Fish Research Project Phase I

Oregon: Evaluation of the Success of Supplementing Imnaha River Steelhead with Hatchery Reared Smolts

Completion Report
1980 - 1993

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FISH RESEARCH PROJECT
OREGON

Evaluation of the Success of Supplementing Imnaha River Steelhead with Hatchery Reared Smolts
Phase One

Completion Report

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ABSTRACT

Two streams in the Imnaha River subbasin (Camp Creek and Little Sheep Creek) and eight streams in the Grande Ronde River subbasin (Catherine, Deer, Five Points, Fly, Indian, Lookingglass, Meadow, and Sheep creeks) were selected as study streams to evaluate the success and impacts of steelhead supplementation in northeast Oregon. The habitat of the study streams was inventoried to compare streams and to evaluate whether habitat might influence the performance parameters we will measure in the study. The mean fecundity of hatchery and natural steelhead l-salts returning to Little Sheep Creek fish facility in 1990 and 1991 ranged from 3,550 to 4,663 eggs/female; the mean fecundity of hatchery and natural steelhead ii-salts ranged from 5,020 to 5,879 eggs/female. Variation in length explained 57% of the variation in fecundity of natural steelhead, but only 41% to 51% of the variation in fecundity of hatchery steelhead. Adult steelhead males had an average spermatocrit of 43.9% at spawning. We were also able to stain sperm cells so that viable (live) cells could be distinguished from unviable (dead) cells. Large, red disc tags may be the most useful for observing adults on the spawning grounds. The density of wild, juvenile steelhead ranged from 0 fish/100m^2 (age-0 and age-l) to 35.1 (age-O) and 14.0 (age-l) fish/100m^2. Evidence provided from the National Marine Fisheries Service suggests that hatchery and wild fish within a subbasin are genetically similar. The long-term experimental design is presented as a component of this report.

INTRODUCTION

Outplanting of hatchery-reared anadromous salmonids has been ongoing for many years throughout the Columbia Basin. However, little research has been conducted to evaluate the effectiveness of enhancing natural production or the impacts on wild populations. The need for critical assessment of supplementation recently has been recognized (Supplementation Technical Work Group 1988). Steward and Bjornn (1990) provide a comprehensive review of supplementation of salmon and steelhead stocks with emphasis on interactions between hatchery and wild fish.

We will evaluate the success and impacts of enhancing summer steelhead Oncorhynchus mykiss natural production with hatchery-reared smolts of endemic stock origin. We had originally planned to conduct the study exclusively in the Imnaha subbasin. However, we expanded the study area to include streams in the Grande Ronde subbasin to add replication.

The goal of this project is to develop an understanding of the success and impacts of supplementing wild steelhead populations with hatchery-reared smolts of endemic stock origin. The objectives of the project address the question of whether supplementation techniques used in the Grande Ronde and Imnaha rivers can be effective without negatively impacting genetic and life history characteristics of the natural population. This project will be conducted in two phases. Phase 1 is the identification of experimental opportunities and development of the experimental design and Phase 2 is the implementation of the study. The first phase covers the period 15 September 1989 through 19 December 1994. Work in Phase 1 involved (1) development of a long-term experimental design to address project objectives, (2) collection of samples for baseline genetic characterization, (3) summarization of existing life history data, and (4) habitat inventory of some study streams. This report summarizes work completed in Phase 1.

DESCRIPTION OF PROJECT AREA

Imnaha River Subbasin

The Imnaha River is located above eight dams in the Columbia River system (Figure 1). The basin drains an area of about 980 square miles of the eastern Wallowa Mountains and the plateau located between the Wallowa River drainage and Hells Canyon of the Snake River in the extreme northeast corner of Oregon. The Imnaha River is located 191.7 miles above the mouth of the Snake River and 516 miles above the mouth of the Columbia River. Elevations range from 10,000 feet at the headwaters in the Eagle Cap Wilderness Area of the Wallowa Mountains to 975 feet at the river's confluence with the Snake River.

The major tributaries of the Imnaha River are the North Fork and South Fork of the Imnaha River, Grouse, Big Sheep, Horse, Lightning, and Cow creeks. All the major tributaries in the basin lie within the Hells Canyon National Recreation Area or the Eagle Cap Wilderness Area except Big Sheep Creek and its tributaries and upper Grouse Creek. The mainstem of the Imnaha River from the forks (RM 63.5) to RM 51 is in the Hells Canyon National Recreation Area. From RM 51 to the confluence with the Snake River, the valley floor is mixed private and public.ownership.

Maximum stream flows generally occur April through June; minimum flows occur from August through November. Minimum summer flows in August (190 cfs) and September (150 cfs) at Imnaha (RM 19.3), although below the recommended minimum (200 cfs), pose no serious problems for rearing juvenile salmonids (Carmichael and Boyce 1987). Flows are above recommended minimums during the principal months of upstream migration (January-March) and spawning (April-June).

Grande Ronde River Subbasin

The Grande Ronde River is located above eight dams in the Columbia River system (Figure 1). The basin drains an area of about 3,950 square miles of the Wallowa and Blue mountains in the northeast corner of Oregon. The northern part of the basin drains about 120 square miles of southeast Washington.. The Grande Ronde River is located 168.7 miles above the mouth of the Snake River and 493 miles above the mouth of the Columbia River.

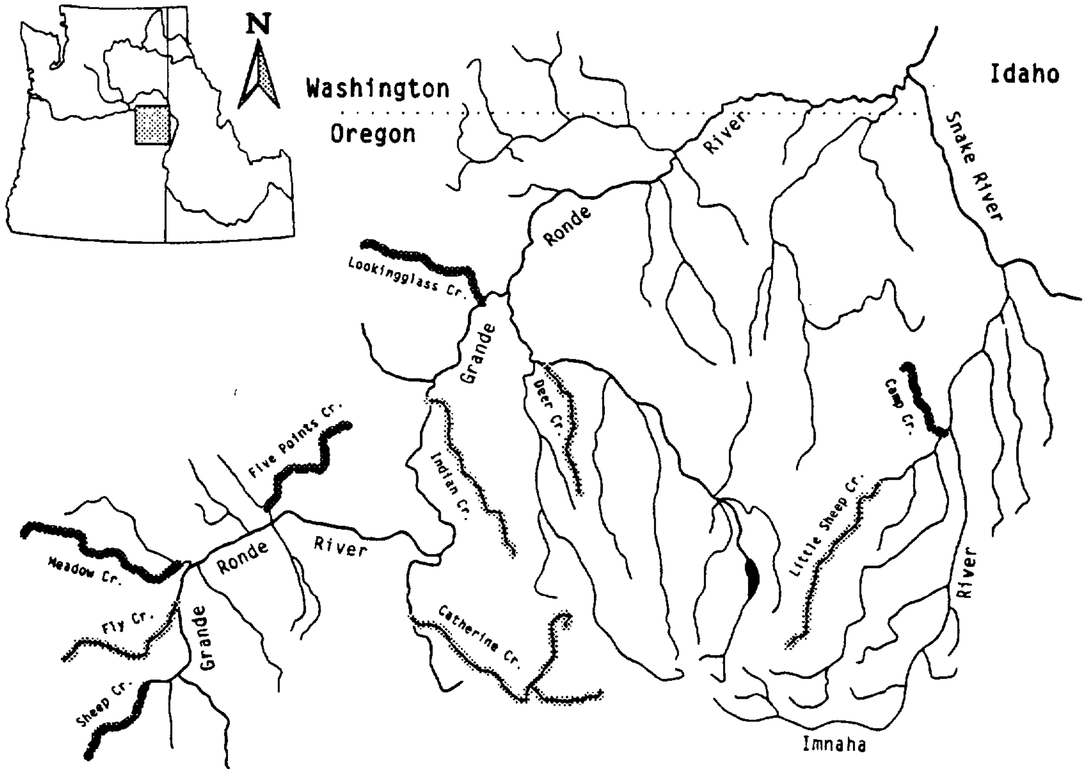

Figure 1. Map of the Grande Ronde and Imnaha river subbasins showing proposed study areas for the steelhead supplementation project. ▒▒▒ supplemented streams: nonsupplemented streams ███

The basin is characterized by rugged mountains and two major river valleys. The Blue Mountains, which border the drainage to the west and northwest, and the Wallowa Mountains, located to the southeast, give rise to the headwater streams. Peaks in the Blue Mountains reach as high as 7,700 feet while those in the Wallowa Mountains approach 10,000 feet. The Grande Ronde Valley is located between the Blue and Wallowa mountains and covers about 360 square miles. The Wallowa Valley, adjacent to the northern slope of the Wallowa Mountains, covers about 250 square miles. Grande Ronde basin streams are generally fed by snowmelt and thus have high stream flows from March through May and low stream flows from July through November.

DESCRIPTION OF HATCHERY STEELHEAD PRODUCTION

Supplementation is an important part of the effort to restore and maintain natural production of spring chinook salmon and summer steelhead and reestablish sport and tribal fisheries in the Grande Ronde River and Imnaha River subbasins under the Lower Snake River Compensation Plan (LSRCP; Carmichael and Wagner 1983). Steelhead populations have been supplemented under the LSRCP in the Grande Ronde and Imnaha rivers since 1981 and 1983, respectively. The supplementation approach has been to use hatcheries to rear 330,000 smolts of the indigenous stock for release in the Imnaha River and 1,400,000 smolts of a closely related stock in the Grande Ronde River to supplement depressed fish populations, to provide fish for harvest, and to increase natural production (Carmichael 1989).

Imnaha River Hatchery Production

The Little Sheep Creek Facility serves as the advanced rearing and release site and adult collection facility for Imnaha River basin steelhead. The facility was constructed for the LSRCP and is located on Little Sheep Creek at RM 5. Adults are trapped here and held for broodstock, or are passed above the facility to spawn naturally. Temporary facilities were used at this location from 1982 through 1986. The permanent facilities were completed in 1987.

The steelhead hatchery program in the Imnaha River basin began in 1982 with the trapping of Little Sheep Creek wild steelhead, for broodstock and the subsequent release of smolts in 1983. This stock was founded with approximately 300 total wild spawners from 1982 to 1985. In those years the number of wild spawners returning to Little Sheep Creek ranged from about 75 to 200 fish annually. Since 1985 when the first hatchery adults returned, broodstock have been selected from natural and hatchery-reared individuals.

Broodstock are held for spawning at the collection facility. Eggs are incubated to the eyed stage at Wallowa Hatchery in the Grande Ronde River subbasin. Eyed eggs are transported to Irrigon Hatchery on the south bank of the Columbia River near Irrigon, Oregon for final incubation and rearing in well water. Fish are trucked from Irrigon Hatchery to the Little Sheep Creek Facility for release. Most of the fish, 200,000 in 1992, are held in an acclimation pond at the facility for two to nine weeks before release. All acclimated smolts are released at the facility. Some of the fish, 50,000 in 1992, are released.directly from the truck into Little Sheep Creek at the facility on the same day fish are released from the acclimation pond. An additional 80,000 smolts are released directly into the Imnaha River. The smolts are released as yearlings in April at a target size of 5 fish/lb. Table 1 shows the release sites and release numbers for hatchery steelhead in the Imnaha basin.

Grande Ronde River Hatchery Production

Wallowa Hatchery, located on Spring Creek one mile from its confluence with the Wallowa River, serves as the primary incubation, advanced rearing and release site and adult collection facility for hatchery steelhead in the Grande Ronde basin. Wallowa Hatchery was expanded in 1985 to meet the production of the LSRCP. The facility includes an adult trap, adult holding pond, two large acclimation ponds, and incubation facilities. Wallowa Hatchery is designed for the incubation of 2,775,000 eggs and for the acclimation and release of 600,000 steelhead smolts at 5 fish/pound.

The Big Canyon Facility, located at the confluence of Deer Creek and the Wallowa River, also serves as an advanced rearing and release facility and an adult trapping facility. The Big Canyon facility was completed in the summer of 1987. The facility includes an adult trap, one small adult holding pond, and two advanced rearing ponds. This facility is designed for the advanced rearing and release of 125,000 spring chinook and 225,000 steelhead smolts annually. The spring chinook advanced rearing pond has been used for steelhead advanced rearing in recent years 275,000 steelhead smolts have been released from the facility. The facility serves as a backup broodstock collection facility for Wallowa Hatchery. Adults not held for broodstock are passed above the facility to spawn naturally. The supplementation program in Deer Creek began in 1983 with the release of Wallowa Hatchery smolts from a temporary facility at the Big Canyon Facility site.

Washington Department of Wildlife (WDW) operates an advanced rearing and release facility at the confluence of Cottonwood Creek and the Grande Ronde River in Washington. The Cottonwood conditioning pond is designed for the advanced rearing and release of 200,000 steelhead smolts annually.

The hatchery broodstock originated from approximately 220 wild steelhead trapped at Snake River dams 1976-78 and fish returning to Wallowa Hatchery 1980-present. Broodstock are collected at Wallowa Hatchery. When additional eggs are needed for the program, adults trapped at the Big Canyon Facility are held and spawned on site, and adults trapped at Cottonwood Conditioning Pond on the lower Grande Ronde River in Washington are transported to Wallowa Hatchery and spawned.

Adults are trapped for broodstock and held for spawning at Wallowa Hatchery. Eggs are incubated to the eyed stage Wallowa Hatchery. Eyed eggs are transported to Irrigon Hatchery for final incubation and rearing in well water. Fish are trucked from Irrigon Hatchery to advanced rearing sites in the Grande Ronde basin, or are transported to release sites and released directly into the stream. Fish are held in advanced rearing ponds at the facilities for two to nine weeks before release from the ponds. The fish are released as yearlings in April at a target size of 5 fish/lb. Table 1 shows the release sites and release numbers for hatchery steelhead in the Grande Ronde basin.

Table 1. Steelhead release sites in the Imnaha River and the Grande Ronde River basins.

Basin, release site	Stock	Number released	Type of release
Imnaha			
Little Sheep Creek	Imnaha'	200,000	acclimated
Little Sheep Creek	Imnaha	50,000	stream
Imnaha River	Imnaha	80,000	stream
Total		330,000	
Grande Ronde			
Wallowa Hatchery	Wallowa	662,500	hatchery
Deer Creek	Wallowa	50,000	stream
Big Canyon Facility	Wallowa	375,000	advanced-rearing ponds
Grande Ronde R. at Wildcat Creek[a]	Wallowa	50,000	stream
Catherine Creek	Wallowa	62,500	stream
Upper Grande Ronde R	Wallowa	200,000	stream
Cottonwood Creek[b]	Wallowa	200,000	conditioning ponds
Total		1,600,000	

a Fish were last released at this site in 1992. These fish were reallocated to other release sites.

b Released in Washington by Washington Department of Wildlife.

METHODS AND MATERIALS

Habitat Inventories

We inventoried the habitat of some study streams before implementing the study because it is important that treatment and control streams are similar in habitat type. A thorough evaluation of habitat quantity and quality in each study stream is necessary to allow for habitat comparison. These comparisons will allow us to evaluate whether the habitat is influencing the performance parameters we measure in the study.

We surveyed Deer Creek in the Grande Ronde River subbasin, and Camp and Little Sheep creeks and the lower four miles of Grouse Creek in the Imnaha River subbasin to assess the quantity and quality of spawning and rearing habitat for steelhead. We used survey methods developed by the Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventories Project, which were based on visual estimation methods described by Hankin and Reeves (1988).

Streams were divided into reaches during the surveys. A new reach began when one of the following characteristics changed significantly: (1) channel morphology, (2) percentage of the channel margin in contact with the constraining feature, (3) ratio of the width of the active stream channel to the width of the valley floor, (4) composition and age of the riparian vegetation, or (5) land use.

Each stream was surveyed by a team of two surveyors, the estimator and the numerator, starting at the mouth or beginning of the study section. For each habitat unit, the estimator was responsible for recording the habitat unit type (type of pool, glide, riffle, rapid, or cascade), channel type (single or, if multiple channels, primary, secondary, tertiary, etc.), percent flow in each channel, estimated length and width, maximum depth, slope, shading, and aspect. The estimator estimated the width and height of the active channel and terrace for every fifth or 10th habitat unit. For each habitat unit, the numerator was responsible for recording the percentage abundance of substrate material (sand and organics, gravel, cobble, boulder, and bedrock), number of boulders that protrude above the low-flow water surface, rating of bank stability, percentage of streambank that was undercut, rating of complexity of woody debris, and the percentage of woody debris cover. The numerator also measured the length and width of every fifth or 10th habitat unit to calibrate the length and width estimates of the estimator.

Selection of Study Streams

We selected streams in the Imnaha and Grande Ronde subbasins in which to conduct the supplementation study. Some of the streams will-be supplemented (treatment streams) and others will not be supplemented (control streams) during the study. Streams were considered for selection as study streams after discussion with ODFW district fish biologists. Selection was based on the following criteria:

1. Steelhead must be currently using the stream for spawning and rearing.

2. Potential trap sites for juvenile and adult steelhead must be reasonably accessible throughout the migration period.

3. Spawning and rearing areas must be accessible for sampling.

4. Landowners along the stream must allow access to the trapping sites and spawning and rearing areas for the duration of the project.

5. Fish management plans must be consistent with the experimental approach.

6. Land management plans must not cause significant changes in stream habitat for the duration of the project.

In addition, streams selected as treatment streams must have a local hatchery broodstock available or plans to develop a local hatchery broodstock. Treatment streams must also have access sites for release of hatchery smolts.

Fish Distribution In Study Streams

We used electrofishing techniques to determine the distribution of juvenile steelhead in the proposed study streams during summer 1992. We selected sampling locations in the streams near the proposed adult trapping site and then upstream at 5 to 10 mile intervals, and also in tributaries to the study streams. At each sampling location we selected two riffle-pool sampling units, or other habitat types if riffle-pool units were not available. We measured the total length and mean width of each sampling unit to estimate the surface area of the unit sampled. We placed blocking nets with 6 mm mesh across the stream at the top and bottom of the sampling unit to prevent fish from moving into or out of the unit during sampling. A two or three person sampling crew made 2 or 3 passes through the unit with an electrofisher. Stunned fish were netted and placed in a bucket of water. Fish captured during each pass were held in separate buckets and later anesthetized, identified, enumerated, measured for fork length (mm) and released in the general area of capture. We used a multiple pass removal method (Zippen 1958) to estimate juvenile steelhead abundance within the sampling unit when possible. We calculated density of juvenile steelhead by dividing the estimated number of steelhead in the sampling unit by the surface area of the unit. When we were not able to estimate the abundance of juvenile steelhead within a sampling unit we calculated a minimum density of juvenile steelhead by dividing the number of fish captured by the surface area of the sampling unit.

Fecundity

We began collecting information on fecundity of steelhead before implementing of the study because we had identified fecundity as an important parameter to monitor. We estimated the fecundity of hatchery and natural steelhead spawned for broodstock at the Little Sheep Creek Facility, 1990-92. Each fish sampled for fecundity was weighed and measured for fork length. Fecundity of an individual fish was estimated as follows: spawned eggs were drained of ovarian fluid and weighed, two samples of approximately lo-15 grams of eggs were weighed and counted to determine average number of eggs per gram, and the total number of eggs spawned was estimated by multiplying the average number of eggs per gram by the weight of spawned eggs. The number of eggs left in the fish were added to the total number of eggs spawned to determine the total number of eggs per fish.

Male Reproductive Potential

We assessed three methods to evaluate the reproductive potential of male steelhead: sperm motility, spermatocrit, and sperm viability.

We estimated sperm motility of spring chinook salmon at Lookingglass Hatchery for logistical reasons. We placed 1×10^{-3} ml of semen on a microscope slide and then added 1×10^{-3} ml of water to activate the sperm. The percentage of active sperm was estimated as 0, 25, 50, 75, or 100% by observation at 400X magnification immediately after activation.

We determined the spermatocrit (percentage of spermatozoa in the total semen volume) of spring chinook salmon at Lookingglass Hatchery and steelhead at Little Sheep Creek facility. Semen samples were drawn into capillary tubes, sealed with clay, and then centrifuged. The height of the packed sperm cells and the total height of the semen were measured to determine the spermatocrit.

We evaluated a differential staining technique to estimate the percentage of live sperm cells in semen of steelhead at the Little Sheep Creek facility and Wallowa Hatchery. We evaluated a technique described by Fribourgh (1966) for goldfish sperm in which one drop of 5% eosin stain is mixed with one drop of semen and then mixed with 2 drops of 10% nigrosin stain. We also varied the relative concentrations of the stains to determine optimum concentrations for staining of steelhead sperm cells. A sample of this semen-stain mixture is placed on a microscope slide and then smeared to a thin layer with a cover slip. The slide preparation is dried over a flame and then stored for later examination under oil-immersion at 1000X magnification. Live sperm cells appear unstained (clear or white) and dead sperm cells appear stained (reddish).

Observation Of Adult Fish

We evaluated the feasibility of using colored Petersen disc tags or colored Floy FD-68B anchor tags to identify adult fish on the spawning grounds. For logistical reasons, we tagged and observed spring chinook salmon, rather than steelhead, in Lookingglass Creek. We tagged chinook salmon with one 23 mm diameter red disc on one side and a white disc of the same size on the opposite side directly below the dorsal fin. The white disc of each fish was hand imprinted with a 3 digit number in black waterproof ink. Males were tagged with the white disc on the right side and females were tagged with the white disc on the left side. We also tagged some of the disc tagged fish with an anchor tag which had a 37 mm long colored (orange, yellow or white) plastic sleeve. Orange anchor tags were placed on the side of the fish with the white disc tag, white anchor tags were placed on the side with the red disc tag, and yellow anchor tags were placed on the left or right side of the fish independent of the color of the disc tag.

Spawning ground surveys were conducted weekly to locate and identify tagged fish. Surveyors were instructed to record the type and color of the tag first seen, the number on the white disc tag, the color of the anchor tag, and the sides of the fish that have the white disc tag and the anchor tag.

Baseline Genetic Characterization

We sampled populations of steelhead in the Imnaha and Grande Ronde subbasins for the National Marine Fisheries Service (NMFS) Genetic Monitoring and Evaluation Program. We identified genetic monitoring as an important part of this study and added several more streams to the sampling plan to obtain background information on additional populations.

We collected juvenile steelhead from hatchery, supplemented, and wild populations in the Grande Ronde and Imnaha river subbasins for genetic analyses. Fish were collected from streams using electrofishing gear and from hatcheries using dip nets. All samples were immediately frozen and transported to the National Marine Fisheries Service laboratory in Seattle, Washington for electrophoretic and meristic analyses. These populations are being monitored in cooperation with NMFS as part of the Genetic Monitoring and Evaluation Program. The Genetic Monitoring and Evaluation Program is a study to evaluate the genetic effects of using hatchery-reared fish to supplement natural populations of chinook salmon and steelhead in the Snake River basin.

Development of Experimental Design

We developed the experimental design following considerations outlined by the Regional Assessment of Supplementation Project (RASP; RASP 1992). Testable hypotheses were developed to address uncertainties in the following areas cited by RASP: post-release performance, reproductive success, long-term fitness, and ecological interactions. Statistical sensitivity analyses were performed to determine our ability to detect changes in the performance and life history characteristics we will measure.

RESULTS AND DISCUSSION

Habitat Inventories

We surveyed Little Sheep Creek from the Little Sheep Creek fish facility (RM 5) to the Wallowa Valley Canal (RM 26.5) in July and August 1990, and from its confluence with Big Sheep Creek to the fish facility (RM 5) in July 1991. Little Sheep Creek is a riffle-dominated stream with riffles composing 81% of the wetted area, and pools and glides composing 16% and 2% of the area, respectively. The substrate is dominated by gravel (34%) and cobble (32%), but sand and organics (21%) are prevalent also. The average gradient of the surveyed stream section is 2.7%. The upper 3.7 miles of the survey section has an average gradient of 4.1% compared to the rest of the surveyed section, which has a gradient of 2.4%. Detailed habitat inventory information by reach is presented in APPENDIX A.

We surveyed Camp Creek from its confluence with Big Sheep Creek to the end of the spawning-ground survey index area (RM 6) in June and July 1990. During the survey, the upper 100 m of this section was dry. Flow was intermittent in this area during spawning-ground surveys in April and May 1990 and 1991. Numerous springs are present in the upper 0.5 mile of the survey area and maintain perennial flows in the stream below this area. Camp Creek is a riffle-dominated stream with riffles composing 88% of the wetted area, and pools and glides composing 10% and 2% of the area, respectively. The substrate is dominated by cobble (43%) and gravel (30%). The average gradient is 2.7% and is generally consistent throughout the surveyed stream section. Detailed habitat inventory information by reach is presented in APPENDIX A.

We surveyed Grouse Creek from its confluence with the Imnaha River to Road Canyon (RM 4.3) in September 1990. Personnel from the Wallowa-Whitman National Forest surveyed the Grouse Creek drainage above Road Canyon. This section of Grouse Creek is riffle and rapid dominated with riffles composing 53% of the wetted area, rapids composing 27%, and glides and pools composing

11% and 9% of the area, respectively. The substrate is dominated by cobble (49%) and gravel (34%). The average gradient is 3.3%. Detailed habitat inventory information by reach is presented in APPENDIX A.

We surveyed Deer Creek from its confluence with the Wallowa River (RM 0) to Sage Creek (RM 10) in July 1992. Personnel from the Wallowa-Whitman National Forest surveyed the Deer Creek drainage upstream of the forest boundary (RM 9). Deer Creek is a riffle-dominated stream with riffles composing 82% of the wetted area and pools composing 12% of the area. The substrate is dominated by cobble (40%) and gravel (38%). The average gradient is 2.2%. Detailed habitat inventory information is presented in APPENDIX A.

The remaining study streams, Five Points Creek, Fly Creek, Indian Creek, Lookingglass Creek, Meadow Creek, and Sheep Creek have been surveyed by the ODFW,Aquatic Inventories Project or the Wallowa-Whitman National Forest.

Selection Of Study Streams

In the Imnaha River subbasin we examined Big Sheep, Camp, Cow, Grouse, Horse, Lightning, and Little Sheep creeks (Table 2). We selected Camp and Little Sheep creeks as study streams (Table 3). We did not select Big Sheep, Cow, Grouse, Horse, and Lightning creeks as study streams. Big Sheep Creek has.very poor access to spawning and rearing areas during the winter season and an early adult migration season (generally from November to April). Cow, Horse, and Lightning creeks are remote and have very poor access to the spawning and rearing areas. Grouse Creek was eliminated because we could not reach a long-term agreement for access to the creek with a landowner. In the Grande Ronde River subbasin, we examined and selected Catherine, Deer, Five Points, Fly, Indian, Lookingglass, Meadow, and Sheep creeks (Tables 2 and 3).

Little Sheep Creek in the Imnaha subbasin has been supplemented since 1982 with hatchery steelhead smolts derived from the endemic run returning to Little Sheep Creek. Deer Creek in the Grande Ronde subbasin has been supplemented since 1983 with Wallowa Hatchery stock steelhead. Both supplementation programs are part of the Lower Snake River Compensation Plan (LSRCP) and have permanent advanced-rearing and adult-trapping facilities. Catherine Creek has been supplemented with Wallowa Hatchery stock steelhead since 1987, but does not have rearing or trapping facilities. However, ODFW is pursuing acquisition of a site at RM 20 on Catherine Creek for acclimation and adult trapping. The other seven proposed study streams have not been supplemented (see Figure 2 for summary).

Trap sites have been identified in all proposed study streams. Instream construction, that may be associated with adult and juvenile traps, is generally restricted to 15 July - 1 April in the Imnaha basin and 1 July - 15 August in the Grande Ronde basin.

Table 2. Streams examined for use as study streams and selection criteria.

Subbasin, stream	Steelhead use	Accessibilitv trap sites	rear/ spawn	Landowner agreement	Mot olan compatibilitv fish	land
Imnaha:						
Big Sheep Cr.	yes	no	yes	yes	yes	--
Camp Cr.	yes	yes	yes	yes	w	--
Cow Cr.	yes	--	no	--	w	--
Grouse Cr.	yes	w	yes	no	w	--
Horse Cr.	yes	--	no	--	w	--
Lightning Cr.	yes	--	no	--	w	--
Little Sheep Cr.	yes	yes	yes	yes	yes	--
Grande Ronde:						
Catherine Cr.	yes	yes	yes	yes	w	--
Deer Cr.	yes	yes	yes	yes	yes	--
Five Points Cr.	yes	yes	yes	yes	yes	--
Fly Cr.	yes	yes	yes	yes	yes	--
Indian Cr.	yes	yes	yes	--	yes	--
Lookingglass Cr.	yes	yes	yes	w	w	--
Meadow Cr.	yes	yes	yes	yes	yes	--
Sheep Cr.	yes	yes	yes	yes	w	--

Table 3. Study streams in the Grande Ronde River and Imnaha River subbasins.

Subbasin, stream	Trib to, at RM	Length (miles)	Adult trap location (RM)	Treatment or control
Imnaha:				
Camp Creek	Big Sheep, 1.2	6	0	control
Little Sheep Creek	Big Sheep, 3.2	29	5	treatment
Grande Ronde:				
Catherine Creek	Grande Ronde, 140	43		treatment
Deer Creek	Wallowa, 11.5	19	0	treatment
Five Points Creek	Grande Ronde, 165	17	2	control
Fly Creek	Grande Ronde, 184	15	0	treatment
Indian Creek	Grande Ronde, 102	20	5	treatment
Lookingglass Creek	Grande Ronde, 86	16	2	control
Meadow Creek	Grande Ronde, 180	24	3	control
Sheep Creek	Grande Ronde, 194	13	6	control

STREAM	ACTIVITY
Fly Creek	(1967)<——Redd counts——————>D D D D H H N N N N
Catherine Creek	S S S S S S S D D D D H H N N N N
Indian Creek	D D D D H H N N N N
Deer Creek	SSSSSD D D D H H N N N N
Lookingglass Creek	D D D D H H N N N N
Five Points Creek	(1967)<——Redd counts——————>D D D D H H N N N N
Meadow Creek	(1967)<——Redd counts——————>D D D D H H N N N N
Sheep Creek	D D D D H H N N N N
Little Sheep Creek	SSSSSSSSSSD D D D H H N N N N N
Camp Creek	(1964)<——Redd counts——————>D D D D H H N N N N

82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01

YEAR

S = Supplementation under LSRCP
D = Pre-supplementation data collection
H = Post-supplementation, hatchery release only
N = Post-supplementation, with natural production

Figure 2. Status of supplementation and historical data.

Table 4. Study streams and property owners in the Grande Ronde River and Imnaha River subbasins.

Subbasin, stream	Landowner	RM
Imnaha:		
Camp Creek	D. C. Justice	0
	A. Duckett	0
	D. Hubbard	5
Little Sheep Creek	H. Chitwood	0
	L. Moore	3
	ODFW	5
	E. Talbot	13
Grande Ronde:		
Catherine Creek	W. Ricker	20
	Oregon State Parks	26
	Hanson Natural Resources	29
	USFS	32
Deer Creek	ODFW	0
	Boise Cascade	2
	USFS	7
Five Points Creek	USFS	2
Fly Creek	R. Schiller	0
	USFS	10
Indian Creek	Beckland Ltd. (Sharon Beck)	3
	Boise Cascade	11
	USFS	14
Lookingglass Creek	ODFW	0
	Boise Cascade	3
	Neilsen	4
	Rysdam	7
Meadow Creek	J. Schiller	0
	M. Tipperman	3
	K L Ranches Inc	3
	USFS	5
Sheep Creek	J. Schiller	0
	USFS	6

Fish Distribution In Study Streams

Densities of juvenile steelhead in each of the study streams are shown in Tables 5-14. Juvenile hatchery steelhead that had been released in April were found in Little Sheep, Camp, and Deer creeks during our summer,sampling. Juvenile spring chinook salmon were found in Catherine, Deer, Fly, Lookingglass and Camp creeks. Bull trout were found in Little Sheep Creek, Chicken Creek (tributary to Sheep Creek), Middle Fork and South Fork Catherine Creek, Indian Creek and Lookingglass Creek.

Table 5. Densities of juvenile steelhead and presence of other species in Fly Creek and tributaries, summer 1992. BT= Brook trout; BUT= Bull trout; CHS= Spring chinook salmon; COT= Sculpin; D= Dace; RSS= Redside shiner; SQ= Squawfish; SU= Sucker; WF= Whitefish

		Steelhead density (fish/100 m^2)				
		natural			hatchery	Other
Stream	RM	age 0	≥ age 1	all ages[a]	≥ age 1	species
Fly Creek	1	7.143[b]	2.857[b]		0	CHS COT D
Fly Creek	10	3.313[c]	4.688[b]		0	COT D
Little Fly Creek	5			56.000	0	COT
Lookout Creek	3.5			21.812	0	COT

a Age classes not separated. Minimum density based on number observed includes all juvenile ages.

b Estimated density based on multiple pass removal techniques.

c Minimum density based on number observed.

Table 6. Densities of juvenile steelhead and presence of other species in Sheep Creek and tributaries, summer 1992.

		Steelhead density (fish/100 m^2)				
		natural			hatchery	
Stream	RM	age 0	$\geq$ age 1	all ages[a]	$\geq$ age 1	Other species
Sheep Creek	6	0.782’	13.959[c]		0	COT
East Sheep Creek	0.5			17.468	0	COT
Chicken Creek	2	1.961[b]	11.765[b]		0	COT D
Chicken Creek	6			10.618	0	BUT

a Age classes not separated. Minimum density based on number observed includes all juvenile ages.
b Estimated density based on multiple pass removal techniques.
c Minimum density based on number observed.

Table 7. Densities of juvenile steelhead and presence of other species in Meadow Creek and tributaries, summer 1992.

		Steelhead density (fish/100 m^2)				
		natural			hatchery	
Stream	RM	age 0	$\geq$ age 1	all ages[a]	$\geq$ age 1	Other species
Meadow Creek	0	11.468[b]	0.870[b]		0	COT D RSS SQ
Meadow Creek	5	2.348’	0.444[b]		0	COT D RSS WF SQ
Meadow Creek	11			12.261	0	COT D RSS SQ SU
McCoy Creek	1			5.399	0	COT D RSS

a Age classes not separated. Minimum density based on number observed includes all juvenile ages.
b Estimated density based on multiple pass removal techniques.
c Minimum density based on number observed.

Table 8. Densities of juvenile steelhead and presence of other species in Five Points Creek and tributaries, summer 1992.

		Steelhead density (fish/100 m^2)				
		natural			hatchery	
Stream	RM	age 0	≥ age 1	all ages[a]	≥ age 1	Other species
Five Points Creek	1	16.176’	3.561[b]		0	COT D WF
Five Points Creek	2	13.334[b]	7.000[c]		0	COT D
Five Points Creek	6.5	2.941[b]	7.143[b]		0	COT D
Five Points Creek	9	26.490'	11.226'		0	COT
Little John Day Cr.	0	32.000’	0		0	COT
Dry Creek	0			20.668[b]	0	

a Age classes not separated. Minimum density based on number observed includes all juvenile ages.
b Estimated density based on multiple pass removal techniques.
c Minimum density based on number observed.

Table 9. Densities of juvenile steelhead and presence of other species in Catherine Creek and tributaries, summer 1992.

		Steelhead densitv (fish/100 m^2)				
		natural			hatcher-v	
Stream	RM	age 0	≥ age 1	all ages[a]	≥ age 1	Other species
Catherine Creek	9	0	0.400[c]		0	D RSS SQ
Catherine Creek	18	5.655’	1.333[b]		0	BT CHS COT D WF
Catherine Creek	27	0.192[b]	0.333[c]		0	BT CHS COT D
Little Catherine	0.5			28.254	0	CHS COT D
Little Catherine	5	17.500[c]	28.215[b]		0	
M.F. Catherine Cr.	1			3.601	0	BUT
N.F. Catherine Cr.	1	0	3.750[b]		0	CHS COT
N.F. Catherine Cr.	2.5			3.651	0	
S.F. Catherine Cr.	0.5			5.491	0	CHS COT
S.F. Catherine Cr.	5	0.286[b]	2.165[b]		0	BT BUT
Little Creek	1.5	0	0		0	COT D SU

a Age classes not separated. Minimum density based on number observed includes all juvenile ages.
b Estimated density based on multiple pass removal techniques.
c Minimum density based on number observed.

Table 10. Densities of juvenile steelhead and presence of other species in Indian Creek and tributaries, summer 1992.

		Steelhead density (fish/100 m^2)				
		natural			hatchery	
Stream	RM	age 0	≥ age 1	all ages[a]	≥ age 1	Other species
Indian Creek	0 11	0	0		0	COT D RSS SQ SU
Indian Creek				4.765	0	BUT COT
Indian Creek	15.5	0.527[b]	3.040[b]		0	BUT
Little Indian Cr.	2			11.335	‘0	
Shaw Creek	3.5			20.477	0	

a Age classes not separated. Minimum density based on number observed includes all juvenile ages.
b Estimated density based on multiple pass removal techniques.

Table 11. Densities of juvenile steelhead and presence of other species in Lookingglass Creek and tributaries, summer 1992.

		Steelhead densitv (fish/100 m^2)				
		natural			hatchery	
Stream	RM	age 0	≥ age 1	all ages[a]	≥ age 1	Other species
Lookingglass Cr.	0.3	6.102[b]	7.619[b]		0	CHS COT D
Lookingglass Cr.	4.5			4.499	0	CHS COT
Lookingglass Cr.	10	0	14.251[b]		0	BUT
Lookingglass Cr.	15.5			9.333	0	
Little Lookinggl.	0.5			12.366	0	COT
Little Lookinggl.	1.5			14.123	0	CHS COT
Mottett Creek	3			25.000	0	

a Age classes not separated. Minimum density based on number observed includes all juvenile ages.
b Estimated density based on multiple pass removal.techniques.

Table 12. Densities of juvenile steelhead and presence of other species in Deer Creek and tributaries, summer 1992.

Stream	RM	Steelhead density (fish/100 m^2) natural age 0	natural ≥ age 1	natural all ages[a]	hatchery ≥ age 1	Other species
Deer Creek	0	15.758[b]	1.212[b]		54.546[b]	CHS COT D
Deer Creek	1	19.880[b]	7.551[b]		6.018[b]	CHS COT D
Deer Creek	10	10.435[b]	11.167[b]		0.870[b]	D
Sage Creek	0.5			24.668	0	COT

a Age classes not separated. Minimum density based on number observed includes all juvenile ages.
b Estimated density based on multiple pass removal techniques.

Table 13. Densities of juvenile steelhead and presence of other species in Camp Creek, summer 1992.

Stream	RM	Steelhead density (fish/100 m^2) natural age 0	natural ≥ age 1	natural all ages[a]	hatchery ≥ age 1	Other species
Camp Creek	0	21.765[b]	5.552[b]		2.941[b]	BT CHS COT D
Camp Creek	5	9.344[c]	0		0	COT

b Estimated density based on multiple pass removal techniques.
c Minimum density based on number observed.

Table 14. Densities of juvenile steelhead and presence of other species in Little Sheep Creek and tributaries, summer 1992.

		Steelhead density (fish/100 m^2)				
		natural			hatchery	
Stream	RM	age 0	$\geq$ age 1	all ages[a]	$\geq$ age 1	Other species
Little Sheep Cr.	0.3	3.242’	4.936[b]		13.160[b]	COT D
Little Sheep Cr.	5	10.954[b]	0.749[b]		31.151[b]	COT D
Little Sheep Cr.	12.5	11.401[b]	4.337[b]		1.445[b]	COT D
Little Sheep Cr.	20	35.077[b]	5.556[b]		1.111[b]	COT
Little Sheep Cr.	24			9.006	0	BUT
Lightning Creek	0.5			18.333	1.000[c]	BUT COT
Bear Gulch	0.3	27.500’	25.000’		5.000[c]	
Bear Gulch	1	51.250'	23.929[c]		0	

a Age classes not separated. Minimum density based on number observed includes all juvenile ages.
b Estimated density based on multiple pass removal techniques.
c Minimum density based on number observed.

Fecundity

We estimated fecundity of 22 natural and 41 hatchery steelhead spawned at the Little Sheep Creek facility in 1990 (Table 15). Natural l-salt steelhead were significantly smaller and had lower fecundity than hatchery l-salt steelhead (t test; $P \leq 0.05$). Length and fecundity of natural and hatchery 2-salt steelhead were not significantly different ($P > 0.05$). The relationships of fecundity and fork length (mm) for natural and hatchery steelhead in 1990 were:

(natural) FECUNDITY = -2465.18 t 11.57 LENGTH; r^2=0.57, N=22, $P \leq 0.001$;

(hatchery) FECUNDITY = -3999.00 t 14.69 LENGTH; r^2=0.51, N=41, $P \leq 0.001$.

Slopes of the regression of fecundity on length are not different for hatchery and natural steelhead, but the elevations of the lines are significantly different ($P \leq 0.05$).

We estimated fecundity of 9 natural and 40 hatchery steelhead spawned at the Little Sheep Creek facility in 1991 (Table 15). The small sample sizes of l-salt and 2-salt natural steelhead precluded meaningful comparisons with hatchery steelhead. The relationships of fecundity and fork length (mm) for natural and hatchery steelhead in 1991 were:

(natural) FECUNDITY = -5745.34 t 16.53 LENGTH; r^2=0.57, N=9, $P \leq 0.05$;

(hatchery) FECUNDITY = -2884.33 t 11.59 LENGTH; r^2=0.41, N=40, P 5 0.001.

We estimated fecundity of 30 natural and 38 hatchery steelhead spawned at the Little Sheep Creek facility in 1992 (Table 15). Natural 1-salt and 2-salt steelhead were significantly smaller than hatchery 1-salt and 2-salt steelhead, respectively (t test; $P \leq 0.05$). Fecundity of natural 1-salt and 2-salt were not significantly different than hatchery 1-salt and 2-salt steelhead, respectively ($P > 0.05$). The relationships of fecundity and fork length (mm) for natural and hatchery steelhead in 1992 were:

(natural) FECUNDITY = -2607.40 t 11.84 LENGTH; r^2=0.22, N=30, $P \leq 0.01$;

(hatchery) FECUNDITY = -3512.50 t 13.30 LENGTH; r^2=0.46, N=38, $P \leq 0.001$.

We estimated fecundity of 18 natural and 80 hatchery steelhead spawned at the Little Sheep Creek facility in 1993 (Table 15). Natural 2-salt were significantly smaller than hatchery 2-salt steelhead (t test; $P \leq 0.05$); whereas the lengths of natural and hatchery 1-salt steelhead were not significantly different ($P > 0.05$). Fecundity of natural 1-salt steelhead was significantly lower than that of hatchery 1-salt steelhead (t test; $P \leq 0.05$) and fecundity of natural 2-salt steelhead was significantly lower than that of hatchery 2-salt steelhead (t test; $P \leq 0.10$). The relationships of fecundity and fork length (mm) for natural and hatchery steelhead in 1993 were:

(natural) FECUNDITY = -5773.08 t 16.77 LENGTH; r^2=0.63, N=18, $P \leq 0.001$;

(hatchery) FECUNDITY = -4263.68 t 15.06 LENGTH; r^2=0.62, N=80, $P \leq 0.001$.

Table 15. Mean fork length (mm) and fecundity by origin and ocean-age of steelhead sampled at the Little Sheep Creek facility, 1990-93. Standard deviation is shown in parentheses.

Year,	1-salt			*-salt		
origin	N	Length	Fecundity	N	Length	Fecundity
1990:						
Natural	11	566 (24)	4,071 (625)	11	685 (21)	5,469 (784)
Hatchery	32	586 (27)	4,663 (760)	9	681 (27)	5,879 (1,148)
1991:						
Natural	3	576 (17)	3,713 (541)	6	673 (29)	5,407 (989)
Hatchery	28	553 (24)	3,550 (684)	12	687 (25)	5,020 (1,552)
1992:				4		
Natural	26	572 (24)	4,122 (749)	16	651 (21)	5,391 (1,084)
Hatchery	22	583 (19)	4,260 (890)		693 (34)	5,672 (1,089)
1993 :						
Natural	10	571 (39)	3,802 (977)	8	664 (16)	5,379 (734)
Hatchery	42	567 (21)	4,315 (627)	38	685 (34)	6,018 (1,168)

Male Reproductive Potential

Sperm motility ranged from 25% to 100% for 28 spring chinook salmon examined. Motility generally decreased as length of time since milt extrusion increased and decreased noticeably within 30 to 60 seconds after activation. Sperm motility does not appear to be a useful field technique for our study to quantify male reproductive capacity as the examination should be performed immediately after milt extrusion, and the technique is not very sensitive.

Spermatocrits of spring chinook salmon were 45.36 + 1.47 (mean + SE). Steelhead spermatocrits were 43.85 + 1.98 (mean + SE). Steelhead spermatocrits were not related to length of fish. Spermatocrits may not be a valuable technique for our study to quantify male reproductive as the biological significance of a low spermatocrit is unclear. The amount of semen produced by individual males appears to be highly variable, and the concentration of sperm in the semen appears to be in the order of magnitude of 10^9 sperm cells per milliliter of semen (ODFW unpublished data).

Differential staining techniques reported for goldfish provided the most distinctive staining of cells. Viable sperm cells were most abundant on slides prepared within 5 minutes of milt extrusion. This differential staining technique may be useful to index male reproductive capacity in our study as it provides a quantifiable measure of sperm viability.

Observation Of Adult Fish

We tagged and released upstream 133 adult spring chinook salmon with disc tags at Lookingglass Hatchery from 21 May to 10 September 1992. We also tagged 49 of the disc tagged fish with a colored anchor tag. We used 16 yellow tags, 16 white tags and 17 orange tags. We conducted 9 surveys between 15 July and 23 September 1992 and made 127 observations of tagged fish. We observed 99 fish with only disc tags, 21 fish with disc and anchor tags, and 7 fish with only anchor tags. Red disc tags tended to be the tag first seen on fish with only disc tags (69 of 99 observations) and on fish with disc and anchor tags (12 of 21 observations). Orange and yellow anchor tags were seen first at about the same rate on fish with only anchor tags. Numbers on the disc tags were not able to be read on live fish. The seven observations of fish with only anchor tags indicates that some disc tags were lost. We have no knowledge of the extent of loss of disc or anchor tags. Use of colored disc tags appears to be a feasible technique to differentially mark hatchery and wild adult steelhead for identification on the spawning grounds.

Baseline Genetic Characterization

We collected juvenile steelhead from four streams in 1989, six streams in 1990, five streams in 1991 and 1992, and from two hatchery stocks in 1990-93 (Table 16). Preliminary results indicate genetic similarity between hatchery and natural fish from Little Sheep Creek and between Wallowa Hatchery fish and natural fish from Deer Creek (R. Waples, NMFS, unpublished data).

Table 16. Collection sites of juvenile steelhead for genetic baseline development, 1989-1993.

Subbasin, stream, RM	Month, year collected	Brood years	Stock
Grande Ronde:			
Chesnimnus Creek, 12	09/89	1986-89	Grande Ronde wild
Chesnimnus Creek, 12	09/90	1987-90	Grande Ronde wild
Chesnimnus Creek, 12	09/91	1988-91	Grande Ronde wild
Chesnimnus Creek, 12	09/92	1989-92	Grande Ronde wild
Deer Creek, 0.5	09/89	1986-89	Grande Ronde supplemented
Deer Creek, 0.5	09/90	1987-90	Grande Ronde supplemented
Deer Creek, 0.5	09/91	1988-91	Grande Ronde supplemented
Deer Creek, 0.5	09/92	1989-92	Grande Ronde supplemented
Wallowa Acclimation	04/90	1989	Wallowa hatchery
Wallowa Acclimation	04/91	1990	Wallowa hatchery
Wallowa Acclimation	04/92	1991	Wallowa hatchery
Wallowa Acclimation	04/93	1992	Wallowa hatchery
Imnaha:			
Camp Creek, 1.2	09/90	1987-90	Imnaha wild
Camp Creek, 1.2	09/91	1988-91	Imnaha wild
Camp Creek, 1.2	09/92	1989-92	Imnaha wild
Grouse Creek, 1	09/90	1987-90	Imnaha wild
Lick Creek, 0.3	09/89	1986-89	Imnaha wild
Lick Creek, 0.3	09/90	1987-90	Imnaha wild
Lick Creek, 0.3	09/91	1988-91	Imnaha wild
Lick Creek, 0.3	09/92	1989-92	Imnaha wild
Little Sheep Creek, 18	09/89	1986-89	Imnaha supplemented
Little Sheep Creek, 18	09/90	1987-90	Imnaha supplemented
Little Sheep Creek, 18	09/91	1988-91	Imnaha supplemented
Little Sheep Creek, 19	09/92	1989-92	Imnaha supplemented
Little Sheep Facility	04/90	1989	Imnaha hatchery
Little Sheep Facility	04/91	1990	Imnaha hatchery
Little Sheep Facility	04/92	1991	Imnaha hatchery
Little Sheep Facility	04/93	1992	Imnaha hatchery

Development of Experimental Design

The experimental design is presented in Appendix E. The experimental design includes specific objectives, testable hypotheses, general methods and specific tasks, estimates of statistical sensitivity, descriptions of the hatchery production strategies, the schedule for implementation and completion, and a budget.

SUMMARY AND CONCLUSIONS

We inventoried the habitat of study streams in the Imnaha River subbasin and of Deer Creek in the Grande Ronde River subbasin to compare streams and to understand if habitat is influencing the performance parameters we will be measuring in the study. The remaining study streams in the Grande Ronde River subbasin were inventoried by the ODFW Aquatic Inventories Project and the Wallowa-Whitman National Forest.

We selected two streams in the Imnaha River subbasin and eight streams in the Grande Ronde River subbasin for use as study streams to evaluate the success and impacts of supplementation on wild steelhead populations. Within each subbasin we will have an equal number of treatment (supplemented) and control (nonsupplemented) study streams. We added Grande Ronde River subbasin streams to the study to increase replication.

We estimated the fecundity of hatchery and natural steelhead returning to the Little Sheep Creek fish facility in 1990 and 1991. Variation in length explained 57% of the variation in fecundity of natural steelhead in each of the two years and only 41% and 51% of the variation in fecundity of hatchery steelhead in the two years of sampling.

We sampled steelhead from supplemented and nonsupplemented streams and the hatchery programs in the two subbasins for genetic and meristic analyses by the National Marine Fisheries Service. To date, we have not received the results of these analyses.

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APPENDIX A

Summaries Of Habitat Inventories Of Camp, Grouse, And Little Sheep Creeks In The Imnaha River Subbasin And Deer Creek In The Grande Ronde River Subbasin

APPENDIX TABLE A-l. Habitat summary by reach for Camp Creek from its confluence with Big Sheep Creek (RM 0) to the end of perennial flow (RM 6).

Reach, Habitat group	Number units	Total length(m)	Mean width(m)	Mean depth(m)	Wetted Area (m^2)	Wetted Area %	Large boulders number	Large boulders no./100m^2	Wood class[a]
Reach 1									
Glides	1	11	3.0	0.3	32	1.86	0	0.00	1.0
Riffles[b]	14	107	3.0,	0.5	319	18.32	1	0.31	1.4
			2.8	0.2	1,388	79.69	29	2.09	1.0
Step/Falls	2	1	3.6	0.0	2	0.12	0	0.00	1.5
Reach 2									
Glides	5	43	3.5	0.4	158	2.77	10	6.33	1.4
Riffles[b]	25 52	148	3.1	0.5	475	8.32	16	3.37	1.4
		1,713	2.7	0.2	5,066	88.86	206	4.07	1.2
Step/Falls	3	1	3.7	0.0	3	0.05	3	100.00	1.3
Reach 3									
Glides	2	18	4.7	0.3	83	1.83	1	1.21	1.0
Riffles[b]	26 38	168	3.2	0.5	559	12.36	8	1.44	2.0
		1,345	2.9	0.2	3,879	85.74	51	1.31	1.3
Step/Falls	2	1	2.7	0.0	3	0.07	0	0.00	3.0
Reach 4									
Glides	8	62	3.1	0.3	192	1.58	11	5.72	1.1
Riffles[b]	103 51	299	3.1	0.4	962	7.91	40	4.16	1.6
		3,410	3.1	0.2	10,997	90.45	533	4.85	1.2
Step/Falls	4	2	4.0	0.0	8	0.06	8	102.56	2.3
Reach 5	6								
Glides	27	67	2.8	0.2	181	2.96	8	4.42	1.2
Riffles[b]	46	175	3.8	0.4	670	10.95	19	2.84	1.9
		1,649	3.2	0.2	5,267	86.05	219	4.16	1.4
Step/Falls	1	<1	5.1	0.0	2	0.03	0	0.00	3:o

a 1= Little or no wood present, no habitat complexity;
2= Some wood present, but contributes little to habitat complexity;
3= Moderate amount of wood present, providing cover and complex habitat at low to moderate flow;
4= Moderate to large amount of wood present, providing cover and complex habitat at most flows;
5= Moderate to large amount of wood present, providing excellent persistent and complex habitat at all flows.

b Includes rapids and cascades.

APPENDIX TABLE A-2. Reach summary for Camp Creek from its confluence with Big Sheep Creek (RM 0) to the end of perennial flow (RM 6).

Reach	Gradient (%)	Units/100 m	Undercut banks (%)	Substrate (% wetted area) silt/sand	gravel	cobble	boulder	bedrock
1	2.5	6.6	5.0	8	36	43	5	0
2			2.7		30	41	9	2
3	3.0 2.8	4.5 4.4	11.8	13 17	32	46	3	0
4	2.9	4.4	4:4	12	26	45	14	0
5	2.8	4.2	5.3	14	32	41	10	0

APPENDIX TABLE A-3. Stream summary for Camp Creek from its confluence with Big Sheep Creek (RM 0) to the end of perennial flow (RM 6).

Number units	Total length (m)	Mean width (m)	Mean depth (m)	Total area (m^2)	Substrate (% wetted area) silt/sand	gravel	cobble	boulder	bedrock
437	9,680	3.1	0.3	30,245	13	30	43	10	1

APPENDIX TABLE A-4. Habitat summary by reach for Grouse Creek from its confluence with the Imnaha River (RM 0) to Road Canyon (RM 4.5).

Reach, Habitat group	Number units	Total length(m)	Mean width(m)	Mean depth(m)	Wetted Area (m^2)	Wetted Area %	Large boulders number	Large boulders no./100m^2	Wood class[a]
Reach 1									
Glides	15	133	3.3	0.3	453	21.59	126	27.83	
Pools									1.0
Riffles[b]	26 16	379 89	3.2 2.9	0.5 0.3	1,368	65.01 12.77	591 62	43.33 23.15	1.0
Step/Falls	4	5	2.6	0.1	13	0.63	15	113.64	1.0
Reach 2									
Glides	38	443	4.4	0.3	2,015	10.97	189	9.38	1.0
Riffles[b]	136 66	401	3.4 4.3	0.5 0.3	1,332	80.95 7.25	151	21.51 11.34	1.5
		3,391			14,869		3,198		1.0
Step/Falls	17	37	4.2	0.1	154	0.84	84	54.65	1.1
Reach 3									
Glides	3	98	6.1	0.3	230	7.24	16	6.97	1.0
Riffles[b]	15	516	3.6 3.6	0.5 0.3	375	75.63 11.82	382 18	15.94 4.80	1.3
					2,397				1.0
Step/Falls	3	5	3.3	0.1	168	5.31	6	3.57	1.0
Reach 4									
Glides	14	115	3.9	0.3	493	7.35	65	13.19	1.1
Riffles[b]	32 52	172	3.9 4.1	0.6 0.3	632	82.83 9.43	69	10.92	1.8
		1,330			5,552		1,418	25.54	1.2
Step/Falls	11	9	2.8	0.2	26	0.39	22	83.33	1.9

a 1= Little or no wood present, no habitat complexity;
2= Some wood present, but contributes little to habitat complexity;
3= Moderate amount of wood present, providing cover and complex habitat at low to moderate flow;
4= Moderate to large amount of wood present, providing cover and complex habitat at most flows;
5= Moderate to large amount of wood present, providing excellent persistent and complex habitat at all flows.

b Includes rapids and cascades.

APPENDIX TABLE A-5. Reach summary for Grouse Creek from its confluence with the Imnaha River (RM 0) to Road Canyon (RM 4.5).

Reach	Gradient (%)	Units/100 m	Undercut banks (%)	Substrate (% wetted area) silt/sand	gravel	cobble	boulder	bedrock
1	2.4	10.1	0.8	2	28	44	11	16
2						52	7	2
3	3.0 5.3	6.0 6.0	0.6 0.0	3 2	35 39	50	4	6
4	3.5	6.7	0.3	2	33	46	11	4

APPENDIX TABLE A-6. Stream summary for Grouse Creek from its confluence with the Imnaha River (RM 0) to Road Canyon (RM 4.5).

Number units	Total length (m)	Mean width (m)	Mean depth (m)	Total area (m^2)	Substrate (% wetted area) silt/sand	gravel	cobble	boulder	bedrock
468	7,201	3.9	0.3	30,339	3	34	49	8	5

APPENDIX TABLE A-7. Habitat summary by reach for Little Sheep Creek from the Little Sheep Creek fish facility (RM 5) to the Wallowa Valley Canal (RM 26).

Reach, Habitat group	Number units	Total length(m)	Mean width(m)	Mean depth(m)	Wetted Area (m^2)	Wetted Area %	Large boulders number	Large boulders no./100m^2	Wood class[a]
Reach 1									
Glides	28	319	4.6	0.4	1,475	4.00	22	1.49	1.6
Riffles[b]	208 160	1,530	4.4	0.6	6,895	18.71	96	1.39	1.9
		6,160	4.4	0.4	28,401	77.07	1,102	3.88	1.4
Step/Falls	14	17	5.1	0.1	83	0.23	11	13.24	3.1
Reach 2									
Glides	9	127	5.2	0.4	662	2.54	5	0.76	1.3
Riffles[b]	108 131	4,208 961	4.7	0.6	4,721	18.12	85	1.80	2.1
			4.4	0.3	20,640	79.22	517	2.50	1.3
Step/Falls	14	7	5.1	0.1	32	0.12	0	0.00	3.1
Reach 3									
Glides	0	0	0	0	0	0	0	0	0
Riffles[b]	18	559 118	4.4	0.6	513	16.92	8	1.56	2.5
			4.0	0.4	2,516	82.99	138	5.48	1.9
Step/Falls	1	<1	6.7	0.1	3	0.09	0	0.00	4.0
Reach 4									
Glides	22	267	4.0	0.3	1,146	1.63	12	1.05	1.8
Riffles[b]	413 276	13,574 2,502	4.2	0.5	10,834	15.38	90	0.83	2.3
			3.8	0.3	58,427	82.95	903	1.55	1.5
Step/Falls	15	6	5.0	0.1	26	0.04	1	3.80	2.8
Reach 5	4								
Glides	102	40	3.4	0.4	133	0.73	0	0.00	1.8
Riffles[b]	193	537	3.9	0.5	2,065	11.31	13	0.63	3.0
		5,284	3.0	0.3	15,897	87.05	267	1.68	2.7
Step/Falls	45	31	4.3	0.1	152	0.83	0	0.00	3.7

a 1= Little or no wood present, no habitat complexity;
2= Some wood present, but contributes little to habitat complexity;
3= Moderate amount of wood present, providing cover and complex habitat at low to moderate flow;
4= Moderate to large amount of wood present, providing cover and complex habitat at most flows;
5= Moderate to large amount of wood present, providing excellent persistent and complex habitat at all flows.

b Includes rapids and cascades.

APPENDIX TABLE A-8. Reach summary for Little Sheep Creek from the Little Sheep Creek fish facility (RM 5) to the Wallowa Valley Canal (RM 26).

Reach	Gradient (%)	Units/100 m	Undercut banks (%)	Substrate (% wetted area) silt/sand	gravel	cobble	boulder	bedrock
1	2.6	5.1	3.7	20	25	38	13	1
2	2.2	4.9	4.1	24	31	29	11	1
3	2.8	4.4	7.0	21	31	28	17	0
4	2.4	4.4	13.7	20	40	31	6	0
5	4.1	5.8	9.1	19	34	29	5	0

APPENDIX TABLE A-9. Stream summary for Little Sheep Creek from the Little Sheep Creek fish facility (RM 5) to the Wallowa Valley Canal (RM 26).

Number units	Total length (m)	Mean width (m)	Mean depth (m)	Total area (m^2)	Substrate (% wetted area) silt/sand	gravel	cobble	boulder	bedrock
1,773	36,264	4.1	0.4	154,637	21	34	32	8	0

APPENDIX B

Summaries Of Fecundity Sampling At The Little Sheep Creek Facility, 1990 to 1993

Appendix Table B-l. Length, weight, age, origin, and fecundity of individual steelhead sampled at the Little Sheep Creek facility, 1990. All fish were sampled when ripe. Age is expressed as years spent in fresh water prior to migration: years spent in ocean prior to spawning migration.

Fish sample number	Fork length (mm)	Body weight (kg)	Age	Ovary weight (9)	eggs/gram	Total eggs	Origin
2.1	585	2.1	1:l	401.2	11.04	4,429	Hatchery
3.1	560	1.9	1:l	360.9	12.38	4,468	Hatchery
4.1	618	2.2	1:l	408.0	9.57	3,905	Hatchery
5.1	555	1.7	3:l	354.8	11.13	3,949	Natural
7.1	548	1.6	1:l	339.6	10.72	3,641	Hatchery
8.1	605	2.3	1:l	437.5	14.43	6,313	Hatchery
9.1	602	1.9	1:l	312.9	11.84	3,705	Hatchery
10.1	671	2.8	2:2	558.6	9.60	5,363	Natural
11.1	564	1.6	1:l	308.4	14.00	4,318	Hatchery
12.1	561	0.0	1:l	356.9	11.97	4,272	Hatchery
13.1	650	2.5	1:2	503.0	10.19	5,126	Hatchery
14.1	623	2.4	1:1	434.9	11.12	4,836	Hatchery
15.1	590	1.8	1:1	327.8	13.21	4,330	Hatchery
16.1	672	2.7	1:2	447.9	12.16	5,446	Hatchery
17.1	532	1.6	2:l	285.4	14.22	4,058	Natural
18.1	533	1.5	1:1	279.7	11.41	3,191	Hatchery
19.1	699	2.8	2:2	492.8	11.00	5,421	Natural
20.1	617	2.4	1:1	407.6	13.00	5,299	Hatchery
21.1	544	1.6	1:1	257.9	15.82	4,080	Hatchery
22.1	671	2.8	1:2	515.0	10.59	5,454	Hatchery
23.1	594	2.0	1:1	366.9	14.77	5,419	Hatchery
24.1	618	2.2	1:1	371.5	12.35	4,588	Hatchery
25.1	706	2.3	2:2	553.8	10.44	5,782	Natural
26.1	557	1.8	1:1	369.2	13.30	4,911	Hatchery
27.1	528	1.5	1:1	289.1	12.89	3,727	Hatchery
28.1	606	2.0	1:1	263.7	14.76	3,892	Hatchery
29.1	607	2.3	1:1	409.5	12.91	5,286	Hatchery
30.1	572	1.8	1:1	327.7	14.24	4,666	Hatchery
31.1	581	2.0	1:1	351.7	12.57	4,421	Hatchery
32.1	693	2.9	2:2	519.4	12.09	6,280	Natural

Appendix Table B-l. Continued.

Fish sample number	Fork length (mm)	Body weight (kg)	Age	Ovary weight (9)	eggs/gram	Total eggs	Origin
33.1	680	3.0	1:2	469.2	13.00	6,099	Hatchery
34.1	604	2.2	1:1	376.7	13.24	4,987	Hatchery
35.1	680	2.9	1:2	446.4	10.48	4,678	Hatchery
36.1	571	1.9	1:1	431.4	11.89	5,129	Hatchery
37.1	720	3.6	1:2	576.1	12.86	7,409	Hatchery
38.1	675	2.9	1:2	569.2	12.21	6,950	Hatchery
39.1	620	2.4	1:1	494.8	11.50	5,690	Hatchery
40.1	584	2.0	1:1	374.1	13.73	5,137	Hatchery
41.1	656	2.8	1:2	394.7	11.02	4,350	Hatchery
42.1	564	1.8	1:1	351.4	12.99	4,565	Hatchery
43.1	576	1.9	2:1	356.7	9.91	3,535	Natural
44.1	685	3.0	2:2	489.8	14.44	7,073	Natural
45.1	618	2.6	1:1	441.6	14.82	6,544	Hatchery
46.1	730	3.8	1:2	631.6	11.71	7,396	Hatchery
47.1	564	1.9	2:1	291.9	13.53	3,949	Natural
48.1	677	2.8	2:2	479.1	12.01	5,754	Natural
49.1	606	2.3	1:1	376.2	14.76	5,552	Hatchery
50.1	603	2.3	1:1	410.1	12.33	5,057	Hatchery
51.1	600	2.0	2:1	380.2	10.44	3,969	Hatchery
52.1	645	2.4	2:2	436.3	10.59	4,620	Natural
53.1	704	3.1	2:2	515.3	8.91	4,591	Natural
053.3	658	2.7	2:2	412.8	11.07	4,570	Natural
54.1	535	1.6	2:1	346.0	12.00	4,152	Natural
54.3	580	1.8	2:1	342.2	13.74	4,702	Natural
55.1	586	1.9	2:1	378.0	12.83	4,850	Natural
56.1	590	1.2	1:1	338.6	12.86	4,354	Hatchery
57.1	708	3.3	2:2	564.5	10.28	5,803	Natural
58.1	528	1.2	2:1	216.7	15.44	3,346	Natural
59.1	583	2.0	2:1	395.8	10.51	4,160	Natural
59.2	594	2.2	2:1	394.4	12.81	5,052	Natural
59.3	588	1.7	2:1	237.1	12.79	3,033	Natural
60.1	692	2.7	2:2	481.1	10.20	4,907	Natural
61.2	608	2.5	211	429.6	10.57	4,541	Hatchery

Appendix Table B-2. Length, weight, age, origin, and fecundity of individual steelhead sampled at the Little Sheep Creek facility, 1991. All fish were sampled when ripe.

Fish sample number	Fork length (mm)	Body weight (kg)	Age	Ovary weight (9)	Eggs/gram	Total eggs	Origin
1.1	734	3.3	1:2	572.2	12.45	7,124	Hatchery
2.1	594	1.8	2:1	332.2	10.44	3,468	Natural
3.1	562	1.5	1:1	277.8	12.84	3,567	Hatchery
4.1	616	2.0	1:1	352.4	14.23	5,015	Hatchery
4.2	725	3.2	1:2	590.9	9.94	5,874	Hatchery
5.1	672	3.1	2:2	501.4	9.89	4,959	Natural
5.2	535	1.4	1:1	197.6	12.37	2,444	Hatchery
6.1	700	3.2	1:2	317.7	9.31	2,958	Hatchery
6.2	532	1.4	1:1	219.8	15.38	3,380	Hatchery
7.1	666	2.8	1:2	531.4	12.77	6,786	Hatchery
7.2	653	3.4	1:2	297.6	10.84	3,226	Hatchery
8.1	538	1.5	1:1	308.2	11.94	3,680	Hatchery
8.2	705	3.3	1:2	549.3	9.99	5,488	Natural
9.1	564	1.8	1:1	293.7	13.57	3,986	Hatchery
9.2	535	1.4	1:1	170.3	13.86	2,361	Hatchery
10.1	674	2.6	1:2	355.4	9.86	3,504	Hatchery
11.1	540	1.4	1:1	220.6	13.97	3,082	Hatchery
12.2	522	1.3	1:1	233.1	13.81	3,219	Hatchery
13.1	574	2.0	1:1	353.5	11.23	3,970	Hatchery
14.1	562	1.6	1:1	210.8	11.90	2,508	Hatchery
15.1	675	2.8	1:2	420.7	9.24	3,887	Hatchery
16.2	534	1.9	1:1	295.8	13.21	3,908	Hatchery
17.1	557	1.7	1:1	259.2	13.37	3,465	Hatchery
18.1	505	1.3	1:1	239.9	14.32	3,436	Hatchery
19.1	540	1.5	1:1	279.7	14.39	4,025	Hatchery
20.1	570	1.6	1:1	212.6	12.73	2,707	Hatchery
21.1	678	2.9	1:2	581.3	10.38	6,034	Hatchery
22.1	573	1.9	1:1	312.7	13.02	4,071	Hatchery
23.1	571	1.8	1:1	323.9	13.53	4,383	Hatchery
24.1	542	1.6	1:1	331.5	12.62	4,183	Hatchery
25.1	707	3.4	1:2	563.6	12.24	6,899	Hatchery
26.1	672	2.6	1:2	293.3	12.25	3,593	Hatchery
27.1	570	1.7	1:1	198.4	11.52	2,285	Hatchery
28.1	561	1.8	1:1	200.5	17.38	3,485	Hatchery
29.1	601	2.1	1:2	306.5	12.68	3,887	Hatchery

Appendix Table B-2. Continued.

Fish sample number	Fork length (mm)	Body weight (kg)	Age	Ovary weight (9)	Eggs/gram	Total eggs	Origin
30.1	694	1.5	1:1	476.2	9.79	4,662	Hatchery
31.2	523	3.6	2:2	228.7	14.09	3,222	Hatchery
32.1	706	[illegible]		659.6	10.62	7,005	Natural
33.1	658	2.8	212	420.1	14.04	5,898	Natural
34.1	546	1.7	1:1	292.0	12.88	3,761	Hatchery
35.1	671	2.8	1:2	483.3	11.79	5,698	Hatchery
36.1	540	1.5	1:1	268.9	14.17	3,811	Hatchery
37.1	545	1.5	1:1	258.1	17.05	4,400	Hatchery
38.1	666	2.9	2:2	389.6	10.51	4,095	Natural
39.1	560	1.8	1:2	235.7	12.30	2,899	Hatchery
40.1	571	2.0	1:1	318.8	13.33	4,249	Hatchery
42.1	574	1.9	2:1	274.5	12.16	3,338	Natural
44.1	630	2.6	2:2	378.3	13.22	5,001	Natural
44.2	560	1.9	2:1	287.5	15.07	4,333	Natural

Appendix Table B-3. Length, weight, age, origin, and fecundity of individual steelhead sampled at Little Sheep Creek Facility, 1992. All fish were sampled when ripe.

Fish sample number	Fork length (mm)	Body weight (kg)	Age	Ovary weight (g)	Eggs/gram	Total eggs	Origin
1.2	648	2.5	2:2	386.2	11.01	4,252	Natural
4.3	660	2.1	1:2	295.2	12.62	3,726	Hatchery
5.1	563	1.4	1:1	310.5	12.84	3,987	Hatchery
5.3	740	3.1	1:2	596.9	9.30	5,551	Hatchery
6.1	660	2.0	1:2	457.2	9.75	4,458	Hatchery
7.1	584	1.8	2:1	356.0	12.81	4,561	Natural
8.1	630	2.2	2:2	511.3	12.44	6,360	Natural
8.2	558	1.5	1:1	276.7	14.14	3,913	Hatchery
9.1	563	1.7	2:1	314.7	11.87	3,736	Natural
9.3	665	2.7	1:2	385.4	12.05	4,644	Hatchery
10.1	580	1.8	2:1	218.8	9.40	2,057	Natural
10.3	558	1.7	2:1	347,4	12.71	4,416	Natural
11.1	680	2.8	1:2	464.3	12.12	5,627	Hatchery
12.1	570	1.5	2:1	322.1	10.94	3,524	Natural
13.1	580	1.7	2:1	326.2	12.87	4,198	Natural
14.1	688	2.8	1:2	563.5	9.88	5,567	Hatchery
15.1	577	1.8	1:1	362.2	11.44	4,143	Hatchery
16.1	530	1.4	2:1	230.9	12.56	2,900	Natural
17.1	562	1.6	2:1	318.6	12.19	3,884	Natural
18.1	705	3.2	1:2	593.2	10.84	6,430	Hatchery
19.1	571	1.7	1:1	322.4	16.00	5,159	Hatchery
20.1	634	2.5	1:2	539.2	11.59	6,249	Hatchery
21.1	570	1.6	2:1	192.3	13.94	2,681	Natural
22.1	589	1.8	1:1	318.1	10.69	3,401	Hatchery
23.1	690	3.2	1:2	524.9	11.83	6,209	Hatchery
24.1	744	3.5	1:2	395.4	11.05	4,369	Hatchery
25.1	595	2.0	2:1	392.4	11.81	4,634	Natural
26.1	570	1.7	1:1	367.3	12.48	4,584	Hatchery
27.1	595	2.0	1:1	426.5	14.66	6,252	Hatchery
28.1	600	1.8	1:1	287.5	12.61	3,625	Hatchery
29.1	585	1.8	1:1	420.0	12.86	5,401	Hatchery
30.2	735	3.8	1:2	608.5	11.03	6,712	Hatchery
31.1	551	1.5	1:1	274.6	12.91	3,545	Hatchery
32.1	658	2.5	1:2	368.9	12.34	4,552	Hatchery
33.1	574	1.8	1:1	357.5	12.33	4,408	Hatchery

Appendix Table B-3 continued.

Fish sample number	Fork length (mm)	Body weight (kg)	Age	Ovary weight (9)	Eggs/gram	Total eggs	Origin
34.1	555	1.7	1:1	335.0	10.70	3,585	Hatchery
35.1	592	1.7	1:1	350.3	11.46	4,015	Hatchery
36.1	570	1.5	1:1	242.2	12.96	3,139	Hatchery
37.1	590	1.7	1:1	345.7	13.25	4,580	Hatchery
38.1	568	1.7	1:1	151.8	13.14	1,994	Hatchery
39.1	577	1.8	2:1	346.6	11.00	3,813	Natural
40.1	592	1.7	1:1	363.9	12.83	4,669	Hatchery
41.1	680	2.8	2:2	507.2	12.37	6,274	Natural
42.1	690	3.2	1:2	667.1	9.33	6,224	Hatchery
43.1	612	2.2	1:1	422.4	12.22	5,162	Hatchery
44.1	610	2.0	1:1	331.7	12.41	4,116	Hatchery
45.1	703	3.3	1:2	626.9	10.10	6,332	Hatchery
46.1	552	1.6	2:1	315.2	13.19	4,158	Natural
46.2	560	1.6	2:1	367.5	10.62	3,903	Natural
46.3	601	1.8	2:1	409.1	10.53	4,308	Natural
46.4	610	1.8	2:1	361.6	11.60	4,195	Natural
47.1	742	3.4	1:2	646.4	12.32	7,964	Hatchery
49.1	646	2.3	1:2	440.4	10.62	4,677	Natural
52.1	596	1.8	2:1	307.0	12.91	3,964	Natural
53.1	582	1.8	2:1	377.1	14.82	5,588	Natural
53.3	498	1.0	2:1	276.4	16.88	4,665	Natural
54.1	590	2.0	2:1	340.1	14.66	4,986	Natural
54.3	574	1.6	2:1	293.7	13.90	4,083	Natural
55.1	564	1.4	2:1	296.3	13.15	3,897	Natural
55.2	588	1.5	2:1	267.7	17.52	4,690	Natural
55.3	587	1.7	1:2	344.7	12.16	4,192	Natural
56.1	587	1.8	2:1	351.9	14.54	5,116	Natural
56.3	694	2.7	1:2	561.8	10.93	6,141	Hatchery
57.1	610	2.0	1:1	389.2	12.05	4,690	Hatchery
58.1	536	1.4	2:1	279.5	15.79	4,413	Natural
58.3	612	2.3	1:1	406.7	11.27	4,584	Hatchery
59.1	593	1.8	2:1	285.9	16.14	4,615	Natural
60.1	580	2.0	1:1	407.3	11.75	4,786	Hatchery

Appendix Table B-4. Length, weight, age, origin, and fecundity of individual steelhead sampled at the Little Sheep Creek facility, 1993, All fish sampled were ripe unless otherwise noted.

Fish sample number	Fork length (mm)	Body weight (kg)	Age	Ovary weight (g)	Eggs/gram	Total eggs	Origin
20	585	1.8	:	329.0	12.30	4,047	Natural
27	675	3.1	:	595.4	11.18	6,657	Hatchery
28	680	3.0	:	557.5	13.33	7,432	Hatchery
35	558	1.5	:	255.7	12.92	3,303	Hatchery
45	630	2.3	:	491.5	9.56	4,699	Hatchery
64[a]	685	2.8	:	597.2	8.86	5,291	Hatchery
79[a]	590	1.8	:	340.9	12.02	4,098	Hatchery
117[a]	530	1.5		292.5	13.90	4,066	Hatchery
125[a]	715	2.4		367.5	11.20	4,116	Hatchery
132[a]	552	1.5	·	335.1	11.86	3,974	Hatchery
139[a]	590	1.8	:	328.4	12.90	4,236	Hatchery
145[a]	655	2.7	:	468.8	10.93	5,124	Hatchery
152[a]	580	1.9	:	339.1	12.04	4,083	Hatchery
236	715	3.3	:	595.5	10.67	6,354	Hatchery
249	522	1.4	·	254.8	13.40	3,414	Hatchery
269	550	1.4		220.7	12.38	2,732	Natural
275	665	3.0		398.6	11.36	4,528	Natural
282	680	3.0	·	529.2	13.11	6,938	Hatchery
296	585	1.8		314.2	14.34	4,506	Hatchery
327	655	2.7	:	553.0	11.17	6,177	Hatchery
401[a]	585	1.7	:	335.7	12.50	4,196	Hatchery
402[a]	560	1.5	:	277.7	16.82	4,671	Hatchery
403[a]	720	3.5	:	738.7	12.19	9,005	Hatchery
404[a]	705	3.1	:	653.5	11.08	7,241	Hatchery
405[a]	660	2.6	.	445.0	10.85	4,828	Hatchery
406[a]	610	1.7	:	296.5	12.78	3,789	Hatchery
495[a]	570	1.6	:	309.8	14.78	4,579	Hatchery
496[a]	695	2.8	.	547.5	11.90	6,515	Hatchery
497[a]	560	1.5	·	222.7	15.86	3,532	Hatchery
498[a]	565	1.7		319.9	13.20	4,223	Hatchery

a Fish was sampled when **green.** *Ovary weight and* **eggs/gram** *may be lower than if fish was sampled when ripe.*

Appendix Table B-4. Continued.

Fish sample number	Fork length (mm)	Body weight (kg)	Age	Ovary weight (g)	Eggs/gram	Total eggs	Origin
499[a]	670	2.8		504.6	13.81	6,969	Hatchery
500[a]	550	1.7		308.0	12.46	3,838	Hatchery
575	720	3.4		684.2	10.31	7,054	Hatchery
601	730	3.2		638.0	10.69	6,820	Hatchery
605	585	1.9		345.4	12.54	4,331	Hatchery
618	735	3.6		653.1	9.64	6,296	Hatchery
627	550	1.6		299.4	13.42	4,018	Hatchery
646	580	1.7		334.6	12.25	4,099	Hatchery
667	635	2.4		449.6	8.81	3,961	Hatchery
824	675	2.2		484.2	9.95	4,818	Natural
831	490	1.1		182.3	13.22	2,410	Natural
1090	725	3.7		786.5	8.17	6,426	Hatchery
1091	550	1.6		279.8	14.24	3,985	Hatchery
1092	690	3.3		534.3	12.53	6,695	Hatchery
1093	690	3.0		457.5	11.26	5,151	Hatchery
1094	575	1.8		304.0	15.56	4,730	Hatchery
1095	560	1.6		256.1	14.10	3,611	Hatchery
1096	685	3.1		575.9	9.76	5,621	Hatchery
1097	590	1.9		329.8	12.63	4,165	Hatchery
1098[a]	675	2.9		642.4	9.67	6,212	Hatchery
1099[a]	570	1.6		286.5	16.01	4,587	Hatchery
1100[a]	550	1.5		247.4	18.72	4,631	Hatchery
1101[a]	550	1.6		253.9	15.36	3,900	Hatchery
1102[b]	715	3.0		360.6	14.27	5,146	Hatchery
1103[b]	590	2.1		322.9	15.02	4,850	Hatchery
1104[b]	555	1.5		252.4	14.85	3,748	Hatchery
1111	605	2.0		337.0	11.69	3,940	Natural
1119	560	1.5		268.2	12.86	3,449	Natural
1332[a]	715	3.5		631.0	10.97	6,922	Hatchery
1333[a]	620	1.8		394.4	11.40	4,496	Hatchery
1334[a]	568	1.5		246.4	14.41	3,551	Hatchery
1394[b]	645	2.3		368.1	12.46	4,586	Hatchery
1395[b]	565	1.8		308.6	14.67	4,527	Hatchery
1396[b]	555	1.4		223.9	19.48	4,362	Hatchery
1448	705	3.0		590.5	10.79	6,372	Hatchery

[a] *Fish was sampled when green. Ovary weight and eggs/gram may be lower than if fish was sampled when ripe.*
[b] *Fish was sampled when green. Ovary weight and eggs/gram reflect weights after preservation in 5% formalin.*

Appendix Table B-4. Continued.

Fish sample number	Fork length (mm)	Body weight (kg)	Age	Ovary weight (g)	Eggs/gram	Total eggs	Origin
1449	665	2.8		476.7	12.17	5,801	Hatchery
1450	555	1.5		226.5	15.11	3,423	Hatchery
1451	693	3.1		557.3	12.14	6,766	Hatchery
1452	720	3.3		653.0	10.76	7,026	Hatchery
1453	540	1.5		243.6	18.12	4,414	Hatchery
1454	577	1.8		321.1	16.12	5,176	Hatchery
1455	590	1.7		262.2	15.42	4,043	Hatchery
1461	665	2.9		626.9	10.00	6,269	Natural
1462	605	1.9		386.7	15.14	5,854	Natural
1468	690	2.8		531.3	12.72	6,758	Natural
1478	610	2.1		363.3	11.69	4,247	Natural
1581	550	1.4		292.3	15.89	4,645	Hatchery
1582	705	2.3		471.5	10.79	5,088	Hatchery
1583	560	1.7		345.2	16.95	5,851	Hatchery
1584	625	2.4		372.7	12.41	4,625	Hatchery
1585	570	1.6		277.5	15.23	4,226	Hatchery
1586[a]	545	1.7		276.6	16.76	4,636	Hatchery
1587[a]	530	1.5		259.1	17.34	4,493	Hatchery
1588[a]	600	1.8		399.3	16.10	6,429	Hatchery
1589[a]	680	2.6		529.9	12.51	6,629	Hatchery
1611	650	2.4		506.0	10.93	5,531	Natural
1613	535	1.3		302.7	14.88	4,504	Natural
1617	675	2.6		476.8	11.36	5,416	Natural
1619	640	2.5		450.8	10.82	4,878	Natural
1623	655	2.3		475.6	10.17	4,837	Natural
1625	605	2.0		331.2	11.02	3,650	Natural
1695	580	1.8		405.2	12.88	5,219	Hatchery
1696	650	2.5		527.9	10.04	5,300	Hatchery
1697	770	3.9		765.9	11.06	8,471	Hatchery
1698	670	2.7		473.0	10.58	5,004	Hatchery
1699	610	1.8		317.5	15.97	5,071	Hatchery
1700	645	2.4		468.4	10.37	4,857	Hatchery
1708	570	1.6		250.8	12.69	3,183	Natural

[a] *Fish was sampled when* **green. Ovary** *weight and eggs/gram may be lower than if fish was sampled when ripe.*
[b] *Fish was sampled when green. Ovary weight and eggs/gram reflect weights after preservation in 5% formalin.*

APPENDIX C

Summary Of Life History And Genetic Information For Imnaha River Summer Steelhead

Introduction

This appendix is a compilation of life history and genetic information currently available for Imnaha River summer steelhead. This information will be used to guide the development of the Imnaha River steelhead supplementation project.

Production

Wild and hatchery stocks of summer steelhead occur in the Imnaha River system. Wild summer steelhead are found throughout the Imnaha drainage in all available suitable habitat. Hatchery steelhead smolts are released in Little Sheep Creek, and eventually will be released in Horse Creek and the upper Imnaha River.

The hatchery program began in 1982 under the Lower Snake River Compensation Plan (LSRCP) to supplement natural production and maintain life history and genetic characteristics of the wild population, and to restore and enhance sport and tribal fisheries. Hatchery smolts have been released in Little Sheep Creek since 1983. A portion of the adult hatchery steelhead run returning to Little Sheep Creek has been allowed to spawn naturally in Little Sheep Creek. In 1988, 60 adult hatchery steelhead returning to the Little Sheep Creek facility were outplanted in Gumboot Creek to supplement natural production.

The annual hatchery smolt production goal for the Imnaha River subbasin is 330,000 smolts. All hatchery smolts were released into Little Sheep Creek for broodstock development during 1983-88. Some smolts were released at Imnaha in 1989. Once the broodstock is developed, the release sites for the hatchery smolts will be Little Sheep Creek (250,000 smolts), Horse Creek (40,000 smolts), and the upper Imnaha River (40,000 smolts; Carmichael 1989). These release sites have been developed to provide for broodstock collection, restoration of natural production, and re-establishment of tribal and sport fisheries.

Adults are trapped and spawned at the Little Sheep Creek facility. Fertilized and water-hardened eggs are transferred to Wallowa Hatchery for incubation to the eyed stage. Eyed eggs are transferred to Irrigon Hatchery for final incubation and rearing to smolt stage. Smolts are transported to the Little Sheep Creek facility for a two-to four-week acclimation period in an advanced-rearing pond and then released. Smolts released in the Imnaha subbasin in locations other than Little Sheep Creek are transported from Irrigon Hatchery and released directly into the stream.

Origin

Summer steelhead are indigenous to the Imnaha River system. The Imnaha hatchery stock was developed from the wild stock of summer steelhead returning to Little Sheep Creek. Wild steelhead were used exclusively for broodstock from 1982-84; wild and hatchery steelhead have been used for broodstock since 1985, when the first hatchery steelhead returned to the Little Sheep Creek facility. There have been no known introductions of non-native steelhead stocks in the Imnaha subbasin. A few stray hatchery steelhead (origin unknown) were captured at the Little Sheep Creek facility before 1985 when the first Imnaha hatchery stock adults returned. The extent of straying of non-native steelhead into the Imnaha River system is not known, but is assumed to be minimal.

Adult Life History

Run Size, Harvest, and Escapement

Historical run sizes of Imnaha River summer steelhead are unknown. The run size in the 1960s prior to construction of the four lower Snake River dams was estimated to be 4,000 adults (USACE 1975). The run size in the early 1970s was estimated to be 3,030 adults (ODFW 1975). In the mid-1980s, the run size was estimated to be 1,000 adults (Carmichael and Boyce 1987).

Steelhead redds have been counted annually in Camp Creek (tributary to Big Sheep Creek) since 1966 (Appendix Table C-l). The highest redd counts were in 1966 and 1967 with 18.0 redds/mile. The lowest counts were in the mid-1970s with less than 1 redd/mile. The redd counts have been increasing in Camp Creek since 1985, which may indicate rebuilding due to the supplementation program on Little Sheep Creek and subsequent straying, Columbia River passage improvements, and harvest restrictions. Redd counts ranged from 0 to 4.0 redds/mile in three miles of Lightning Creek (tributary to Little Sheep Creek) from 1966 to 1978 (Appendix Table C-l). Redds have not been counted regularly in other Imnaha subbasin streams.

Counts of summer steelhead trapped at the Little Sheep Creek facility since 1982 are shown in Appendix Table C-2. The hatchery run is generally increasing annually as the hatchery program becomes established. River flow conditions in the Imnaha, Snake, and Columbia rivers play a large part in determining survival of smolts and thereby influence the resulting run size. Wild and hatchery adult summer steelhead are released above the Little Sheep Creek facility to spawn naturally (Appendix Table C-3).

Appendix Table C-l. Summer steelhead redd counts in the lower six miles of Camp Creek (tributary to Big Sheep Creek), 1966-90, and in three miles of Lightning Creek (tributary to Little Sheep Creek), 1966-78 (Carmichael 1989; ODFW, unpublished information).

	Camp Creek		Lightning Creek	
Year	Redds	Redds/mile	Redds	Redds/mile
1966	108	18.0	1	0.3
1967	108	18.0	3	1.0
1968	11	1.8	8	2.7
1969	24	4.0	3	1.0
1970	46	7.7	6	2.0
1971	63	10.5	9	3.0
1972	10	1.7	12	4.0
1973	6	1.0	7	2.3
1974	14	2.3	0	0.0
1975	4	0.7	0	0.0
1976	1	0.2	0	0.0
1977	6	1.0	2	0.7
1978	11	1.8	7	2.3
1979	16	2.7		--
1980	34	5.7		--
1981	9	1.5		--
1982	7	1.2		
1983	17	2.8		--
1984	14	2.3	--	--
1985	39	6.5	--	
1986	43	7.2		
1987	64	10.7	--	--
1988	101	16.8	--	--
1989	65	10.8	--	
1990	100	16.7		

Appendix Table C-2. Number of adult summer steelhead trapped at the Little Sheep Creek facility, 1982-90. Number of females spawned for hatchery broodstock is in parentheses.

Year	Wild fish		Hatchery fish	
	Males	Females	Males	Females
1982[a]	9	44 (25)	0	0
1983[a]	15	30 (24)	0	
1984[a]	27	45 (34)	0	8
1985[a]	40	123 (75)	26	26 (19)
1986[a]	14	35 (32)	7	16 (10)
1987	50	60 (11)	255	365 (151)
1988[b]	21	26 (6)	366	442 (165)
1989	19	37 (20)	71	235 (109)
1990	20	37 (23)	456	468 (156)

a Incomplete trapping of adult steelhead due to high water and/or late installation of temporary weir. An unknown number of steelhead passed above the facility when the weir was not operating.

b Thirty male and 30 female hatchery fish were outplanted in Gumboot Creek to supplement natural production.

Appendix Table C-3. Number of adult summer steelhead released to spawn above the Little Sheep Creek facility, 1985-90.

Year	Wild fish		Hatchery fish	
	Males	Females	Males	Females
1985[a]	6	21	1	0
1986[a]	1	1	0	0
1987	34	38	149	186
1988	14	18	189	223
1989	10	16	31	121
1990	7	11	293	305

a Incomplete trapping of adult steelhead due to high water and/or late installation of temporary weir. An unknown number of steelhead passed above the facility when the weir was not operating.

Sport harvest of summer steelhead in the' Imnaha River averaged 805 fish from 1959 to 1973 (Appendix Table C-4). The steelhead sport fishery was closed from 1974 to 1977 and 1979 to 1985 to protect the wild run. The season was reopened in 1986 for harvest of adipose-marked steelhead and the sport harvest has averaged 7 fish from 1986 to 1988. All steelhead harvested prior to 1986 were wild fish. The steelhead sport fishery in the Imnaha River has been open for the harvest of only adipose-marked fish since the fishery reopened in 1986. The sport harvest has averaged 9 fish from 1986 to 1989 (Appendix Table C-4). As the hatchery run size increases and the fishery becomes more popular, the harvest and exploitation rate in the Imnaha River should increase.

Imnaha River hatchery steelhead are caught in Columbia, Deschutes, Snake and Imnaha river fisheries (Appendix Table C-5). The Columbia River fisheries take the largest share of the harvest. Harvest of wild steelhead out of the Imnaha subbasin is unknown, but it is probably similar to that of the hatchery stock for which coded-wire tag (CWT) recovery information is available.

The Nez Perce and Umatilla tribes have usual and accustomed fishing sites in the Imnaha subbasin. Presently Indian harvest of steelhead in the Imnaha is considered to be minimal (CBSP 1989).

Time Of Migration

Imnaha summer steelhead enter the Columbia River in June and July (Howell et al. 1985) and begin entering the Imnaha River in August, with the majority entering in September and October (Carmichael and Boyce 1987).

Coded-wire-tagged Imnaha hatchery steelhead are caught in Columbia River fisheries above Bonneville Dam in August, September, February, and March. Imnaha hatchery steelhead are also caught in the Deschutes River (a Columbia River tributary in The Dalles pool) from August to March.

Timing of the summer steelhead run to the Little Sheep Creek facility is shown in Appendix Table C-6. The wild stock reaches the trapping site from early April to mid-May, whereas the hatchery stock reaches the trapping site from late March to late May.

Time Of Spawning

Summer steelhead spawn from late April to early June in the Imnaha subbasin (Carmichael and Boyce 1987). Hatchery and wild steelhead are spawned in April and May at the Little Sheep Creek facility (Appendix Table C-7).

Appendix Table C-4. Sport harvest of summer steelhead in the Imnaha River, 1959-90, (Carmichael and Boyce 1987; Carmichael et al. 1986, 1987, 1988).

Year	Harvest[a]
1959	1,334
1960	1,018
1961	995
1962	928
1963	704
1964	354
1965	937
1966	784
1967	1,066
1968	1,282
1969	667
1970	473
1971	638
1972	609
1973	280
1977	48
1986[b]	18
1987[c]	0
1988[d]	4
1989[d]	13
1990[d]	37

a Harvest estimated from angler salmon-steelhead tags, 1959-77. Harvest estimated from statistical creel surveys, 1986-90.
b October and November 1985, and March 1986.
c October and November 1986, and March 1987.
d 1 March to 15 April.

Appendix Table C-5. Total catch, escapement, and survival of coded-wire-tagged summer steelhead released in the Imnaha River subbasin, 1985-86 broods.

Brood year, tag code	Catch distribution				
	Columbia R.		Deschutes River	Snake River	Imnaha River
	Net	Sport			
1985:					
07 37 60	100	15	2	5	6
07 37 61	49	13	5	16	3
1986[a]:					
07 41 22r1	3	0	0	0	4
07 41 22r2	13	0	0	5	0

Brood year, tag code	Hatchery escapement	Hatchery return rate (%)	Survival rate (%)
1985:			
07 37 60	110	0.41	0.88
07 37 61	117	0.43	0.75
1986[a]:			
07 41 22r1	3	0.01	0.04
07 41 22r2	8	0.03	0.11

a Includes only age-3 returns.

Appendix Table C-6. Cumulative percent of summer steelhead run trapped at the Little Sheep Creek facility by week of the year, 1984-89.

Week	1984 wild	1985 wild	1985 hatchery	1986 wild	1986 hatchery
9				--	
10					
11				--	
12	--	--	--	--	
13	15.3	0	0	--	--
14	31.9	8.3	7.1	0	0
15	69.4	30.8	47.6	6.1	4.3
16	76.4	46.7	59.5	28.6	39.1
17	100.0	63.9	71.4	40.8	39.1
18	--	87.6	92.9	67.3	69.6
19	--	91.7	97.6	75.5	73.9
20	--	100.0	100.0	98.0	100.0
21	--	100.0	100.0	100.0	100.0
22	--	--	--	100.0	100.0

Week	198/ wild	198/ hatchery	1988 wild	1988 hatchery	1989 wild	1989 hatchery
9	--	--	0	0.1	--	--
10	--	--	0	0.8	--	--
11	--	--	0	0.9	0	0.3
12	0	0	0	2.3	0	1.7
13	0.9	2.1	0	4.1	3.0	4.4
14	39.1	25.0	0	12.3	7.6	11.5
15	49.1	44.7	1.7	57.5	33.3	42.0
16	70.0	67.0	47.5	82.3	71.2	80.7
17	97.3	95.8	84.7	89.7	81.8	90.8
18	99.1	100.0	100.0	90.7	86.4	94.9
19	100.0	100.0	100.0	96.9	93.9	98.0
20	--	--	100.0	99.7	100.0	99.0
21	--	--	100.0	100.0	100.0	100.0

Appendix Table C-7. Cumulative percent of summer steelhead spawned at the Little Sheep Creek facility by week of the year, 1986-89.

Week	1986 wild	1986 hatchery	1987 wild	1987 hatchery
13		--	0	0
14	--	--	0	0
15	0	0	0	0
16	0	0	36.4	57.0
17	12.5	10.0	63.6	86.8
18	21.9	20.0	72.7	96.0
19	43.8	50.0	100.0	100.0
20	56.3	80.0	--	
21	56.3	80.0'		--
22	93.8	100.0	--	--
23	93.8	--	--	--
24	100.0	--	--	

Week	1988 wild	1988 hatchery	1989 wild	1989 hatchery
13	--	--	--	--
14	0	0		--
15	28.6	17.1	-5.0	21.1
16	71.4	44.5	25.0	49.5
17	85.7	73.2	50.0	75.2
18	85.7	86.0	70.0	87.2
19	100.0	92.7	90.0	96.3
20	--	100.0	100.0	100.0

Spawning Areas

Steelhead spawn throughout the Imnaha River and tributaries with accessible suitable habitat.

In addition to adults collected for broodstock for the hatchery program, hatchery and wild fish are passed above the Little Sheep Creek facility to spawn for supplementation of natural production in Little Sheep Creek (Appendix Table C-3). In 1988, 60 adult hatchery steelhead returning to the Little Sheep Creek facility were outplanted in Gumboot Creek to supplement natural production.

Age Composition

Age composition of wild and hatchery steelhead by return year and brood year trapped at the Little Sheep Creek facility is shown in Tables C-8 and C-9, respectively. One-salts tend to be more prevalent than 2-salts among wild and hatchery steelhead at the Little Sheep Creek facility.

Size At Return

Mean lengths of wild summer steelhead captured at the Little Sheep Creek facility are shown in Appendix Table C-10. Males tend to be larger than females of the same ocean-age. Mean lengths of l-salt males and females were 592 mm and 582 mm, respectively. Mean lengths of 2-salt males and females were 698 mm and 684 mm, respectively.

Mean lengths of hatchery summer steelhead captured at the Little Sheep Creek facility are shown in Appendix Table C-11. Males tend to be larger than females of the same ocean-age. Mean lengths of l-salt males and females were 594 mm and 579 mm, respectively. Mean lengths of 2-salt males and females were 727 mm and 689 mm, respectively.

Sex Ratio

The sex composition of adult steelhead trapped at the Little Sheep Creek facility is shown in Appendix Table C-11. Females are more prevalent than males. Information is needed on the age-specific sex composition.

Fecundity

Fecundity of steelhead spawned at the Little Sheep Creek facility is shown in Tables C-12 and C-13. More information is needed on the age-specific fecundity of the hatchery and wild stocks.

The relationship of fecundity and fork length (mm) for wild steelhead in 1990 is:

$$FECUNDITY = -2465.18 + 11.57\ LENGTH;\ r^2=0.57,\ N=22.$$

The relationship of fecundity and fork length (mm) for hatchery steelhead in 1990 is:

$$FECUNDITY = -3999.00\ t\ 14.69\ LENGTH;\ r^2=0.51,\ N=41.$$

Appendix Table C-8. Percent age composition by return year of adult summer steelhead trapped at the Little Sheep Creek facility, 1983-89. Age is e expressed as years spent in fresh water prior to migration: years spent in ocean prior to spawning migration.

Origin,		1-salt			2-salt		
Year	N	1:1	2:1	3:1	1:2	2:2	3:2
Wild:							
1983	25	0	68.0	0	0	32.0	0
1984	53	0	96.2	0	1.9	1.9	0
1985	74	0	47.3	2.7	4.0	44.6	1.4
1986	47	0	78.7	0	0	21.3	0
1987	19	15.8	73.7	0	5.3	5.3	0
1988	14	0	57.1	0	7.1	35.7	0
1989	29	0	55.2	0	0	44.8	0
Mean		2.3	68.0	0.4	2.6	26.5	0.2
Hatchery:							
1985	27	100.0	0	0	0	0	0
1986	16	87.5	0	0	12.5	0	0
1987	294	99.7	0.3	0	0	0	0
1988[a]	808	85.3	0.7	0	13.3	0	0
1989	306	14.7	0	0	85.3	0	0
Mean		77.4	0.2	0	22.2	0	0

a Six stray hatchery fish of age 1:3 accounted for 0.7%.

Appendix Table C-9. Percent age composition by brood year of adult summer steelhead trapped at the Little Sheep Creek facility, 1981-85 broods.

Origin, brood year	N	Ocean age 1-salt	Ocean age 2-salt
Wild:			
1981	48	72.9	27.1
1982	38	97.4	2.6
1983	20	70.0	30.0
1984	25	44.0	56.0
	Mean	71.1	28.9
Hatchery:			
1982	29	93.1	6.9
1983	15	100	0
1984	406	73.6	26.4
1985	950	72.5	27.5
	Mean	84.8	15.2

Appendix Table C-10. Mean fork length (mm) by age group for wild and hatchery adult summer steelhead that returned to Little Sheep Creek Facility, 1983-1990. Standard deviation is shown in parentheses.

Age group	1983 Wild male N	length	1983 Wild female N	length	1984 Wild male N	length	1984 Wild female N	length
1.2	0		0	--	0			729
2.1	5	596 (20)	12	576 (25)	14	580 (23)	3:	578 (25)
2.2	0	--	8	681 (29)	0	--	1	692

Age group	1985 Wild male N	length	1985 Wild female N	length	1985 Hatchery male N	length	1985 Hatchery female N	length
1.1	0	--	0		7	598 (33)	20	570 (16)
1.2	0	--	3	667 (9)	0	--	0	--
2.1	4	600 (31)	31	587 (24)	0	--	0	--
2.2	0	--	33	687 (29)	0	--	0	--
3.1	0	--	2	570 (33)	0	--	0	--
3.2	0	--	1	655	0	--	0	--

Age group	1986 Wild male N	length	1986 Wild female N	length	1986 Hatchery male N	length	1986 Hatchery female N	length
1.1	0	--	0	--	6	575 (20)	8	598 (51)
1.2	0	--	0	--	0	--	1	610
2.1	9	578 (18)	28	588 (21)	0	--	0	--
2.2	1	641	9	678 (41)	0	--	0	--

Age group	1987 Wild male N	length	1987 Wild female N	length	1987 Hatchery male N	length	1987 Hatchery female N	length
1.1	1	590	2	579 (4)	115	593 (26)	147	580 (25)
1.2	0	--	1	692	0	--	0	--
2.1	8	590 (24)	6	585 (28)	1	575	0	--
2.2	0	--	1	644	0	--	0	--

Appendix Table C-10. Continued.

Age group	1988											
	Wild						Hatchery					
	male			female			male			female		
	N	length		N	length		N	length		N	length	
1.1	0	--										
1.2	0	--		0 1	711 --		140 8	595 729	(27)	163 41	577	(22)
1.3	0	--		0	--		0	--	(37)		689	(37)
										3	706	(16)
2.1	5	618	(29)	3	570	(20)	1	593		2	607	(67)
2.2	1	692		4	713	(17)	0	--		0	--	

Age group	1989											
	Wild						Hatchery					
	male			female			male			female		
	N	length		N	length		N	length		N	length	
1.1	0	--		0	--		9	585	(24)	10	577	(18)
1.2	0	--		0	--		29	727	(34)	104	689	(30)
2.1	6	616	(25)	10	570	(27)	0	--		0	--	
2.2	2	742	(53)	11	672	(23)	0	--		0.	--	

Age group	1990											
	Wild						Hatchery					
	male			female			male			female		
	N	length		N	length		N	length		N	length	
1.1	0	--		0	--		141	590	(24)	133	583	(25)
1.2	0	--		0	--		7	725	(56)	12	684	(27)
2.1	11	571	(23)	11	567	(24)	8	637	(26)	16	615	(28)
2.2	2	711	(23)	11	688	(20)	0	--		0	--	
3.1	0	--		2	562	(9)	0	--		0	--	

Appendix Table C-11. Percent sex composition of summer steelhead trapped at the Little Sheep Creek facility, 1987-90.

Year	Wild fish		Hatchery fish	
	Male	Female	Male	Female
1987	45.5	54.5	41.1	58.9
1988	44.7	55.3	45.3	54.7
1989	33.9	66.1	23.2	76.8
1990	35.1	64.9	49.4	50.6
Mean	39.8	60.2	39.8	60.3

Appendix Table C-12. Fecundity of summer steelhead spawned at the Little Sheep Creek facility, 1984-89, hatchery and wild fish and all ages combined.

Year	Fecundity
1984	5,281
1985	4,530
1986	4,565
1987	4,291
1988	4,836
1989	5,876

Appendix Table C-13. Fecundity of summer steelhead spawned at the Little Sheep Creek facility by origin and ocean age, 1989 and 1990. Standard deviation is shown in parentheses.

Year, origin	l-salt		2-salt	
	N	Fecundity	N	Fecundity
1989:				
Wild	3	3,248 (700)	4	4,932 (532)
Hatchery	8	4,086 (836)	14	6,089(1,313)
1990:				
Wild	12	4,258 (879)	11	5,470 (784)
Hatchery	31	4,610 (709)	9	5,880(1,149)

Hatchery Broodstock

The number of wild and hatchery stock females spawned each year at the Little Sheep Creek facility is shown in Appendix Table C-2. Wild steelhead continue to be used in the broodstock to maintain similar genotypic variation and life history characteristics between the wild and hatchery stocks.

The prespawning mortality of steelhead held at the Little Sheep Creek facility is shown in Appendix Table C-14. The prespawning mortality has decreased in recent years after the permanent facilities at Little Sheep Creek were completed.

Juvenile Life History

Time Of Emergence

No specific information on time of emergence of wild fish is available.

Age-0 steelhead first appeared in diversion traps in Big Sheep Creek in June and were also captured in July (Gaumer 1968). Age-0 steelhead first appeared in traps in the Imnaha River above Big Sheep Creek and above Freezeout Creek in July (Gaumer 1968).

Hatchery incubation temperature is controlled so that eggs begin hatching in late May and all fish are ponded in late June.

Rearing Areas

Juvenile steelhead rear in tributaries and the mainstem. Electrofishing indicated that age-0 steelhead were rearing throughout the tributaries in fall, winter, and spring. Sampling in summer (June) indicated that most steelhead had left the tributaries. Steelhead up to age-2 were found in each stream sampled (Gaumer 1968). Juveniles of three age classes were captured by electrofishing in tributaries (Camp, Grouse, Lick, and Little Sheep creeks) in September 1990, indicating that tributaries are used year-round for rearing.

The amount of available rearing area in the mainstem and tributaries is shown in Appendix Table C-15.

Appendix Table C-14. Prespawning mortality (%) of adult summer steelhead held for broodstock at the Little Sheep Creek facility, 1985-89.

Brood year	Wild fish		Hatchery fish	
	Males	Females	Males	Females
1985	60.0[a]	24.5	80.8[a]	26.9
1986	35.7	5.7	57.1	37.5
1987	12.5	4.8	10.7	5.8
1988	0	0	9.2	8.4
1989	44.4	0	37.5	14.3

a Includes prespawning mortality and mortality of spawned males held for repeat spawning.

Appendix Table C-15. Rearing area and smolt production potential of summer steelhead in the Imnaha River subbasin (Carmichael and Boyce 1987).

Stream section	Rearing area (m^2)[a]	Smolt production potential[b]
Mainstem Imnaha River	2,060,532	51,513
Big Sheep Creek and tribs	708,266	46,037
Little Sheep Creek and tribs	218,944	14,231
Cow Creek	85,332	5,547
-Lightning Creek and tribs	128,287	8,339
Horse Creek and tribs	,97,708	6,351
Freezeout Creek	39,284	2,553
Grouse Creek and tribs	181,583	11,803
Summit Creek	20,037	1,302
Crazyman Creek	32,681	2,124
Mahogany Creek	8,624	561
Gumboot Creek and tribs	58,607	3,809
Dry Creek and tribs	23,260	1,512
Skookum Creek	7,961	517
Totals	3,671,106	156,199

a Total stream area.
b Assuming 0.03 smolts/m^2 for the main stem Imnaha and 0.078 smolts/m^2 for tributaries.

Time Of Migration

Good information on timing of juvenile steelhead migration is lacking. The best available information is presented in Gaumer (1968). Variations in trapping efficiency, low numbers of steelhead caught, and trap malfunctions weaken the migration timing information of Gaumer (1968). Trapping efficiency ranged from 0% to 21%, with means of 3-4% for the Imnaha River traps, and 1% for the Big Sheep Creek facility.

Catch of juvenile steelhead at diversion traps in the upper Imnaha River near Freezeout Creek was highest in August-September (Gaumer 1968). Catch at a trap in the lower Imnaha River near Horse Creek was highest in August-November. A trap in the Imnaha River upstream from Big Sheep Creek captured juvenile steelhead throughout the year, but did not show any distinct peak. Steelhead catch at a trap in lower Big Sheep Creek was highest in October 1964-January 1965, but this pattern did not repeat the following year (Gaumer 1968).

Only 1,297 steelhead were trapped in 14 months (July 1965-September 1966) at the upper Imnaha River trap; 1,277 steelhead were trapped in 23 months (September 1964-August 1966) at the Big Sheep Creek facility; and 764 steelhead were trapped in nine months (September 1966-May 1967) at the lower Imnaha River trap near Horse Creek.

Four Imnaha River steelhead marked in 1965 and 1966 were recovered at Ice Harbor and McNary dams in May following tagging (Gaumer 1968). The downstream-migrant fish collection facilities were. only operated during spring.

Size And Age At Migration

Multiple age classes of steelhead were caught throughout the year at each diversion trap in the Imnaha River and in Big Sheep Creek (Gaumer 1968).

Spring migrants consisted primarily of age-l+ and age-2t steelhead; few age-3t steelhead were caught (Gaumer 1968). Age-l+ and age-2t migrants had modal lengths of 9.5 cm in June and 14.5 cm in May, respectively. Age-2t steelhead captured at the diversion trap near Horse Creek in May had a modal length of 16.0 cm (Gaumer 1968).

Steelhead migrants captured in Big Sheep Creek had modal lengths of 5.0 cm in June (age Ot), 9.5 cm in June (age lt), 12.5 cm in October (age l+), and 14.5 cm in May (age 2t). Steelhead migrants captured in the Imnaha River near Freezeout Creek had modal lengths of 4.0 cm in September (age Ot) and 8.0 cm in July (age l+). Steelhead migrants captured in the Imnaha River near Big Sheep Creek had modal lengths of 3.5 cm in July (age Ot) and 6.5 cm in April (age l+).

Scale analysis of adult wild steelhead returning to the Little Sheep Creek facility, 1983-89, showed that most steelhead entered the ocean at age 2+, and a few fish entered at aqe l+ and age 3t Appendix Table C-8; Carmichael and Messmer 1985: Carmichael et-al. 1986; 1987; and unpublished data).

Number, Time, Size, and Age at Release of Hatchery Smolts

The LSRCP annual steelhead smolt production goal for the Imnaha subbasin is 330,000 smolts. This goal was attained for the first time with the release of the 1987 brood smolts in 1988. The target size for the smolts is 5 fish/lb.

Hatchery summer steelhead smolts released in the Imnaha subbasin are shown in Appendix Table C-16. Smolts are released at age 1 in April or May depending on the passage conditions in the Snake River.

Hatchery smolts marked Ad-LVtCWT released in the Imnaha subbasin are shown in Appendix Table C-17.

Survival Rates

No information is available for the following survival rates of the wild stock: egg-to-fry, fry-to-smolt, smolt from rearing areas to Lower Granite Dam, and smolt-to-adult.

Survival rates of summer steelhead at several life stages in the hatchery are shown in Appendix Table C-18.

The recovery rate of cold-branded steelhead at Lower Granite Dam is an . indication of survival from release to Lower Granite Dam. Tables C-19 and C-20 show the release and recovery information for cold-branded hatchery steelhead. In "good" water years, smolts begin to arrive at Lower Granite Dam about two weeks after release; survival ranges from 2% to 12%. In "poor" water years, smolts do not begin to reach Lower Granite Dam until four weeks after release; survival is less than 1%.

Smolt Abundance And Capacity

No information is available for actual steelhead smolt abundance in the Imnaha subbasin.

Smolt production capacity in the Imnaha subbasin is estimated to be 156,200 smolts (Appendix Table C-15), based on available rearing area, observed densities of yearling steelhead in the Warm Springs River (0.05 yearling steelhead/m^2) and eastern Oregon tributaries (0.13 yearling steelhead/m^2), and rate of 60% for yearling-to-smolt survival (Carmichael and Boyce 1987).

Appendix Table C-16. Releases of hatchery summer steelhead in the Imnaha River subbasin, 1982-88 broods. Standard deviation is shown in parentheses. (LSC = Little Sheep Creek facility, Imnaha = Imnaha River at RM 23).

Brood year, date released	Number released	Size (fish/lb)	Location of release	N[a]	Mean fork length (mm)
1982:					
05/02-05/83	46,803	5.0-7.4	LSC	--	--
05/05/83	16,428	5.6	LSC	--	
1983 :					
04/23/84	22,819	4.7	LSC	--	188
04/30-05/02/84	35,786	7.8-10.2	LSC	--	176
1984:					
04/10/85	25,296	5.1	LSC	--	
04/29-30/85	30,005	7.9-10.0	LSC	201	162 (0.1)
04/30-05/01/85	23,924	4.9-5.0	LSC	202	203 (2.4)
1985:					
04/25-29/86	55,481	4.4-5.3	LSC	400	207 (4.0)
04/25-29/86	55,252	5.6-6.5	LSC	600	192 (5.1)
04/29/86	4,702	11.2	LSC	200	151 (3.2)
1986:					
05/01-05/87	82,916	4.6-5.0	LSC	287	205 (3.5)
05/05/87	10,800	8.0	LSC	260	172 (2.7)
1987:					
04/21-22/88	26,091	4.3	LSC	--	--
04/22-28/88	58,412	5.9	LSC	258	195(18.3)
04/13/88	246,944	5.3	LSC	300	202(19.1)
1988:					
04/24/89	249,456	5.3	LSC	441	201(18.4)
05/01-03/89	72,367	5.5	Imnaha	447	197(19.3)

a Samples are composed of replicate groups of approximately 100 fish.

Appendix Table C-17. Release information for, hatchery summer steelhead marked Ad-LVtCWT and
Imnaha River subbasin, 1985-88 broods. Standard deviation is shown in parentheses.

Brood year, location of release	Tag code replicates	Date released	Number released	N[a]	Mean weight (g)	M e a fork length (mm)
1985:						
Little Sheep Creek	07 37 60	04/25-30/86	27,128	300	82.5	197 (3.4)
	07 37 61		27,162			
1986:						
Little Sheep Creek	07 41 22[b]	05/01-OS/87	47,836	547	89.9 (3.7)	201 (3.4)
1987:						
Little Sheep Creek	07 40 33	04/14/88	27,329	300	87.6 (17.8)	.202 (19.1)
	07 40 34		27,545			
1988:						
Little Sheep Creek	07 46 56	04/21-24/89	27,461	441	94.8 (29.0)	201 (18.4)
	07 46 57		27,235			

[a] Samples are composed of replicate groups of approximately 100 fish.
[b] Tag code composed of equal numbers of Rl and R2 replicates.

Appendix Table C-18. Egg-take and survival of summer steelhead spawned at the Little Sheep Creek facility, 1984-89.

Brood year	Eggs collected	Egg loss (%)	Egg-to-fry survival (%)	Egg-to-smolt survival (%)
1984	179,550	32.6	63.5	44.1
1985	425,844	39.0	56.0	49.1
1986	191,721	29.4	68.3	60.2
1987	695,000	35.4	58.9	52.6
1988	827,000	33.8	60.0	48.4
1989	758,000	28.8	68.3	

Appendix Table C-19. Release information for hatchery summer steelhead cold branded and re
Imnaha River subbasin, 1985-88 broods. Standard deviation is shown in parentheses.

Brood year, location of release	Brand	Date released	Number released	N[a]	Mean weight (g)	Mean fork length (mm)
1985:						
Little Sheep Creek	RA J 2	04/25-30/86	13,240	300	82.5	197 (3.4)
	RA J 4		13,217			
1986:						
Little Sheep Creek	RD J 4	05/01-05/87	15,660	547	89.9 (3.7)	201 (3.4)
	LD J 4		15,642			
1987:						
Little Sheep Creek	LA IM 2	04/14/88	24,026	119	82.0 (22.0)	198 (16.9)
	LA IF' 2		26,023	92	84.6 (28.7)	200 (20.3)
1988:						
Little Sheep Creek	RD J 1	04/21-24/89	26,209	441	94.8 (29.0)	201 (18.4)
	LD J 1		26,637			

a Samples are composed of replicate groups of approximately 100 fish.

Appendix Table C-20. Recovery information for cold-branded hatchery summer steelhead releas River subbasin and recaptured at Lower Granite Dam, 1985-87 broods. Number of observed rec in parentheses.

Brood year, brand	Estimated number recovered	Percent of number released	Cumulative percent recovered bv Julian week 17	18	19	20	21	22	23	24	25
1985:											
RA J 2	922(5)	7.0	0	0	5.9	13.0	29.5	61.5	93.8	98.8	98.
RA J 4	1,626(84)	12.3	0	0	11.0	18.1	46.4	83.8	95.8	95.8	99.
1986:											
RD J 4	0	0									
LD J 4	36(3)	0.2	0	0	0	0	0	30.6	30.6	69.4	69.
1987:											
LA IM 2	440(14)	1.8	21.1	25.9	39.6	39.6	67.7	89.1	94.6	97.5	100
LA IF 2	1,032(37)	4.0	8.2	16.1	21.9	25.6	40.4	76.9	90.1	93.6	96.

Genetic Characteristics

Genetic characteristics of Imnaha wild and hatchery summer steelhead,are shown in Appendix Table C-21.

Morphological and Meristic Characteristics

Meristic characteristics of Imnaha steelhead are shown in Appendix Table C-22 and morphological characteristics are shown in Appendix Table C-23.

Disease History

Infectious hematopoietic necrosis virus (IHNV) was detected in adult summer steelhead spawned at the Little Sheep Creek facility in 1985 and 1987-89. IHNV was detected in less than 1% of the adults sampled. Ceratomyxa shasta, the causative agent of ceratomyxosis, was detected in adult prespawning mortalities at the Little Sheep Creek facility.

Costia, a gill parasite, was found on 1989 brood year juvenile steelhead rearing at Irrigon Hatchery.

Myxobolus cerebralis, the causative agent of whirling disease, has not been found in Imnaha summer steelhead.

Appendix Table C-21. Isozyme gene frequencies and sample sizes (N) as determined by electrophoresis for wild (w) and hatchery (h) Imnaha River steelhead. Numbers at the top of each column are the relative mobilities for each allele present in the enzyme system. Minus signs indicate cathodat migration. An asterisk indicates that an allele was present at a frequency of less than 0.005 (Schreck et al. 1986).

Year sampled, origin	ACONITATE HYDRATASE				ALCOHOL DEHYDROGENASE			
	N	100	83	66	N	-100	-76	-82
1983 (w)	89	.78	.21	.01	96	1.00		
1984 (w)	57	.83	.16	.01	58	1.00		
1984 (h)	100	.79	.21	*	100	1.00		

Year sampled, origin	CREATINE KINASE			GLUCOSE PHOSPHATE ISOMERASE-1				GLUCOSE PHOSPHATE ISOMERASE-2		
	N	100	70	N	100	130	25	N	100	120
1983 (w)	81	1.00		96	1.00			96	1.00	
1984 (w)	58	1.00		58	1.00			58	1.00	
1984 (h)	100	1.00		100	.90	.10		100	1.00	

Year sampled, origin	GLUCOSE PHOSPHATE ISOMERASE-3				ASPARTATE AMINO-TRANSFERASE-1,2			ASPARTATE AMINO-TRANSFERASE-3		
	N	100	120	92	N	100	112	N	100	77
1983 (w)	96	1.00			86	1.00		96	1.00	
1984 (w)	58	1.00			58	1.00		58	1.00	
1984 (h)	100	1.00			100	1.00		83	1.00	

Appendix Table C-21. Continued.

Year sampled, origin	ISOCITRATE DEHYDROGENASE-3,4 N	100	40	120	71	LACTATE DEHYDROGENASE-4 N	100	76	111
1983 (w)	96	.70	.14		.16	96	.29	.71	
1984 (w)	57	.72	.13		.15	58	.28	.72	
1984 (h)	87	.74	.08	*	.18	99	.39	.61	

Y	e				a				r
sampled, origin	DEHYDROGENASE-1.2 N	100	140	70	40	DEHYDROGENASE-3,4 N	100	83	110	90
1983 (w)	96	1.00				96	1.00			
1984 (w)	58	1.00				58	1.00			
1984 (h)	50	1.00				100	1.00			

Year sampled, origin	NADP+ MALATE DEHYDROGENASE N	100	85	MANNOSE PHOSPHATE ISOMERASE N	100	94	110	L-IDITOL DEHYDROGENASE N	100	195
1983 (w)	94	1.00		96	.98	.01	.01	96	1.00	
1984 (w)	58	1.00		58	1.00			58	1.00	
1984 (h)	100	1.00		100	1.00			100	1.00	

Appendix Table C-21. Continued.

Year sampled, origin	DIPEPTIDASE					TRIPEPTIDE AMINOPEPTIDASE				
	N	100	110	85	95	-N	100	129	74	50
1983 (w)	100	.97	.03			100	1.00			
1984 (w)	58	.94	.06			58	1.00			
1984 (h)	100	.99	.0l			100	1.00			

Year sampled, origin	PHOSPHO-GLUCOMUTASE-1				PHOSPHO-GLUCOMUTASE-2		
	N	-100	-115	-85	N	-100	-140
1983 (w)	96	1.00			87	1.00	
1984 (w)	58	1.00			58	1.00	
1984 (h)	100	1.00			100	1.00	

Year sampled, origin	SUPEROXIDE DISMUTASE				GLYCEROL-3-PHOSPHATE DEHYDROGENASE		
	N	100	152	48	N	100	140
1983 (w)	86	.95	.04	.0l	--		
1984 (w)	58	.90	.02	.09	55	1.00	
1984 (h)	89	.91	.03	.06	100	1.00	

Appendix Table C-22. Meristic character means (standard deviations in parentheses) of wild (w) and hatchery (h) Imnaha River steelhead (Schreck et al. 1986).

Year sampled, origin	Scales in lateral series	Scale rows	Anal fin rays	Dorsal fin rays
1983 (w)	150.55 (5.86)	30.84 (1.89)	11.55 (0.51)	11.65 (0.67)
1984 (w)	148.11 (7.65)	30.25 (1.52)	11.45 (0.51)	11.75 (0.55)
1984 (h)	148.21 (6.18)	28.89 (1.24)	11.47 (0.61)	11.62 (0.51)

Year sampled, origin	Pelvic fin rays	Pectoral fin rays	Gill rakers	Left branchi-ostegals	Vertebrae
1983 (w)	9.85 (0.37)	14.45 (0.51)	7.70 (0.66)	11.70 (0.66)	64.25 (0.72)
1984 (w)	9.85 (0.37)	14.25 (0.44)	7.15 (0.37)	11.55 (0.83)	64.25 (0.72)
1984 (h)	10.00 (0.33)	14.26 (0.81)	7.28 (0.67)	11.58 (0.77)	64.47 (0.61)

Appendix Table C-23. Body shape character means (standard deviations in parentheses) of wild (w) and hatchery (h) Imnaha River steelhead (Schreck et al. 1986).

Year sampled, origin	Head width	Head length	Head depth	Inter-orbital width	Depth caudal peduncle
1983 (w)	9.797 (0.42)	23.805 (1.20)	17.035 (0.75)	5.973 (0.28)	9.138 (0.50)
1984 (w)	9.917 (0.28)	23.361 (0.70)	17.488 (0.58)	6.085 (0.24)	9.393 (0.52)
1984 (h)	9.708 (0.33)	21.518 (1.05)	17.517 (0.59)	5.592 (0.24)	9.339 (0.39)

Year sampled, origin	Pectoral fin	Pelvic fin	Maxillary length	Anal fin height	Anal fin base
1983 (w)	16.565 (1.06)	13.755 (0.54)	11.159 (0.86)	11.484 (0.75)	9.299 (0.68)
1984 (w)	16.891 (0.94)	13.738 (0.60)	10.944 (0.60)	11.465 (0.51)	9.697 (0.40)
1984 (h)	13.886 (0.63)	12.841 (0.59)	9.904 (0.71)	9.828 (0.58)	9.289 (0.54)

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APPENDIX D

Summary Of Life History And Genetic Information For Grande Ronde River Summer Steelhead

Introduction

This appendix is a compilation of life history and genetic information currently available for Grande Ronde River summer steelhead. This information will be used to guide the development of the Grande Ronde River steelhead supplementation project.

Production

Wild and hatchery stocks of summer steelhead occur in the Grande Ronde River system. Wild summer steelhead are found throughout the Grande Ronde drainage in all available suitable habitat. Hatchery steelhead smolts are released at Wallowa Hatchery, Big Canyon facility, in the lower upper Grande Ronde River, Catherine Creek and the upper Wallowa River.

The Grande Ronde River steelhead broodstock development program began in 1976 under the Lower Snake River Compensation Plan (LSRCP). The objective of the program is to restore and enhance sport and tribal fisheries. Outplanting of summer steelhead smolts has been in areas to maximize contributions to sport fisheries. Outplanting to supplement natural production has been limited because of high escapement levels of natural fish and concerns for genetic and competitive interactions with wild populations.

The annual hatchery smolt production goal for the Grande Ronde River subbasin is 1,400,000 smolts.

Adults are trapped at Wallowa Hatchery and Big Canyon facility and spawned at Wallowa Hatchery. Eggs are incubated to the eyed stage at Wallowa Hatchery. Eyed eggs are transferred to Irrigon Hatchery for final incubation and rearing to smolt stage. Smolts are transported to Wallowa Hatchery and Big Canyon facility for a two-to four-week acclimation period in advanced-rearing ponds and then released. Smolts released in the Grande Ronde subbasin at locations other than Wallowa Hatchery and Big Canyon facility advanced-rearing ponds are transported from Irrigon Hatchery and released directly into the stream.

Origin

Summer steelhead are indigenous to the Grande Ronde River system. The Wallowa hatchery stock was developed from summer steelhead of unknown origin trapped at Snake River dams from 1976 to 1979, and hatchery fish returning to Wallowa Hatchery from 1980 to the present. The extent of straying of non-native steelhead into the Grande Ronde River system is not known, but is believed to be minimal.

The Minam and Wenaha rivers and Joseph Creek are currently managed as wild stock streams.

Adult Life History

Run Size, Harvest, and Escapement

Historical run sizes of Grande Ronde River summer steelhead are unknown. The run size in 1963, prior to construction of the four lower Snake River dams, was estimated to be 15,900 adults (USACE 1975). The run size in the early 1970s was estimated to be 10,600 adults (ODFW 1975). In the mid-1980s, the run size was estimated to be 4,000 adults (Carmichael and Boyce 1987).

Steelhead redds have been counted annually in Grande Ronde River tributaries since 1964 (Appendix Table D-l). Redd counts ranged from 2.7 to 8.8 redds/mile prior to 1974 with high counts in 1966 and 1967 of 8.8 and 8.7 redds/mile, respectively. Redd counts did not exceed 2.5 redds/mile from 1974 to 1984. Redd counts in 1985 and 1986 were above 8 redds/mile, which may indicate rebuilding due to the hatchery program and subsequent straying, Columbia River passage improvements and harvest restrictions.

Counts of summer steelhead trapped at the Big Canyon facility and Wallowa Hatchery since 1980 are shown in Appendix Table D-2. The hatchery run increased from 1980 to 1988 as the hatchery proqram became established. River flow conditions in the Wallowa, Grande Ronbe; Snake and Columbia rivers play a large part in determining survival of smolts and thereby influence the resulting run size.

Sport harvest of summer steelhead in Oregon's portion of the Grande Ronde subbasin declined from 2,204 fish in 1959 to 403 fish in 1973 (Appendix Table D-3). The steelhead sport fishery was closed from 1974 to 1986, with the exception of a catch and release fishery in 15 miles of the mainstem near Troy in 1983. The sport fishery was reopened to the harvest of hatchery fish in 1986 (Appendix Table D-4) through the success of the LSRCP hatchery program.

Appendix Table D-l. Total Grande Ronde River basin summer steelhead redd counts, 1964-92 (Carmichael 1989, and ODFW Fish District Annual Reports).

Year	Miles surveyed	Redds	Redds/mile
1964	113	331	2.9
1965	175	636	3.6
1966	247	2,168	8.8
1967	161	1,404	8.7
1968	155	543	3.5
1969	158	610	3.9
1970	151	533	3.5
1971	146	388	2.7
1972	131	490	3.7
1973	148	463	3.1
1974	112	265	2.4
1975	86	147	1.7
1976	84	66	0.8
1977	83	210	2.5
1978	110	173	1.6
1979	109	31	0.3
1980	117	275	2.4
1981	100	183	1.8
1982	89	169	1.9
1983	99	157	1.6
1984	63[a]	138	2.2
1985	91	792	8.7
1986	92	680	7.4
1987	88	666	7.6
1988	87	702	8.1
1989	84.5	417	5.1
1990	82.5	438	5.2
1991	61[a]	89	1.5
1992	80.5	300	3.7

a Wallowa Fish District only.

Appendix Table D-2. Number of adult summer steelhead trapped at the Big Canyon-facility and Wallowa Hatchery, 1980-91 (Carmichael and Messmer 1985, Carmichael et al. 1986-88, Messmer et al. 1989, 1990). Number of females spawned for hatchery broodstock is in parentheses.

	Big Canyon facility[a]						Wallowa Hatchery	
	Wild fish			Hatchery fish			Hatchery fish	
Year	Males	Females		Males	Females		Males	Females
1980	--	--	--	--	--	--	57	85 (85)
1981	--	--	--	--	--	--	52	153 (142)
1982	--	--	--	--	--	--	29	111 (111)
1983	--	--	--	--	--	--		225 (216)
1984	--	--	--	--	--	--	4;:	431 (384)
1985	--	--	--	--	--	--	181	325 (318)
1986	--	--				--	973	987 (812)
1987	1	9	(8)	48	124	(0)	1,763	2,092 (590)
1988	11	16	(0)	'27	31	(0)	697	1,376 (551)
1989	8							605 (400)
1990	18	8 7	(1)(7)	140 111	197(112)		615 467	486 (462)
1991	14	7	(0)	141	266(262)		253	225 (210)

a Big Canyon facility began operation in 1987.

Appendix Table D-3. Estimated Oregon sport harvest of summer steelhead in the Grande Ronde River and major tributaries during 1959-73 calendar years.

Year	Grande Ronde River	Wenaha River	Wallowa River	Minam River	Catherine Creek	Total
1959	1,590	72	260	30	90	2,204
1960	709	85	221	65	59	1,139
1961	838	104	122	90	21	1,175
1962	1,278	68	44	27	27	1,444
1963	1,049	81	200	42	3	1,375
1964	691	9	177	148		1,025
1965	1,574	35	201	81	--	1,891
1966	1,921	60	115	26	13	2,135
1967	1,319	90	453	100		2,028
1968	1,252	18	272	1, 221		1,663
1969	1,319	75	61	38		1,493
1970	1,017	14	233	35	4	1,303
1971	630	99	664	87	4	884
1972	706	23	35	0	0	764
1973	268	4	107	16	8	403

Appendix Table D-4. Estimated Oregon sport harvest of summer steelhead in the Grande Ronde River and major tributaries during 1985-86 to 1990-91 run years (Carmichael et al. 1988-90, Flesher et al. 1991).

Year	Grande Ronde River	Wallowa River	Catherine Creek	Total
1985-86	--	2		2
1986-87	45	641		686
1987-88	31	517		548
1988-89	421	294		715
1989-90	766	840		-1,606
1990-91	18	151		169[c]

a **Low run** *year, emergency fishery closure from 15 November through 15 April.*

Columbia River fisheries catch a significant portion of steelhead destined for Wallowa Hatchery. The Zone 6 fishery caught 45 percent of the marked 1982 brood Wallowa Hatchery steelhead, and the Columbia River sport fishery caught 4 percent of the 1982 brood Wallowa Hatchery stock, based on recoveries of coded-wire tags. There is no data available on exploitation of Grande Ronde wild steelhead stocks in the Columbia River, but it is likely that these fish are also caught in Columbia river sport and Zone 6 fisheries.

The Nez Perce and Umatilla tribes have usual and accustomed fishing sites in the Grande Ronde subbasin. Presently Indian harvest of steelhead in the Grande Ronde subbasin is considered to be minimal.

Time Of Migration

Returning Grande Ronde River adult summer steelhead pass Bonneville Dam during July and pass John Day Dam primarily during August through October. Like most populations in the Snake River basin, Grande Ronde River summer steelhead migrate through the lower Snake River during two periods; a fall movement that peaks mid to late September, and a spring movement that peaks during March and April. Some adult summer steelhead enter the lower Grande Ronde River as early as July but most adults enter from September through March.

Wallowa stock hatchery steelhead was developed from broodstock collected early in the spring in 1976-78 at Ice Harbor or Little Goose dams and may have selected for adults that had migrational patterns different from the Grande Ronde wild steelhead. A majority of the wild and hatchery steelhead destined for areas above Lower Granite Dam pass by the dam from August through December. Carmichael et al. (1990) used radio telemetry to determine migratory patterns of Wallowa stock summer steelhead from Lower Granite Dam to Wallowa Hatchery. Known Wallowa stock steelhead were trapped and radio tagged at Lower Granite Dam from early October to late November 1987. The steelhead tended to hold in the Snake River near the mouth of the Grande Ronde River, and entered the Grande Ronde from November through March. The steelhead that entered the Grande Ronde River early tended to hold in the lower river below the Oregon-Washington state line until mid February to March before moving upstream, whereas the fish that entered after mid February moved steadily upriver without holding in the lower river.

Adults move into smaller tributaries to spawn in the following spring. Hatchery steelhead enter the facilities from early March to mid May with the peak usually in early to mid April (Appendix Table D-5).

Appendix Table D-5. Cumulative percent of summer steelhead run trapped at Wallowa Hatchery by week of the year, 1984-91 (Carmichael and Messmer 1985, Carmichael et al. 1986-88, Messmer et al. 1989, 1990).

Week	1984	1985	1986	1987	1988
9	0.4	--	--	--	--
10	0.7	--	--	0	5.1
11	6.5		0	17 6	18.8
12	25.1	-2.4	7.4	32:0	34.5
13	32.3	20.1	22.1	53.9	45.2
14	41.7	46.7	47.4	83.4	60.8
15	58.8	88.6	65.5	91.2	88.3
16	80.1	92.3	84.3	96.6	96.5
17	86.8	95.8	87.6	98.4	98.7
18	93.6	98.0	93.1	98.4	99.9
19	99.2	100.0	98.9	100.0	99.9
20	100.0	100.0	100.0	100.0	100.0
21	--	--	100.0	--	100.0
22	--	--	100.0	--	--

Week	1989	1990	1991	1992
9		--	0.0	
10	--	2.2	2.3	
11	--	6.0	4.4	
12	2.9	25.6	13.0	
13	34.5	63.4	21.2	
14	73.5	77.3	32.7	
15	88.2	93.6	64.7	
16	95.7	97.3	74.5	
17	97.9	100.0	89.0	
18	99.4	100.0	94.4	
19	100.0	100.0	99.4	
20	100.0		100.0	
21	--	--	--	
22				

Time Of Spawning

Wild steelhead spawn from March through June. Hatchery steelhead spawn soon after returning to the hatchery facilities (Appendix Table D-6).

Appendix Table D-6. Cumulative percent of summer steelhead spawned at Wallowa Hatchery by week of the year, 1986-91 (Carmichael and Messmer 1985, Carmichael et al. 1986-88, Messmer et al. 1989, 1990).

Week	1986	1987	1988	1989	1990
13	1.5		--	--	14.8
14	17.7	40.1	--	--	33.1
15	42.1	67.4	23.9	26.8	69.6
16	60.7	84.7	63.1	68.8	84.4
17	73.6	95.4	95.8	93.8	97.0
18	88.4	95.4	100.0	97.6	99.2
19	98.9	100.0	--	99.3	100.0
20	100.0	--	--	100.0	--

WeeK	1991	1992
12	7.1	
13	18.1	
14	27.6	
15	64.8	
16	79.1	
17	92.4	
18	96.2	
19	99.5	
20	100.0	

Spawning Areas

Hatchery steelhead are spawned at Wallowa Hatchery. Wild steelhead spawn throughout the Grande Ronde subbasin. Principal spawning areas for wild steelhead include middle and upper mainstem tributaries, Joseph Creek, Wenaha River, Wallowa River, Minam River, Deer Creek, Bear Creek, and the Lostine River (Fulton 1970).

Age Composition

Age composition of hatchery steelhead trapped at Wallowa Hatchery by return year is shown in Appendix Table D-7. Hatchery steelhead return primarily as one and two salt fish.

Appendix Table D-7. Percent age composition of adult summer steelhead that returned to Wallowa Hatchery 1981-91 (Carmichael and Messmer 1985, Carmichael et al. 1986-88, Messmer et al. 1989, 1990). Age is expressed as years spent in freshwater prior to ocean migration: years spent in ocean prior to spawning migration.

Return Year	N	Age 1:1	1:2	1:3	2:1	2:2	2:3	3:1	3:2
1981	70	--	4.8	--	81.5	11.0	--	2.7	--
1982	92	4.1	2.0	3.0	34.3	56.6	--	--	--
1983	192	2.1	8.9	2.1	43.5	43.4	--	--	--
1984	577	30.0	0.1	--		6.9	--	0.4	--
1985	496	42.1	44.4	1.6	62.4 4.4	6.7	0.2	0.4	0.2
1986	1535	94.1	4.2	--	1.6	0.1	--	--	--
1987	3855	60.4	38.6	--	0.5	0.5	--	--	--
1988	2073	36.2	62.3	0.1	1.0	0.4	--	--	--
1989	1217	59.8	39.1	--	0.9	0.2	--	--	--
1990	954	53.4	41.4	0.1	4.5	0.5	--	0.1	--
1991	478	44.4	53.1	--	2.1	0.4	--	--	--

Size at Return

Mean lengths of adult steelhead trapped at Wallowa Hatchery and Big Canyon Facility are shown in Appendix Table D-8 and D-9, respectively. Males tend to be larger than females of the same ocean-age.

Appendix Table D-8. Mean fork length (mm) by age group for adult summer steelhead that returned to Wallowa Hatchery, 1981-91 (Carmichael and Messmer 1985, Carmichael et al. 1986-88, Messmer et al. 1989, 1990). Standard deviation is shown in parentheses.

Age	1981				1982			
	male		female		male		female	
group	N	length	N.	length	N	length	N	length
1.1	0	--	0	--	3	578 (39)	1	580
1.2	0	--	4	691 (87)	0	--	2	732 (11)
2.1	12	584 (28)	48	589 (24)	4	672 (33)	25	599 (17)
2.2	0	--	0	--	3	694 (30)	56	696 (77)
3.1	0	--	0	--	0	--	2	634 (20)

Age	1983				1984			
	male		female		male		female	
group	N	length	N	length	N	length	N	length
1.1	2	599 (33)	1:	533	57	592 (29)	82	578 (25)
1.2	3	704 (44)		691 (28)	0	--	0	--
1.3	0	--	6	717 (43)	0	--	1	755
2.1	32	635 (33)	54	611 (27)	96	596 (33)	210	572 (28)
2.2	10	736 (60)	64	723 (38)	5	760 (29)	43	723

Age	1985				1986			
	male		female		male		female	
group	N	length	N	length	N	length	N	length
1.1	116	591 (3)	86	584 (3)	659	624 (28)	781	603 (25)
1.2	30	730 (8)	154	696 (3)	17	688 (41)	51	689 (36)
1.3	1	733	7	749 (10)	0	--	0	--
2.1	6 3	591 (18)	16	610 (7)	7	654 (35)	19	611 (31)
2.2		699 (18)	25	700 (8)	1	690	0	--
2.3	0	--	1	772	0	--	0	--
3.1	2	467 (27)	0	--	0	--	0	--
3.2	0	--	1	666	0	--	0	--

Appendix Table D-8. Continued.

Age group	1987 male N	1987 male length		1987 female N	1987 female length		1988 male -N	1988 male length		1988 female N	1988 female length	
1.2	137	589	(38)	110	577	(28)	238	601	(31)	153	592	(28)
1.3	59 0	743 --	(53)	183 0	[illegible]	(37)	98 0	726 --	(39)	318 2	697 768	(33)
												(18)
2.1							1					
2.2	0 1	652 --		3 1	577 718		1	836 585		0 2	606 690	(48)
						(15)						(64)

Age group	1989 male N	1989 male length		1989 female N	1989 female length		1990 male N	1990 male length		1990 female N	1990 female length	
1.1												
1.2	247 39	593 726	(28)	221 135	693 580	(23)	272 105	595 733	(30)	290 169	585 702	(26)
1.3			(45)			(30)	1	758	(37)	0	--	(29)
2.1	4	618	(57)	1	656		15	649	(46)	24	640	(37)
2.2	1	732		1	725		2	739	(1)	3	726	(50)
3.1	0	--		0	--		0	--		1	576	

Age group	1991 male N	1991 male length		1991 female N	1991 female length		1992 male N	1992 male length	1992 female N	1992 female length
1.1				38						
1.2	173 73	568 723	(27)	179	695 563	(20)				
			(43)			(31)				
2.1	9	585	(31)	1	537					
2.2	1	750		1	684					

Appendix Table D-9. Mean fork length (mm) by age group for adult summer steelhead that returned to Big Canyon Facility, 1989-91 (Messmer et al. 1989, 1990). Standard deviation is shown in parentheses.

	1989							
	Wild				Hatcherv			
Age	male		female		male		female	
group	N	length	N	length	N	length	N	length
1.1	0	--	0	--	30	595 (26)	59	574 (21)
1.2	0	--	0	--	0	--	0	--
2.1	1	645	1	618	0	--	0	--
2.2	0	--	0	--	0	--	0	--

	1990							
	Wild				Hatchery			
Age	male		female		male		female	
group	N	length	N	length	N	length	N	length
1.1	0	--	0	--	42	600 (28)	55	584 (21)
1.2	0	--	0	--	10	747 (43)	2	704 (33)
2.1	7							
2.2	3	596 684 (40) (54)	3 5	619 654 (14) (22)	0 1	609 --	6 0	622 -- (17)
3.1	1	640	0	--	0	--	0	--

	1991							
	Wild				Hatcherv			
Age	male		female		male		female	
group	N	length	N	length	N	length	N	length
1.1	0	--	0	--	81	563 (27)	39	559 (20)
1.2	0	--	0	--	54	740 (36)	223	702 (33)
2.1	14[a]		7[a]		1	627	1	531
2.2					0	--	1	668

a Not measured.

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Fecundity

Estimates of fecundity of wild steelhead are not available. Estimates of mean fecundity of hatchery steelhead spawned at Wallowa hatchery ranged from 5,029 to 5,674 eggs per female (Appendix Table D-10).

Appendix Table D-10. Average fecundity for hatchery steelhead spawned at Wallowa Hatchery, 1986-1991 (Carmichael and Messmer 1985, Carmichael et al. 1986-88, Messmer et al. 1989, 1990).

Year	N	Fecundity
1986	812	5,029
1987	590	5,674
1988	551	5,493
1989	400	5,408
1990	462	5,249
1991	789[a]	5,362

a Includes Wallowa stock steelhead trapped at Washington Department of Wildlife's Cottonwood facility and transported to Wallowa Hatchery for spawning.

Juvenile Life History

Time Of Emergence

No specific information on time of emergence of wild fish is available. Age-0 steelhead were captured in Grande Ronde basin tributaries in late June 1992 when sampling began for residual hatchery steelhead (ODFW unpublished information).

Hatchery incubation temperature is controlled so that eggs begin hatching in late May and all fish are ponded in late June.

Rearing Areas

Juvenile steelhead rear in tributaries and the main stem Grande Ronde River.

Time Of Migration

Information on the time of migration of juvenile wild steelhead is not available.

Size And Age At Migration

Scale analysis of adult wild steelhead returning to Big Canyon facility showed that the steelhead entered the ocean at age 2t.

Number, Time, Size, and Age at Release of Hatchery Smolts

Hatchery steelhead smolts are released in spring as yearlings in the Grande Ronde River basin (Appendix Tables 11 and 12).

Appendix Table D-11. Oregon summer steelhead smolt releases in the Grande Ronde River basin, 1976-1991 (Carmichael 1989, Carmichael and Messmer 1985, Carmichael et al. 1986-88, Messmer et al. 1989, 1990).

Stock Brood Year	Hatchery of Rearing	Number Released	Size (fish/lb.)	Date of Release	Location of Release
Snake River					
1976	Wallowa	79,608	6.2	05/08/78	Spring Creek
1977	Wallowa	20,020	13.0	05/12/78	Spring Creek
1977	Wallowa	75,259	6.8-8.9	04/30/79	Spring Creek
1977	Wallowa	21,095	14.7	05/16/79	Spring Creek
1978	Wallowa	34,900	5.0	04/05/80	Spring Creek
Pahsimeroi					
1979	Wallowa	28,308	10.6	04/21/80	Spring Creek
1979	Wallowa	62,000	5.1-5.3	04/03/81	Spring Creek
Wallowa					
1980	Irrigon	34,418	5.0-6.0	04/03/81	Spring Creek
1980	Wallowa	43,763	5.0-8.0	04/09/82	Spring Creek
1981	Irrigon	76,896	5.0-7.6	04/09/82	Spring Creek
1981	Wallowa	64,950	10.0-10.10	5/10/82	Spring Creek
1981	Cascade	57,250	6.6-6.9	04125183	Big Canyon Creek
1982	Lyons Ferry	75,878	4.7-7.4	05/02/83	Spring Creek
1982	Lyons Ferry	18,600	15.5	05/05/83	Spring Creek
1982	Lyons Ferry	64,591	8.3-10.4	05/04/83	Spring Creek
1982	Wallowa	41,600	8.4	05/06/83	Spring Creek
1983	Wallowa	46,818	7.1-9.0	04/24/84	Spring Creek
1983	Lyons Ferry	443,175	5.0-9.3	04/23/84	Spring Creek
1983	Lyons Ferry	57,100	6.8-9.3	04/27/84	Big Canyon Creek
1984	Irrigon	15,690	6.0	03/01/85	Wallowa Hatchery
1984	Irrigon	346,334	5.9	04/29/85	Wallowa Hatchery
1984	Lyons Ferry	284,021	7.5	04/29/85	Wallowa Hatchery
1984	Lyons Ferry	49,600	7.8-8.8	04/25/85	Big Canyon Creek
1984	Lyons Ferry	46,440	7.8-8.8	04/25/85	Catherine Creek
1985	Irrigon	194,553	4.2	05/05/86	Wallowa Hatchery
1986	Irrigon	535,328	3.6-5.3	04/24/87	Wallowa Hatchery
1986	Irrigon	52,078	4.4	04/22/87	Spring Creek

Appendix Table D-11. Continued.

Stock Brood Year	Hatchery of Rearing	Number Released	Size (fish/lb.)	Date of Release	Location of Release
Wallowa					
1986	Irrigon	151,053	4.4-5.0	04/15/87	Grande Ronde River
1986	Irrigon	291,332	4.4-4.9	04/08/87	Upper Grande Ronde
1986	Irrigon	72,438	4.4-5.0	04/13/87	Catherine Creek
1986	Irrigon	160,032	4.5-7.0	04/20/87	Wallowa River
1986	Irrigon	12,000	5.0	04/29/87	Hurricane Creek
1986	Irrigon	24,257	4.5-5.0	04/29/87	Prairie Creek
1986	Irrigon	222,526	4.4	04/29/87	Big Canyon Cr.
1986	Lyons Ferry	53,335	5.4-5.9	04/28/87	Wildcat Creek
1987	Irrigon	372,741	5.0	04/16/88	Wallowa Hatchery
1987	Irrigon	88,821	4.3	04/16/88	Wallowa Hatchery
1987	Irrigon	29,424[a]	5.0	04/16/88	Wallowa Hatchery
1987	Irrigon	60,863	4.8	04/18/88	Spring Creek
1987	Irrigon	113,403	5.6	04/13/88	Upper Wallowa River
1987	Irrigon	236,825	5.0	04/05/88	Upper Grande Ronde
1987	Irrigon	62,520	4.9	04/04/88	Catherine Creek
1987	Irrigon	223,196	5.1	04/13/88	Big Canyon Cr.
1987	Irrigon	149,985	5.1	04/16/88	Lower Grande Ronde
1987	Lyons Ferry	50,640	6.0	04/28/88	Lower Grande Ronde
1988	Irrigon	408,942	4.9	04/20/89	Wallowa Hatchery
1988	Irrigon	87,969	3.8	04/20/89	Wallowa Hatchery
1988	Irrigon	53,965	5.2	04/24/89	Spring Creek
1988	Irrigon	111,052	5.2	04/20/89	Upper Wallowa River
1988	Irrigon	234,516	5.4	04/10/89	Upper Grande Ronde
1988	Irrigon	62,601	5.5	04/10/89	Catherine Creek
1988	Irrigon	273,496	5.0	04/27/89	Big Canyon facility
1988	Irrigon	109,603	5.2	04/25/89	Lower Grande Ronde
1987	Lyons Ferry	50,410	5.2	04/25/88	Lower Grande Ronde
1989	Irrigon	90,136	4.2	04/15/90	Wallowa Hatchery
1989	Irrigon	405,769	4.9	04/15/90	Wallowa Hatchery
1989	Irrigon	53,747	5.1	04/19/90	Spring Creek

Appendix Table D-11. Continued.

Stock Brood Year	Hatchery of Rearing	Number Released	Size (fish/lb.)	Date of Release	Location of Release
1989	Irrigon	61,377	5.4	04/18/90	Upper Wallowa River
1989	Irrigon	199,013	5.3	04/12/90	Upper Catherine Grande Creek Ronde
1989	Irrigon	85,212		04/18/90	
1989	Irrigon	223,379	4.8	04/19/90	Big Canyon facility
1989	Irrigon	50,036	5.4	04/30/90	Big Canyon facility
1989	Irrigon	94,393	5.4	04/24/90	Lower Grande Ronde
1990	Irrigon	90,566	3.9	04/22/91	Wallowa Hatchery
1990	Irrigon	406,582	5.1	04/22/91	Wallowa Wallowa Hatchery
1990	Irrigon	109,529		05/02/91	Hatchery
1990	Irrigon	200,466	5.3	04/08-11/91	Upper Grande Ronde
1990	Irrigon	111,464	5.5	04/11-16/91	Catherine Creek
1990	Irrigon	221,785	5.5	04/26/91	Big Canyon Facility
1990	Irrigon	47,187	5.4	05/06/91	Big Canyon Facility
1990	Irrigon	52,487	5.3	04/26/91	Deer Creek
1990	Irrigon	98,783	5.4	04/30-05/01/91	Lower Grande Ronde
1990	Lyons Ferry	52,500	5.3	05/04/91	Lower Grande Ronde

a Progeny from wild lookingglass population and Big Canyon population . Smolts were 100% right ventral fin-marked.

Appendix Table D-12. Summary of Washington Department of Wildlife steelhead smolt releases in the Grande Ronde River system. Releases From 1970 to 1982 were Skamania River stock. Releases since 1985 were Wallowa Hatchery stock.

Year	Hatchery	# Released	Fish/pound	Remarks
1970	Ringgold	75,010	7.0	30,075 Adtclip 30,115 branded
1973	Ringgold	57,235	5.1	
1974	Ringgold	50,046	6.0	
	Tucannon	88,064	6.0	
1975	Ringgold	30,000	6.5	74,522 Adtclip
	Tucannon	88,064	6.5	
1976	Tucannon	79,721	7.8	
1978	Tucannon	59,682	7.4	55,557 Adtclip
	Dworshak	207,630	918.0	fry
1981	Tucannon	113,700	6.5	106,800 Adtclip and branded
1982	Tucannon	35,239	8.0	Adtclip & branded
1985	Lyons Ferry	149,408	5.5 - 10.1	Adtclip
1986	Lyons Ferry	124,200	4.6	Ad+clip/60,477 LV clip and branded

Genetic Characteristics

Genetic characteristics of Grande Ronde wild and hatchery summer steelhead collected in 1983 and 1984 and reported by Schreck et al. 1986, are shown in Appendix Table D-13.

Grande Ronde steelhead were collected for genetic analyses by NMFS, Seattle, Washington from 1989 to 1992. The analyses have not been completed.

Appendix Table D-13. Isozyme gene frequencies and sample sizes (N) as determined by electrophoresis for wild (w) and hatchery (h) Grande Ronde River steelhead. Numbers at the top of each column are the relative mobilities for each allele present in the enzyme system. Minus signs indicate cathodal migration. An asterisk indicates that an allele was present at a frequency of less than 0.005 (Schreck et al. 1986).

Stock, origin, year sampled	ACONITATE HYDRATASE				ALCOHOL DEHYDROGENASE			
	N	100	83	66	N	-100	-76	-82
Grande Ronde River (w)								
1983	43	.80	.19	.01	50	1.00		
1984	96	.85	.14	.01	110	1.00		
Wallowa-Lostine (w)								
1983	71	.86	.14		73	.99	.01	
1984	58	.87	.13		100	1.00		
Wallowa Hatchery (h)								
1984	100	.78	.15	.08	100	1.00		

Stock, origin, year sampled	CREATINE KINASE			GLUCOSE PHOSPHATE ISOMERASE-1				GLUCOSE PHOSPHATE ISOMERASE-2		
	N	100	70	N	100	130	25	N	100	120
Grande Ronde River (w)										
1983	50	1.00		50	1.00			50	1.00	
1984	110	1.00		110	1.00			110	1.00	
Wallowa-Lostine (w)										
1983	73	1.00		73	1.00			73	1.00	
1984	62	1.00		62	1.00			62	1.00	
Wallowa Hatchery (h)										
1984	100	.99	.01	100	1.00			100	1.00	

Appendix Table D-13. Continued.

Stock, origin, year sampled	GLUCOSE PHOSPHATE ISOMERASE-3				ASPARTATE AMINO-TRANSFERASE-1.2			ASPARTATE AMINO-TRANSFERASE-3		
	N	100	120	92	N	100	112	N	100	77
Grande Ronde River (w)										
1983	50	1.00			50	1.00		50	1.00	
1984	110	.99	.0l		110	1.00		60	1.00	
Wallowa-Lostine (w)										
1983	73	1.00			36	1.00		--		
1984	62	1.00			--			62	1.00	
Wallowa Hatchery (h)										
1984	100	1.00			100	1.00		100	1.00	

Stock, origin, year sampled	ISOCITRATE DEHYDROGENASE-3.4					LACTATE DEHYDROGENASE-4			
	N	100	40	120	71	N	100	76	111
Grande Ronde River (w)									
1983	50	.70	.15		.14	49	.25	-75	
1984	74	.72	.12		.17	109	.39	.61	
Wallowa-Lostine (w)									
1983	72	.75	.14		.12	73	.34	.66	
1984	57	.71	.12	*	.17	62	.36	.64	
Wallowa Hatchery (h)									
1984	92	.67	.16		.17	100	.24	.77	

Appendix Table D-13. Continued.

Stock, origin, year sampled	MALATE DEHYDROGENASE-1.2					MALATE DEHYDROGENASE-3.4				
	N	100	140	70	40	N	100	83	110	90
Grande Ronde River (w)										
1983	50	.98	.02			50	.99	.01		
1984	110	1.00				110	.99	*		-01
Wallowa-Lostine (w)										
1983	73	.99		.01		73	.95	.01	.04	
1984	--					62	.95	.01	.04	.o
Wallowa Hatchery (h)										
1984	100	1.00				100	.96	.01	.03	

Stock, origin, year sampled	NADP+ MALATE DEHYDROGENASE			MANNOSE PHOSPHATE ISOMERASE				L-IDITOL DEHYDROGENASE		
	N	100	85	N	100	94	110	N	100	195
Grande Ronde River (w)										
1983	50	1.00		--				50	.93	.07
1984	110	1.00		50	1.00			110	1.00	
Wallowa-Lostine (w)										
1983	73	1.00		73	.99	.01		73	1.00	
1984	62	1.00		62	1.00			62	1.00	
Wallowa Hatchery (h)										
1984	100	1.00		100	1.00			100	1.00	

Appendix Table D-13. Continued.

Stock, origin, year sampled	DIPEPTIDASE N	100	110	85	95	TRIPEPTIDE AMINOPEPTIDASE N	100	129	74	50
Grande Ronde River (w)										
1983	50	.93	.04	.03		50	1.00			
1984	110	.90	.09	.01		110	.99		.01	
Wallowa-Lostine (w)										
1983	73	1.00				73	1.00			
1984	62	.93	.07			52	1.00			
Wallowa Hatchery (h)										
1984	100	.93	-06	.01		100	1.00			

Stock, origin, year sampled	PHOSPHO-GLUCOMUTASE-1 N	-100	-115	-85	PHOSPHO-GLUCOMUTASE-2 N	-100	-140
Grande Ronde River (w)							
1983	50	.99		.01	50	1.00	
1984	110	1.00			110	1.00	
Wallowa-Lostine (w)							
1983	73	1.00			73	1.00	
1984	62	1.00			62	.99	.01
Wallowa Hatchery (h)							
1984	100	1.00			100	1.00	

Appendix Table D-13. Continued.

Stock, origin, year sampled	SUPEROXIDE DISMUTASE				GLYCEROL-3-PHOSPHATE DEHYDROGENASE		
	N	100	152	48	N	100	140
Grande Ronde River (w)							
1983	50	.90	.10		50	.98	.02
1984	110	.93	.01	.06	100	.96	.04
Wallowa-Lostine (w)							
1983	73	.95	.03	.02	--		
1984	62	.90	.03	.07	100	1.00	
Wallowa Hatchery (h)							
1984	100	.99		.01	98	1.00	

Morphological and Meristic Characteristics

Meristic characteristics of Grande Ronde steelhead collected in 1983 and 1984 and reported by Schreck et al. 1986, are shown in Appendix Table D-14 and morphological characteristics of those fish are shown in Appendix Table D-15.

Appendix Table D-14. Meristic character means (standard deviations in parentheses) of wild (w) and hatchery (h) Grande Ronde River steelhead (Schreck et al. 1986).

Stock, origin, year sampled	Scales in lateral series	Scale rows	Anal fin rays	Dorsal fin rays
Grande Ronde River (w)				
1983	145.00 (8.63)	30.30 (1.72)	11.35 (0.49)	11.70 (0.66)
1984	149.41 (5.51)	30.82 (1.51)	11.47 (0.61)	11.42 (0.69)
Wallowa-Lostine (w)				
1983	147.65 (5.24)	30.76 (1.89)	11.56 (0.51)	11.77 (0.44)
1984	147.22 (8.06)	30.88 (1.69)	11.65 (0.49)	11.74 (0.56)
Wallowa Hatchery (h)				
1984	146.47 (6.74)	29.17 (1.98)	11.42 (0.61)	11.40 (0.52)

Appendix Table 14. Continued.

Stock, origin, year sampled	Pelvic fin rays	Pectoral fin rays	Gill rakers	Left branchi-ostegals	Vertebrae
Grande Ronde River (w)					
1983	9.85 (0.37)	14.20 (0.52)	7.20 (0.70)	11.30 (0.73)	64.45 (1.00)
1984	9.58 (0.51)	13.53 (0.51)	7.32 (0.67)	11.05 (0.52)	64.32 (0.89)
Wallowa-Lostine (w)					
1983	9.76 (0.56)	14.29 (0.47)	7.18 (0.64)	11.18 (0.53)	64.00 (0.79)
1984	9.74 (0.45)	14.00 (0.56)	7.35 (0.49)	11.35 (0.49)	64.25 (0.91)
Wallowa Hatchery (h)					
1984	10.00 (0.00)	14.00 (0.58)	7.74 (0.73)	11.47 (0.70)	64.00 (0.58)

Appendix Table D-15. Body shape character means (standard deviations in parentheses) of wild (w) and hatchery (h) Grande Ronde River steelhead (Schreck et al. 1986).

Stock, origin, year sampled	Head width	Head length	Head depth	Inter-orbital width	Depth caudal peduncle
Grande Ronde River (w)					
1983	10.096 (0.42)	23.596 (0.62)	17.281 (0.50)	6.016 (0.23)	9.268 (0.47)
1984	10.262 (0.35)	24.272 (0.87)	17.517 (0.60)	6.311 (0.23)	9.453 (0.38)
Wallowa-Lostine (w)					
1983	9.577 (0.36)	23.120 (1.42)	16.661 (0.56)	5.981 (0.34)	8.963 (0.47)
1984	9.558 (0.33)	23.059 (0.60)	17.182 (0.50)	5.919 (0.15)	9.190 (0.50)
Wallowa Hatchery (h)					
1984	9.609 (0.30)	21.898 (1.10)	17.618 (0.56)	5.682 (0.16)	9.574 (0.37)

Appendix Table D-15. Continued.

Stock, origin, year sampled	Pectoral fin	Pelvic fin	Maxillary length	Anal fin height	Anal fin base
Grande Ronde River (w)					
1983	17.145 (0.99)	13.855 (0.80)	11.505 (0.65)	11.698 (0.87)	9.382 (0.35)
1984	17.549 (0.85)	14.031 (0.57)	11.666 (0.63)	11.666 (0.51)	9.925 (0.60)
Wallowa-Lostine (w)					
1983	21.947 (0.96)	16.842 (0.63)	10.527 (0.60)	12.609 (0.51)	9.704 (0.40)
1984	15.484 (0.71)	12.735 (0.58)	10.329 (0.41)	10.668 (0.31)	9.590 (0.56)
Wallowa Hatchery (h)					
1984	13.589 (0.53)	12.081 (0.73)	9.790 (0.45)	9.658 (0.56)	9.203 (0.65)

Disease History

Infectious hematopoietic necrosis virus (IHNV) was detected in adult summer steelhead spawned at Wallowa Hatchery in 1985-87.

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APPENDIX E

Experimental Design

Introduction

We are proposing a supplementation study to evaluate the effectiveness and impacts of enhancing summer steelhead *(Oncorhynchus* mykiss) natural production in northeast Oregon. Hatchery-reared smolts originating from an endemic stock, will be used to supplement five treatment streams while five control streams will remain unsupplemented. The concept behind this type of supplementation program is to increase the number of smolts and subsequent number of adults that are produced from a given spawner. An increase in production is based on the general hypothesis that juvenile survival in the hatchery will be greater than natural survival rates and that this advantage can be sustained through adulthood (Clune and Dauble 1991). For this type of supplementation program to be successful, wild or natural stocks must be enhanced without compromising their productivity, adaptability or fitness. Although outplanting of hatchery-reared fish has occurred for many years throughout the Columbia River basin, little quantitative research has been conducted to evaluate the effectiveness of supplementation (Smith et al. 1985).

Project Goal

The ultimate goal of this project is to evaluate the success of supplementing wild steelhead populations with hatchery-reared smolts originating from an endemic stock as well as develop an understanding of the biological impacts on the ecosystem. More specifically, we need to assess whether the supplementation techniques we are proposing to use in these basins can be effective without negatively impacting natural production or the integrity of the endemic population. Supplementation is an important part of our efforts to increase natural production of summer steelhead and reestablish sport and tribal fisheries in the Grande Ronde and Imnaha river basins. Original compensation goals in northeast Oregon, largely dictated by the Lower Snake River Compensation Plan, are to have 9,184 summer steelhead return to the Grande Ronde basin and 2,000 summer steelhead return to the Imnaha basin.

Ideally, supplementation may be viewed as a temporary aid to populations during stressful periods. However, for recovery to persist it may be necessary to continue supplementing over a long, although poorly defined, period of time (Bowles and Leitzinger 1992; RASP 1992). Thus, we will participate in an adaptive management strategy (see Walters et al. 1988) which will involve evaluating three options during and at the end of this study. Option 1 is to terminate supplementation efforts in some streams while continuing efforts in other streams, and evaluate whether population abundance levels will remain stable after supplementation is terminated completely

Option 2 is to continue supplementation efforts indefinitely and, thus, sustain increased levels of abundance in each population. Option 3 is to terminate supplementation efforts because they were unsuccessful. Our working hypothesis is that, when this study ends, environmental conditions will be similar or worse than they are now, that juvenile survival under natural conditions will be poor and that adult-per-parent ratios will remain less than one. Therefore, until environmental conditions improve, we may need to continue to provide the juvenile survival advantage in freshwater that is achieved through supplementation.

Relevance to the Columbia River Fish and Wildlife Program and the Regional Assessment of Supplementation Project

The proposed study was specifically designed to address concerns of the Columbia River Fish and Wildlife Program (CRFWP) and was subsequently modified to fit guidelines proposed by the Regional Assessment of Supplementation Project (RASP). CRFWP (1987) has identified a system-wide policy for the Columbia basin. It proposed a goal of doubling existing run sizes by using a mix of wild, natural and hatchery fish in a variety of procedures which include supplementation (section 204, D). CRFWP (1987) specifically identified the Imnaha and Grande Ronde river basins as areas where supplementation is needed and should be evaluated (section 703, F, 5, a, vii). CRFWP (1987) also identified these as geographical areas to determine the best method of supplementation (section 703, H, 1). CRFWP (1987) emphasized the need to increase run sizes in a biologically sound manner (section 206, A, 2) which includes conserving genetic resources (section 203, A) and minimizing the effects on the current ecosystem (section 703, F, 5, a, vii). RASP's (1992) concept of supplementation includes the maintenance or increase of natural production without having a substantial impact on other aspects of the ecosystem. RASP emphasized that supplementation requires ongoing evaluation and identified a broad set of objectives. RASP proposed that the success of supplementation be assessed by examining four population responses; 1) post-release survival (hereafter referred to as post-release performance), 2) reproductive success, 3) long-term fitness and 4) ecological interactions. We propose to conduct a long-term evaluation of an attempt to increase the natural production of northeast Oregon summer steelhead using a supplementation program in both the Imnaha and Grande Ronde river basins. The design, which calls for the use of stream-specific broodstock, has been established to monitor a variety of biological responses of the steelhead populations. In addition, the design will utilize a total of ten streams found in two basins, will be evaluated over multiple generations and will have global application.

Justification

Run sizes of salmon and steelhead are depressed throughout the Columbia River basin (Nehlsen et al. 1991). For example, record numbers of steelhead (Oncorhynchus mykiss) were recorded in the Columbia River during the late 1800's but, more recently, upriver stocks have been at or near historic low levels (WDF and ODFW 1992). Although variable from year to year, evaluation of four year averages suggest that summer steelhead run sizes were at a plateau in the 1930's, 1940's and 1950's, began to decline during the 1960's and reached minimal values during the 1970's (WDF and ODFW 1992). Total run sizes rebounded, somewhat, in the 1980's due in part to large increases in hatchery production (WDF and ODFW 1992). Since 75% of the fish returning in the 1980's were from hatchery releases (WDF and ODFW 1992), further analysis indicates that wild and naturally-produced summer steelhead run sizes are continuing to decline. These trends in run size are reflected in current harvest regulations. Commercial harvest of salmon and steelhead has been restricted in Zone l-5 (Columbia River) since 1975, while sport harvest in most tributaries above Bonneville Dam is limited to hatchery fish (WDF and ODFW 1992).

A similar trend in steelhead production has been observed in northeastern Oregon. Redd counts in Camp Creek have been variable from year to year (Carmichael and Boyce 1987). However, an evaluation of, four year averages since 1967 indicates an 8-fold reduction in the number of redds/mile by the late 1970's. In spite of some recovery in the 1980's, the number of redds/mile in Camp Creek were still only 59% of the original values in the late 1960's. Taken as a whole, this evidence suggests that the aquatic ecosystems in northeast Oregon have the potential to support increased steelhead production.

A variety of strategies have been proposed to increase the abundance of declining salmonid stocks, including steelhead. We will focus on artificial propagation as a means to increase the abundance of steelhead populations. At one end of the spectrum, hatchery fish may be used for mitigation purposes. In this role hatchery fish for harvest. At the other end of the spectrum hatcheries fish may be used for supplementation. In this role hatchery fish to improve the production of naturally-spawning populations. (See Hilborn 1992; Martin et al. 1992; Daley 1993 for recent debates on the role and effectiveness of hatcheries.) Modelling efforts suggest that, in addition to artificial production, small improvements in freshwater habitats (Fryer and Mundy 1993) and downstream passage (Byrne et al. 1992) would enhance efforts to rebuild population sizes. Although extremely valuable, these areas are beyond the current scope of this proposal. Instead, we propose to evaluate the use of artificial propagation for the purpose of supplementation.

RASP (1992) defines supplementation as "...the use of artificial propagation in the attempt to maintain or increase natural production while maintaining the long-term fitness of the target population, and keeping the ecological and genetic impacts on non-target populations within specified biological limits". Although supplementation has been defined in a variety of other ways (Smith et al. 1985; Miller et al. 1990; Steward and Bjornn 1990), RASP's is the most recent and perhaps most useful definition of supplementation. Furthermore, it is the definition we will use in this study. If a survival advantage can be sustained throughout the fishes life history, increases in productivity are expected to result from supplementation because of the improved freshwater survival rate that hatchery-reared fish experience over naturally-produced fish (Clune and Dauble 1991).

A limited number of studies have attempted to assess the effectiveness of supplementation on salmonid populations. Reisenbichler and McIntyre (1977) reported that steelhead embryos from wild parents survived better in streams than embryos from hatchery parents. They also suggested that steelhead progeny from wild parents may grow at different rates than progeny from hatchery parents. Leider et al. (1984) reported that hatchery steelhead generally spawn earlier than wild steelhead, but these researchers point out evidence of reproductive interaction ,between hatchery and wild fish. They suggested that the introgression of hatchery and wild characteristics may reduce the fitness of the wild steelhead. Nickelson et al. (1986) reported that, when compared to unstocked streams, streams supplemented with coho presmolts initially had a higher abundance of juveniles. However, subsequent monitoring showed similar abundances of adults that returned at a later time and after these adults spawned supplemented streams had lower juvenile densities. Chilcote et al. (1986) reported that hatchery steelhead were only 28% as effective as wild steelhead at producing offspring in the natural environment. Leider et al. (1990) reported that offspring of hatchery fish have a higher rate of mortality than wild fish throughout their natural life cycle and that this difference is greatest during the subyearling to smolt stage. This data raises questions about the utility of supplementation as an effective strategy to increase natural production while maintaining the biological characteristics of salmonid populations.

Supplementation remains a potential management tool for restoring populations (see Clune and Dauble 1991; RASP 1992) despite the discouraging evidence. In part, this is because of limitations imposed by the design of the previous supplementation studies on the interpretation of their results. Limiting factors in these studies included 1) the source of the broodstock, 2) the level of stocking and 3) the duration of analysis. In most of the studies cited above (Leider et al. 1984; Chilcote et al. 1986; Nickelson et al. 1986; Leider et al. 1990) the broodstock used for artificial propagation was highly domesticated, not derived from a locally-adapted population and, in some cases, selected for traits that differed from those of the local stocks. The exception to this was the study of Reisenbichler and McIntyre (1977) who used broodstock that were generally no more than two generations removed from the wild. However, because they collected broodstock from 1 October through 1 March and because many fish stray into the Deschutes River, their broodstock probably included a mix of wild, natural and hatchery fish from the Deschutes River basin as well as from numerous other basins from the Columbia and Snake rivers (Olsen et al. 1991). Thus, it is reasonable to presume that this broodstock was also composed, at least in part, of fish that were not locally adapted to the Deschutes River basin (also see Leider et al. 1984; Chilcote et al. 1986; Leider et al. 1990). (Note: From this point on we will distinguish between wild and natural fish. Wild fish are those which we have no reason to believe have been genetically impacted by hatchery fish in any significant manner and are produced naturally. Natural fish are those which we have reason to believe may have been genetically impacted by hatchery fish in a significant manner and are produced naturally.) In addition, the evidence presented by Chilcote et al. (1986) suggests that in many of these investigations the streams were stocked with excessive numbers of juveniles which, at times, resulted in hatchery spawners representing more than 80% of the fish in the system. This may have dramatically altered the balance of the ecosystems being studied. Finally, only Nickelson et al. (1986) and Leider et al. (1990) examined the subsequent production from hatchery fish that returned to spawn naturally. We are not aware of any multiple generation, long-term studies which have directly evaluated the production and characteristics of the populations being supplemented (although see Bowles and Leitzinger 1991; Clune and Dauble 1991 for proposed studies). Due to these limitations, additional investigations on supplementation are warranted.

In an effort to evaluate the potential for supplementation to be successful, we propose to use stream-specific, locally-adapted steelhead as hatchery broodstock. This is a logical next step in supplementation evaluations (see Krueger et al. 1981; Chilcote et al. 1986; Leider et al. 1990; Reisenbichler and Phelps 1989). One shortcoming that may be imposed by this strategy is the maximum size of the broodstock. However, we anticipate using an average of 48 fish (range 20-100) as broodstock from each stream. This should result in an average loss of only l-3% of the genetic variability of the original population over five generations (Meffe 1986; Allendorf and Ryman 1987; Uerspoor 1988). Despite this potential loss, using local broodstock remains the most appropriate supplementation strategy because of the evidence that stocks may adapt to specific local environmental conditions (Sibly and Calow 1986; Barns 1976; Altukhov and Salmenkova 1987). The stock concept was popularized by Ricker (1972) and emphasizes that adaptation to local environmental conditions creates a unique set of characteristics which increase the fitness of an individual in the local environment (Nehlsen et al. 1991). Although fish returning to a given basin may tend to be more closely related to each other than to fish returning to a different basin (Ricker 1972), geographic distance is not a perfect measure of genetic similarity (Parkinson 1984) and steelhead from different streams within a basin may have substantially different adaptive characteristics. Therefore, as long as the size of the effective breeding population is sufficient, stream-specific broodstock are more likely to be successful in a supplementation program than basin- or region-specific broodstock (see Steward and Bjornn 1990). Furthermore, we propose to release 25% fewer smolts than we estimate are necessary to fully seed a given stream (Carmichael and Boyce 1986), restrict the number of hatchery fish spawning naturally (Chilcote et al. 1986) to 50% of the total population and evaluate this supplementation strategy over multiple (approximately five) generations. This design should allow us to test hypotheses that are alternatives to those examined in the previous studies on supplementation and to more thoroughly assess the potential role of supplementation in restoring salmonid runs in the Columbia River basin.

Artificial Propagation of Summer Steelhead in Northeast Oregon

Hatchery-reared steelhead have been outplanted for mitigation in numerous Imnaha and Grande Ronde river tributaries (see Carmichael 1989). Recently, hatchery-reared steelhead have been released by ODFW for Lower Snake River Compensation purposes at standardized locations. For example, in the spring of 1992, hatchery-reared steelhead smolts were released in the Grande Ronde and Imnaha river basins in the approximate numbers and at the approximate locations that follow: Spring Cr., river mile (RM) 2 (662.5 K); Deer Cr., RM 0 (429 K); Catherine Cr., RM 17 (62.5K); Grande Ronde R., RM 162 (100 K), RM 155 (100 K), and RM 54 (50 K); Little Sheep Cr., RM 5 (250 K); Imnaha R., RM 23 (25 K). Of these streams, however, only Little Sheep Creek, Deer Creek and Catherine Creek have been chosen as experimental streams in the proposed study.

A preliminary summer steelhead supplementation program in northeast Oregon began at Little Sheep Creek in the Imnaha River basin in 1982. Wild adults were trapped in a temporary weir which was operated on Little Sheep Creek from 1982-87. A permanent facility, for adult trapping and spawning as well as juvenile acclimation, was completed in 1988. In the Little Sheep program, naturally-produced adults and adults returning from hatchery outplants are used for hatchery broodstock as well as passed above the facility to spawn naturally. This program uses fish from the endemic stock and the protocol is to pass an equal ratio of-hatchery and natural fish above the weir. A historical summary of broodstock practices and juvenile releases for the Little Sheep Creek program are presented in Carmichael (1989) and Messmer et al. (1991). The program at Little Sheep Creek is specifically attempting to increase the natural production of steelhead while maintaining the long-term fitness of the population and, thus, clearly fits the definition of supplementation provided by RASP (1992).

The summer steelhead program in northeast Oregon was expanded to Deer Creek in the Grande Ronde basin with releases of steelhead smolts in 1983. The Big Canyon trapping, spawning and acclimation facility at Deer Creek has been in operation since 1987. The current protocol is to allow all the natural adults that return to the Big Canyon facility, along with an equal number of adults returning from hatchery releases, to spawn naturally above the weir. Prior to 1993 these fish were not collected until late in their reproductive development (after April 15) and were actively transported upstream, presumably to better spawning habitat. Since 1993 these fish were released above the weir as they entered the facility, which was opened on 1 March. Some of the hatchery adults which return to the Big Canyon facility are also, at times, used for Wallowa stock (see Carmichael 1989 for the history and derivation of the Wallowa stock) hatchery brood. The juveniles that have been released in Deer Creek were not necessarily from an endemic broodstock but, more generally, originated from the Wallowa stock (Carmichael 1989). Furthermore, juveniles that are released at Big Canyon are not necessarily the progeny of adults that specifically returned to the Big Canyon facility but, rather, may have been the progeny of adults that returned to Wallowa Hatchery. Traditionally, the Big Canyon program uses artificial propagation to help ODFW meet compensation goals (Carmichael 1989). Since the focus of this program has not been on the natural production and long-term fitness of the Deer Creek steelhead population, it would not be currently considered supplementation.

The steelhead population from Catherine Creek has been enhanced with Wallowa stock smolt outplants since 1987 (see Carmichael 1989 for a summary of juvenile releases into Catherine Creek). Catherine Creek is lacking a permanent facility and adult steelhead that return here are not collected for broodstock. Traditionally, once again, the natural production and long-term fitness of the steelhead population in Catherine Creek has not been the focus of the program. Thus, it would not be currently considered a supplementation program.

Current Production Strategies

In the spring, adult steelhead are collected and held at the Little Sheep and Big Canyon facilities as well as at Wallowa Hatchery. All natural adults and some of the hatchery adults that return to Little Sheep Creek are either collected as Imnaha stock brood or passed above the weir. Established guidelines attempt to 1) have natural fish compose 30% of the broodstock, 2) have an equal ratio of hatchery and natural fish passed above the weir, and 3) have a maximum of 30% of the returning natural fish removed for hatchery broodstock. Imnaha broodstock are spawned at the Little Sheep facility and fertilized embryos are transported to Wallowa Hatchery. Typically Wallowa stock brood are derived from adult steelhead that return to Wallowa Hatchery. Occasionally, hatchery adults that return to the Big Canyon facility at Deer Creek are also collected as Wallowa stock brood. Wallowa broodstock collected at Wallowa Hatchery are spawned at the hatchery. Prior to 1993 Wallowa broodstock that were collected at the Big Canyon facility were spawned there and fertilized embryos were transported to Wallowa Fish Hatchery. Currently, Wallowa broodstock that are collected at the Big Canyon facility are transported to Wallowa Fish Hatchery for spawning.

Incubation of both Imnaha and Wallowa stock embryos begins in well water at Wallowa Fish Hatchery. After this initial period the embryos (or early hatchlings) are transported to Irrigon Hatchery for final incubation (also in well water). After hatching is complete the fish are reared at Irrigon Hatchery (indoors as fry in circular fiberglass tanks, ponded outdoors as parr into cement raceways). The growth of these fish is accelerated by mild well water temperatures which generally remain near 10°C. As 10-12 mo old steelhead, Imnaha stock fish are trucked to the Little Sheep facility while a portion of the Wallowa stock fish are trucked to the Big Canyon facility and Catherine Creek. Finally, these fish are released as smolts into their respective streams, either directly or after a period of acclimation (at the Little Sheep and Big Canyon facilities only). There are no records of steelhead being outplanted in any of the other streams that we are proposing to study.

Proposed Production Strategies

CRFWP (1987) called for doubling of existing run sizes which has been interpreted to imply that streams are generally at or near 50% of full seeding levels. However, very little specific information is available on the actual seeding level of any particular stream or basin in northeast Oregon and there is no specific error estimate around the level of 50%. Thus, increases of this nature may put adult numbers at or above the carrying capacity of a system. The desired increase in adult numbers along with estimates of parent-per-spawner ratios for hatchery-produced fish often drive smolt production goals and dictate how many smolts are released into each stream. To avoid the risk of exceeding full seeding levels, of either smolts or adults, our conservative goal is to target a 1.5-fold increase in adult numbers returning to our supplemented streams.

Specific guidelines have been developed, partly resulting from Oregon Department of Fish and Wildlife's Wild Fish Management Policy (ODFW 1992), to determine the disposition of the adult steelhead returning to each stream. In control streams (unsupplemented), all adults will be passed above the weir. Each treatment stream (supplemented) will have a specific broodstock developed from adults returning to that stream. In other words, only juveniles produced from, for example, Indian Creek adults will be used to supplement Indian Creek. In the first two years of the study, of the adults returning to treatment streams, approximately 33% of the wild fish will be kept (by sex) for broodstock while approximately 67% of the wild fish will be passed (by sex) above the weir to spawn naturally. Once hatchery fish begin to return, for each wild adult kept, two hatchery adults of the same sex will also be kept for broodstock. Furthermore, for each wild fish passed above the weir, a hatchery fish of the opposite sex will also be passed above the weir. The total number of steelhead retained for broodstock from each stream will not exceed that needed to meet production goals. Adults representing the entire run timing distribution will be collected and spawned. To minimize any effects on run timing, spawning will be proportional to the number of fish returning each week. One female will be fertilized by one male when the total broodstock exceeds 100 fish. When the total broodstock is at or below 100 fish, fertilization will occur in a 2x2 matrix scenario. Adults will either be spawned at satellite facilities or trucked to and spawned at Wallowa Hatchery. In years when the availability of broodstock is greater than what is needed for supplementation efforts, surplus steelhead will be passed above the weir to maximize the size of the naturally spawning population while keeping it an equal mix of hatchery and natural fish. In years when available broodstock are fewer than needed for supplementation efforts our production goals will be adjusted downward. This strategy should allow us to attain broodstock for each stream being supplemented while at the same time insure adequate numbers of natural spawners.

Juvenile production and rearing will follow similar protocols to those being used presently. Briefly, embryos will begin their incubation at Wallowa Hatchery. They will then be transported to Irrigon Hatchery where they will complete incubation and fry will begin rearing. These fish will be targeted for smolt release at an average size of 90-100 g. Ten to twelve month old smolts will be released the following spring (late April/early May) into the stream to which their parents returned. Hatchery steelhead production and rearing strategies in northeast Oregon are summarized by Carmichael (1989).

General Approach

Adults. Adult weirs and traps (floating or semi-permanent) are or will be installed below the spawning areas of each experimental stream. In each year the weirs will become operational either by mid-February or after the ice cover leaves the stream (whichever occurs at a later date). They will operate into May or June until a seven day period passes during which no steelhead adults are captured or observed. Preliminary data suggests that majority of adult steelhead will return to their natal stream between 1 March and 31 May (Messmer et al. 1991). The adult steelhead arriving at the weir will be enumerated each day. Each fish will also have a scale sample collected as well as their length, sex and origin determined and recorded. Adults that are allowed to spawn naturally will be tagged for identification and then released above the weir each day. Adults to be used as hatchery broodstock will also be tagged and then returned to the holding area of the trap or satellite facility. Fish to be used as hatchery brood will either be transported weekly to Wallowa Hatchery for spawning or spawned at a satellite facility. The disposition of surplus hatchery fish that may return to each stream after supplementation begins will be determined each year.

Juveniles. Gaumer (1968) presented data which suggests that juvenile steelhead in northeast Oregon may leave their natal stream each month of the year. Thus, we will operate traps to capture emigrant juveniles from each stream during as much of the year as possible. In most cases we will use screw traps to accomplish this objective. Traps will be checked once or twice each day when steelhead emigration is heavy. During times when the numbers of fish emigrating is moderate the traps may be checked less frequently. When possible, the emigrant traps will be operated continuously. Exceptions may be during periods when ice covers the stream or the water discharge is extremely high and traps cannot be operated effectively. Water temperatures below 0°C are necessary for ice to form on moving water such as creeks and rivers. When water temperatures are this cold fish activity is minimal. Thus, a negligible amount of emigration should occur during times when the stream is covered with ice. If water discharge becomes too great to operate the traps, then the number of fish emigrating during those days will be extrapolated from the data collected surrounding this time period.

We anticipate 50-60 mm young-of-the-year (YOY) steelhead will begin to appear in the traps in June or July (Gaumer 1968). The fork length and weight will be measured as well as a scale sample taken from 10% of the juveniles that we capture. All of these fish will be enumerated and passed below the trap. Water discharge and environmental conditions will be recorded during each trapping period. By October the fork length of fish from this cohort should average 75 mm. Once the juvenile steelhead reach 65-70 mm, some of the fish that are sampled will also receive PIT tags. An additional 60-100 of these fish will be given partial fin clips for identification, then transported and released approximately 1 km upstream. These partially fin-clipped steelhead will be used to estimate trap efficiency for each weekly period and associated flow conditions. This data will help us make expanded estimates of total emigration by season. This protocol will be followed each year of the study for each population of steelhead.

Statistics. Evaluations will be made on three levels. To evaluate post-release performance and reproductive success, comparisons will be made between hatchery-reared and wild or natural fish within each of the five supplemented streams. To evaluate long-term fitness and ecological interactions, wild or natural fish from supplemented streams will be compared to wild fish from non-supplemented streams. Finally, each variable will be monitored over time to assess trends relative to pre- and post-supplementation periods. Preferably, parametric statistical analyses will be performed. However, if the data do not meet the assumptions associated with or requirements of these techniques, non-parametric analyses will be performed.

1. SPECIFIC PRODUCTION GOALS

POPULATION RESPONSE: POST-RELEASE PERFORMANCE

OBJECTIVE 1: Evaluate the performance of hatchery smolts.

BACKGROUND

Artificial propagation is a fundamental component of a supplementation program. The steelhead supplementation program in northeast Oregon has been designed around the hatchery production of juveniles to be released as smolts. Fish are reared in captivity to minimize the juvenile mortality which would occur under natural circumstances (Clune and Dauble 1991). This benefit must be balanced against potential reductions in the survival of smolts after release and, ultimately, the production of adults (Reisenbichler and McIntyre 1977). From a given cohort, we anticipate that the survival of hatchery-reared juveniles to release as smolts will be greater than the survival of wild fish to the smolt stage. However. it is not clear whether the post-release survival of hatchery-reared fish allows them to maintain this advantage over wild fish. Thus, we will evaluate the productivity of hatchery-reared fish and compare this to that of wild fish.

QUESTION 1.1 Is the proportion of hatchery smolts that successfully migrate seaward the same as the proportion of wild smolts that successfully migrate seaward?

H_0: The estimated proportion of released hatchery smolts that reach Lower Granite Dam (Lower Granite Dam) will be equal to the estimated proportion of wild smolts that leave their home stream in the spring and reach Lower Granite Dam.

APPROACH

Task 1.1.1 PIT-tag approximately 500 of the hatchery steelhead smolts near the time of release in each supplemented study stream.

Task 1.1.2 Release hatchery-reared fish into appropriate study streams.

Task 1.1.3 PIT-tag approximately 500 of the wild steelhead juveniles leavinq each supplemented stream near the time when hatchery fish are released'..

Task 1.1.4 Interrogate PIT-tagged steelhead juveniles at Lower Granite Dam. Estimate the number of tagged smolts arriving at Lower Granite Dam based on sampling and efficiency rates at Lower Granite Dam.

Task 1.1.5 Calculate the proportion of wild and hatchery PIT-tagged smolts that reach Lower Granite Dam.

Task 1.1.6 Compare the proportions of hatchery and wild juveniles from each supplemented stream that reach Lower Granite Dam.

STATISTICS

Analyses. Use a t-test for paired comparisons to evaluate whether the overall mean difference between hatchery and wild fish is different than zero. Use a binomial test to evaluate differences between hatchery and wild fish within a supplemented stream.

Sensitivity. Approximately a 61% overall mean difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 5% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

QUESTION 1.2: Is the production of smolts per parent similar for adults that are spawned in a hatchery and those allowed to spawn naturally?

H_0: Smolt per adult ratios will be the same from hatchery and natural production.

APPROACH

Task 1.2.1 Capture and enumerate adult steelhead which are allowed to spawn naturally in each supplemented stream.

Task 1.2.2 For each hatchery stock (i.e. each supplemented stream), determine the number of adults spawned in the hatchery and the number of juvenile fish that were released from this spawn.

Task 1.2.3 Collect scales from approximately 10% of the wild fish captured in downstream migrant traps.

Task 1.2.4 Use PIT-tagged fish from tasks 1.1.1 and 1.1.2 to estimate (Task 1.1.3) the number of naturally-produced and hatchery-reared, juvenile steelhead from each study stream that reached Lower Granite Dam.

Task 1.2.5 Determine the age composition and brood year of wild steelhead through scale samples from a portion of juveniles migrating from each supplemented stream.

Task 1.2.6 Determine the ratio of juveniles per adult for each stream (by brood year) by dividing the total number of juveniles from each brood year by the total number of adults responsible for the production of those juveniles.

Task 1.2.7 Compare the juvenile per adult ratios for fish spawned in the hatchery to the ratios for fish allowed to spawn naturally.

STATISTICS

Analyses. Use a t-test for paired comparisons to evaluate whether the overall mean difference between hatchery and wild fish is different than zero. Use a binomial test to evaluate differences between hatchery and wild fish within a supplemented stream.

Sensitivity. Approximately a 57% overall mean difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 15% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

QUESTION 1.3: Do hatchery smolts return to reproduce at the same rate as wild smolts?

H_0: Smolt-to-adult survival for hatchery smolts is the same as smolt-to-adult survival for wild smolts.

APPROACH

Task 1.3.1 Adipose-clip all hatchery steelhead smolts released in supplemented study streams to easily identify the fish as hatchery origin upon return as adults.

Task 1.3.2 Near the time of release, coded-wire-tag approximately 20,000 of the hatchery fish released into each stream. Clip the left ventral fin of these fish.

Task 1.3.3 Near the time when hatchery fish are released, coded-wire-tag up to 10,000 wild fish captured from each supplemented stream. Clip the right ventral fin of these fish.

Task 1.3.4 For each brood year, estimate the number of naturally-produced smolts migrating from study streams by methods described in the general approach.

Task 1.3.5 Capture and enumerate adult steelhead returning to each study stream. Determine the origin (hatchery or natural) and age (via scale samples) of each adult steelhead.

Task 1.3.6 Determine juvenile-to-adult survival for a given brood year by dividing the total number of juveniles from that brood year.by the number of returning adults from the same brood year (tagged population and total population estimates). Calculate the juvenile-to-adult survival rate for each brood year and production strategy (hatchery and wild from supplemented streams).

Task 1.3.7 Determine juvenile-to-adult survival for a migration year by dividing the total number of smolts produced from that migration year by the number of returning adults from the same migration year. Calculate the juvenile-to-adult survival for each migration year and production strategy.

Task 1.3.8 Compare juvenile-to-adult survival for a given brood year of hatchery origin steelhead to that of natural origin steelhead.

Task 1.3.9 Compare juvenile-to-adult survival for a given migration year of hatchery origin steelhead to that of natural origin steelhead.

STATISTICS

Analyses. Use a t-test for paired comparisons to evaluate whether the overall mean difference between hatchery and wild fish is different than zero. Use a binomial test to evaluate differences between hatchery and wild fish within a supplemented stream.

Sensitivity. Approximately a 74% overall mean difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 34% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

POSSIBLE OUTCOMES AND IMPLICATIONS

If hatchery juveniles perform more poorly than wild juveniles, then the utility of the supplementation program is limited and the strategy may need to be modified. If hatchery juveniles perform as well as wild juveniles, then the goal of this aspect of the supplementation program has been reached. If hatchery juveniles perform better than wild juveniles, then this aspect of the supplementation program is exceeding all expectations.

POPULATION RESPONSE: REPRODUCTIVE SUCCESS

OBJECTIVE 2: Evaluate the quality of adults returning from hatchery releases.

BACKGROUND

For this supplementation program to be successful, adults returning from hatchery releases need to be similar in quality to wild adults. In general, hatchery practices are designed to minimize the duration of juvenile development in freshwater (Piper et al. 1982). With respect to northeast Oregon steelhead this practice results in smolts that are released near the time when they are 10 mo. old and approximately 210 mm (Messmer et al. 1991). In contrast, wild steelhead smolts generally migrate when they are 22 mo. old and at a length of approximately 170 mm. Growth rates of hatchery-reared fish, which are greatly accelerated over those that would be experienced naturally, may influence the characteristics of the returning adults (Thorpe 1986). Thus, we will compare reproductive characteristics of adults returning from wild and hatchery-reared smolts.

QUESTION 2.1: Is the age composition of hatchery adults the same as the age composition of wild adults?

H_0: The ocean-age of adults (by sex and brood year) returning from hatchery releases is the same as the ocean-age of adults returning from wild smolts.

APPROACH

Task 2.1.1 Capture adults returning to each study stream and determine their origin (hatchery or natural) and sex. Collect scales from each adult steelhead.

Task 2.1.2 Use the scales collected in Task 2.1.1 to determine the ocean-age of adult steelhead by sex, origin and brood year.

Task 2.1.3 Compare the ocean-age by sex and brood year of hatchery steelhead and wild steelhead adults from supplemented streams.

STATISTICS

Analyses. Use a t-test for paired comparisons to evaluate whether the overall mean difference between hatchery and wild fish is different than zero. Use a Chi-square test to evaluate differences between hatchery and wild fish within a supplemented stream.

Sensitivity. Approximately a 60% overall mean difference between hatchery and wild fish should be detectable at the $\alpha=0.05$ level. Approximately a 13% difference between hatchery and wild fish within a supplemented stream should be detectable at the $\alpha=0.05$ level.

QUESTION 2.2: Is the size composition of hatchery adults the same as the size composition of wild adults?

H_0: The size at ocean-age (by sex and brood year) of adults returning from hatchery releases is the same as the size at ocean-age of adults returning from wild smolts.

APPROACH

Task 2.2.1 Capture and determine age, sex and origin of adult steelhead returning to each study stream (Tasks 2.1.1 and 2.1.2).

Task 2.2.2 Measure the length and weight of each adult captured in Task 2.1.1.

Task 2.2.3 Compare length and weight at ocean-age (by sex and brood year) of adults returning from hatchery releases to that of adults returning from wild smolts in supplemented streams.

STATISTICS

Analyses. Use nested Analysis of Variance techniques to evaluate whether the mean difference between hatchery and wild fish from all streams is different than zero and to evaluate whether the difference between hatchery and wild fish within each supplemented stream is different from zero.

Sensitivity. Approximately a 62% overall mean difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 4% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

QUESTION 2.3: Do hatchery adults have the same reproductive potential as wild adults?

H_0: The fecundity at ocean-age of adults returning from hatchery releases is equal to that of adults returning from wild smolts in supplemented streams.

APPROACH

Task 2.3.1 Capture, determine the age, sex and origin of adult steelhead returning to each study stream (Tasks 2.1.1 and 2.1.2). Measure the length and weight of each captured adult that is spawned in the hatchery (Task 2.2.2).

Task 2.3.2 Weigh the total ovary and five replicates of a known number of eggs to determine egg weight, ovary weight and the total number of eggs per female.

Task 2.3.3 Calculate the fecundity (as a function of egg weight, ovary weight and total number of eggs per total fish weight) of each female steelhead spawned for hatchery broodstock.

Task 2.3.4 Compare fecundities by size, ocean-age and brood year of hatchery origin steelhead to natural origin steelhead from supplemented streams.

STATISTICS

Analyses. Develop linear fecundity at size relationships for both hatchery and wild fish in each stream. Use a t-test for paired comparisons to evaluate whether the overall mean difference in the slope and Y intercept of the lines between hatchery and wild fish is different than zero. Also evaluate whether the slope and Y intercept of the lines for hatchery and wild fish within each supplemented stream are different from zero.

Sensitivity, Approximately a 62% difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 10% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

POSSIBLE OUTCOMES AND IMPLICATIONS

One of the goals of the supplementation program is to avoid altering the characteristics of the adults which return. If the reproductive characteristics of adults returning from hatchery-reared smolts differ significantly from those of wild adults, then the supplementation program cannot be considered successful. Changes, most likely in the rearing strategies, would then need to be implemented in an attempt to restore natural characteristics.

POPULATION RESPONSE: LONG TERM FITNESS

OBJECTIVE 3: Evaluate the performance and quality of juvenile and adult steelhead which are naturally-produced after supplementation.

BACKGROUND

Supplementation is designed such that hatchery smolts return as adults and, at least some, reproduce naturally. We presume that during the course of natural reproduction hatchery and wild adults will interact and interbreed (see Fleming and Gross 1992). Therein, the next generation will consist of hatchery-hatchery, hatchery-wild and wild-wild crosses. If maladapted genes or gene complexes are perpetuated by hatchery fish, then salmonid cohorts resulting from such crosses may not perform as well as a wild population (Reisenbichler and McIntyre 1977; Allendorf et al. 1987). Reduced performance of a steelhead population that results from the influx of genes from hatchery fish may be manifested in either juveniles or adults. Furthermore, the traits observed in the first filial generation may not be indicative of what will occur in subsequent generations (Gharrett and Smoker 1992). Thus, we will examine the long term performance and quality of steelhead populations produced naturally after supplementation.

JUVENILES

QUESTION 3.1: Is the production of juveniles per parent similar for fish producing naturally in supplemented and nonsupplemented steams?

H_0: Juvenile per adult ratios will be the same from natural production in supplemented and nonsupplemented streams.

APPROACH

Task 3.1.1 Capture and enumerate adult steelhead that are allowed to spawn in each study stream.

Task 3.1.2 Estimate the number of wild or naturally-produced juvenile steelhead migrating from each study stream using methods previously described in the general approach.

Task 3.1.3 To determine age composition, collect scale samples from a portion of the naturally-produced juveniles migrating from each study stream.

Task 3.1.4 Determine the ratio of juvenile migrants per adult for each stream by dividing the total number of juveniles from each brood year by the total number of adults that returned to spawn in the same brood year.

Task 3.1.5 Compare the juvenile migrant per adult ratios for fish allowed to spawn naturally in supplemented and nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean juvenile migrant per adult ratio in supplemented streams is different than the mean ratio in nonsupplemented streams.

Sensitivity. Approximately a 57% difference between supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

QUESTION 3.2: Is the proportion of naturally-produced smolts from supplemented streams that successfully migrate seaward the same as the proportion of wild smolts from nonsupplemented streams that successfully migrate seaward?

H_0: The estimated proportion of naturally-produced smolts from supplemented streams that reach Lower Granite Dam will be equal to the estimated proportion of wild smolts from nonsupplemented streams that reach Lower Granite Dam.

APPROACH

Task 3.2.1 PIT-tag approximately 500 of the wild or naturally-produced juvenile steelhead leaving each supplemented stream (see Task 1.1.2).

Task 3.2.2 PIT-tag approximately 500 wild fish leaving each nonsupplemented stream.

Task 3.2.3 Interrogate PIT-tagged steelhead at Lower Granite Dam. Estimate the number of tagged fish arriving at Lower Granite Dam based on sampling and efficiency rates at Lower Granite Dam (Task 1.1.3).

Task 3.2.4 Calculate the proportion of PIT-tagged fish that reach Lower Granite Dam from each study stream.

Task 3.2.5 Compare the migration success of naturally-produced fish from supplemented streams with that of wild fish from nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the overall mean proportion of successful migrants from supplemented streams is different than the mean from nonsupplemented streams.

Sensitivity. Approximately a 57% difference between supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

QUESTION 3.3: Do naturally-produced juveniles from supplemented and wild juveniles from nonsupplemented streams have similar survival rates?

H_0: Smolt-to-adult survival for naturally-produced smolts from supplemented streams is the same as smolt-to-adult survival for wild smolts from nonsupplemented streams.

APPROACH

Task 3.3.1 Near the time when smolt migration occurs in the spring, coded-wire-tag up to 10,000 wild or naturally-produced fish captured from each study stream. Clip the right ventral fin of these fish.

Task 3.3.2 For each brood year, estimate the number of naturally-produced or wild smolts migrating from each study stream by the methods described in the general approach.

Task 3.3.3 Capture and enumerate adult steelhead returning to each study stream. Determine the origin (hatchery or natural) and age (via scale samples) of each adult steelhead.

Task 3.3.4 Determine juvenile-to-adult survival for a given brood year by dividing the total number of juveniles from that brood year by the number of returning adults from the same brood year (tagged population and total population estimates). Calculate the juvenile-to-adult survival rate for each brood year and study stream.

Task 3.3.5 Determine juvenile-to-adult survival for a migration year by dividing the total number of smolts produced from that migration year by the number of returning adults from the same migration year. Calculate the juvenile-to-adult survival for each migration year and study stream.

Task 3.3.6 Compare juvenile-to-adult survival for a given brood year of naturally-produced fish from supplemented streams to that of wild steelhead from nonsupplemented streams.

Task 3.3.7 Compare juvenile-to-adult survival for a given migration year of naturally-produced fish from supplemented streams to that of wild steelhead from nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean juvenile-to-adult survival in supplemented streams is different than the mean in nonsupplemented streams.

Sensitivity. Approximately a 61% difference between supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

QUESTION 3.4: Do naturally-produced juveniles from supplemented streams migrate seaward at the same age as wild juveniles from nonsupplemented streams?

H_0: The age of juveniles from supplemented streams will be equal to the age of juveniles from nonsupplemented streams.

APPROACH

Task 3.4.1 Operate a trap to capture downstream migrants in each study stream.

Task 3.4.2 Collect scales from haphazardly selected steelhead captured with each trap (target 50 fish per week, see general approach).

Task 3.4.3 Determine the age of each of these fish by examining their scales.

Task 3.4.4 Construct an age at migration, frequency-distribution curve.

Task 3.4.5 Compare the ages of juvenile steelhead from supplemented streams to those of juveniles from non-supplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean ages of juvenile steelhead from supplemented streams is different than the mean from nonsup-plemented streams.

Sensitivity. Approximately a 10% difference between supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

QUESTION 3.5: Do naturally-produced juveniles from supplemented streams migrate seaward at the same size as wild juveniles from nonsupplemented streams?

H_0: The age-specific length of juvenile .migrants from supplemented and nonsupplemented streams will be the same.

APPROACH

Task 3.5.1 Operate a trap to capture downstream migrants in each study stream (Task 3.4.1).

Task 3.5.2 Measure the fork length of each fish collected in Task 3.4.2.

Task 3.5.3 Calculate the size, by age, using the ages as determined in Task 3.4.3.

Task 3.5.4 Compare the lengths, by age, of migrant steelhead from supplemented and non-supplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean size fish from supplemented streams is different than the mean from nonsupplemented streams.

Sensitivity. Approximately a 31% difference between supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

ADULTS

QUESTION 3.6: Is the age composition of adults from supplemented streams the same as the age composition of wild adults from nonsupplemented streams?

H_0: The ocean-age of adults (by sex and brood year) returning to spawn in supplemented streams is the same as the ocean-age of wild adults returning from nonsupplemented streams.

APPROACH

Task 3.6.1 Capture adults returning to each study stream (Task 2.1.1) and determine their origin (hatchery or natural) and sex. Collect scales from each adult steelhead.

Task 3.6.2 Use these scale samples to determine the ocean-age of naturally-produced adult steelhead by sex and brood year.

Task 3.6.3 Compare the ocean-age, by sex and brood year, of naturally-produced adult steelhead returning to supplemented streams to those returning to nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean ocean-age of fish from supplemented streams is different than the mean from nonsupplemented streams.

Sensitivity. Approximately a 60% difference between supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

QUESTION 3.7: Is the size composition of naturally-produced adults from supplemented streams the same as the size composition of wild adults from nonsupplemented streams?

H_0: The size (length and weight) at ocean-age (by sex and brood year) of naturally-produced adults returning to supplemented streams is the same as the size at ocean-age of wild adults returning to nonsupplemented streams.

APPROACH

Task 3.7.1 Capture and determine the age and sex of adult steelhead returning to each study stream (Tasks 2.1.1 and 2.1.2).

Task 3.7.2 Measure the length and weight of each adult captured in Task 3.7.1.

Task 3.7.3 Compare the length and weight at ocean-age (by sex and brood year) of naturally-produced adults returning to supplemented streams to that of adults returning to nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean size steelhead from supplemented streams is different than the mean from nonsupplemented streams.

Sensitivity. Approximately a 62% difference between supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

QUESTION 3.8: Do naturally-produced adults from supplemented and wild adults from nonsupplemented streams have the same reproductive potential?

H_0: The fecundity at ocean-age of naturally-produced adults returning to supplemented streams is equal to that of wild adults returning to nonsupplemented streams,

APPROACH

Task 3.8.1 Capture, determine the age, sex and origin of adult steelhead returning to each study stream (Tasks 2.1.1 and 2.1.2).

Task 3.8.2 Remove 10% or a maximum of six (by sex) of the adults that return to each nonsupplemented stream for inclusion into the Wallowa broodstock (which is used for production releases).

Task 3.8.3 Measure the length and weight of each captured adult that is spawned in the hatchery (Task 2.2.2).

Task 3.8.4 Weigh the total ovary and five replicates of a known number of eggs to determine egg weight, ovary weight and the total number of eggs per female.

Task 3.8.5 Calculate the fecundity (as a function of egg weight, ovary weight and total number of eggs per total fish weight) of each female steelhead spawned for hatchery broodstock.

Task 3.8.6 Compare fecundities by size, ocean-age and brood year of naturally-produced steelhead from supplemented streams to wild steelhead from nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean fecundity of fish in supplemented streams is different the mean fecundity of fish in nonsupplemented streams. Also develop a linear relationship between fecundity and size for naturally-produced fish in both supplemented and nonsupplemented streams. Use a t-test to evaluate whether the mean slope and Y intercept of the lines from supplemented streams is different than the mean slope and Y intercept from nonsupplemented streams.

Sensitivity. Approximately a 57% difference between hatchery and wild fish should be detectable at the α=0.05 level.

POSSIBLE OUTCOME AND IMPLICATIONS.

If the performance and quality of naturally-produced steelhead from supplemented streams is different than that of wild steelhead from nonsupplemented streams, over multiple generations, supplementation cannot be considered successful. We are assuming that the characteristics of wild fish (i.e. those from nonsupplemented streams) are the best gauge of what is adaptive in the natural environment. Thus, if steelhead from supplemented streams are different than those from nonsupplemented streams, they are considered to be more poorly adapted to the natural environment. If the performance of naturally-produced steelhead from supplemented streams is similar to that of fish from nonsupplemented streams, then supplementation may be considered an effective strategy.

POPULATION RESPONSE: ECOLOGICAL INTERACTIONS

OBJECTIVE 4: Evaluate the effects of steelhead supplementation on the dynamics of the ecosystem.

BACKGROUND

This supplementation project proposes to release relatively large numbers of hatchery-reared juveniles into streams and, ultimately, increase adult production. The changes we desire are probably sudden in terms of evolutionary time and may affect at least two aspects of productivity by disrupting the ecological equilibrium of the stream. An increase in the number of decomposing adult carcasses may alter nutrient dynamics and increase primary production (Kline et al. 1990; Rand et al. 1992). Conversely, if the outplanted fish feed much while in freshwater or if a large number of these fish residualize in freshwater, these consumers may disrupt the ecological balance, reduce the overall nutrient level and cause a decline in productivity (Bechara et al. 1993). Changes such as these may have long term effects on the health of the stream as well as the ultimate success of supplementation efforts. The net effect of these processes may be a disruption of community diversity. It has been suggested that diverse communities are also relatively stable and able to withstand catastrophic events (Woodell and Smith 1969). Thus, we will monitor various indices of productivity and community.structure.

QUESTION 4.1: Does supplementation affect the nutrient levels and primary productivity of a stream?

H_O: Levels of phosphorous, nitrogen and chlorophyll A (chl A), as well as changes in these levels after the onset of supplementation, will be the same in supplemented and nonsupplemented streams.

APPROACH

Task 4.1.1 Each study stream should be stratified into areas representing the headwaters, the middle and the mouth. Based on the areas of the stream that are accessible, randomly select three pool and riffle combinations from each of three strata in the study streams.

Task 4.1.2 Collect water samples from each of the sampling sites. Collect these samples between 1000 and 1400 h, from the middle of the downstream edge of the pools and the middle of the riffle. Collect these samples in June, July and August, near the time when peak productivity would be expected.

Task 4.1.3 Conduct habitat inventories at each site. Include basic limnological measurements such as light intensity, water velocity, water visibility and water temperature.

Task 4.1.4 Analyze the phosphorus, nitrogen and chlorophyll A levels of each water sample.

Task 4.1.5 Compare the nutrient levels and productivity of supplemented and nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean levels of phosphorous, nitrogen, and chl A in supplemented streams is different than the mean levels in nonsupplemented streams. As the study progresses, also compare the change over time between supplemented and nonsupplemented streams. Use a t-test to evaluate whether the mean change in levels in supplemented streams is different than the mean change in nonsupplemented streams.

Sensitivity. How sensitive the analyses are will vary depending on the variable in question. For example, approximately a 66% and 94% difference in nitrogen and phosphorous levels, respectively, between supplemented and nonsupplemented streams should be detectable at the $\alpha=0.05$ level.

QUESTION 4.2: Does supplementation affect the secondary productivity of a stream?

H_0: The density of caddisfly (Trichoptera), mayfly (Ephemeroptera) and stonefly (Plecoptera) larvae, as well as changes in their densities after the onset of supplementation, will be the same in supplemented and nonsupplemented streams.

APPROACH

Task 4.2.1 Use a Hess or Surber sampler to collect benthic invertebrates from at least a $0.10\ m^2$ area, at the times and in the riffle sites sampled in Tasks 4.1.1 and 4.1.2.

Task 4.2.2 Record the area sampled and enumerate, to the most distinct classification possible, the number of caddisfly, mayfly and stonefly larvae that were collected at each site.

Task 4.2.3 Calculate the density of each classification, at each site.

Task 4.2.4 Compare the secondary productivity of supplemented and nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean densities of selected invertebrates in supplemented streams is different than the mean densities in nonsupplemented streams. As the study progresses, also compare the change over time between supplemented and nonsupplemented streams. Use a t-test to evaluate the whether the mean change in supplemented streams is different than the mean change in nonsupplemented streams.

Sensitivity. How sensitive the analyses are will vary depending on the variable in question. However, for example, approximately a 51% difference in Trichoptera levels between supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

QUESTION 4.3: Does supplementation affect the composition of fish species in a stream?

H_0: The species richness and species diversity of fish communities in each stream, as well as any changes that occur in richness or diversity, will be the same in supplemented and nonsupplemented streams.

APPROACH

Task 4.3.1 At the times and sites selected in Tasks 4.1.1 and 4.1.2, conduct fish removal sampling with an electrofisher. Make multiple passes with an electrofisher until the abundance of all fish species encountered can be estimated.

Task 4.3.2 Calculate the species richness (number of species present) and species diversity (using Shannon-Wiener index, which incorporates richness and eveness) for each site in each stream.

Task 4.3.3 Compare the species richness and diversity of supplemented and nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the overall mean species richness and diversity of supplemented streams are different than the means of nonsupplemented streams. As the study progresses, also compare the change over time between supplemented and nonsupplemented streams. Use a t-test to evaluate the whether the mean change in supplemented streams is different than the mean change in nonsupplemented streams.

Sensitivity. Approximately a 52% difference in species richness between supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

POTENTIAL OUTCOMES AND IMPLICATIONS

Productivity and community complexity may be the same in supplemented and nonsupplemented streams, both before and after supplementation. This evidence would suggest that supplementation does not appear to be altering the structure of the ecosystem. A second alternative is that supplementation results in a decrease in productivity and community complexity. This would suggest that supplemental steelhead may be acting as a drain on the system, damaging the ecological equilibrium of the stream and modifying the stability of the ecosystem. A third alternative that should be considered is that supplementation results in an increase in productivity and community complexity. This may suggest that the supplemental steelhead in the stream

are providing additional resources to the system, shifting the ecological equilibrium of the stream and stabilizing the ecosystem.

POPULATION RESPONSE: POST-RELEASE PERFORMANCE

OBJECTIVE 5: Evaluate the biological characteristics of hatchery smolts.

BACKGROUND

The juvenile steelhead being used for supplementation are conventionally reared in a hatchery until they are released as smolts. The hatchery environment represents a relatively benign environment and an artificial set of selective forces. Given that mortality rates are relatively low, the majority of phenotypic and genotypic combinations should be preserved (embryo to smolt survival near 70%, Messmer et al. 1991). Hatchery-rearing may allow non-adaptive traits for life in the natural environment to persist (Suboski and Templeton 1989). Such conditions may result in a variety of biological differences between hatchery-reared and naturally-produced fish (Green 1964; Barns 1967; Ersbak and Haase 1983). It is likely that these biological differences would be reflected by poor post-release performance of hatchery fish and, ultimately, reductions in the success of supplementation (see Steward and Bjornn 1990). Thus, in an attempt to evaluate more comprehensively the post-release performance, we will monitor ecological, behavioral, physiological and genetic characteristics of the juvenile steelhead from each study stream.

Ecological characteristics:

QUESTION 5.1: Do hatchery-reared, juvenile steelhead arrive at Lower Granite Dam at a similar time as wild juvenile steelhead?

H_O: Hatchery-reared and wild juvenile steelhead will have similar arrival times at Lower Granite Dam.

APPROACH

Task 5.1.1 PIT-tag 500 of the hatchery-reared juveniles that are released into each of the study streams (Task 1.1.1).

Task 5.1.2 Release hatchery-reared fish into appropriate study streams (Task 1.1.2).

Task 5.1.3 PIT-tag wild fish throughout the year and throughout their migration, as they are captured in a downstream migrant screwtrap located in each stream (approximately 500 during both the fall and winter preceding their smolt migration and 500 (Task 1.1.3) during the spring of their smolt migration). The majority of juvenile steelhead in northeast Oregon appear to migrate as 20-23 mo. old fish. Therefore, we will focus on this age class of wild fish for our comparisons with hatchery-reared fish.

Task 5.1.4 From interrogations at the dam, recover PIT tag information on the time fish tagged in Tasks 5.1.1 and 5.1.3 arrive at Lower Granite Dam.

Task 5.1.5 Compare the arrival times of the various groups of fish at Lower Granite Dam. In particular, focus on the comparison between hatchery-reared fish and wild fish from the same stream that migrated out of the stream near the time when the hatchery-reared fish were released.

STATISTICS

Analyses. Use nested Analysis of Variance techniques to evaluate whether the mean difference in arrival times to Lower Granite Dam between hatchery and wild fish from all streams is different than zero and evaluate whether mean differences between hatchery and wild fish within a supplemented stream are different than zero.

Sensitivity. Approximately a 25% difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 12% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

Behavioral characteristics:

QUESTION 5.2: Do hatchery-reared and wild juvenile steelhead use similar amounts of time to travel to Lower Granite Dam?

H_0: Hatchery-reared and wild juvenile steelhead will have similar travel times to Lower Granite Dam.

APPROACH

Task 5.2.1 Use the fish which were tagged and released in Tasks 5.1.1 and 5.1.2 and those that were tagged in Task 5.1.3.

Task 5.2.2 From interrogations at the dam, recover PIT tag information on the time which fish tagged in Tasks 5.1.1 and 5.1.3 arrive at Lower Granite Dam.

Task 5.2.3 Use the information from Task 5.2.2, as well as that on the time wild fish were captured in a downstream migrant trap and tagged or hatchery fish were released into the stream, to calculate the travel time of each fish to Lower Granite Dam.

Task 5.2.4 Compare the travel times of the various groups of fish to Lower Granite Dam. In particular, focus on the comparison between hatchery-reared fish and wild fish from the same stream that migrated out of the stream near the time when the hatchery-reared fish were released.

STATISTICS

Analyses. Use nested Analysis of Variance techniques to evaluate whether the mean difference in travel time between hatchery and wild fish from all streams is different than zero and evaluate whether mean differences between hatchery and wild fish within a supplemented stream are different from zero.

Sensitivity. Approximately a 46% difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 27% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

Physiological characteristics:

QUESTION 5.3: Are enerqy stores produced and used similarly by hatchery-reared and wild fish?

H_0: The levels of, as well as seasonal and migrational changes in liver and muscle glycogen and total body lipid will be the same during the development of hatchery-reared and wild fish.

APPROACH

Task 5.3.1 Starting in September, sample 0-age, juvenile steelhead in the hatchery monthly through February, then twice each month in March and April to determine levels of liver and muscle glycogen and total body lipid before release.

Task 5.3.2 Sample wild, juvenile steelhead in the study streams once each month in September, October, December or January and twice each month in March and April, as well as when captured in the downstream migrant trap.

Task 5.3.3 Determine the levels of liver and muscle glycogen and total body lipid in each of these fish.

Task 5.3.4 Use liver and muscle glycogen as well as total body lipid as indices of energy stores in the fish.

Task 5.3.5 Compare the levels and changes in energy stores of hatchery-reared steelhead to levels and changes in energy stores of wild steelhead in supplemented streams.

STATISTICS

Analyses. Use nested Analysis of Variance techniques to evaluate whether the overall mean difference in physiological parameters of hatchery and wild fish from all streams is different than zero and differences between hatchery and wild fish within a supplemented stream is different than zero.

Sensitivity. Approximately a 13% difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 10% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

Genetic characteristics:

QUESTION 5.4: Do different selective forces in hatchery and natural environments result in different genetic combinations being expressed in hatchery and wild juveniles?

H_0: Hatchery and wild smolts will have the same frequency of certain alleles (FCA) at the beginning of their seaward migration.

APPROACH

Task 5.4.1 Collect 40-60 hatchery-reared steelhead immediately prior to release to characterize the FCA at the beginning of their seaward migration.

Task 5.4.2 To characterize the FCA of wild smolts, collect 40-60 wild steelhead smolts captured in migrant traps as they left each supplemented stream at the beginning of their seaward migration. Store these fish at -80°C.

Task 5.4.3 Use established techniques to examine the frequency of more than 21 polymorphic gene loci (see Waples et al. 1990).

Task 5.4.4 Compare the frequency of alleles in hatchery-reared fish at release to the frequency of alleles in wild smolts captured as they leave each supplemented stream.

STATISTICS

Analyses. Conduct a cluster analysis of the unbiased pairwise genetic distance between populations (Nei 1978) to evaluate whether hatchery and wild fish in supplemented streams are different.

Sensitivity, This is a standard technique used in genetic analyses and should allow us to detect biological differences between hatchery and wild fish if they exist. Populations are typically considered different if their genetic distance is greater than 0.01.

POSSIBLE OUTCOMES AND IMPLICATIONS.

Given the theories of evolution and natural selection, the genetic characteristics of wild fish may be intuitively considered the best suited to life in the natural environment. Therefore, if hatchery-reared fish are genetically similar to wild juveniles, either hatchery conditions and management strategies are adequate to produce the appropriate genetic characteristics in juvenile steelhead or we have not examined the critical alleles. If hatchery-reared fish are not similar to wild juveniles then modifications in hatchery practices may be necessary to develop the appropriate characteristics in our supplemental fish. Although we assume that wild fish are not more poorly adapted for life in the natural environment than hatchery-reared fish, we assign a specific fitness value to any particular allele. This task is also beyond the scope of this investigation.

POPULATION RESPONSE : REPRODUCTIVE SUCCESS

OBJECTIVE 6: Evaluate the biological characteristics of adults that return from hatchery smolt releases.

BACKGROUND

Hatchery rearing clearly modifies the primary forces structuring the biological characteristics of a fish (Piper et al. 1982). Current rearing practices may impact the performance of juveniles (see Smith et al. 1985; Miller 1990). Aspects of early life history in the hatchery may also be manifested well into the adult life stage. For example, hatchery-reared fish may return as adults at a younger age (Messmer et al. 1991). In addition, the adults which do return may be lacking specific information that they were unable to obtain in the hatchery (such as a site in the stream on which they imprinted as juveniles). Furthermore, hatchery and wild adults may exhibit different reproductive abilities (Chilcote et al. 1986; Fleming and Gross 1992) Thus, in an attempt to evaluate more comprehensively the reproductive success of hatchery-reared fish, we will monitor some ecological, behavioral, physiological and genetic characteristics of adult steelhead.

Ecological characteristics:

QUESTION 6.1: Do hatchery and wild, adult steelhead in supplemented streams return to their home stream at similar times?

H_O: Hatchery adult steelhead from supplemented streams will return to their home stream to spawn at the same time as wild adult steelhead.

APPROACH

Task 6.1.1 Enumerate and record the date that adult steelhead are captured in upstream migrant traps located in each supplemented stream, The trap should operate so that it is 100% effective. However, fish that are passed upstream will be opercle punched so that we can estimate how many fish may have escaped upstream prior to trap installation.

Task 6.1.2 Develop a run-timing curve for hatchery and wild adults from each supplemented stream.

Task 6.1.3 Compare the run-timing of hatchery and wild adults in supplemented streams.

STATISTICS

Analyses. Use nested Analysis of Variance techniques to evaluate whether the mean difference in migration time between hatchery and wild fish from all streams is different than zero and differences between hatchery and wild fish within a supplemented stream is different than zero.

Sensitivity. Approximately a 13% difference between hatchery and wild fish should be detectable at the $\alpha=0.05$ level. Approximately a 10% difference between hatchery and wild fish within a supplemented stream should be detectable at the $\alpha=0.05$ level.

Behavioral characteristics:

QUESTION 6.2: Are adult steelhead that return from hatchery releases as likely to spawn, or attempt spawning, as wild adults?

H_0: Hatchery and wild adult steelhead are equally likely (based on their relative contribution to the spawning population) to have the nearest proximity to a hatchery or wild fish of the opposite sex and be paired on a redd.

APPROACH

Task 6.2.1 Capture and enumerate adult steelhead returning to each study stream and determine origin (hatchery or wild) and sex of each adult steelhead.

Task 6.2.2 Disc-tag adult steelhead that are passed above weirs. Use different tag colors and orientations to differentiate the origin and sex of each fish.

Task 6.2.3 Also radio-tag a subset of the fish released above the weirs to spawn naturally in supplemented streams. (Target 10 steelhead of each sex and origin, or 40 total steelhead in each supplemented stream.)

Task 6.2.4 To observe adult steelhead on redds, survey each study stream approximately every 10 days. Record origin and sex (determined by tag color and orientation or signal) of adults observed on each redd.

Task 6.2.5 Determine the percentage of hatchery adults that are on redds and the percentage of wild adults that are on redds.

Task 6.2.6 Determine the percentage of redds occupied by only hatchery adults, only wild adults, as well as both hatchery and wild adults.

Task 6.2.7 Compare the percentages described in Tasks 6.2.5 through 6.2.6 for hatchery- and wild-origin adult steelhead found in supplemented streams.

STATISTICS

Analyses. Use a t-test for paired comparisons to evaluate whether the mean difference between hatchery and wild fish for all streams is different than zero. Use a Wilcoxon Rank-Sums test to evaluate differences between hatchery and wild fish within a supplemented stream.

Sensitivity. Approximately a 29% difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 11% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

Physiological characteristics:

QUESTION 6.3: Do hatchery adults have the same reproductive potential as wild adults?

H_0: Males fertility at ocean-age of adults returning from hatchery releases is equal to that of adults returning from wild smolts in supplemented streams.

APPROACH

Task 6.3.1 Capture and collect hatchery and wild adults from each supplemented stream to be used as broodstock.

Task 6.3.2 Determine the age, sex and origin of adult steelhead returning to each study stream (Task 2.1.1 and 2.1.2).

Task 6.3.3 Measure the length and weight of each adult that is spawned at the hatchery.

Task 6.3.4 To evaluate the fertility of each male steelhead, at spawning, collect a sample of semen from each male that expresses milt.

Task 6.3.5 Measure spermatocrit and determine sperm viability (using a stain that distinguishes live and dead cells), expressed as the percent of sperm cells that are alive.

Task 6.3.6 Compare the fertility (by size, ocean-age and brood year) of hatchery males to the fertility of wild males collected from supplemented streams.

STATISTICS

Analyses Use 'a t-test for paired comparisons to evaluate whether the mean difference between hatchery and wild fish is different than zero. Use a Wilcoxon Rank-Sums test to evaluate differences between hatchery and wild fish within a supplemented stream.

Sensitivity. Approximately a 21% overall mean difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 16% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

Genetic characteristics:

QUESTION 6.4: Do adults returning from hatchery releases and wild adults exhibit similar DNA patterns?

H_0: In supplemented streams, the mean percent of mtDNA sequence divergence between adults returning from hatchery releases and wild adults will not be different than zero.

APPROACH

Task 6.4.1 Capture and collect hatchery and wild adults from each supplemented stream to be used as broodstock.

Task 6.4.2 At spawning, collect approximately 5 g of muscle, liver and heart tissue (from a standardized area) from each adult being spawned. Store this tissue at -80°C until allozyme analyses can be conducted.

Task 6.4.3 Use established techniques to examine the mtDNA sequence from the tissue of each adult (see Avise and Saunders 1984j.

Task 6.4.4 Estimate the percent sequence divergence between adults returning from hatchery releases and wi ld adults.

Task 6.4.5 Compare the overall mean percent divergence between steelhead and wild adult steelhead in supplemented streams.

STATISTICS

Analyses. Conduct a t-test for paired comparisons to evaluate whether the overall mean percent divergence between hatchery and wild fish in supplemented streams is different than zero.

Sensitivity. Approximately a 65% overall mean difference between hatchery and wild fish should be detectable at the α=0.05 level. Approximately a 16% difference between hatchery and wild fish within a supplemented stream should be detectable at the α=0.05 level.

POSSIBLE OUTCOMES AND IMPLICATIONS

For supplementation efforts to be successful, it is clear that we need hatchery-reared juveniles to return as adults. In addition, it is also necessary for these fish to spawn effectively in the natural environment. Presently, we assume that the spawning characteristics of wild fish are the most appropriate for the natural environment. If the characteristics of hatchery fish are similar to those of wild fish, then either hatchery conditions and management strategies are adequate to produce adults with appropriate characteristics or, we have not examined the critical characteristics which exhibit differences. If the characteristics of hatchery fish are not similar to those of wild fish then we need to improve our hatchery and management strategies:

POPULATION RESPONSE: LONG TERM FITNESS

OBJECTIVE 7: Evaluate the biological characteristics of juvenile and adult steelhead which are naturally-produced after supplementation.

BACKGROUND

The long-term fitness of a population is an essential aspect of a supplementation program (RASP 1992). Presumably, some of the hatchery-reared fish that are released as smolts will return as adults and spawn naturally with other hatchery fish as well as with wild and naturally-produced fish (McCracken et al. 1993). The genotypic and phenotypic combinations of the juveniles produced by these adults may have a significant impact on the population. For example, evidence suggests that first generation hybrids are fairly vigorous whereas second and subsequent generations may begin to exhibit traits indicative of outbreeding depression (Moav 1978; Wohlfarth 1986; Gharrett and Smoker 1992). Thus, we will evaluate the long-term population fitness by examining ecological, behavioral, physiological and genetic characteristics. A critical concept behind this objective is that we will focus our comparisons on naturally-produced fish in supplemented and nonsupplemented streams rather than on hatchery-reared and wild fish within a supplemented stream. This necessitates waiting until hatchery-reared fish have the opportunity to spawn naturally.

Ecological characteristics:

QUESTION 7.1: Do naturally-produced, juvenile steelhead from supplemented streams move through the migratory corridor at a similar time as wild juveniles from nonsupplemented streams?

> H_0: Naturally-produced juveniles from supplemented streams and wild juvenile steelhead from nonsupplemented streams will have similar arrival times at Lower Granite Dam.

APPROACH

Task 7.1.1 PIT-tag wild and naturally-produced fish throughout the year and throughout their migration, as they are captured in a downstream migrant screwtrap located in each stream (approximately 500 during both the fall and winter preceding their smolt migration and 500 during‘the spring of their smolt migration). The majority of juvenile steelhead in northeast Oregon appear to migrate as 20-23 mo. old fish. Therefore, we will focus on this age class of wild fish for our comparisons with hatchery-reared fish. The wild juveniles, PIT-tagged in the spring, are the same as those identified in Task 3.2.2.

Task 7.1.2 From interrogations at the dam, recover PIT tag information on the time fish tagged in Tasks 7.1.1 arrive at Lower Granite Dam.

Task 7.1.3 Compare the arrival times of the various groups of fish at Lower Granite Dam.

STATISTICS

Analyses. Use a t-test to evaluate whether naturally-produced fish in supplemented and nonsupplemented streams are different.

Sensitivity. Approximately a 25% difference between naturally-produced fish in supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

QUESTION 7.2: Do naturally-produced adult steelhead in supplemented and wild adult steelhead in nonsupplemented streams return to their home stream at similar times?

H_0: Naturally-produced adult steelhead from supplemented streams and wild adult steelhead from nonsupplemented streams will return to their home stream to spawn at the same time.

APPROACH

Task 7.2.1 Enumerate and record the date that adult steelhead are captured in upstream migrant traps located in each study stream. The trap should operate so that it is 100% effective. However, fish that are passed upstream will be opercle punched so that we can estimate how many fish may have escaped upstream prior to trap installation.

Task 7.2.2 Develop a run-timing curve for naturally-produced adults from supplemented and wild adult steelhead from nonsupplemented streams.

Task 7.2.3 Compare the run-timing of naturally-produced adults from supplemented and wild adult from nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether naturally-produced fish in supplemented and wild fish in nonsupplemented streams are different in run timing.

Sensitivity. Approximately a 10% difference between naturally-produced fish in supplemented and wild fish in nonsupplemented streams should be detectable at the α=0.05 level.

Behavioral characteristics:

QUESTION 7.3: Do naturally-produced, juvenile steelhead from supplemented streams migrate from their home stream at a similar rate to wild, juvenile steelhead from nonsupplemented streams?

H_0: Naturally-produced, juvenile steelhead from supplemented streams and wild, juvenile steelhead from nonsupplemented streams will have similar migration rates from their home stream to Lower Granite Dam.

APPROACH

Task 7.3.1 Enumerate and record the date that juvenile steelhead are captured in a downstream migrant screwtrap located in each stream. The majority of juvenile steelhead in northeast Oregon appear to migrate as 20-23 mo. old fish. Therefore, we will focus on this age class of fish for our comparisons between supplemented and nonsupplemented streams.

Task 7.3.2 In particular, record the date that juveniles which were PIT-tagged the preceding summer and fall are captured in the downstream migrant trap.

Task 7.3.3 Record information on stream height, velocity, discharge, turbidity and temperature (see general approach).

Task 7.3.4 Mark and release a portion of the fish captured in the trap upstream of the trap site. Record the number of these fish that are recaptured. Use these numbers to calculate trap efficiencies and relate trap efficiencies to the characteristics of stream flow (see general approach).

Task 7.3.5 Use actual numbers captured along with trap efficiencies to develop an overall run-timing curve for naturally-produced and wild fish from each study stream.

Task 7.3.6 Also, develop a run-timing curve for PIT-tagged fish that are captured in the migrant traps.

Task 7.3.7 Compare the run-timing of naturally-produced juveniles from supplemented and wild juveniles from nonsupplemented streams. Make this comparison for the estimated total run as well as the PIT-tagged migrants.

STATISTICS

Analyses. Use a t-test to evaluate whether naturally-produced and wild fish in supplemented and nonsupplemented streams are different in run timing.

Sensitivity. Approximately a 27% difference between naturally-produced fish in supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

QUESTION 7.4 Is the spawning success of naturally-produced adults in supplemented streams similar to that of wild adults in nonsupplemented streams?

H_O: Naturally-.produced adults from supplemented streams and wild adults from nonsupplemented streams are equally likely (based on their relative contribution to the spawning population) to have the nearest proximity to a fish of the opposite sex and be paired on a redd.

APPROACH

Task 7.4.1 Capture and enumerate adult steelhead returning to each study stream and determine origin (hatchery or wild) of each adult steelhead as in Task 2.1.1.

Task 7.4.2 Disc-tag adult steelhead and pass them above weirs as in Task 6.2.2.

Task 7.4.3 Also radio-tag a subset of the fish released above the weirs to spawn naturally. Target 10 steelhead of each sex and origin in each stream (see Task 6.2.3).

Task 7.4.4 To observe adult steelhead on the spawning grounds, survey each study stream approximately every 10 days. For each adult, record the origin and sex (determined by tag color and orientation or signal) of the fish in the nearest proximity and whether or not the fish was on a redd.

Task 7.4.5 In each stream, determine the percentage of naturally-produced and wild adults that are paired with fish of the opposite sex.

Task 7.4.6 In each stream, determine the percentage of naturally-produced and wild adults that are on redds.

Task 7.4.7 -Compare the percentages described in Tasks 7.4.5 through 7.4.6 for naturally-produced, adult steelhead found in supplemented streams and wild, adult steelhead in nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether naturally-produced fish in supplemented and wild fish in nonsupplemented streams are different in spawning success.

Sensitivity. Approximately a 29% difference between naturally-produced fish in supplemented and nonsupplemented streams should be detectable at the $\alpha=0.05$ level.

Physiological characteristics:

QUESTION 7.5: Are energy stores produced and used similarly by naturally-produced juveniles in supplemented and wild juveniles in nonsupplemented streams?

H_0: The levels of, as well as seasonal and migrational changes in liver and muscle glycogen and total body lipid will be the same during the development of naturally-produced fish in supplemented and wild fish in nonsupplemented streams.

APPROACH

Task 7.5.1 Sample naturally-produced and wild, juvenile steelhead in the study streams once each month in September, October, December or January and twice each month in March and April, as well as when captured in the downstream migrant trap.

Task 7.5.2 Determine the levels of liver and muscle glycogen and total body lipid in each of these fish.

Task 7.5.3 Use liver and muscle glycogen as well as total body lipid as indices of energy stores in the fish.

Task 7.5.4 Compare the levels and changes in energy stores of naturally-produced steelhead in supplemented and nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether naturally-produced fish in supplemented and wild fish in nonsupplemented streams exhibit different energy stores.

Sensitivity. Approximately a 13% difference between naturally-produced fish in supplemented and nonsupplemented streams should be detectable at the $\alpha=0.05$ level.

QUESTION 7.6: Do naturally-produced adults from supplemented and wild adults from nonsupplemented streams have the same reproductive potential?

H_0: Males fertility at ocean-age of naturally-produced adults returning to supplemented streams is equal to that of wild adults returning to nonsupplemented streams.

APPROACH

Task 7.6.1 Capture, determine the age, sex and origin of adult steelhead returning to each study stream (Tasks 2.1.1 and 2.1.2).

Task 7.6.2 Collect a certain number of adults returning to supplemented streams for broodstock (see general approach).

Task 7.6.3 Remove 10% or a maximum of six (by sex) of the adults that return to each nonsupplemented stream for inclusion into the Wallowa broodstock (which is used for production releases).

Task 7.6.4 Measure the length and weight of each captured adult that is spawned in the hatchery (Task 2.2.2).

Task 7.6.5 To evaluate the fertility of each male steelhead, at spawning, collect a sample of semen from each male that expresses milt.

Task 7.6.6 Measure spermatocrit and determine sperm viability using a stain that distinguishes live and dead cells. Sperm viability should be expressed as the percent of sperm cells that are alive.

Task 7.6.7 Compare the fertility (by size, ocean-age and brood year) of naturally-oroduced males from supplemented streams to the fertility of wild-males collected from nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether naturally-produced fish in supplemented and wild fish in nonsupplemented streams exhibit differences in fertility measures.

Sensitivity. Approximately a 21% difference between naturally-produced fish in supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

Genetic characteristics:

QUESTION 7.7: Do juvenile steelhead populations from supplemented and nonsupplemented streams express similar levels of developmental stability?

H_0: Naturally-produced juveniles from supplemented and wild juveniles from nonsupplemented streams will have the same incidence of fluctuating bilateral asymmetry in paired mersitic characteristics.

APPROACH

Task 7.7.1 In September and October, collect 60 age-0 steelhead from supplemented and non-supplemented streams.

Task 7.7.2 On both the left- and right-hand sides off each fish, count and record the number of pectoral fin rays and gill rakers from the first gill arch.

Task 7.7.3 Determine the incidence of fluctuating biilateral asymmetry in these steelhead.

Task 7.7.4 Compare the incidence of fluctuating bilateral asymmetry of paired meristic characteristics in populations of steelhead from supplemented and nonsupplemented populations.

STATISTICS

Analyses. Use a t-test to evaluate whether naturally-produced fish in supplemented and wild fish in nonsupplemented streams exhibit different asymmetry.

Sensitivity. Approximately a 54% difference between naturally-produced fish in supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

QUESTION 7.8: Do adult steelhead populations from supplemented and nonsupplemented streams express the same incidence of fluctuating bilateral asymmetry in paired mersitic characteristics?

H_O: Naturally-produced adults from supplemented and wild adults from nonsupplemented streams will have the same incidence of fluctuating bilateral asymmetry in paired mersitic characteristics.

APPROACH

Task 7.8.1 Capture and collect adults at weirs as they return to each study stream to spawn.

Task 7.8.2 On both the left- and right-hand sides of each fish, count and record the number of pectoral fin rays and gill rakers from the first gill arch.

Task 7.8.3 Determine the incidence of fluctuating bilateral asymmetry in these steelhead.

Task 7.8.4 Compare the incidence of fluctuating bilateral asymmetry of paired meristic characteristics in populations of steelhead from supplemented and nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether naturally-produced fish in supplemented and wild fish in nonsupplemented streams are different.

Sensitivity. Approximately a 54% difference between naturally-produced fish in supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

POSSIBLE OUTCOMES AND IMPLICATIONS

An inherent goal of this project is to have the characteristics of a population be unaffected by supplementation. If the characteristics of second and subsequent generations of naturally-produced steelhead in supplemented streams are similar to those of wild fish then the supplementation program would be considered successful with respect to long-term fitness. However, the time frame for such differences to be detectable is unclear. Thus, it is necessary to monitor these aspects of the populations over an extended time period. If the characteristics of these steelhead populations are different, however, the long-term fitness of supplemented populations is probably reduced and supplementation efforts cannot be considered successful.

POPULATION RESPONSE: ECOLOGICAL INTERACTIONS

OBJECTIVE 8: Evaluate the effects of steelhead supplementation on sympatric bull trout, *Salvelinus confluentus.*

INTRODUCTION

One of the most uncertain biological effects of a supplementation program is its impact on non-target species (RASP 1992). Non-target species may be affected directly through hatchery releases or indirectly through limiting resource availability (see Hillman and Mullan 1989; Steward and Bjornn 1990; Deegan and Peterson 1992). Although very little quantitative data is available, the potential clearly exists for interactions between supplemented and non-target species to occur through direct or indirect competition as well as reciprocal predation. Furthermore, it is reasonable to presume that the likelihood of interaction is greatest among species that share common life histories and resource requirements (i.e. salmonids). In any event, substantial increases in one component of an ecosystem should be associated with changes in one or more other components of the ecosystem (RASP 1992). Preliminary surveys suggest that more than 50% of our study streams have sympatric populations of steelhead and bull trout. Thus, we will examine the effects of steelhead supplementation on native populations of bull trout. Since bull trout populations are relatively small in size and because we have not found bull trout in all of our study streams, this part of the study will place particular emphasis on comparisons between three time periods: 1) pre-supplementation, 2) post-supplementation but before hatchery fish begin to spawn naturally and 3) post-supplementation and after hatchery fish begin to spawn naturally.

Ecological characteristics:

QUESTION 8.1: Does steelhead supplementation affect the distribution of bull trout?

> H_O: The relative distribution (by age) of bull trout in supplemented streams will be the same as that in non-supplemented streams and will not change during the course of the study.

APPROACH

Task 8.1.1 Divide each study stream into thirds. In each of these sections, identify pool, riffle and glide habitat units as sampling locations.

Task 8.1.2 In late June and early July, use electrofishing techniques to estimate the relative densities of bull trout (by age) in supplemented and nonsupplemented streams.

Task 8.1.3 Measure the length and weight as well as collect scale samples from each of the bull trout that are captured.

Task 8.1.4 Quantify the area, habitat type and environmental characteristics at each sampling location. Repeat this task each year of the study.

Task 8.1.5 Use the scale collections to determine the age of each bull trout. From these ages and lengths, develop a length at age relationship for bull trout.

Task 8.1.6 Calculate the proportion of fish (by age) that were found in each habitat type and each section of stream.

Task 8.1.7 Compare the relative densities of bull trout in supplemented streams to the relative densities of bull trout in nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean density of bull trout in supplemented streams is different than the mean in nonsupplemented streams.

Sensitivity. Approximately a 42% difference between fish in supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

Behavioral characteristics:

QUESTION 8.2: Do bull trout feed and grow as well in supplemented streams as they do in nonsupplemented streams?

H_O: The stomach-fullness (young of the year fish only) and age specific length of bull trout will be the same in supplemented and nonsupplemented streams.

APPROACH

Task 8.2.1 Electrofish in each study stream during July to capture bull trout. Capture the bull trout between 1000 and 1400 h (around 1200 h) in an attempt to standardize for changes in stomach-fullness that may be associated with changes in feeding rates during the course of a day.

Task 8.2.2 Collect scales from, measure the fork length and weight of, as well as examine and weigh the stomach contents from, a minimum of 25 juvenile bull trout in each stream. Determine stomach-fullness by dividing the wet weight of the stomach contents by the total body weight of the individual fish and multiplying by 100.

Task 8.2.3 Collect scales and measure the fork length of an additional 25 bull trout (attempt to sample 5 fish from 0-49 mm, 50-99 mm, loo-149 mm, 150-199 mm and >199 mm).

Task 8.2.4 Analyze the scales from each fish to determine its age.

Task 8.2.5 Compare the stomach-fullness and age specific length of bull trout from streams supplemented with steelhead to that of bull trout from nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the overall mean stomach-fullness of bull trout in supplemented streams is different than the mean in nonsupplemented streams.

Sensitivity. Approximately a 37% difference between fish in supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

Physiological characteristics:

QUESTION 8.3: Are energy stores produced and used similarly by bull trout from supplemented and nonsupplemented streams?

H_O: The levels of, as well as seasonal changes in, liver and muscle glycogen and total body lipid will be the same during the development of juvenile bull trout from supplemented and nonsupplemented streams.

APPROACH

Task 8.3.1 Collect 75-150 mm bull trout in the study streams once each month in July, October and January and twice each month in March and April.

Task 8.3.2 Determine the levels of liver and muscle glycogen and total body lipid in each of these fish.

Task.8.3.3 Use liver and muscle glycogen as well as total body lipid as indices of energy stores in the fish.

Task 8.3.4 Compare the levels and changes in energy stores of bull trout from supplemented and nonsupplemented streams.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean measures of bull trout energy stores in supplemented streams are different than the mean measures in nonsupplemented streams.

Sensitivity. Approximately a 13% difference between fish in supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

Genetic characteristics:

QUESTION 8.4: Do bull trout populations from supplemented and nonsupplemented streams express similar levels of developmental stability?

H_0: Juvenile bull trout from supplemented and nonsupplemented streams will have the same incidence of fluctuating bilateral asymmetry in paired mersitic characteristics.

APPROACH

Task 8.4.1 In September and October, collect 60 age-0 bull trout from each supplemented and non-supplemented stream.

Task 8.4.2 On both the left- and right-hand sides of each fish, count and record the number of pectoral fin rays and gill rakers from the first gill arch.

Task 8.4.3 Determine the incidence of fluctuating bilateral asymmetry in these bull trout.

Task 8.4.4 Compare the incidence of fluctuating bilateral asymmetry of paired meristic characteristics in populations of bull trout from supplemented and nonsupplemented populations.

STATISTICS

Analyses. Use a t-test to evaluate whether the mean incidence of asymmetry in bull trout from supplemented streams is different than the mean incidence in bull trout from nonsupplemented streams.

Sensitivity. Approximately a 54% difference between fish in supplemented and nonsupplemented streams should be detectable at the α=0.05 level.

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Anticipated **time table.** Tasks **for time period 1** July 1995 to 30 June 2004.

Task	J	F	M	A	M	J	J	A	S	O	N	D
1.1.1			X	X								
1.1.2				x								
1.1.3			x	x								
1.1.4			x	x	x	X	X				X	X
1.1.5											X	X
1.1.6											x	x
1.2.1			x	x	x							
1.2.2			x	x	x	x						
1.2.3	X'											
1.2.4			x	x	x	x					x	x
1.2.5										x	x	
1.2.6	X	X								X	X	X
1.2.7	X	X								X	x	X
1.3.1									x	x	x	
1.3.2			X	X								
1.3.3			X	X								
1.3.4	X										x	x
1.3.5			X	x	x							
1.3.6	x	x									x	x
	X	X									x	x
1.3.8	X	X									x	x
2.1.1			x	x	x							
2.1.2			x	x	x							
2.2.3	x	x									x	x
2.2.1			X	x	x							
2.2.2			x	x	x							
2.2.3	x	x									x	x
2.3.1			x	x	x							
2.3.2			x	x	x							
2.3.3	x	x								x	x	x
2.3.4	x	x										
3.1.1			x	x	x							
3.1.2	X		X	X	X	X						X
3.1.3	x	x	x	X	X	x	x	x	x	x	X	X
3.1.4										X	X	X
3.1.5	x	x										

Task	J	F	M	A	M	J	J	A	S	O	N	D
3.2.1			x	x								
3.2.2			x	x								
3.2.3			x	x	x	x	x					
3.2.4											x	x
3.2.5	x	x										
3.3.1			x	x	x							
3.3.2		x	x	x	x	x						x
3.3.3			x	x	x						x	x
3.3.4	x	x									x	x
3.3.5	x	x									x	x
3.3.6	x	x										
3.3.7	x	x										
3.4.1	x	x	x	x	x	x	x	x	x	x	x	x
3.4.2	x	x	x	x	x	x	x	x	x	x	x	x
3.4.3	x	x									x	x
3.4.4	x	x										
3.4.5	x	x										
3.5.1	x	x	x	x	x	x	x	x	x	x	x	x
3.5.2	x	x	x	x	x	x	x	x	x	x	x	x
3.5.3	x	x									x	x
3.5.4	x	x										
3.6.1			x	x	x							
3.6.2	x									x	x	x
3.6.3	x	x										
3.7.1			x	x	x							
3.7.2			x	x	x							
3.7.3	x	x									x	x
3.8.1			x	x	x							
3.8.2			x	x	x							
3.8.3			x	x	x							
3.8.4			x	x	x							
3.8.5											x	x
3.8.6	x	x										
4.1.1	x	x										
4.1.2						x	x	x				
4.1.3						x	x	x				
4.1.4											x	x
4.1.5	x	x										

Task	J	F	M	A	M	J	J	A	S	0	N	D
4.2.1						x	x	x				
4.2.2						x	x	x			x	x
4.2.3	X	X										
4.2.4	X	X										
4.3.1						X	X	X				
4.3.2											x	x
4.3.3	x	x										
5.1.1			x	x								
5.1.2			X	X								
5.1.3	x	x	x	X	x	x	x	x	x	x	x	x
5.1.4			X	X	x	x	x					
5.1.5	x	x									x	x
5.2.1	x	x	x	x	x	x	x	x	x	x	x	x
5.2.2											X	X
5.2.3											X	X
5.2.4	x	x										
5.3.1	x	x	x	x					x	x	x	X
5.3.2	X		X	X					x	x		X
5.3.3									X	x	x	x
5.3.4											x	x
5.3.5	x	x										
5.4.1			x	x								
5.4.2			x	x								
5.4.3										x	x	x
5.4.4	x	x										
6.1.1			X	x	x							
6.1.2											x	x
6.1.3	x	x										
6.2.1			X	x	x							
6.2.2			X	X	X							
6.2.3			X	X	X							
6.2.4			x	x	x	x	X					
6.2.5											x	x
6.2.6											x	x
6.2.7	x	x										

Task	J	F	M	A	M	J	J	A	S	O	N	D
6.3.1			x	x	x							
6.3.2			x	x	X					x	x	x
6.3.3			x	x	X							
6.3.4			x	x	X							
6.3.5			x	x	X						x	x
6.3.6	x	x										
6.4.1			x	x	x							
6.4.2			x	x	x							
6.4.3											X	X
6.4.4											X	X
6.4.5	x	x										
7.1.1	x	x	x	x	x	x	x	x	x	x	x	x
7.1.2											x	x
7.1.3	x	x										
7.2.1			x	x	x							
7.2.2											x	x
7.2.3	x	x										
7.3.1		x	x	x	x							
7.3.2		x	x	x	x							
7.3.3		X	x	x	x							
7.3.4		X	x	x	x							
7.3.5											x	x
7.3.6											x	x
7.3.7	x	x										
7.4.1			x	x	x							
7.4.2			x	x	x							
7.4.3		x	x	x								
7.4.4		x	x	x	x							
											X	X
7.4.6											X	X
7.4.7	x	x										
7.5.1	X		x	x					x	x		X
7.5.2								x	x	x		
7.5.3										x	x	x
7.5.4	X	X										x

Task	J		M	A	M	J	J	A	S	O	N	D
7.6.1			x	x	x							
7.6.2			x	x	x							
7.6.3			x	x	x							
7.6.4	x	x	X									
7.6.5			X	x	x							
7.6.6			x	x	x					x	x	x
7.6.7	x	x										
7.7.1									x	x		
7.7.2									x	x		
7.7.3											x	x
7.7.4	x	x										
7.8.1			x	x	x							
7.8.2			X	x	x							
7.8.3									X	X		
7.8.4											x	x
8.1.1	x	x										
8.1.2						x	x					
8.1.3						X	X					
8 . 1 . 4						x	x					
8.1.5											x	x
8.1.6											x	x
8.1.7	x	x										
8.2.1							X					
8.2.2							X				x	
8.2.3							X					
8.2.4											x	x
8.2.5	x	x										
8.3.1	X		x	x			X			X		
8.3.2							x	x	x			
8.3.3							x	x	x			
8.3.4	X											X
8.4.1									x	x		
8.4.2									x	x		
8.4.3											x	x
8.4.4	x	x										

Budget

<u>Personal Services</u>	
Program Leader (PEMD), 20 mo @ $4,098/mo	$81,960
Project Leader (FWB3), 60 mo @ $3,472/mo	208,320
Assistant Project Leader (FWB2), 120 mo @ $3,010/mo	361,200
Project Assistant (FWBl), 240 mo @ $2,733/mo	655,920
Word Processing Tech 2, 20 mo @ $l,869/mo	37,380
Subtotal	1,344,780
OPE (41%)	551,360
Seasonal Assistants, 110 mo @ $l,654/mo	1.825.950
OPE (26%)	4741747
TOTAL PERSONAL SERVICES	$4,196,837
<u>Services and Supplies</u>	
Travel, 500 days @ $57/day	$28,500
Commercial travel, 15 plane trips @ $500/trip	7,500
Vehicle rental, 540 mo @ @60/mo	140,400
Vehicle mileage, 675,000 miles @ 0.l5/mi	101,250
Office rental, 30 mo @ $500/mo	15,000
Communications, 120 mo @ $lOO/mo	12,000
Duplicating, printing, slides	4,000
Office supplies	7,000
Field gear (waders, boots, etc.)	15,000
Field supplies (MS222, nets, seines, etc.)	50,000
Publications	2,500
Analyses	
Liver glycogen	105,000
Muscle glycogen	105,000
Total lipid	70,000
Allele frequency	150,000
mtDNA	150,000
Tagging and marking	
PIT-tagging	350,000
Coded-wire-tagging	81,000
radio-tagging	247,500
disc-tagging	5,000
adipose fin-clipping	**100;000**
TOTAL SERVICES AND SUPPLIES	**$1,746,650**
<u>Capital Outlay</u>	
Adult weirs, 7 @ $200,000/weir	1,400,000
Juvenile screw traps, 8 @ $12,500/trap	100,000
Compaq 486 laptop computer	3,100
Macintosh powerbook, desk top computer	4,000
Computer software	
Compaq: MS Word, Widows, QPro	750
Macintosh: MS Word, Pagemaker, Cricket graph, MacDraw	1,000
PIT tag data stations, 5 @ $l0,000/station	50,000
PIT tag readers, 5 @ $2,000/reader	10,000
Coded-wire tag field stations (including generators) 5 @ $13,90O/station	**69,500**
Flow meters, 5 @ $2,500/meter	**12,500**

Dissecting microscopes, 3 @ $1,000/microscope	3,000
Electrofishers (including batteries), 5 @ $3,500 each	17,500
Mobile radio-tacking stations (including SRX receiver, antennae, cables, etc), 2 @ $10,000 each	20,000
TOTAL CAPITAL OUTLAY	$1,691,350

PERSONAL SERVICES and SERVICES AND SUPPLIES	**$5,943,487**
INDIRECT (27.5%)	1,634,459
TOTAL CAPITAL OUTLAY	1.691.350
GRAND TOTAL (10 YEARS)	**$9,269,296**