RFS# 001

Title Page

Investigation of the Relative Reproductive Success of Hatchery and Wild Steelhead in the Deschutes River Basin

This proposal addresses RPA Actions 182 and 184

Applicant

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Project Summary

Spawning tributaries within the Deschutes River basin provide an excellent opportunity to study the reproductive success of stray hatchery and wild steelhead. The lower Deschutes River downstream from the Pelton/Round Butte hydroelectric complex (river mile 100) supports significant tribal and sport summer steelhead (*Oncorhynchus mykiss*) fisheries. Wild steelhead escapement to the Deschutes River declined significantly during the decade of the 1980's and continued to decline through the late 1990's. The population decline in the Deschutes River and other Middle Columbia River tributaries prompted the National Marine Fisheries Service to list steelhead populations in the Middle Columbia Evolutionary Significant Unit as a threatened species warranting protection under the Endangered Species Act. During the same period of time that escapement of wild steelhead declined, a significant increase in the number of stray hatchery origin steelhead was detected at several trapping and counting sites in the Deschutes River subbasin. The number of stray hatchery steelhead captured at the Sherars Falls trap (river mile 44) peaked during the 1997-98 run when escapements of stray hatchery steelhead were nearly ten times that of wild steelhead. Stray hatchery steelhead are either harvested in fisheries, leave the Deschutes River and continue their migration, or remain in the subbasin to spawn. The number of stray hatchery steelhead that remain in the subbasin to spawn naturally is unknown. Stray hatchery steelhead remaining in subbasin and spawning naturally with wild fish, can impact the ability of the wild stock to maintain a discrete phenotype and genotype, and may cause a reduction in the fitness and productivity of the wild stock. The project proposal has three primary objectives. They are to: 1) determine the relative reproductive success of stray hatchery and wild steelhead; 2) determine the number of stray hatchery steelhead escaping into the Bakeoven and Buck Hollow creeks, and 3) compare measures of fitness and productivity of the wild population and introgressed population. Project objectives will be achieved by operating juvenile and adult migrant steelhead trapping facilities in Bakeoven (treatment) and Buck Hollow (control) creeks. Adult traps and weirs will be used to determine adult escapements, prevent hatchery steelhead from escaping into spawning areas in the treatment stream, and to collect life history data and genetic samples. Wild and hatchery steelhead would be allowed to escape into spawning areas in the control stream. Tissue will be collected from each adult passed above the weirs, and we will determine the multilocus genotype. Naturally produced juvenile offspring and naturally produced adults progeny returning to the creeks will be sampled and DNA typed. We will conduct pedigree reconstruction analysis to determine the relative reproductive success of each parent and relative reproductive success of hatchery and wild fish. Selected life history traits, downstream migrant population estimates, and other indices of fitness will be collected from downstream trapping facilities at both treatment and control streams. Buck Hollow and Bakeoven creeks were selected as study streams due to their close proximity to each other, similar basin size, geology, and land use. The two study streams are both significant spawning tributaries for wild Deschutes steelhead, and have very similar fishery resources. We selected pedigree analysis because it is the most definitive approach to determine relative reproductive success. We chose to conduct this work in the Deschutes because of the importance of Deschutes steelhead to the Mid Columbia ESU and the magnitude of the stray problem in the Deschutes Basin.

Project Description

The lower Deschutes River supports important tribal and sport summer steelhead (*Oncorhynchus mykiss)* fisheries. Tribal anglers have fished the Deschutes since time immemorial. Deschutes River steelhead are important for cultural and subsistence purposes for tribal members. Sport anglers come from around the world and spend over 50,000 angler days of effort each year angling for Deschutes River steelhead. The construction of the Pelton Round Butte hydroelectric complex confined wild Deschutes River summer steelhead to the lower 100 miles of the river in the late 1960's, when it became evident fish passage around the dam complex was not feasible. Round Butte Hatchery was constructed to mitigate for the loss of habitat as a result of the hydroelectric projects. The Deschutes River has been supplemented with hatchery steelhead primarily from Round Butte Hatchery, since its construction in 1972. The Round Butte Hatchery brood stock originally was collected from Squaw Creek, a tributary to the Deschutes River above the dam complex. Wild brood stock collected at both the Sherars Falls and Pelton Ladder traps has been incorporated into the hatchery brood stock since 1988. In addition to Round Butte Hatchery, hatchery steelhead were released into the river from Warm Springs National Fish Hatchery from 1978 to 1980 (ODFW, 1997). Although much steelhead habitat has been lost, and significant numbers of hatchery fish have been released, the Deschutes River still supports populations of wild steelhead. Deschutes River steelhead currently are classified as a wild population on Oregon's Wild Fish Management Policy Provisional Wild Fish Population List. A population meets the definition of a wild population if it is an indigenous species, naturally reproducing within its native range, and descended from a population that is believed to have been present in the same geographical area prior to the year 1800.

Fishery managers believe that the lower Deschutes River currently supports fewer wild steelhead than were historically present. It is believed that escapements to the Deschutes River declined significantly during the decade of the 1980's and continued to decline through the late 1990's. The population decline in the Deschutes River, and other Middle Columbia River tributaries prompted the National Marine Fisheries Service to list steelhead populations in the Middle Columbia Evolutionary Significant Unit as a threatened species warranting protection under the Endangered Species Act in 1999. Deschutes River steelhead are an important component of the Mid Columbia ESU.

Currently there is no methodology to estimate wild steelhead escapement to the mouth of the Deschutes River. An adult fish trap has been operated in the fish ladder at Sherars Falls (river mile 44) from 1977 through the present to estimate the number of summer steelhead migrating past the falls. Population estimates are made at the falls by using mark-recapture methodologies (ODFW, 1997). Estimated numbers of wild steelhead migrating past the Sherars Falls trap ranged from a low of 480 for the 1994-95 run year to a high of 9,600 in the 1985-66 run year (Table 1). From the mid 1980's through the late 1990's there was a relatively constant decline in the number of wild fish captured at the Sherars Falls trap. The population decline appears to have reversed and there has been a slight increase in the 1998-99 and 1999-2000 run year estimates at Sherars Falls. While the population of wild fish has generally declined throughout the last two decades, the number of stray hatchery fish estimated at the Sherars Falls trap and throughout the Deschutes basin has increased dramatically.

Table 1. Estimated number of steelhead that migrated past Sherars Falls, by run year.

Run Year	Wild	Round Butte Hatchery	Stray Hatchery	Total
1977-78	6,600	6,100	900	13,600
1978-79	2,800	3,200	300	6,300
1979-80	4,200	5,400	600	10,200
1980-81	4,100	5,500	500 a/	10,100
1981-82	6,900	3,800	1,200 a/	11,900
1982-83	6,567	3,524	1,249 a/	11,340
1983-84	8,228 b/	7,250	7,684 a/	23,162
1984-85	7,721 b/	7,563	3,824 a/	19,108
1985-86	9,624 b/	7,382	5,056 c/	22,062
1986-87	6,207 b/	9,064	9,803 c/	25,074
1987-88	5,367 b/	9,209	8,367	23,943
1988-89	3,546	3,849	3,909	10,304
1989-90	4,278	2,758	3,659	10,695
1990-91	3,653	1,990	2,852	8,495
1991-92	4,826	3,778	8,409	17,049
1992-93	904	2,539	4,261	7,704
1993-94	1,487	1,159	4,293	6,936
1994-95	482	1,781	4,391	6,654
1995-96	1,662	2,708	11,855	16,225
1996-97	3,458	5,932	23,618	33,008
1997-98	1,820	5,042	17,703	24,465
1998-99	3,800	3,527	11,110	18,437
1999-2000	4,790	2,628	13,785	21,203

a/ May include some AD CWT marked steelhead that originated form Warm Springs NFH, although few of these ever returned to that facility.
b/ May include some unmarked hatchery steelhead outplanted as fry into the Warm Springs River from Warm Springs NFH.
c/ May include adults from a release of 13,000 smolts from Round Butte Hatchery that were accidentally marked with the same fin clip as steelhead released from other Columbia basin hatcheries. of wild fish captured at the Sherars Falls trap.

All hatchery steelhead released from Round Butte Hatchery receive unique hatchery fin marks to prevent stray hatchery fish from being included into the hatchery brood stock. Because of this unique hatchery fin mark, fishery managers have been able to monitor the number of stray hatchery steelhead captured at various sampling sites throughout the subbasin. The number of stray hatchery fish migrating past Sherars Falls, was estimated to be at least twice as large as the number of wild steelhead in nearly every year during the 1990's. The number of strays estimated past Sherars Falls peaked during the 1997-98 run year. The 1997-98 run year estimate was nearly ten times the number of wild fish estimated migrating past the falls. Numbers of stray hatchery fish were noticed to increase throughout the Deschutes Subbasin throughout the 1980's. Increasing numbers of stray hatchery fish were sampled in both sport and tribal fisheries downstream of Sherars Falls beginning in the early 1980's. ODFW estimated that from 1990 through 1995 stray hatchery fish accounted for greater than 80% of all hatchery fish harvested in Deschutes River fisheries (ODFW, 1997). Warm Springs National Fish Hatchery operates an adult migrant trap on the lower Warm Springs River that captures all fish returning to the river. Due to lows returns, summer steelhead production was terminated at the Warm Springs (NFH) in 1981, however since 1987 over 50% of the steelhead observed at the trap have been out of basin hatchery strays (Olson and Pastor, 1998). An adult trap is operated at the base of the Pelton Reregulating Dam, at river mile 100, to capture hatchery fish returning to Round Butte Hatchery. Although capture of stray hatchery steelhead is consistently less than at downstream sites, it still has exceeded 50% of the total catch of Round Butte hatchery fish and wild fish. Due to the inability to identify wild strays the number of wild steelhead straying into the Deschutes River is currently unknown. Chilcote (1998) estimated that as many as 50% of the unmarked steelhead escaping to Sherars Falls may be stray wild steelhead. A work group, consisting of agency and tribal fishery managers, fishery researchers, and conservation groups, was formed in 1997 to examine hatchery straying into the Deschutes River. The Columbia River Basin Steelhead Straying Work Group primarily focused on the magnitude of straying; reasons for elevated straying rates; and origin of strays. However, the work group did not examine the effects of stray hatchery steelhead on the wild population. The Deschutes River Subbasin Summary (Nelson 2001) states that further studies are needed to examine the out-of-basin stray summer steelhead in the Deschutes River.

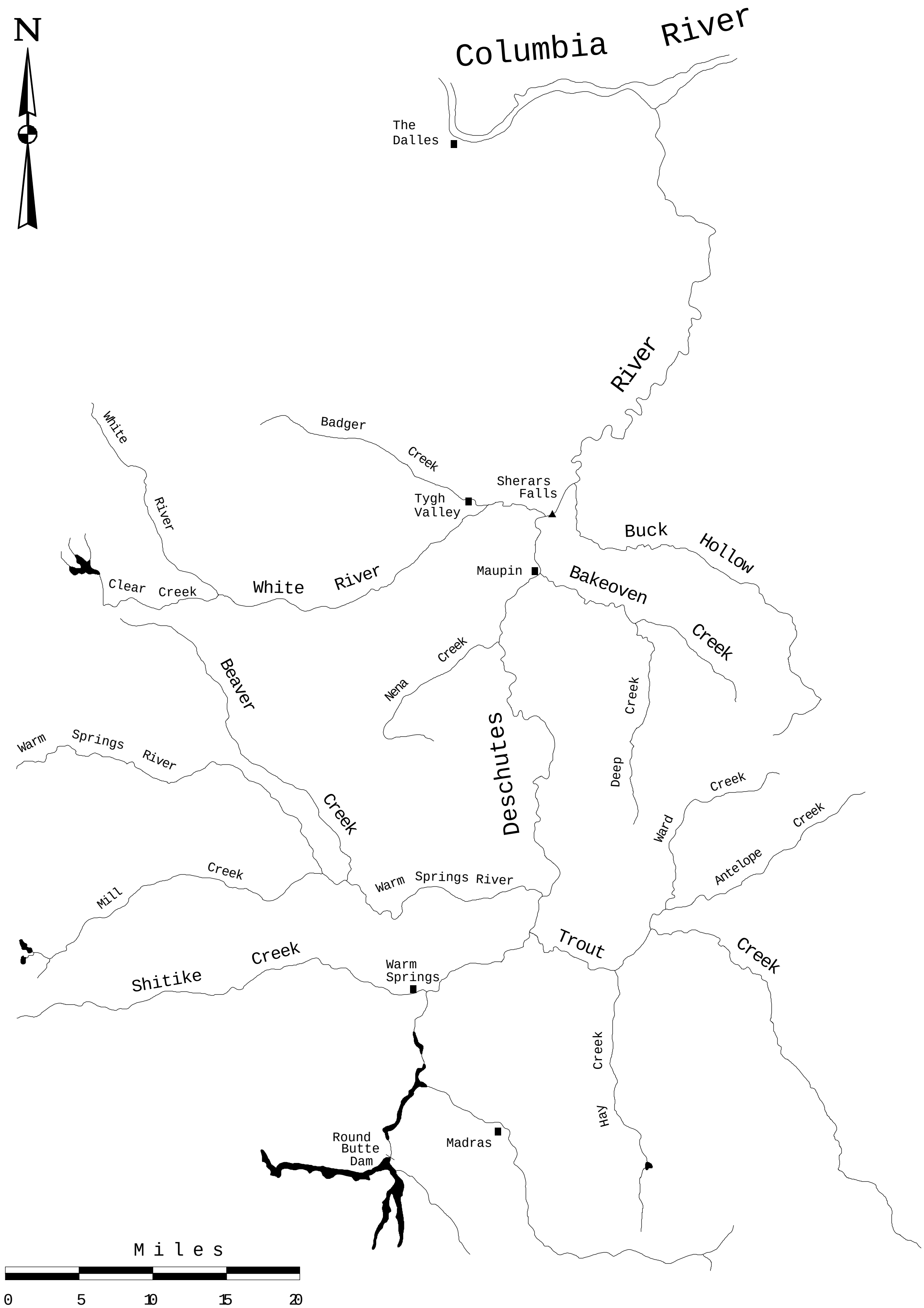
Stray steelhead that enter the Deschutes River are either harvested in fisheries, leave the Deschutes River and continue their migration, or remain in the subbasin to spawn. The number of stray hatchery and stray wild steelhead that remain in the subbasin and spawn is unknown. Based on the ratio of stray hatchery steelhead observed at sampling locations throughout the Deschutes subbasin at the time of spawning, there is some indication that many strays do not leave the Deschutes. The magnitude of straying that is occurring may pose a serious challenge to the continued genetic health and productivity of wild Deschutes steelhead. Chilcote (1998) summarized data on the Deschutes River steelhead while conducting a conservation status review of Oregon steelhead. His assessment of the status of wild Deschutes River steelhead suggested that they are at a serious risk of extinction. He further speculated the likely cause of this risk may be a decrease in the reproductive capacity due to introgression with out-of-basin stray fish.

Some level of straying and gene flow occurs naturally in wild populations. However, the level of this natural gene flow and straying is uncertain, and likely is at a much lower rate than is currently occurring in the Deschutes River. Hatchery fish remaining in the subbasin to spawn may segregate themselves and spawn with other hatchery fish, or they may spawn with wild fish. Temporal or spatial differences in spawning may also act to limit overlap between hatchery and wild fish. Quinn (1999) found that salmon mating is non-random, and that wild fish may reject siblings and hatchery fish as mates. However, an increasing number of hatchery fish have been observed spawning with wild fish in Deschutes River tributaries during spawning surveys conducted by ODFW personnel. Greater than 50% of the steelhead observed while conducting spawning surveys in Bakeoven and Buck Hollow creeks in the late 1990's were determined to be of hatchery origin (ODFW, 2000). In addition, significant numbers of hatchery strays are observed at the Warm Springs Hatchery in the springtime when spawning occurs. Quinn (1997) determined that counting hatchery fish on spawning grounds does not necessarily indicate the level of introgression that may be occurring between hatchery and wild fish. However, fishery managers believe that some level of interbreeding between hatchery and wild steelhead likely occurs in these tributaries.

Several studies have shown that stray hatchery stocks spawning with natural populations can reduce the fitness of natural populations (Leider et al. 1990, Waples 1991, Reisenbichler and Rubin 1999, Chilcote et al. 1986). Gene flow from hatchery strays may dilute beneficial genes in populations of locally adapted wild fish, and disrupt adaptive gene complexes. Hemmingsen et al. (1997) determined that the genetic introgression, as a result of hatchery rainbow trout spawning with wild rainbow trout increased the wild populations susceptibility to disease thus lowering the fitness of the wild population. Chilcote (2000) states "hatchery fish spawning with wild fish appears to negatively affect a wild population's ability to produce recruits." Withler (1995) summarized the conclusions of a panel of biologists and geneticists at a workshop sponsored by the National Marine Fisheries Service on the genetic effects of straying of non-native hatchery fish into natural populations. The panelists agreed that hatchery fish straying and spawning with wild fish decreases levels of diversity among populations, increases the loss of both neutral and beneficial genetic traits within populations, and determined that decreases in productivity of population as a result of interbreeding with hatchery fish can occur quite rapidly. The loss of diversity decreases a population's ability to adapt to changing environmental conditions and decreases its ability for long term persistence

Wild Deschutes River steelhead have a complex life history pattern for freshwater and ocean residence. Juveniles typically rear in freshwater for one to four years before migrating to the ocean, and return after a one to two year ocean residence period. Summer steelhead enter the subbasin from June through October and spawn from January through June. Wild Deschutes River steelhead spawn in the lower mainstem Deschutes River, Warm Springs River, Shitike, Wapinitia, Eagle, Trout, Bakeoven , and Buck Hollow creeks. Little information is available on the current or historic spawning distribution of wild Deschutes River steelhead, but 40 to 70 percent of the natural production is believed to come from the tributaries (ODFW, 1987). Tributaries that enter the Deschutes from the west, such as the Warm Springs River and Shitike and Wapinitia creeks, can be characterized as being heavily influenced by the Cascade Mountains and share many characteristics common to the heavily forested streams that drain the eastern slopes of the Cascades. Eastside tributaries, such as Trout, Bakeoven, and Buck Hollow creeks, are more characteristic of Great Basin streams and are much more arid in nature than the Westside tributaries. Wild Deschutes River steelhead are thought to have evolved slightly different life history strategies to take advantage of the contrasting environmental conditions found in the tributaries. Spawning is believed to occur earlier and juvenile rearing time may be shorter in the eastside tributaries, as stream flow tends to decrease and stream temperatures warm earlier in the more arid eastside streams (Olsen et al. 1991). The ability of wild fish to inhabit streams with harsh environmental conditions, such as the elevated temperatures found in the eastern tributaries, may be the result of local adaptation to particular spawning and rearing conditions. Local adaptations likely affect natural selection, and genetic diversity needs to remain intact to preserve these processes.

Bakeoven and Buck Hollow creeks are two of the three major steelhead spawning tributaries that enter the eastside of the Lower Deschutes River. Bakeoven Creek enters the Deschutes River near the town of Maupin, Oregon (RM 51), and Buck Hollow Creek enters the Deschutes River slightly downstream from Sherars Falls (RM 43) (Figure 1). Both of the subbasins are believed to be important spawning areas for wild Deschutes summer steelhead. The two subbasins which both originate near the town of Shaniko, Oregon, are very similar in size, physical characteristics, discharge, and geology. The Bakeoven and Buck Hollow subbasins encompass approximately 93,472 and 127,000 acres respectively. Soils are shallow in both subbasins, primarily composed of wind deposited loess of the Pleistocene with admixtures of volcanic ash (WCSWCD, 2000). Low stream flow, elevated stream temperatures, and stream bank degradation are believed to be the major habitat factors limiting fish production in both basins. Surface irrigation is minimal or nonexistent in both basins. Stream discharge in both streams is typical of most arid streams of central Oregon, with peak discharge usually occurring in the spring followed by low discharge during the summer and winter months (Personal communication , Larry Toll, Oregon Water Resources Department).


N
Columbia River
The Dalles
River
White River
Badger Creek
Tygh Valley
Sherars Falls
Buck Hollow
Maupin
Bakeoven Creek
Clear Creek
White River
Beaver
Nena Creek
Creek
Deep Creek
Warm Springs River
Creek
Deschutes
Ward Creek
Antelope Creek
Mill Creek
Warm Springs River
Trout Creek
Shitike Creek
Warm Springs
Creek
Hay Creek
Round Butte Dam
Madras
Miles
0
5
10
15
20

Little is known about the life history or abundance of steelhead inhabiting either Buck Hollow or Bakeoven creeks. Along with steelhead, both streams are believed to support populations of resident redband trout (*Oncorrhyncus mykiss*), largescale sucker (*Catostomus macrocheilus*), mountain sucker (*Catostomus platyrhynchus)*, redside shiner (*Richardsonius balteatus*), and long nose dace (*Rhinichthys cataractae*). Neither basin has been intentionally supplemented with hatchery fish. Fishery management personnel from ODFW have periodically conducted spawning surveys in both streams. Single pass redd counts have been conducted annually in both streams since 1990 and have ranged from less than 10 to nearly 70 redds and from less than 10 to nearly 180 redds in Bakeoven and Buck Hollow, respectively (ODFW, 2000). Adult steelhead escapements to both subbasins remain unknown.

The geographic proximity to each other and the geologic similarities between the Bakeoven and Buck Hollow subbasins provide an excellent opportunity for a control and treatment experiment to examine the effects of stray hatchery steelhead in the Deschutes Basin. The geographic, geologic, and fishery resource similarities between the two subbasins provides the ability to utilize one stream as a treatment and the other as a control for purposes of experimental design. Stream flow, lack of large woody debris, channel morphology, and the relatively narrow run timing of migrant adult steelhead into the two study streams make them excellent candidates to conduct a successful trapping experiment. We propose constructing and operating adult fish weirs and traps near the confluence with the Deschutes River on each stream. The traps would be used to sample all returning migratory fish. In addition, downstream migrant traps would be constructed and operated to estimate freshwater production. Along with adult and juvenile migrant trapping, we propose conducting comprehensive spawning surveys throughout each subbasin. For a period of two complete generations of steelhead, only wild origin steelhead will be passed above the adult weir in the treatment stream. Hatchery origin steelhead captured at the trap in the treatment stream will be returned to the Deschutes River. Both hatchery origin and wild origin steelhead will be passed above the weir throughout the course of the experiment in the control stream. Throughout the implementation phase of the experiment, where hatchery origin steelhead are excluded from the treatment stream, life history, survival, and production data will be gathered from both study streams. Estimates of survival, freshwater production, and selected life history attributes will be tested between the treatment and control streams to determine how these indices of fitness are affected by hatchery strays.

Fishery managers are becoming increasingly concerned over the issue of stray hatchery steelhead in the Deschutes River subbasin. This proposal is designed to address many of these concerns. This proposal will provide information that will: 1) determine the relative reproductive success of hatchery and wild steelhead; 2) estimate the number of stray hatchery steelhead that enter Bakeoven and Buck Hollow creeks; and 3) compare aspects of life history and productivity between an introgressed and wild population. Along with information provided on straying and its possible effects, this project will provide fishery managers with information on adult escapement, freshwater production, survival to several different life stages, and a detailed life history assessment of wild Deschutes River steelhead that is currently not available.

This project addresses two needs identified in the Deschutes River Subbasin Summary:

- Studies of life history, genetics, distribution, and abundance of juvenile and adult anadromous salmonid populations.
- Studies of out-of-basin hatchery summer steelhead straying into the Deschutes River and analysis of need for measures to heighten protection of native summer steelhead populations.

This project is designed to meet several objectives and strategies identified in the Deschutes River Subbasin Summary, among them:

- Wy-Kan-Ush-Mi Wa-Kish-Wit Vol. II. (CRITFC 1995)
  - Objectives 1, 2, and 4.
- Integrated Resource Management Plan I, 1992-2001 (CTWS 1992)
  - Objective 4: Protect the genetic integrity of wild fish populations.
- Lower Deschutes River Subbasin Management Plan (ODFW 1997)
  - Objective 3, Strategy 3.7: Monitor summer steelhead spawning in the mainstem lower Deschutes River and tributaries to determine habitat utilization.
  - Objective 3, Strategy 3.8: Monitor summer steelhead spawning in the mainstem lower Deschutes River and tributaries to determine the hatchery to wild ratio in the spawning population.
  - Objective 3, Strategy 3.9: Work with other agencies to reduce straying hatchery summer steelhead into the lower Deschutes River.

This proposal is consistent with several sections in the 1994 Columbia Basin Fish and Wildlife Program (NWPPC 1994). Guiding principles for the research program, as set out in Section 4.2A, call for salmon and steelhead research designed to reduce scientific uncertainty and increase knowledge to achieve the salmon and steelhead goal and policies of the program, and research to analyze major uncertainties and problems associated with increasing runs in a biologically sound manner. Section 7.1C calls for base-line information that will improve management and conservation of wild and naturally spawning populations. Elements identified in Section 7.1C.3 that are suggested for proposals include development of a profile on the status of wild and naturally spawning populations, development of a profile on genetic, life history, and morphological characteristics of wild and naturally spawning populations, identification of limiting factors for wild and naturally spawning populations, and identification of natural carrying capacity of habitat for populations. Section 7.1F calls for studies to evaluate the cumulative and systemwide impacts of existing and proposed artificial production activities on the ecology, genetics and other important characteristics of anadromous and resident fish populations. Section 7.2A.5 identifies genetic and ecological interaction policies to avoid adverse effects on wild fish populations. The problem of straying in steelhead and its effect on wild populations is not well understood. This project is designed to provide critical baseline information concerning the effects of straying of out-of-subbasin straying of summer steelhead on the Deschutes River wild population.

Section III.A.2 of the 2000 Fish and Wildlife Program (NWPPC 2000) states that "Artificial production and other non-natural interventions should be consistent with the central effort to protect and restore habitat and avoid adverse impacts to native fish and wildlife species." And that experimental designs and techniques should be included as part of management actions, including monitoring and research to evaluate their effects on the ecosystem. Certainly monitoring of interactions between stray hatchery and wild summer steelhead would go far to evaluate the effects of hatchery straying.

The National Marine Fisheries Service has stated in section 9.6.5 of the 2000 FCRPS Biological Opinion that understanding the extent and reproductive success of natural spawning of hatchery fish is a critical need in the Columbia River Basin. This information is necessary in order to develop meaningful conclusions in monitoring and evaluation studies of anadromous salmonids. Primary consideration is given to this critical uncertainty in the Biological Opinion, for annual and 5-year planning, and for the 5- and 8-year check-ins. Section 4.1.8.5 of the 2000 Biological Opinion, which discusses hatchery influence on the Deschutes River segment of the Mid-Columbia Steelhead ESU, states, "A key unresolved question about the large number of strays in the Deschutes basin is how many stray fish remain in the basin and spawn naturally." This project will begin to answer this key question.

Action 182: The Biological Opinion identifies a need for studies to determine the reproductive success of hatchery fish relative to wild fish in each ESU. NMFS believes the masking of wild population status by naturally spawning hatchery fish makes it difficult to determine population goals and performance standards, and that studies are needed to identify both the genetic contribution of hatchery-origin spawners to subsequent generations and the temporal and spatial distribution of those spawners. This project is designed to collect juvenile production, life history, and genetic information, which can be used to determine spawning success of both hatchery and wild summer steelhead in these tributaries to the Deschutes River.

Action 184: The Biological Opinion calls for assessment of the ecological and genetic effects of hatchery production on local wild populations, including determination of numbers of naturally spawning first-generation hatchery fish, relative reproductive success of naturally spawning hatchery fish compared to those of wild origin, and frequency and magnitude of ecological interactions between hatchery and wild fish. Although this action is designed to evaluate the cumulative effects of hatchery production within the subbasin containing the hatchery, the effects of those hatchery fish on wild populations outside of the subbasin of origin may be of more critical importance to the continued viability of the wild Deschutes River summer steelhead population.

Hatchery production has increased significantly since the 1980's in the Columbia Basin. Protecting wild stocks from potentially deleterious effects caused by hatchery fish straying into and spawning with wild fish is concern for fishery managers throughout the Columbia Basin. The Northwest Power Planning Council funds several hatchery supplementation projects throughout the Columbia Basin. Information obtained through implementation of this project will provide fishery managers a better understanding of the magnitude and potential impacts these hatchery supplementation programs may be having on wild stocks.

The Deschutes Subbasin Summary (Nelson, 2001) acknowledges the fact that a large number of steelhead from other Columbia Basin production areas stray into the lower Deschutes River. It further discusses the need to determine the number of stray fish that remain in the lower Deschutes River subbasin to spawn, and the need to determine the amount of genetic interchange between stray fish and wild Deschutes Fish. This project is designed to provide the information necessary to specifically address the issue of stray hatchery steelhead escaping into wild steelhead spawning areas in the Deschutes Basin.

The proposed project would share office space, office machines, tools and field equipment with the two Bonneville funded projects and the North Central Oregon ODFW fish screening and passage project. The office complex will provide office space, storage facilities, and provide the opportunity to utilize the metal shop associated with this facility. Combining several projects into one field office will permit a significant savings in annual operating costs. The savings are achieved by combining the general expenses associated with maintaining an office facility and equally sharing them among several projects, thereby, reducing overhead costs associated with each project. In addition, savings are achieved by having access to field equipment and tools that may not be needed at all times that can be shared amongst all the projects.

Council funded habitat restoration projects are being implemented in Bakeoven (Restoration of Riparian Habitat in Bakeoven/Deep Creeks #199900600) and Buck Hollow creeks (Buck Hollow Watershed Enhancement #9303000). Estimates of adult steelhead escapements and freshwater production provided by this project can be used to evaluate the success of habitat restoration activities. Life history information collected on steelhead from both streams can be used to guide restoration activities that provide the most benefit for steelhead.

Objectives and Methods

Objective 1. Determine the relative reproductive success of stray hatchery and wild steelhead in critical production areas in the Deschutes River basin.

General Approach: Adult weirs and traps will be operated on Bakeoven and Buck Hollow creeks to collect all adults that return to these streams from 2004-2013. For five years we will remove all hatchery fish from Bakeoven Creek and allow only wild fish to pass and spawn naturally. In Buck Hollow Creek we will allow all wild and stray hatchery fish to pass upstream to spawn naturally. Juveniles typically spend two years in fresh water prior to seaward migration and return to freshwater as adults after one or two years in the ocean. Thus, fish spawn four or five years after the embryo stage. The last adult progeny from the fifth treatment year (2008) will return in 2013. All wild adults will be sampled in all years.

Sub-objective 1. Use parentage analysis to assess the natural reproductive success of stray hatchery and wild adults in Bakeoven and Buck Hollow Creeks.

> **Task 1.** Select a set of highly variable microsatellite loci to conduct parentage analysis.

Methods: We will screen 20 microsatellite loci that have been shown to be well suited for parentage analysis in steelhead trout (William Ardren unpublished data on Hood River, OR steelhead; Paul Moran unpublished data on Little Sheep Creek, OR steelhead; Bentzen *et al.* 2001) on a sample of 50 adults from each population. DNA will be extracted from fin tissue in a Chelex 100 (Sigma Chemical Co.) resin solution as described by Miller and Kapuscinski (1996). Template DNA will be PCR-amplified in a MJ Research PTC-200 DNA engine thermocycler in 15 μL reactions containing 1x polymerase buffer (10 mM Tris-HCL, 50 mM KCL, 1% Triton X-100), 1.5 to 2 mM $MgCl_2$, 0.2 mM each dNTP, 0.5μM of each primer and 0.5 U Taq DNA polymerase (obtained from Promega Corporation). The PCR products will be fractioned on 2% agarose gels to determine the quality of the PCR product. Genotypes will be determined by post-PCR multiplexing the amplified loci and using the ABI 310 DNA sequencer with the G5 filter set to produce electropherograms. GeneScan and Genotyper software from Applied Biosystems Incorporated (ABI) will be used to identify alleles at each locus and genotype each fish. Loci with the highest expected heterozygosity and allelic diversity will be selected for further analysis. A subset of 10-15 highly variable loci, which are easy to score (i.e., no indication of upper allele dropout or null alleles), will be selected.

To determine the total number of loci needed to resolve parentage with 95% confidence, we will use simulations to determine the resolving power of the loci given the allele frequencies in each population (Marshall *et al.* 1998; Gerber *et al.* 2000). These simulations involve using the allele frequencies for each population to generate parent-offspring pairs or triplets and random genotypes representing unrelated candidate parents. From these simulated data sets, we will calculate the expected distribution of the test statistic, delta, which is the difference in likelihood ratios between the two parents (or parent pairs) most likely to have parented the offspring. From the distributions of delta scores generated in the simulations we can determine a set of loci that will produce 95% confidence in assignment of parentage.

> **Task 2.** Parentage Analysis of steelhead spawning in Bakeoven and Buck Hollow Creeks.

Methods: All adult steelhead passing upstream of the weir to spawn in each of the streams will have a fin clip taken, and represent the potential parents. Approximately 300 offspring produced by each set of potential parents will be collected as juveniles throughout each stream. All tissue samples will be stored in 100% ethanol. DNA extractions, microsatellite loci, and PCR conditions will be as outlined in **Task 1**. Parentage of each offspring collected will be determined by comparing the multilocus genotypes for the potential parents and offspring using Medelian rules of inheritance and likelihood approaches that allow for microsatellite scoring errors (Marshall *et al.* 1998; Gerber *et al.* 2000). After the third year of the project, we will be able to assigning parentage to the adults returning to the weir (i.e., fish aged as 2004 brood year would be considered potential offspring of adults sampled during the 2003 run year).

Task 3: Analysis of the Parentage Results

Using the parent-offspring information gained from **Task 2**, we will be able to:

1) Measure the reproductive success of each wild and stray hatchery steelhead allowed to spawn in Bakeoven and Buck Hollow Creeks by examining their offspring at the pre-smolt and adult life stages. The ability to examine both of these life stages is important because it allows us to determine if there is differential survival during the ocean life history phase for fish with stray hatchery or wild parents. The adult to adult survival data will also give us an estimate of lifetime reproductive success among the stray hatchery and wild fish.

2) Determine if the wild and stray hatchery fish mate randomly and produce offspring that have equal survival rates. This will be accomplished by comparing the observed distribution of wild by wild, wild by stray hatchery, and stray hatchery by stray hatchery matings against the null hypothesis (the two groups randomly mate and have offspring with equal survival rates).

3) Estimate the heritability of important life history traits, such as return timing, using the methods of Milner *et al*. (2000).

4) Better understand the rate of loss of genetic diversity over time in these populations by estimating the effective number of breeders in each population using direct and indirect genetic methods (Ardren and Kapuscinski 2003).

5) Estimate the wild stray rate and contributions by resident rainbows trout. Offspring that we are unable to assign parentage to at the juvenile stage will be considered the progeny of resident fish. Wild adult steelhead captured in either weir, that do not have anadromous parents from either stream, will be considered a stray or the offspring of resident fish. We will check to see if any of the wild adult steelhead returning to Buck Hollow Creek, that are unassigned to a parent or parent pair, were actually hatched in Bakeoven Creek. This will be accomplished by running the unassigned steelhead collected at the Buck Hollow Creek weir in a parentage analysis with the potential parents from the appropriate Bakeoven Creek run year. The same procedure will be used with unassigned wild adult steelhead captured at the Bakeoven weir. This will allow us to directly estimate the stray rate of wild fish between Buck Hollow and Bakeoven Creeks.

Objective 2. Determine the number and proportion of stray hatchery steelhead entering Backoven and Buck Hollow creeks.

Methods: All adults entering these creeks will be trapped and examined to determine origin. Most all hatchery steelhead in the Columbia Basin are marked with adipose fin clips and hatchery reared steelhead that have not been marked are recognizable by dorsal fin length and shape. Adult traps will be checked daily when significant numbers of fish are moving and at longer intervals when few fish are moving. All hatchery fish will be scanned for the presence of PIT Tags.

Objective 3. Determine and compare aspects of juvenile and adult life history between Bakeoven Creek and Buck Hollow Creek.

Methods: We will monitor and compare a variety of adult life history characteristics including age structure, length at age, run timing, and sex composition. Comparisons will be made between hatchery and natural fish within creeks and natural fish between creeks. Most importantly we will compare life history characteristics of F_1 adult returns resulting from the introgressed population (control) and the wild only population (treatment).

In addition, we will monitor and compare aspects of juvenile life history including juvenile migration timing, age at migration, and size at migration. Data to make these comparisons will be obtained by operating juvenile traps near the mouth of Backoven and Buck Hollow creeks during the entire period of juvenile outmigration. We plan to operate the juvenile traps to provide life history data for offspring of five treated broodyears (2004-2008).

Objective 4. Determine and compare measures of production and productivity in Bakeoven and Buck Hollow creeks.

Methods: Juvenile production in Bakeoven and Buck Hollow creeks will be estimated for each broodyear based on outmigrant estimates from juvenile traps. We will determine migrant abundance for each of the five treatment broodyears (2004-2008). Estimates will be derived using trap-efficiency bootstrap methodology. Adult progeny production will be determined based on natural adult returns identified to have originated from the parent stream based on DNA analysis. To compare productivity between the treatment and control streams, we will determine the number of juveniles produced per adult and the number of adult progeny produced per parent.

Future Opportunities

We believe there are a number of other critical questions that could be addressed within this study, however given the short timeframe for proposal development and the project cost limitations we did not fully develop and include objectives and approaches to address additional questions. Following is a brief summary of additional questions that could be addressed.

Determine the relative performance during the juvenile freshwater phase for offspring of wild x wild, stray hatchery x stray hatchery, and wild x stray hatchery crosses.

Assess mate selection preference of wild and stray hatchery fish.

Assess redd site selection and spawning distribution of wild and stray hatchery fish.

Determine the adequacy of redd counts as a method to index or estimate steelhead spawner escapement.

Qualifications of Participants

Richard W. Carmichael will serve as the Principal Investigator for this project. Mr. Carmichael is employed by the Oregon Department of Fish and Wildlife as the Program Director of the Northeast Fisheries Research and Development Program. He oversees a diversity of research projects associated with salmonid restoration and enhancement. Specifically related to this proposed project, Mr. Carmichael has over 15 years of experience evaluating supplementation, life history, natural production, and genetics studies. He oversees supplementation, conservation and life history studies of steelhead and chinook salmon in the Imnaha and Grande Ronde basins. Mr. Carmichael has previously served on Columbia Basin-wide review and planning committees, including Chairman of the NPPC Supplementation and Genetics workgroup. Currently he is a member of the Interior Columbia Basin Technical Recovery Team. Mr. Carmichael has been principal investigator for many successful projects.   References for past and ongoing projects include: Mr. Dan Herrig, USFWS (208-378-5321), Mr. Mark Shaw, BPA (503-230-5239), Dr. Robin Waples, NMFS (206-860-3254), and Dr. Rick Williams, ISRP (208-888-5668).

Cooperators include Dr. Don Campton and Dr. William Ardren. Dr. Campton has worked in the area of fishery genetics for over 25 years and has contributed to 30 publications. He currently works as a conservation geneticist for the USFWS at the Abernathy Fish Technology Center. Dr. Campton also serves on a number of regional committees responsible for review and implementation of hatchery reforms as well as monitoring and evaluation.

William R. Ardren has a Ph.D. in Fisheries Science from the University of Minnesota. He is currently the lead molecular population geneticist for the U.S. Fish and Wildlife Service, Region 1, Conservation Genetics Laboratory at Abernathy Fish Technology Center. Dr. Ardren has extensive experience examining microsatellite loci in steelhead trout populations. Examples of related publications include: describing the inheritance of microsatellite loci in steelhead populations and using genetic variation at microsatellite loci to estimate effective population size. In addition, he has co-authored a review paper on methods of parentage analysis in natural populations that is currently in review at Molecular Ecology.

Implementation Timelines

We would begin work as soon as a contract was obtained. Initial work in 2003 would focus on obtaining landowner easements for access, selecting trap sites, and designing and constructing adult and juvenile traps. Adult trap and weir installation would occur in early 2004 in time to collect all adult returns from the 2003-2004 run year. We will begin adult sampling in early 2004 and also begin removal of hatchery fish in the treatment stream. Juvenile trapping will begin in the early summer of 2004. We will repeat the treatment for five years through the year 2008. Adult progeny from the final treatment year will return as Age 5 fish in 2013, therefore adult sampling will continue through 2013.

Estimated Costs and Coordination

First year cost estimated at approximately $420,000 and annual costs following will be approximately $300,000. Exact cost estimates will be developed with a statement of work if project is approved. Anticipated total project cost is about $3,120,000.

Field staff to support this project will be located in The Dalles, Oregon. Office facilities for the project will be shared with other Bonneville funded ODFW projects at the ODFW regional fish screening office and shop facility located near the port of The Dalles. In addition to office facilities, this facility will provide a complete metal shop for fabricating and repairing trapping and field equipment, and storage areas for project vehicles and field equipment. Preliminary adult trapping site investigations indicate that a picket type of weir and trap may be most effective for capturing adult steelhead in Bakeoven and Buck Hollow creeks. The use of picket weirs and traps to capture adult salmonids is described in detail in Schroeder (1996). Downstream migrant traps to be used in the two study streams will consist of rotary screw traps or downstream fyke traps depending on the suitability of the site. The types downstream migrant traps that are to be used will be similar to those used in the Hood River subbasin and are described in Olsen et al. (1996). Trapping facilities will be constructed on private or Bureau of Land Management lands in both study streams. Laboratory work will be conducted at the Abernathy Salmon Genetics Laboratory.

Environmental Compliance

Applicant is willing to cooperate as needed to comply with all NEPA, ESA, NHPA, and other laws. Applicant has many similar projects funded by BPA and other Federal agencies where identical compliance is required. Applicant has extensive experience in ESA Section 10, Section 7, and 4d permitting, consultation, and reporting.

BPA Contractual Requirements

The applicant has a great deal of experience working with BPA contracting. The PI currently has numerous BPA contracts and is able to meet all of the BPA contractual requirements.

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