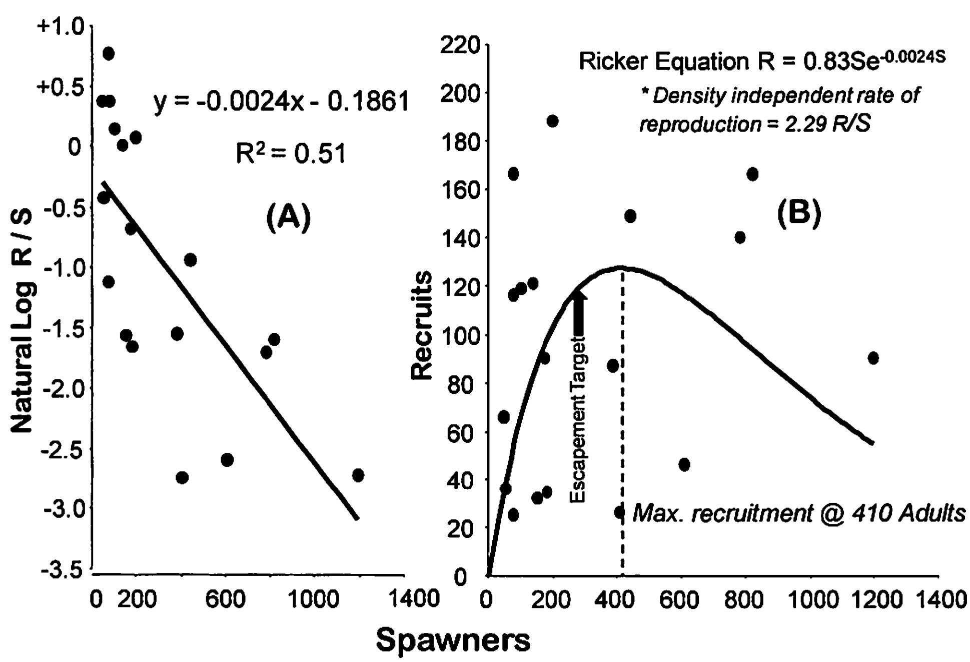

Figure 21. Adult-to adult stock recruitment for Imnaha stock steelhead spawning above the weir in Little Sheep Creek. (A) is a least square regression fit of the natural log of recruits/spawner plotted against the number of spawners; (B) is a Ricker recruitment curve fit to the number of recruits plotted against the number of spawners. The management target is for 250 adults to be passed above the weir.

One of the important management objectives for this program is to restore recreational fisheries to historical levels. As stated previously, the recreational fishery was closed from 1975 through 1985. Sport fisheries have occurred every year since the fishery was reopened in 1986 and the number of miles of river open to fishing has increased slightly compared to historic fishing areas. Total combined catch of hatchery and natural fish increased annually from the late 1990s through 2006 (Figure 22). The highest total catch occurred in the 2007-2008 run year when we estimated a catch of nearly 2,500 steelhead. Natural fish consistently comprise greater than 50% of the fish caught. Total harvest has been variable; however, we have observed an increasing trend in harvest since the late 1990s (Figure 23).

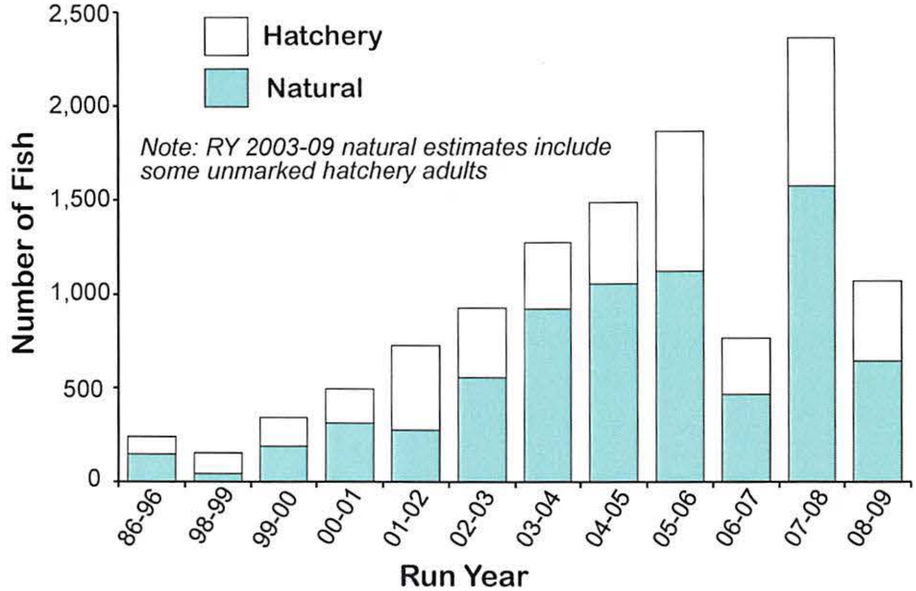

Figure 22. Estimated number of hatchery- and natural-origin steelhead caught in the Imnaha River fishery based on a statistical creel survey. Data from 1986-96 are an average annual catch estimate.

The steelhead recreational fishery was closed from 1975 to 1985 due to the depressed status of the natural population. The season was reopened in 1986 in the main stem Imnaha River in the same areas that had historically been open to fishing. The season has been open from early fall through mid-April and the fishery has been managed as a marked fish select harvest fishery with mandatory release of all natural-origin fish.

Annual harvest has been well below the historical average of 627 adults. Catch rates have been good since 2000 and have been far better than our goal of 10 hours/fish (Figure 24). Angler effort in the Imnaha fishery as indicated by angler days has been consistently below the historical average and has remained relatively stable at about 1,000 angler days. The majority of anglers participating in the Imnaha steelhead fishery are local anglers from Wallowa and Union counties (Figure 25).

We estimated annual economic value for summer steelhead recreational fisheries in the Grande Ronde, Wallowa, and Imnaha river basins based on total estimated angler days (total hours fished/hours per completed angler), origin of anglers (local = Union and Wallowa counties; non-local = all other Oregon counties; Washington, and other states), and average expenditures of local and non-local angler days. Estimated angler days and origin of anglers

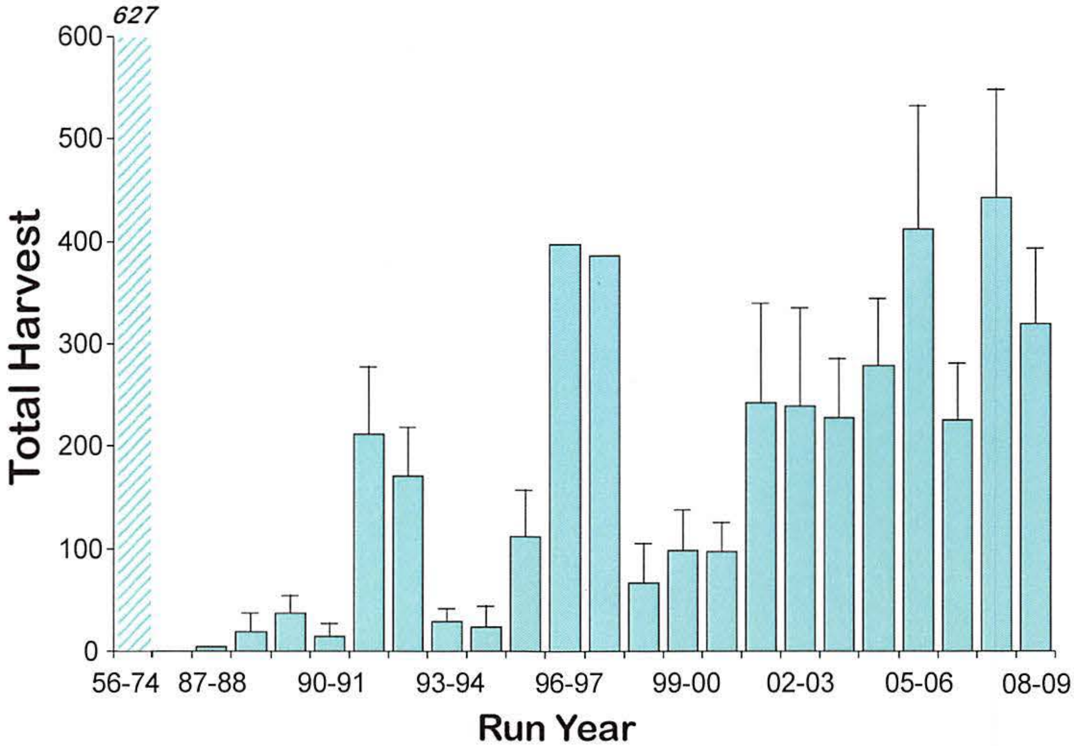

Figure 23. Estimated total annual harvest of hatchery-origin steelhead in the Imnaha River based on a statistical creel survey, run years 1987-88 to 2008-09. Data from 1956-74 are an average annual harvest estimate.

were summarized from angler surveys conducted on the lower Grande Ronde, Wallowa, and Imnaha rivers each year from 1999 through 2009.

Average angler day expenditures for local and non-local anglers was obtained from data reported in *Fishing, Hunting, Wildlife Viewing, and Shellfishing in Oregon, 2008 State and County Expenditure Estimates*. These estimates included expenditures per day for the eastern Oregon travel region that included both "travel expenditures" and "fishing-related equipment expenditures" for freshwater local anglers ($74.31 per angler day) and for non-local anglers ($90.09 per angler day). Travel-related expenditures include accommodations, food services, food stores, ground transportation, outfitter/guide service, and equipment (tackle, clothing, boats, etc.).

Estimated annual expenditures by anglers participating in the Imnaha steelhead fishery is relatively low at less than $100,000 (Figure 26). Low angler effort is the primary reason that overall expenditures are low.

The principle fish health issue influencing the Imnaha steelhead program is cold-water disease (Table 6). Cold-water disease was responsible for substantial mortality in only a few years during the program's operational history.

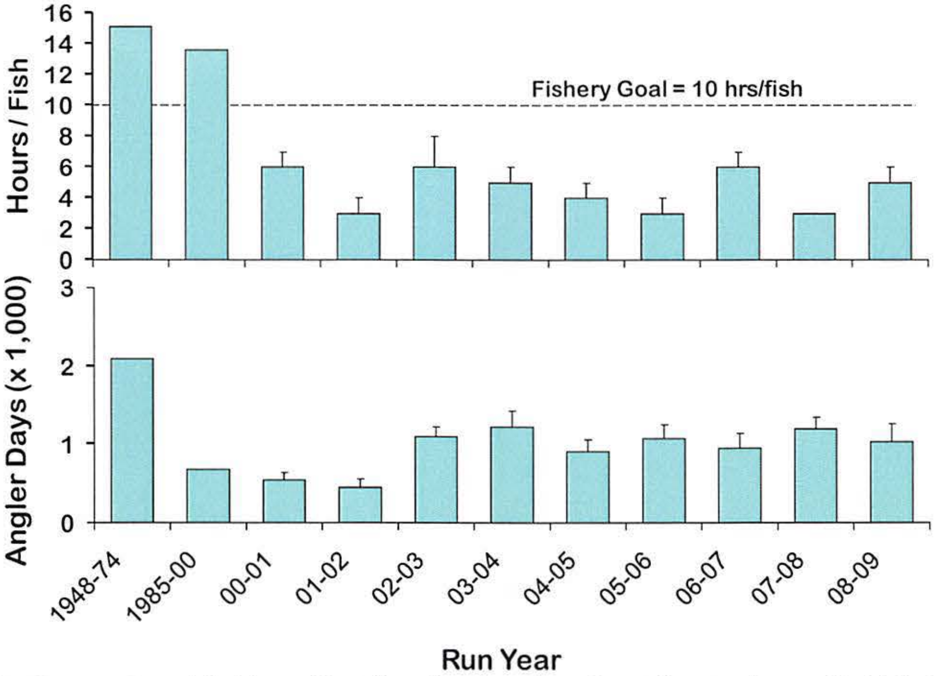

Figure 24. Recreational fishing effort (angler days) and catch rate (hours/fish) in the Imnaha River steelhead fishery based on a statistical creel survey, run years 2000-01 to 2008-09. Data from 1948-74 and 1985-2000 are average annual estimates.

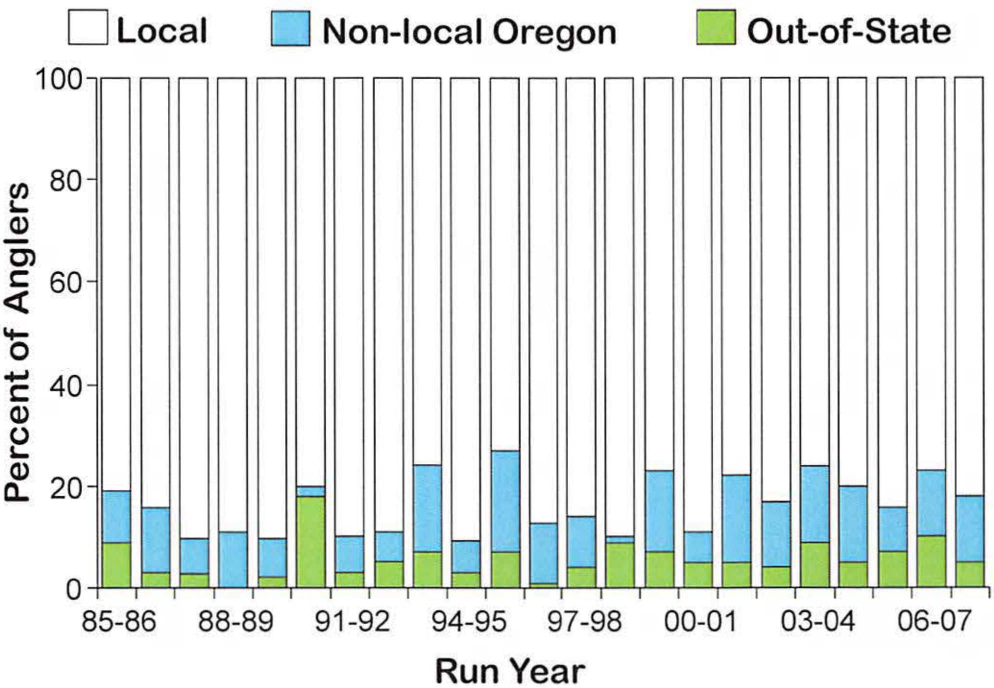

Figure 25. Origin of anglers fishing the Imnaha River, run years 1985-1986 to 2006-2007.

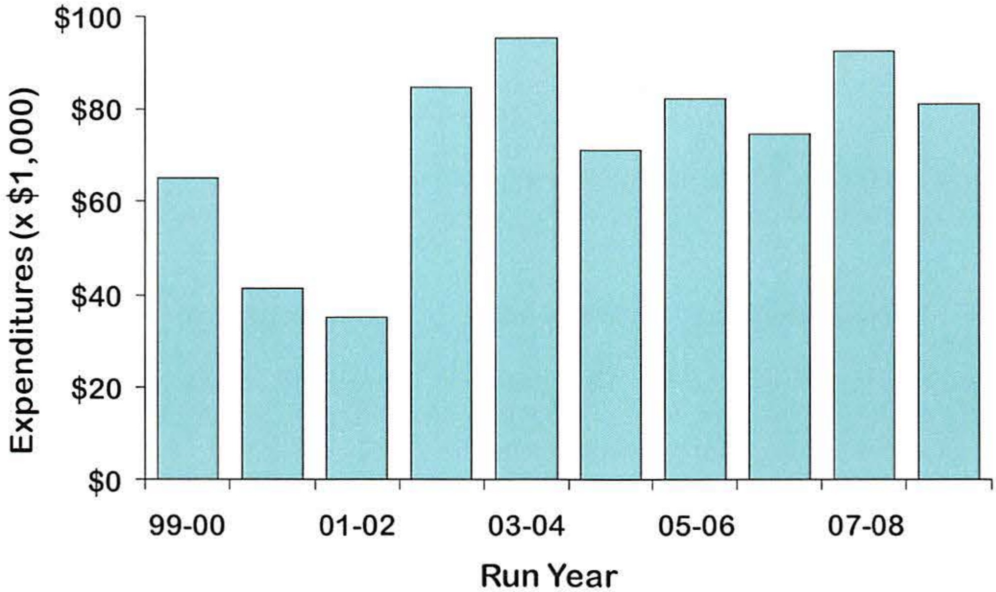

Figure 26. Estimated annual expenditures by anglers fishing the Imnaha River in run years 1999-00 to 2008-09.

Table 6. Fish health issues in the Imnaha stock steelhead hatchery program.

Disease Issues	Consequences	Fish Health Response
Bacterial cold-water disease (CWD) caused by *Flavobacterium psychrophilum*	• CWD loss in most brood years primarily after ponding fry into indoor circular tanks at Irrigon Hatchery in late June/early July • After hauling to acclimation some smolts develop open sores with CWD bacteria being a contributing factor	• Antibiotic treatment with florfenicol for 10 d • 2005-2009 used florfenicol at 15 mg/kg • Recent years have had to treat at 10 mg/kg. Some repeat treatments necessary. • New approaches to be taken in 2012 for prevention of early lifestage CWD loss: 1)Vexar substrate for heath trays for both stocks 2)BioPro starter feed trial for both stocks

SUMMARY AND CONCLUSIONS

Broodstock Development and Management

Broodstock development to levels providing adequate returns to meet smolt production goals occurred rapidly (by year six). Natural-origin fish dominated the broodstock composition from 1982-1986; however, natural-origin fish comprised a very small fraction of broodstock from

1987-2007. The PNI was very low until recent years when the new escapement and broodstock collection sliding scale management plan was implemented.

In-Hatchery Performance

Adult prespawn mortality poses no significant problem in the program. Egg-to-smolt survival has been highly variable and poor in some years, primarily due to cold-water disease related mortality.

Production, Survival, and Adult Return Performance

We have reached our production goals in most years since 1988 and for those years in which we did not meet our goals we were only slightly below target. Smolt survival rates to Lower Granite Dam are moderate compared to other Snake River hatchery steelhead and are lower than rates for Wallowa stock. We have consistently reached our adult return goals with achievement in eight of the last ten years. SAR goals have been achieved in eight of the last ten years. The SAS goal has not been achieved for any broodyear to date. The R/S values for hatchery fish have been consistently high and have averaged nine times the R/S of natural spawners in Little Sheep Creek.

Imnaha hatchery steelhead are exploited at very low rates (36%) relative to other Snake River hatchery steelhead stocks. Thus, the resulting escapement rates to the release locations are high. Large numbers of surplus hatchery fish return to Little Sheep Creek annually and most of this surplus is outplanted to Big Sheep Creek. A significant proportion of the Big Sheep outplants rerun back to Little Sheep Creek. There is inadequate monitoring underway to assess the benefits or impacts of outplanting into Big Sheep Creek.

Stray rates have generally been low for Imnaha hatchery fish and the majority of strays are recovered in the Deschutes River basin. Few strays have been recovered in the Snake River basin tributaries. Although recreational fisheries have been reopened and sustained on an annual basis, harvest and effort have not been restored to historical levels.

Natural Production Monitoring

The natural population viability status is unknown due to a lack of abundance data at the population scale. Abundance and productivity monitoring has been expanded considerably with PIT tag arrays and weir counts operated by the Nez Perce Tribe. These efforts will significantly improve estimates of abundance/productivity, spatial structure, and hatchery fraction.

Supplementation: Life History and Spawning Characteristics

Hatchery fish return at a similar ocean age as do natural-origin fish for combined sexes. However, a higher proportion of hatchery males return as 1-ocean adults. Run timing and spawn timing are similar between hatchery and natural fish. We have not observed any difference in size-at-age.

Supplementation: Abundance and Productivity

We have achieved a significant life cycle survival advantage for hatchery steelhead with a R/S advantage of 9:1. We have substantially increased total spawners in Little Sheep Creek with passage of large numbers of hatchery fish above the weir. We have observed a trend of increasing number of natural-origin fish in many years; however, the trend parallels the Snake River aggregate natural-origin abundance and therefore cannot be attributed to supplementation.

Recruits per spawner for naturally spawning natural- and hatchery-origin fish has averaged much less than 1.0 and has been above replacement for only five of the last 18 brood years. The relative reproductive success of hatchery fish is less than one-half that of natural-origin fish. This poor natural production performance is a strong contributor to the low R/S for the spawning aggregate.

Stock recruitment analyses indicate that adult escapement levels were well into the range of strong density dependence for many recent years. It appears that the escapement target of 250 adults annually is a sound management target near the inflection of the stock-recruitment curve.

Imnaha Steelhead Hatchery Program Adaptive Management Changes

We have made many adaptive changes to this program throughout the years of operation. Adaptive management changes included the following: 1) reduced smolt production numbers to reduce the magnitude of surplus returns to Little Sheep Creek; 2) modified sliding scale to increase proportion of natural-origin broodstock, reduce hatchery proportion above the weir, improve PNI, and provide a more reasonable escapement level given capacity considerations; 3) implemented volitional release strategies with removal of non-migrants to reduce juvenile ecological interaction risks; 4) implemented 4.5/lb release size goal over 5/lb to maximize SAS; and 5) developed food bank outlets for surplus hatchery returns.

Imnaha Steelhead Program Hatchery Scientific Review Group (HSRG) and Hatchery Review Team (HRT) Recommendations and Responses

HSRG – Develop conservation objectives for the Big Sheep Creek component, develop abundance and productivity estimates, develop a properly integrated program with appropriate PNI, pNOB and pHOS to achieve conservation standards. Requires ability to collect natural origin adults and manage spawning composition.

Response: Outplanting of large numbers of adults continues and discussions are underway on conservation objectives and monitoring plan. Adult PIT tag arrays will provide estimates of natural escapement.

HSRG – Convert the existing integrated program into a “stepping stone” program for Little Sheep Creek. Include a small integrated program to achieve conservation benefit and a segregated program to achieve harvest.

Response: Managers have not yet adopted this strategy; rather, they reduced smolt production and revised the sliding scale management plan to address the concerns with low PNI.

HRT – Discontinue the release of smolts and adults into Big Sheep Creek unless this activity can be justified based on specific goals. Goals must be developed and weighed against the risks that outplants pose to the natural population, which are currently high. Develop a monitoring and evaluation program that will determine if the desired benefits are being obtained.

Response: The Big Sheep outplanting program is under co-manager discussion. No actions have been taken to address the HRT recommendations.

<u>HRT</u> - Revisit and adjust the sliding scale so that it is consistent with research and conservation goals of the program.

<u>Response</u>: The sliding scale has been revised to reduce hatchery proportions spawning naturally to 50% and to increase the natural-origin proportions in the broodstock.

<u>HRT</u> – Continue to monitor residualism.

<u>Response</u>: Monitoring of residual abundance and characteristics continues annually in Little Sheep Creek.

FUTURE PROGRAM CHALLENGES AND NEEDS

There are a number of program challenges that face this hatchery program in the future. It is desirable to improve the PNI for this program to a level that is appropriate for a supplementation program. This will be difficult given the numbers of natural-origin fish that return annually and the substantial number of broodstock needed to meet annual smolt production goals.

The disposition of large numbers of surplus hatchery adults remains a challenge. Continued outplanting of large numbers of hatchery adults into Big Sheep Creek places the Big Sheep Creek spawning aggregate at risk. Recent data indicate that there are substantial numbers of natural-origin spawners that return to Big Sheep Creek and supplementation may not be warranted.

We have documented significant residualism of hatchery releases in Little Sheep Creek. Continued focus on developing rearing and releasing strategies that maximize SAS and minimize residualism would be prudent.

Improving the relative reproductive success of hatchery fish is essential to achieving supplementation success; however, alternatives other than improving PNI have not been identified.

Increasing angler participation to increase in-basin exploitation and reduce surplus hatchery fish is desired; however, beyond increasing public outreach few other alternatives are available.

Imnaha River Juvenile Steelhead Evaluations

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Department of Fisheries Resources Management

Prepared for:

U.S. Fish and Wildlife Service
Lower Snake River Compensation Plan
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Cooperative Agreement Number 141101J005

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INTRODUCTION

The long-term success of the Lower Snake River Compensation Plan (LSRCP) Imnaha River endemic steelhead hatchery mitigation program relies on accurate monitoring and evaluation to inform management decisions. Understanding the performance of hatchery and natural steelhead allows the hatchery program to maximize its' success while minimizing risk to natural populations.

This project monitors the life stage performance of hatchery- and natural-origin steelhead (*Oncorhynchus mykiss*; Héeyey in Nez Perce language) emigrating from the Imnaha River. Monitoring the Lower Snake River Compensation Plan (LSRCP) steelhead program originating from the Little Sheep Creek Acclimation Facility provides information that can be used to evaluate the early life history and determine how closely the hatchery-origin fish mimic the life history characteristics of naturally produced fish in the Imnaha River. Performance measures evaluated for juvenile performance included emigrant abundance, emigration timing, size and condition factor, juvenile arrival timing at Lower Granite Dam (LGR) and juvenile survival at LGR. We also evaluated and compared hatchery- and natural-origin adult performance measures including adult arrival timing at Bonneville Dam (BON) and LGR, adult conversion rate from BON to LGR and smolt to adult return rate (SAR).

This project was funded by the LSRCP as a cost-share with the Bonneville Power Administration Imnaha River Smolt Monitoring Project (199701501) as part of the Fish Passage Center's in-season smolt performance evaluations.

METHODS

Fish Trapping

Emigrating juvenile steelhead were captured using a rotary screw trap (E.G. Solutions Inc., Corvallis, OR) consisting of a 2.1m diameter cone, 6.7 m long floating pontoons, a live box and debris drum. The trap was operated in the Imnaha River at river kilometer 7 (rkm), which was as close to the confluence with the Snake River as possible and while still being accessible by road (Figure 1). Both juvenile steelhead and Chinook salmon were captured and tagged. For the purpose of this report we will only focus on Imnaha River natural-origin (IRN) and hatchery-origin (IRH) juvenile steelhead monitoring. The placement of the screw trap was below 95% of the available steelhead spawning habitat in the Imnaha River, the exception being Cow Creek.

During the years 1994 through 1999 the trap operated during the peak spring outmigration period from late February through mid June. Starting in 2000 operations were expanded to include a fall trapping period, mainly targeting emigrating Chinook salmon presmolts (early October through early December). Implementation of year round trapping has occurred since 2010, except for short periods of heavy ice flows, during the winter and short periods in the summer for trap maintenance. Trapping operations during all years were affected by generally short periods of high water during spring runoff (late April through mid May).

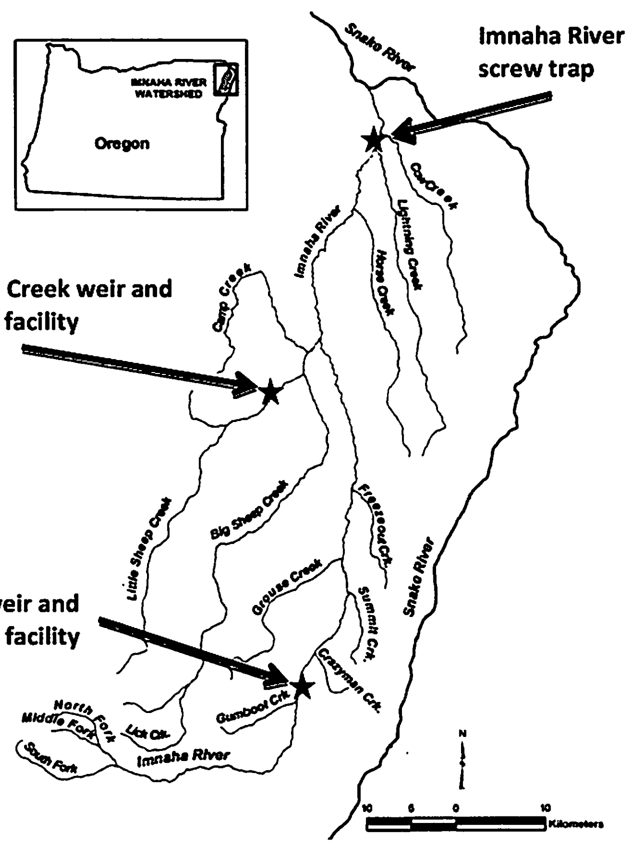


Figure 1. Map of the Imnaha River study area showing the location of the rotary screw trap, the Gumboot Chinook salmon acclimation facility and the Little Sheep Creek steelhead acclimation facility.

Fish Handling

The trap was checked early in the morning and several times throughout each night and day if warranted by large numbers of fish, high flows or excessive debris in the river. Captured juvenile steelhead were anaesthetized in a MS-222 bath (6 ml MS-222 stock solution (100 g/L) per 19 L of water) buffered with Propolyaqua. All fish were examined for existing marks (e.g. fin clips), PIT tags using a Destron Fearing FS2001F PIT tag reader, presence of all other tags, and percent descaling and general health. Non-target piscivorous fish and other non-target fish were removed from the live box first, scanned for PIT tags and then released 30-50 m downstream.

IRN and/or IRH steelhead juveniles were measured for fork length to the nearest millimeter and weighed to the nearest 0.1gram and PIT tagged using hand injector units following the methods described by Prentice et al. (1986, 1990) and Matthews et al. (1990, 1992). Hypodermic injector units and PIT tags were sterilized prior to each use in ethanol. Only fish above 80 mm were tagged because it was likely that smaller fish were not actively emigrating from the system or may represent resident rainbow trout. Tagging was discontinued when water temperatures exceeded 15° C. Mortality due to tagging was recorded. Captured steelhead juveniles were held in perforated recovery containers in the river, checked for shed tags and mortality, and released after dark.

From 1994 through 2007 both natural- and hatchery-origin juvenile steelhead were PIT tagged after capture at the Imnaha River screw trap. Beginning in 2008 hatchery-origin juveniles were PIT tagged at the hatchery prior to release, and survival was evaluated from release to the screw trap using recapture/interrogation data collected at the screw trap. Arrival timing and survival to Lower Granite Dam (LGR) was determined using fish PIT tagged (pre 2008) or recaptured (2008 – present) at the screw trap.

During peak emigration periods the trap captured juvenile steelhead and Chinook salmon in numbers large enough to overload the trap box and jeopardize fish health. During these periods a subsampling procedure was used to obtain a representative sample of juveniles that was used to estimate the abundance and composition of fish passing the trap. The sub sampling procedure estimated the abundance of juveniles passing the trap by multiplying the total number of juveniles captured by an appropriate time ratio determined by the duration of sub sampling each hour. For example, if the trap was operated for 15 minutes each hour then the ratio would be 1:4 and the estimated total number of fish passing the trap would be calculated by dividing the total number of fish captured by the sample rate (in this example – ¼ = 0.25). The composition (species, origin, length, etc.) of the juveniles passing the trap was determined by expanding by the composition of the captured fish. During the subsampling procedure a partition was placed in the trap to by-pass fish around the trap box and through a PIT tag antennae to monitor for recaptures (tag efficiency or previously tagged fish).

Prior to starting the subsampling procedure the trap box was emptied, either by processing all of the fish in the trap box or by subsampling fish in the trap box. All fish were processed if the quantity of fish in the trap was determined small enough to process in a reasonable time during the beginning of the subsampling procedure. When the quantity of fish in trap box was judged to be large enough to make it impossible to process all of the fish in less than an hour then the trap box was sampled by processing one or two net-full scoops of fish and releasing the remaining net-full scoops. The released net-full scoops were released after they were passed through a separate PIT Tag antenna to interrogate any previously PIT tagged fish. The abundance and composition of the processed net-full scoops were expanded by the number of net-full scoops to determine the abundance and composition of all fish that were in the trap box.

Trap Efficiencies

Daily trap efficiency (TE) trials were conducted using PIT tagged IRN steelhead smolts across the entire trapping period (Steinhorse, et al, 2004). Fish marked for TE trials were held in perforated containers in the river during daylight hours (up to 12 h) and then transported upstream approximately 1 km and released after dark. The daily goal was to randomly PIT tag

50 IRN steelhead for TE trials however, fish numbers during off peak periods made it impossible to achieve that goal each day. TE rates were calculated by week when at least seven marked TE fish were recaptured and flows remained relatively stable. Weeks with less than seven recaptures or when flows dramatically increased during the week were grouped with either the preceding week or the following week depending on similarity of flow conditions. Trap efficiency was determined by E = R/M; where E is estimated trap efficiency, R is number of marked fish recaptured, and M is number of fish marked and released. The reported 95% confidence intervals are based on a bootstrap calculation within the Gauss program (Aptech Systems Inc., Maple Valley, Washington).

Data Management

Data collected at the screw trap were checked for errors then sent to the NPT Joseph, OR Field Office for final verification. Once verified, the compiled data was uploaded to the Fish Passage Center's database within one to five days as part of the in-season smolt survival monitoring program.

Monitoring and Evaluations Performance Measures

Performance measures calculated for juvenile steelhead (IRN and IRH independently) captured at the Imnaha River screw trap followed definitions developed by the Collaborative Systemwide Monitoring and Evaluations Project (CSMEP; web site) and adopted by the Ad Hoc Supplementation Work Group (Beasely et al. 2008).

Performance measures included:

1. **Index of juvenile emigrant abundance:** an index of the number of steelhead smolts emigrating from the Imnaha River determined through PIT tagging and trap efficiency trials. This is a minimum abundance estimate calculated from trapping operations not encompassing the entire trapping period.
2. **Juvenile emigrant timing:** the measure of the timing of smolt captures at the Imnaha River screw trap estimated using the following parameters; 1) median - date that 50th percent of the total juvenile steelhead were captured and; 2) range – determined by the first and last fish and the 10th and 90th percentiles of total juvenile steelhead captures.
3. **Size-at-emigration:** the length distribution of juvenile steelhead captured at the screw trap.
4. **Condition of juveniles at emigration:** a length to weight relationship (weight/length^3) of juvenile steelhead captured in the screw trap.
5. **Juvenile arrival timing to Lower Granite Dam:** arrival timing of juvenile steelhead smolts at Lower Granite Dam (LGR) determined by PIT tag interrogations in the juvenile by-pass system estimated using the following parameters; 1) median –date of the 50th percentile of the total juvenile steelhead were interrogated at LGR and; 2) range – determined by the first and last fish and the 10th and 90th percentiles of total juvenile steelhead interrogations.
6. **Juvenile survival:** survival from the screw trap to LGR and McNary Dam (MCN) determined by PIT tag interrogations.
7. **Adult arrival timing at Bonneville and Lower Granite Dams:** arrival timing of adult steelhead to Bonneville Dam (BON) and LGR determined by PIT tag interrogations in the adult fish ladders estimated using the following parameters; 1) median –date that the 50th percentile of the total adult steelhead were interrogated and; 2) range – determined by the first and last fish and the 10th and 90th percentiles of total adult steelhead interrogations.

8. **Adult conversion rate:** conversion rate from BON to MCN and BON to LGR determined by PIT tag interrogations in the adult fish ladders.
9. **Smolt-to-Adult return index:** number of PIT tagged adult steelhead interrogated at LGR divided by the number of PIT-tagged juveniles interrogated at LGR determined by migration year (brood year was not determined because smolts were not aged).

RESULTS

Screw trap operations

Over the entire study period (1994 – 2011) the median start and end dates for the spring trapping period were February 28 and June 20, respectively. Until 1999 the main objective of the project was to provide PIT tagged juvenile steelhead for the Smolt Monitoring Program (Fish Passage Center; http://www.fpc.org/about_fpc.html). Expanded trapping to include a fall period and two years of year-round trapping enabled us to define the IRN juvenile steelhead emigration period in the Imnaha River. Results indicated that approximately 95% of IRN juvenile steelhead emigrated during the spring trapping period (March 1 – June 15), with a small number of steelhead captured during the fall/winter period and approximately 5% captured during the summer. Consequently, we are confident that the trap operations prior to 2010 encompassed > 90% of juvenile steelhead emigration period in the Imnaha River.

Although the trap operated during the peak emigration period, the trap was removed during periods of excessively high water in most years. High water created unsafe conditions for the crew or choked the trap with debris, potentially compromising fish health. Operations were non-continuous in 17 of 18 years, with non-operational periods ranging from 0 to 73 days per year with a median of 22 days (Table 1). Since 2000 an effort was made to operate the trap as much as possible, and this reduced the median number of days that the trap was not operational to 13 days, with a range of 0 to 23 days. In spite of these efforts it was likely that significant numbers of fish were missed. Annual total numbers of juvenile steelhead captured are presented in Table 1.

Juvenile Performance Measures

Index of Juvenile emigrant abundance

Imnaha River natural-origin steelhead juvenile emigrant abundance was estimated from 2004 -2009. Trap efficiencies trials were not conducted prior to 2004. Results revealed that other than 2006, minimum estimates of IRN steelhead juvenile abundance ranged from 50,000 to 75,000 emigrants per year (Table 2). Estimates from 2006 were significantly greater than those of other years and the low number of recaptured TE fish and wide confidence intervals suggested that the total estimate was less accurate than the other years (Table 2). The similar emigrant abundance estimates from the other years suggest that the Imnaha River consistently produces a minimum of 50,000 IRN juvenile steelhead smolts per year. This should be considered a minimum abundance because we did not include an estimate of emigrants passing the site during periods of high water and/or debris. Although methods are available to extrapolate fish passage during times when the screw trap was not operational, we have not completed those analyses. We plan to go back and determine total juvenile abundance estimates using alternative methods that account for non-operational periods in a future report.

Table 1. Annual trapping operations at the Imnaha River screw trap including year, total days per season, days not fish, trapping start date, trapping end date and total natural-origin steelhead captured.

Year	Days Per Season	Days Not Fished	Trapping Start Date	Trapping End Date	Natural steelhead captured
1994	107	15	3/1/94	6/15/94	5332
1995	135	73	2/6/95	6/20/95	789
1996	123	44	2/23/96	6/24/96	3786
1997	110	40	3/9/97	6/27/97	877
1998	112	43	2/26/98	6/16/98	3569
1999	115	28	3/1/99	6/25/99	2748
2000	110	18	2/26/00	6/15/00	5041
2001	120	23	2/22/01	6/20/01	6462
2002	102	16	3/4/02	6/12/02	6956
2003	112	5	3/7/03	6/24/03	8771
2004	123	8	2/25/04	6/27/04	8204
2005	111	13	3/2/05	6/21/05	5374
2006	111	15	3/1/06	6/20/06	2334
2007	113	0	3/1/07	6/21/07	10323
2008	111	22	2/28/08	6/18/08	4247
2009	112	10	2/25/09	6/17/09	5703
2010	116	11	2/24/10	6/20/10	7247
2011	112	19	2/28/11	6/20/11	3883

Table 2. Annual Imnaha River natural-origin (IRN) juvenile steelhead abundance estimates determined by mark/recapture analysis at the Imnaha River juvenile screw trap including the upper and lower 95% confidence interval (C.I.), Standard Error (SE), number captured, number marked, number recaptured and the average annual trap efficiency.

Year	Abundance Estimate	Upper 95% C.I.	lower 95% C.I.	SE	Number Captured	Number Marked	Number Recaptured	Average Trap efficiency (%)
2004	76,678	98,640	61,537	9,508	8,204	1,820	156	9.0
2005	51,991	65,339	43,331	5,828	5,374	1,976	218	11.4
2006[1]	172,605	287,537	108,852	48,897	2,334	1,482	17	9.0
2007	59,504	65,001	54,695	2,698	10,323	2,412	419	17.8
2008	50,311	64,576	39,688	2,909	4,247	954	87	11.3
2009	56,298	74,595	45,378	6,661	5,703	1,362	146	10.1

[1]imprecise estimate resulting from few recaptures and low trap efficiencies

Juvenile steelhead arrival timing at the screw trap

Combining arrival timing data from 2008 – 2011 indicated that the median arrival timing at the screw trap for the Big Sheep Creek direct released fish was April 13 compared to May 7 for both the natural population and the Little Sheep Creek acclimated group. Cumulative arrival timing graph revealed that the Little Sheep Creek group closely mimicked the natural population and both of these groups were significantly later than the Big Sheep Creek group (Figure 2; Kolmogorov-Smirnov two-sample test, $P < 0.01$). Results suggest that the Big Sheep Creek direct released fish rapidly moved down stream and entered the Snake River whereas the acclimated/volitionally released group from Little Sheep Creek emigrated similarly to that of the natural population. Only 2008 – 2011 data were used for this analysis because prior to 2008 only 1,000 fish were PIT tagged from each hatchery group to estimate survival to Lower Granite Dam, resulting in relatively few PIT tag recaptures at the screw trap (ranging from 9 to 59) and relatively imprecise estimates of arrival timing at the screw trap. Since 2008, greater than 10,000 IRH juveniles were PIT tagged from each group, resulting in high numbers of IRH PIT tag recaptures at the screw trap.

Significantly different arrival timing results in IRH compared to IRN indicate emigration patterns influenced by the timing and release strategy rather than natural environmental cues. Assuming that IRN juveniles emigrate at the optimal time and speed, significant differences may limit survival of the hatchery groups. Hatchery releases have varied over the years, but in general there were two hatchery groups that utilized acclimated (Little Sheep Creek) and a direct (Big Sheep Creek) release strategies (for example, see Lower Snake River Compensation Plan, 2011). Combining recapture data from both releases revealed a protracted emigration period from release to the screw trap that did not represent emigration patterns of the individual IRH groups. Consequently, we analyzed the groups separately to get a more accurate representation of the emigration patterns of the two distinct release groups and allow for the evaluation of the two release strategies. Our results suggested that the emigration timing of Big Sheep direct release was significantly different than that of the Little Sheep Creek acclimated release and the natural population, which were similar. A closer examination of juvenile survival and adult returns should be conducted to determine if the Big Sheep Creek release have decreased survival, and if the release strategy could have affected hatchery steelhead performance.

Size at emigration

Imnaha River hatchery-origin juveniles were significantly larger than IRN juveniles for both fork length and weight (Table 3; t-test, $P < 0.001$). We only presented data from 2009, but this was representative of fish captured in the other years. The lower C.V. for fork length compared to weight suggested that length was more uniform than weight for both IRH and IRN juveniles.

Condition of juveniles at emigration

Condition factor measures a species length to weight relationship as an index of growth and is calculated as weight/length^3. Table 3 presents mean condition factor for IRH and IRN juvenile steelhead captured in 2009 and is representative of data from other years. Although the fork lengths and weights were significantly greater in hatchery fish compared to naturals, equivalent condition factors indicated that growth and body conditions were similar.

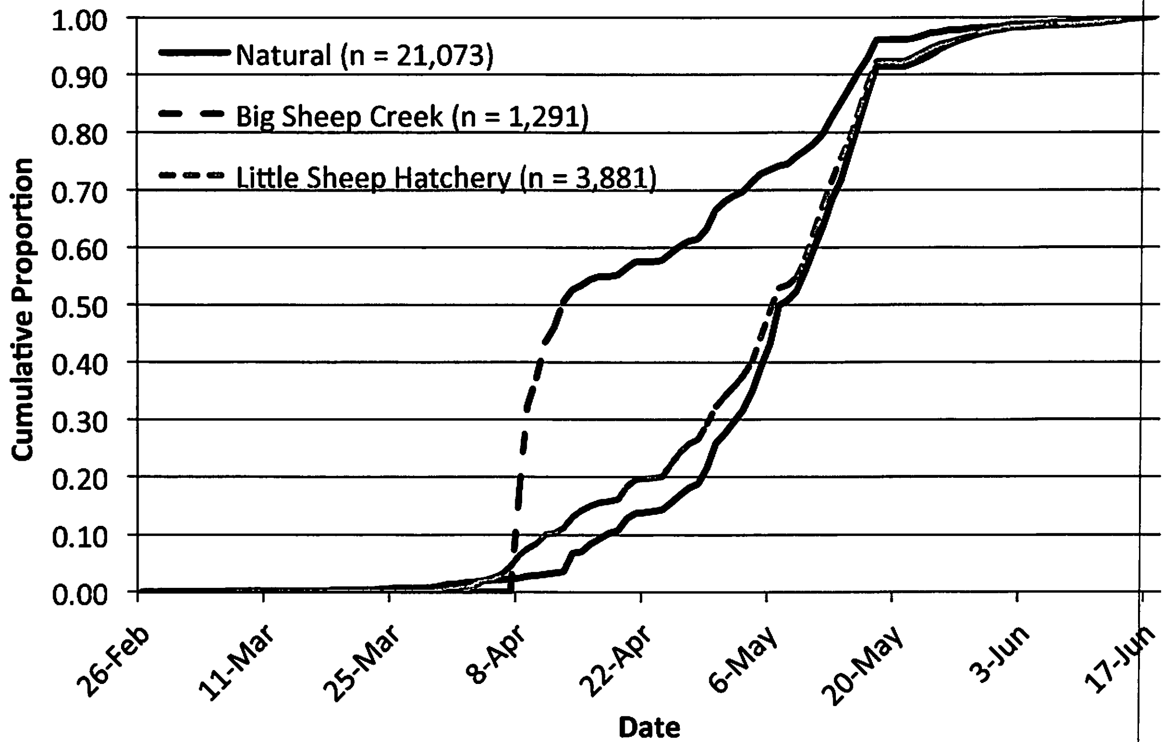


Figure 2. Line graph showing cumulative arrival timing (n = sample size) at the Imnaha River screw trap for natural-origin, Big Sheep Creek hatchery and Little Sheep Creek hatchery juvenile steelhead from 2008 – 2011.

Juvenile arrival timing at Lower Granite Dam

Arrival timing at Lower Granite Dam was determined by detections of IRH and IRN juvenile steelhead that were PIT tagged or recaptured at the Imnaha River screw trap. The median, 10th and 90th percentile arrival times for Imnaha River IRH, IRN and Snake River aggregate (SRA; an aggregate of PIT tag detections from juvenile steelhead tagged throughout the Snake River basin, data provided by the Fish Passage Center) are presented in Table 4. The median arrival timing date of SRA was May 8, four days earlier than IRN and seven days earlier than IRH.

Cumulative arrival timing distributions (Figure 3) indicated that both IRN and IRH initially arrived later than the SRA, but by the end of the emigration period the cumulative arrival of IRN was similar to that of SRA (same 90% arrival timing date). A Kolmogorov-Smirnov two-sample test measuring the maximum difference (max D) in the distributions revealed that arrival of IRN was similar to that of SRA (same 90% arrival timing date). A Kolmogorov-Smirnov two-sample test measuring the maximum difference (max D) in the distributions revealed that the arrival timing distribution of the SRA was significantly earlier than that of IRH (Max D = 0.222; $P < 0.05$; occurring on May 7), but not IRN steelhead (Max D = 0.152; $P > 0.05$). The arrival timing of IRH steelhead was not significantly different than that of IRN steelhead (Max D = 0.140; $P > 0.05$).

The emigration timing of Imnaha River juvenile steelhead reflects a localized ecological pattern as it relates to the Snake River aggregate, and similar timing by the hatchery component generally corresponds with a later pattern of outmigration of Imnaha River steelhead smolts. Similar to emigrant arrival timing at the screw trap, significant differences may signify non-adaptive patterns in emigration of the hatchery release groups with the potential to reduce juvenile survival and adult returns. Our data showing similar arrival timing at LGR for IRN and IRH indicate a localized pattern of emigration persists in the hatchery release groups.

Table 3. Size-at-emigration of natural- (IRN) and hatchery-origin (IRH) juvenile steelhead captured at the Imnaha River screw trap in 2009, including sample size (n), mean length (centimeters – mm) and mean weight (grams – g) and standard deviation (S.D.), coefficient of variation (C.V.), minimum and maximum for both measures.

	IRN	IRH
Mean length (mm)	172.9	218.6
Sample (n)	5,171	1,987
S.D.	17.6	23.4
C.V.	10.2%	10.7%
Minimum	120	130
Maximum	257	315
Mean weight (g)	54.5	110.3
Sample (n)	5,169	1,928
S.D.	16.9	38.6
C.V.	31.0%	35.0%
Minimum	14.9	20.2
Maximum	174.7	376.3
Mean condition (W/L^3)	1.03	1.02
Sample (n)	5,163	1,923
S.D.	0.08	0.08
C.V.	7.8%	7.8%
Minimum	0.64	0.76
Maximum	1.52	1.42

Table 4. Juvenile steelhead median, 10th and 90th percentile arrival time dates to Lower Granite Dam for Imnaha River natural-origin (IRN), Imnaha River hatchery-origin (IRH) and Snake River aggregate (SRA).

	Date		
	10th %	median	90th %
IRN	24-Apr	12-May	25-May
IRH	26-Apr	15-May	31-May
SRA	23-Apr	8-May	25-May

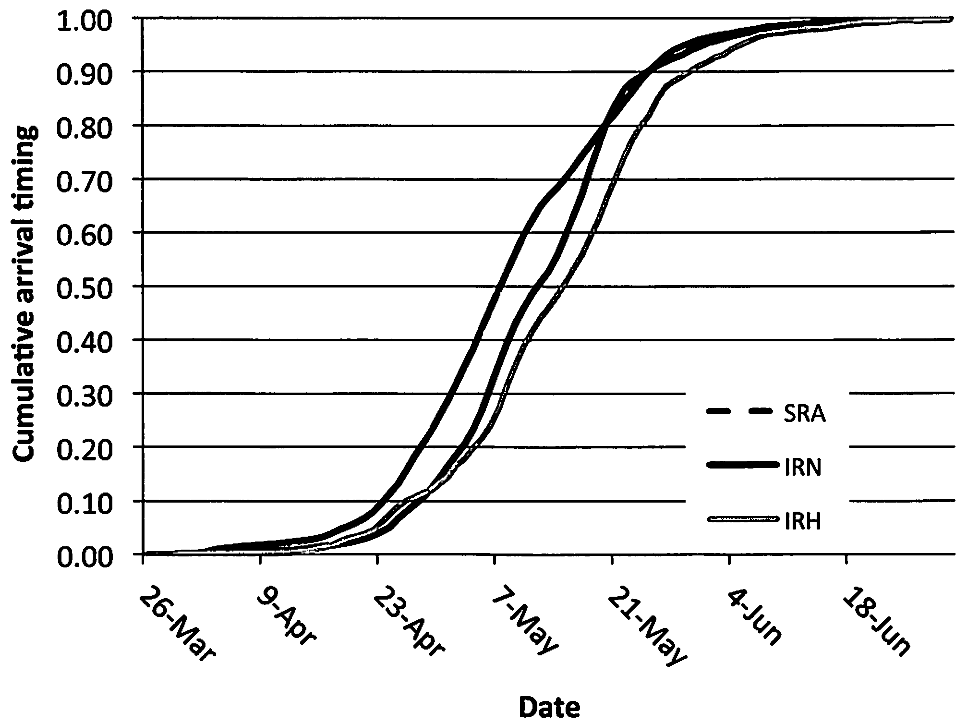


Figure 3. Cumulative distribution of arrival time at Lower Granite Dam for Imnaha River hatchery-origin (IRH), Imnaha River natural-origin (IRN) and Snake River aggregate (SNA) from 1998 – 2010.

Juvenile survival

Juvenile survival from the screw trap to LGR and MCN were determined for IRN and IRH steelhead using juveniles PIT tagged or recaptured (hatchery-origin juveniles) at the Imnaha River screw trap and PIT tag interrogations at the juvenile bypass facilities. From 1995 – 2011 survival from the Imnaha River screw trap to LGR was high for both IRN and IRH averaging 84.7% (4.0) and 84.4% (10.3), respectively. In contrast to the relatively consistent survival to LGR, survival from the screw trap to MCN was highly variable for both IRN an IRH juveniles (Figure 4), averaging 52.9 (14.3) and 52.1 (17.9), respectively. Survival of IRN compared to IRH juveniles was not significantly different to LGR ($t = 0.668$; $P = 0.510$) or MCN ($t = 0.112$; $P = 0.913$) indicating that hatchery- and natural-origin steelhead survived at the similar rate from the screw trap to MCN.

Our report focused on the effects of Imnaha and Snake River conditions above LGR. A more comprehensive review of the effects of environmental conditions on juvenile survival through the hydrosystem can be found in the CSS report (http://www.fpc.org/documents/CSS.html). An analysis of the relationship between Snake River flow and surivival to LGR revealed that Snake River flow was positively related to juvenile survival to LGR for IRN ($R^2 = 0.298$, $P = 0.023$), but not IRH ($R^2 = 0.066$, $P = 0.353$; Figure 5). The lack of relationship between higher flow and IRH survival suggests that hatchery fish were less influenced by annual variations in river flow compared to natural-origin juveniles. The larger juvenile size, later release and migratory behavior may enable hatchery steelhead to rapidly migrate to LGR under variable conditions, whereas the emigration timing of natural-origin steehead was determined by environmental cues, such as flow, that were advantageous to survival.

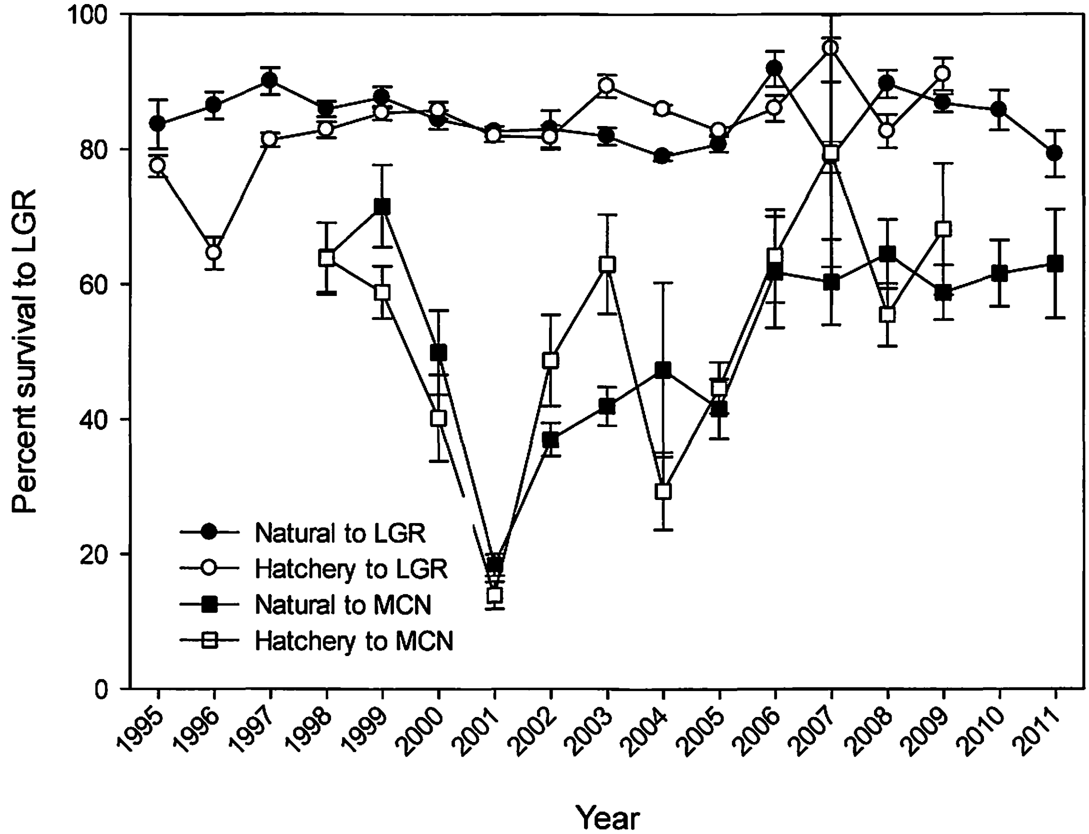


Figure 4. Natural-origin (IRN) and hatchery-origin (IRH) juvenile steelhead survival from the Imnaha River screw trap to Lower Granite Dam (LGR; 1995 – 2011) and McNary Dam (MCN, 1998 – 2011).

Adult arrival timing

Imnaha River adult steelhead arrival timing to BON and LGR were estimated from PIT tag interrogations at the adult fishways. Both IRH and IRN adults were first detected at BON in late June with the last detections occurring in mid September. The median arrival timing at BON was July 31 for IRN and August 7 for IRH (Table 5). Adults were first detected at LGR in early – mid July, with the last detections occurring the following May. The median arrival timing at LRG was September 25 for IRN and September 21 for IRH (Table 5). Approximately, 5% of IRN adults pass LGR the following spring, compared to 1% of IRH.

Cumulative arrival timing to BON and LGR (Figure 6) demonstrated that IRN arrived earlier at BON compared to IRH. The relationship was reversed at LGR, with IRH arriving earlier than IRN. Kolmogorov-Smirnov two-sample test (K-S test) for differences in arrival timing between IRN and IRH revealed that the maximum difference in cumulative arrival timing at BON (Max D = 0.175; P > 0.05) was not have significantly different for IRN compared to IRH adults. In contrast, arrival timing at LGR was significantly earlier for IRH compared to IRN (Max D = 0.117, P < 0.05; occurring on September 30) indicating that the cumulative arrival timing distribution of IRH was significantly earlier than that of IRN.

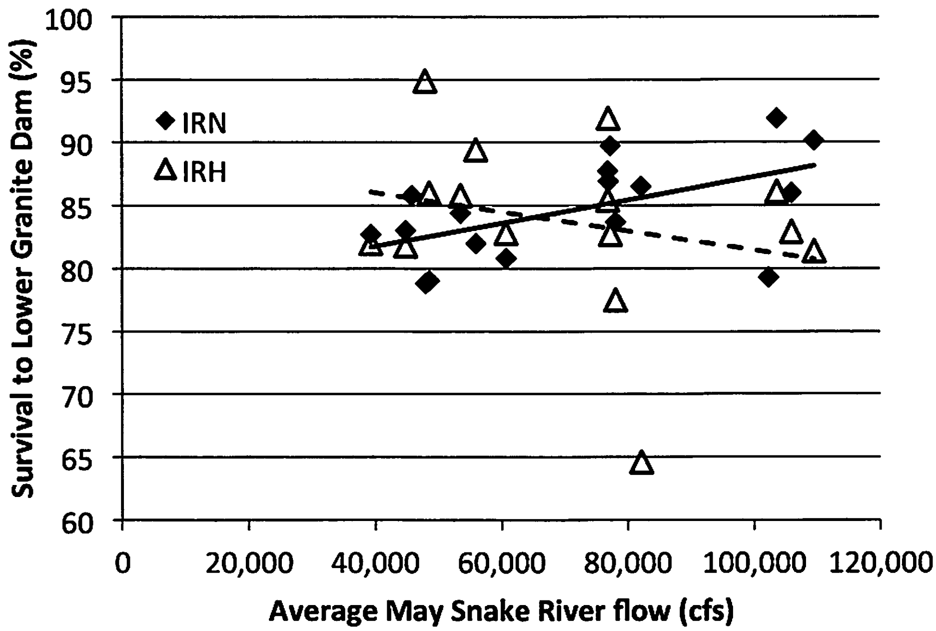


Figure 5. Relationship between average May Snake River flow and survival from the Imnaha River screw trap to Lower Granite Dam (LGR) for Natural-origin (IRN) and hatchery-origin (IRH). Solid line represents the IRN trend and dashed line represents the IRH trend. Snake River flow in cubic feet per second (cfs).

Table 5. Adult arrival timing at Bonneville Dam (BON; a) and Lower Granite Dam (LGR; b) for natural-origin (IRN) and hatchery-origin (IRH) steelhead PIT tagged in the Imnaha River from 2000 – 2011. Data includes medial arrival date, 10th percentile date (10th), 90th percentile date (90th) and date of first and last fish.

a. Arrival timing at BON

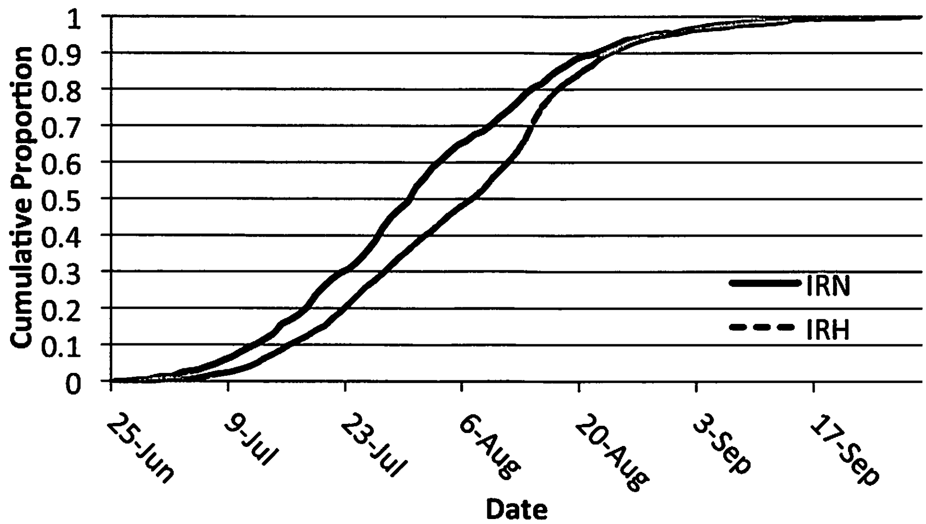
	median	10th	90th	First	Last
IRN	31-Jul	12-Jul	21-Aug	27-Jun	27-Sep
IRH	7-Aug	16-Jul	23-Aug	27-Jun	22-Sep

b. Arrival timing at LGR

	median	10th	90th	First	Last
IRN	25-Sep	21-Aug	5-Nov	12-Jul	16-Jun
IRH	21-Sep	2-Sep	19-Oct	19-Jul	15-Jun

Adult conversion rates

IRN and IRH adult conversion rates from BON to LGR were compared using PIT tag interrogations at the adult fishways. The average conversion rate from 2002 through 2010 was 0.75 (0.06) and 0.78 (0.10) for IRN and IRH, respectively. The rates were relatively consistent (Figure 7), with no difference in average conversion between IRN and IRH (T-test; $P > 0.05$). Most of the loss occurred between BON and MCN, conversions from MCN to LGR averaged greater than 95% for both IRN and IRH (data not shown). Similar conversion rates between adipose fin-clipped hatchery fish and unmarked natural fish was surprising and suggested that the mark-selective sport fishery in the mid Columbia River had little or no effect on conversion rate of Imnaha River adipose fin clipped hatchery steelhead between BON and LGR.



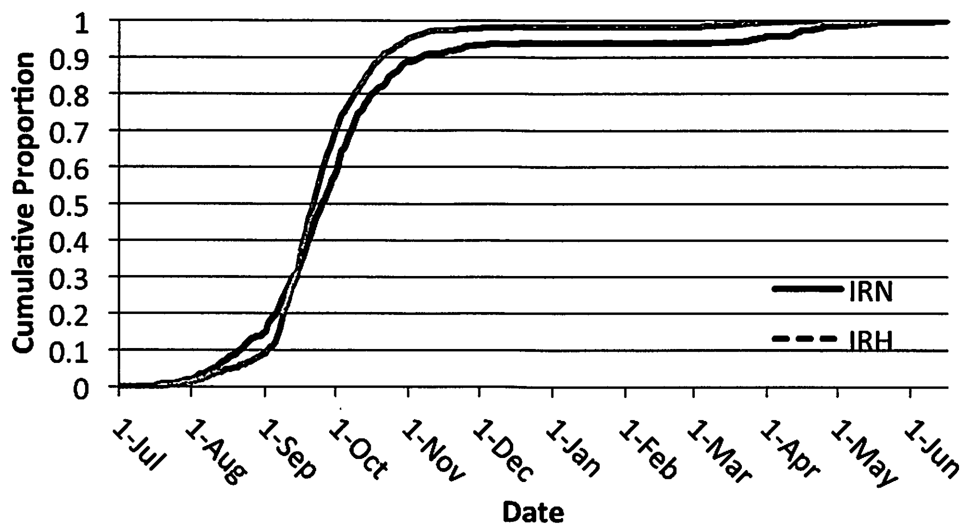


Figure 6. Adult arrival timing at Bonneville Dam (top) and Lower Granite Dam (bottom) for Imnaha River natural-origin (IRN) and hatchery-origin (IRH) steelhead determined from PIT tag interrogations.

Smolt-to-adult return Index

Smolt-to-adult (SAR) return index rates were estimated from juveniles PIT tagged at the Imnaha River trap and subsequent PIT tag interrogations at LGD as juveniles and adults. In the early years of the study the main objective was to analyze in-river juvenile migration, resulting in a majority of the tagged fish being bypassed back to the river. Consequently, SAR index results presented here do not represent the run-at-large and have limited management utility. They are presented mainly as a comparison between natural- and hatchery-origin fish under similar conditions. Results demonstrated that SAR index rates from LGR to LGR were slightly higher for IRH compared to IRN (Table 6).

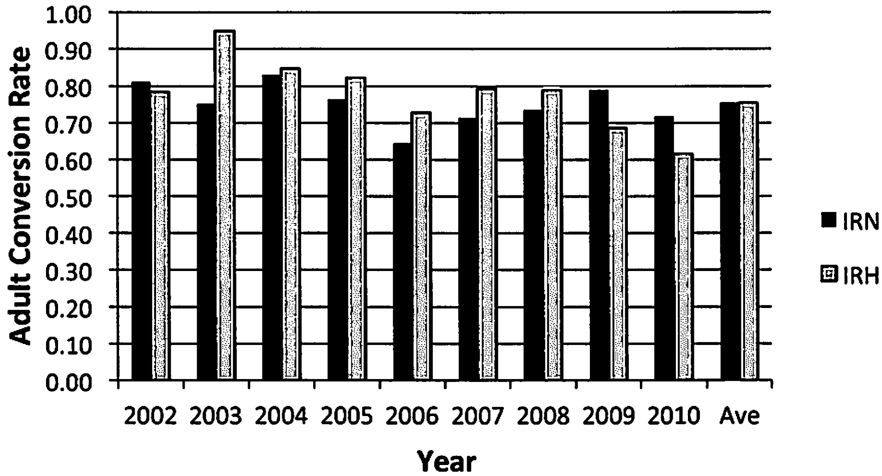


Figure 7. Natural-origin (IRN) and hatchery-origin (IRH) adult steelhead conversions from Bonneville Dam (BON) to Lower Granite Dam (LGR) from 2002 – 2010. Ave – average conversion rate across all years.

Conclusions

The performance measures evaluated here provide important information for the entire Imnaha River population/Major Population Group (MPG). Significant results included: 1) natural-origin juvenile steelhead index of abundance emigrating from the Imnaha River averaged greater than 50,000 per year. Combined with the estimated juvenile survival to LGR, an estimated 40,000 natural-origin juvenile steelhead from the Imnaha River survive to LGR. 2) Emigration from the Imnaha River peaks in April/May, with greater than 95% of the total Imnaha River juvenile steelhead leaving during this peak migration period. The emigration timing of the volitionally-released hatchery juveniles from the Little Sheep Creek Acclimation Facility closely mimicked the timing of the natural-origin population as measured by arrival timing at the screw trap. In contrast, the direct release from Big Sheep Creek was significantly earlier with a more compressed migration period. There were not enough PIT tagged steelhead that originated from the Big Sheep Creek release to evaluate the effects of the different emigration pattern on juvenile survival through the hydrosystem or subsequent adult returns. 3) Hatchery-origin juveniles had significantly larger average fork length and weight, but condition factor was not significantly different compared to natural-origin fish. Larger size did not appear to positively affect survival to LGR or MCN, but may have positively affected SAR rates. 4) Arrival timing at LGR for hatchery-origin juveniles was slightly later than that of natural-origin juveniles. Both hatchery- and natural-origin Imnaha River juvenile steelhead arrived at LGR later compared to the Snake River aggregate. This was likely a localized adaptation of Imnaha River steelhead that has been retained in the hatchery population. 5) Juvenile survival to LGR was relatively consistent, averaging approximately 80% for both hatchery- and natural-origin juveniles. In contrast, juvenile survival to MCN was highly variable, suggesting that environmental conditions had a much greater effect on survival below compared to above LGR. 6) Adult arrival timing patterns were not significantly different. Natural-origin adult steelhead arrived at BON earlier than hatchery-origin adults, with the relationship reversed at LGR. A higher proportion of natural-origin adults arrive at LGR the following spring compared to hatchery-origin adults. 7) Adult conversion rates from BON to LGR averaged 75%, with similar rates for hatchery- and natural-origin steelhead. Conversion rates from MCN to LGR were > 95% indicating that most of the loss occurred between BON and MCN. Slightly different migration patterns indicated by different arrival timing at BON and LGR did not significantly affect conversion rates to LGR. 8) Smolt-to-adult return index rates were slightly higher for hatchery- compared to natural-origin steelhead. However, the analysis measured bypassed in river juveniles only and did not represent the run at-large.

Table 6. Hatchery- and natural-origin steelhead smolt-to-adult return index (SAR) from the Imnaha River screw trap to Lower Granite Dam (LGR) and from LGR to LGR determined from fish PIT tagged and/or captured and released at the Imnaha River screw trap. All fish were designated in river survival mode as they passed through the hydrosystem and don't represent the run-at-large.

Migration Year	Number PIT Tagged	Estimated Smolts at LGR	Number of Adult detections at LGR	1 Ocean[1]	2 Ocean[2]	SAR Index Imnaha R. to LGR %	SAR Index LGR to LGR (%)
Hatchery-origin							
2000	5,846	5,016	65	49	16	1.11	1.30
2001	3,463	2,840	3	3	0	0.09	0.11
2002	2,153	1,787	25	18	7	1.16	1.40
2003	5,227	4,673	38	26	12	0.73	0.81
2004	4,487	3,854	16	11	5	0.36	0.42
2005	6,570	5,440	21	19	2	0.32	0.39
2006	1,494	1,286	20	17	3	1.34	1.55
2007	1,492	1,416	22	17	5	1.47	1.55
Natural-origin							
2000	4,737	3,998	69	51	18	1.46	1.73
2001	3,680	3,043	10	1	9	0.27	0.33
2002	4,809	3,934	37	21	16	0.77	0.94
2003	6,302	5,168	34	18	16	0.54	0.66
2004	1,506	1,190	1	0	1	0.07	0.08
2005	4,400	3,555	5	3	2	0.11	0.14
2006	2,063	1,896	26	21	5	1.26	1.37
2007	3,238	2,552	32	18	14	0.99	1.25

Naturally selected populations should provide the model for successful artificially reared populations, in regard to population structure, behavior, growth and other biological characteristics (NPCC, 2009). These results indicated that the post release performance of the LSRCP hatchery program fish was similar to that of the natural population for survival to LGR, migration timing (arrival timing at the screw trap and at LGR), adult arrival timing to BON, adult BON to LGR conversion rate and SAR rate. The major differences observed were juvenile size. However, hatchery juvenile growth rates were purposely increased in order to produce larger juveniles at time of release. The significantly larger juvenile size likely conferred a survival advantage as juveniles, and this translated to increase survival to adult. Hatchery programs that mimicked the life history of the natural population also reduces risk factors associated with supplementation fish mating with the natural-origin fish. The Imnaha River supports an integrated hatchery program that allows for and encourages hatchery/natural interaction (Little Sheep and Big Sheep Creek outplants). Thus it is important that the hatchery fish are as similar as possible, in genetics and behavior, to the natural population (NPCC, 2009). This study provides information critical to addressing these objectives. Juvenile abundance estimates and survival provide an important data for assessing productivity and diversity, both of which are important to population viability (McElhany et al. 2000).

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Adult Steelhead Evaluations in Imnaha River Tributaries

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Lower Snake River Compensation Plan
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Introduction

Significant declines in abundance resulted in the Snake River basin steelhead (*Oncorhynchus mykiss*; Héeyey in Nez Perce language) being listed as a threatened species under the United States Endangered Species Act (ESA). Although declines were apparent at the ESU level based on long-term trends at the four lower Snake River dams, the status of individual major population groups (MPG) were largely unknown. The viable salmonid population (VSP) concept outlines methods for determining the conservation status of populations and understanding the parameters used to determine viability status, both critical to the establishment of ESA delisting goals and the formulation of recovery plans (McElhany et al. 2000). The status of naturally spawning steelhead in the Imnaha River MPG was largely unknown as it related to the four VSP parameters, abundance, population growth rate, spatial structure and diversity.

In addition, the influence of the Lower Snake River Compensation Program's Endemic Little Sheep Creek Summer Steelhead program has not been determined for any spawning aggregation within the Imnaha River population except within Little Sheep Creek (USFWS, 2011). In this study we attempted to determine the status of three spawning aggregations in the lower Imnaha River and assess the presence of hatchery-origin fish in these systems.

The goal of the project is to evaluate the abundance and population composition of adult steelhead escapement in the lower Imnaha River spawning aggregates. We monitored and evaluated three natural steelhead spawning aggregates in the lower Imnaha River from 2000 – 2011. Prior to the implementation of this study the spatial and temporal spawner distribution, presence/absence of hatchery-origin steelhead and life history diversity of the natural-origin spawning aggregates in the Imnaha River were largely unknown. Results provided information directly related to VSP parameter assessments of abundance, diversity and spatial structure of the Imnaha River MPG.

The information collected by this project will be evaluated as part of a basin-wide monitoring and evaluation effort on the Imnaha River steelhead MPG. In addition to this project, two other Bonneville Power Administration funded projects have begun to evaluate adult steelhead status and trends in the upper Imnaha River (Imnaha River Adult Steelhead Monitoring Project; ISAM; http://www.cbfish.org/Project.mvc/Display/2010-032-00) and abundance in the entire basin

(Integrated Status and Effectiveness Monitoring Project; ISEMP; http://www.cbfish.org/Project.mvc/Display/2003-017-00). The ISAM project operates weirs in the upper Imnaha River tributaries to describe the abundance, diversity and spatial distribution within the Imnaha River subbasin. The ISEMP project uses proportional tagging of natural-origin steelhead at Lower Granite Dam with recaptures recorded on instream passive integrated transponder (PIT) tag arrays to generate abundance estimates to the entire basin. Combined with the data collected by this project, a comprehensive assessment of the status and viability of the entire Imnaha River subbasin will relate performance at the MPG level to status assessments of entire Snake River basin Distinct Population Segment (DPS).

Methods

Monitoring adult steelhead spawner abundance requires intensive methods, utilizing weirs and traps operated during high spring flows. For this reason, we operated 1-2 weirs per year on a rotational basis in three streams, Cow Creek, Lightning Creek and Horse Creek (Figure 1). Weirs and adult traps were placed in Cow Creek from 2001 – 2007, in Lightning Creek from 2000 to 2007 and in Horse Creek from 2008 – 2011. Rotating the placement of weirs enabled a greater number of streams to be evaluated given the limited resources. The objective was to collect 4-5 years of reliable abundance data from each tributary, understanding that high water may limit operations and data collection during some years. In addition, a resistivity counter was operated in Lightning Creek (2007) and Camp Creek (2008 – 2009; Figure 1) to evaluate the effectiveness of this technology for monitoring steelhead population abundance.

Temporary bi-directional weirs were operated from early March through mid-June, or 10 days after the last fish was captured. Standard picket weirs were used from 2000 – 2008. Beginning 2008 a floating panel weir was used to reduce the effects of high water, safeguard equipment and provide greater safety for fish and personnel. The weir was checked daily during its period of operation, and often twice a day (mornings and evenings) during the peak migration period. The upstream and downstream trap boxes were checked and debris was removed from any points on the structure. Adult steelhead captured were released upstream if captured in the upstream trap box or released downstream if captured in the downstream trap box. Surveys looking for spawning activity (spawning fish or redds) below the weir were conducted weekly.

All captured fish were netted out of the trap box and placed in a large tote until biological data could be obtained. Biological data recorded included fork length, sex, origin, marks, and tags and scales were removed for age analysis. Fish were scanned for the presence of a coded wire tag (CWT) or passive integrated transponder (PIT) tag. Hatchery-origin fish were determined by the absence of an adipose fin or CWT the in the case that unclipped hatchery fish were captured. Fish were marked with operculum punch and the resulting tissue sample was preserved for future DNA analysis. Fish captured moving upstream or downstream that possessed an opercle punch mark were measured, observed for other tags and marks, and recorded as a recapture. Beginning in 2011, fish were marked by inserting a PIT tag in the pelvic girdle to facilitate a mark recapture study and track downstream kelt migration.

Calculations of adult monitoring performance measures were based on the biological data collected from adult steelhead trapped at the weir and estimated through adjusted Peterson mark-recapture formula expansions (*see below*). Proportional assignment of biological data (e.g., origin, sex, or length) obtained from fish that were handled provided the basis for determinations made on fish that were not handled and thus lacked the biological information needed to account for all fish estimated to have returned to the tributary. Methods of derivation and assumptions used are presented below, following those presented in Vogel et al. (2005).

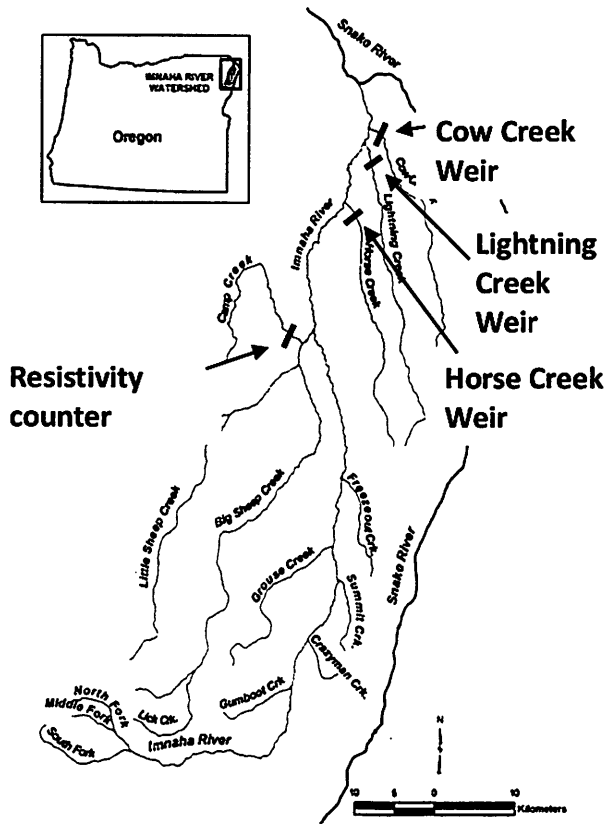

Figure 1. Map of the Imnaha River and tributaries with the locations of the Cow, Lightning and Horse Creek weirs and the resistivity counter in Camp Creek.

The total adult steelhead abundance was estimated by marking adult fish at the trap and then 'recapturing' the marks from downstream migrating fish captured in the downstream trap box. Total operculum-tagged and unmarked steelhead captured in the upstream and downstream traps were tallied (assuming equal distribution and probability of recovery). We used the adjusted Petersen estimator (Chapman 1951), a commonly used mark-recapture formula (Cousens et al. 1982), to approximate an unbiased escapement estimate. Adult data was applied to the following terms:

$$A\hat{A}W_{M/R} = \frac{(M+1)(C+1)}{(R+1)} - 1$$

Where *M* is the number of marked (opercular-tagged) adults released above the weir, *C* is the total number of steelhead captured (marked and unmarked) moving downstream, and *R* is the number of marked (opercular-tagged, or lost opercular-tag with identifying staple marks) steelhead captured moving downstream. The variance for this estimate was calculated as:

$$Var_{A\hat{A}W} = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}$$

Adult Monitoring - Performance Measures

Performance measures calculated from biological data obtain from adult steelhead collected at the Cow, Lightning and Horse creek traps followed definitions developed by the Collaborative Systemwide Monitoring and Evaluations Project (CSMEP; web site) and adopted by the Ad Hoc Supplementation Work Group (Beasely et al. 2008).

Performance measures included:

Spawner abundance: the raw measure of the number of adult steelhead that escaped passed the weir derived from a mark/recapture analysis plus an estimate of the number of adults that spawned below the weir. This is equivalent to adult escapement since no fishery occurred above the weir and prespawn mortality is assumed to be rare.

Hatchery fraction: calculated by dividing the total number of unique hatchery-origin steelhead captured by the total number of unique steelhead captured, assuming an equal probability of capture for hatchery- and natural-origin fish. Generally, mark/recapture point estimates for hatchery-origin fish were not reliable given the small number of hatchery-origin fish captured.

Age-at-return: the age distribution of spawning steelhead determined by scale pattern analysis. Total age and freshwater and ocean residency times were determined.

Size-at-return: the average size (fork length) and size distribution of steelhead captured in each stream, by origin. Size at return for natural-origin and hatchery-origin steelhead was compared using at t-test of means.

Adult spawner sex ratio: the proportion of female and male steelhead captured at the weir.

Return (spawn) timing: estimated using the following measures; 1) median - date that 50th percent of the total steelhead were captured and; 2) range – determined by the first and last fish and the 10th and 90th percentiles of total steelhead captures.

Resistivity counter

A Logie 2100C fish counter was installed in Lightning Creek in 2007 and in Camp Creek in 2008 and 2009 to evaluate the utility of this technology for enumerating adult steelhead abundance. This technology uses differences in resistivity that are generated when a fish passes over a electric field produced by a panel or set of panels laid across the stream bottom. Signal processing software can determine fish size and direction of movement based on signal amplitude and signal pattern, respectively, and distinguish non-fish targets. Additional information related to the technology can be found at:http://www.aquantic.com/. The counter was installed approximately 50 meters below the Lightning Creek weir in order to document weir impedance and verify the abundance estimates determined by the mark/recapture analysis. In 2008 and 2009 the counter was operated in Camp Creek approximately one half mile above its confluence with the Imnaha River in order to estimate adult steelhead abundance.

Results

Weir operations

Weirs were operated in Cow, Lightning and Horse creeks (tributaries in the lower Imnaha River) from 2000 – 2011. Weir operation dates and first and last fish capture dates are presented in Figure 2. Based on the date of the first and last captures the weir operation period generally encompassed the migration and spawning period of adult steelhead in these systems. The exceptions were those years where high flow precluded weir operations later in the season. Comparing the date of last fish captured during the high flow years to that of extended weir operations demonstrated that fish were likely missed during high flow years and this impacted the resulting population estimates. A total of five years were impacted by high water (Figure 2).

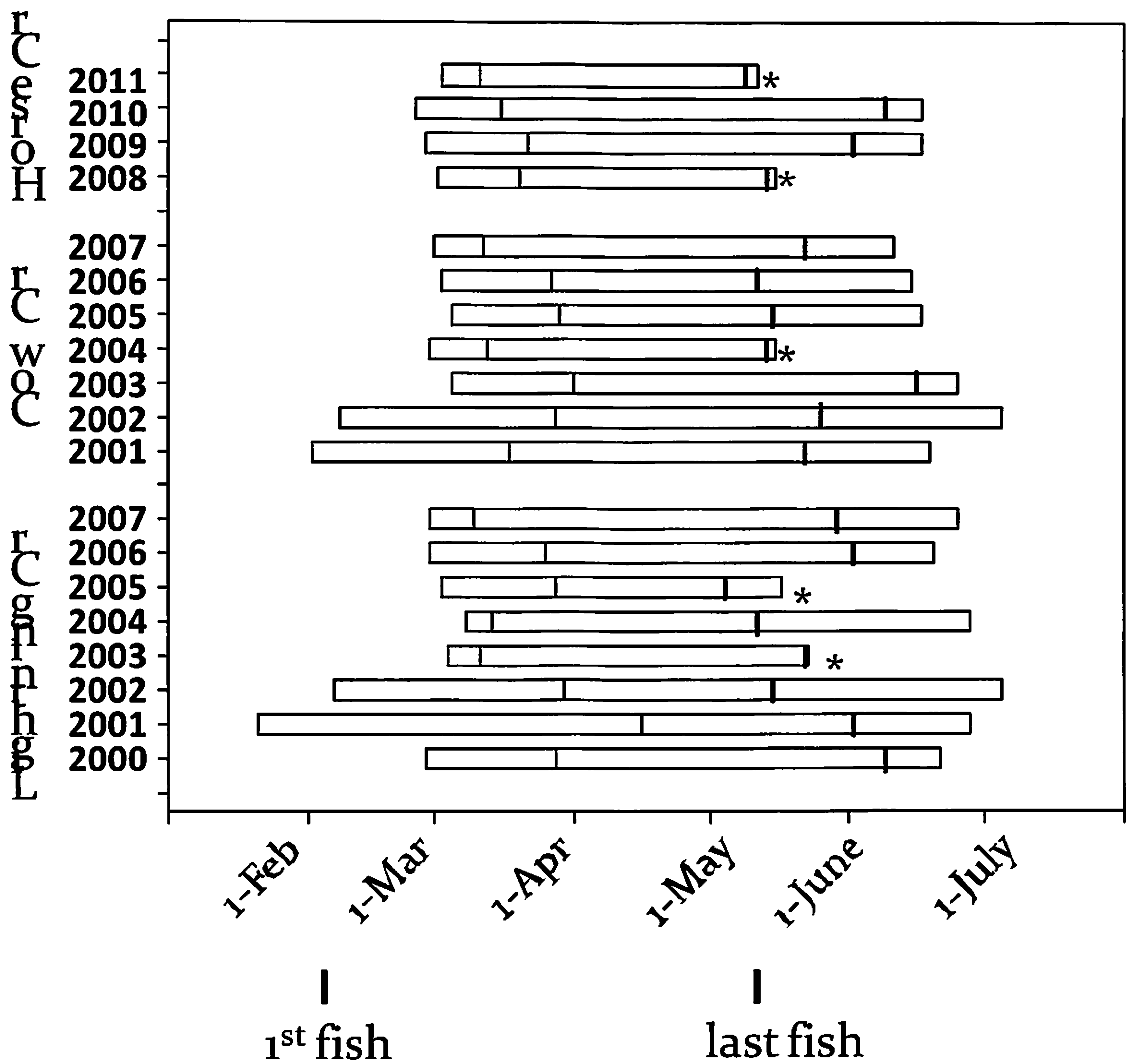

Figure 2. Annual operation dates (gray bars) for Lightning, Cow and Horse Creek weirs. First and last unique upstream migrating fish are indicated by the vertical bars. Asterisk indicates years where high water limited weir operations.

Spawner escapement

Steelhead returns were highly variable over the study period. Average abundance estimates (coefficient of variation – C.V.) were 77 (10.8) for Cow Creek, 126 (13.6) for Lightning Creek and 228 (17.5) for Horse Creek (Figure 3; Table 1). Overall C.V.'s were low, suggesting moderate to high precision around the estimates, even during high flow years when weir operations were curtailed and capture probabilities approached zero. Relatively low C.V. estimates during high flow years indicated high precision around the population estimate and raise a concern with inaccuracy of mark/recapture models in high flow years when using weirs for steelhead spawner escapement estimates. Steelhead return and spawn over a two to three month period, with early fish spawning and leaving the system to migrate back to the ocean. Early in the season when the water was low, a high proportion of the adults were captured and marked, then recaptured as they migrated downstream after spawning. This provided an adequate number of mark and recapture events to derive a low standard error around the estimate for the entire year. Consequently, violations of mark/recapture model assumptions that all fish have an equal probability of being marked and recaptured was not met during high flow years, making abundance estimates likely inaccurate (biased low) in high flow years.

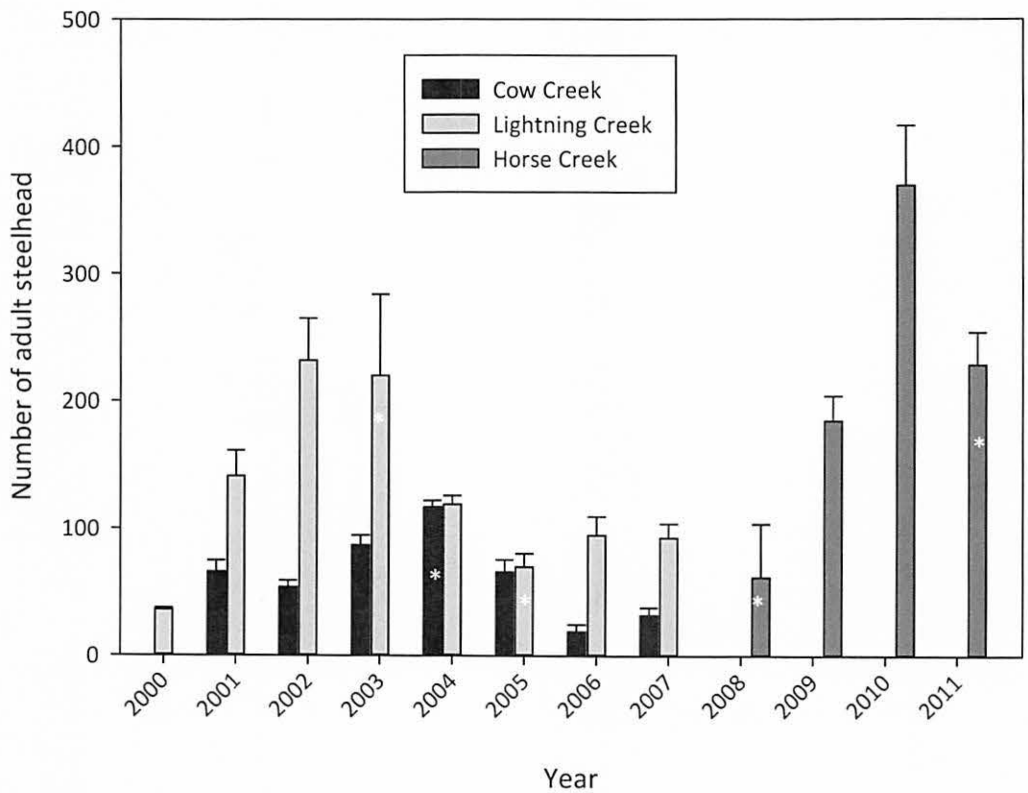

Figure 3. Annual spawner abundance for Cow, Lightning and Horse creeks. Asterisk indicated years where high water limited weir operations.

Hatchery Fraction

The average hatchery fraction measured by the percent hatchery-origin fish captured at the weirs was highest in Cow Creek and lowest in Horse Creek (Figure 4). Variation was high, ranging from a low of 2.2% in Horse Creek in 2009 and 2010 to a high of 29.6% in Cow Creek in 2002. In general only two to eight hatchery steelhead were captured at each trap in any given year (Table 2). However, the small size of the spawning aggregates, especially Cow Creek, resulted in a relatively high hatchery fraction. For example, in 2006 and 2007 only 3 hatchery fish were captured in Cow Creek, but this generated a hatchery fraction estimate of 15.8% and 9.4%, respectively. Consequently, even a small number of dispersing hatchery fish has the potential to significantly influence a small spawning aggregation. Total returns of Imnaha River hatchery steelhead above Lower Granite Dam averaged greater than 2,000 fish per year (Warren et al. 2011), making the number of hatchery fish that dispersed to these streams small relative to the total number of hatchery fish in the Imnaha River subbasin. Their influence to these small populations could not be determined.

Table 1. Adult steelhead capture data for Cow (a), Lightning (b) and Horse (c) creeks, including year, number of unique captures, number marked passing upstream (marked upstream), number captured passing downstream (captured downstream), number of marked steelhead recaptured passing downstream (recaptured downstream), mark/recapture point estimate, lower and upper 95% confidence interval (CI) and the coefficient of variation (CV%).

a. Cow Creek

Year	Unique captures	Marked upstream	Captured downstream	Recaptured downstream	Point estimate	Lower 95% CI	Upper 95% CI	CV%
2001	66	46	42	22	87	69	104	10.1
2002	54	37	40	23	64	54	74	7.9
2003	87	42	75	30	104	89	120	7.3
2004	117	103	71	57	128	118	138	3.9
2005	66	51	35	20	88	69	107	10.7
2006	19	10	14	5	27	16	37	20.5
2007	32	30	8	6	39	27	51	15
				Mean	77			10.8
				S.E.	35.7			

b. Lightning Creek

Year	Unique captures	Marked upstream	Captured downstream	Recaptured downstream	Point estimate	Lower 95% CI	Upper 95% CI	CV%
2000	35	33	23	21	36	33	39	3.7
2001	84	52	50	18	141	101	182	14.3
2002	125	54	92	21	232	166	297	14.2
2003	73	30	49	6	220	93	348	29.0
2004	103	90	53	40	119	105	132	5.7
2005	55	52	11	8	70	49	90	14.6
2006	60	37	37	14	95	66	124	15.3
2007	66	46	39	19	93	71	115	11.8
				Mean	126			13.6
				S.E.	69.3			

c. Horse Creek

Year	Unique captures	Marked upstream	Captured downstream	Recaptured downstream	Point estimate	Lower 95% CI	Upper 95% CI	CV%
2008	38	22	19	3	114	30	198	36.6
2009	142	132	30	21	186	148	225	10.3
2010	184	103	110	30	371	278	465	12.6
2011	147	108	72	33	233	185	281	10.3
				Mean	226			17.5
				S.E.	108.3			

Table 2. Annual number of hatchery steelhead captured and percent hatchery fraction for Cow, Lightning and Horse creeks.

	Cow Creek		Lightning Creek		Horse Creek	
	# of hatchery fish	hatchery fraction %	# of hatchery fish	hatchery fraction %	# of hatchery fish	hatchery fraction %
2000			2	5.4		
2001	4	6.1	2	2.4		
2002	16	29.6	8	6.4		
2003	5	5.7	7	9.6		
2004	21	17.9	8	7.8		
2005	5	7.6	3	5.5		
2006	3	15.8	3	5.4		
2007	3	9.4	5	7.6		
2008					10	26.3
2009					3	2.2
2010					4	2.2
2011					7	4.7

Age at return

Scale pattern analysis resolved total and European ages (freshwater age.ocean age) for steelhead captured from Cow and Lightning Creeks. Fish returned predominantly as total age 3 for both streams, with a significantly higher proportion of age 4 in Lightning Creek compared to Cow Creek (chi-square - 2 d.f., $P < 0.01$; Figure 5). European ages distinguishing freshwater and ocean residency times indicated predominantly 2.1 and 2.2 aged fish, with a small number of age 3.2 adults (Figure 5 and Figure 6). The total age differences observed between the two streams was explained by a greater proportion of 2-ocean steelhead in Lightning Creek compared to Cow Creek. A small number of 0-ocean fish were documented, suggesting a contribution of resident rainbow trout in the population.

Size at Return

Mean fork lengths of female and male adult steelhead captured in Cow, Lightning and Horse creeks are presented in Table 3. No significant differences in length were observed between steelhead captured from Cow and Lightning creeks or between males and females within Cow and Lightning creeks, but females were significantly larger than males in Horse Creek (t-test – $P = 0.002$). Length comparisons were not performed between Horse Creek and the other two streams because of the potential for annual size variation to affect the results. There was no significant difference in mean length between natural- and hatchery-origin fish. Length distributions from all captured steelhead indicated that although a majority of steelhead were less than 78 cm, representing the management criteria for Snake River A-run steelhead, a small number (1.3%) fish greater than 78 cm were captured in these streams and would be categorized as B-run as they migrate through the hydrosystem (Figure 7).

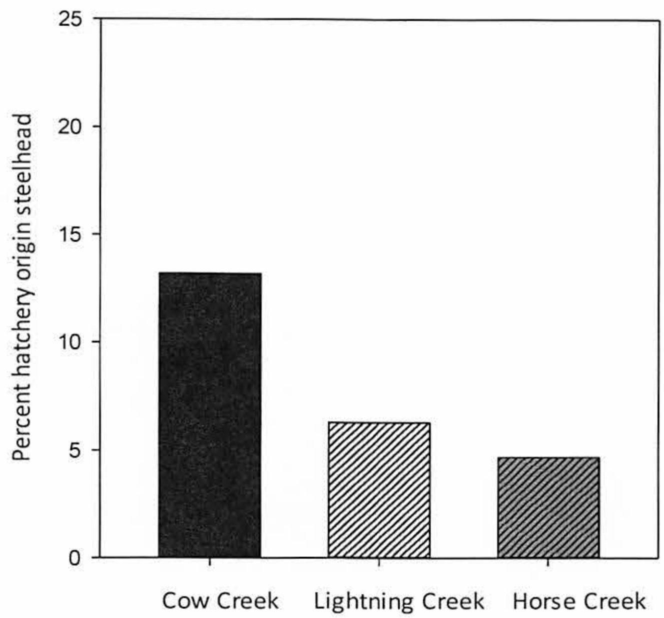

Figure 4. Average percent hatchery-origin steelhead trapped at Cow, Lightning and Horse creeks.

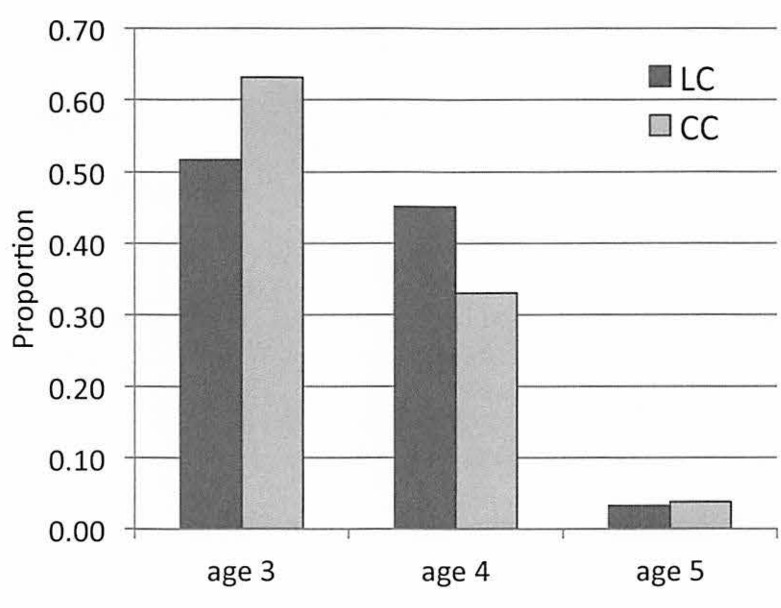

Figure 5. Proportions of age 3, age 4 and age 5 steelhead captured in Lightning Creek (LC) and Cow Creek (CC).

Sex Composition

Sex composition of adult steelhead returning to the study streams were predominantly female. Females comprised an average of 0.64 female (0.11), from Cow Creek, 0.70 (0.11) from Lightning Creek and 0.63 (0.02) from Horse Creek. The higher proportion of females in the anadromous population suggests a contribution of resident males to the spawning population. A small number of fish that appeared to be resident rainbow trout based on coloration and size were captured and their external phenotype suggested that they were males.

Adult run timing

The adult steelhead return encompassed a period from early April through mid May (Table 4; Figure 8). Median return dates and cumulative adult run timing was not significantly different among the three streams and likely represented travel times associated with distance from the mouth of the Imnaha River.

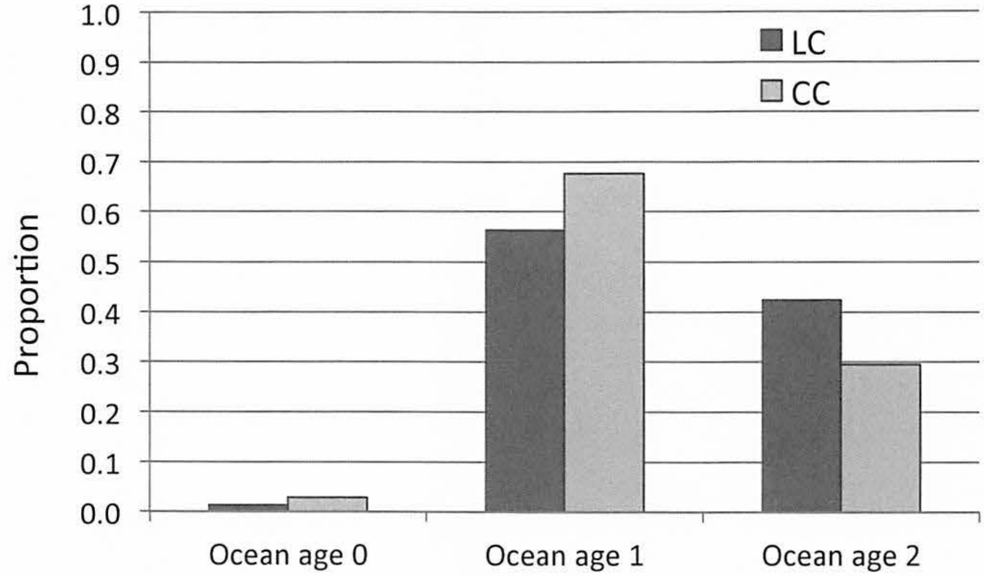

Figure 6. Proportions of adult steelhead by freshwater (FW; top graph) and ocean (bottom graph) ages captured at the Lightning Creek (LC) and Cow Creek (CC) weirs.

Table 3. Mean fork length (Mean FL), standard deviation (S.D.) and sample size (n) of adult steelhead captured in Cow, Lightning and Horse creeks.

	Cow Creek		Lightning Creek		Horse Creek	
	Female	Male	Female	Male	Female	Male
Mean FL	61.6	61.0	62.0	61.2	63.7	61.8
S.D.	6.2	6.0	6.7	7.2	6.5	6.2
n	243	141	398	159	319	188

Operation of the resistivity counter in Camp Creek provided imprecise adult steelhead abundance estimates. Placement of the counter in the middle of the spawning region resulted in a large number of up and down movement across the counting panels that, similar to above, resulted in high rates of signal misclassifications. Video evidence indicated that as fish moved downstream accross the counter they were often higher in the water column and turned sideways, resulting in the misclassification of a true "fish" signal as a random or "non target" event. This negatively impacted the ability to get a reliable estimate of the total net number of steelhead moving up stream. In spite of these issues, the data from the counter and a video camera operated at the site confirmed the presence of a relatively large adult steelhead spawning population in Camp Creek, with abundance estimates greater than 200 adults per year.

Both of these trials demonstrated the challenges associated with passive technologies such as the resistivity counter and highlight the importance of site location. In both studies the counter was placed in an area were steelhead were likely to pass up and down across the panels multiple times as opposed to a location further downstream where single upstream passages were more likely. Our recommendation is to locate this type of equipment in areas well downstream from weirs or spawning habitat so as to minimize multiple passage events.

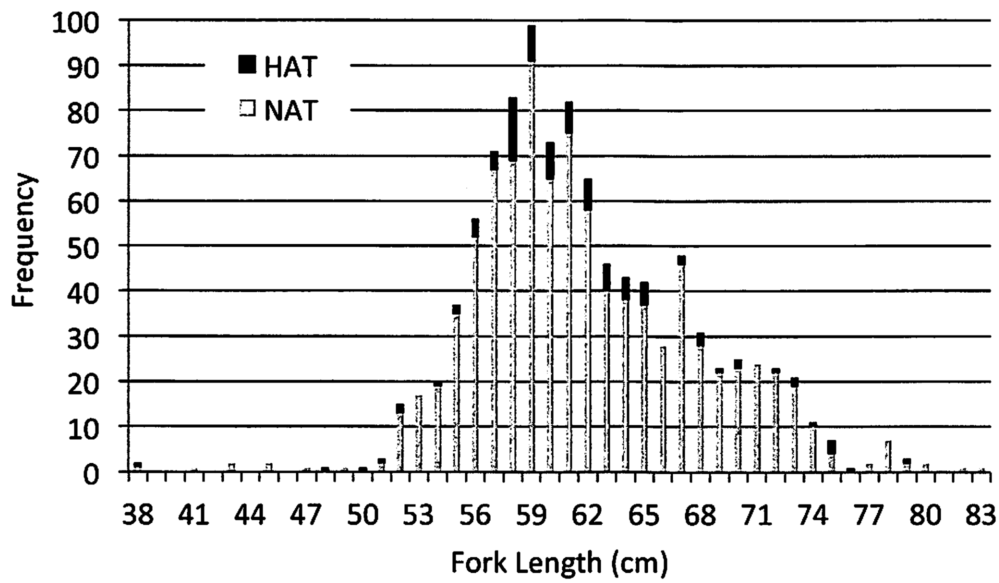

Figure 7. Fork length distribution of hatchery-origin (HAT) and natural-origin (NAT) adult steelhead captured in Cow, Lightning and Horse creeks.

Table 4. Median, 10th and 90th percent return dates of adult steelhead captured in Cow, Lightning and Horse creeks.

Section	Median	10th percentile	90th percentile
Cow Creek	4/19	3/25	5/19
Lightning Creek	4/24	4/1	5/18
Horse Creek	4/25	4/6	5/14

Discussion

Knowledge of population status, including percentage of hatchery origin spawners (pHOS), is central to the monitoring and evaluation of hatchery programs (Beasley et al. 2008). Intensive research and evaluation of the endemic Little Sheep Creek steelhead hatchery program has been focused within the Little Sheep Creek spawning aggregate of Imnaha River Steelhead population/MPG. The performance measures evaluated here provide important information for the other spawning aggregates within the Imnaha River population/MPG. Significant results included: 1) although small, Cow, Lightning and Horse creeks make significant contributions to the total steelhead escapement in the Imnaha River subbasin. In addition, being at low elevation close to the Imnaha River mouth, they contribute significantly to the spatial distribution and diversity of steelhead in the entire MPG. 2) Observed hatchery fractions generally ranged from 2% – 10%, and exceeded 20% during some years, suggesting a potential for benefit/risk to the natural population. However, the relatively high hatchery fraction was disproportionately affected by high returns from three years, with a low overall number of hatchery steelhead captured in most years. Given that as many as 2,000 hatchery steelhead per year returned to the basin during some years of the study (Warren et al. 2011), these represented a small number of hatchery fish dispersing to these steams. However, preliminary results from the ISAM (Jim Harbeck, personal communication) and ISEMP (Rick Orme, personal communication) projects suggest that a significant proportion of the steelhead production from the Imnaha River result from spawning in smaller tributary streams. Consequently, small numbers of dispersing hatchery fish at levels similar to that observed by this study could have significant influence to these spawning aggregations. 3) Adult steelhead size at return was similar among the streams with no difference between males and females. Overall steelhead from these spawning aggregate were predominantly less than 78 cm size, with approximately 1.3% of the fish being greater than 78 cm (B-run characterization threshold for mainstem Columbia management purposes). 4) Steelhead captured in Cow and Lightning creeks were 60% age 3 and 40% age 4. Over 90% spent 2 years in freshwater, with a small number that resided for 3 years in freshwater. Ocean age varied between the streams with a significantly higher proportion of 2 ocean fish returning to Lightning Creek. Overall an estimate 37% of the returning adults to Cow and Lightning creeks were spent 2 years in the ocean. It was unclear whether the age differences observed between Cow and Lightning creeks resulted from differences in population dynamics, hatchery fish introgression or was just random. However, age composition differences in spatially close spawning aggregates suggested that the small population size and high hatchery fractions observed in Cow Creek may be influencing age at return in that stream. 5) Adult sex composition indicated greater than 60% of the returning adult steelhead were female. Presence of resident O. mykiss males was documented. 6) The starting and ending and duration of the migration period was similar for all three streams, beginning in early April, peaking in late April and ending in mid May. Upstream migrating fish were captured as early as late March and as late as late May. Unique fish returning in late May apparently spawned after a majority of the earlier spawning fish had migrated downstream past the weir, suggesting a long duration spawning period for steelhead in these streams. Comparisons with spawning aggregates in the upper Imnaha River (ISAM project) will provide important information on the level of run timing diversity in the entire MPG.

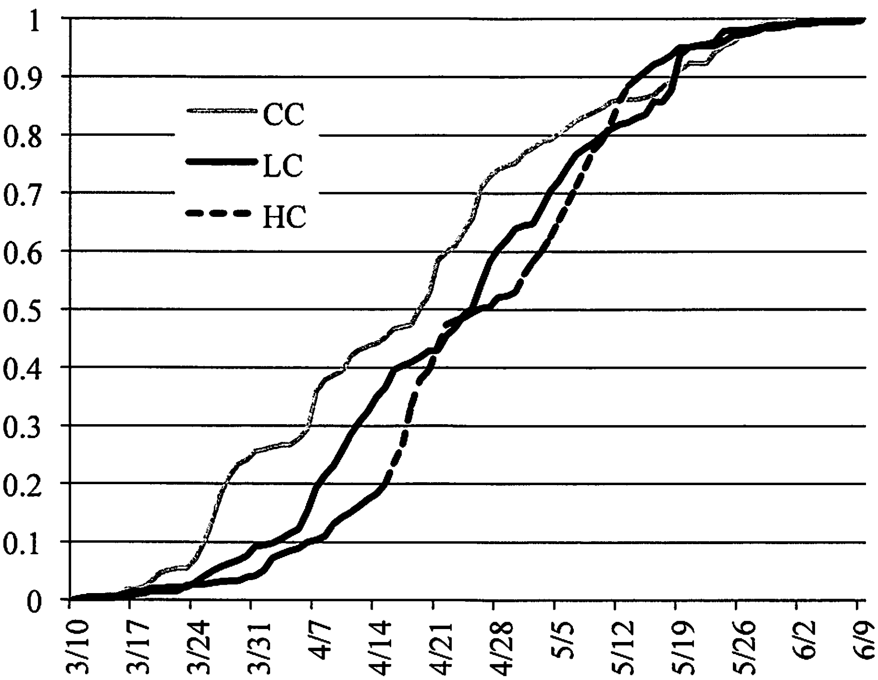

Figure 8. Cumulative run timing of steelhead captured at the Cow Creek (CC), Lightning Creek (LC) and Horse Creek (HC) weirs.

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Steelhead Streamside Incubation Program

LSRCP Steelhead Program Review Presentation
June 21, 2012

Lytle P. Denny and David J. Evans
Shos

Shoshone-Bannock Tribes
Fish and Wildlife Department

Introduction

The Shoshone-Bannock Tribes (SBT) initiated a Steelhead Streamside Incubation (SSI) Program in 1995 to maintain, rehabilitate, and enhance steelhead populations in the upper Salmon River basin. The SSI Program was developed to preserve cultural, traditional, and subsistence-based linkages to anadromous fish.

A research, monitoring, and evaluation (RM&E) strategy was developed in 2005 to guide and inform the SSI Program enhancement efforts. In 2009, a parental exclusion/pedigree analysis was conducted on the adult steelhead (broodstock) used to produce gametes that were outplanted in remote site incubators (RSI) from 2006 – 2008, and compared to juvenile steelhead sampled in tributary habitats of Yankee Fork from 2006 - 2009. The objective of the study was to determine whether the SSI Program produces juveniles, as this was never documented and a much needed step before investing in infrastructure to evaluate whether adults are produced. Parental genotypes of broodstock fish were compared to unknown origin juvenile steelhead sampled in the Yankee Fork to determine relative abundance of SSI progeny. Comprehensive results indicate that from brood years 2006 – 2008, 13.8% of the juvenile steelhead population, encountered in Yankee Fork was of SSI origin (range 11.4% - 16.1%).

The SBT plans to expand upon existing RM&E efforts in Yankee Fork, based upon results from the genetic parentage analysis, while developing new RM&E efforts in Panther and Indian creeks. Future work includes genetic sampling parental broodstock, outplanting genetically marked gametes in RSIs and quantifying the number of juveniles emigrating and ultimately the number of adults that return that are SSI origin. A detailed study design will be included in the SBT RM&E Plan, which is currently being developed.

Background

Prior to 1970, anadromous fish were an abundant and sustainable natural resource that provided ample subsistence opportunities for the indigenous peoples of the Salmon River basin. Since the development of the Federal Columbia River Power System (FCRPS), anadromous fish abundance has been greatly diminished and this has resulted in policy direction changes within the SBT.

Beginning in the 1970's, anadromous fisheries plummeted to levels that could no longer support subsistence-based harvest. By 1972, the Shoshone-Bannock Tribes Fort Bridger Treaty Rights were challenged over a Chinook salmon fishing incident in the Yankee Fork. The State vs. Tinno (1972) decision, favored the SBTs right to harvest anadromous fish and remain sovereign from state and federal jurisdiction.

The SBT recognized the need for internal regulation of Tribal harvest of both fish and wildlife; therefore, the Shoshone-Bannock Tribal Game Code was established in 1975. Regulations included in the Tribal Game Code limited the amount of harvest of Chinook salmon and steelhead to "the reasonable need of his immediate family." At the time of the implementation of the Tribes Natural Resource Ordinance and Policies, "reasonable need" was defined as no more than four salmon per family, per year.

During the 1980's, in response to the precipitous decline of anadromous fisheries in the Salmon River basin, the SBT increased efforts to preserve native fish populations by designating certain areas for harvest (e.g., Yankee Fork), and curtailing other areas (i.e., Bear Valley Creek); however, designated harvest areas were nearly vacant of fish and Tribal interest in traditional fishing practices waned. Despite an occasional "bathtub fishery", Tribal harvest opportunities became more and more limited and cultural values of the SBT were at risk of not being embraced by the younger generations. During this period of time, the SBT maintained a strong policy direction to rebuild natural fish populations and the use of artificial propagation was not a supported enhancement strategy.

In the 1990s, the SBT began to recognize the benefits that hatchery produced Chinook salmon were providing to the South Fork Salmon River fishery (Figure 1). Decent numbers of hatchery fish for harvest were rejuvenating interest in fishing, thus, saving cultural, traditional, and subsistence-based linkages to anadromous fish. In turn, policy makers began to consider making a shift to supporting artificial production as a tool to provide harvest opportunities. Ultimately, the least intrusive artificial propagation techniques (somewhere between gravel and concrete) were pursued by the SBT and a Chinook salmon egg incubation program was proposed to state and federal agencies.

Figure 2. Shoshone-Bannock Tribal youth spearfishing in the South Fork Salmon River, Idaho (photo courtesy of Enrique Patino, NOAA Fisheries).

The Chinook salmon egg incubation proposal did not receive the necessary support from the state and federal agencies, in part, due to a lack of available Chinook salmon broodstock. Intent on initiating a low cost artificial propagation technique that honored the SBT policy of minimally intrusive native fish population management, the SBT proposed using RSIs with steelhead broodstock instead of Chinook salmon. In 1995, the SBT Steelhead Streamside Incubation Program was initiated.

The SSI Program has been in operation since 1995, results indicate the technology can produce juvenile fish. However, the SBT has not been able to determine whether the SSI Program has produced adult fish, which is the primary goal. This report documents the RM&E work that was completed as part of funding received by the Lower Snake River Compensation Plan (LSRCP) to document whether juvenile fish are produced by the SSI Program.

Vision Statement

The decision to implement the SSI Program was a major policy shift for the SBT. A tribe that had been extremely focused on natural production policies was forced to accept artificial propagation or risk losing a lifelong connection to a resource that is inherent in every aspect of the culture that still survives today. Ultimately, the SSI Program fell directly under the "Vision Statement" of the SBT. The Vision Statement is a written expression of the SBT cultural and natural resource values, and pronounces the intention to protect, preserve, and enhance rights reserved by the Fort Bridger Treaty of 1868. This statement reflects the three goals envisioned by Tribal policy makers, and the management objectives by which these goals will be accomplished.

"The Tribes will pursue, promote, and where necessary, initiate efforts to restore the Snake River systems and affected unoccupied lands to a natural condition. This includes the restoration of component resources to conditions which most closely represents the ecological features associated with a natural riverine ecosystem. In addition, the Tribes will work to ensure the protection, preservation, and where appropriate-the enhancement of Rights reserved by the Tribes under the Fort Bridger Treaty of 1868 and any inherent aboriginal rights."

Goals

The SBT initiated the SSI Program in 1995 to help maintain, rehabilitate, and enhance steelhead populations in the upper Salmon River. The clear imbalance of hatchery fish and depleted natural-origin summer steelhead in the Salmon River led the SBT to seek alternative management options for increasing abundance of naturally spawning fish. The primary goal of the SSI Program is to increase adult abundance and provide harvest opportunities for Tribal members. Although the primary goal is to increase harvest opportunities, it is equally important to provide connection with cultural and social values.

The SSI Program was designed primarily to utilize eggs that are considered excess or surplus to those required to meet summer steelhead production goals at nearby local hatcheries. The SBT believe that rather than discard these surplus eggs, they could be used to augment production in Salmon River tributaries where summer steelhead historically spawned and/or are absent.

Management Objectives

Objective 1. Provide traditional harvest opportunities for steelhead in historical fishery areas in the Salmon River basin.

Steelhead numbers in traditional Tribal fishing areas of the Salmon River basin have been eliminated or severely reduced by local habitat degradation and mainstem Snake and Columbia rivers hydropower development. The entire upper Salmon River basin is currently being managed primarily for hatchery-driven fishery mitigation purposes. Hatchery steelhead smolt releases in Salmon River basin provide some opportunity for tribal anglers but most of these fish are intercepted by fisheries downstream from traditional Tribal fish hunting areas. SSI production increases steelhead returns into upper basin tributaries to provide tribal fishery opportunity.

Production Targets

The fish production objectives for the SSI Program, consistent with the *US v Oregon* Agreement, are to incubate and release one million eyed eggs annually. The production targets are as follows: 1) incubate 500,000 eyed-eggs in the Yankee Fork; 2) incubate 400,000 eyed-eggs in Panther Creek; and 3) incubate 100,000 eyed-eggs in Indian Creek.

Operational and Maintenance Objectives

The operational and maintenance objectives include: 1) testing the streamside incubator technology for successful hatching; 2) increasing egg to fry survival; 3) determining optimum RSI densities and configurations; 4) providing incentives for habitat improvements; 5) minimizing cost; 6) minimizing process; 7) minimizing fish handling; 8) increasing community education, involvement, and caring; 9) fulfilling the requirements of *US v Oregon*; 10) fulfilling the requirements of the LSRCP; and 11) fulfilling the requirements of Idaho Power Company mitigation (Kutchins 1995).

Methods

Broodstock Collection and Spawning

Hatchery broodstock for the SSI Program are collected from hatchery adult summer steelhead returning to Sawtooth and Pahsimeroi fish hatcheries, located in the upper Salmon River. Hatchery adult summer steelhead are trapped at weirs from early March through mid-May and held until spawning. Eyed-eggs obtained from Pahsimeroi Fish Hatchery are transferred to RSIs in Panther and Indian creeks, while eyed-eggs obtained from Sawtooth Fish Hatchery are transported to Yankee Fork.

Spawning generally occurs over the same time period of adult trapping. Adult fish are spawned following IDFG spawning protocols. Adults are spawned on a one by one basis and the following information is collected: tissue sample and fork length. Green eggs are water hardened and incubated on well water, and held separately from general production gametes. Upon eye-up, dead eggs are removed and eyed-eggs are prepared for transfer to RSIs.

Remote Site Incubator Configurations and Egg Outplanting

RSIs are constructed in Panther Creek, Indian Creek, and Yankee Fork (Figure 2) from April through May to incubate eyed-eggs. Four RSIs are located in Beaver Creek a tributary of Panther Creek, a single RSI is located in Indian Creek, and five RSIs are installed in Yankee Fork.

All RSIs are standardized to optimum configurations. Each RSI consists of a 189.3 L polyurethane cylinder with an inflow pipe, stand pipe, water diffuser, and outflow pipe (Figure 3a). The RSI contains pea gravel, bio-saddles, and several egg trays (Figure 3b). Gravity flow is achieved using standardized 5.1 cm polyvinyl chloride (PVC) pipe plumbed into the RSI, leading to a 7.6 cm head collection pipe, located 10 – 70 m upstream. The inflow pipe also contains a regulator to adjust flow to the desired gallons/minute setting. Each head pipe is fitted with 0.6 cm mesh screen to minimize sediment and debris collection. A catch tank consisting of a 113.6 L Rubbermaid polyurethane tub with a custom fit cover is attached to the outflow pipe, where volitionally migrating juveniles can transition from the RSI to the natural stream environment.

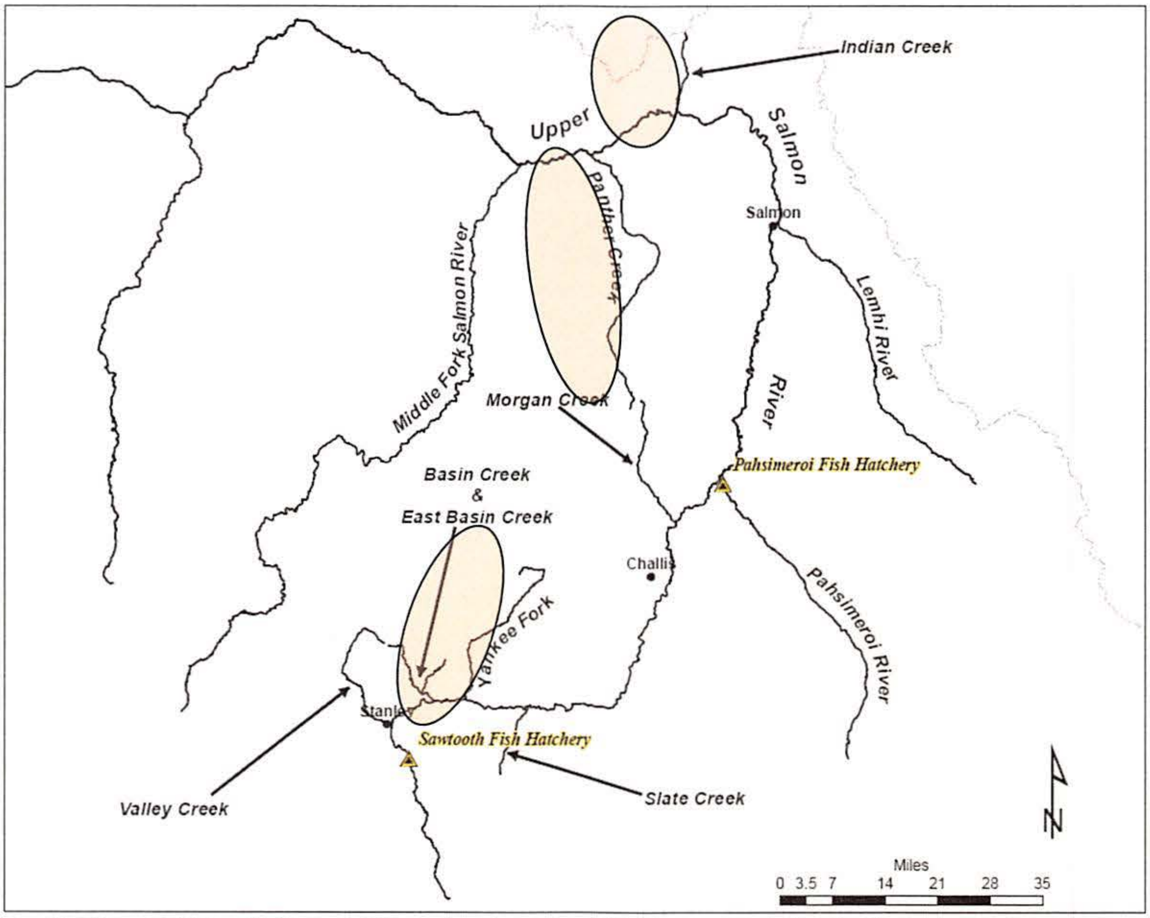

Figure 3. Map of the Salmon River basin and SSI Program tributaries.

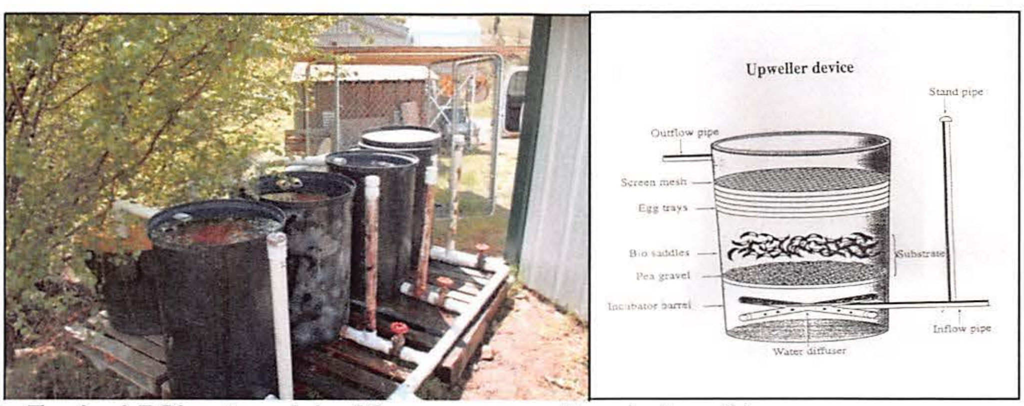

Figure 4. Typical RSI set-up (a) with a cross-sectional view (b).

Eyed-eggs are obtained from the hatchery at least one week prior to the anticipated hatch date. Eggs are loaded into plastic bags filled with river water and O_2, stored in a cooler with ice, and transported to the RSI within a few hours. Using the standpipe and flow regulator, water level is lowered to the height of the desired tray being loaded. The eyed-eggs are gently poured over the tray and then flow is raised to the next tray. This process is continued until the RSI is loaded with the desired egg quota, which is generally about 100,000 eggs or 20,000 – 25,000 eggs per tray. Once all of the eggs are loaded, the standpipe is raised and flow is adjusted. Flow is monitored regularly through the incubation process.

Incubation and Hatching Success

RSIs are monitored and maintained at least one a week after installation from April until removal in July or August. Chemical monitoring includes recording flow, water height, and temperature. Biological monitoring includes recording embryo stage development and ultimately hatch success. Upon full volitional fry emigration, fry production is estimated by enumerating dead eggs and dead fry remaining in the RSI or catch tank.

Program Accomplishments

Several types of incubation units have been used and evaluated, including RSIs constructed from discarded refrigerators, commercial upwelling incubators of various sizes, and in-stream incubation systems (e.g., wooden boxes, Jordan-Scotty, and Haddix boxes) (Haddix 2000). RSIs that are upwelling units have become the sole unit used to incubate eyed-eggs in the SSI Program since 2007. A properly functioning RSI unit typically exceeds 95% hatch success.

From 1995 – 2010, the SSI Program outplanted 14,903,040 eyed eggs and seeded 12,321,905 fry in twenty eight different locations (Table 1). The number of eggs incubated in a given year ranges from 201,600 in 1995 to 1,135,510 in 2008. Over this period, survival from eyed-egg to hatching averaged 81.9% (range 56.8% in 2004 to 99.3% in 2005). The number of individual RSI sites has decreased from 23 in 2003 to 10 in 2012.

Table 2. Number of eyed-eggs planted and hatched as part of the SSI Program from 1995 – 2010.

Year	Eggs Planted	Eggs Hatched	% Hatch
1995	201,600	149,570	74.2%
1996	646,000	510,000	78.9%
1997	1,000,000	755,000	75.5%
1998	1,050,210	856,751	81.6%
1999	836,960	632,388	75.6%
2000	874,181	722,948	82.7%
2001	976,297	880,641	90.2%
2002	845,585	815,379	96.4%
2003	1,085,431	1,053,509	97.1%
2004	1,004,939	570,333	56.8%
2005	1,109,730	1,101,941	99.3%
2006	989,608	606,792	61.3%
2007	1,070,051	896,278	83.8%
2008	1,135,510	1,044,319	92.0%
2009	1,010,461	900,217	89.1%
2010	1,066,477	825,839	76.8%
Total	14,903,040	12,321,905	81.9%

Research, Monitoring, and Evaluation

Since its initiation in 1995, the SBT have demonstrated a strong ability to hatch eyed-eggs in almost any setting. Production targets for hatching have been achieved and public outreach objectives have been met both on and off of the reservation. In fact, the Shoshone-Bannock High School has been involved in the project through the "Dance of the Salmon" program and numerous adolescents have been taught the value of protecting natural resources. In addition, private landowners have and continue to participate in the SSI Program by allowing us to place the RSIs on their land and/or use their water. We've also completed some preliminary monitoring and evaluation studies using DNA parentage analysis, and recently, secured funding to fully implement a long-term RM&E Plan.

The Tribes RM&E approach in the Yankee Fork was: 1) spawn and genotype hatchery adult steelhead; 2) collect and incubate fertilized eggs; 3) incubate eyed-eggs in RSIs; 4) release fry volitionally from RSIs; 5) collect age 0+ parr during first fall; 6) collect age 1+ parr during second fall (Figure 6). Upon collection of tissue from age 0+ and 1+ parr, samples were analyzed to genotype fish back to either streamside incubator or natural origin.

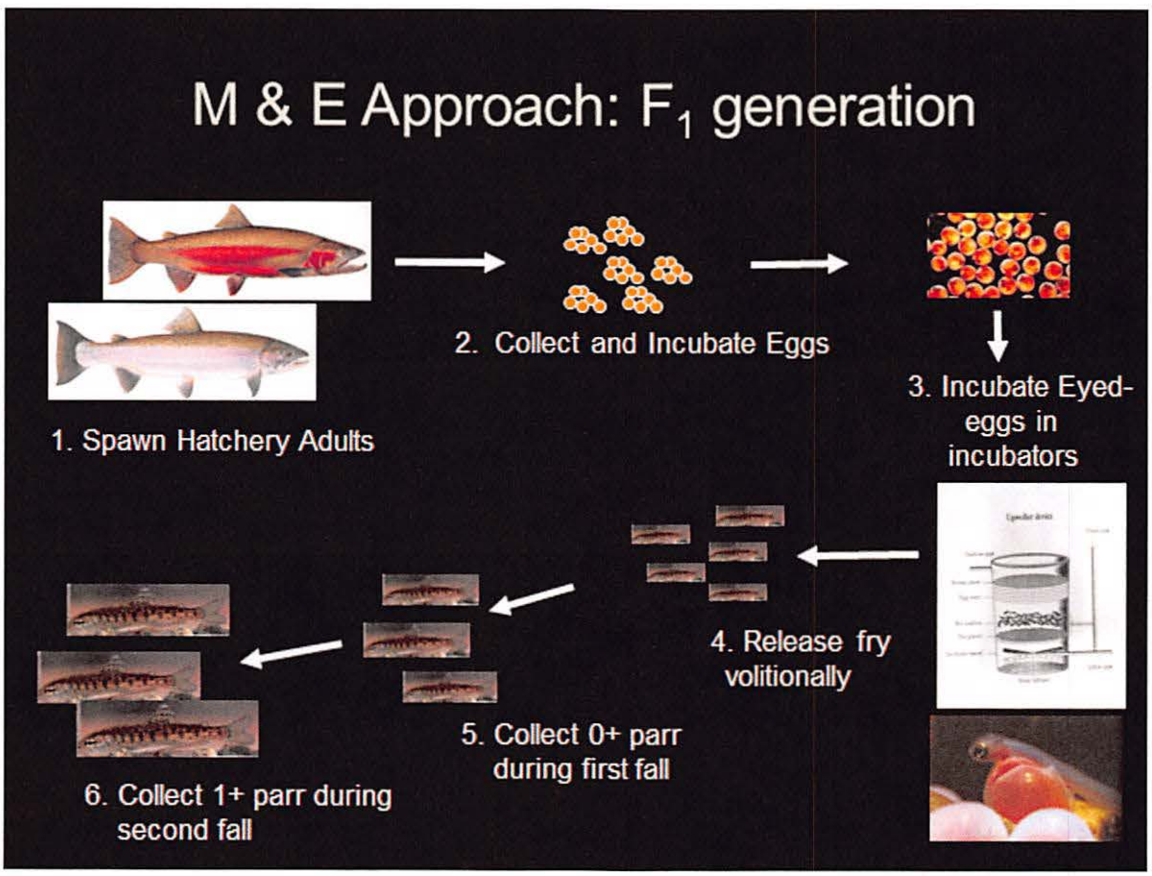

Figure 5. Monitoring and Evaluation approach through F_1 generation.

Parental based tagging is an approach that uses inherent genetic differences among individual fish to use parentage assignment of stocked offspring as an internal, non-destructive, tag to identify released animals and evaluate their growth, movement, and/or survival rates (Lethcher and King, 2001). Pairs of hatchery adults (P1) are spawned then genotyped using 14 microsatellite DNA loci. Gametes produced from the P1 adults are incubated in assigned trays at local hatcheries until they reach the eyed-egg stage of development. Once the eyed-eggs are water hardened and ready to be placed in the RSIs, each family is tracked and placed in pre-assigned RSI trays. Hatch success is monitored for each tray/family, and the resulting fry (F1) are volitionally released into the river. During the first and second fall following release, tissue from age 0+ and age 1+ parr are collected, respectively. A parental exclusion/pedigree analysis is used to differentiate juvenile steelhead produced by the SBT streamside incubator project from all other steelhead produced naturally or planted artificially in the study watershed.

Juvenile sampling was conducted in the Yankee Fork drainage during September of 2006, 2007, 2008, and 2009 to determine whether SSI progeny were surviving. Following Kondpacky et al. (1985, 1986), the Yankee Fork drainage was divided into seven distinct strata; three reaches were selected within each stratum including Pond Series 1 and 3 except for stratum five which contained four reaches (Figure 7). The 25 total sites were selected for a variety of habitats (pools, glides, riffles) and ease of accessibility for an upper, middle, and lower location within each stratum. Sites were generally rectangular in shape, aligned with the shoreline, and divided into transects for habitat measurements.

Multiple-pass electrofishing requires closed populations to minimize emigration and immigration; hence the use of block nets. Sites were predominately 100 m in length, but did reach above 100 m due to habitat inclusion and accessibility for block net placement. Upstream and downstream ends of the sampling reach were blocked using 7-mm-mesh nets secured to the streambed with tri-pods and rebar, generally at habitat unit separations. Sites were electrofished in an upstream direction between 20 – 30 minutes with one crew member electroshocking (Smith-Root, Inc. Pulsed DC LR-24 Backpack Electrofisher) and two to three others utilizing dip nets to capture fish drifting downstream under electronarcosis. Voltage and frequency were adjusted and monitored to maximize capture, but limit fish injury (voltage: 350-450, frequency: 30-50 Hz, duty cycle: 10-12%). Fish were transferred immediately to a bucket and then to a holding tub for further analysis.

Population estimates and probability of capture was calculated using model $M_{(b)}$ (Zippen removal population estimator, Zippen 1956) by the program CAPTURE. CAPTURE computes estimates of capture probability and population size for all electrofishing passes based on a stationary population, equal probability of capture for each animal, and constant probability of capture.

Adult steelheed were spawned by the SBT at Sawtooth Fish Hatchery in 2006-2008. During this period, tissue samples were taken from 1194 age 0+ and 243 age 1+ juvenile steelhead collected from electrofishing efforts (Table 2). In addition, approximately 295 age 1+ steelhead were collected in the rotary screw trap. Comprehensive analysis of the number of assignments showed an overall RSI contribution to the Yankee Fork steelhead population of 0.140, 0.161, and 0.114 in 2006, 2007, and 2008, respectively (Table 2).

Genetic Parentage Analysis

Parentage assignment with real data

Parentage assignments observed in the brood year 2006 (Matala and Ardren 2008), 2007 (Williamson and Matala 2009), and 2008 Yankee Fork pedigree analyses provide evidence that juvenile steelhead trout produced by the SSI Program successfully emerge and survive in-stream through the first year of life (Table 2). The 2008 parentage assignment identified 64

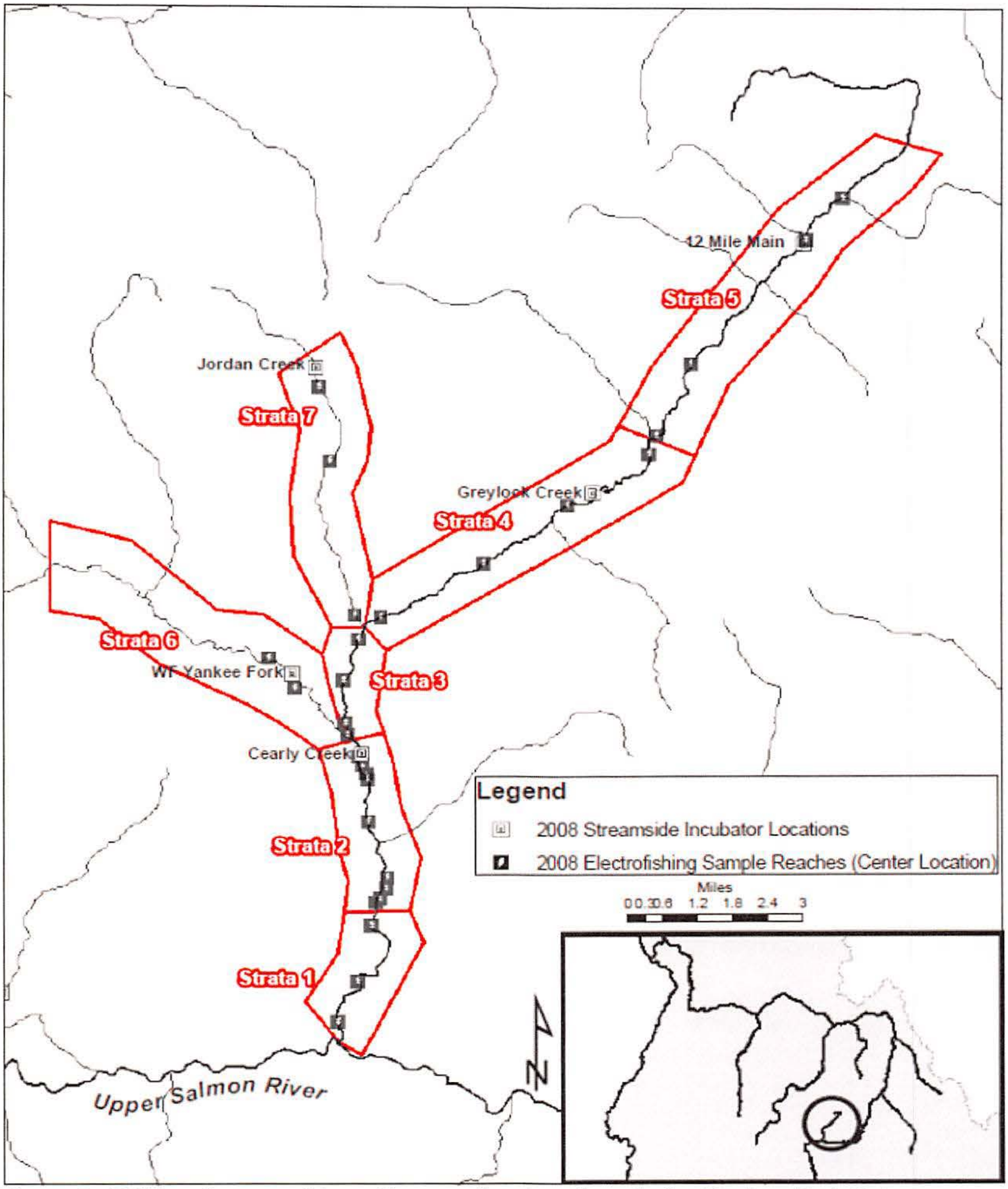

Figure 6. RSI incubator and juvenile sampling locations in the Yankee Fork Salmon River, Idaho, 2008

age-0^{+} and 6 age-1^{+} juveniles produced from RSIs, with an overall assignment proportion of 0.114 RSI juveniles produced from the 2008 spawning efforts among all steelhead juveniles genotyped (N = 614). The overall proportion of RSI assigned juveniles in the 2008 analysis was similar to that observed in the brood year 2006 (0.131; Matala and Ardren 2008) and 2007 (0.135; Williamson and Matala 2009) analyses. Not surprisingly, the comprehensive parentage analysis that utilized the combined 2006 to 2008 datasets detected additional age-1^+ and age-2^+ RSI assigned steelhead in Yankee Fork. The brood year 2007 age-2^+ individuals were primarily detected at the rotary screw trap as they emigrated from Yankee Fork in 2009. Detection of these age-2^+ smolts provides evidence that juvenile steelhead trout produced by the SSI Program continue to survive in-stream through the second year of life and that the age of seaward migration may vary for juvenile steelhead produced from the streamside upweller program. Comparison of the proportions of RSI and natural-origin age-2^+ steelhead smolts that emigrate from Yankee Fork could not be performed since age-specific data (i.e. scale or otolith samples) were not taken from migrating natural-origin steelhead smolts. The estimated abundance of age-0^+ *O. mykiss* in Yankee Fork for 2008 was 36,647 juveniles, with an estimated 7,786 individuals produced by the streamside incubators.

Table 3. Comparison of the number of parent pair/offspring assignments detected by either single year parentage analyses (i.e., assignment of juveniles collected during 2007 electrofishing and 2008 screw trap sampling to 2007 brood stock), or comprehensive parentage analysis (i.e., assignment of all juveniles collected between 2006-2009 to combined 2006-2008 brood stock).

	No. of steelhead genotyped				Single year analysis			Comprehensive analysis			
		Electrofishing		Trap	No. of ssignments			No. of assignments			
Year	Brood stock	Age-0^+ Juveniles	Age-1^+ Smolts	Age-1^+ Smolts	Age-0^+ Juveniles	Age-1^+ Smolts	Overall HAT	Age-0^+ Juveniles	Age-1^+ Smolts	Age-2^+ Smolts	Overall HAT
2006	104	349	123	--	57	5	0.131	57	5	4	0.140
2007	174	459	120	67	72	15	0.135	72	20	12	0.161
2008	213[a]	386[b]	0	228	64	6	0.114	64	6	--	0.114
totals:	491	1194	243	295	193	26		193	31	16	

[a] One duplicate individual detected in 2008 brood stock was excluded from parentage analyses.
[b] Includes four age-0^+ steelhead sampled at the West Fork Yankee Fork screw trap in 2008.

Progeny distribution and movement

Similar to the brood year 2007 analysis (Williamson and Matala 2009), brood year 2008 RSI juvenile steelhead were not evenly distributed throughout the Yankee Fork drainage system (Table 3). The majority of the brood year 2008 age-0^+ and age-1^+ RSI assigned offspring were encountered in stratum #4 and one of the dredge ponds in stratum #2 (Figure 7; Table 4). In contrast, the majority of brood year 2007 RSI assigned juveniles offspring were encountered in stratum #7 (Williamson and Matala 2009). Comparison between the brood year 2007 and 2008 age-0^+ RSI progeny distributions may be made for only strata #2, #3, #4, #6, #7. Between 2007 and 2008, no significant differences were observed in the percentage of age-0^+ RSI assigned juveniles encountered in the five strata compared (data not shown). Many (83%) of the age-0+ steelhead encountered within dredge pond (series #3; located in stratum #2) were RSI assigned individuals. None of the brood year 2008 RSI steelhead were detected elsewhere in stratum #2. Interestingly, all juveniles sampled in stratum #2, site-2 in previous parentage analyses of brood year 2006 (Matala and Ardren 2008) and 2007 (Williamson and Matala 2009) were RSI assigned. Since RSI progeny have been consistently encountered from year to year within stratum #2, this region of Yankee Fork may represent favorable or preferred rearing habitat for

RSI juvenile steelhead produced by the streamside upweller program in Yankee Fork. Brood year 2008 age-1$^+$ RSI assigned offspring were encountered only at the rotary screw trap on the mainstem Yankee Fork. Since age-1$^+$ steelhead were not captured in the Yankee Fork tributaries during the fall 2008 electrofishing surveys, comparison of the distributions of brood year 2007 and 2008 RSI age-1$^+$ steelhead within Yankee Fork could not be performed.

Table 4. Parentage assignment results from the progeny perspective. The numbers of parent-progeny matches are reported for each juvenile collection location (e.g., stratum and site).

		Age-0$^+$ juveniles			Age-1$^+$ juveniles		
Location		n sampled	# HAT assigned	% HAT assigned	n sampled	# HAT assigned	% HAT assigned
Stratum 1	Site 1	14	0	0	0	0	0
	Site 2	14	0	0	0	0	0
	Site 3	13	0	0	0	0	0
Stratum 2	Site 1	24	0	0	0	0	0
	Site 2	9	0	0	0	0	0
	Site 3	21	0	0	0	0	0
Stratum 3	Site 1	23	0	0	0	0	0
	Site 2	28	0	0	0	0	0
	Site 3	24	1	4	0	0	0
Stratum 4	Site 1	26	0	0	0	0	0
	Site 2	25	22	88	0	0	0
	Site 3	--	--	--	0	0	0
	Site 4	25	10	40	0	0	0
Stratum 5	Site 1	--	--	--	--	--	--
	Site 12M	--	--	--	--	--	--
Stratum 6	Site 1	25	1	4	0	0	0
	Site 2	25	2	8	0	0	0
	Site 3	25	0	0	0	0	0
Stratum 7	Site 1	4	1	25	0	0	0
	Site 2	--	--	--	--	--	--
	Site 3	14	7	50	0	0	0
Pond	Series 1	19	0	0	0	0	0
Pond	Series 3	24	20	83	0	0	0
Screw Trap		4[a]	0	0	228	6	3
Overall by age-class		386	64	17[b]	228	6	3[b]

[a] Age-0+ steelhead sampled at the West Fork Yankee Fork screw trap in 2008.

[b] These values are the % HAT assigned by age-class.

Since family identity was preserved during egg outplant and the identity of the 2008 brood stock pairs represented in each RSI was recorded, data describing the migratory behavior, habitat preference, and successful RSI site selection for all RSI assigned juvenile steelhead trout during their first year of life in the Yankee Fork watershed may be documented. Comparison of the locations where brood year 2008 age-0^+ RSI juvenile steelhead had been outplanted into an RSI and where they were subsequently captured indicated that juveniles are often not encountered in the same stratum into which they had been outplanted. In fact, 25 of the brood year 2008 RSI assigned steelhead initially placed into and incubated in the streamside upweller on Jordan Creek (stratum #7) were subsequently encountered downstream within stratum #4. Likewise, temporally replicate field sampling of a brood year 2007 putative natural-origin juvenile was observed, first as an age-0^+ individual in stratum #7 and subsequently as an age-1^+ individual in stratum #1 (Williamson and Matala 2009). These observations coincide with those of other studies showing that movement of juvenile Chinook salmon and steelhead trout during the first year of life will be relatively small, and in a predominantly downstream direction (Richards and Cernera 1989; Close and Anderson 1992; Peery and Bjornn 2000).

The comprehensive parentage analysis permitted an expanded assessment of RSI production in Yankee Fork for brood years 2006 and 2007 and provided evidence that at least some RSI juveniles migrate seaward as age-2^+ individuals. Interpretation of the results and inferences about changes in the overall distribution of RSI steelhead in Yankee Fork as well as the age of seaward migration of RSI progeny requires a cautious approach. First, the Yankee Fork sub-basin experiences periods of high water flow (K. Tardy, personal communication) which may create a dynamic environment wherein the accessibility, location, and quality of suitable rearing habitat may change from year to year. Second, the Sawtooth Hatchery also has a program to release age-1^+ juveniles into the Yankee Fork (Denny and Tardy 2008). Migratory behaviors perpetuated and inherited through a history of domestication selection (Lynch and O'Hely 2001; Ford 2002) in the hatchery may be conveyed to RSI progeny outplanted into RSIs. For instance, RSI origin trout may have a tendency to migrate at a younger age relative to their natural-origin counterparts, thus fewer age-1^+ RSI steelhead were detected, compared to age-0^+ RSI and age-1^+ natural-origin steelhead, throughout Yankee Fork. Alternative explanations may be that age-0^+ juveniles migrate to more hospitable over-wintering habitat in the mainstem Salmon River, and/or RSI juvenile steelhead have lower survival relative to natural-origin juveniles.

Descriptive statistics

Patterns of observed allelic diversity or the brood year 2008 genetic analysis were similar to those observed during the previous analysis for 2007 (Williamson and Matala 2009). Similar to previous analyses of genetic diversity of brood year 2006 (Matala and Ardren 2008) and 2007 (Williamson and Matala 2009) Yankee Fork steelhead, departures from HWE expectations primarily occurred at *Omy77* and *Ots1*. The observed number of private alleles was higher (10 over all 17 loci) in the 2008 brood stock compared to all putative natural-origin and the RSI assigned collections (range: 0-4 over all 17 loci). A similar pattern was observed in the 2007 brood year analysis (Williamson and Matala 2009). Likewise, higher linkage disequilibrium, was detected in both the brood year 2007 (Williamson and Matala 2009) and 2008 brood stocks compared to all putative natural-origin and the RSI assigned collections. This evidence suggests that steelhead obtained from the Sawtooth Fish Hatchery and used as brood stock in the 2007 and 2008 Yankee Fork SSI program may represent admixed samples, or have family structure owing to the brood stock collections containing a higher proportion of RSI individuals. However, unlike the brood year 2007 analysis, moderate levels of LD were also detected in multiple 2008 natural-origin juvenile collections (strata #3, #4, and #6). Linkage disequilibrium observed for putative natural-origin juvenile collections may indicate sample admixture between the offspring of recognized resident rainbow trout and naturally spawning RSI steelhead.

Population differentiation

Clear differences exist between the 2008 RSI collections (brood stock and assigned juveniles) and the remaining putative natural-origin collections. This pattern is similar to that observed for earlier analyses [brood year 2006 (Matala and Ardren 2008); brood year 2007 (Williamson and Matala 2009)], and is illustrated in Figure 5. Each of the RSI groups are dispersed (rather than all RSI collections being clustered together) in the topology of the phenogram (Figure 6). This arrangement indicates that year to year variation in allele frequencies occurs within the brood stock collections taken for the Yankee Fork SSI Program. Two possible explanations follow. First, logistical limits on the numbers of adults selected as brood stock for the Yankee Fork SSI program may preclude a representative sample being taken each year from the Sawtooth Fish Hatchery. Numbers of brood stock for 2007 and 2008 were 174 and 213 individuals, respectively. Given these numbers of adults, it seems unlikely that the broodstock collections do not constitute representative samples on the sole basis of low numbers. Second, adult steelhead taken at the Sawtooth Fish Hatchery may represent either an admixed sample, or contain family structure. It is conceivable that yearly differences in the degree of sample admixture and/or family structure may lead to significant allele frequency differences in the collections of adults taken as brood stock for the SSI Program from year to year. Elevated linkage disequilibrium and higher numbers of private alleles observed in the 2007 and 2008 brood stock collections suggest that family structure may be a more plausible explanation. In addition, a limited number (3-4) of artificial spawning events were performed over a fairly short period (2-3 weeks) for brood years 2007 and 2008. It is possible that the limited number of spawning events performed over a relatively short period do not necessarily capture a representative sample of the genetic diversity of steelhead that return to Sawtooth Fish Hatchery. Comparison of a collection of Sawtooth Fish Hatchery steelhead that were sampled over the entire duration of the Sawtooth Fish Hatchery spawning run with the 2007 and 2008 collections of adults selected as brood stock for the Yankee Fork SSI Program would provide a way to resolve the explanations (i.e. admixture or family structure) of the observed genetic signals (i.e. higher LD detected and number of private alleles observed) in the brood stock used to seed the RSIs.

Future Work

A comprehensive RM&E Plan is currently being drafted by the Shoshone-Bannock Tribes Fish and Wildlife Department that will serve as a guide for future work in the Salmon River basin, and a reference for all co-managers on the policy and direction of our growing program.

Future monitoring will track the number of parent fish (P_1) spawned, and subsequent F_1 juveniles that survive and migrate out of the treated watershed and return as F_1 adults to spawn. A similar approach will be used to track the productivity of F_1 adults that produce F_2 juveniles that survive and migrate out of the watershed and return as F_2 adults to spawn. Research, monitoring, and evaluation is planned to determine the overall contributions of fish resulting from the SSI Program. RM&E components include: 1) operating rotary screw traps; 2) operating weirs; 3) conducting creel surveys; 4) conducting electrofishing surveys; and 5) operating PIT tag arrays.

Overall, the Tribes will determine the number of adults that return from SSI Program activities.

Continued genetic evaluation is critical to determine the long-term efficacy of steelhead streamside supplementation activities. Limited information on numbers of returning adults, redd counts, size of the natural origin population, and migration timing restricts our ability to fully estimate the relative productivity of upweller supplementation. The SBT propose that the addition of a weir and continued screw trap operation would greatly increase the ability to document the natural spawning population and estimate the efficacy of RSIs at increasing population abundance in Yankee Fork.

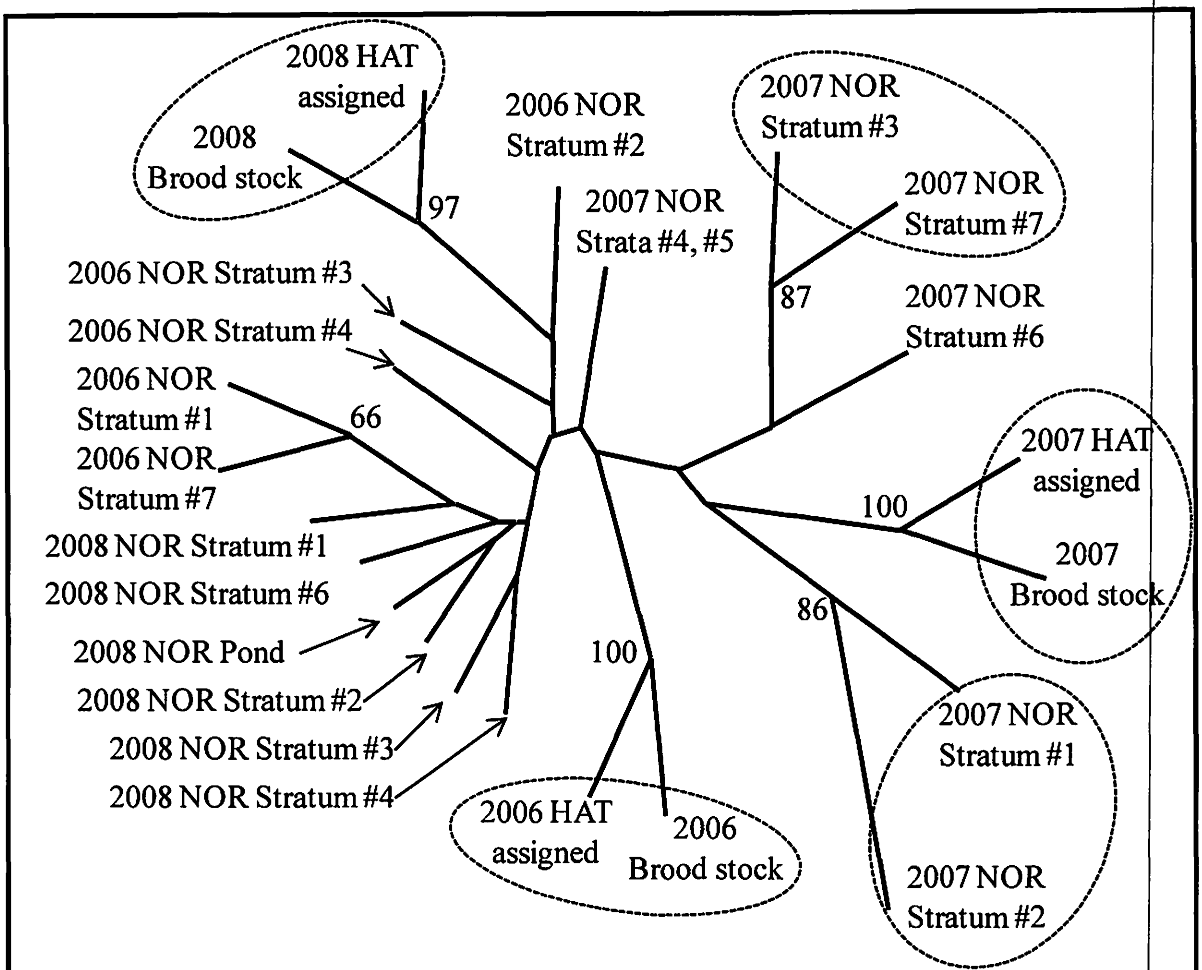

Figure 7. Unrooted Neighbor-joining phenogram based on Cavalli-Sforza and Edwards (1967) chord distance units among the 2006 to 2008 Yankee Fork age-0$^+$ steelhead trout juveniles grouped by stratum where they were sampled. The phenogram was constructed with PHYLIP (Felsenstein 1989) using data from 14 microsatellite loci. For 1000 boot-strap replicates, node values of 50% and greater are given. Clusters of samples for which there is strong bootstrap support are circled. Based on parentage assignment to adults used to supply streamside upwellers from 2006 to 2008, juvenile fish were classified as hatchery origin (HAT). Remaining putative natural origin (NOR) individuals were grouped according to year and sampling strata within Yankee Fork.

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Life History and Abundance of Native Summer Steelhead in Lookingglass Creek, Oregon

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Abstract

The operation of the Lookingglass Hatchery adult trap and Lookingglass Creek rotary screw trap enables managers the opportunity to collect life history data across both juvenile and adult life stages for Lookingglass summer steelhead. Adult wild summer steelhead returning to the Lookingglass Hatchery trap averaged 188 during run years 2001-2011. Catches correlated well with wild "A" run catches at Lower Granite Dam, and sex ratios were dominated by females (approximately 60% of the catches each year). Mean FL fluctuated around 650 mm each year. The percentages of the catch considered as resident rainbow trout were usually less than 5% of the total catch and "large" fish (>78 cm FL) less than 4%. One-ocean and two-ocean returns were dominant with much lower numbers of three-ocean fish. Mean FL at age for males and females were similar. Arrival timing at the trap was usually early April for males and late April for females. For all but two years, the percentage of hatchery fish was 0-2% of the total catch. Detections at the Lookingglass Hatchery trap of adults tagged as outmigrating juveniles showed most returns passing Bonneville Dam in July-August and Lower Granite Dam in August-November prior to spring arrival at the Lookingglass Hatchery trap. Adults that were PIT tagged at Lower Granite Dam were usually tagged during the months of July-November prior to spring

arrival at the Lookingglass Hatchery trap. A few fish of each group moved into freshwater in the spring and rapidly moved up the hydrosystem to Lookingglass Creek.

Juvenile outmigrants averaged 33,132 for 9 completed migration years from 2001-2011. Most juveniles out-migrants left during the spring season (mean 61%). Mean FL of outmigrants was highest during March-April and September-October, at approximately 150 mm. Outmigrants were freshwater ages 0-3, but age 2 was dominant. Survival probabilities to Lower Granite Dam for fall groups ranged from 0.15-0.30, and from 0.30 -0.90 for spring groups with most in the 0.50-0.70 range. Median arrival dates at Lower Granite Dam were similar for fall and spring groups and were usually during the first three weeks of May. Mean travel times were about 200 d for fall groups and 10-20 d for spring groups. Mean FL at tagging for fall groups detected the following spring were 150-160 mm FL, while mean FL at tagging for spring groups detected the same spring was slightly larger.

Abundances of both returning adults and juvenile outmigrants on average were about 3 times higher during 2001-2011 compared to data from the late 1960s. Adults arrived at the trap earlier in the late 1960s compared to 2001-2011. Small numbers of returning adults enter freshwater in the spring and rapidly move through the hydrosystem to Lookingglass Creek. Other life history attributes for both adults and juveniles are similar to those reported for the late 1960s for Lookingglass Creek and other populations in the region.

Lookingglass Creek is a significant part of the Upper Grande Ronde major population. Group designated for recovery planning. Catches of adults for the last decade have shown relatively little variability, indicating a stable population. Observed differences in adult returns and juvenile outmigrants between the late 1960s and current period may be explained by differences in hydrosystem conditions, ocean productivity, or interspecific relationships.

Introduction

Many anadromous salmonid stocks in the Snake River Basin have declined to the point of extinction, principally due to construction and operation of hydroelectric facilities, overfishing, and the loss and degradation of critical spawning and rearing habitat (Nehlsen et al. 1991). The Grande Ronde River Basin once supported large populations of fall and spring Chinook (*O. tshawytscha*), sockeye (*O. nerka*), and coho (*O. kisutch*) salmon and summer steelhead (*O. mykiss*), and these populations have declined for similar reasons (U. S. Army Engineer District 1975, Nehlsen et al. 1991).

Hatcheries were built in Oregon, Washington and Idaho under the LSRCP to compensate for losses of summer steelhead due to the construction and operation of the four most downstream Snake River dams. Co-managers began augmenting populations in the Grande Ronde River using non-endemic Wallowa Hatchery stock in the early 1980s and Sport harvest was reopened in 1986 (Flesher et al. 2008). Natural summer steelhead populations continued to decline and Snake River summer steelhead were listed as threatened under the Endangered Species Act of 1973 on 18 August 1997. Co-managers discontinued off-station releases of Wallowa Hatchery stock summer steelhead into Catherine Creek (1998) and the upper Grande Ronde River (1999) due to high stray rates.

Little was known about native summer steelhead in the Grande Ronde subbasin prior to the late 1960's. Adult and juvenile bypass traps were installed near the current site of Lookingglass Hatchery in 1964, providing adult data for run years 1964-1974 (Burck 1993). McLean et al. (2001) summarized unpublished 1965-1974 return data for Lookingglass Creek summer steelhead collected by Wayne Burck (ODFW). Adult counts at the Lookingglass hatchery trap have also been compiled since 1997. The Lookingglass Creek summer steelhead population appears to be doing well in relatively undisturbed habitat with little influence from hatchery fish.

A juvenile bypass trap was operated on Lookingglass Creek and data for outmigrating *O. mykiss* were obtained for migration years 1966-1969 (Mullarkey 1971). We have captured juvenile *O. mykiss* in the Lookingglass Creek screw trap since 1992, and began PIT-tagging juvenile *O. mykiss* during the spring of 1999 to describe arrival timing and survival to Snake and Columbia River dams and other aspects of life history. A summary of life history information for several Grande Ronde subbasin tributaries is contained in Anderson et al. (2011). Operations of the Lookingglass Creek adult and rotary screw traps were initiated to evaluate reintroduction of spring Chinook salmon above the Lookingglass Hatchery trap. The presence of these traps provided a good opportunity to obtain valuable life history information on ESA-listed summer steelhead.

The goal of this work is to provide basic life history data to guide management actions that aid in recovery of ESA-listed Snake River summer steelhead.

The preceding goal is consistent with the overall mission statement of the CTUIR Department of Natural Resources:

"To protect, restore, and enhance the First Foods; water, salmon, deer, cous, and huckleberry - for the perpetual cultural, economic, and sovereign benefit of the CTUIR. We will accomplish this utilizing traditional ecological and cultural knowledge and science to inform: 1) population and habitat management goals and actions; and 2) natural resource policies and regulatory mechanisms."

The CTUIR DNR Fisheries Program mission statement is:

"To provide sustainable harvest opportunities for aquatic species of the first food order by protecting, conserving and restoring native aquatic populations and their habitats."
Individual reports summarizing Lookingglass Creek summer steelhead life history data are available at http://www.fws.gov/lsnakecomplan/Reports/CTUIRreports.html

Study Area

The Lookingglass Creek watershed is in the Blue Mountains of northeast Oregon with the headwaters at an elevation of 1,484 m above sea level (Figure 2). Flow is to the southeast for 25 river km (rkm) through the Umatilla National Forest then through private land before entering the Grande Ronde River at rkm 137, at an elevation of 718 m above sea level. Lookingglass Creek has five major tributaries: Lost Creek, Summer Creek, Eagle Creek, Little Lookingglass Creek, and Jarboe Creek. Nearly all summer steelhead spawning occurs in Lookingglass Creek and Little Lookingglass Creek. Lookingglass Hatchery is located at approximately rkm 4.0 on Lookingglass Creek.

Methods

Standard methods were used to collect summer steelhead and obtain data (Johnson et al. 2007). Adults were collected in the Lookingglass Hatchery weir and trap near the water intake (Figure 1). The weir consists of horizontal pickets over a concrete or rock apron for about 2/3 the width of the stream, with vertical removable metal pickets for the remainder. The fish trap consists of a steep pass fish way leading into a fyke, then into the fish holding area. The trap is installed about 1 March annually by ODFW Lookingglass Hatchery staff. The trap is normally checked Monday-Wednesday-Friday but more frequently if large numbers of fish are being trapped. The horizontal pickets also allow downstream passage of fish, as long as sufficient flow occurs. This means that some upstream migrants passed upstream are recaptured in the trap, and that post spawn fish are rarely recaptured. Week of capture was designated by the first day of the week (e.g. week of 1 January included 1-7 January). Hatchery-origin returns were euthanized and removed from the stream. Wild adults were transported about 0.6 rkm upstream and released.

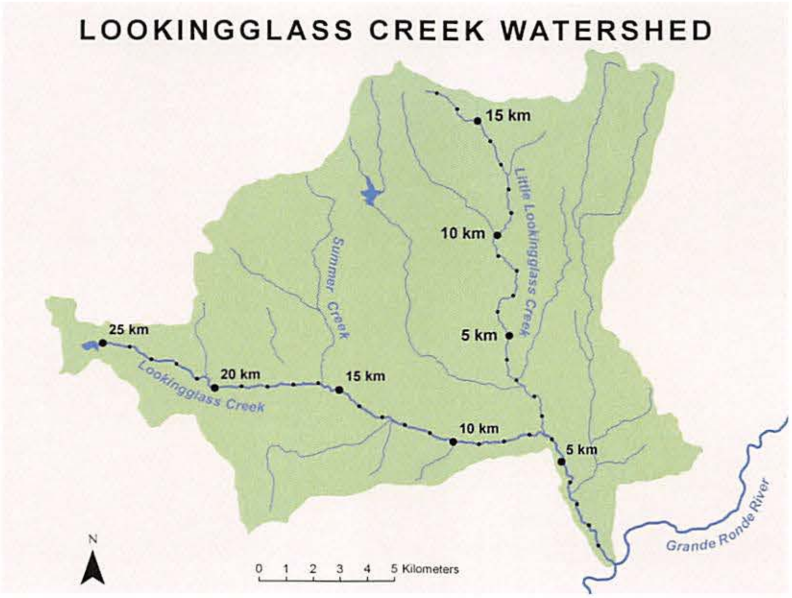

Figure 1. Lookingglass Creek watershed.

Data collected for each trapped fish included fork length, sex, and any external (fin clips, radio or other tags) and internal (PIT tags) marks or tags. Fish were anesthetized in MS222 until 2010, thereafter, fish were handled "hot" (without anesthetic). Tissues collected included scales for age determination and opercle punches for genetics analysis (Narum et al. 2006). Data and tissues were collected from all fish, including those that were less than 50 cm FL. Fish less than 50 cm (i.e. 20 in.) are assumed to be resident *O. mykiss* and not anadromous returns. Sex was based on external characteristics (snout, belly and vent appearance). Fish were scanned using a Digital Angel FS2001F PIT tag reader. Scales were taken from the standard area just above the lateral line on a diagonal from the posterior end of the dorsal fin to the anterior end of the anal fin. Scales were placed in envelopes, dried, and hot-pressed onto cellulose acetate for later examination under a microfiche reader. Freshwater and saltwater annuli were determined using characteristics by Mosher (1969).

Measures used to describe adult life history included escapement, sex ratio, size composition, age composition (ocean), fork length-at-age, arrival timing at trap, % hatchery-origin, and detections at the trap of PIT-tagged returns.

Figure 2. Lookingglass Hatchery adult fish trap located at rkm 4.0 on Lookingglass Creek near the hatchery water intake.

Figure 3. Summer steelhead sampling at the Lookingglass Hatchery trap.

We collected outmigrating juvenile *O. mykiss* using the 1.52 m diameter rotary screw trap at rkm 4.0 on Lookingglass Creek near Lookingglass Hatchery. The screw trap was operated continuously during 2007-2008 except for brief periods during the spring freshet, when flows were low and temperatures high (July-August), and when iced up in winter. The trap was usually checked 3 times a week or more frequently if catches or flows were high. All *O. mykiss* were enumerated, examined for external marks, scanned with a PIT tag reader, measured (nearest mm FL), and weighed (nearest 0.1 g). First-time captures in good condition (no injuries or obvious disease) were PIT-tagged using standard methods (PIT Tag Steering Committee 1999). In most years, a lower length limit of 80 mm FL was used. Some fish received a partial fin clip (lower caudal) instead of PIT tag and were released above the trap to supplement the PIT-tagged sample for trap efficiency estimates. Recaptures of fin-clipped fish were apportioned to the various recapture periods using the percentages observed for PIT-tagged recaptures. All newly-PIT tagged and clipped outmigrants were released about 100 m above the screw trap; recaptures were released about 0.3 rkm below the screw trap.

Figure 4. Lookingglass Creek rotary screw trap (1.5 m diameter) at rkm 4.0, just below the Lookingglass Hatchery adult weir and trap.

We used DARR 2.0 (Bjorkstedt 2008) to estimate the numbers of outmigrants. DARR 2.0 uses mark-recapture data stratified by time period, pooling those with similar capture probabilities. We used the "one trap" and "no prior" pooling of strata options.
O. mykiss juveniles (all wild, no hatchery releases) out migrate from Lookingglass Creek during the entire year, with peaks during the spring (usually March-May) and fall (usually September and October). The conventional migration year was used (1 July of year *x* through 30 June of year *x*+1). Fall groups were caught from 1 July-31 December of each year and spring groups from 1 January-30 June.

FL and weight at PIT-tagging, travel time, survival and capture probability to Lower Granite Dam data were obtained from the PIT tag database maintained by the Pacific States Marine Fisheries Commission at http://www.ptagis.org/. We estimated arrival timing to Lower Granite Dam using daily PIT tag detections expanded for spill using flow data from the U. S. Army Corps of Engineers Portland District website (http://www.nwd-wc.usace.army.mil/perl/dataquery.pl?k=id:LWG) and calculating a daily expansion factor [(Powerhouse Outflow+ Spill) /Powerhouse Outflow]. Median arrival date at Lower Granite Dam for each group was obtained using the date of 50% expanded daily detections. Survival, capture probabilities, and travel time to Lower Granite Dam were estimated using PitPro (Westhagen and Skalski 2008). We used the standard configuration, excluded the *.rcp file and included the mortality file. Observation sites, in downstream order, were Lower Granite Dam, Little Goose Dam, Lower Monumental Dam, Ice Harbor Dam, McNary Dam, John Day Dam, Bonneville Dam, and the Estuary Towed Array (Juvenile). Survival, capture probabilities, and travel time were estimated for only those outmigrants detected during the year following tagging. Outmigrants leave Lookingglass Creek at a wide range of sizes and may be detected as out-migrating through the hydro system during several years, spending time in the Grande Ronde River below Lookingglass Creek to add growth before continuing their outmigration.

Figure 5. PIT-tagging outmigrating Lookingglass Creek juvenile *O. mykiss*.

Measures used to describe juvenile life history included abundance, size at capture, freshwater age, survival probability to Lower Granite Dam, hydrosystem detection of outmigrants <115 mm FL, arrival date at and travel time to Lower Granite Dam and size at detection in the hydrosystem.

Results and Discussion

The average trap catch was nearly 3 times higher for the 2001-2011 period and was also less variable than during the 1965-1974 period (Figure 6). The Lookingglass Hatchery trap catches correlated well with the wild "A" run counts at Lower Granite Dam (Figure 7). The mean sex ratios from 2001 to 2011 showed 60% of adult returns were females (Figure 8). The mean FL of returning fish varied around 650, and was more variable during run years 2002-2006 (Figure 9). The percentage of fish <50 cm FL (considered resident rainbow trout) was variable, but usually less than 5% (Figure 10). With the exception of 2003, "large" returns were less than 4% of the total. The ocean age composition of fish aged was primarily ages 1 and 2, with age 1 fish dominant in 5 of 8 years (Figure 11). Age 3 fish were a minor component of the run each year, present in only 4 run years. Mean FL at ocean age for males and females showed were similar for the sexes, but were highly variable within an age group (Figures 12-13). The median weeks of arrival at the trap were earlier for males than females (Table 1). Median week of arrival timing at the trap from Burck's (unpublished data) was most commonly in mid-May (McLean et al. 2001). For all but two years, the percentage of hatchery-origin fish (ad-clipped) fluctuated from zero to slightly over 2% (Figure 14). The run year with the highest percentage (2011) was also the year of highest escapement for wild fish. Ad-clipped fish have normally been euthanized at the trap, but in 2010, some were released below the trap to allow anglers to catch them.

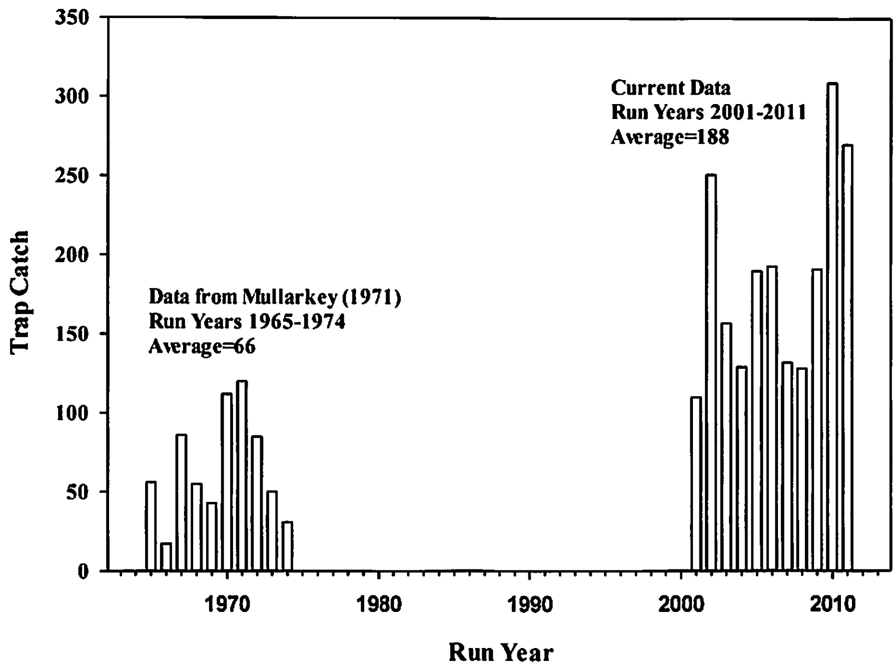

Figure 6. Trap catches of summer steelhead, run years 1965-1974 (Mullarkey 1972) and 2001-2011.

PIT tag detections of adults at the Lookingglass Hatchery trap totaled 64 during run years 2008-2011, and included both fish tagged as outmigrating juveniles and returning adults (Tables 2-3). In run year 2010, there were 11 adult detections at the Lookingglass Hatchery trap of fish tagged and released as outmigrants. Four were tagged and released from the Lookingglass Creek screw trap, 5 at Lower Granite Dam, 1 at the Tucannon River screw trap, and 1 at the South Fork John Day screw trap. One adult detected at the Lookingglass Hatchery Trap in 2008 was tagged and released at Priest Rapids Dam. Detections at Bonneville Dam occurred in July or August, preceding arrival the following spring at the Lookingglass Hatchery trap. Detections at Lower Granite Dam were usually in September-October (the fall previous to capture at the Lookingglass Hatchery trap, but 2 were in April and March).

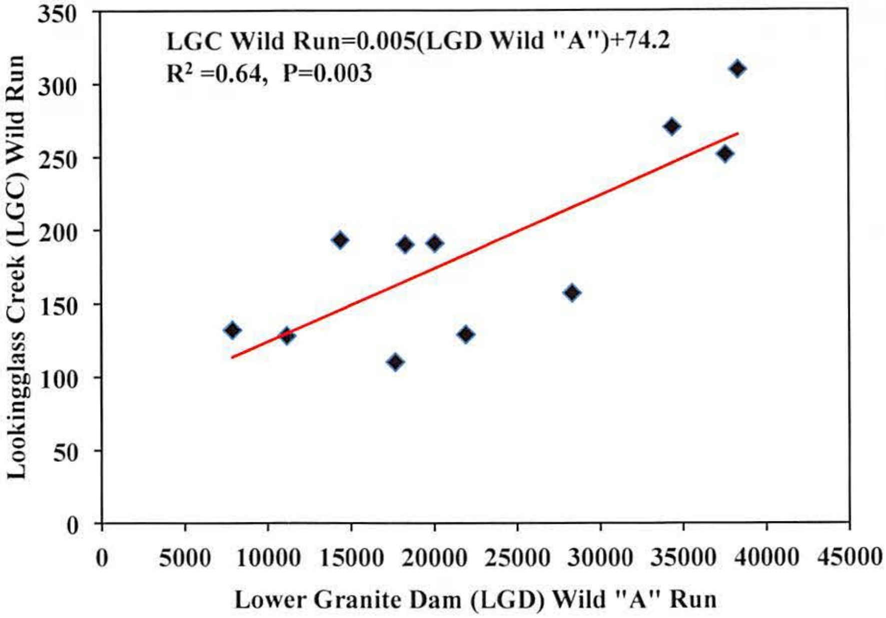

Figure 7. Comparison of summer steelhead escapement at Lookingglass Creek and Lower Granite Dam.

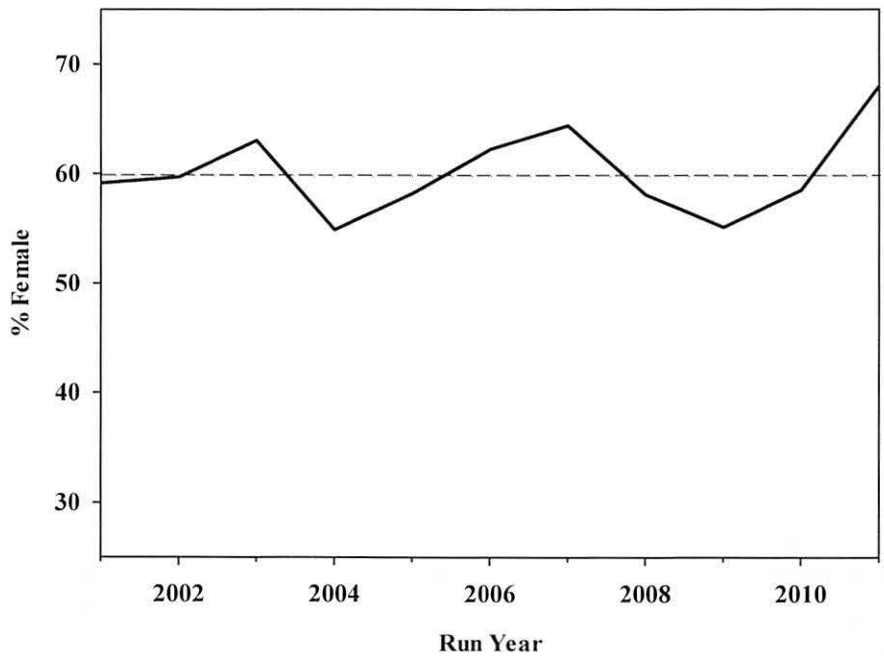

Figure 8. Sex ratios (% female) of returning summer steelhead captured at the Lookingglass Hatchery trap (dashed line is average for run years 2001-2011).

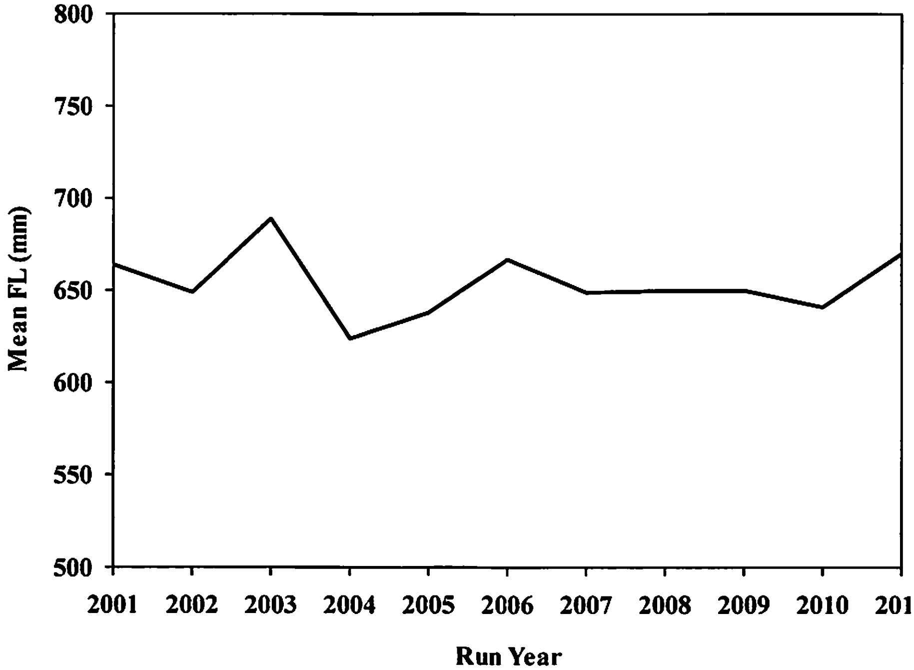

Figure 9. Mean FL of returning summer steelhead captured at the Lookingglass Hatchery trap.

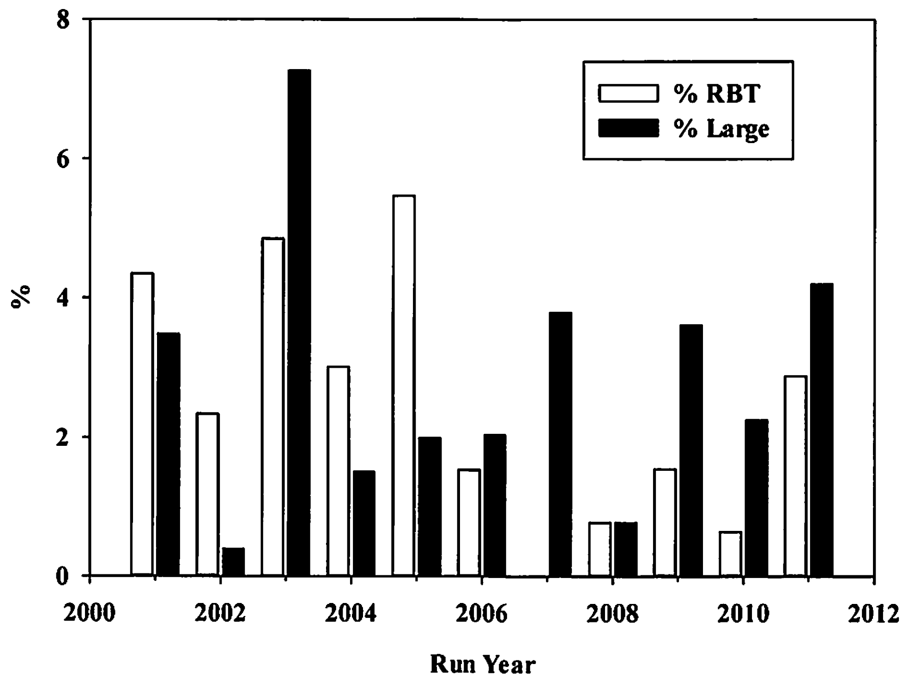

Figure 10. Percent “rainbow trout” (RBT) and “large” fish (≥78 cm FL) for returning summer steelhead captured at the Lookingglass Hatchery trap.

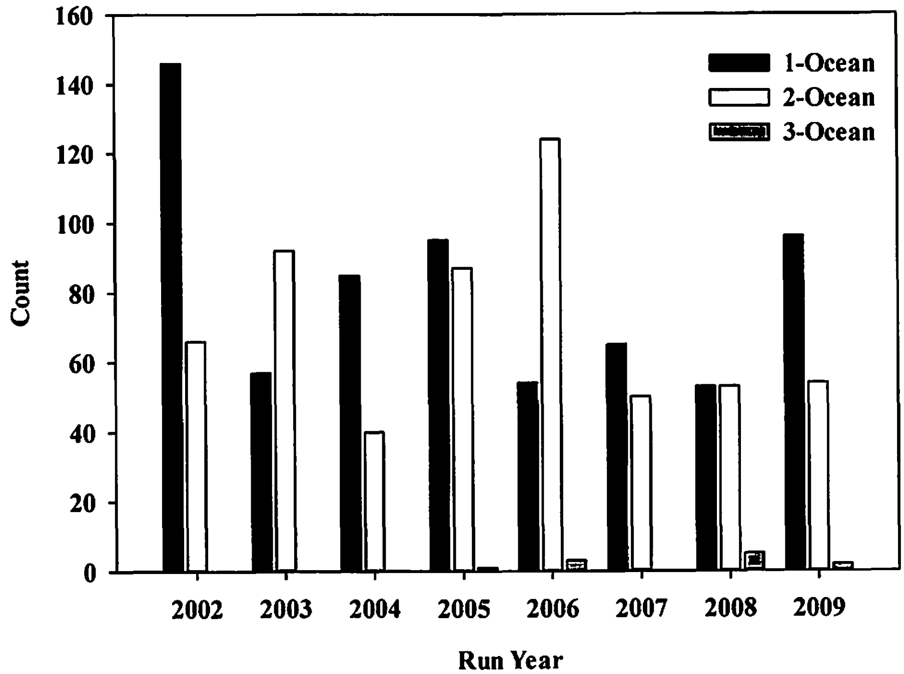

Figure 11. Age composition of returning summer steelhead captured at the Lookingglass Hatchery trap.

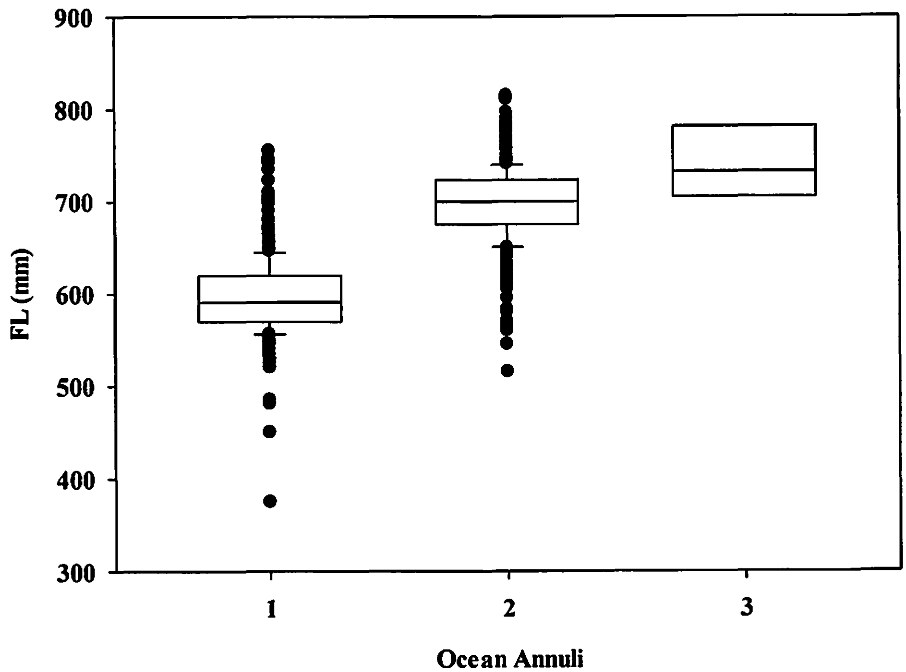

Figure 12. FL at age of returning female summer steelhead captured at the Lookingglass Hatchery trap.

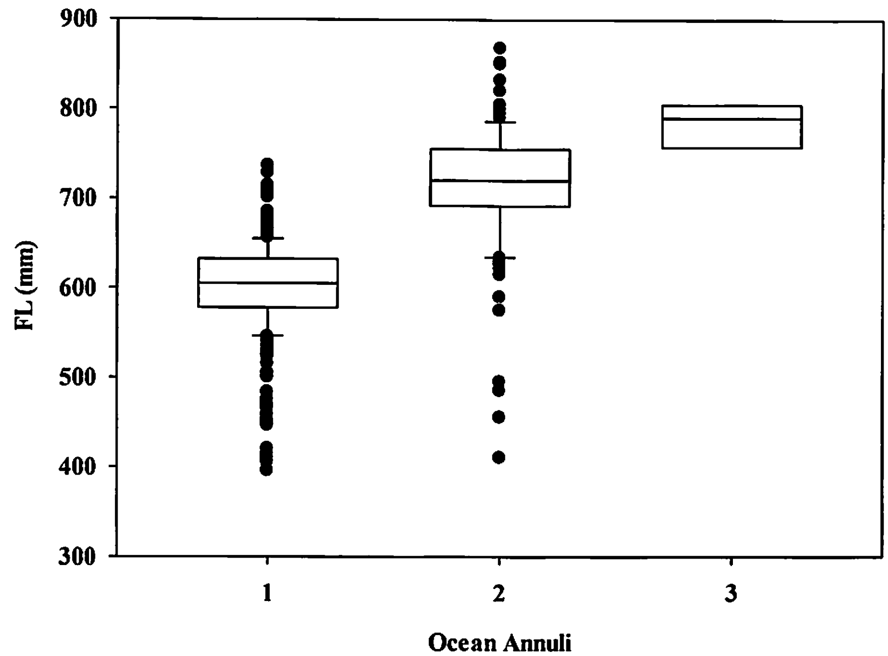

Figure 13. FL at age of returning male summer steelhead captured at the Lookingglass Hatchery trap.

Table 1. Median arrival week (April 2, 9, 16, 23, or 30) at the Lookingglass Hatchery adult trap for returning summer steelhead 500 mm FL or greater.

	Males		Females		Combined	
Run Year	Week	N	Week	N	Week	N
2001	23	42	23	68	23	110
2002	9	99	23	159	16	258
2003	2	56	9	101	9	157
2004	9	57	23	72	16	129
2005	9	75	16	115	16	190
2006	9	71	9	122	9	193
2007	23	47	23	85	23	132
2008	23	53	30	75	23	128
2009	9	85	16	106	16	191
2010	16	128	16	181	16	309
2011	16	83	30	187	23	270

Substantial numbers are being PIT-tagged under the ISEMP project, with more instream arrays being established throughout the Columbia River Basin. (ODFW has operated one in the Lookingglass Hatchery fish ladder). Recaptured adults in the Lookingglass Hatchery trap were tagged at Lower Granite Dam primarily during July-November preceding arrival at Lookingglass Creek the following spring. However, there were 2 adults tagged at Lower Granite Dam in the in the spring that were recaptured at Lookingglass Creek shortly afterward.

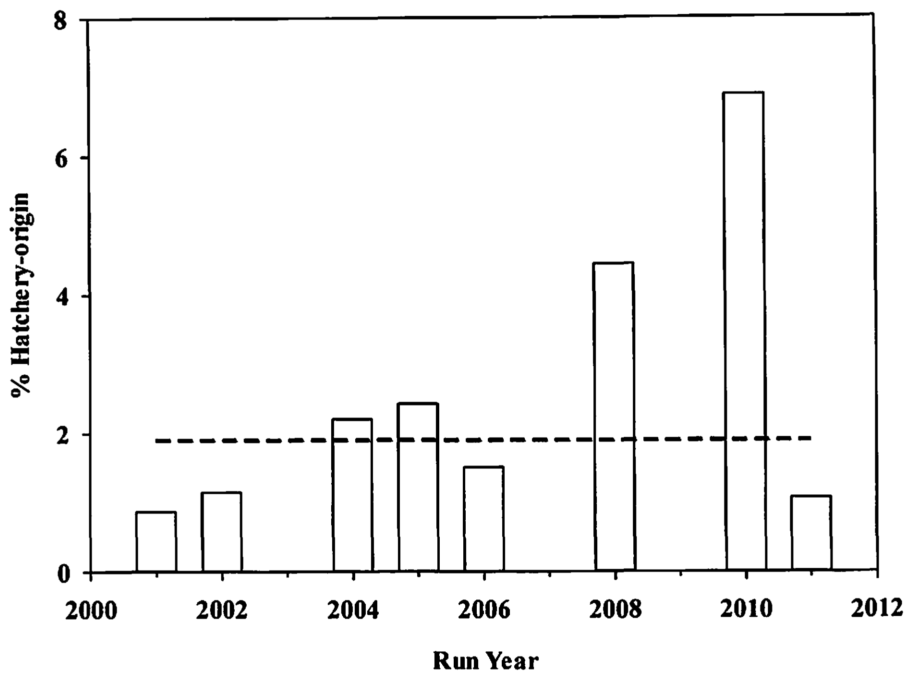

Figure 14. Percent ad-clipped (hatchery-origin) of returning summer steelhead captured at the Lookingglass Hatchery trap.

Table 2. Adult return history of summer steelhead PIT-tagged as juvenile outmigrants from Lookingglass Creek.

	Months of Detection at	
Run Year (N)	Bonneville Dam	Lower Granite Dam
2008 (7*)	July-3, August-3	September-1, October-4, April ('08)-1
2009 (8)	July-7, August-1	July-1, August-1, September-3, October-1, November-1, March ('09)-1
2010 (11*)	July-5, August-3, October-1	August-2, September-2, October-3, November-2
2011 (5)	July-5	July-3, October-1, November-1

Table 3. Return history of summer steelhead PIT-tagged as adults at Lower Granite Dam.

Run Year	N	Month of Tagging
2010	14	September-6, October-4, November-2, March ('10)-1
2011	17	July-1, August-2, September-8, October-4, November-1, March ('11)-1

The estimated outmigrants by migration year averaged 33,132 for years when both fall and spring estimates were available, or slightly over 3 times the average from the late 1960s. Mullarkey (1971) reported estimates ranging from 7,727-13,261 (mean 10,914).
Spring outmigrants ranged from 32-91% of the total outmigrants for migration years 2002-2008 and 2010-2011, and averaged 61%. Mullarkey (1971) reported that spring was the most important season for outmigration, with the lowest numbers in August and December.

Mullarkey (1971) observed peaks in the percentages of fish less than 130 mm in length in January and June, with a trough in April. A similar pattern was observed over four migration years.

Mean FL of first-time captures at the Lookingglass Creek screw trap showed peaks in March-April and September-October, corresponding to peaks in outmigration (Figure 16). The age composition of the fall group of outmigrants was dominated by age 2 fish, with much smaller numbers of ages 0, 1, and 3 (Figure 17). Spring groups had higher numbers of ages 0 and 1 (Figure 18). Mullarkey (1971) observed 78-93% of outmigrants were age 1+ and 2+ fish. Zero aged fish were variable at 0.7-12.8% and 3+ fish were 0-13.9%.

Survival probabilities of fall groups were variable, fluctuating around 0.15-0.30 for all migration years except 2003 (Figure 19). Survival probabilities of spring groups (≥115 mm FL) were higher and more variable than fall groups (Figure 20). The largest numbers of outmigrants tagged at FL less than 115 mm FL are detected in the hydrosystem one year later, with much smaller numbers detected during the same migration year of tagging and two years after tagging (Figure 21). Median arrival dates at Lower Granite Dam were similar for both spring and fall groups (Figure 22). Mean travel times for fall groups fluctuated around 200 d, and for spring groups, approximately 10-20 d (Figure 23). Mean FL at tagging for fall groups detected the following spring were 150-160 mm FL (Figure 24), while mean FL at tagging for spring groups detected the same spring appeared to be slightly larger (Figure 25).

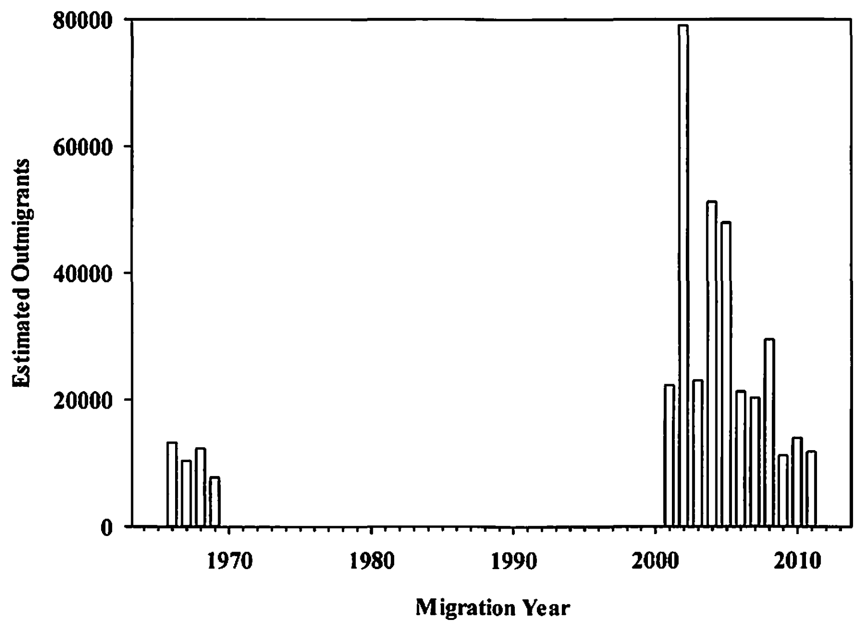

Figure 15. Lookingglass Creek *O. mykiss* outmigrants by migration year.

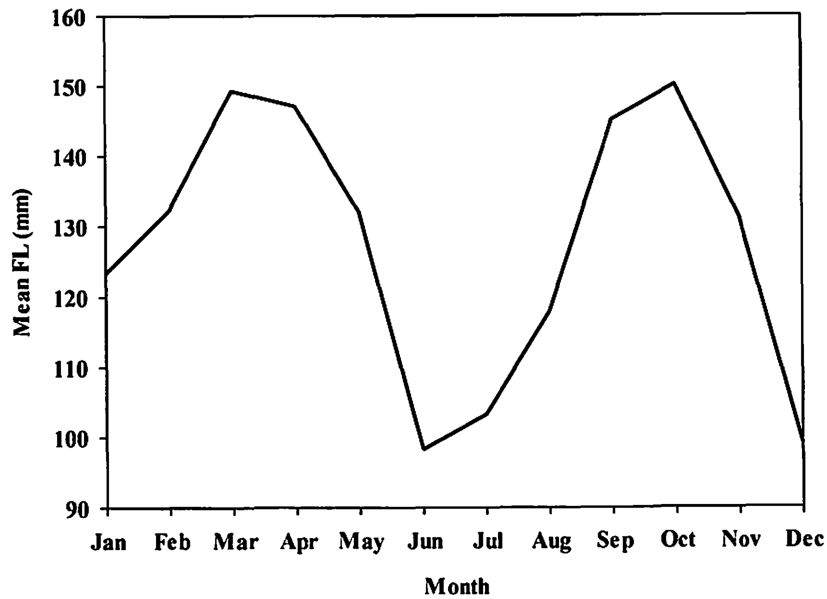

Figure 16. Mean FL (mm) of outmigrating Lookingglass Creek *O. mykiss*.

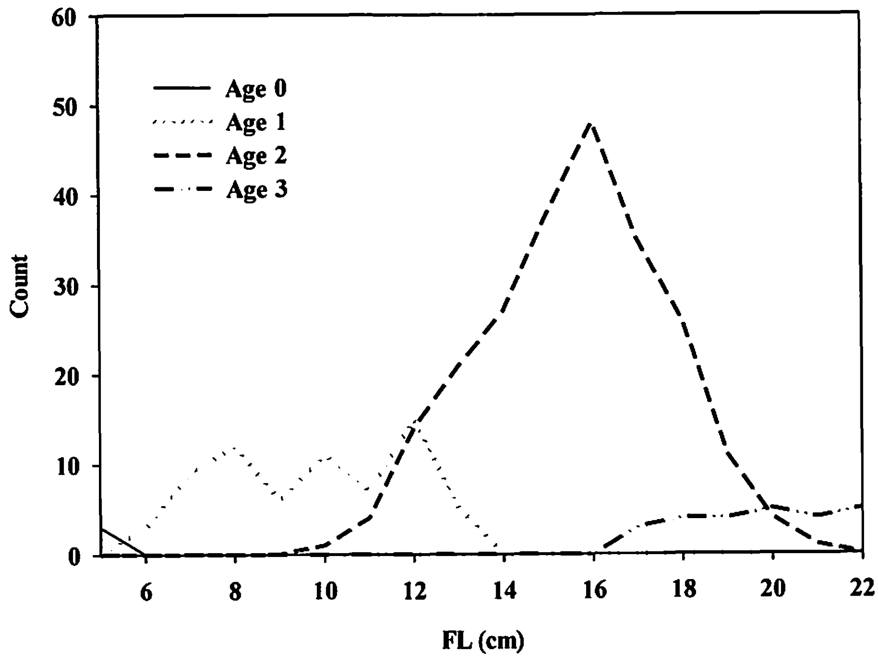

Figure 17. Freshwater age composition of spring group outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, migration years 2008-2010.

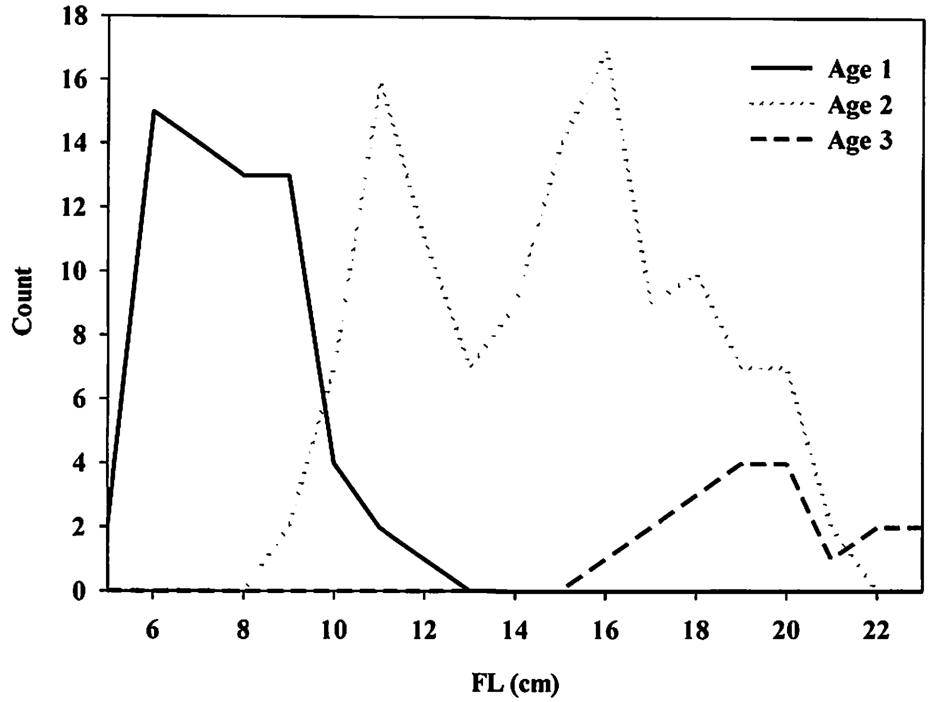

Figure 18. Freshwater age composition of spring group outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, migration years 2008-2010.

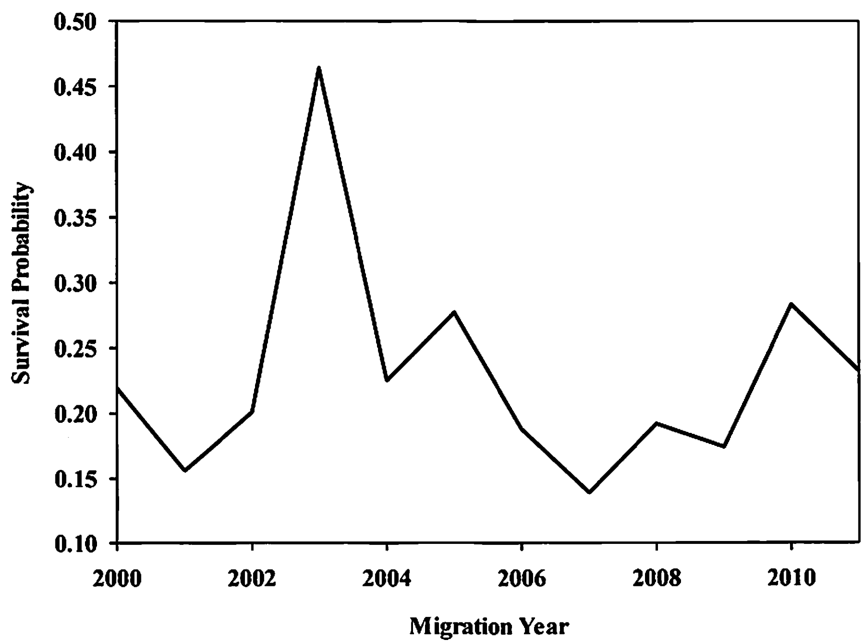

Figure 19. Survival probabilities to Lower Granite Dam of the fall groups (all sizes) of outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, PIT-tagged and released.

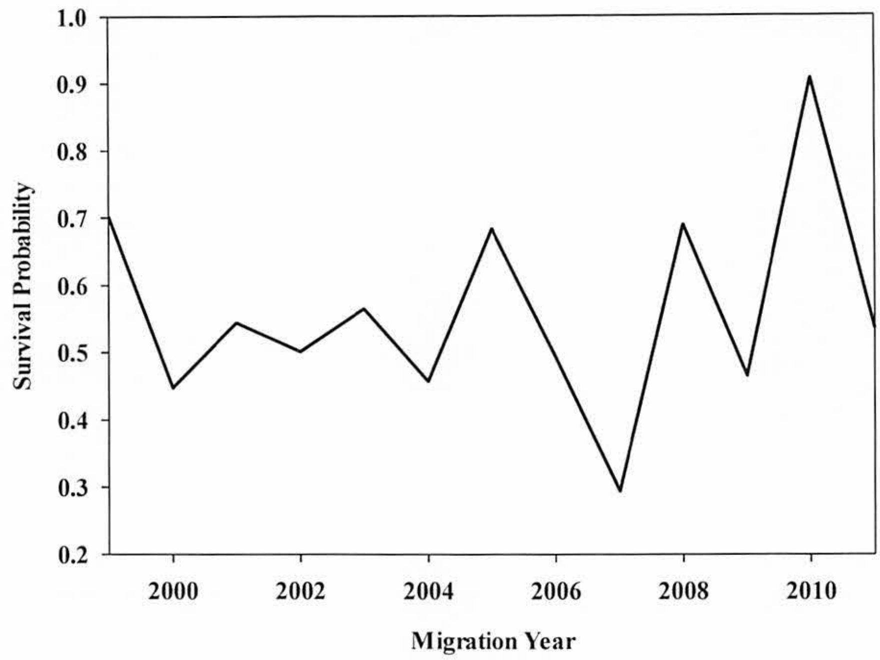

Figure 20. Survival probabilities to Lower Granite Dam of the spring groups (≥115 mm FL) of outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, PIT-tagged and released.

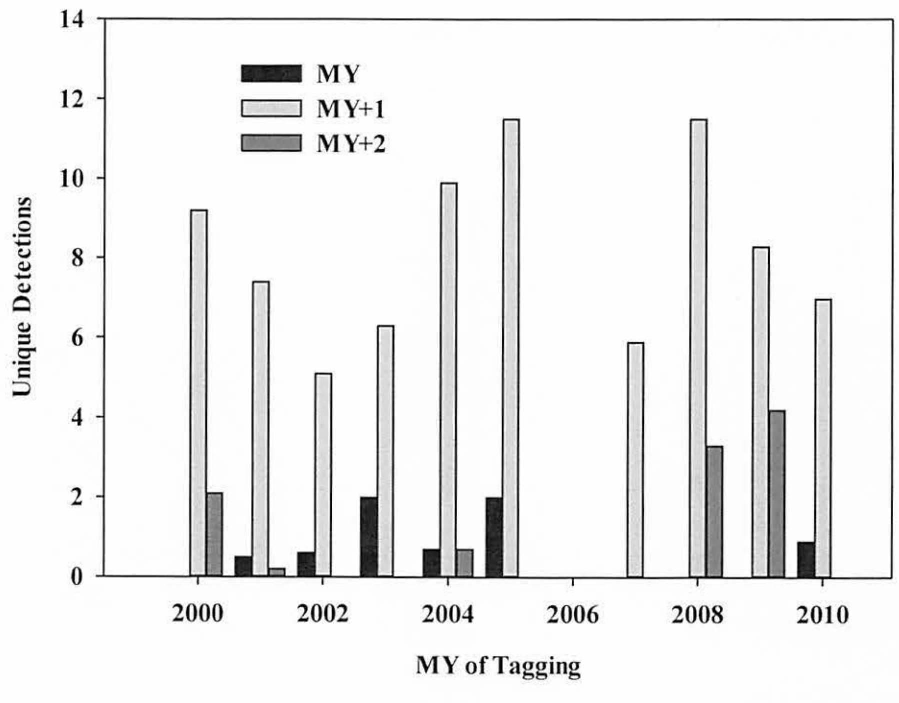

Figure 21. Hydroystem detections of small (<115 mm FL) outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, PIT-tagged and released.

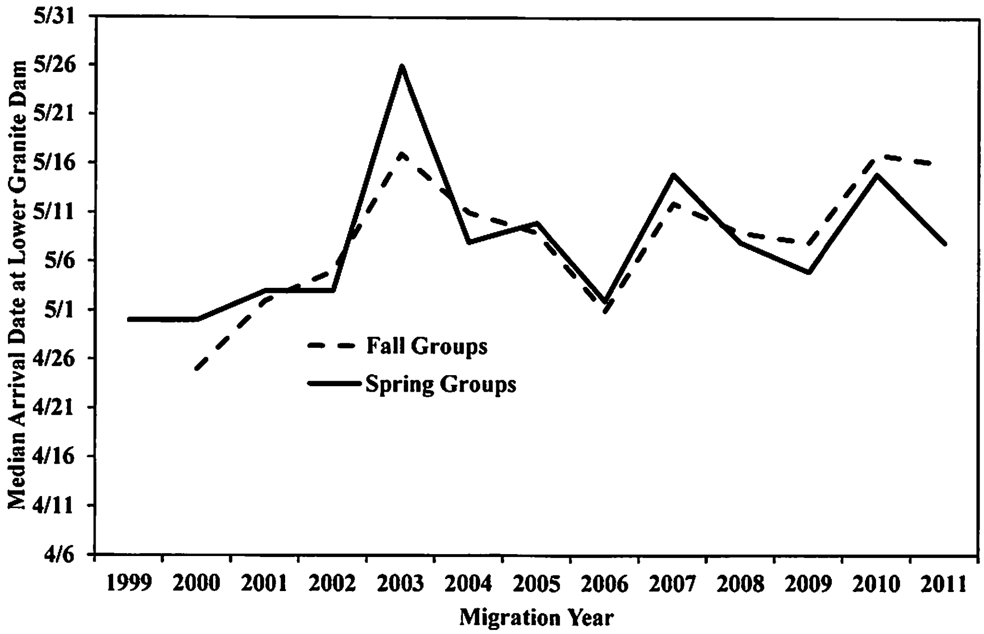

Figure 22. Median arrival dates at Lower Granite Dam for fall and spring groups of the same migration year of outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, PIT-tagged and released.

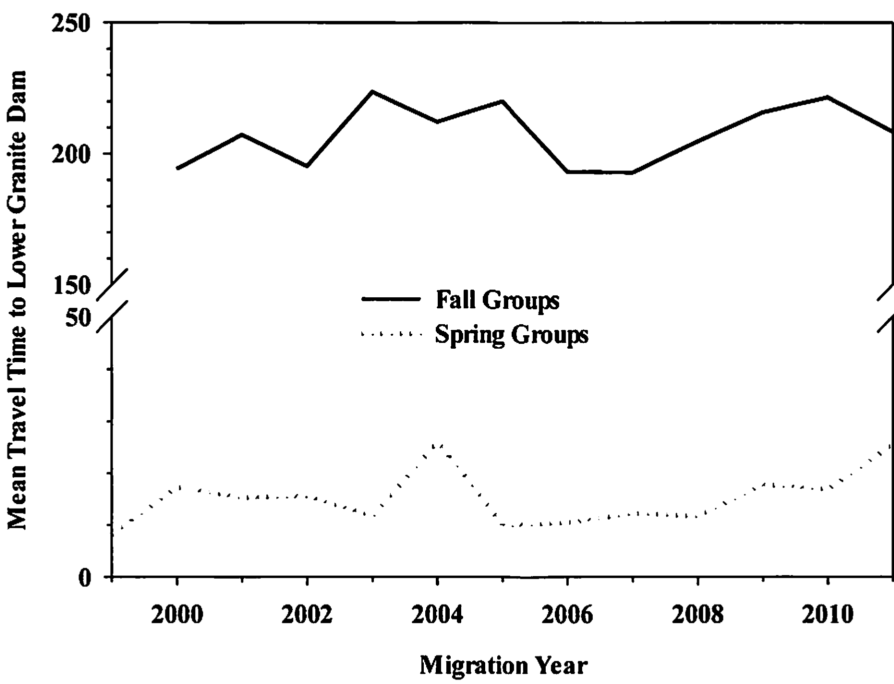

Figure 23. Mean travel time (d) from the Lookingglass Creek rotary screw trap to Lower Granite Dam for fall and spring groups in the same migration year of outmigrating *O. mykiss*.

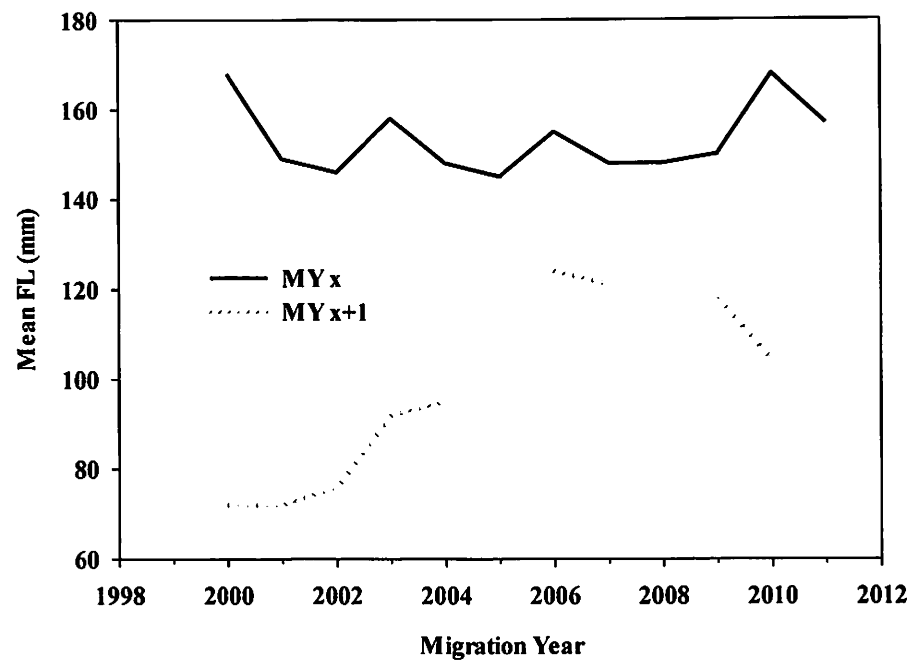

Figure 24. Mean FL (mm) at PIT-tagging of outmigrants from fall groups detected at in the Columbia and Snake Rivers hydrosystem.

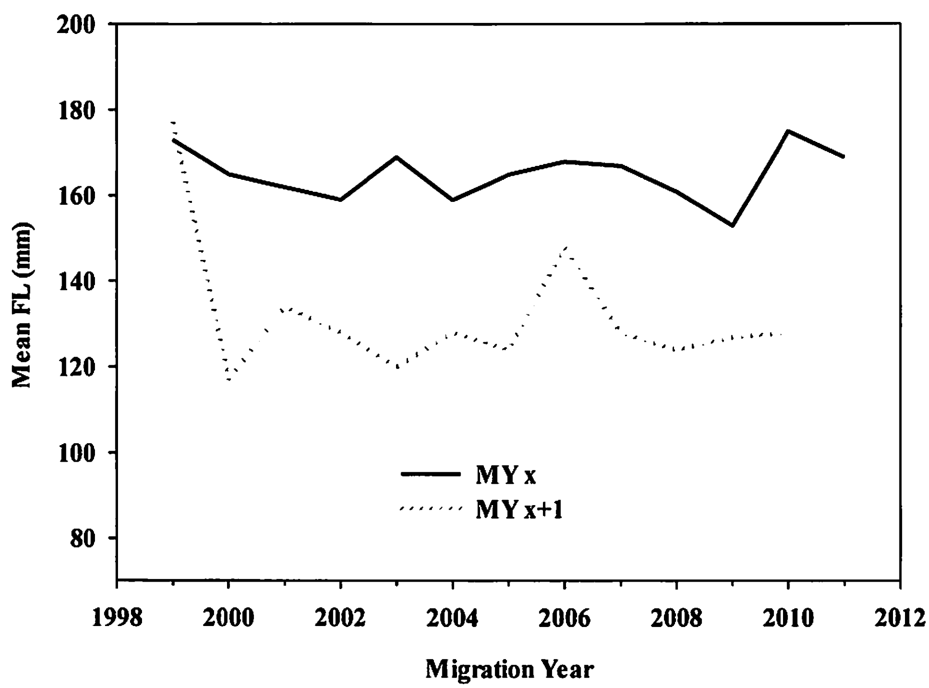

Figure 25. Mean FL (mm) at PIT-tagging of outmigrants from spring groups detected at in the Columbia and Snake Rivers hydrosystem.

Summary

Adult abundance showed a 3-fold increase from 1965 to 1974 time period compared to 2001-2011, and has been relatively stable the past 11 years. Arrival timing at the Lookingglass Hatchery trap has been later during the 2001-2011 period compared to 1965-1974. Life history attributes of adults collected during 2001-2011 have shown variability from year to year but are consistent with the limited contemporary data available for other populations in the region. Catches were dominated by females and almost all fish were ocean ages 1 and 2. PIT tag information showed migration patterns consistent with previous studies, although small numbers of returning fish entered freshwater in the spring rather than the previous fall, and rapidly moved upstream.

Outmigrant totals during 2001-2011, similar to adult catches, were on average, 3 times the average reported during the late 1960s by Mullarkey (1971). Size, freshwater age composition, and seasonal distribution of outmigration were all similar to observations of Mullarkey (1971). For fish leaving Lookingglass Creek the same year, survival was lower for fall outmigrants than spring. Outmigrants less than 115 mm FL were usually detected a year later than larger fish. Arrival timing at Lower Granite Dam was similar for fall and spring outmigrants during the same migration year.

Recovery Implications

Lookingglass Creek summer steelhead within the Upper Grande Ronde population Upper Grande Ronde is one of 4 populations within the Grande Ronde MPG (others Lower Grande Ronde, Wallowa R., Joseph Creek). The Minimum Abundance Threshold is 1,500 for Upper Grande Ronde population; therefore Lookingglass Creek is a significant part of this population. Catches of adults for the last decade have shown relatively little variability, indicating a stable population. This has occurred despite the influence of dams, that has perhaps been mitigated by the good spawning and nursery habitat that exists in Lookingglass Creek.

The differences in both adult returns and juvenile outmigrants between the late 1960s and current period may be explained by differences in hydro system conditions, ocean productivity, or perhaps interspecific relationships. The numbers of juvenile outmigrants have declined during the same period when the numbers of adult spring Chinook spawners above the hatchery weir have increased. The numbers of adult summer steelhead returning, also in the current era, have been relatively stable in the face of much higher variability in juvenile *O. mykiss* out-migrant abundance.

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Tucannon and Touchet River Endemic Broodstock Development

Hatchery Program Review 2000-2012

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This program is a cooperative effort of the Washington Department of Fish and Wildlife, the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation. The program is funded by the Bonneville Power Administration and administered by the United States Fish and Wildlife Service under the Lower Snake River Compensation Plan.

INTRODUCTION and BACKGROUND

This paper provides background information, program development history and an assessment of program performance for the Washington Department of Fish and Wildlife's (WDFW) Tucannon and Touchet rivers endemic stock summer steelhead (*Oncorhynchus mykiss)* hatchery program. The coverage period is from program initiation in 2000 to the present (spring of 2012).

A precipitous decline in numbers of Snake River steelhead and other anadromous fish between 1962 and the mid-1970s alarmed management agencies such as the 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, where 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 and operation of the four lower Snake River power dams. The Lyons Ferry and Wallowa stock steelhead programs were initiated early on to achieve mitigation goals and have been described in other LSRCP summary documents.

Snake River and Mid-Columbia summer steelhead populations were listed as threatened under the Endangered Species Act (ESA) in 1997. The NOAA Fisheries 1998 Hatchery Biological Opinion (BiOp) cited Lyons Ferry stock steelhead as constituting "jeopardy" to listed Snake River and Mid-Columbia River summer steelhead populations. One recommendation from the BiOp was that new broodstocks be developed to replace the Lyons Ferry stock. In 1999, WDFW, the LSRCP, and the tribal co-managers within SE Washington agreed to start "tests" of endemic broodstocks (consisting of natural origin fish trapped from local streams) in the Tucannon and Touchet Rivers (Figure 1). The Tucannon and Touchet rivers were chosen as possible locations based on rivers where Lyons Ferry stock fish were currently being released and the presence of, and close proximity to, existing LSRCP facilities where adult trapping locations existed. These "test" programs were to be initially evaluated for 5-years, after which a decision would be made regarding their ability to replace the existing hatchery stock program for mitigation in their respective river while reducing potential negative effects mentioned in the BiOp. Performance of each program has varied, and the information to make an informed decision of whether or not to fully implement these program was incomplete at 5-years, so the "test" programs were extended.

The overall goal of each endemic stock program was for the eventual replacement of the Lyons Ferry stock steelhead in the Tucannon and Touchet rivers. However, based on biological information at the time, the management intents for each river were different. In the Tucannon River, the summer steelhead population was considered depressed and declining, so the intent/priority of the endemic stock program was to 1) provide a conservation program whereby hatchery fish would be unmarked (not available for harvest) so they could contribute to spawning in the Tucannon River to rebuild the natural origin steelhead population, and 2) provide a harvest mitigation program in the Tucannon River, but with a stock of native origin so that if they escaped the fishery they would be of the most appropriate stock for natural spawning.

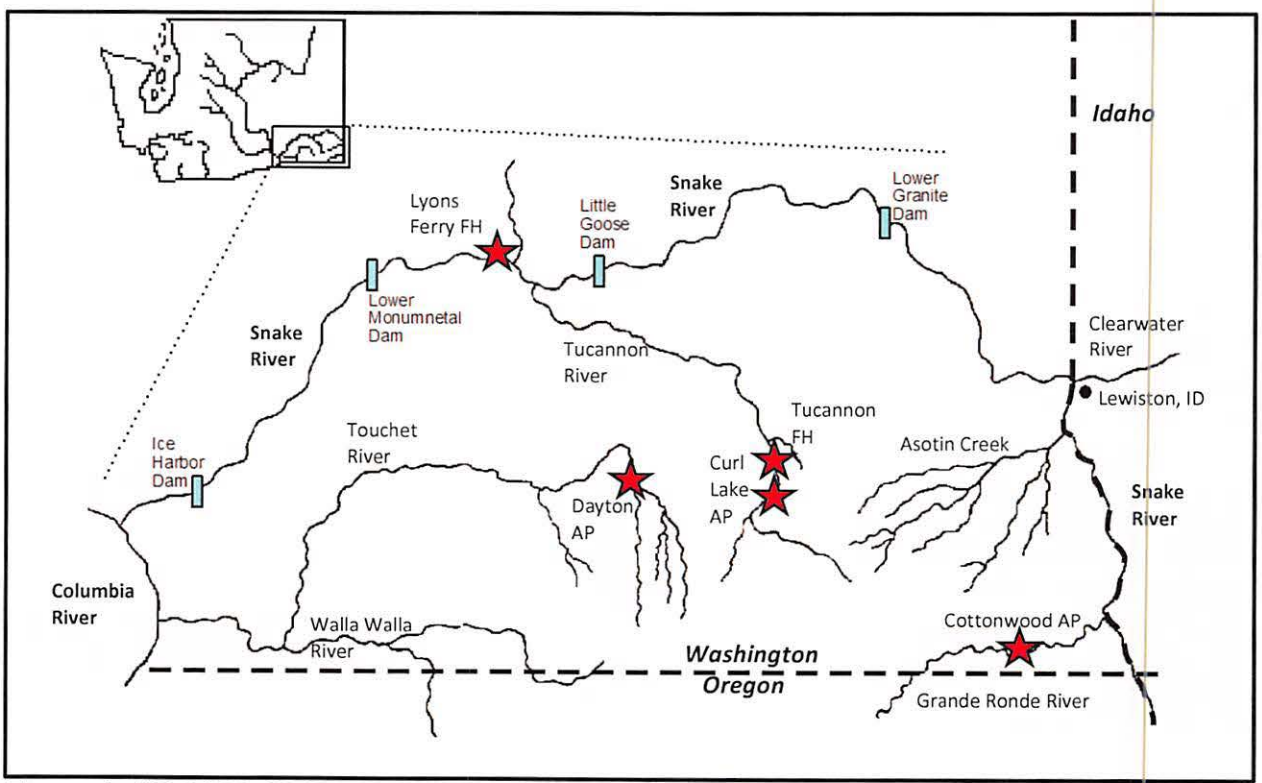

Figure 1. WDFW LSRCP hatchery facilities (hatcheries and acclimation ponds) in SE Washington.

In the Touchet River the summer steelhead population was considered depressed, but appeared stable (300-400 spawners/year based on a population index area above the city of Dayton). As such, WDFW believed that implementing a conservation program was not necessary, rather, the sole intent should be to provide fish for harvest mitigation. However, similarly to the Tucannon River program, should they escape the fishery, the fish would be the appropriate stock for natural spawning. This management intent was not agreed to by the co-manager (Umatilla Tribe), but was allowed to move forward for testing the feasibility of the program. Before full-implementation of the program can occur, both parties will have to agree on the overall intent of the program in the Touchet River.

Each test program was set to produce 50,000 smolts annually. This number was decided upon based on available raceway space at Lyons Ferry Hatchery, assumed smolt-to-adult returns, and the number of broodstock available (natural origin) that would have to be trapped from each river. Concurrently, smolt production of Lyons Ferry stock steelhead in each river was reduced. Each program would be deemed successful if smolt-to-adult return rates (SARs) were at least 0.5%. Natural origin adults would be trapped from each river (32 total from each: ~16 males and ~16 females) to meet broodstock needs. Trapped fish would be transported to LFH, held, spawned, and the progeny reared to either the pre-smolt (Tucannon) or smolt (Touchet) stage and direct stream released. The Tucannon stock would be transported to Tucannon FH in February for final rearing on Tucannon River water prior to release as smolts in the upper Tucannon River basin. Each program was to rear fish to a target size of 4.5 fish/lb at Age 1.

WDFW established short term management objectives for the endemic stock programs, those objectives were: 1) Establish endemic broodstocks, 2) Return adults and achieve SAR's of 0.5%, 3) Remove the potentially depressing effect of a long-term out-of-basin hatchery stock on ESA listed populations, and 4) ensure that each program was compliant with the ESA and WDFW Policies to protect and recover wild stocks. The long-term goals and program intents have been previously stated.

To determine the success/failure of each endemic stock program, monitoring and evaluation staff developed criteria by which they would asses each program: 1) in-hatchery survival and performance 2) estimate adult returns and survival to each river, 3) Increase our understanding of the status and trends of natural origin steelhead in each river, 4) determine life history and genetic characterization of natural steelhead populations in the Touchet and Tucannon rivers, and 5) assess feasibility and impacts to the natural populations from broodstock collections.

PROGRAM ASSESSMENT

The first step to development of the endemic broodstocks was to determine if adequate numbers of natural origin steelhead could be trapped from each river. Based on prior information (Figure 2), it was believed that trapping enough fish at the Dayton Adult Trap for the Touchet stock would be reasonably easy, with broodstock needs requiring about 10-15% of the population from the surveyed index area in the upper Touchet River Basin. However, in the Tucannon River, numbers of adult steelhead trapped at the Tucannon Fish Hatchery were very low, and would not support the number of fish needed for broodstock. Monitoring and evaluation staff constructed a temporary floating weir and deployed it in the lower Tucannon River (rkm 17) to trap fish for broodstock. Higher stream flows and debris frequently sunk the floating weir allowing fish to pass unimpeded, but adequate numbers of steelhead were trapped to establish the broodstock and meet program egg goals.

During this time of broodstock development, WDFW actively collected tissue samples from all wild origin adults captured at the adult traps so genetic profiles could be determined from each stock. Since the Lyons Ferry stock program had been in existence in each of these rivers for nearly 20 years, and there were known temporal and spatial overlaps of fish that spawned in the river, there was concern that considerable introgression could have occurred between the Lyons Ferry and natural origin stocks. If this was the case, WDFW, the co-managers, and NOAA Fisheries would have to question whether or not the development of these endemic stocks was worth the effort. The genetic comparisons showed there were still distinct stocks (Figure 3). The Touchet River stock appeared more genetically distinct, while the Tucannon River stock was more similar to the Lyons Ferry stock.

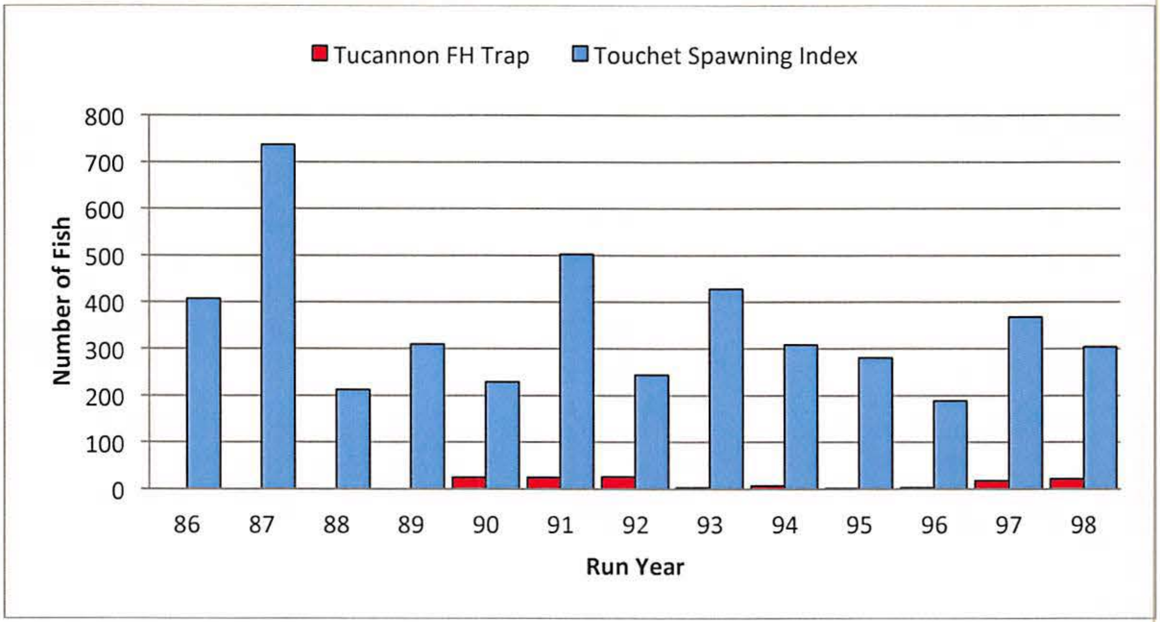

Figure 2. The number of summer steelhead trapped at the Tucannon FH adult trap, or estimated summer steelhead in an index area of the Touchet River upstream of Dayton, 1986-1998 Run Years.

At the end of the 5-year "test", WDFW evaluation staff summarized and provided an assessment and recommendations for each program. Broodstock collections were going well and the genetic data supported the presumption that we still had distinct stocks of steelhead within the Tucannon and Touchet rivers. However, due to difficulties in adult trapping in both rivers (high stream flows and debris which disabled traps), we were not able to assess total adult returns or survival; the basis for our determining program success and implementation. As such, WDFW staff recommended continuing the "test" period and transitioned to the use of PIT Tags for adult return and survival evaluations. In addition, there were many issues during rearing at the hatchery that had yet to be resolved: 1) multiple and extended eggtakes, 2) unripe or not enough males available for spawning, 3) poor feeding of the juveniles (especially in the Touchet stock) as they appeared to maintain a very high fright response while in the raceways, 4) size goals not being achieved, 5) very high coefficients of variation (fork length) with bi-modal distribution at release; with many in the lower mode that were considered non-migrants. All of these factors were confounding each program to some degree, so it was felt more time was needed to properly evaluate each program. Over the next five years, steps were taken to improve aspects of the hatchery rearing. At the same time, information from returning adults with PIT tags was available, so each program could be further and more effectively evaluated.

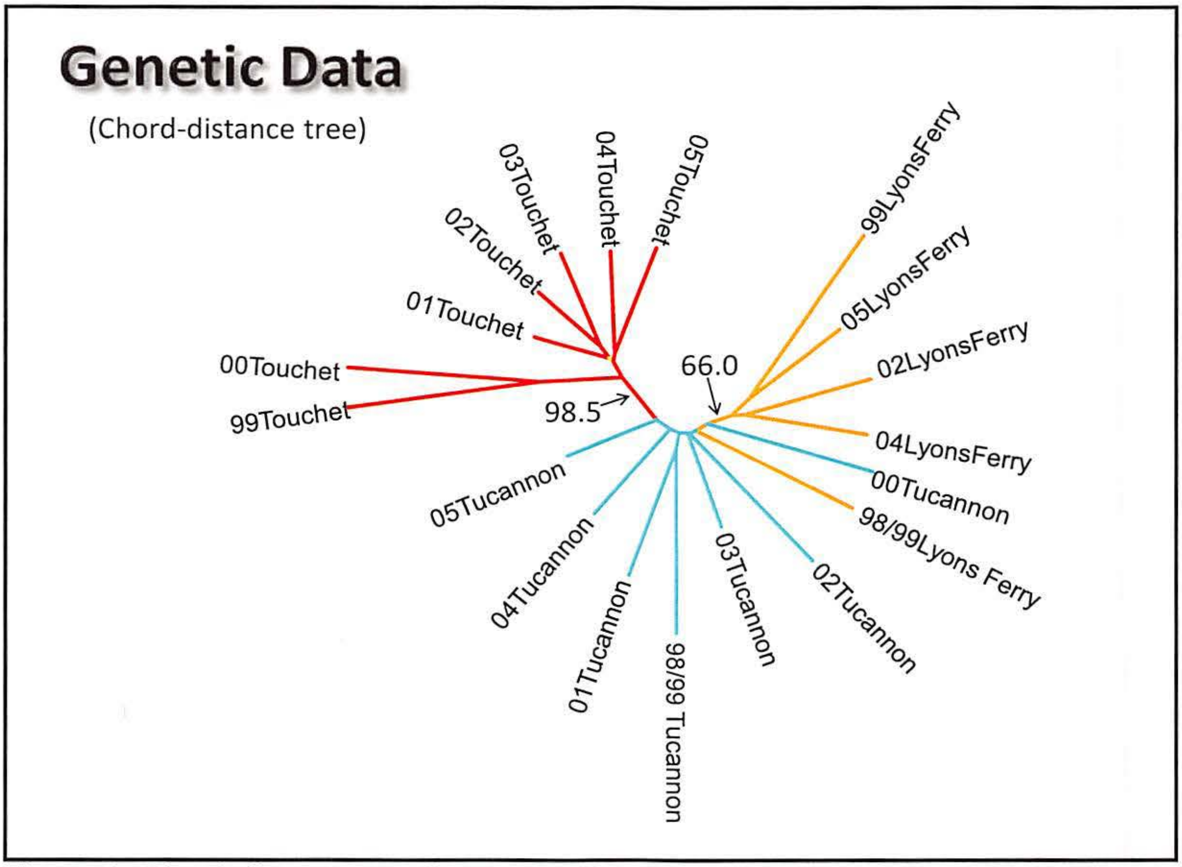

Figure 3. Chord-distance tree for temporally stratified adult samples. Node support numbers are values from bootstrap analysis (1000 bootstraps).

For the Tucannon River stock, size at release became more consistent with less variability, and adult returns and survival improved accordingly. Further, during our development of Hatchery and Genetic Management Plans (HGMP's) in 2009, NOAA Fisheries indicated they would no longer support the continued release of Lyons Ferry stock steelhead into the Tucannon River. As such, WDFW and the co-managers agreed to cease all Lyons Ferry stock releases into the Tucannon following the 2010 release, with the intent to ramp up to full implementation of the endemic stock program in the Tucannon River. Hatchery modifications were needed before the full endemic stock program (150,000 smolts) in the Tucannon River could be achieved. Therefore, an interim program goal of 75,000 smolts (100% conservation) was agreed upon, with the program increasing in steps once facility modifications occurred. The program is anticipated to increase to 100,000 smolts with the 2013 brood (50,000 conservation, 50,000 harvest mitigation), and 150,000 smolts by 2015 (50,000 conservation, 100,000 harvest mitigation).

For the Touchet River stock, size at release has improved and adult returns and survival responded. However, for an unknown reason(s), overall survivals and returns of the Touchet River stock have been about 1/3 of the Tucannon River stock. In addition, there are still some negative aspects in the hatchery rearing and continuing concerns about the need for any form of supplementation (intentional or defacto) in the Touchet. As such, WDFW and the co-managers have not reached a decision on the fate of this program. A decision is expected in late 2012.

PROGRAM ASSESSMENT – TUCANNON STOCK

Currently, about 18-19 females (and an equal or greater number of males) are needed to meet program needs of 75,000 smolts. A 2x2 matrix spawn is typically applied when enough males are ripe on spawn days; though some males get used multiple times during the spawning season. Due to the low number of spawners, the effective population size (N_e) each year has been relatively small (Table 1), which has raised concerns within WDFW management about the use of F_1 generation hatchery fish for future broodstock use. To date, 6% of the Tucannon endemic broodstock have consisted of F_1 hatchery origin fish.

Table 1. Effective population size of Tucannon River endemic hatchery steelhead broodstock, 2000-2012 broods.

Brood	00	01	02	03	04	05	06	07	08	09	10	11	12
N_e	36	30	29	32	30	36	29	25	23	---	34	41	36

Run timing of both natural and endemic stock fish have been documented at the Tucannon FH Trap. Over the last four years of adult trapping, hatchery endemic stock fish return about 1-week earlier than natural origin fish. Broodstock collection has typically been from the earlier part of the run, allowing for earlier spawning and more time for rearing. However, since the decision was made to implement the program, we've attempted to collect the brood from the center portion of the run to the Tucannon FH (Figure 4). The number of steelhead returning to the Tucannon FH trap has dramatically increased over the past few years (Figure 5). The returns have been dominated by wild and endemic origin steelhead, with very few Lyons Ferry stock fish returning to the Tucannon FH. This has been a direct result of moving all Lyons Ferry stock releases to the lower Tucannon River.

Between 2000 and 2012, disposition of the Tucannon River broodstock was as follows: 86% have been spawned, 7% were pre-spawn mortalities and 7% were not used and returned to the river for natural spawning. We have collected scales from the broodstock and from representative adults trapped on the river to determine age composition of each year's run. Fish collected for broodstock are similar in overall age distribution of the run (Figure 6). Based on the scale samples collected, about 1% of the annual return of natural origin steelhead are repeat spawners.

For each steelhead program at Lyons Ferry Hatchery, counts or estimates of production are made at various life stages. Over the years, the number of green eggs and eyed-eggs have been estimated through either volumetric or weight sampling methods, or from mechanical egg counters. Eyed egg-to-smolt survival has been relatively consistent, though variable, for the entire Tucannon River endemic steelhead program (Figure 7). Fish health has generally not been a problem at LFH because of high quality pathogen free ground water. However, in 2009, 2011 and 2012, IHNV was detected in the ovarian fluid of spawned Tucannon River females. Per agency protocol, progeny from these females were not reared at the hatchery, but were released back into the Tucannon River as fry. In the 2011 brood, the presence of IHNV in the broodstock and the subsequent release of those fry limited the overall production of steelhead for that year (Figure8); other years have not been as affected and program goals were met. Bacterial coldwater disease has sometimes been present during the rearing cycle, though the disease has not affected overall smolt production of the Tucannon stock.

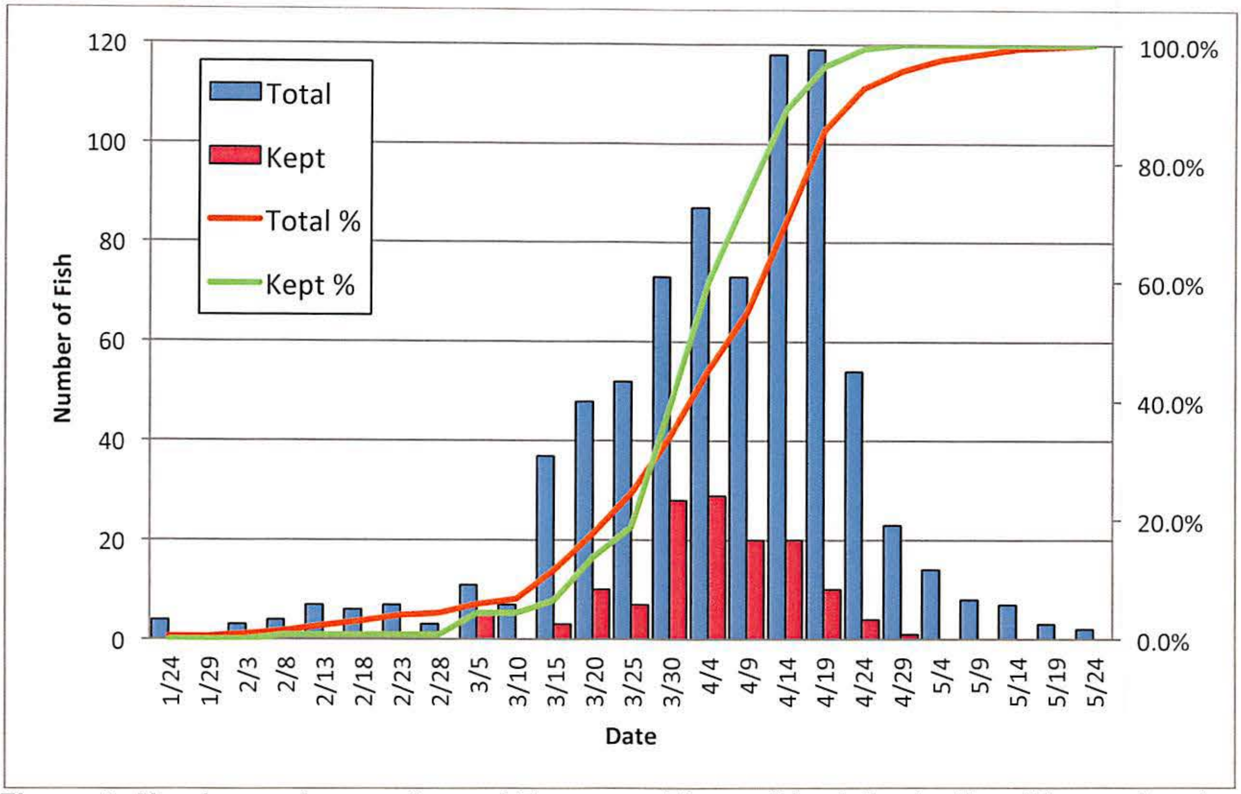

Figure 4. Number and percentage of Tucannon River wild origin steelhead trapped and collected for broodstock at the Tucannon FH adult trap (2008-2011 run years).

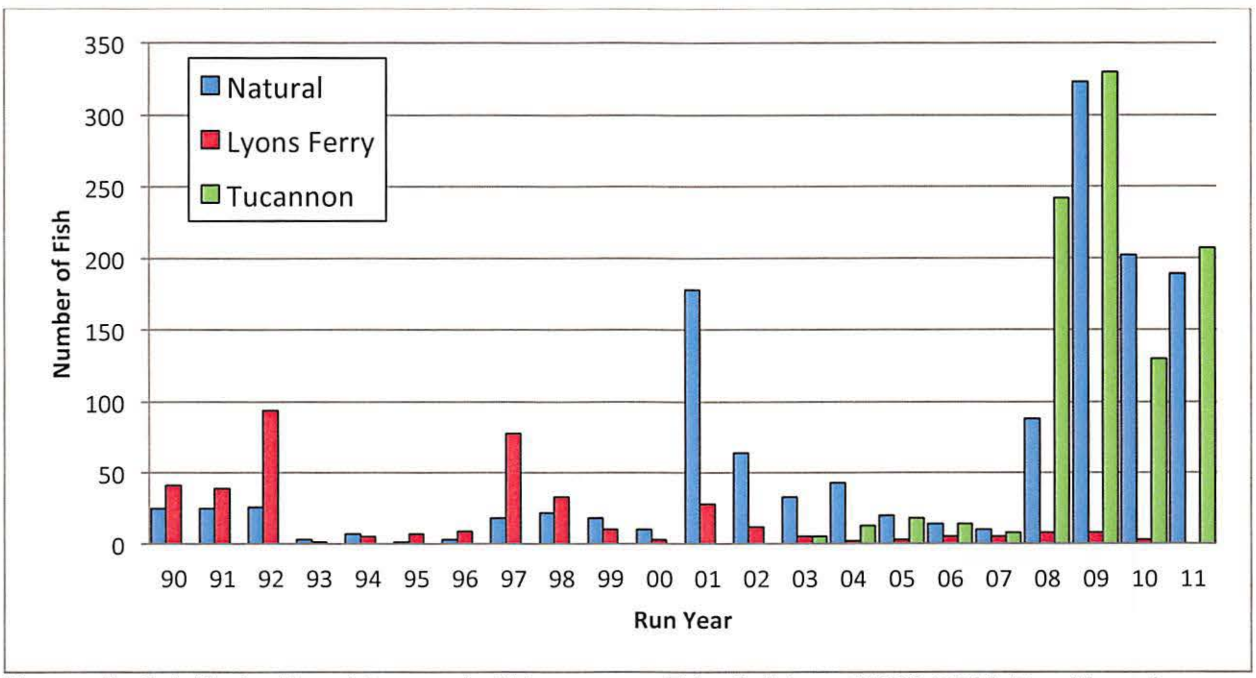

Figure 5. Adult steelhead trapped at Tucannon FH adult trap (1990-2011 Run Years).

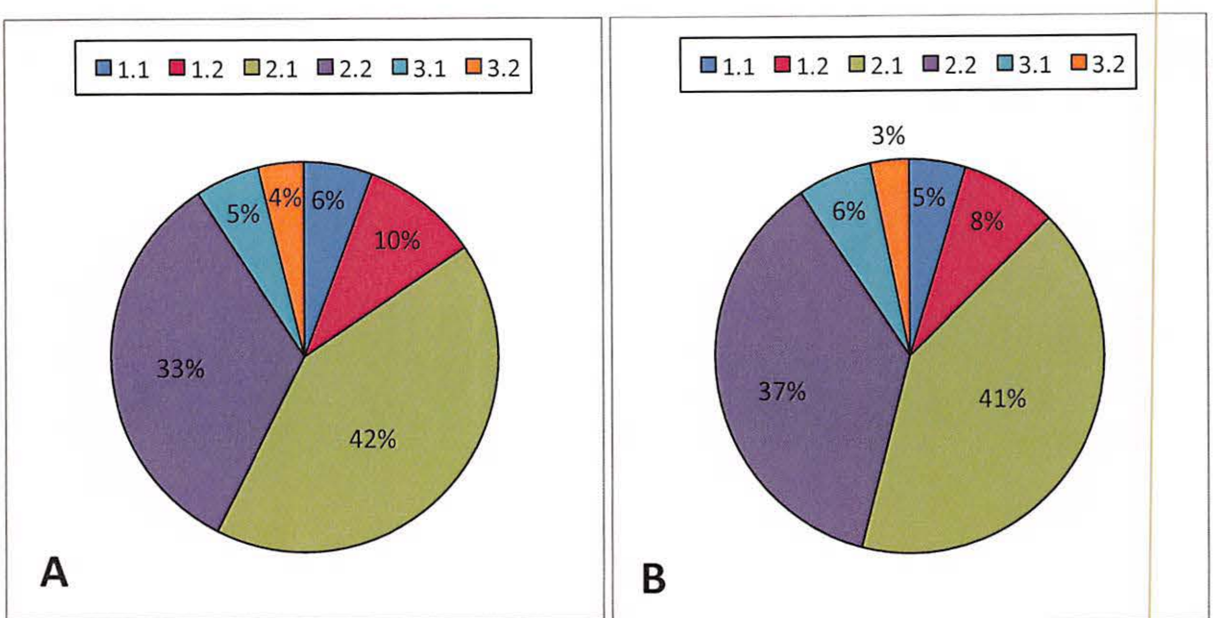

Figure 6. Age composition of natural origin summer steelhead collected for broodstock (A) or from the entire population (B) of the Tucannon River, 1999-2010 Run Years.

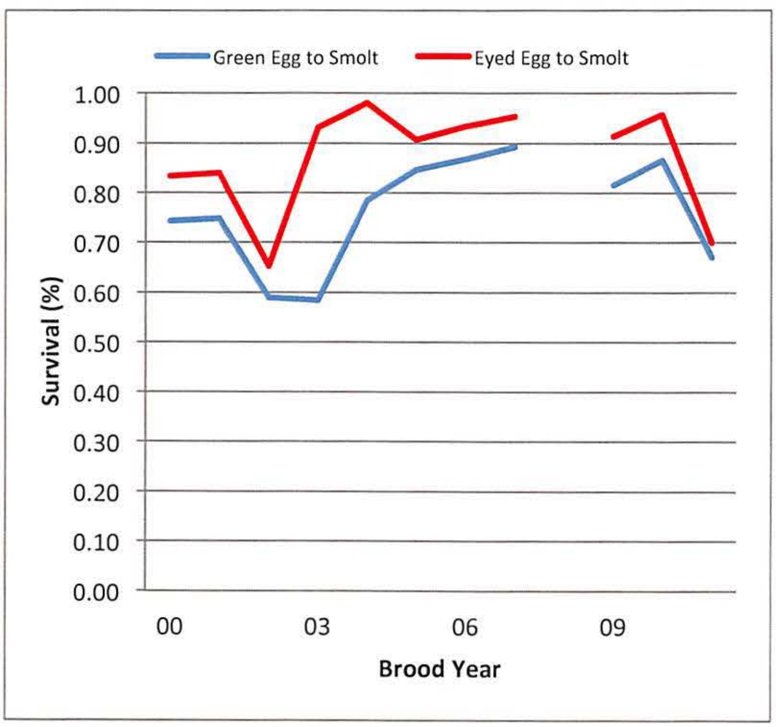

Figure 7. Green-egg and eyed-egg to smolt survival of LFH stock fish reared at Lyons Ferry Hatchery.

Each release group is currently 100% coded-wire tagged and currently receives 15,000 PIT tags for estimating adult returns and assessing straying. None of these fish are currently marked for harvest (ad-clip), but a portion will be clipped in future years. During coded-wire tagging, a complete count of the stock is provided, with any mortalities subtracted from that point forward to estimate total smolt release numbers. At release, a minimum of 200 smolts are sampled a few days before release to estimate smolt size (length, weight, CV, fish/lb, K-Factor). During the first few years of the program, program size goals were not being met (Figure 9). Changes in rearing strategies were implemented and since then program goals have been met on a more consistent basis since.

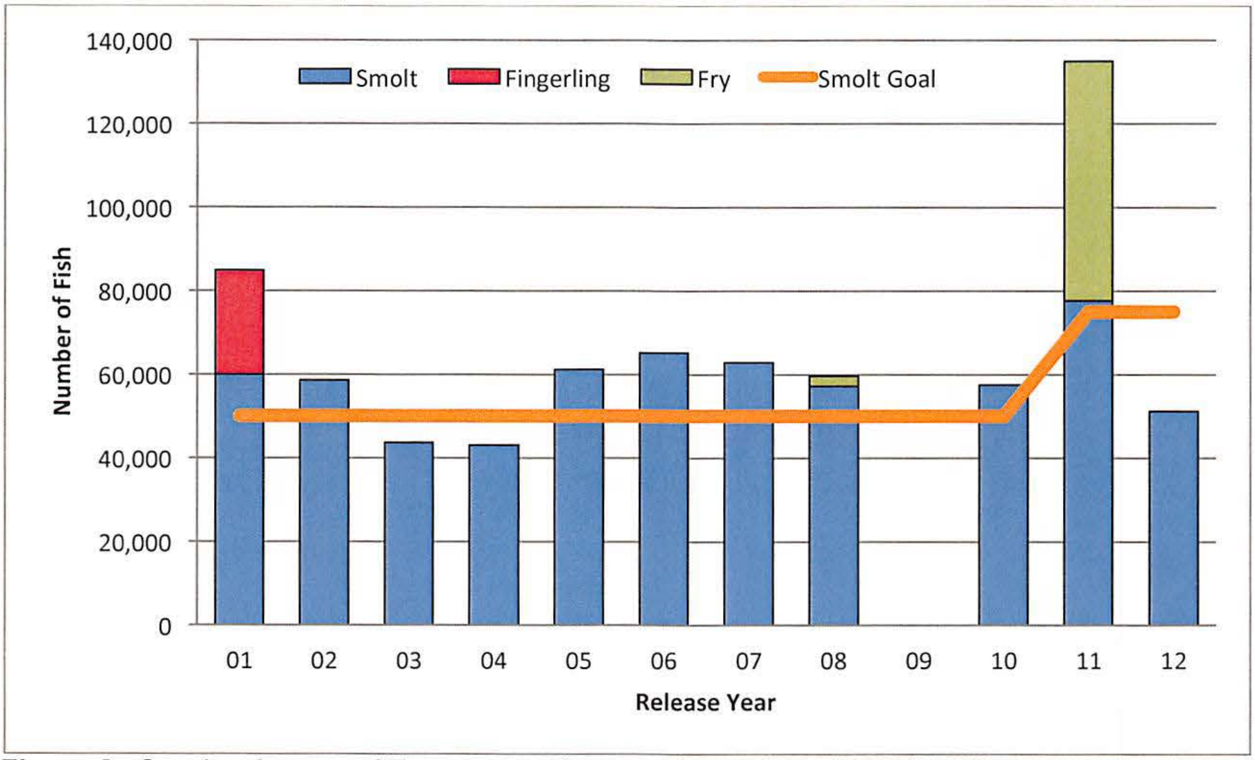

Figure 8. Smolt releases of Tucannon River stock steelhead, 2001-2012 release years.

With the implementation of the steelhead programs in SE Washington in the early 1980's, WDFW established monitoring efforts that gathered information on the hatchery steelhead (electrofishing for residuals in streams, migrants captured in smolt traps, estimating returning adults through creel surveys, spawning ground surveys, and the operation of adult traps). These monitoring activities also allowed WDFW to collect information on natural steelhead production. However, efforts to fully understand the interaction of hatchery and natural fish are incomplete as environmental conditions often limited the quality of the data (i.e. high stream flows during spawning surveys, or washed out adult traps).

Due to these problems, WDFW has recently focused their natural production monitoring for steelhead in the Tucannon River with PIT tags. Natural origin migrants (Figure 10) are tagged at the smolt trap in the lower Tucannon River, and currently WDFW has deployed four in-stream PIT Tag arrays throughout the Tucannon River basin (Figure 11) to estimate adults returning to the river. PIT Tags implanted in both natural and hatchery endemic fish will allow WDFW to estimate natural and hatchery origin compositions into the Tucannon River.

Through the use of PIT Tags, WDFW has been able to compare run timing of natural, endemic and LFH stock adults back to the Snake (at Ice Harbor Dam) and Tucannon rivers (Figure 12). Lyons Ferry stock steelhead return to each river significantly earlier.

Smolt-to-adult survival of endemic stock fish closely mirrors survivals that have been estimated for natural origin steelhead from the Tucannon River (Figure 13), and are similar to

Lyons Ferry stock steelhead performance in the last few years. More importantly, the Tucannon endemic stock survival to the project area is well above the 0.5% goal that was established when the program began, providing one of the basic factors in our decision to expand this program and eliminate the releases of Lyons Ferry stock into the Tucannon River. Progeny per Parent for the Tucannon endemic stock back to the project area (above Ice Harbor Dam) has averaged 28, another indicator of the program's success.

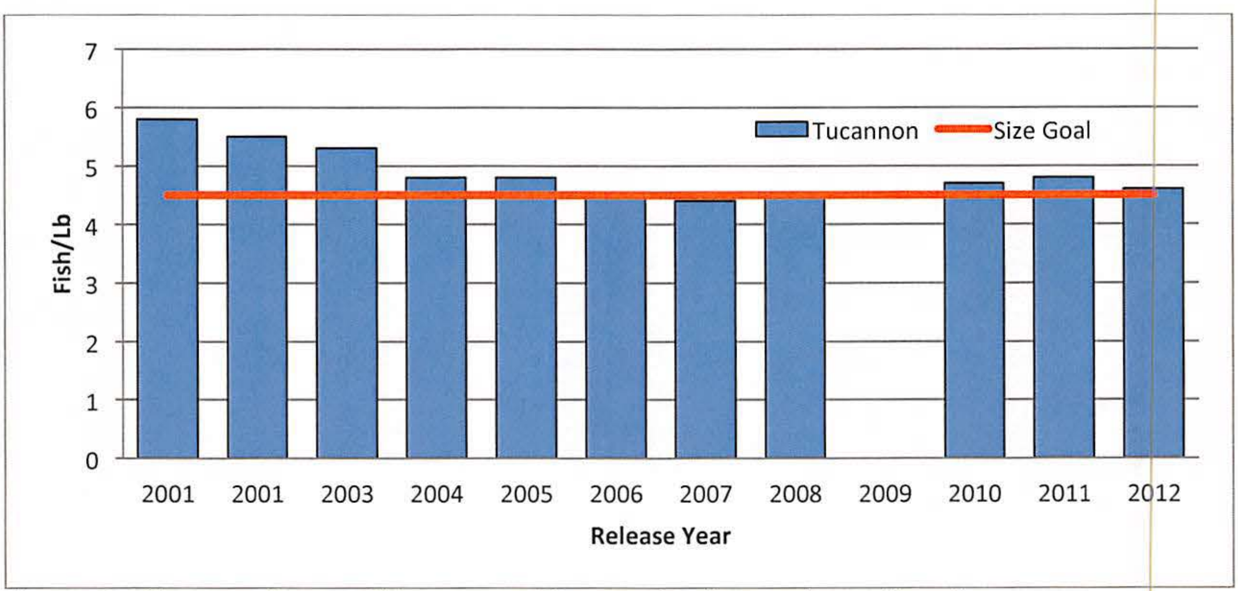

Figure 8. Size at release of Tucannon River endemic stock steelhead.

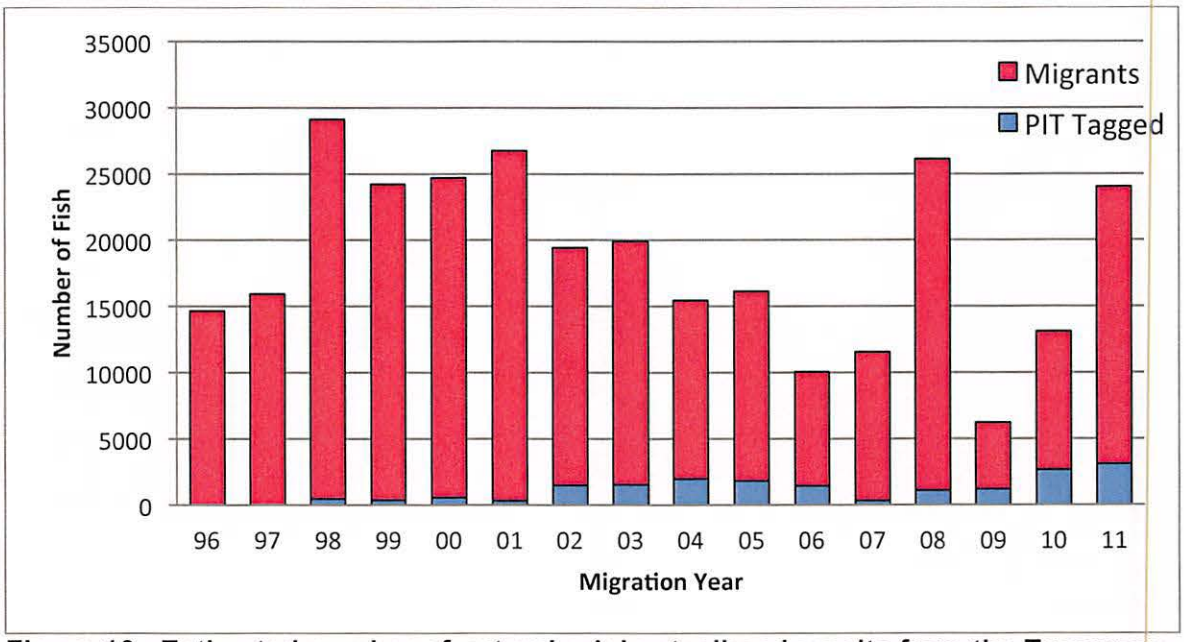

Figure 10. Estimated number of natural origin steelhead smolts from the Tucannon River, 1996-2011 migration years, and the number of PIT tagged smolts.

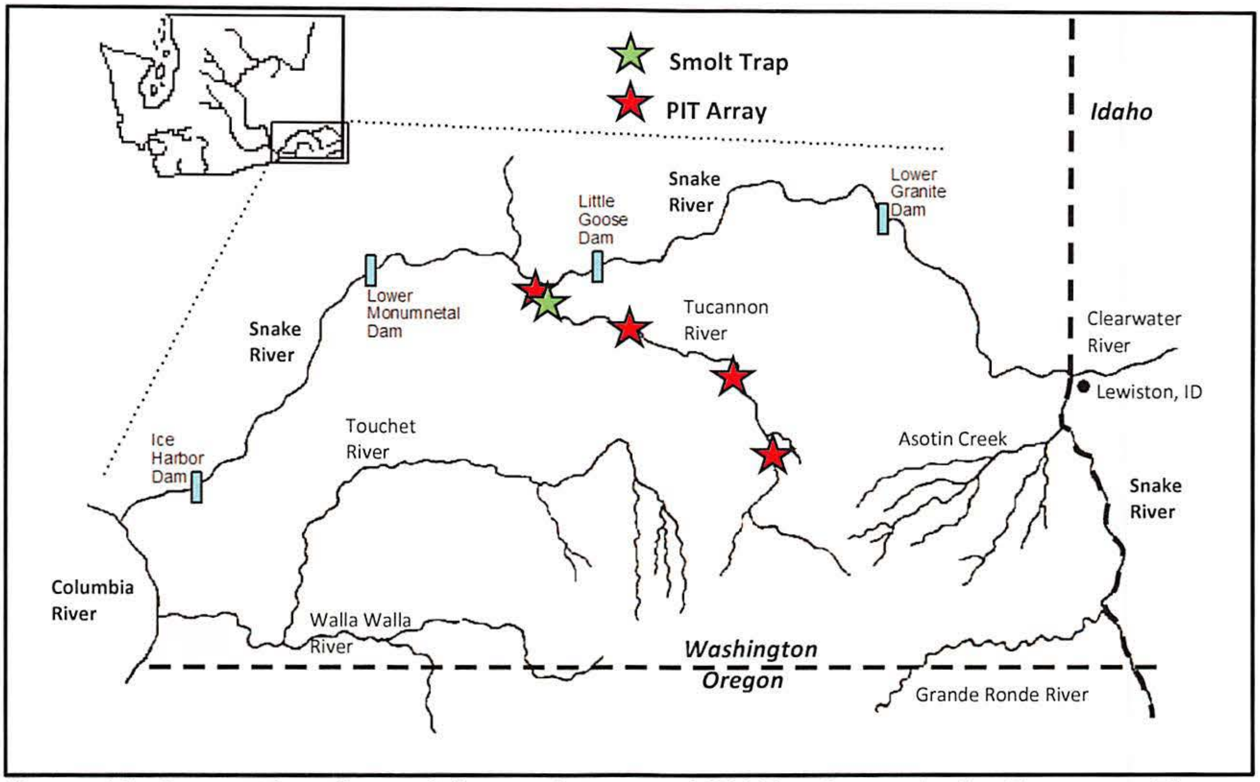

Figure 11. Current locations of the smolt trap and PIT Tag Arrays in the Tucannon River.

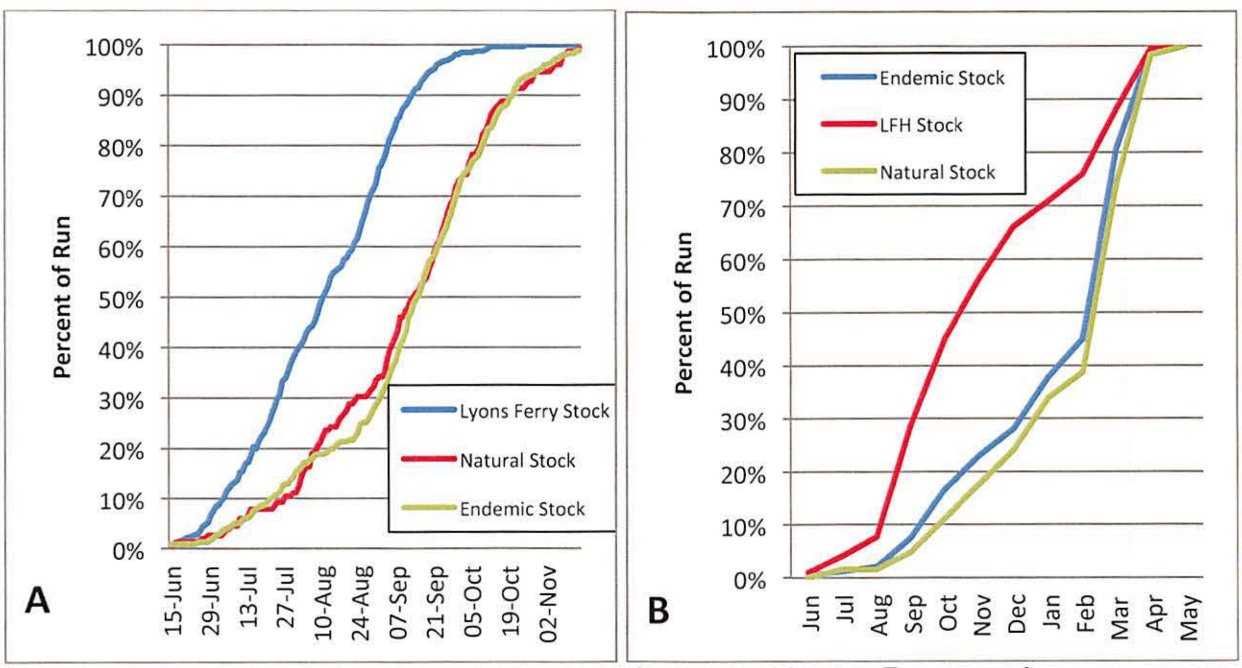

Figure 12. Run timing of natural, hatchery endemic, and Lyons Ferry stock summer steelhead (Tucannon River releases) over Ice Harbor Dam (A) or into the Tucannon River (B) based on PIT Tags, 2009-2011 run years.

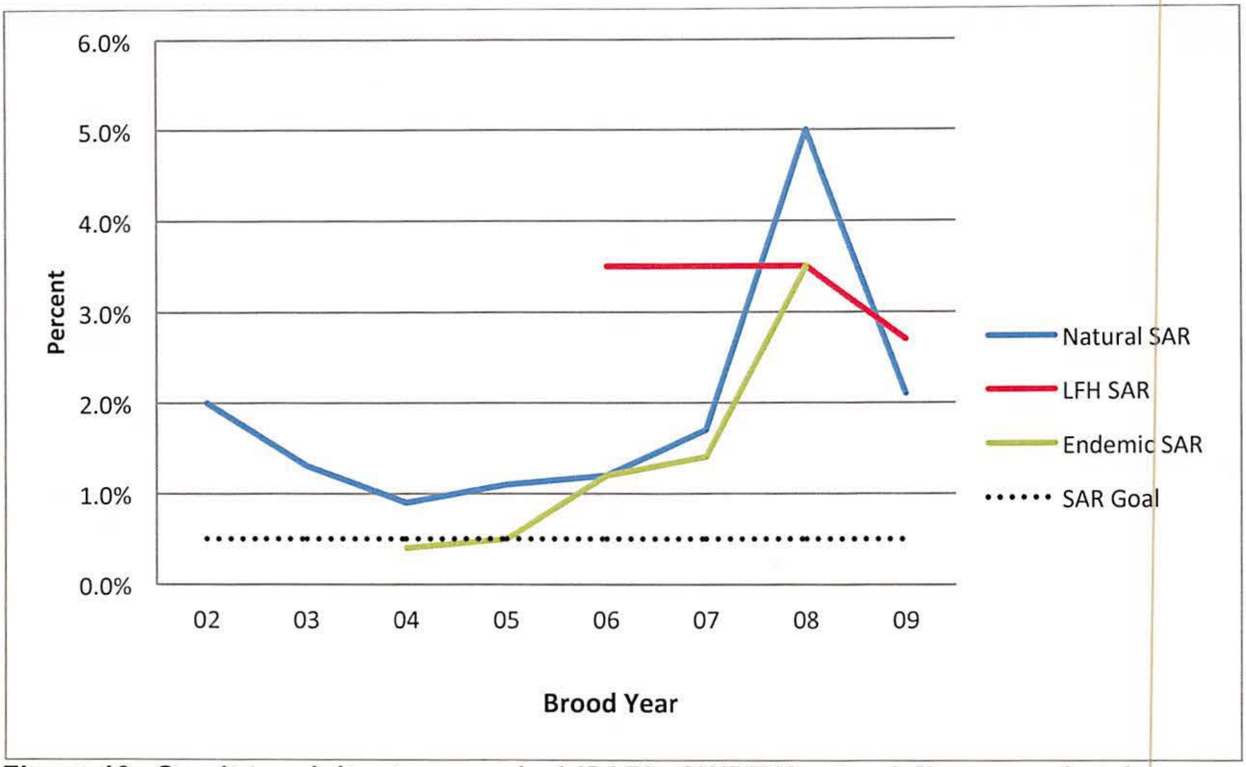

Figure 13. Smolt-to-adult return survival (SAR) of WDFW natural, Tucannon hatchery endemic, and Lyons Ferry stock summer steelhead from the Tucannon River.

PIT Tags in returning adults (all three stocks of steelhead in the Tucannon River) provided us with the necessary data to make decisions about expanding the Tucannon endemic hatchery program in the Tucannon River. In addition, the data have provided insight as to what has been limiting steelhead production in the Tucannon River (Table 2). Based on multiple years of return data from all three stocks of steelhead that come out of the Tucannon River, we believe that only 30-35% (could be as high as 50%) of the adult steelhead that cross Ice Harbor Dam actually return to the Tucannon River, with the remaining entering other locations – the majority in areas above Lower Granite Dam. WDFW believes this behavior is either 1) a natural migration pattern, 2) adults are following cold water coming from the Clearwater River basin, 3) adults are seeking over-wintering locations outside the reservoir impacted area caused by the four lower Snake River Dams, or 4) are blocked by the dams from returning downstream to the Tucannon River later in the winter/early spring. Initially, about 65-70% of the returning adults migrate upstream of Lower Granite Dam, with about 15-20% estimated to fall/migrate back, some of which return to the Tucannon River. By taking these estimates of "straying" into consideration, WDFW has calculated a modified Progeny:Parent ratio of fish returning to the Tucannon River only. Between 2000-2009, WDFW had collected 319 fish for use as broodstock, with an estimated 1,950 returns to the Tucannon River, for a progeny:parent ratio of 6.1:1.

With both natural and hatchery fish PIT Tagged, WDFW has been able to estimate escapement into the Tucannon River (Figure 14). For the estimates, we've assumed that as high as 50% of Tucannon origin steelhead that cross Ice Harbor Dam return to the Tucannon River. Overall escapement of wild origin steelhead to the Tucannon River remains low, and is below the recommended minimum abundance threshold (MAT) of natural-origin adults (285 spawners) described in WDFW's Fishery Management Evaluation Plan (FMEP) and by the Interior Columbia Technical Review Team (ICTRT).

Table 2. Estimated percentages of summer steelhead (hatchery and natural) from the Tucannon River that return to the Tucannon River or remain above Lower Granite Dam, based on PIT Tag detections.

Stock (Migration Years)	Number of PITs Detected at IHR Dam (N)	Enter Tucannon River	Remain above LGR Dam	Unknown Location
LFH – Tucannon Release (06-10)	790	23%	55%	22%
Tucannon Endemic (04-10)	752	29%	55%	16%
Tucannon Natural (04-10)	165	29%	53%	18%

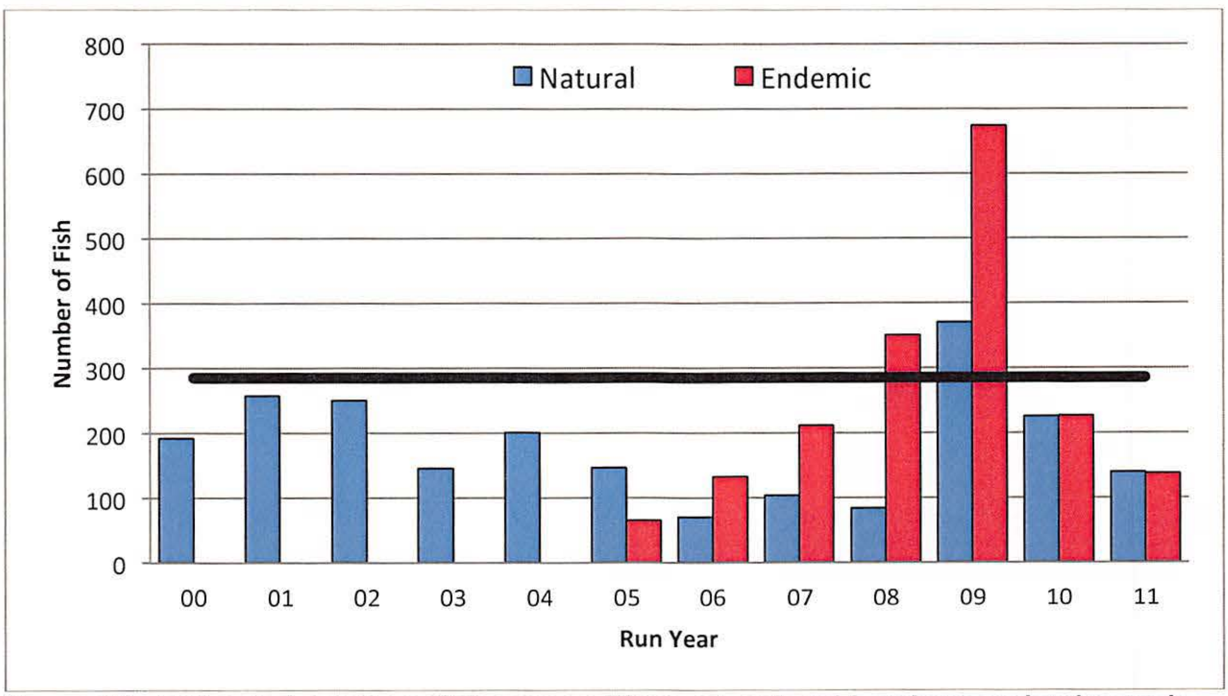

Figure 14. Estimated number of Tucannon River natural and hatchery endemic stock steelhead escaping into the Tucannon River, 2000-2011 run years.

According to NOAA Fisheries and the ICTRT, the Tucannon River summer steelhead population is comprised of the Tucannon River and other smaller tributaries that flow directly into the Snake River below Lower Granite Dam (Almota Creek, Deadman Creek, Alkali Flat Creek, and Penewawa Creek). The estimates provided in Figure 14 are only for the Tucannon River. Limited information is available on the natural steelhead population sizes in these smaller tributaries of the Snake River. However, according to the FMEP, natural origin spawning escapement below the MAT does not meet the minimum for allowing fisheries for hatchery steelhead to occur where that population exists. Obtaining population estimates and determining stock origin of natural origin steelhead from these smaller tributaries of the Snake River may be vital in order to maintain a mitigation fishery on the Tucannon River.

Examining adult PIT tag returns, we've observed that all three groups of steelhead that are from, or were released into, the Tucannon River (natural origin, LFH stock, Tucannon endemic stock), "stray" above Lower Granite Dam, and return to the Tucannon River at about the same rate every year (Table 2). This observation of "straying" into areas above point of origin is not unique to Tucannon River steelhead. The PIT Tag array near the mouth of the Tucannon has provided data indicating that other populations of steelhead (both hatchery and wild) are straying into the Tucannon as well. In fact, the PIT tag data indicates that about 1/3 of the natural origin steelhead entering the Tucannon River during the spring months are from other river basins (Figure 15).

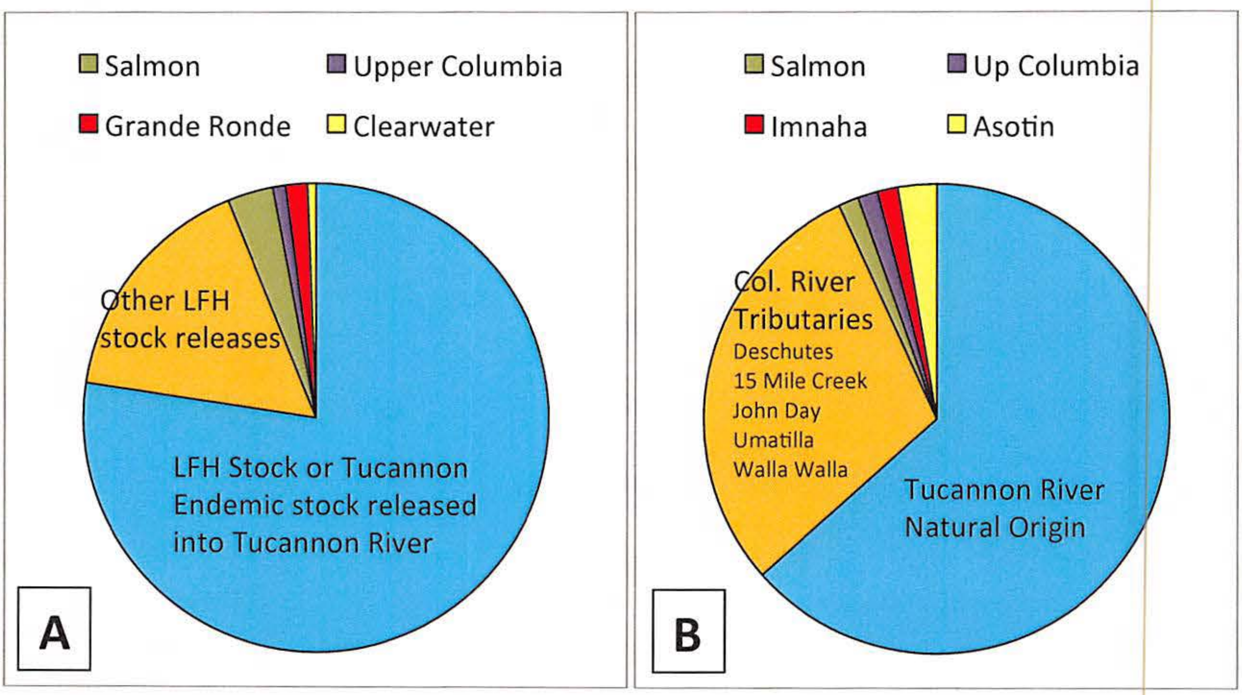

Figure 15. Percent composition (actual number – not expanded by mark rate) of Hatchery (A) and Wild (B) origin adult PIT tagged steelhead entering the Tucannon River between February-April, 2005-2011 Run Years.

Similar to the Tucannon River steelhead that stray above Lower Granite Dam, these other populations, especially those from the Columbia River tributaries, initially pass the mainstem dams and then are unable or unwilling to fallback to their natal stream. With the Tucannon River natural population at depressed/critical levels, these other populations represent a genetic risk to the natural population.

PROGRAM ASSESSMENT – TOUCHET STOCK

Currently, about 13-15 females (and an equal or greater number of males) are needed to meet program needs of 50,000 smolts. A 2x2 matrix spawn is typically applied when enough males are ripe on spawn days; though some males get used multiple times during the spawning season. Due to the low number of spawners, the effective population size (N_e) each year has been relatively small (Table 3), which is a concern of WDFW management should F_1 generation hatchery fish be needed for future broodstock use until the program could be expanded. To date, we have not used any Touchet Endemic hatchery stock in the spawning process.

Table 3. Effective population size of Touchet River endemic hatchery steelhead broodstock, 2000-2012 broods.

Brood	00	01	02	03	04	05	06	07	08	09	10	11	12
N_e	18	25	31	33	24	33	36	33	24	27	28	25	29

Run timing of both wild and endemic stock fish have been documented at the Touchet River Adult Trap. Unlike the Tucannon River, run timing to the Touchet River Adult Trap is similar between the two stocks. Due to issues with extended spawn times and poor rearing success with this stock in the hatchery, broodstock have been collected over the earlier part of the run, allowing for earlier spawning and more time for rearing (Figure 16). However, for the last two years, collection of broodstock has been compressed to a 3-week time period during the peak of the run. The number of steelhead estimated on the spawning grounds above the city of Dayton (natural and hatchery origin) has remained relatively stable over time (Figure 17). The returns within this area have been dominated by natural origin steelhead, with generally less than 20% hatchery fish on the spawning grounds.

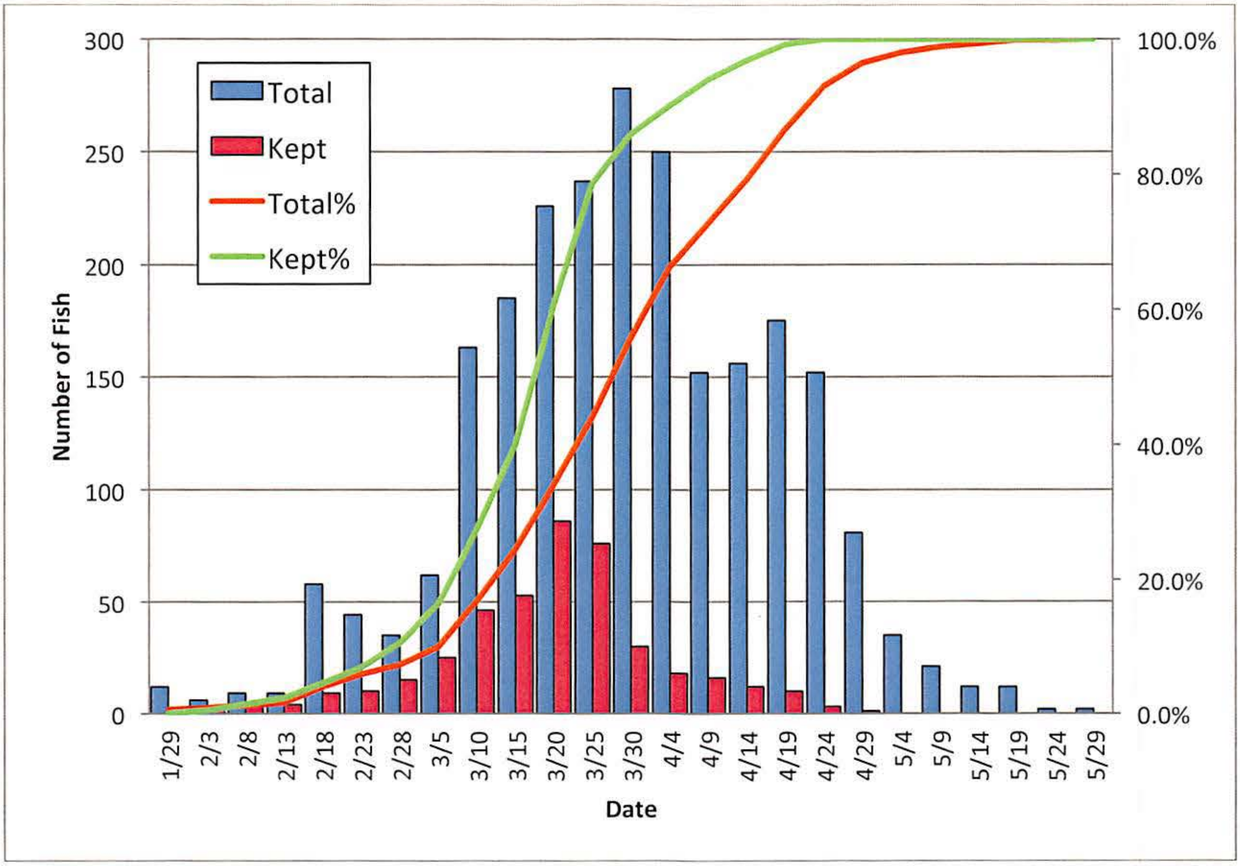

Figure 16. Number and percentage of Touchet River wild origin steelhead trapped and collected for broodstock at the Dayton Adult trap, Touchet River (1999-2011 run years).

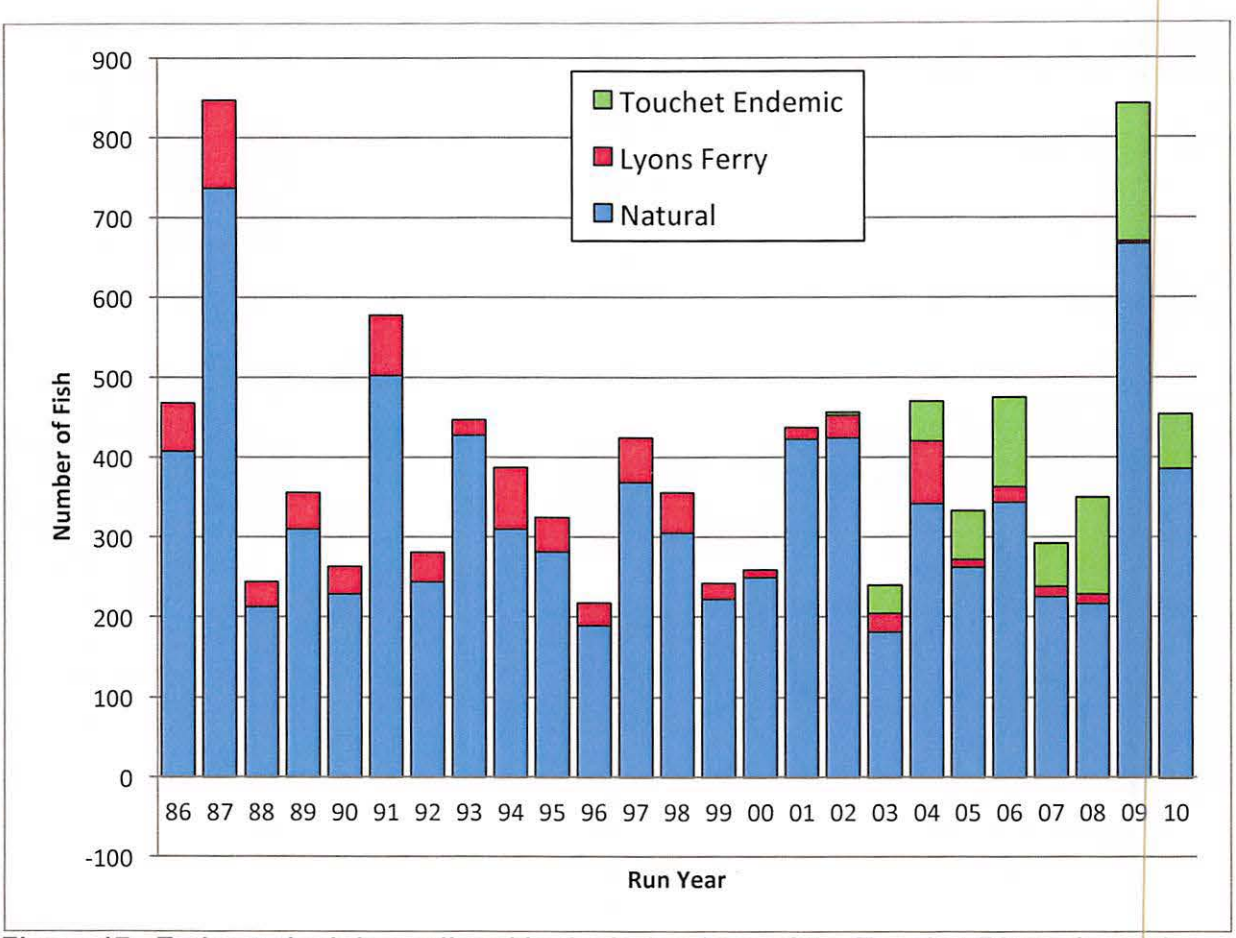

Figure 17. Estimated adult steelhead in the Index Area of the Touchet River above the city of Dayton (1986-2010 Run Years).

Between 2000 and 2012, disposition of the Touchet River broodstock was as follows: 86% have been spawned, 11% were pre-spawn mortalities, and 3% were not used and returned to the river for natural spawning. WDFW evaluation staff has collected scales from the broodstock collections and from representative samples of adults trapped on the river to determine age composition of each year's run. Fish collected for broodstock are similar in overall age distribution of the run (Figure 18). About 5% of the annual return of natural origin steelhead are repeat spawners.

For each steelhead program at Lyons Ferry Hatchery, counts or estimates of production are made at various life stages. Over the years, the number of green eggs and eyed-eggs have been estimated through either volumetric or weight sampling methods, or from mechanical egg counters. Eyed egg-to-smolt survival has been relatively consistent, though variable, for the entire Touchet River endemic steelhead program (Figure 19). Fish health has generally not been a problem at LFH because of high quality pathogen free ground water. However, in 2005, 2006 and 2009, IHNV was detected in the ovarian fluid of spawned Touchet River females. Per agency protocol, progeny from these females were not reared at the hatchery, but were released back into the Touchet River as fry. Additional females were collected to offset the loss, and overall production was not impacted. Bacterial coldwater disease has sometimes been present during the rearing cycle, though the disease has not affected overall smolt production of the Touchet stock (Figure 20).

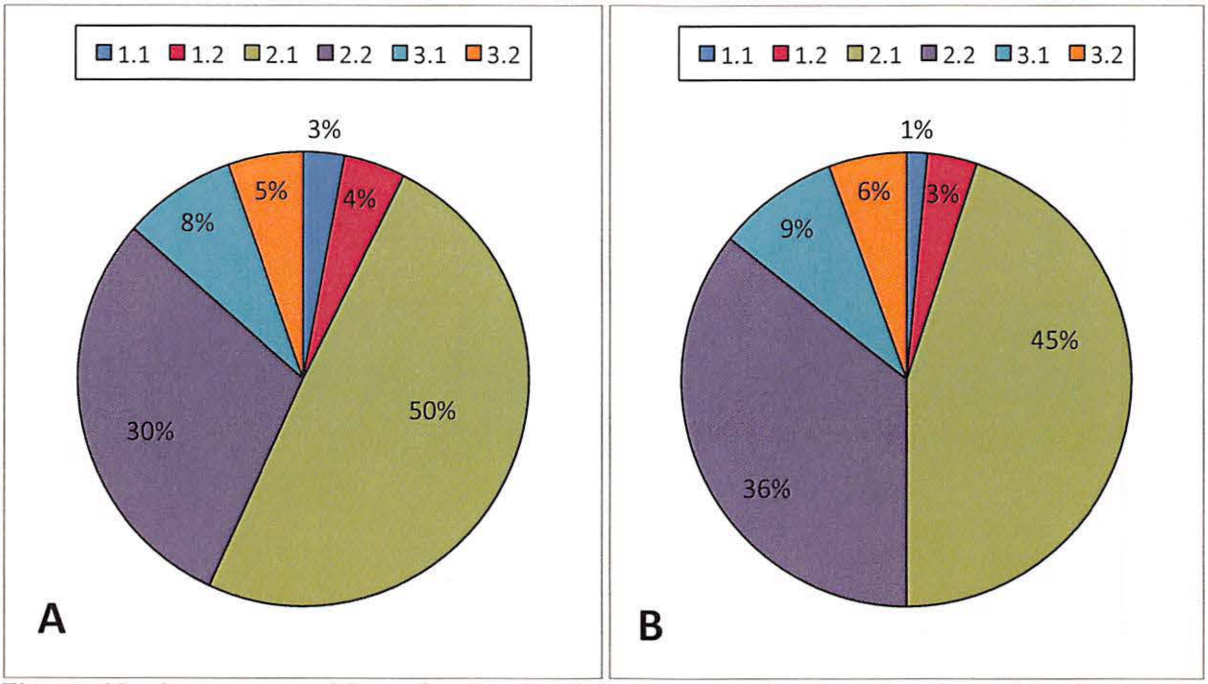

Figure 18. Age composition of natural origin summer steelhead collected for broodstock (A) or from the entire population (B) of the Touchet River, 1999-2010 Run Years.

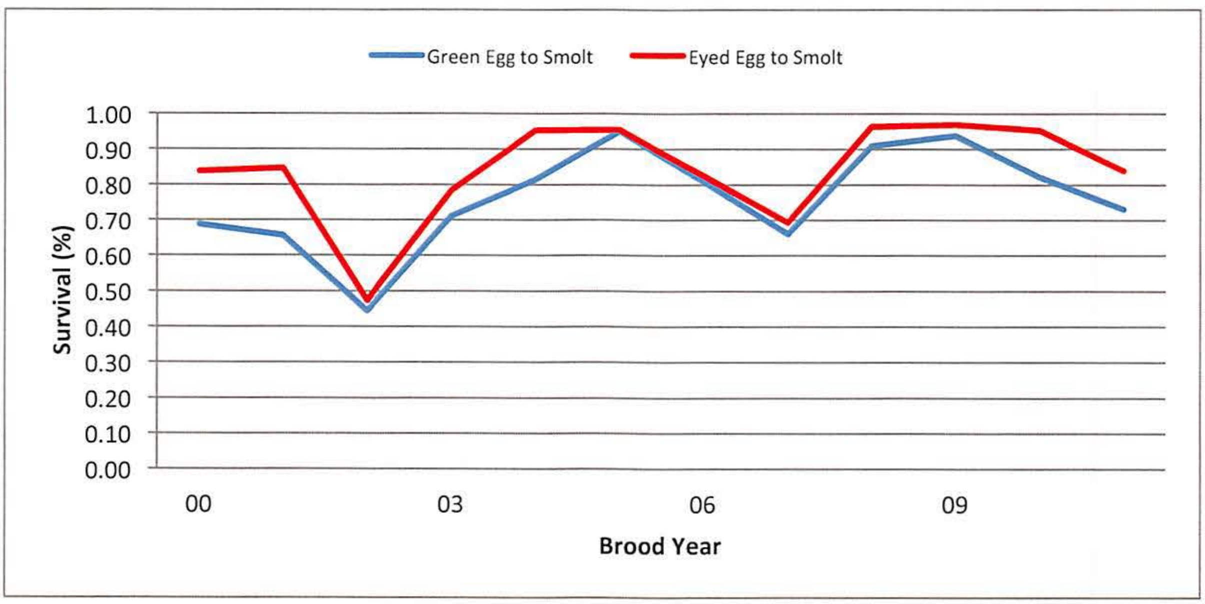

Figure 19. Green-egg and eyed-egg to smolt survival of Touchet River endemic stock fish reared at Lyons Ferry Hatchery.

Each release group is currently 100% coded-wire tagged and currently receives 5,000-10,000 PIT tags for estimating adult returns and assessing straying. None of these fish are currently marked for harvest (ad-clip), but all would be clipped in future years if the program is expanded for harvest mitigation. During coded-wire tagging, a complete count of the stock is provided, with any mortalities subtracted from that point forward to estimate total smolt release numbers. At release, a minimum of 200 smolts are sampled a few days before release to estimate smolt size (length, weight, CV, fish/lb, K-Factor). During the first few years of the program, program size goals were not being met (Figure 21). Changes in rearing strategies were implemented and program goals have been met on a more consistent basis since.

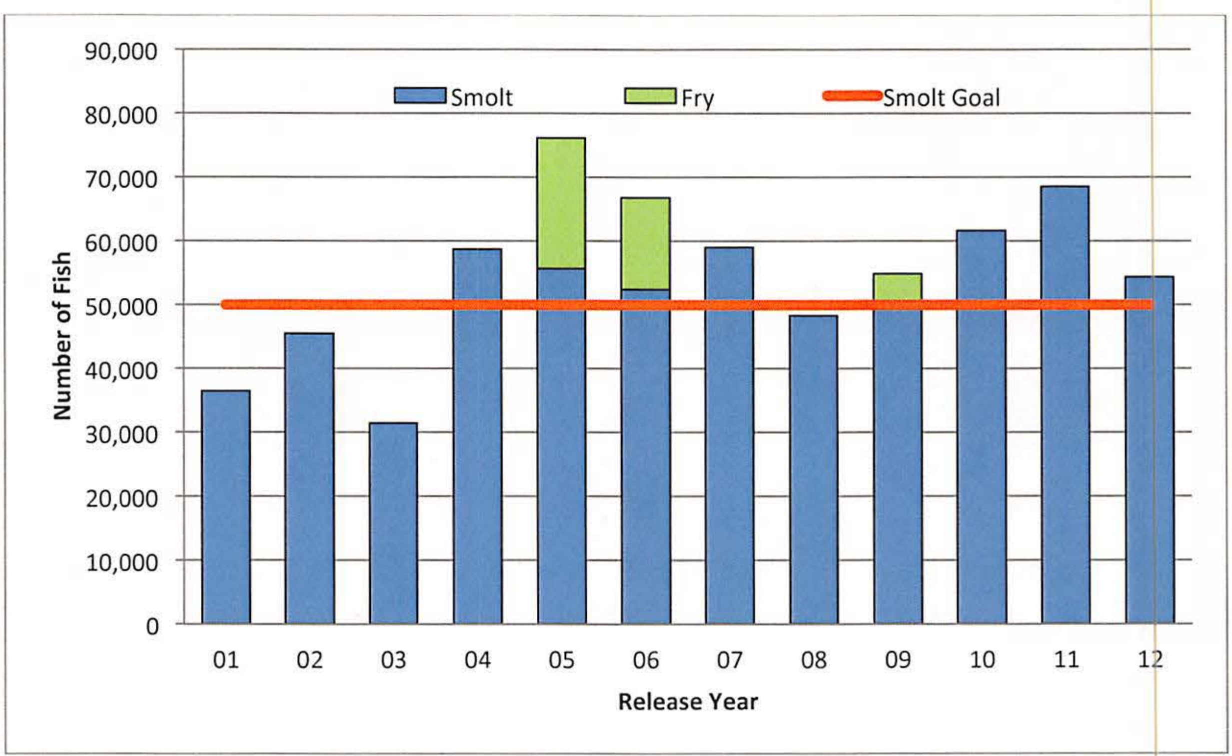

Figure 20. Smolt releases of Touchet River stock steelhead, 2001-2012 release years.

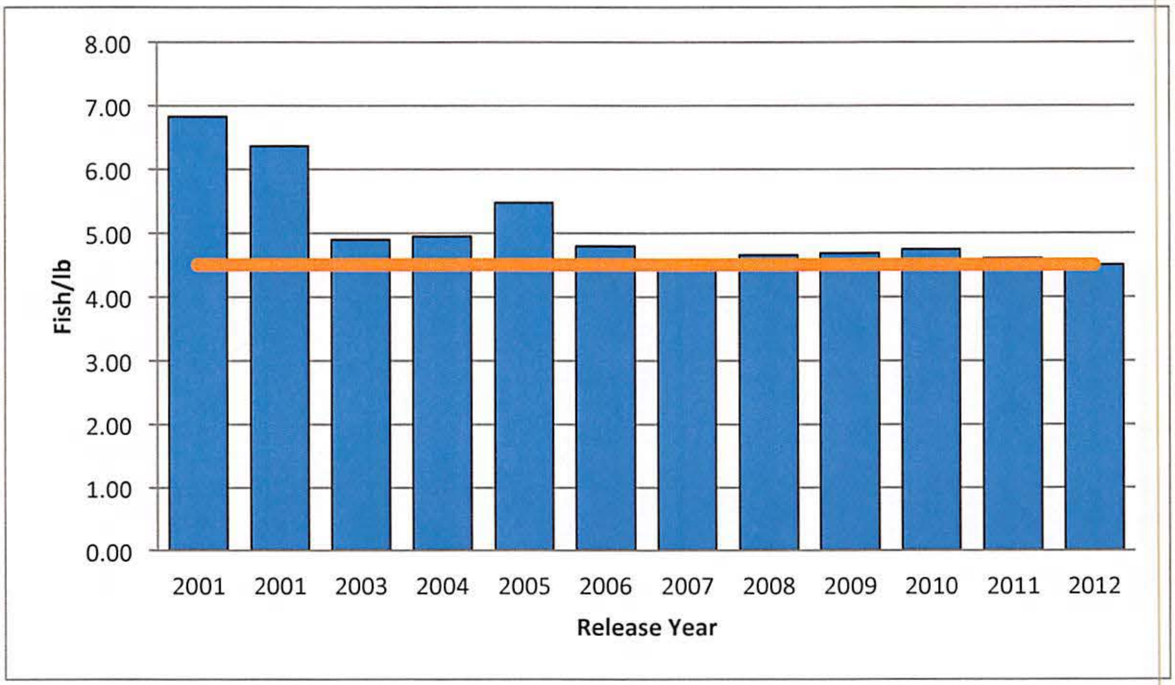

Figure 21. Size at release of Touchet River endemic stock steelhead.

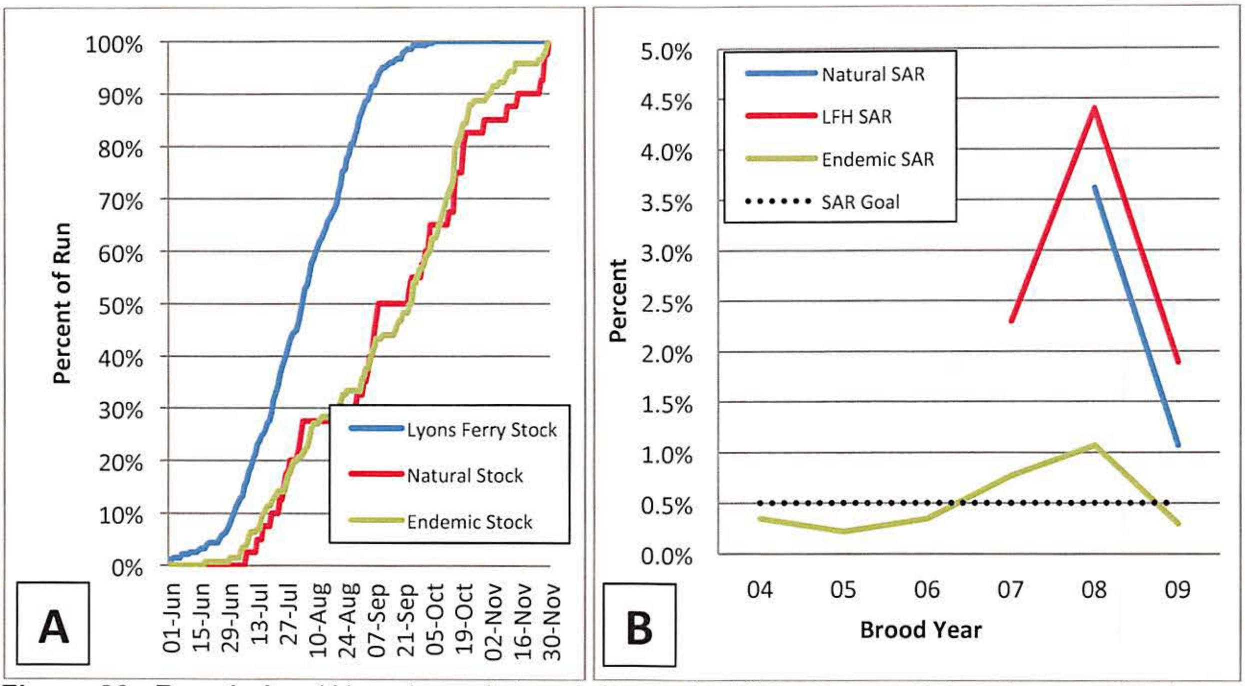

Figure 22. Run timing (A) and smolt-to-adult survival (B) of natural, hatchery endemic, and Lyons Ferry stock summer steelhead (Touchet River releases) as measured at McNary Dam.

Table 4. Estimated percentages of summer steelhead (hatchery and natural) from the Touchet River that return to the Walla Walla Basin, or pass/remain above Ice Harbor Dam, based on PIT Tag detections.

Stock (Migration years)	Number of PITs Detected at McNary Dam	Pass Above IHR Dam	Enter Walla Walla River	Unknown Location
LFH – Touchet River Release (08-10)	286	84%	12%	4%
Touchet River Endemic (08-10)	145	50%	36%	14%
Touchet River Natural (08-10)	47	34%	28%	38%

Unfortunately, the PIT Array in the Touchet River has not been in operation long enough to allow estimates of adults back to the Touchet River. Lyons Ferry stock steelhead arrive at McNary Dam significantly earlier than either the endemic or natural stock. Smolt-to-adult survival of endemic stock fish is much lower than has been estimated for natural origin or Lyons Ferry stock steelhead from the Touchet River (Figure 23). The mean estimated survival of the Touchet Endemic stock as measured at McNary Dam is only 0.45%, below our established criteria for the program performance to the Touchet.

Also similar to the Tucannon River steelhead, all three Touchet River stocks of steelhead are straying into the Snake River Basin upon initial return (Table 4), though with later run timing, both the endemic stock and natural origin fish tend to stray into the Snake River at a lower rate as compared to the Lyons Ferry stock fish. However, with as many as 50% of the endemic stock steelhead straying into the Snake River basin, SAR's of the endemic stock will have to substantially improve to meet program goals of adults and survival to the Touchet River. As with the Tucannon River, the cause of this staying behavior is unknown. However, low stream flows and high water temperatures in the Walla Walla River when adults are returning are likely factors.

By taking these estimates of "straying" into consideration, WDFW has calculated a modified Progeny:Parent ratio of fish returning to the Touchet River only. Between 2000-2009, WDFW had collected 299 fish for use as broodstock, with an estimated 679 returns to the Touchet River, for a progeny:parent ratio of 2.3:1; an indication of this programs overall poor success. Further, production estimates for Touchet River natural steelhead indicate the stock is near replacement levels (Figure 24). Given the poor success of the endemic program, and indications that the natural population is stable and may recover to a healthy level, local fish management and evaluation staffs have recommended that the Touchet endemic stock program be stopped. A final policy decision has not been reached.

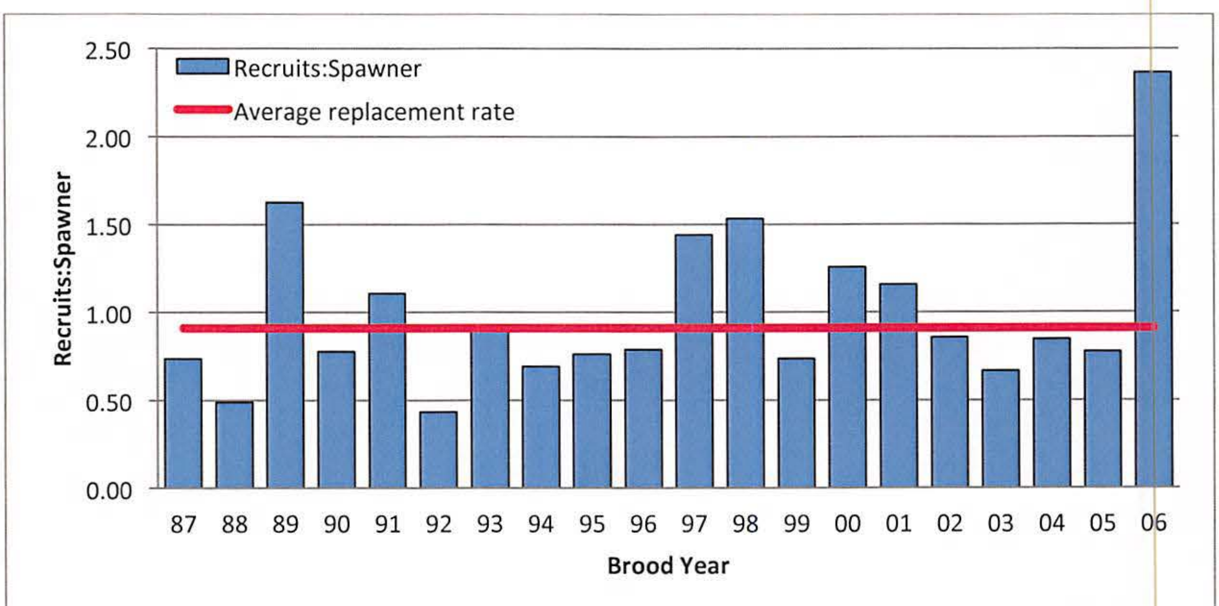

Figure 24. Recruits:Spawner ratios of naturally produced summer steelhead from the Touchet River based on index area spawning population estimates in the upper Touchet Basin.

SUMMARY AND CONCLUSIONS

Broodstock Development and Management

WDFW developed both Tucannon and Touchet endemic stocks through trapping of returning natural origin adults at traps within each river system. Broodstock availability has not been a limiting factor for either program to date. However, due to low returns in the Tucannon River, broodstock levels to reach full program needs may be limited in future years.

In-Hatchery Performance

Over the course of each program, spawn timing has remained consistent. Pre-spawning mortality has remained low, egg-to-smolt survival rates have been variable but within acceptable limits, and have not affected overall program performance. No major outbreaks of disease have occurred in either program, but detection of IHNV in female broodstock limited production in the Tucannon stock for one year. Bacterial coldwater disease sometimes occurs, but has not prevented either program from achieving smolt release goals. Smolt releases (target number) have generally be met, but size at release has often fallen short, especially early on in each program. Problems with late spawning, multiple egg takes, high fright response when feeding, etc...., has prompted new rearing techniques and strategies, which have generally overcome problems seen early on in the programs.

Survival and Adult Return Performance

For the Tucannon River stock, we determined that smolt-to-adult survival was above the minimum goal set, and further releases of Lyons Ferry stock into the Tucannon River would not be supported by NOAA Fisheries. As such, and in order to maintain a harvest mitigation program in the Tucannon River for summer steelhead and despite straying problems for all stocks in the Tucannon, WDFW implemented expansion of the Tucannon endemic stock program. While facility modifications need to occur, we expect to reach full program levels by the 2015 brood.

For the Touchet River stock, we have determined that smolt-to-adult survival has been below the goal set for the program. In addition, many of the returning adults are not returning to the Touchet River. The natural population appears to be stable, despite loss of habitat and having a hatchery mitigation program present in the basin. Local fish management and evaluation staffs have recommended that this program, as originally intended as a harvest mitigation program to replace the Lyons Ferry stock, be terminated. A formal policy decision from WDFW and agreement with our co-manager under US v. OR are pending.

Variation in Straying Patterns and Rates of Snake River Hatchery Steelhead Stocks in the Deschutes River Basin, Oregon

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Information related to this presentation can be viewed in:

Carmichael, R. W., and T. L. Hoffnagle. 2006. Hatchery steelhead straying in the Deschutes River Basin. The Osprey, Issue No. 55. Federation of Fly Fishers, Livingston, Montana. http://ospreysteelhead.org/archives/TheOspreyIssue55.pdf

Ruzycki, J. R., and R. W. Carmichael. 2010. Summary of out-of-basin steelhead strays in the John Day River Basin. Report to the Independent Scientific Advisory Board. Oregon Department of Fish and Wildlife, La Grande, Oregon. 10pp. http://www.nwcouncil.org/library/isab/2010-2/John%20Day%20Stray%20Summary%20Ruzycki%20Carmichael.pdf

The Use of Passive Integrated Transponder (PIT) Tags as a Tool to Monitor and Manage Steelhead

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Passive Integrated Transponder (PIT) tags were introduced to the market in 1987 and the PTAGIS database was implemented in 1991. Through the 1990's and early 2000's, PIT tags were primarily used in anadromous fish to assess juvenile survival rates during outmigration through the Snake River and Columbia River hydropower system. However, in more recent years, PIT tags have been more readily used in evaluating returning adult numbers and behavior. Currently, PIT tags are used to monitor a variety of juvenile and adult metrics in steelhead.

In juvenile steelhead, PIT tags are used to estimate stock- and release site-specific travel times and juvenile survival rates from release to Lower Granite Dam (LGD) as well as arrival timing at LGD (Figure 1). Additionally, PIT tags are currently being used in cooperative work with the Comparative Survival Study (CSS) to evaluate survival related to migration route and subsequent smolt-to-adult return rates (SARs).

Hatchery	Release Group	Stock	PIT-tagged Fish Released	Release Date	50% Passage Date	80% Arrival Window (# Days)	% Survival (95% CI)
Clearwater	Newsome Creek	DWOR	3,591	4/11-4/18	5/15	4/28 - 6/2	**74.7 (± 4.1)**
	Peasley Creek	DWOR	5,195	4/15	5/9	4/21 - 5/20	**81.1 (± 2.5)**
		DWOR	2,098	4/15	4/28	4/20 - 5/16	**83.2 (± 3.9)**
		SFCLW	11,277	4/15	5/10	4/21 - 5/22	**80.3 (± 1.7)**
		SFCLW	3,987	4/15-4/15	5/10	4/21 - 5/23	**80.5 (± 2.6)**
	Red House Hole	DWOR	7,674	4/12-4/13	4/21	4/17 - 5/11	**81.8 (± 1.6)**
Hagerman	Upper East Fork Salmon River	EFNAT	6,981	5/3-5/5	5/19	5/13 - 6/5	**79.9 (± 4.1)**
National	Sawtooth Weir	SAW	13,409	4/13-4/29	5/9	4/29 - 5/16	**82.8 (± 2.5)**
	Yankee Fork	SAW	4,070	5/6-5/16	5/26	5/19 - 6/12	**77.9 (± 4.5)**
	Yankee Fork	SAW	4,142	5/6-5/16	5/29	5/17 - 6/15	**72.3 (± 4.3)**
Magic Valley	Colston Corner	PAH	2,095	4/6-4/8	5/12	4/25 - 5/8	**71.6 (± 4.3)**
	Little Salmon River	DWOR	3,981	4/12-4/14	5/13	4/29 - 5/27	**85.0 (± 3.1)**
		PAH	3,678	4/8-4/12	5/10	4/21 - 5/22	**85.7 (± 2.7)**
	Lower East Fork Salmon River	DWOR	4,983	4/14-4/18	5/14	5/9 - 5/23	**72.1 (± 3.9)**
	McNabb Point	SAW	2,093	4/22-4/25	5/10	5/3 - 5/15	**87.1 (± 5.8)**
	Pahsimeroi Weir	DWOR	1,795	4/26	5/12	5/9 - 5/21	**83.9 (± 5.9)**
		USAL	5,371	4/26-4/27	5/12	5/8 - 5/21	**89.3 (± 3.8)**
	Red Rock	PAH	2,081	4/4-4/5	5/11	4/26 - 5/16	**75.9 (± 4.4)**
	Shoup Bridge	PAH	1,599	4/5-4/6	5/11	4/24 - 5/14	**76.4 (± 5.3)**
	Squaw Creek	DWOR	5,076	4/19-4/22	5/14	5/9 - 5/26	**60.4 (± 3.2)**
Niagara	Hells Canyon Dam	OXA	8,234	3/28-4/4	5/2	4/6 - 5/21	**72.8 (± 2.0)**
Springs	Little Salmon River	PAH	6,922	4/5-4/11	5/11	4/20 - 5/28	**79.4 (± 2.4)**
	Pahsimeroi Weir	PAH	12,840	4/12-4/28	5/12	5/5 - 5/19	**75.2 (± 2.3)**

Figure 1.

In adult steelhead, PIT tags are being used to estimate stock-specific escapement to Bonneville, McNary, Ice Harbor, and Lower Granite dams as well as conversion rates between the dams (Figure 2), and after-hours passage and fallback/reascension rates at the dams.

	(%) Bonneville to McNary		(%)Bonneville to LGD	
	One-ocean	Two-ocean	One-ocean	Two-ocean
DWOR (Clearwater)	88.3	71.1	84.5	70.8
DWOR (Salmon)	80.3	88.7	79.7	73.1
E.F. Naturals	99.4	79.7	98.7	79.2
Oxbow	78.8		65.4	
Pahsimeroi	79.1	82.8	73.0	82.6
Sawtooth	85.0	80.6	77.6	74.9
Upper Salmon River B's	79.1	68.9	40.9	58.3

Figure 2.

Additionally, tags are used to monitor adult hatchery-, stock-, and release site- specific migration timing, relative smolt-to-adult return rates (Figure 3), and stray/wandering rates. Lastly, PIT tags are often used as a tool in-season to coordinate the anticipated abundance of hatchery returns, by release site, as fish are returning and being detected downriver.

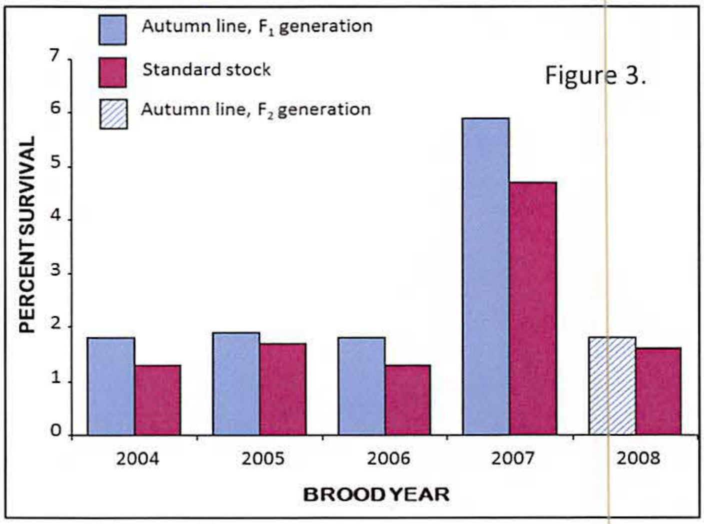


Figure 3.

Because PIT tags provide real-time, in-season data, it is important for agencies to communicate findings throughout the run in order for accurate management decisions to be made. To facilitate this coordination, weekly teleconference calls are held throughout the fall (in conjunction with fall Chinook salmon coordination) to discuss run status and its potential impacts on hatchery operations and fisheries. Participation in the teleconference process typically includes Idaho Department of Fish and Game (IDFG), Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, Nez Perce Tribe, Shoshone Bannock Tribe, and Idaho Power Company.

Figure 4.

While PIT tags are an important tool that provide real-time data valuable to researchers and managers, there are shortcomings associated with using the tags as a monitoring tool. Because tags can be shed and survival rates of tagged fish could differ from those of untagged fish, a PIT tagged group could underrepresent the adjacent untagged population. Underrepresentation has been shown in Chinook salmon. Historically, it had been difficult to determine the rate of tagged fish in adult returns because hand scanning at the hatchery racks is not 100% efficient and the actual efficiency of the hand scanning could not be determined. To get at true tagged proportions in adult returns, IDFG installed in-ladder detection arrays at the Sawtooth Trap (Figure 4). These repeat arrays, coupled with routine hand scanning, allow us to determine overall detection efficiencies and get at the true proportion of tagged fish in the adult return. Through two years of evaluating, results are mixed as to how well returning adult PIT tagged steelhead account for untagged fish based on juvenile tagging rates with uncorrected expansion estimates accounting for 65-140% of the actual return (Figure 5). Much of the variability observed to date is likely directly related to some small sample sizes and continued monitoring of returns to these arrays will provide more insight.

Brood Year	Return Year	Juvenile Expansion Rate	Run At Large PIT Tags at Trap Array	Return to River PIT Tags at Trap Array	Estimated Expanded Return	Actual Return	Corrected Expansion Rate
2007	09/10	108.6	50	19	5,449	5,699	113.6
2007	10/11	113.6	6	0	656	1,003	101.6
2008	10/11	141.3	20	3	2,799	2,000	173.5

Figure 5.

Monitoring and evaluation staff will continue to work towards identifying rates of PIT tag loss and this type of work is ongoing in both steelhead and Chinook salmon. Additional work double tagging Chinook salmon at LGD to evaluate tag loss in adults between LGD and adult traps is also ongoing. Also, the expanded use of parental based tagging (PBT) in the Snake River Basin and at LGD, will provide a tool to directly compare return estimates based on PIT tags versus those generated from genetic sampling and provide another comparison point for estimating the level of representation provided by expanding PIT tags in returning adults.

This report summarizes how well the combined LSRCP steelhead program has done to meet the mitigation program objectives. It also highlights the achievements and limitations observed over the program history with a brief description of the adaptive management approaches taken by the managers. Information presented in this report represents the combined efforts of many people from several state, tribal, and federal entities.

For most metrics, two figures are presented to show 1) the average or weighted average across all programs in WA, OR, and ID to convey how well LSRCP program is performing relative to the mitigation goals and 2) data series for individual programs to show both the synchrony and variability between programs. Definitions for all of the metrics provided in this summary were agreed upon by the data contributors to ensure the metrics would be comparable across programs. The intent of this report is not to focus on or to address nuances in individual programs but rather to provide an overview of the program relative to the stated mitigation objectives.

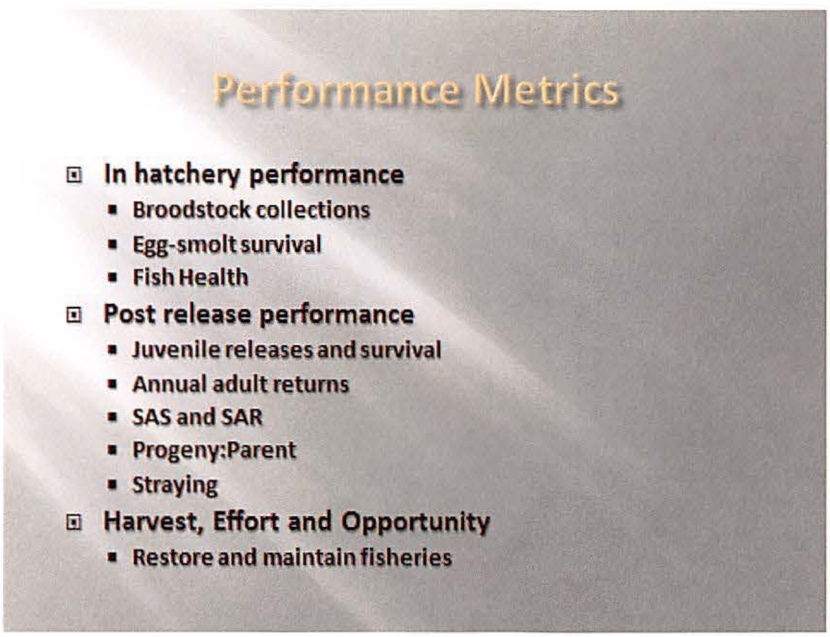
LSRCP Mitigation Objectives

The LSRCP steelhead hatchery mitigation program was established to provide in-kind and in-place mitigation for lost harvest opportunity resulting from the construction and operation of the four lower Snake River hydroelectric dams. Total mitigation expected for the LSRCP is 165,300 adults to be produced annually. This is based on an assumed 2:1 ratio of catch (downstream of project area; Lower Granite Dam) to escapement (upstream of the project area) (Corps of Engineers, 1975). During the program development, it was anticipated that the majority of the harvest mitigation benefits would be distributed downstream of the project area. However, less than expected returns of hatchery fish produced within the program and the depressed status of natural-origin fish influenced Columbia River fisheries management programs. The anticipated 2:1 distribution of harvest benefits downstream: upstream of Lower Granite Dam has not been realized. It is important to note that while the individual program presentations at this symposium have reported mitigation goals in terms of meeting objectives for "catch below the project area" and "escapement to the project area", this delineation is based more on the historic convention of how the mitigation objectives were originally described and less on actual management goals (Table 1). It may be more appropriate to think in terms of the total mitigation objective (165,300 adults) realizing that, for reasons mentioned above, the observed distribution of harvest benefits is more skewed to the terminal areas.

Table 1. Adult steelhead hatchery mitigation goals for the LSRCP program in Washington, Oregon, and Idaho.

	LSRCP-Adult Mitigation Goal		
	Project Area (Escapement)	Below Project Area (Catch)	Total Mitigation Goal
Washington	**4,655**	**9,310**	**13,965**
Oregon	**11,185**	**22,370**	**33,555**
Idaho	**39,260**	**78,520**	**117,780**
Total	**55,100**	**110,200**	**165,300**

While some of the LSRCP resources are devoted to support conservation goals and objectives, the majority of resources within the program are focused on harvest mitigation. This roll-up presentation will focus at the programmatic level and not address individual project specific goals and objectives.



Broodstock Collections and In-hatchery Survival

With some exceptions, broodstock collections have not limited that abilty of managers to meet smolt producioтn targets.During the early years of the program, the observed egg to smolt survial rates were generally high but considerable variation was observed between years (Figure 1). Since 1995, in-hatchery survival has remained stable and has averaged 84%. With few expceptions, in-hathcery survival has not limited managers' ability to meet smolt production targets.

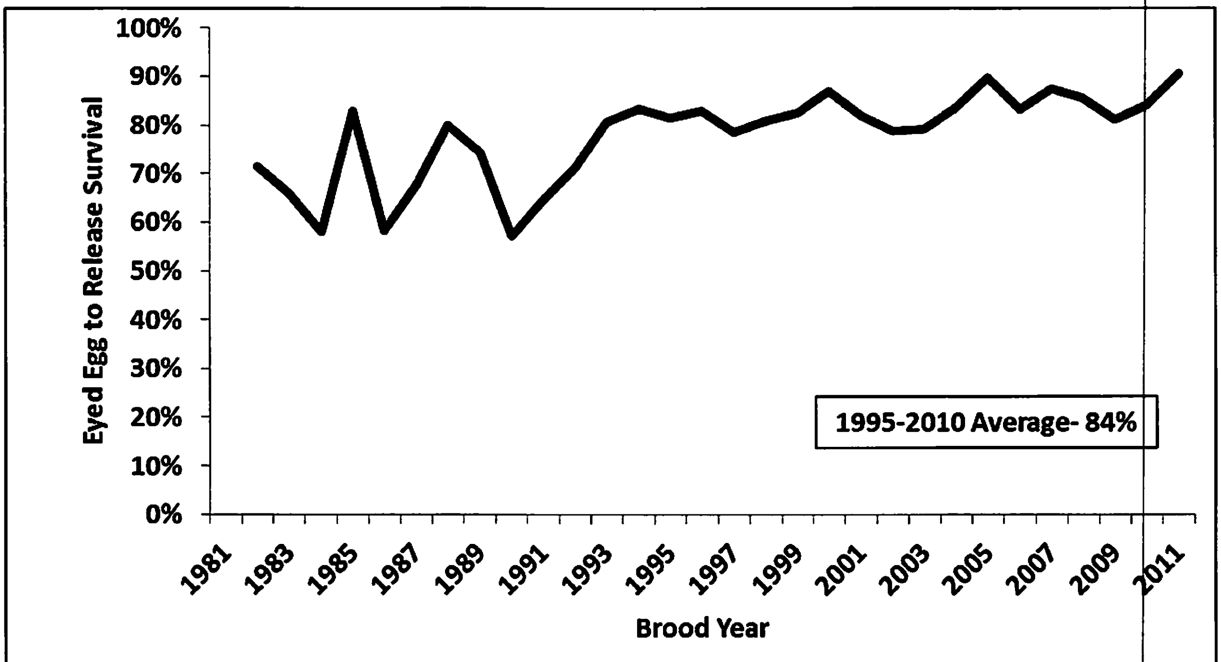


Figure 1. Average eyed-egg to smolt survival rates for all programs within the LSRCP steelhead mitigation program.

Smolt Releases

The original modeled smolt production targets needed to achieve adult mitigation objectives of 165,300 adults were based on releasing 11,020,000 smolts at eight fish per pound with a Smolt to Adult Survival (SAS) of 1.5%. During the 1980s as programs were developing, annual smolt releases across the program were increasing. During the 1990s and 2000s, Oregon and Washington reduced the number of smolts released while releases in Idaho remained stable. Overall, smolt releases for the LSRCP program have declined from approximately 6.25M in 1989 to 5.35M in 2010 (Figure 2).

Fish Health

With some exceptions, fish disease has not limited the ability of managers to meet smolt production targets and all programs currently have scheduled fish heath diagnostic screenings.

Post Release Performance

Survival of juveniles from their release site to Lower Granite Dam is estimated using PIT tags. Prior to 1993, other methods such as freeze brands were used and likely not comparable to estimates derived from PIT tags. From 1993-2011, the average survival has been 71% (range: 53-79%) (Figure 3). While managers have not defined a benchmark or goal for this metric, the range of survival rates observed across individual programs is similar. There also appears to be some level of synchrony between programs through time indicating the importance of environmental variables that fish experience after release.

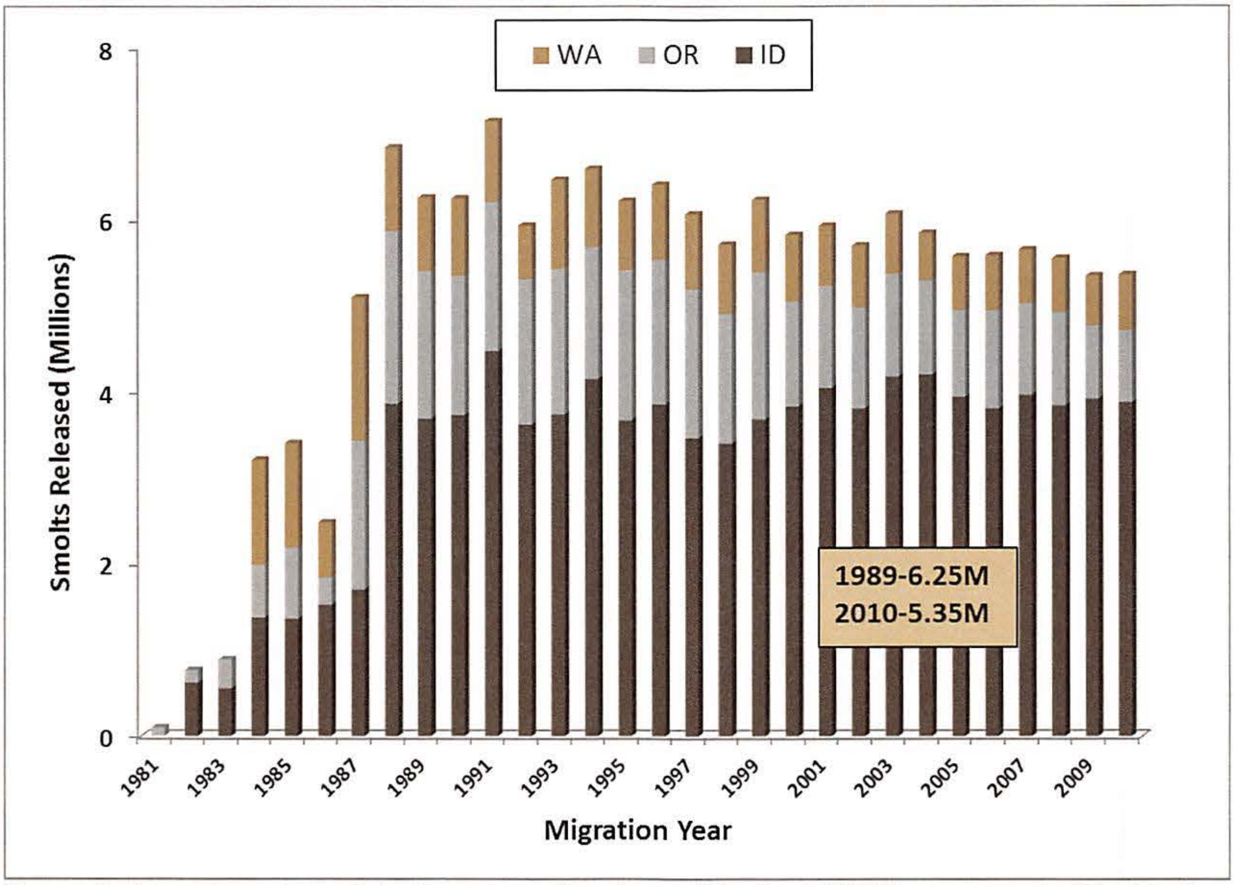


Figure 2. Annual number of steelhead smolts released for the LSRCP programs in Washington, Oregon, and Idaho 1981-2010.

Smolt to Adult Survival

Smolt to Adult Survival (SAS) is calculated as the survival rate prior to any human exploitation of adults. Average (weighted) SAS rate for brood years 1980-2005 is 1.14% (Range: 0.26-2.81%) and is highly variable annually (Figure 4). As stated previously, the original modeling indicated the need for a 1.5% SAS to meet the mitigation goal of 165,300 adults produced annual based on 11,020,000 smolts released. Current smolt releases include approximately 5.35M smolts. At this level of smolt production, an SAS of approximately 3.1% is needed to meet the adult mitigation objective. In most years, the observed SAS has been well below this level but for brood year 1999, an SAS of 2.81% was observed resulting in 154,000 adults produced (93% of total mitigation goal).

In addition to the high degree of variability observed temporally, we have observed in excess of a six-fold difference in SAS between programs within the same year (Figure 5). Also notable is the high degree of synchrony between programs indicative of the importance of migration and ocean conditions to the SAS.

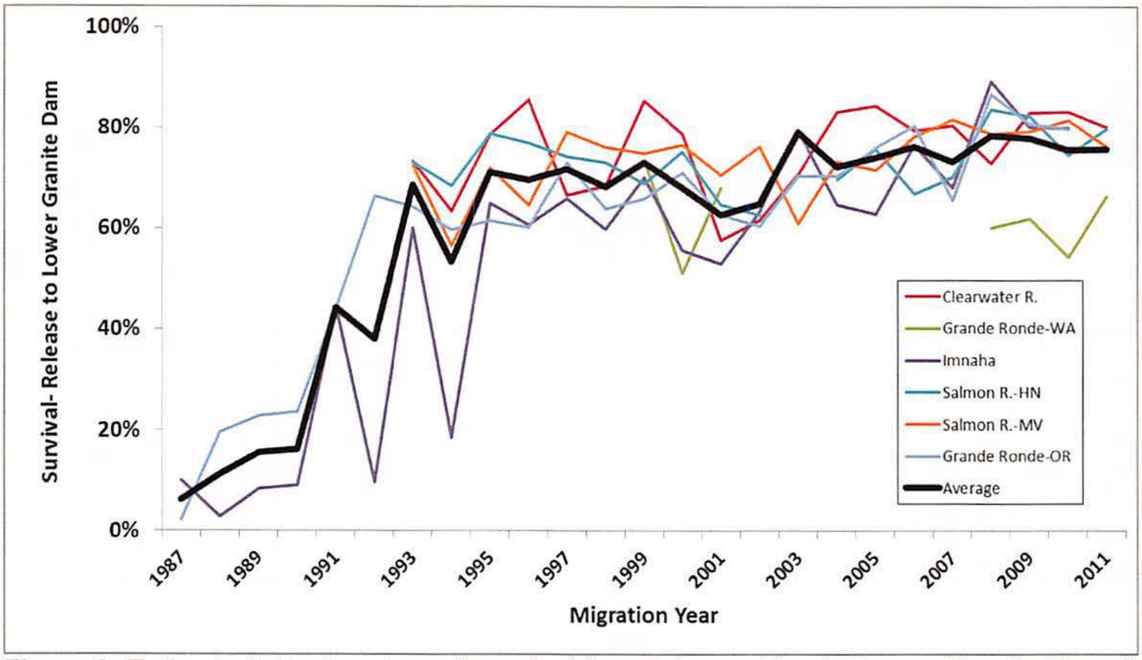


Figure 3. Estimated steelhead smolt survival from release sites to Lower Granite Dam (LGD) 1987-2011. Does not include smolt releases from Washington downstream of LGD (Snake R., Walla Walla R., Touchet R., and Tucannon R.).

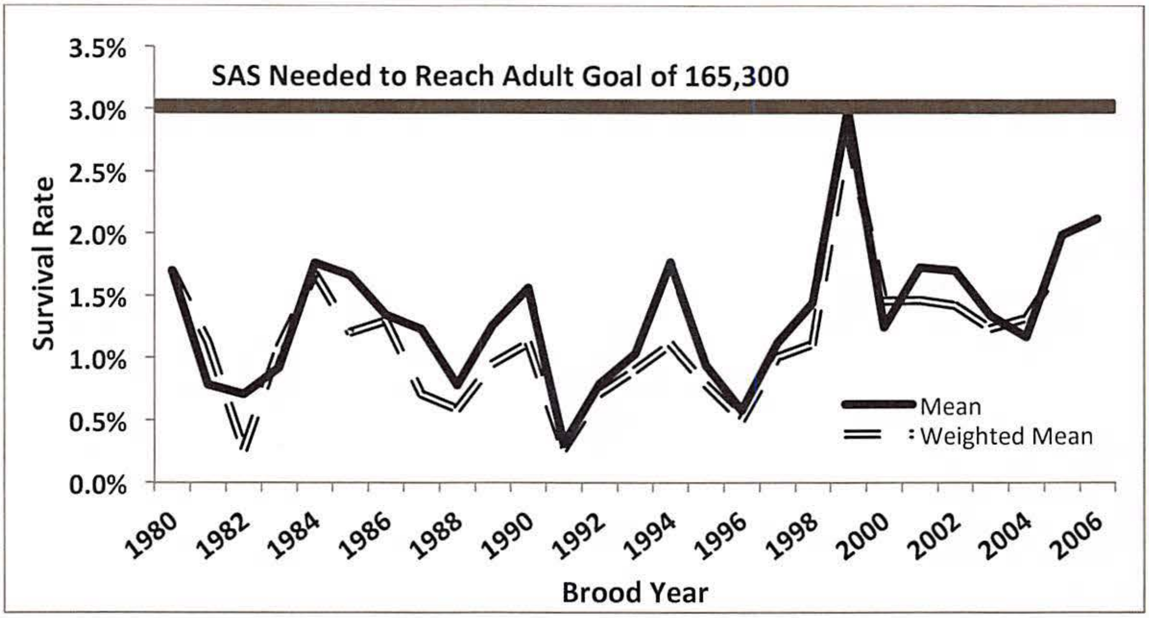


Figure 4. Mean Smolt to Adult Survival (SAS) rates for the combined LSRCP steelhead releases for brood years 1980-2005.

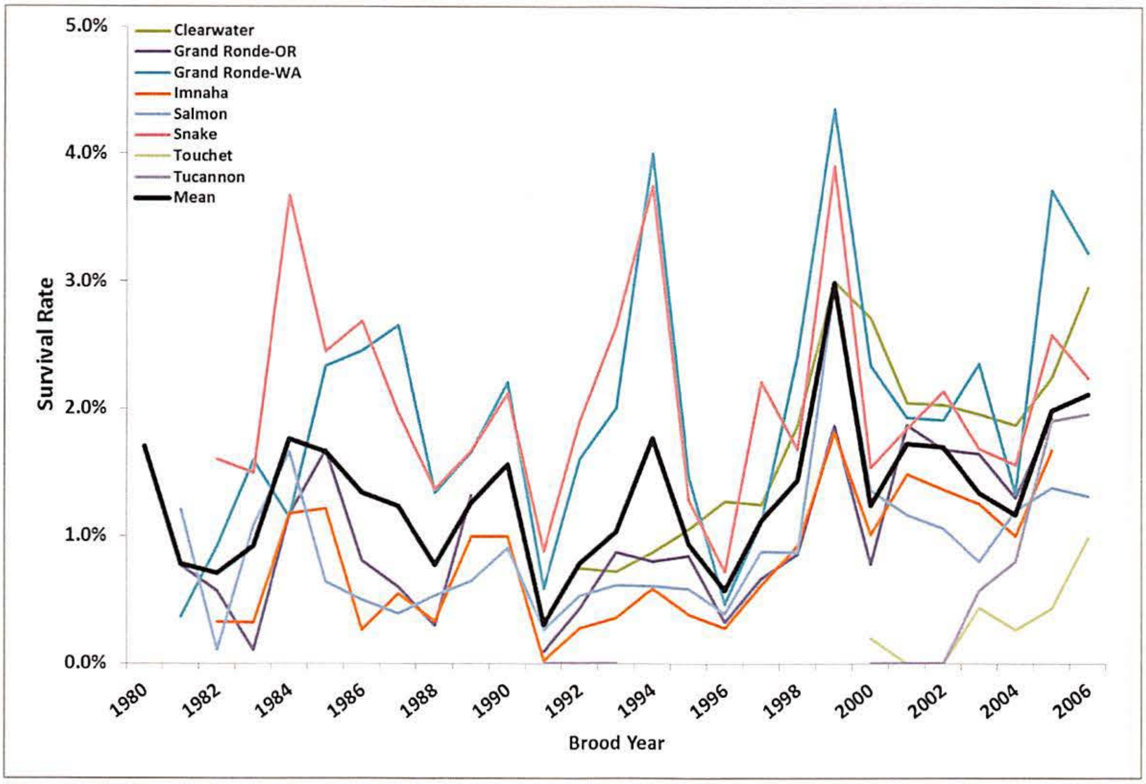


Figure 5. Smolt to Adult Survival (SAS) rates observed for individual LSRCP programs for brood years 1980-2005.

Smolt to Adult Return Rates

The Smolt to Adult Return (SAR) rate is calculated as the survival of smolts from release to return as adults back to the project area. Based on the release of approximately 5.35M smolts, an SAR of 1% is necessary to return 55,100 adults to the project area. Over the history of the program, the weighted SAR has been in excess of 1% in 12 out of 26 years through brood year 2005 (Figure 6). The average SAR observed over the same period is 0.96%. Similar to Figure 5, highly variable SAR rates are observed between programs (Figure 7).

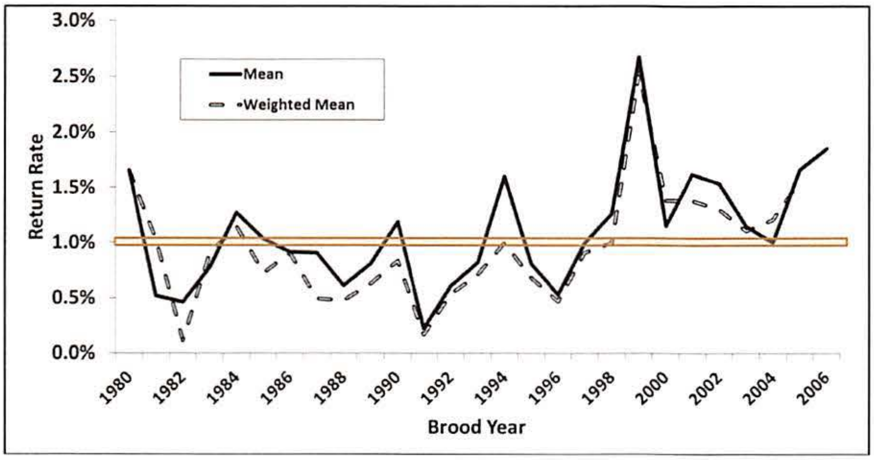


Figure 6. Smolt to Adult Return (SAR) rate of the combined LSRCP steelhead program for brood years 1980-2005.

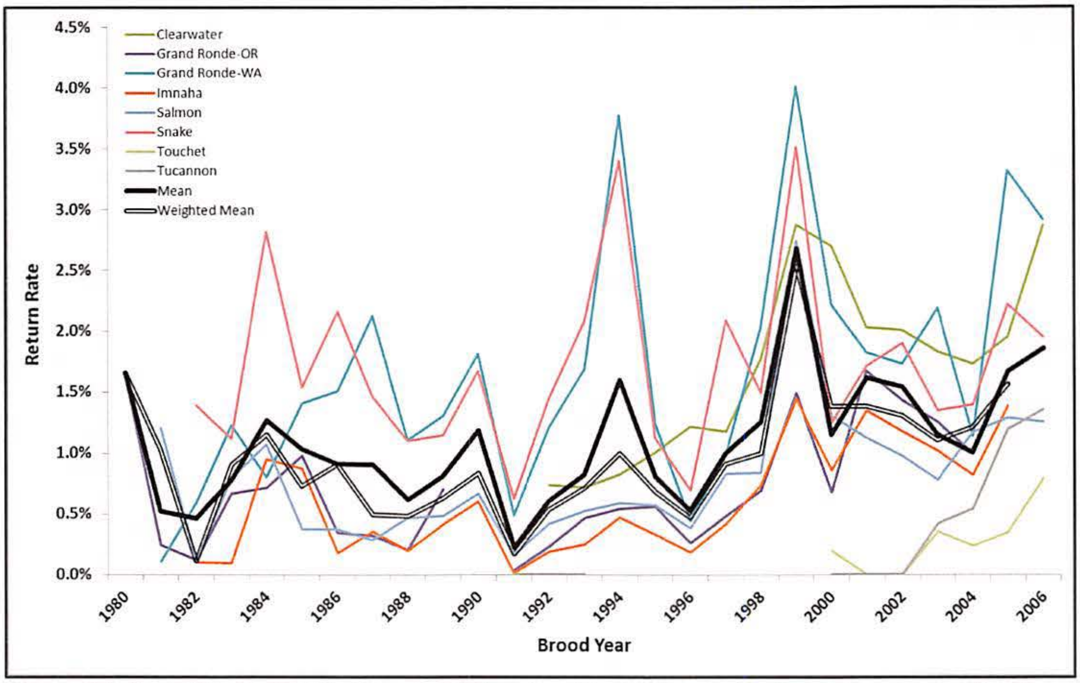


Figure 7. Smolt to Adult Return (SAR) rate of individual steelhead program for brood years 1980-2005.

Annual Adult Returns

The annual escapement of adults to the project area is provided to compare the program performance against the original escapement objective of 55,100 adults to the project area. This adult return objective is after an assumed 2:1 catch (downstream of the project area) to escapement (to the project area). As previously mentioned, this performance metric is based more on a historical convention and not on current fisheries management. During the period 1984-2009, the escapement objective of 55,100 adults was exceeded in nine years. The average annual escapement to the project area since 1984 is 50,292 adults.

Progeny per Parent Ratios (P:P)

The ratio of adult progeny produced per parent (P:P) provides a full lifecycle productivity metric that is useful to assess the relative advantage a hatchery program can provide by significantly increasing the adult-to-smolt survival rate from what is observed in natural spawning populations. For brood years 1981-2005, an average of 17 (range: 2-45) adult progeny were produced for every parent in the broodstock. The P:P ratio was greater than seven for all but two years (1982 and 1991) in the time series. As with other productivity metrics discussed, a significant variation in P:P ratios across programs within the same year was observed (Figure 10)

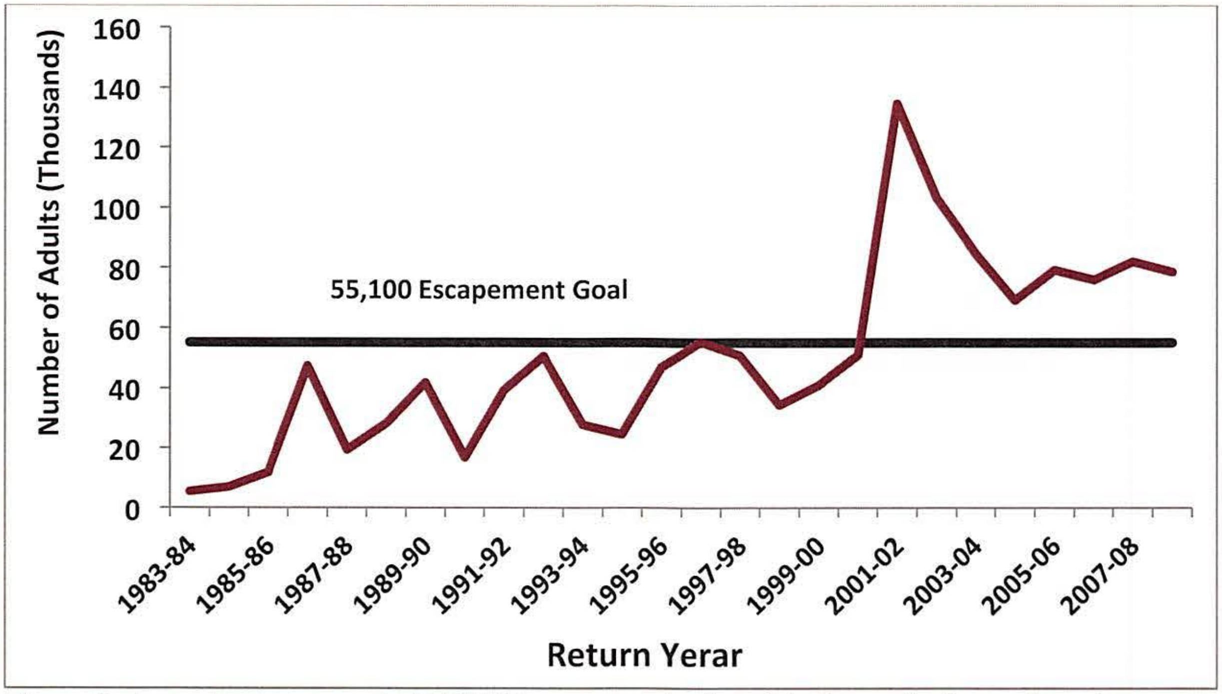


Figure 8. Annual escapement of LSRCP program steelhead to the project area for return years 1984-2009.

Progeny per Parent Ratios (P:P)

The ratio of adult progeny produced per parent (P:P) provides a full lifecycle productivity metric that is useful to assess the relative advantage a hatchery program can provide by significantly increasing the adult-to-smolt survival rate from what is observed in natural spawning populations. For brood years 1981-2005, an average of 17 (range: 2-45) adult progeny were produced for every parent in the broodstock. The P:P ratio was greater than seven for all but two years (1982 and 1991) in the time series. As with other productivity metrics discussed, a significant variation in P:P ratios across programs within the same year was observed (Figure 10).

Straying

Adult steelhead recovered (fisheries, hatchery traps, spawning grounds etc.) anywhere outside of the direct path to the release location during any part of the adult migration are considered strays. It is possible that fish harvested outside of the direct path to the release site during the summer and fall months may have ended up back on the direct path had they not been harvested but there is not a good method to estimate this parameter. It should also be noted that the stray rate estimates reported here are based strictly on fish that are recovered as strays in fisheries and natural spawning areas where sampling programs are in place. Because not all fisheries and natural spawning populations are sampled, reported stray rates are most likely underestimated.

The weighted average stray rate across all LSRCP programs for brood years 1982-2005 is 8.7% (Figure 11). Similar to other metrics provided in this report, observed stray rates are variable between programs (Figure 12). While not as obvious as for some of the productivity metrics presented, there does appear to be some level of synchrony with stray rates across many of the programs. This synchrony may be associated with similar juvenile (transportation vs. in-river migration) and adult (e.g. river temperature) migration conditions across programs. Another issue discussed at the symposium that may explain some of the observed straying was the drastic change observed in overwintering habitat for some of the programs after sections of the mainstem Snake River were impounded.

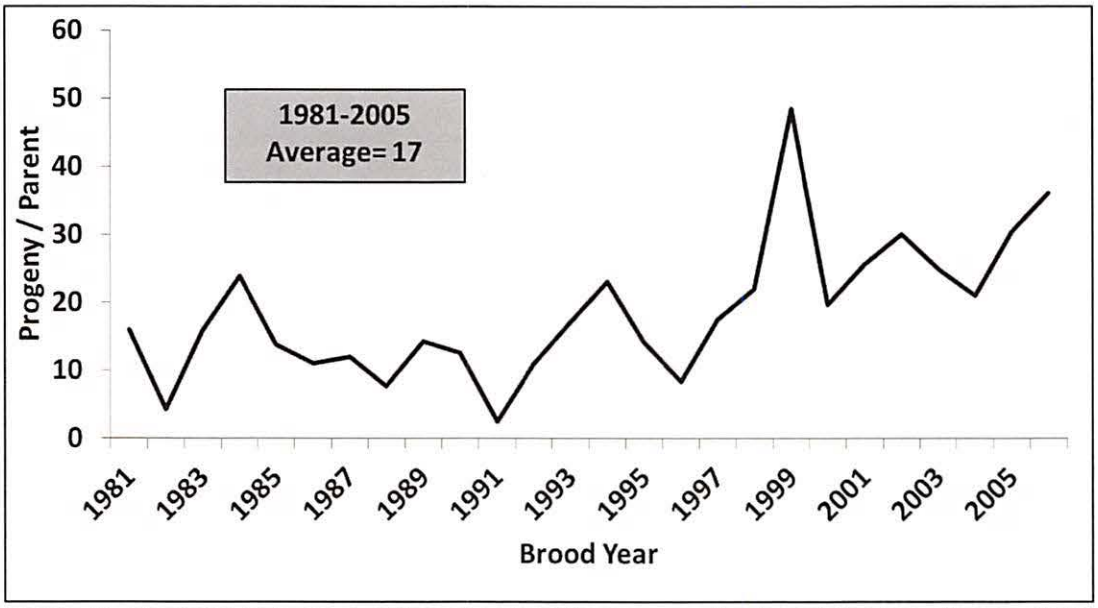


Figure 9. Progeny to parent ratios of LSRCP program steelhead for brood yeas 1981-2005

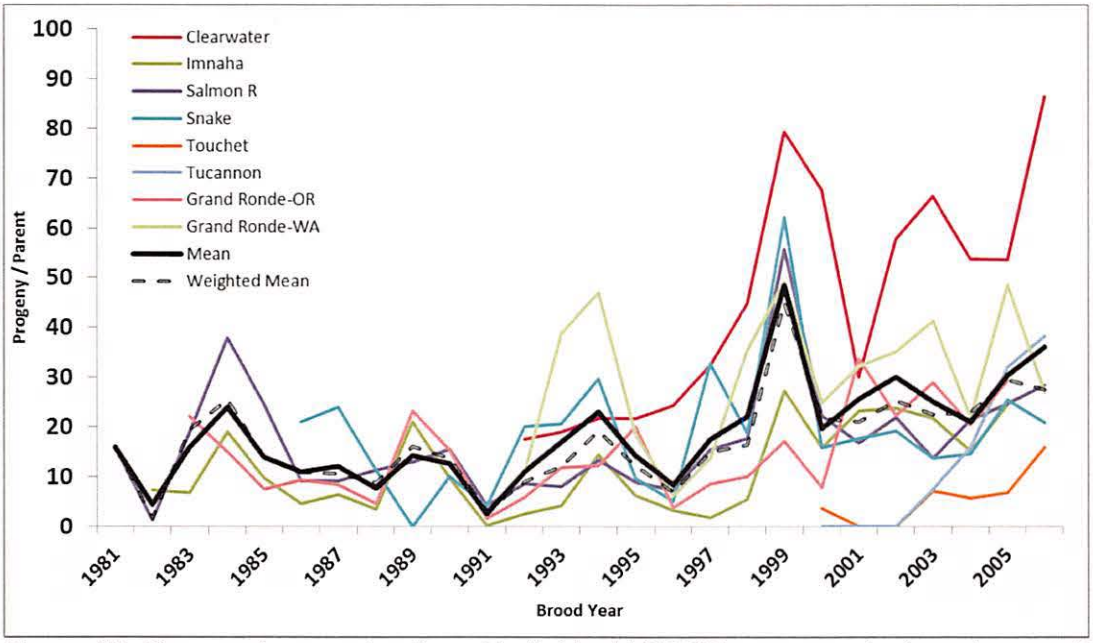


Figure 10. Progeny to parent ratios of individual LSRCP programs for brood years 1981-2005.

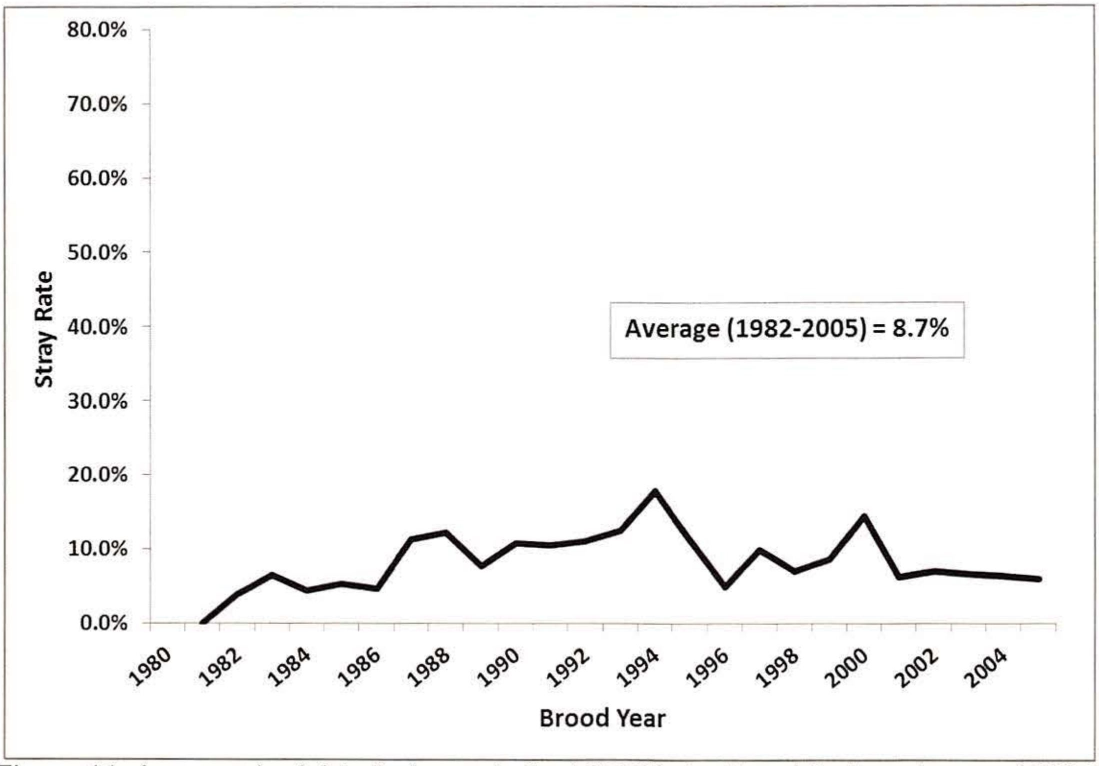


Figure 11. Average (weighted) stray rate for LSRCP steelhead for brood years 1982-2005.

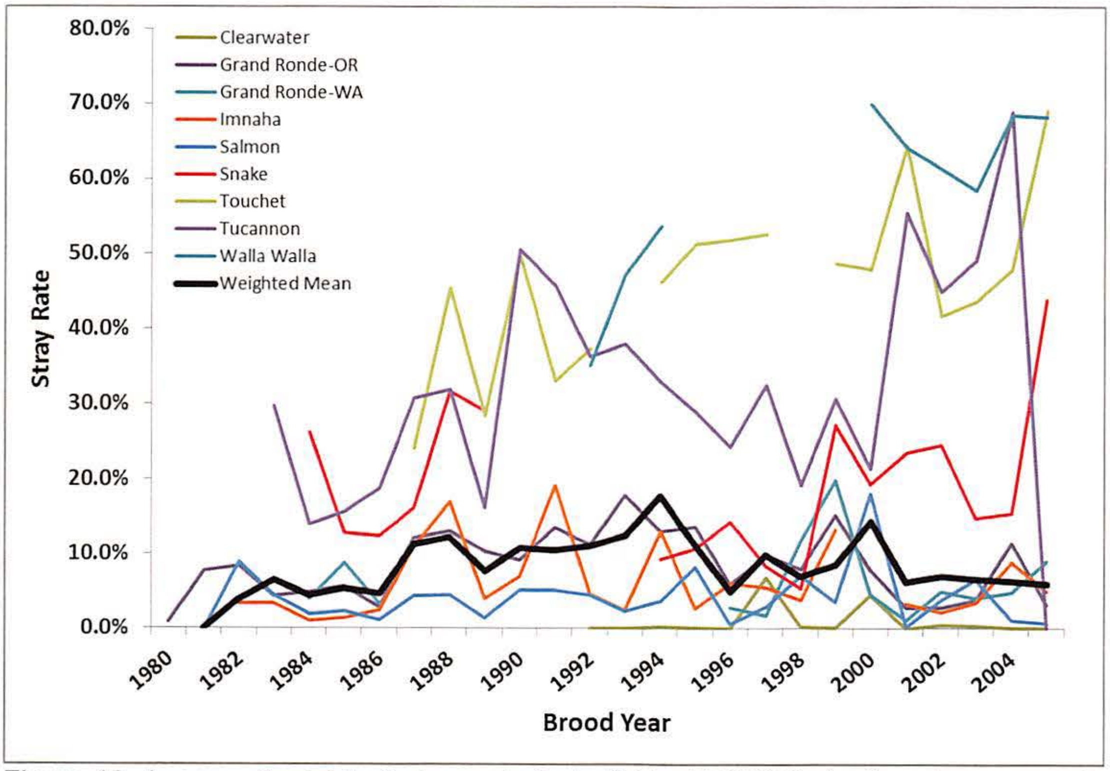


Figure 12. Average (weighted) stray rate for individual LSRCP steelhead programs for brood years 1982-2005.

Contribution to Fisheries Downstream of the Project Area

Within the founding language for the LSRCP program, compensation for the loss of mainstem Columbia River fisheries in kind and in-place was identified. During the program development, a 2:1 catch (downstream of the project area) to escapement (back to the project area) was the anticipated outcome of the LSRCP mitigation program. However, due to declining returns of wild fish and less than anticipated returns of LSRCP program fish, the 2:1 catch to escapement has not been realized. Prior to the min-1990s, harvest rates in the mainstem Columbia River and Snake River below Lower Granite dam were in the 20-50% range (Figure 13). Since them, harvest rates have generally been in the 5-20% range. As noted in the symposium, the individual program harvest rates were compared to the aggregate harvest rates for A-run and B-Run composite index stocks report by the US vs. OR Technical Advisory Committee (TAC) and it appears that the harvest rate for the Idaho stocks are underestimated. Potential explanations for the discrepancies are provided in the Salmon River and Clearwater River program reports in this document.

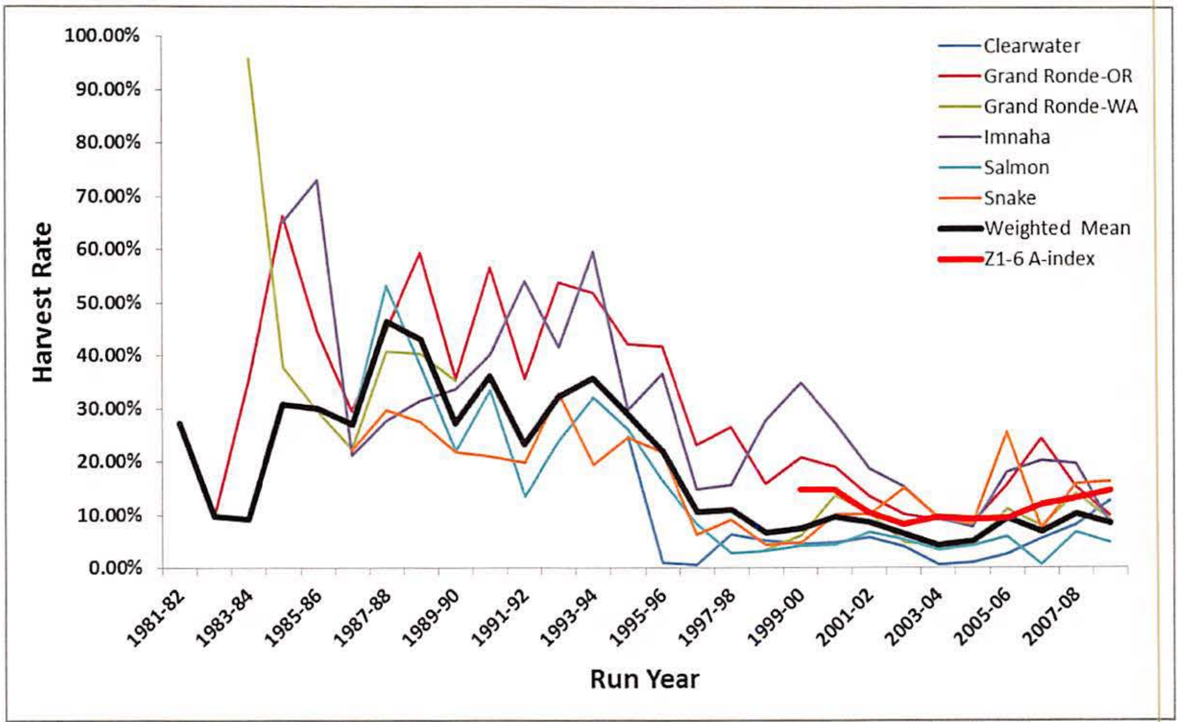


Figure 13. Estimated harvest rates of individual LSRCP programs for fisheries located downstream of the project area, 1982-2009

Restoring and Maintaining Historic Fisheries

One of the primary objectives across all of the programs that have been presented during this symposium is to restore and maintain the historic steelhead fisheries that occurred in the project area. This objective was evaluated both in terms of harvest and opportunity. To evaluate this, we compared the number of fish harvested during the period prior to the development of the LSRCP program to the periods after the LSRCP program was initiated. Prior to the LSRCP program, an average of 26,474 steelhead were harvested annually in the project area recreational fisheries (Figure 14). During the early part of the LSRCP mitigation (1985-1999), the annual harvest of 26,516 was very similar to the pre-program period. In the years since 1999, the average annual harvest has increased to 61,717 (range: 42,697-97,483) which is significantly greater than the harvest observed during the pre-program period. Likewise, we have also observed a significant increase in the angling effort for steelhead (Figure 15). During the pre-program period, the number of angler days averaged 130,000 annually. Since 1999, the number of angler days has increased to 474,500 annually.

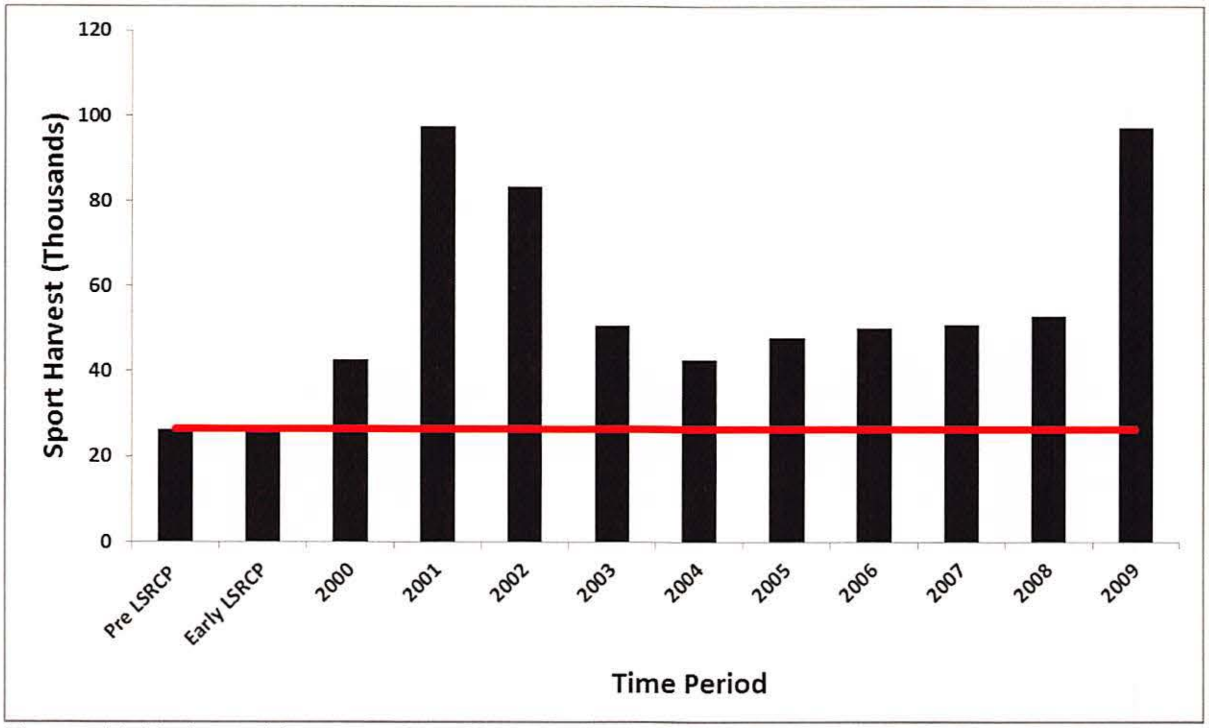


Figure 14. Estimated harvest of steelhead in Snake River project area recreational fisheries prior to and subsequent to the development of the LSRCP mitigation program. The red horizontal line represents the annual harvest observed during the pre-program period.

The number of days open to steelhead fishing annually has remained similar to the pre-program period. In some areas, the number of river miles open to steelhead fishing has seen some minor changes (plus or minus) and in other areas, there have been significant decreases in the river miles available to fish in order to provide refuge areas for wild stocks of steelhead. In terms of harvest, effort, and opportunity, the program has met the objective of maintaining historic steelhead fisheries in the project area.

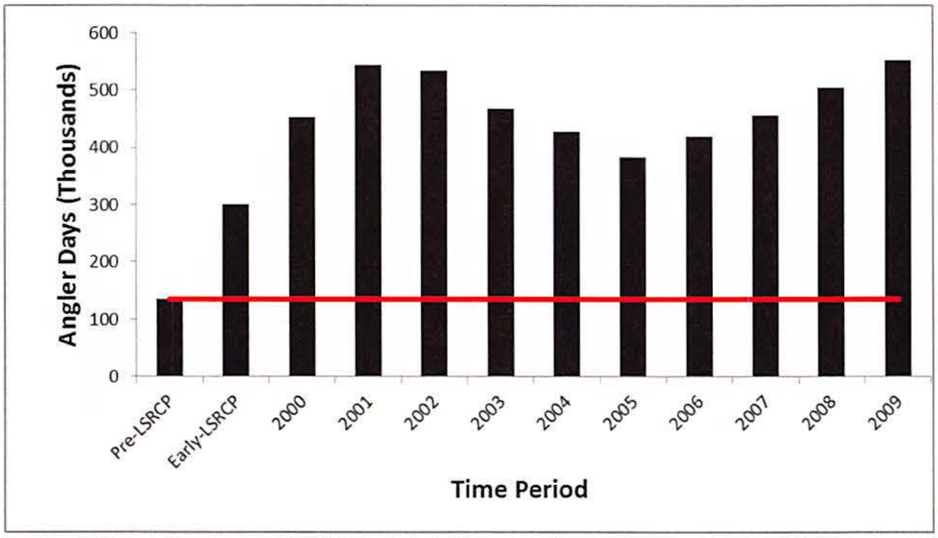


Figure 15. Estimated angler effort (angler days) for steelhead in Snake River project area recreational fisheries prior to and subsequent to the development of the LSRCP mitigation program. The red horizontal line represents the annual angler effort observed during the pre-program period.

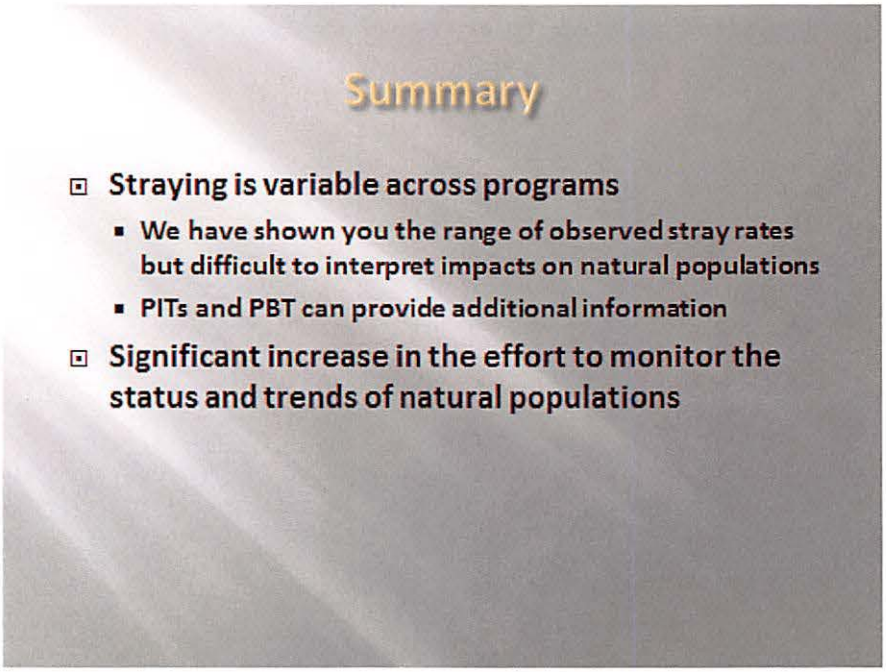
Summary and Moving Forward

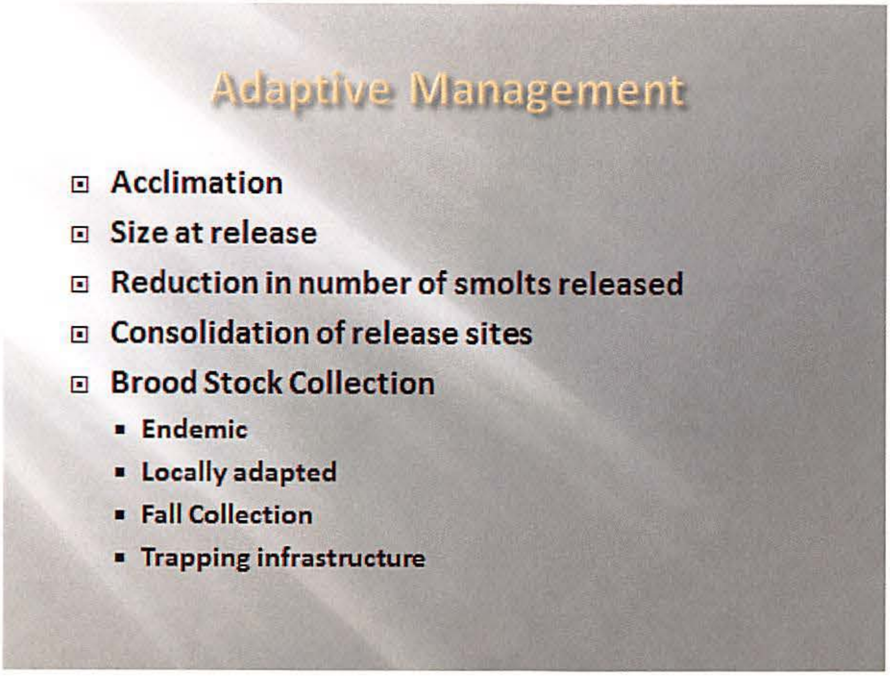
It was made clear in the individual program presentations that managers have prioritized harvest mitigation as the LSRCP program's primary function. Even so, managers are evaluating the use of hatchery supplementation to increase natural production but at a smaller scale. Fish culture across the individual programs is generally producing healthy smolts and with a few exceptions, broodstock collection and in-hatchery survival have not limiting the ability of managers to meet smolt production targets.

Post-release survival rates have been variable over the program history. While the overall production goal of 165,300 adults has never been reached, for brood years 1983-2005 the program produced an average of 55,960 adults (range: 9,708-154,043). For brood year 1999, 154,043 adults representing 93% of the total mitigation goal were produced.

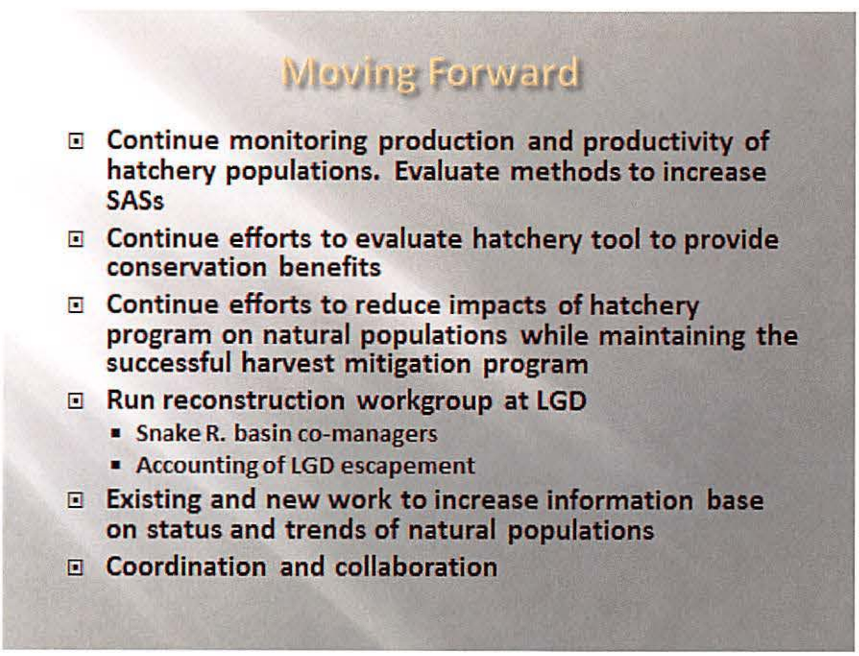
Adult steelhead produced by the LSRCP program contribute to fisheries in the mainstem Columbia River, Snake River and tributaries of the Snake River. When the LSRCP program was being developed, it was anticipated that the majority (2:1) of the harvest benefits would be distributed downstream of the project area. However, due to declining returns of wild fish and less than anticipated returns of LSRCP program fish, the 2:1 catch to escapement has not been realized and the majority of harvest benefits are distributed upstream of the project area. Across all programs, one of the primary goals has been to restore and maintain historic fisheries in the project area. The estimated angler effort and harvest is greater across all programs than it was during the pre-program period. Fisheries in the project area provide a significant opportunity through time and space with fisheries occurring for as many as 304 days over hundreds of river miles and provide a significant economic impact to state and local economies.

Straying of hatchery steelhead and potential impacts to ESA listed natural populations are a concern for the LSRCP the program. The average stray rate observed over the program history is 8.7% (range: 3.9-17.9%) but likely underrepresent the true stray rate because not all stray fish can be recovered. Managers have implemented or are implementing various measures such as development of localized brood stocks, fall brood collections, acclimation, consolidation of release sites and others to reduce the number of hatchery strays. Even with these changes to individual program aimed to reduce stray rates, environmental conditions and smolt transportation also influence stray rates.





Over the program history, managers have been modifying production and management strategies of the program to increase survival, reduce straying, and maximize harvest of program fish. As we move forward, we will continue to monitor the production and productively of the hatchery programs and strive to increase smolt to adult survival while minimizing impacts to natural populations. Managers are also working to increase the information base on the status and trends of natural populations of steelhead in the Snake River. Collaboration and coordination continue to increase as managers in the Snake River basin work to fill data gaps. An example of this is the new collaborative effort to estimate the escapement and disposition, by stock and origin, of all steelhead upstream of Lower Granite Dam.



Acknowledgements

As evidenced in the title slide at the beginning of this presentation, there are many individuals across several state, tribal, and federal entities that contributed to all of the presentations and to the overall success of this program. We would like to express our sincere appreciation to all of the hatchery staffs for their tireless work to continually improve fish culture protocols and to produce healthy steelhead smolts that ultimately contribute to the successful harvest programs.

References

Corps of Engineers. 1975. Special Report, Lower Snake River Fish and Wildlife Compensation Plan. Lower Snake River Washington and Idaho. U.S. Army Engineer District, Walla Walla Washington. 96 pgs. plus appendices.