RFS# 007

Reproductive Success of Hatchery Spawners in the Chinook River, WA

A Research, Monitoring, and Evaluation Proposal to address
FCRPS Biological Opinion RPA182

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PROJECT SUMMARY

We will use genetic pedigree analysis to investigate the relative reproductive success of Hatchery-Origin (HOR) and Natural-Origin (NOR) coho salmon in the Chinook River. By integrating this project with other ongoing monitoring and evaluation activities in the watershed we will also be able to assess the genotypic basis of life history characters at multiple life stages. The project will also assist in assessing the potential risks of HOR fish spawning in natural systems and the appropriateness and effectiveness of artificial production as a tool to recover depressed populations of anadromous fishes - such as Lower Columbia coho salmon.

Sea Resources' efforts to use HOR fish to reestablish a viable self-sustaining population of coho salmon in the Chinook River provides an excellent opportunity to conduct this investigation. In 1996 and 1997 Sea Resources imported HOR coho salmon fry from the Elochoman River to initiate the reintroduction effort. Since 1999, the majority of HOR and NOR fish have been passed upstream to produce naturally in the river. Monitoring has demonstrated that these fish are successfully producing offspring and that the offspring are surviving to adult. However, the relative reproductive success and subsequent offspring survival of HOR and NOR fish is unknown. Determining the effectiveness of the HOR portion of the naturally reproducing population will help estimate the degree of population growth necessary to achieve recovery of the population and terminate supplementation of the natural population with hatchery fish.

Once genotypic and phenotypic information is integrated and analyzed we will be able to determine differences in reproductive success of F1 and F2 coho salmon of all potential HOR and NOR parent combinations across multiple generations; determine if NOR and HOR fish mate randomly and produce offspring that have equal survival rates; estimate the hereditability of important adult life history traits; describe the relative life history diversity of juvenile offspring for all possible parent cross types (F1 and F2); estimate the NOR stray rate; estimate contribution of jacks to the natural population; and evaluate population growth of NOR and HOR populations to determine when the supplementation program is successful.

Sea Resources will work collaboratively with the U.S. Fish and Wildlife Services' Abernathy Fish Technology Center (AFTC) to accomplish the tasks of this project. Sea Resources will coordinate all sampling and data gathering activities from its facilities in Chinook, WA. All genetic and physiological analyses will be completed by the AFTC.

PROJECT DESCRIPTION

I Background

A. Project Overview

This project is intended to meet the requirements of Reasonable and Prudent Alternative 182 of the NOAA Fisheries' 2000 Biological Opinion on the Operation of the Federal Columbia River Power System. We will use genetic pedigree analysis to determine the relative reproductive success of Hatchery-Origin (HOR) and Natural-Origin (NOR) salmon in the Chinook River. Due to the current level of monitoring and evaluation on this Columbia River tributary (described below in Section D) we will not only be able to determine reproductive success but also the genotypic basis of life history characters at multiple life stages. Phenotypic traits such as survival at multiple life history stages will be integrated with genotypic information to determine the importance of those traits for individual fitness measures. Determining the effectiveness of the HOR portion of the naturally reproducing population will help estimate the degree of population growth necessary to achieve recovery of the population and terminate supplementation of the natural population with hatchery fish.

The most recent conclusions from NMFS' BRT (February 2003) identified Lower Columbia River (LCR) coho as in the "danger of extinction" category. Naturally spawning populations of coho salmon throughout the Columbia River Basin are severely depressed. Native populations are considered extinct in the Snake River and in the Columbia River upstream from Bonneville Dam, except in the Hood River (Nehlsen et al. 1991; Johnson et al. 1991). Populations throughout the LCR were severely impacted by logging practices and overfished to near extirpation after the development of an extensive hatchery program in the 1960's (Flagg et al. 1995). A *biological review team* for NMFS concluded that they could not find evidence for any remaining native populations of coho salmon in the LCR except in the Clackamas River (Johnson et al. 1991). NMFS concluded that native populations may be largely extinct because of severe overfishing and extensive straying and natural spawning by transplanted (or outplanted) HOR fish. Much of the critical freshwater habitat for coho salmon in the LCR has not fully recovered since old-growth forests were logged and splash dams were used to transport felled trees. Coho salmon juveniles are highly dependent on deep pool areas and large woody debris in small streams for refuge and feeding (Cedarholm et al. 1997), and these types of freshwater habitats may require many decades to recover fully to their historical levels of natural productivity.

Evaluating the appropriateness and effectiveness of hatchery restoration in this tributary of the Columbia River will provide direction for other similar efforts throughout the Basin and in the Region. There are extensive efforts underway to reintroduce and enhance naturally spawning populations of coho salmon throughout the middle and upper Columbia River Basin using hatchery strategies (Craig Busack, WDFW; Joel Hubble, YIN, pers. comm). However, these strategies have yet to be proven and the success of HOR and NOR coho have yet to be evaluated. The currently proposed project in the LCR may provide information valuable to those programs.

Locally, the project has immediate and direct applicability to salmon recovery efforts by Sea Resources in the watershed. In accordance with recent conclusions concerning LCR coho salmon, Sea Resources has multiple projects addressing restoration of critical freshwater and estuary habitat for coho salmon and other native species. This proposed project will provide information necessary to make informed hatchery management/salmon restoration decisions. Sea Resources is working to use a hatchery broodstock to reestablish a viable self-sustaining population of coho salmon in the Chinook River.

The project will be accomplished through a collaborative effort between Sea Resources and the U.S. Fish and Wildlife Service's Abernathy Fish Technology Center (AFTC).

B. Project Context

In 1893, the State of Washington established the Chinook River hatchery to support the local commercial fishing industry. Commercial fishers captured returning adult salmon from the mainstem Columbia River and transported them in live boxes to the Chinook River. The fish were subsequently passed above a retaining rack/weir 2 kilometers upriver preventing their return to the Columbia River. The salmon would ripen and swim upriver to a secondary trap where they were captured and taken into the hatchery. At the height of its operation the hatchery maintained a production capacity of over 9 million fry – though actual production rarely exceeded 4 million. Chinook salmon were the primary species produced, coho salmon and chum salmon constituted a relatively small proportion of the hatchery production.

The two actions of 1) creating a migration blockage in the lower river to prevent the escape of captured broodstock and 2) introducing massive numbers of offspring (from parents of mixed origin) into the river likely eliminated any endemic salmon populations in the Chinook River. In 1935, fish traps were outlawed and without this ready source of brood stock the hatchery was closed.

In 1968, local community members resurrected the historic hatchery to create a nonprofit vocational education program for area youth. There was also a desire that the refurbished hatchery could restore severely depressed salmon populations in the Chinook River. Nevertheless, after years of poor salmon returns, program supporters began to accept the reality that the hatchery could not bare the entire burden of salmon restoration. A new strategy was required. Hatchery production was only addressing a symptom (lack of salmon) of a larger problem (impaired habitat).

In 1996, Sea Resources initiated a new salmon restoration effort in the Chinook River. The restoration strategy emphasized the reestablishment of lost or impaired watershed processes that shape and maintain the diversity of habitats required for all freshwater and estuary life stages of native salmon. The strategy also suggested the use of artificial production to reintroduce extirpated salmon species to the river. Today, Sea Resources operates the Chinook River hatchery to propagate Chinook salmon, coho salmon, and chum salmon – species believed to be native to the river. Returning adults of all species are either passed above the hatchery or taken as broodstock. The primary intent of the artificial production program is that, over time, HOR fish will naturalize in the Chinook River.

In 1996 and 1997, Sea Resources received over 47,000 coho fry from the WDFW Elochoman River Hatchery to support the coho salmon reintroduction effort (Table 2). In 1999, Sea Resources began passing the majority of returning adult salmon upriver in an attempt to reestablish a naturally reproducing population (Table 1). In 1999-2002 a mixture of both HOR and NOR fish were released above the hatchery. The remaining fish were taken as hatchery broodstock. In 2000, Sea Resources installed two rotary screw migrant traps (Figure 1) to monitor the result of natural production. The upper trap is located at Sea Resources' facility (RKm 6.2) and the lower trap is located in the tidal waters at the river's mouth. In 2001, an estimated 36,410 age 0+ and 3,182 age 1+ coho salmon emigrated from the upper watershed where HOR and NOR fish spawning occurred. In 2002, the emigrant estimates were 34,222 for age 0+ and 1,174 for age 1+. At the lower trap we observed 6,875 coho smolts (age 1+) in 2001 and 9,003 smolts in 2002. It was clear that natural production was occurring in the river – however the relative success of HOR and NOR fish is unknown.

A series of independent scientific reviews have been prepared to address concerns and potential risks related to the operation of artificial production facilities (Independent Scientific Group 1996; National Research Council 1996; Independent Scientific Advisory Board 1998; Northwest Power Planning Council 1999; and Independent Multidisciplinary Science Team 2000). Most recently (April 16, 2001), the Independent Scientific Advisory Board (ISAB) produced a document that addressed questions related to natural spawning by hatchery-reared salmon. Sea Resources is in the process of developing an artificial production management plan that will integrate all applicable recommendations offered by these reviews. The plan will be consistent with the overall goal of restoring viable self-sustaining natural populations in the Chinook River. Current hatchery management strategies include reduction of rearing densities, "naturalizing" the rearing environment, introducing predators into the rearing environment, integrating a factorial spawning design to maximize genetic diversity, tracking fecundity and offspring survival for each female, and replacement of an out of basin chum salmon stock (from Willapa Bay) with a Columbia River stock (Grays River).

Table 1. Coho Salmon Return History, 1996 to 2002, Chinook River, WA.

	Hatchery Broodstock			Released upstream of SR			Total Returns		
Return Year	Males*	Females	Total	Males*	Females	Total	Males*	Females	Total
1996	2	4	**6**	0	0	**0**	2	4	**6**
1997	19	32	**51**	11	11	**22**	30	43	**73**
1998	5	9	**14**	1	2	**3**	6	11	**17**
1999	13	9	**22**	157	115	**272**	170	124	**294**
2000	2	19	**21**	60	80	**140**	62	99	**161**
2001	10	8	**18**	21	19	**40**	31	27	**58**
2002	0	10	**10**	280	279	**559**	280	289	**569**

*Does not include jacks.

Table 2. Coho salmon release summary 1996 to 2002, Chinook River, WA.

Parent Return Year	Brood Year	Release Year	Return Year	Number Released	Stock
		1996	1997	0	
	1996	1997	1998	47,598	Elochoman
1996	1997	1998	1999	47,099	Elochoman
1997	1998	1999	2000	2,289	Chinook River
1998	1999	2000	2001	0	
1999	2000	2001	2002	28,850	
2000	2001	2002	2003	3,420	

Sea Resources' long-term monitoring strategy is to evaluate the effectiveness of all restoration actions in the Chinook River – including hatchery production. These restoration actions are to be treated as experiments to allow for the broader applicability of lessons learned to other similar efforts throughout the Lower Columbia/Pacific region.

C. The Chinook River

The Chinook River drains a relatively small watershed that encompasses about 34 km^2. The river flows into Baker Bay - at approximately River Kilometer (RKm) 9 of the Columbia River (Figure 1). Five species of salmonids reproduce naturally in the watershed. Chum salmon and Chinook salmon are listed as threatened under the Endangered Species Act (ESA), coho salmon

are a candidate species (and have been strongly recommended by NMFS for listing in the LCR) for listing under the ESA, and steelhead trout and coastal cutthroat trout reproduce in the river at depressed levels. Sea Resources' facilities are situated at RKm 6.2 of the Chinook River. Sea Resources is a community-based non-profit organization dedicated to the dual mission of watershed restoration and science-based education.

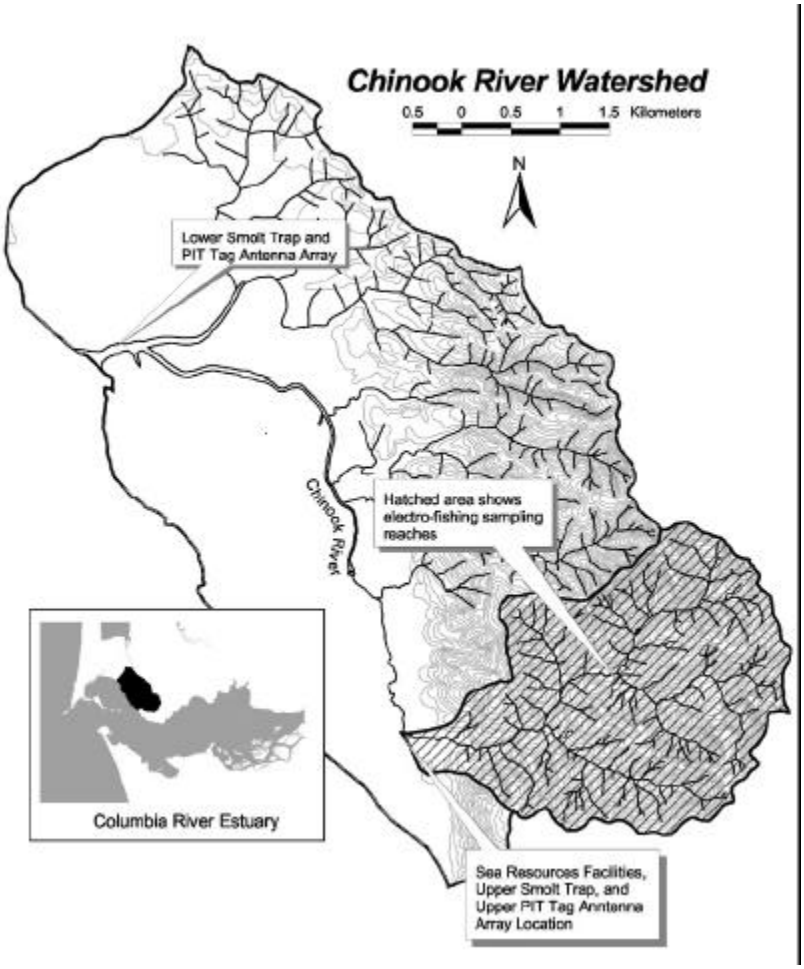

Figure 1. Map of the Chinook river watershed.

D. Concurrent complementary activities / Cost Savings

This project will take advantage of opportunities provided by a variety of ongoing research, monitoring, and evaluation activities – thereby maximizing the cost effectiveness of this project.

Hatchery Propagation of Coho Salmon

As described above, Sea Resources is managing an artificial production program in the Chinook River. This provides a significant potential cost savings for the project. Hatchery operations are supported through Sea Resources' general budget, volunteer community support, and student assistance. Activities associated with the capture and passing of adults will provide opportunities to fulfill Objective 1 Tasks a and b, and Objective 2 Task a. All hatchery reared fish are fin-clipped to allow identification of HOR and NOR fish captured as smolts or adults.

Effectiveness monitoring of the Chinook River estuary restoration project

BPA has recently confirmed its intent to fund a project Sea Resources submitted under the latest Provincial Review Process. This project has been funded to design and implement a long-term monitoring and evaluation plan to investigate salmon population responses to the Chinook River estuary restoration project. Project tasks include operation of two rotary screw migrant traps to monitor magnitude and timing of juvenile salmon migration events (Figure 1). We will operate these traps daily through out the year. This monitoring and evaluation effort will be used for cost savings under Objective 2 Task b of this proposed study. These sampling activities will be used to capture, collect biological data, and PIT tag individuals, collect genetic samples, and assign life history traits to individuals.

Movements of coastal cutthroat trout (*Oncorhynchus clarki*) in the Lower Columbia River: tributary, main-stem and estuary use

The U.S. Fish and Wildlife Service has implemented a study on the mainstem Columbia River and a series of Lower Columbia River tributaries (including the Chinook River) to characterize coastal cutthroat habitat use and life history traits (P.I. Joseph Zydlewski, U.S. Army Corps of Engineers funded). As a result, two PIT tag interrogation arrays have been installed on the Chinook River - at both migrant trap locations. These arrays allow passive monitoring of movement and habitat use of individuals bearing PIT tags. The cutthroat study also involves electrofishing upper watershed reaches. This monitoring and evaluation effort will also be used for cost savings under Objective 2 Task b. These sampling activities will be used to collect genetic samples and assign life history traits to individuals.

II Proposal Objectives, Tasks, and Methods

Objective 1. Assess the natural reproductive success of hatchery-origin (HOR) and natural-origin (NOR) adults in the Chinook River using parentage analysis.

Task a. 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 coho salmon (Mike Ford, NMFS, unpublished data on Minter Creek, WA) on a sample of 50 HOR and 50 NOR adults. 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 b. Conduct parentage analysis of HOR and NOR adult coho salmon spawning in the Chinook River.

Methods: All adult coho salmon passed upstream of the weir at Sea Resources (Figure 1) to spawn will have a fin clip taken, and represent potential parents. Approximately 2000 offspring produced by each set of potential parents will be collected as juveniles at multiple life history stages (for details please see Objective 2). All tissue samples will be stored in 100% ethanol. DNA extractions, microsatellite loci, and PCR conditions will be as outlined in **Task a**. 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 assign 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, see attached timeline).

Objective 2. Assess phenotypic traits to explain the mechanisms responsible for survival differences.

Task a. Determine phenotypic traits of returning adults (F1 and F2 of known parentage).

Hypothesis: Phenotypic traits of adults from all cross-types (NORxNOR, NORxHOR, and HORxHOR) are the same.

Alternate hypothesis: Phenotypic traits of F1 and F2 adults from different crosses are different. For example, egg size of HORxHOR crosses may be smaller than those of NORxNOR, and migration timing of HORxHOR crosses may be earlier than those of NORxNOR. Analysis of these types of data will allow estimates of directional selection on these characters.

Methods:

All coho salmon adults (NOR = unclipped; HOR = adipose clipped) collected at the Sea Resources adult weir will be fin-clipped for genetic analysis (see Objective 1 task b) and measured (length, weight, and morphometrics) before being passed upstream. Fecundity and egg size will be determined for each female spawned at the hatchery (fin-clips will be taken from these individuals for determination of parentage, particularly for F1 and F2 generations). Migration timing of every individual will be recorded for reconstruction of the run by cross-type. An approximately equal proportion of NOR and HOR adults will be passed upstream of the weir for natural production of the F2 generation to be sampled as juveniles the following winter, summer, and spring (see Task b) then as adults two and three years later (please see attached timeline).

Task b. Determine phenotypic traits of progeny (F1 and F2) produced from all cross-types of naturally produced coho salmon.

Hypothesis: Phenotypic traits demonstrated as juveniles are the same for all cross-types.

Alternate hypothesis: Phenotypic traits of F1 and F2 juveniles are different for different cross-types. For example, fry to parr survival is greater in NORxNOR crosses than in HORxHOR crosses; physiological characters of smolting are more strongly demonstrated in NORxNOR crosses than in HORxHOR crosses; and smolt migration timing is earlier for HORxHOR than for

NORxNOR. These types of analyses will begin to uncover mechanisms resulting in differential survival at multiple life stages.

Methods:

A trap, located adjacent to the adult weir (Figure 1), will be operated year-round to collect virtually all outmigrant juveniles emigrating from the watershed above the adult weir (effectively monitoring all production of all adults passed above the weir). A seasonally stratified sample of fry will be fin-clipped for genetic analysis to determine fry survival of each cross-type in the F1 and F2 generations of previously pedigreed individuals. The fry will also be measured to determine differential survival based on size.

Parr survival will also be estimated using depletion estimates with electrofishing techniques. Approximately 1000 individuals will be collected in a stratified manner throughout the watershed upstream of the adult weir. All individuals will be fin-clipped for genetic analyses, measured for length, weight, morphometrics, and PIT tagged (for passive monitoring of migration timing).

Smolt survival and life history characteristics: behavioral (outmigration timing), physiological (gill Na^+,K^+-ATPase activity and thyroid hormone profile), and morphological characters (morphometrics) will be examined at the trap at Sea Resources. The remote PIT tag monitoring station already in place at Sea Resources will collect outmigration timing of previously genotyped individuals (see parr section). Annually over 400 naturally produced smolts are collected at the trap. All individuals will be fin-clipped for genetic analysis and morphological measurements will be taken. A subsample (up to half) will be sampled non-lethally for physiological measurements.

Objective 3. Integrate genotypic and phenotypic information.

Task a: Analyze parentage results in the context of phenotypes.

Methods:

Parent-offspring information gained from Objectives 1 and 2 will be analyzed using appropriate statistical methods (most likely ANOVA to determine differences in distribution and chi-squared tests to determine differences in proportions of cross-types produced), we will be able to:

1) Determine statistically significant differences in reproductive success of F1 and F2 coho salmon from HORxHOR, HORxNOR, NORxNOR parents naturally spawned in the Chinook River. This will be done by determining the adult to adult survival of genotyped individuals and their progeny when they return as adults for multiple generations. This allows an absolute measure of fitness from adult to adult.

2) Determine the relative production of F2 progeny produced from HORxHOR, HORxNOR, and NORxNOR parents naturally spawning in the Chinook River. This will be done by measuring the reproductive success of NOR and HOR coho salmon at multiple life history stages and examining the offspring of genotyped adults at the fry, parr, smolt and adult life stages. The ability to examine multiple life stages is important because it allows us to determine if there is differential survival during the ocean life history phase for fish with HOR or NOR parents.

3) Determine if NOR and HOR fish mate randomly and produce offspring that have equal survival rates (at the fry, parr, smolt, and adult life history stages). This will be accomplished by comparing the observed distribution of NORxNOR, NORxHOR, and

HORxHOR matings against the null hypothesis (the two groups randomly mate and have offspring with equal survival rates).

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

5) Relate the distribution of juvenile (F1 and F2) life history traits (physiological-ATPase and thyroid hormone; morphological-morphometrics; and behavioral-juvenile migration timing) to adult survival of all possible cross-type.

6) Relate the distribution of adult life history (fecundity and egg size) and behavioral (migration timing) traits of F1 adults with adult survival.

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

8) Estimate the NOR stray rate. NOR adult salmon captured at the weir that we are unable to assign parentage to will be considered strays.

9) Estimate the contribution of jacks to the natural population. All jacks will be genotyped and their overall contribution to the juveniles produced will be determined. This will allow us to determine the number of jacks to incorporate into the hatchery program and over time will allow evaluation of the potential change in the importance of jacks to the natural population.

10) Evaluate population growth of NOR and HOR populations to determine when the supplementation program is successful and HOR adults do not need to be passed above the adult weir.

IV. References:

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QUALIFICATIONS OF PARTICIPANTS

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Education:

M.S., Environmental Science – Aquatic Ecology, University of Idaho, 1999
B. Arch., Architecture, University of Idaho, 1993

Employment:

2000-present: Executive Director, Sea Resources, Inc., Chinook, WA

1998-2000: Natural Resource Specialist, Columbia River Estuary Study Taskforce, Astoria, Oregon.

1997: Field Technician, Lower Snake River Primary Productivity Assessment Project, Department of Fish and Wildlife, University of Idaho, Moscow, ID.

Project Roles:

Project administration and management, fiscal management, field work coordination, sample collection, data management, and report writing.

Qualifications:

Robert is responsible for administration and oversight of all of Sea Resources' restoration and education programs. He is currently Principal Investigator of 1 new project with the Bonneville Power Administration (contract pending), and manages 2 contracts with the Salmon Recovery funding Board ($775,000 total) 2 projects with the Bonneville Environmental Foundation ($85,000), and a variety of other smaller private grants.

Robert's experience includes implementation of the Chinook River watershed restoration plan; restoration project design, management and coordination; monitoring program design, organizational financial management; grant proposal writing; personnel supervision; public speaking and presentations; project proposal development; and participation in delivery of the educational program.

Relevant Grants:

Warren, R.F., G. Gale. 2003. Effectiveness monitoring of the Chinook River estuary restoration project. $95,000. BPA Project #2003-999-02 (contract pending). May 1, 2003-April 30, 2004. COTR: Jessica Wilcox.

Warren, R.F. 2000. Chinook River estuary restoration project. Salmon Recovery Funding Board. $375,000. End date March 2005. Project Manager: Barbara McIntosh.

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Education:

Ph.D., Oceanography, University of Maine, 1996
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B.S., Biology, Southeastern Massachusetts University, 1990

Employment:

1999-present: Behavioral Physiologist, U.S. Fish and Wildlife Service, Abernathy Fish Technology Center, Longview, WA
1997-1999: Postdoctoral Research Associate, USGS/BRD, Conte Anadromous Fish Research Center, Turners Falls, MA
1996-1997: Postdoctoral Research Associate, University of Maine, School of Marine Sciences, Orono, ME

Project Roles:

Project coordination with U.S. Fish & Wildlife Service, PIT tag database management, physiological and morphological analyses, statistical integration of phenotypic and genotypic information..

Additional Qualifications:

Gayle has served as Principal Investigator or co-investigator on 7 contracts with associated grants, including one from the Bonneville Power Administration and two from the U.S. Army Corps of Engineers. She has authored and co-authored approximately 10 peer-reviewed publications. She has worked professionally in the area of fish behavior and physiology for approximately 12 years and currently investigates the relationships between juvenile rearing strategies and adult return rates; the effects of modifications and enhancements to hatchery rearing environments on fish growth, behavior, physiology and survival; new approaches to investigate the extent of interactions between hatchery-reared and wild fish; and restoration and recovery strategies for populations in decline. The collaborative project on cutthroat trout listed below resulted in construction of PIT monitoring systems on the Chinook River.

Relevant Grants:

Zydlewski, G.B., A. Haro, T. Coley, J. Johnson. 2001. Evaluate new methodologies for monitoring Pacific salmon and steelhead: Methods for evaluating the effectiveness of restoration and recovery programs. $ 217,000. BPA Project #2001-012-00. 15 May 2001 – 15 August 2002. Contracting Officer: Pat Poe.

Zydlewski, J. (G.B. Zydlewski co-investigator). 2002. Movements of the Coastal Cutthroat Trout in the Lower Columbia River: Tributary, Main-Stem and Estuary Use. U.S. Army Corps of Engineers. $360,000. April 2002 – April 2007.

Recent Publications:

Zydlewski, G.B., A.J. Haro, K.G. Whalen, & S.D. McCormick. 2001. Performance of stationary and portable Passive Transponder detection systems for monitoring of fish movements. Journal of Fish Biology. 58(5): 1471-1475.

Zydlewski, G.B., S. Foott, K. Nichols, S. Hamelberg, J. Zydlewski, B. Th. Björnsson. In Press. Enhanced smolt characteristics of steelhead trout exposed to alternative hatchery conditions during the final month of rearing. Aquaculture.

Zydlewski, G.B., J. R. Johnson. 2002. Response of bull trout fry to four water diversion screen types. North American Journal of Fisheries Management. 22: 1276-1282.

Zydlewski, G.B., S.D. McCormick, & A.J. Haro. In Review. The role of temperature in downstream migratory behavior of Atlantic salmon smolts.

William R. Ardren

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EDUCATION

Ph.D. (Fisheries Science): June, 1999. University of Minnesota, Department of Fisheries, Wildlife and Conservation Biology, St. Paul, MN.
Advisor: Anne Kapuscinski.

B.A. (Biology): May, 1993. St. John's University, Department of Biology, Collegeville, MN.

EMPLOYMENT

2002-present: Molecular Population Geneticist, U.S. Fish & Wildlife Service, Abernathy Fish Technology Center, Longview, WA.

2001-2002: Post-Doctoral Research Associate, Department of Zoology, Oregon State University, Corvallis OR.

1999-2001: Assistant Professor, Department of Biology, Luther College 700 College Dr., Decorah IA.

PROJECT ROLES

Oversee genetic analysis of all samples, conduct parentage analysis, maintain genetic database, and carry out statistical analyses to determine the reproductive success of hatchery and wild spawners.

ADDITIONAL QUALIFICATIONS

W.R. Ardren 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's post-doctoral research at Oregon State University involved using microsatellite loci and pedigree reconstruction to determine the relative reproductive success of hatchery and wild steelhead trout (*Oncorhynchus mykiss*) in the Hood River, OR. Examples of other research projects Dr. Ardren has accomplished include describing the inheritance of microsatellite loci in steelhead trout, conducting a genetic analysis of a captive breeding program for an endangered steelhead trout population, and using demographic and genetic estimates of effective population size to clarify the relationship between long-term changes in genetic diversity and population productivity. In addition, he has isolated and characterized microsatellite loci for two species of fish and co-authored a review paper on methods of parentage analysis in natural populations.

RELEVANT GRANTS

Ardren, W.R., and D.E. Campton. Genetic Analyses of Steelhead in the Hood River. $14,436, BPA Contract No. 00013429, April 1, 2003 – September 30, 2003. BPA Contracting Officer: Tom Morse, 503-230-3694.

Ardren, W.R. Genetic Analysis of the Keogh River Steelhead Trout Living Gene Bank. $7351, British Columbia Ministry of Fisheries Contract No. 1070-20/01-49 and British Columbia Conservation Foundation Contract No. LM00-02, 1999-2001.

RELEVANT PUBLICATIONS

Ardren, W.R., S.O. Borer, F. Thrower, J.E. Joyce and A.R. Kapuscinski. 1999. Inheritance of 12 microsatellite markers in *Oncorhynchus mykiss.* Journal of Heredity, 90:529-536.

Ardren, W.R., L.M. Miller, J.A. Kime, and M.A. Kvitrud. 2002. Microsatellite loci for fathead minnow (*Pimephales promelas*). Molecular Ecology, Notes 2:226-227.

Ardren, W.R. and A.R. Kapuscinski. 2003. Demographic and genetic estimates of effective population size (N_e) reveals genetic compensation in steelhead trout. Molecular Ecology, 12:35-49.

Jones, A.G. and **W.R. Ardren**. Review Paper: Methods of parentage analysis in natural populations. Molecular Ecology, *Accepted for publication pending minor revision.*

Ardren, W.R. and M. Blouin. Relative reproductive success of hatchery and wild steelhead trout spawning in Hood River Oregon. *In Preparation.*

	Anticipated Project Cost					
	FY04	**FY05**	**FY06**	**FY07**	**FY08**	**FY09**
Personnel (includes Sea Resources and USFWS staff)	41,337	44,777	48,527	52,616	57,075	61,940
Equipment	5,000	0	0	0	0	0
Supplies	1,200	4,350	4,350	4,350	4,350	4,350
Genetic Samples	78,000	90,000	72,600	90,600	90,600	30,600
Physiological Samples	1,000	3,200	3,200	3,200	3,200	3,200
Overhead (Combined Sea Resources and USFWS)	26,804	30,222	27,273	32,007	32,949	21,078
Yearly Total	153,341	172,550	155,950	182,772	188,174	121,168
Grand Project Total	**973,955**					

Timeline for examining reproductive success and phenotypic traits relative to survival for coho salmon in the Chinook River. Like colors follow RY and BY through different life history stages from F1 through F2 generations.

Timeline	Life History Event	Generation	Task	Sample sizes
Sep-03				
Oct, Nov, Dec-03	RY 03	P	Spawn (collect morphometrics) & track adults (monitor behavior of adults)	[a]600
Jan-04				
Feb, Mar, Apr-04	BY 04 hatch	F1	Collect BY 04 fry (morphometrics)	[b]1000
May, Jun, Jul-04				
Aug-04		F1	Collect BY 04 parr (morphometrics, PIT tag to monitor smolt behavior)	[c]1000
Sep-04				
Oct, Nov, Dec-04	RY 04		Spawn	600
Jan-05				
Feb, Mar, Apr-05	BY 05 hatch BY 04 emigrate	F1	Collect 05 fry Collect BY 04 smolts (morphometrics and physiology)	1000 [d]400
May, Jun, Jul-05				
Aug-05			Collect 05 parr	1000
September-05				
Oct, Nov, Dec-05	RY 05 (BY 03)	F1	Collect 04 jacks returning (morphometrics & monitor behavior)	[e]20
Jan-06				
Feb, Mar, Apr-06	BY 06 hatch BY 05 emigrate		Collect 06 fry Collect 05 smolts	1000 400
May, Jun, Jul-06				
Aug-06			Collect 06 parr	1000
Sep-06				
Oct, Nov, Dec-06	RY 06 (BY 04) *Produce F2 progeny*	F1	Collect BY 04 age 3 returning (morphometrics and behavior) Collect 05 jacks returning	600 20
Jan-07				
Feb, Mar, Apr-07		F2 F1	*Collect F2 progeny fry* Collect 06 smolts	1000 400
May, Jun, Jul-07				
Aug-07		F2	*Collect F2 progeny parr*	1000
Sep-07				
Oct, Nov, Dec-07	*Produce F2 progeny*		Collect 05 age 3 returning Collect 06 jacks returning	600 20
Jan-08				
Feb, Mar, Apr-08		F2 F2	*Collect F2 progeny fry* *Collect F2 progeny smolts*	1000 400
May, Jun, Jul-08				
Aug-08		F2	*Collect F2 progeny parr*	1000
Sep-08				
Oct, Nov, Dec-08		F1	Collect 06 age 3 returning *Collect F2 jacks returning*	600 *20*

Table continued below.

Jan-09				
Feb, Mar, Apr-09		F2	*Collect F2 progeny smolts*	400
May, Jun, Jul-09				
Aug-09				
Sep-09				
Oct, Nov, Dec-09		F2	*Collect F2 age 3 returning* *Collect F2 jacks returning*	600 *20*

Notes: Measurements indicated in parentheses for RY 03 and BY 04 will also be conducted for subsequent RYs and BYs of the same life stage.

[a] A maximum of 600 adults are predicted to return to the adult weir at Sea Resources in Fall of 2003.

[b] Annually, approximately 8000–10000 fry are trapped at Sea Resources during the emigration in the winter/early spring.

[c] Based on fry and smolt estimates and several electrofishing trips, up to 1000 parr can be collected upstream of Sea Resources.

[d] Annually, approximately 400 smolts are trapped at Sea Resource during the emigration in two springs after hatch.

[e] Annually, 6 – 26 jacks have been passed upstream of Sea Resources over the past 4 years.