Basinwide Supplementation Evaluation – Phase I

Table 1. Proposal Metadata

Project Name	Basinwide Supplementation Evaluation – Phase I
Project Number	2009-009-00
Proposer	Peter F. Galbreath
Short Description	This project integrates several actions which support recommendations from the *Ad Hoc* Supplementation Workgroup (AHSWG) for implementation of a basinwide evaluation of the long term effects of supplementation on productivity of natural anadromous salmonid populations in the Columbia basin. In this first year (Phase I) of the 10-year project, four specific project objectives have been identified: 1) to use a pair of Dual-Frequency Identification Sonars (DIDSON) to obtain an estimate of the 2009 natural spawning escapement of spring Chinook in the upper basin of the Klickitat River, 2) to complete development of a mark-recapture likelihood model which incorporates tag loss into the inference for population abundance, 3) to initiate a relative reproductive success (RRS) study in a project chosen from among supplementation monitoring and evaluation (M&E) programs for which tissue samples have been collected but for which genetic analysis and estimation of RRS remains unfunded, and 4) to initiate studies to obtain estimates of RRS of natural-origin versus hatchery-origin salmon which naturally spawn for four to five different populations which have been reintroduced (following extirpation of the native population) and supported through hatchery supplementation.
Province(s)	*Basinwide*
Subbasin(s)	*Basinwide*
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NOTE: This integrated project combines three projects previously identified separately under the Columbia Basin Fish Accords (Accords 2008), whose tasks are found within one or more of the integrated Project Objectives:

Original Accord Title	Original Project No.	Tasks Within 2009-009-00 Project Objectives
Improved Escapement Estimation	2008-513-00	Objectives #1 and #2
Basin-wide Evaluation of Supplementation Benefits and Risks	2008-522-00	Objectives #3 and #4
Supplementation Monitoring	2008-523-00	Objective #4

A draft narrative for the Supplementation Monitoring project (No. 2008-523-00), renamed Relative Reproductive Success of Reintroduced Columbia River Salmon Populations – Phase I, was submitted on November 3, 2008 under its original project number. In response to comments received from the ISRP on December 15, 2008, the rationale and design of the proposal were modified, and the proposal was then incorporated into this integrated project (2009-009-00) as Project Objective #4. Additional information regarding responses to ISRP comments is contained in a separate document, uploaded as an attachment to Project 2009-009-00 in PISCES entitled “200852300 Reply to ISRP.doc”.

A. Abstract

The goal of this project is to initiate a series of actions which support recommendations of the *Ad Hoc* Supplementation Workgroup (AHSWG) for a basinwide evaluation of the long term effects of hatchery supplementation on productivity of naturally spawning anadromous salmonid populations in the Columbia River basin (AHSWG 2008). The AHSWG used the widely accepted definition of supplementation provided by the Regional Assessment of Supplementation Project (RASP 1992):

> *Supplementation is the use of artificial production in an 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.*

The primary focus of the AHSWG (2008) recommendations is on acquisition and evaluation of more, and more reliable (accurate and precise), information on: a) trends in abundance and productivity of supplemented salmon and steelhead populations (Recommendation I, p. 3), and b) relative reproductive success (RRS) of naturally spawning salmon of natural origin versus hatchery origin within supplemented populations (Recommendation II, p. 24). Natural origin (NO) fish are defined as ones which are the product of a natural spawning that occurred in a stream. Hatchery origin (HO) fish are defined as those which are derived from artificially fertilized eggs which, generally speaking, were then incubated and the fry reared in a hatchery for some period. (HO fish could also include those which were artificially spawned and released as early as fertilized eggs or hatchlings, although this management option is infrequently used.)

The plan for Phase I of this project proposal covers only the first year of the 10-year period of the Accords (2008). Phase I includes four specific Project Objectives (with the total number of years projected for each Objective within the period of the Accords indicated in parentheses):

1) to use a pair of Dual-Frequency Identification Sonars (DIDSONs) to obtain an estimate of the 2009 natural spawning escapement of the supplemented spring Chinook population upstream of the Castile Falls complex in the upper basin of the Klickitat River (3 years)
2) to complete development of a mark-recapture likelihood model which incorporates tag loss, including the uncertainty of the tag loss estimate, into the inference for population abundance (1 year)
3) to perform a relative reproductive success (RRS) study of NO versus HO salmon in a population associated with an ongoing supplementation monitoring and evaluation (M&E) program for which tissue samples have been collected but for which genetic analysis and estimation of RRS remains unfunded (10 years)
4) to perform RRS studies of NO versus HO salmon in four to five different populations which have been reintroduced (following extirpation of the native population) and supported through hatchery supplementation (10 years)

B. Background

In 2005, the Independent Scientific Review Panel (ISRP) and Independent Scientific Advisory Board (ISAB) submitted to the Northwest Power and Conservation Council (NPCC) a report entitled “Monitoring and Evaluation of Supplementation Projects” (ISRP and ISAB 2005). The request by the NPCC for this review was prompted by controversy among fisheries scientists and managers over critical uncertainties regarding use of hatchery supplementation to rebuild depressed populations - whether supplementation can indeed provide the intended short term demographic benefits, and whether these benefits might be outweighed by longer term decreases in natural fitness of the affected population (ISRP 2005). In their report, the ISRP and ISAB examined the nature of the demographic, genetic and ecological risks associated with supplementation. They described the challenges to collecting the kind and amount of monitoring data that would be needed to quantify effects of supplementation on population abundance and productivity, both within and across programs, and provide ideas and recommendations for development of a coordinated basinwide evaluation of supplementation. Finally, they recommended creation of an interagency work group to take on the task of elaborating a design(s) to perform this evaluation.

In response to this latter recommendation, the *Ad Hoc* Supplementation Workgroup (AHSWG) was formed – a group of volunteer scientists and managers associated with tribal, state and federal fisheries agencies, as well as power companies and other non-governmental agencies. Building off discussions held during three successive Supplementation Monitoring and Evaluation Workshops, the AHSWG summarized their analysis and recommended a three-pronged approach to an assessment of supplementation (AHSWG 2008). This approach would involve: 1) treatment/reference (T/R) comparisons of long-term trends in the abundance and productivity of supplemented (treatment) populations relative to un-supplemented (reference) populations, 2) conducting a series of relative reproductive success (RRS) studies to quantify short-term impacts through comparisons of productivity within broodyears of hatchery-origin and natural-origin fish in supplemented populations, and 3) development of a request for proposals to fund several intensive small-scale studies designed to elucidate various biological mechanisms by which introduction of hatchery-produced fish may influence natural population productivity. Past and ongoing M&E of hatchery supplementation programs have provided a large amount of information for T/R studies, and RRS studies have been initiated in several populations. However, the highly variable nature of the physical environment and the fisheries and habitat management programs, both within supplemented populations over time, and among supplemented populations, renders application of analytical designs for both study types problematic. The AHSWG therefore recommended that M&E programs be expanded to provide additional data on population abundance and productivity, to lend more power to the analyses. The AHSWG also recognized that even with increased data, logistical and design constraints make neither the T/R nor the RRS approach alone sufficient to clarify the uncertainties regarding long-term effects of supplementation. However, they concluded that the two approaches are complementary, and that if both are pursued, together will provide managers with an increasingly clear picture of the nature and magnitude of these long-term effects.

The unifying objective of the present project is to implement actions which support these recommendations from the AHSWG – in particular, actions which improve abundance and productivity estimation procedures used in monitoring supplemented and reference populations, actions which provide RRS information from supplemented populations, and actions to support coordinated analysis of this information within the context of a general evaluation of the risks and benefits of supplementation as a management strategy. In this plan for the first year (Phase I) of this 10 year project, we propose the following four objectives: 1) to use a pair of Dual-Frequency Identification Sonars (DIDSON) to obtain an estimate in 2009 of the naturally spawning population of spring Chinook in the upper basin of the Klickitat River, 2) to complete development of a likelihood model which incorporates tag loss, including the uncertainty associated with the estimate of the rate of tag loss, into the inference for population abundance based on data from mark-recapture studies, 3) to evaluate RRS of natural origin (NO) and hatchery origin (HO) adults for a project chosen from among ongoing supplementation monitoring programs for which tissue samples have been collected but for which genetic analysis and estimation of RRS have remained unfunded, and 4) to obtain RRS estimates of naturally spawning salmon of natural versus hatchery origin, in four to five different populations which have been reintroduced (following extirpation of the native population) and supported through hatchery supplementation.

Project Objective #1: DIDSON Escapement Estimation

Estimates of annual adult escapement of reasonable accuracy are necessary for informed management of any anadromous salmonid population, and are of particular importance when assessing population abundance and productivity trends in supplemented versus reference (unsupplemented) populations. Not only did the AHSWG call for increased monitoring of these population metrics, they emphasized the need for standardization of protocols, and adoption of methodologies which provide improved levels of accuracy and reliability.

In river systems where fish can be trapped at a weir or dam, direct observation of migrating fish can provide accurate estimates of population abundance. However, these structures do not exist in many river systems, or they exist but only capture a portion of the population (e.g., Lyle Falls fish ladder on the Klickitat River – see below). In these instances, alternative methodologies must be used to make indirect

estimates of total escapement. A technique commonly used by fisheries managers involves counting of redds over the spawning season, the number of which is expanded by an estimate of the average number of adult fish per redd, to obtain the estimate of total escapement. However, sources of uncertainty are numerous in redd counting protocols and in calculation of the expansion factor, which together compromise the reliability of abundance estimates generated by this method (e.g., Mosey and Truscott 1999, Murdoch and Miller 1999, Dunham et al. 2001, Faurot and Kucera 2005, Gallagher et al. 2007). Escapement estimation in open river systems based on tower counts is another alternative, though of limited applicability due to its inability to provide counts at night (unless external lighting is installed), and to difficulties in obtaining accurate counts during periods of reduced visibility caused by glare, turbulence, and turbidity, etc. (Woody 2007). In lieu of direct visualization of fish practiced in tower counting, sonars of various types have also been used to enumerate fish passage events, with which to estimate population escapement. Because these instruments use sound waves as opposed to light waves, sonar systems have the advantage of remaining operational at night and under conditions of poor visibility. Single-beam, dual-beam and split-beam sonars have all been used for fish enumeration in lakes and rivers, however, each has problems with sensitivity and requirements for site-specific validation which compromise accuracy and precision of the resulting population estimates (Simmonds and MacLennan 2005, Maxwell 2007).

Technical improvements in a recently developed sonar system, the Dual-Frequency Identification Sonar (DIDSON™;Sound Metrics Corporation, Seattle, Washington, www.soundmetrics.com), address many of the short-comings of the previous sonar systems. A DIDSON repetitively emits multiple sound beams and uses its unique patented lens to resolve the reflections of objects passing within its field of view into a two-dimensional image – making it a sort of acoustic video camera. The standard model of the DIDSON (DIDSON-S) 48 or 96 sound beams at a high frequency (HF) or low frequency (LF) of 1.1 or 1.8 MHz, respectively. The long-range model (DIDSON-LR) emits 48 sound beams at 0.7 or 1.2 MHz. Placed in a body of water and oriented to transmit horizontally through the water column, it produces a top-down ("bird's-eye") view of the conically-shaped ensonified field. In field testing for fisheries applications, including salmon escapement estimation in rivers, the DIDSON has shown some significant advantages relative to other sonars (Moursund et al. 2003, Johnson et al. 2004, Maxwell and Gove 2004, Faurot and Kucera 2005, Galbreath and Barber 2005, Xie et al. 2005, Kucera and Orme 2006, Burwen et al. 2007, Maxwell 2007, Faulkner and Maxwell 2008, Melegari and Osborne 2008).

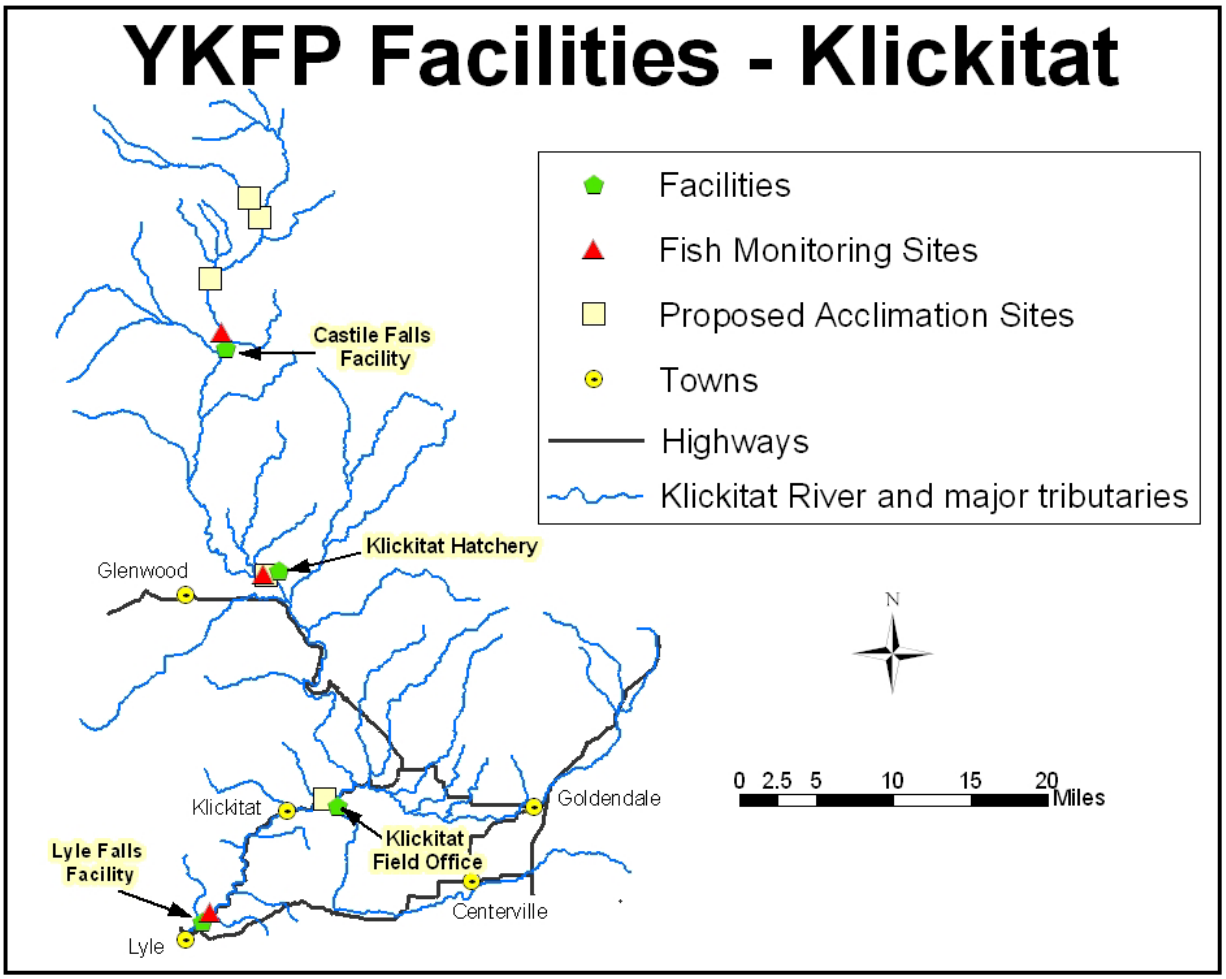
Despite its advantages, numerous logistical and technical factors must be taken into consideration if a DIDSON is to provide accurate counts of fish passage, with a final judgment on relative utility involving substantial site-specificity. The higher frequencies at which a DIDSON operates, relative to the other sonar systems, offer greater resolution to the images of moving objects. However, the operational range of a DIDSON decreases with an increase in frequency. For example, DIDSON-LR operated at LF (0.7 MHz) will resolve images at distances greater than 40m, but when operated at HF (1.2 MHz) the range is reduced to 20 to 25 m. For a DIDSON-S operated at HF (1.8 MHz), range is further reduced to 10 to 12 m. Siting and positioning of the DIDSON within the water body is also very important. The bottom conformation at the chosen location must be sufficiently regular so as to preclude shadowed areas within which fish movement would be undetected. High sediment loads and turbulence (which can entrain clouds of air bubbles into the water column) in the water will reflect the sound waves, generating a "noisy" background and substantially reducing resolution of images of migrating fish. Additionally, even under "ideal" conditions, the DIDSON provides only a rough image of shape and size of moving objects within the water column, and this image decreases in resolution with increasing distance. Distinguishing between species of similar sized fish within a DIDSON recording is therefore generally not possible. For example, in our initial tests of a DIDSON-LR in the Methow River, we were only able to categorize the images of passing fish into small, medium or large size classes. Steelhead and spring Chinook were migrating concurrently in the river at that time, and both were placed in the large category. As such, we were only able to provide a total count of upstream and downstream movement of large fish, not a count per species (Galbreath and Barber 2005). Another factor to consider is that while one can distinguish between, for example, large migrating salmonids versus smaller freshwater resident fish, presence of resident fish creates additional moving targets, which when in large number, makes the file reading process much more laborious. Ease of accessibility to the site, provision of power to the instrument, and security from vandalism or high water events are additional considerations.

A preliminary test to evaluate the capabilities of a DIDSON-LR to provide daily passage counts in the Klickitat River was conducted in 2008. The interest in use of a DIDSON in the Klickitat was motivated by the desire of managers to confirm the relative reliability of spring Chinook abundance estimates derived from annual redd counts in this river. A hatchery supplementation program for spring Chinook is ongoing in the Klickitat, with goals to rebuild an abundant natural population and to provide a harvestable surplus for tribal and non-tribal fishermen. Of note, responsibility for operation the hatchery was recently turned over to the Yakama Nation (YN), and broodstock management has been altered from a segregated to an integrated protocol, in line with recommendations of the Hatchery Scientific Review Group (HSRG 2004). Additionally, substantial effort is underway to improve and increase spawning and juvenile rearing habitat in the upper basin of the Klickitat (YN 2008). YN fisheries managers are therefore keenly interested in monitoring spring Chinook population trends, in order to evaluate the hatchery and habitat improvement programs. There is no dam nor weir in this river at a location upstream of the Klickitat Hatchery but downstream of the natural spawning area, at which escapement could be determined directly. Therefore, a systematic series of spring Chinook redd surveys are conducted annually, and these data are used to estimate total adult escapement (YN 2008, Chapter 3 Table 2). While these surveys do provide an index of trends in population size, an estimate of absolute abundance requires multiplication by an expansion factor. The expansion factor which has been used in the past is an average value (which ignores the year-to-year variability in this parameter) calculated for fish and redd abundance estimates derived not in the the Yakima River, not the Klickitat. A limited number of fish-per-redd estimates were estimated for in the upper basin of the Klickitat in recent years, however they were based not on naturally migrating fish, but instead on manual releases of Klickitat Hatchery origin adults collected in the hatchery ladder. Natural spawning success of these fish was likely not as high as that of naturally migrating fish, and as such, the resulting expansion factor likely overestimates the value for a natural population. If a DIDSON study could provide a reliable estimate of total abundance in one or more years, this value(s) could be used to calculate a Klickitat-specific estimate for the redd count expansion factor, which could be compared to the values derived in the Yakima River and from the hatchery releases, and appropriate correction, if warranted, could be made to improve accuracy of current and past population estimates of the Klickitat population.

In the 2008 trial, the DIDSON-LR was positioned at a site approximately 300m upstream of the Klickitat Hatchery, and all fish migrating above this location were presumed to be part of the naturally spawning population. While the Klickitat also has a steelhead population, the upstream migration of steelhead is essentially finished by the time the spring Chinook run begins at this location in the upper basin, such that all upstream counts can be attributed to Chinook. Of note, a percentage of post-spawning steelhead (kelts) migrate back out of the river, and kelts likely account for the large majority of downstream passage events observed in the DIDSON files. The number of downstream passage events would be deducted from the number of upstream events within days to provide net upstream daily counts representative of the spring Chinook escapement. The DIDSON-LR was set up in April 2008, and operated until the end of July. The sonar was programmed to record continuous 10-min files, with a field of view that alternated between the near shore (0 to 10 m) recorded at HF, and the far shore (10 to 30 m) recorded at LF.

The 2008 experience demonstrated promise for use of a DIDSON for the purpose of estimating fish passage in this river. Nonetheless, there were also several problems encountered during the trial. These included periods of apparent undercounting due to positioning of the instrument which permitted fish to pass undetected underneath the sound beams through a near-shore thalweg, loss of resolution during high flow events (due to high sediment loads and turbulence), and software “glitches” which caused the programmed recording to cease at unexpected times. In light of the difficulties encountered during the 2008 trial, we have altered the procedures envisioned for a study in 2009. Several km upstream of the Klickitat Hatchery is located the Castile Falls complex (river km 103) – a series of cascades and falls clustered over a one km reach. Upstream of the Falls is over 80 river km of prime Chinook and steelhead spawning habitat; an area which surpasses the habitat available downstream of the falls - see map below, Figure 1 from the Klickitat River Anadromous Fisheries Master Plan, p. 3 (YN 2008). Passage of anadromous fish over the Castile Falls complex was historically difficult, and in the 1960s, a set of structures and tunnels were constructed creating a fishway which bypasses the Falls and facilitates access of the fish to the upper basin. However, the project design proved faulty and instead of increasing

passage of the fish, the fishway became a complete barrier for spring Chinook and steelhead to the upper basin. Between 2003 and 2005, a new project was enacted to renovate the Castile Falls fishway and bring it into compliance with NOAA Fisheries' fish passage standards. Since completion of the project, observation of spring Chinook redds during spawning ground surveys indicates that the fish can now successfully access the upper basin.



The 2008 trial revealed that it would be difficult to obtain a total spring Chinook escapement estimate with a DIDSON(s) located in proximity to the Klickitat Hatchery. However, the restricted size of the opening of the Castile Falls fishway would facilitate using a DIDSON to obtain a count of the number which migrated into the upper basin, and using a total redd count for the upper basin, one could calculate the average number of fish per redd. Use of this value as the expansion factor to estimate total escapement based on the redd count for the whole Klickitat basin, would require the presumption that the ratio is similar above and below Castile Falls. Nevertheless, this assumption is likely more readily accepted than the assumption required for the current use of the Yakima River expansion factor applied to the Klickitat red data. Therefore, in 2009 we propose to perform a study using a pair of DIDSONs to obtain an escapement estimate for spring Chinook and steelhead which migrate above the Castile Falls complex. The study protocols are described in detail in the Methods section below. Briefly, we propose to install a pair of DIDSONs in April 2009, a standard DIDSON (DIDSON-S) positioned adjacent to the outlet of the fishway to enumerate upstream passage out of the fishway, and a long-range DIDSON (DIDSON-LR) upstream of the nearby check dam to enumerate downstream “fall back”. Both DIDSONs will be operated at HF to record sequential 1-hour files on a 24 hours/day, 7 days/week basis until the end of August – a period which will bracket the entire return run of spring Chinook. CRITFC and YN personnel will travel to

the site to confirm correct functioning of the instruments two to three times weekly. During each visit, data files will be downloaded from the field computers and transferred to an office-based server. The files will be read over the course of the project, and the data compiled to provide a total escapement estimate for the spring Chinook, and analyzed to illustrate migration relative to date and water flow, and any diurnal patterns to movement. Presuming results from the 2009 study are satisfactory, we anticipate repeating the study in two additional years (2010 and 2011) within the 10-year time frame of the Accords (2008). If logistically feasible, studies in 2010 and 2011 will commence earlier in the year (February-March), so as to also obtain estimates of steelhead escapement. Also, the DIDSON study in 2011 will be conducted concurrently with the first full year's operation of a new fish passage enumeration system planned for construction/installation within the Fishway in 2010; the choice of the specific technology and commercial manufacturer for the new system is still pending. The time of fish passage events recorded by the DIDSON in 2011 will be compared with those recorded by the new system; concordance between systems will provide mutual validation of the two techniques. Also, if the new system utilizes optical video of sufficient resolution to distinguish species, it will be possible to assess the validity of the presumption of temporal separation between migration of steelhead and of spring Chinook into the upper basin.

Objective #2: Development of a mark-recapture likelihood model

In addition to the methodologies for estimating population abundance discussed in the previous section, a mark-recapture design is an option which is also widely used in fisheries. When applied for estimation of spawning escapement of an anadromous population, the technique involves capture and tagging/marking a sample of the adults during their in-river migration, and subsequent (re)capture/(re)sighting of fish at an upstream barrier or during spawning ground surveys. Information on the number of fish tagged/marked, the number of fish captured/sighted upstream, and the number among them which possessed a tag are entered into Peterson estimators to calculate population abundance and its uncertainty at the time of tagging (Seber 1973, Everhart et al. 1975). This model requires several assumptions, including:

a) the population is closed
b) fish are randomly sampled both at the time of tagging and (re)capture
c) tagging does not bias the chance of being recaptured relative to untagged fish
d) fish do not lose their tags prior to the time of recapture

Mark-recapture studies applied to anadromous populations can generally be designed such that the initial assumptions are valid. However, this is not necessarily the case for the last assumption regarding tag loss. Field studies have shown that tag loss can indeed be substantial among salmonids, even over the relatively short time periods (a few weeks to a few months) expected between tagging and recapture in this application (Carline and Brynildson 1972, Rawstron 1973, Ebener and Copes 1982, McAllister et al. 1992, Guy et al. 1996). When tag loss occurs in a mark-recapture study, the Petersen's estimators will over-estimate abundance (Robson and Regier 1966, Arnason and Mills 1981, Seber and Felton 1981, Guy et al. 1996, McDonald et al. 2003). This bias may be corrected if the rate at which tags are lost can be estimated, and the number of fish initially marked is reduced proportionately. A common means to estimate tag loss rate is to perform a mark-recapture study involving double-tagging of fish. Tag loss rate will be reflected by the proportion of recaptured double-tagged fish which retain both versus only one of the tags (Gulland 1963, Robson and Regier 1966, Smith et al. 1978, Smith and McPherson 1981, Wetherall 1982, Cowen and Schwarz 2006). However, even with a reliable point estimate for tag loss, a further problem remains in that there is no defined manner to incorporate the uncertainty associated with the tag loss estimate into the Petersen estimators. The result is that while the point estimate for abundance can be corrected, the variance of this estimate will be underestimated (Arnason and Mills 1981, Cowen and Schwarz 2006).

We observed this situation in a mark-recapture study performed in 2007 to estimate escapement of kokanee migrating to their spawning grounds in the Metolius River from Lake Billy Chinook, Jefferson County, Oregon (Lovtang et al. 2008). In this study, a portion of the fish chosen for tagging - with a brightly colored plastic anchor tag (Dell 1968) - were tagged twice, once on either side of the dorsal fin, with tags of an alternative color (pink) relative to the majority of the fish which were single-tagged. During the "recapture" process (which consisted of visually observing fish during walking surveys through the

spawning area of the river), when a pink tagged fish was observed, it was also noted whether the fish retained both or only one of the tags. The numbers of resighted pink-tagged fish with one or two tags were then used to estimate the rate of tag loss. However, in order to incorporate a correction for tag loss into the calculation of population abundance that also includes the uncertainty of the tag loss estimate, we developed a new formal, though simple, two-step likelihood model to make these estimations. The first step in the model performs a binomial likelihood inference of tag loss based on mark-recapture data for double-tagged fish, with loss of one tag and/or the other considered as independent events. The resulting estimates for tag loss and its variance are carried into the second step which involves a hypergeometric likelihood inference of abundance based on data for the proportion of resighted single-tagged fish. The output from the combined likelihood model includes a point estimate for the rate of tag loss and of its variance, and a point estimate for abundance and its overall variance (Galbreath and Hyun 2008).

The model was used to recalculate the abundance estimate using the 2007 kokanee data. Additionally, a series of scenarios were run with the model, based on data from the 2007 study, to test the effects that alterations in the mark-recapture design would have had on the relative uncertainty of the abundance estimate. We examined a range of values for the number of fish chosen for tagging, the proportion of these fish which were double-tagged, and the number of (re)captured fish expected from an increase or decrease in survey effort (measured as person-days of work). These tests permitted us to make recommendations for future mark-recapture studies of this population, that involve a decrease the level of effort required, yet result in an increase in precision of the abundance estimate (Galbreath and Hyun 2008; available at http://www.critfc.org/tech/08-07report.html). The computer files for Version 1 of our model were also posted to this site, for downloading and use by the public.

In supplement to this report and initial version of the model, we wish to produce a manuscript describing the model and its utility for publication in a peer-reviewed scientific journal. While the analytical derivation of the likelihood model was described in our previous report (Galbreath and Hyun 2008), we propose to perform an additional validation exercise for inclusion in the manuscript. Validation will involve simulation processes to examine whether the likelihood model outperforms the traditional Petersen's estimators. Additionally, we wish to update the model to address certain weaknesses that the initial version has in both function and form. First, the model was designed to estimate tag loss based on data for fish tagged with two identical non-permanent tags. However, an alternative double-tagging design exists, which involves application of a second tag or mark which is permanent, e.g., a fin clip or operculum punch. The model needs to be revised to accept data for both types of double-tagging designs. The situation may also exist that instead of incorporating double-tagging into a mark-recapture study design, researchers wish to correct their mark-recapture data using estimated values for tag loss and its standard error, obtained from a comparable study in a prior year and/or in a similar river system. We would like to revise our model to accept this option as well. A second weakness is that Version 1 of the model is not sufficiently "user friendly", nor "user foolproof". While we provide a step-by-step tutorial to guide a user through the process of entering data and running the model, there are numerous ways in which someone unfamiliar with its operation may commit errors in these processes. Additionally, the output information is provided in a file separate from the input data, and we did not incorporate a convenient means to merge and save the two sets of values into a specific data file. We propose to expand the functionality of the model by adapting it to an internet web-based interface that will simplify its use and provide a summary of the input values and of the model's tag loss and abundance estimates within a single file, whose format is easier to read and more readily stored.

Development of Version 1 of the model was financed with funds from a project that was run in parallel with the 2007 kokanee mark-recapture study (Galbreath and Hyun 2008) – funds which have been exhausted. Therefore, we are proposing a one-year project within this current Accords (2008) proposal to complete development of the model. Of note, while our focus in this project is on use of mark-recapture methods for estimating spawning escapement of anadromous populations, mark-recapture techniques have widespread use in fisheries for other applications, e.g., redd counting, smolt trap efficiency estimation for juvenile abundance estimation, estimation of mortality rates and fisheries exploitation, etc. The binomial-hypergeometric likelihood model will have utility in each of these applications where the associated assumptions apply.

Project Objective #3: Support for an Unfunded RRS Study

In complement to promoting M&E projects which will provide information with which to assess longer term trends in population abundance and productivity, the AHSWG recommended enacting a series of RRS studies to provide data within a shorter term on possible productivity differences between NO and HO fish associated with hatchery rearing (AHSWG 2008). This recommendation is for enacting a series of RRS studies in supplemented populations, including a minimum of: a) six studies per species for spring Chinook and for steelhead, b) two studies of ocean-type Chinook salmon, one of which would be of Snake River fall Chinook, and c) three studies of reintroduced salmon populations.

The "fitness" of a fish population is typically measured in terms of its demonstrated natural productivity – the number of recruits per natural spawner (R/S), with the recruits enumerated at a juvenile stage and/or as returning adults. However, in cases where the naturally spawning population is supplemented, it consists of alternative parental types, e.g., natural origin versus supplementation hatchery origin). Until recently, researchers have been unable to compare the relative natural productivity among parental types in these populations, due to the inability to differentiate the parental identity of the naturally produced progeny. However, new molecular genetics techniques using multi-locus DNA markers now provide this capability (see reviews by Wilson and Ferguson 2002, Jones and Ardren 2003). The techniques require annual collection of scale and tissue samples from essentially all (or, at least a large majority of) adults which return to a river for natural spawning, with hatchery origin adults identifiable via presence of a tag or an external mark (e.g., clipped adipose fin). The scales are used to age the fish and assign them to a particular broodyear, and the tissue is used as a source of DNA. The DNA is extracted then analyzed to identify the alleles present for a suite of molecular markers, providing a profile for each potential spawner within a particular broodyear. After a generation has passed, the profiles of the adult progeny assigned to each broodyear are compared with those of the broodyear's spawners, and the total number of progeny assigned per adult can be calculated (e.g., Liu and Cordes 2004). The average (and variance) number of adult recruits for each parental type (e.g., out-of-basin HO, versus in-basin HO, versus NO fish) is then calculated and compared among parental types. If analyses are continued over subsequent generations (and if adult collection approaches 100%), it is possible that grand-parentage may also be assessed, permitting finer comparisons of relative reproductive success (RRS) of groups of individuals with differing amounts of HO versus NO background.

Estimation of relative productivity in a supplemented population may also be made at the juvenile stage. To do so, juveniles are captured from the stream prior to their outmigration as smolts, and scales and tissue collected from each. As described previously, scale aging is used to assign each juvenile to its broodyear, and molecular genetics analyses are used to make individual parental assignments. Likewise, the number of progeny per adult is derived, and average values are compared among parental types.

A distinct disadvantage of RRS studies based on juvenile R/S is that they do not provide information on overall population growth, as do those based on adult recruits. However, RRS studies which compare juvenile R/S also present certain advantages. First, juvenile R/S information is obtained within a shorter period, providing managers information within 1 year time frame following initial sample collections versus within a 3 to 5 year generation time. Second, RRS based on juvenile recruits will be logistically easier to perform. To estimate adult R/S, the entire spawning population must be intercepted, which requires construction and operation (assuming one is able to obtain the necessary permits) of a dam/weir at a location low in the river system below all tributary streams with spawning areas for the population of interest. (In fact, if such a dam/weir doesn't already exist, there a very few rivers within the Columbia basin in which one could realistically envision putting in place a structure could that capture the entirety of a population's adult run.) Such a dam/weir will necessarily be harder and more expensive to build and operate, and analyses will be that much more expensive due to the larger numbers of samples involved. On the other hand, to estimate juvenile R/S, a dam/weir may be placed on a smaller tributary stream where the entirety of the "sub-population" which migrate in to spawn in that stream may be sampled, followed by representative sampling of the juveniles produced by these fish prior to their outmigration from the stream. Construction and operation of the dam/weir in a smaller stream will be considerably easier and less expensive, and it is more likely that one will be able to capture (near) 100% of the adults.

Third, measuring productivity at the juvenile stage focuses the analysis on differences which are specifically related to disparity in spawning success and in survival through the egg incubation and early rearing stage. These are the life history stages which differ dramatically between NO and HO fish, during which the fish are subject to very different selective pressures. As such, any genetic divergence of the HO fish is most likely to be observed in differences in traits associated with spawning and juvenile survival. This said, the greatest amount of information will be obtained from studies in which it is possible to measure RRS at both the juvenile and adult stages

Several Columbia basin supplementation projects currently have RRS studies underway within their respective M&E programs (e.g., Project No. 200305400 - Reproduction of steelhead in Hood River, Project No. 200306000 - Evaluating relative reproductive success of wild and hatchery origin Snake River fall Chinook spawners upstream of Lower Granite Dam). Other projects initially received support for a RRS study, but funding was subsequently reduced, or RRS studies within ongoing supplementation M&E programs were proposed but funding was never made available. Examples of supplementation programs in which this has occurred include: Project No. 200303900 - Monitor Reproduction In Wenatchee/Tucannon//Kalama, Project No. 200729900 - Investigation of the Relative Reproductive Success of Stray Hatchery and Wild Steelhead and the Influence of Hatchery Strays on Natural Productivity in the Deschutes River Subbasin, Project Proposal No. 200729900 - Genetic Evaluation of Chinook Salmon Supplementation in Idaho Rivers, Project No. 199604300 - Johnson Creek Artificial Propagation Enhancement Project.

In Phase I of present project, CRITFC proposes to provide financial support to a supplementation monitoring program where a valuable RRS assessment is not being performed due to funding limitations. In this project, we will survey the various ongoing supplementation monitoring programs, looking in particular at those in which the needed tissue samples have been collected but funds are lacking to cover the costs of the genetics analyses involved in the planned RRS studies. We will prioritize one of these programs for financial support, and make arrangements to have the genetic analyses and RRS evaluation performed at the Hagerman Fish Culture Experiment Station (HFCES). We anticipate similar efforts will continue through subsequent Phases of the project over the 10-year duration of the Accords (2008).

Project Objective #4: RRS in Reintroduced/Supplemented Populations

Many factors have been responsible for the current depressed abundance levels of extant natural populations of salmon and steelhead in the Columbia basin upstream of Bonneville Dam, including degradation of the freshwater spawning and juvenile rearing habitat, creation of migration barriers and other alterations to the hydrosystem, and over-harvest in some sport and/or commercial fisheries. These factors have also been responsible for the outright extinction of a large number of additional natural populations. Among these extirpated native populations were spring Chinook in the Hood, Umatilla, Okanogan and Clearwater River basins, and 100% of the native coho salmon populations within the Columbia basin upstream of Bonneville Dam (Fulton 1968, Mullen 1983; Nehlson et al. 1991, O'Toole et al. 1991; see also historical annual dam count data available at: http://www.cbr.washington.edu/dart/adult_annual.html).

Efforts have been made to reintroduce natural populations of these species into some of these river systems through stocking of juveniles produced from out-of-basin hatchery stocks (e.g., Bowles and Leitzinger 1991, Phillips et al. 2000, Underwood et al. 2003, Lutch et al. 2005, Murdoch et al. 2006, Bosch et al 2007, Narum et al. 2007a). Many early projects to reintroduce extirpated populations involved planting of fertilized eggs, or direct release of fry or parr. Generally, mortality of these fish was very high during the period shortly following release, and few if any fish ever completed their life cycle to return to the river as mature adults. More recently, methodologies changed to stocking of juveniles at the smolt or pre-smolt stage, which improved survival and resulted in increased numbers of returning adults. Return rates have been further augmented when the juveniles were acclimated to their release stream for a period of days or weeks prior to release.

Additionally, protocols for the reintroduction programs have generally been modified to progressively phase out use of the original out-of-basin hatchery broodstock. In their place, returning adults are collected in-basin for use as broodfish to produce the juveniles with which to continue supplementation of the new population. The initial generations of this "local origin" broodstock are comprised of mature hatchery origin (HO) adults. In subsequent generations, however, as the number of adults of natural origin (NO) in the return run grows, NO fish can be incorporated into the hatchery broodstock in increasing proportions. The rationale for this strategy is based on the presumption that the genetic characters which facilitated successful return and natural breeding of the original HO fish will be passed on to their progeny, and that over generations a population which is progressively better adapted to the local environment will be established and become increasingly abundant. Given that conditions associated with habitat and hydrosystem are sufficiently well restored and harvest well managed, the hope is that the hatchery program could be phased out as the new natural population establishes itself and grows in abundance.

Results from several of these recent Columbia basin reintroduction programs have been very encouraging. Substantial numbers of the HO juveniles returning as mature adults have been recorded, as well as natural spawning of some portion of these HO fish. Further, NO juveniles at the fry, parr and out-migrating smolt stages have been observed, as have mature NO adults within the subsequent spawning escapement – indicative that a full generation of strictly natural production has occurred (Phillips et al. 2000, Underwood et al. 2003, Lutch 2005, Murdoch et al. 2006, Bosch et al 2007, Narum et al. 2007a). However, what are the possibilities that these reintroduced fish will successfully establish a population which has the potential for natural self-sustainability? Concern has been expressed regarding the deleterious effects of artificial production on long term natural fitness (e.g., Ford 2002, ISRP 2005) - that these effects may be genetic in nature and not readily reversible. If such is the case, there is reason to question whether an out-of-basin stock which has been hatchery-reared over multiple generations, resulting in genetic selection for characters which are advantageous in the hatchery but disadvantageous in a natural environment, will retain sufficient levels and diversity in the genetic characters needed to adapt back to a new natural environment.

Encouragingly, Conover et al. (2009) present what is one of the first reports with direct empirical evidence that natural selective forces can reverse human-induced genetic selection in a fish population. They describe a controlled study conducted with Atlantic silversides (*Menidia menidia*) involving 5 generations of size-selective harvest (at day 190 post-hatch), followed by 5 more generations in which harvest was not size selective. For the populations in which exclusively the larger fish were harvested, a genetic change for smaller mean body size and lower population biomass evolved. However, over the subsequent 5 generations without selective harvest, mean body size and population biomass progressively increased, recovering a significant proportion of the difference in these values relative to the control populations. These results give credence to the presumption that natural selective forces will be able to induce evolution of a hatchery stock possessing low genetic fitness - due to its out-of-basin origin(s), and due to selection for hatchery adaptations - back towards a population with improved natural productivity.

In a recent meta-analysis, Fraser (2008) reviewed published reports for 31 different salmonid reintroduction programs – a list which includes several of the Columbia basin programs cited above. In 16 of these cases, he deemed that a judgment could not be made on the programs' success as they are yet too recent – they had been initiated less than 10 years ago. Fraser expresses the opinion "that a *minimum* 15-20 years will likely be necessary to *potentially* achieve the conservation goal of establishing a self-sustaining population". Of the remaining 15 populations, he qualified 6 as failures – due to a lack of consistent production of naturally spawned juveniles and returning adults. However, he notes that the lack of natural productivity could likely be attributed in part (and generally in large part) to habitat limitations. In each of the populations, degradation of environmental conditions contributed to some extent to extinction of the endemic stock, and if these effects had not been sufficiently reversed, failure of a reintroduction effort would not necessarily reflect on the genetic capacity of the reintroduced stock to readapt to normative environmental conditions. The remaining 9 of the 15 programs were qualified as having been successful in establishing a (potentially) self-sustaining population. Importantly, the habitat

limitations responsible for the (near) extirpation of the original populations within these nine river systems have largely been removed – a requisite condition for success of the effort.

Fraser (2008) used the definition for a successfully self-sustaining population as one "that persists for multiple generations in the absence of *any* human intervention such as supplementation, artificial habitat enhancement or any degree of captive breeding or genetic modification". Fraser does admit, however, that the "Yes" rating to the "Self-sustaining population?" character which he attributed to these nine populations is not fully in line with this definition, noting that hatchery supplementation continues to a greater or lesser degree in each of them. Uncertainty therefore remains whether the natural production observed in these reintroduction/supplementation projects is increasingly supported by spawning of a progressively better adapted naturalized population, as opposed simply to natural production of some number of returning adults from the annually stocked juveniles from the hatchery supplementation program. As implied in his definition for self-sustaining, a definitive assessment of success could only be made based on observation of a population which is continually abundant and naturally productive for an extended number of years following cessation of the hatchery reintroduction/supplementation program. Additionally, this assessment must also consider impacts that harvest may have on population abundance – harvest directed at the reintroduced population itself, and/or impacts from harvest directed at other more abundant populations with which the reintroduced fish find themselves within a mixed-stock fishery. Fraser summarizes the situation stating that, "Owing to several confounding factors, there is also currently little evidence that captive-bred lines of salmonids can or cannot be reintroduced as self-sustaining populations", and that "more empirical investigation is needed to evaluate the genetic/fitness benefits and risks associated with" the reintroduction protocols used to present, as well as alternative approaches. The present project seeks to provide some of this needed empirical data with which to guide fisheries managers in making these assessments.

While it will not be possible to make a definitive determination whether or not a reintroduced population is self-sustainable prior to monitoring of population abundance over several years following cessation of the supplementation project, it is possible to obtain information that the process of adaptation might, or might not, be occurring. An out-of-basin stock, particularly one which has been hatchery-reared over multiple generations, can be presumed to be (far) less than ideally adapted to a given natural environment than the endemic stock had been. A low level of adaptation of the introduced stock will be reflected by a low level of productivity (R/S). If, however, the reintroduced fish go through a process of naturalization/adaptation to the new environment over successive generations of reintroduction/supplementation, it will be illustrated by a trend for increasing productivity (R/S). Unfortunately, because of year-to-year environmental variability, observation of a significant trend requires long term data sets. On the other hand, the confounding effect of environmental variation can be circumvented if one can compare natural productivity within generations among parental types, categorized by the management protocols and the number of generations of hatchery influence. That is, if the process of naturalization is occurring, one would expect to observe a disproportionately higher number of progeny per in-basin HO adult relative to out-of-basin HO fish, of in-basin NO fish relative to in-basin HO fish, and of second generation in-basin NO fish relative to first generation in-basin NO fish, etc. The ability to make these comparisons of productivity among parental types necessitates being able to identify the individual parents of each of the naturally spawned fish within the sample from a given broodyear. The molecular genetics techniques described in the previous section for estimating RRS can be applied for this purpose. Likewise, the same analytical procedures described for data obtained in the RRS studies of extant supplemented populations in Project Objective #3 will be used here, to take into consideration effects of any differences in size or spawn timing and distribution among parental types.

The studies within Project Objective #4 directly reflect the thinking of the AHSWG (2008), which recommended that an expanded number of RRS studies be performed on supplemented populations within the basin, and that that number should include a minimum of three which are of reintroduced populations. Moreover, the Tribes find extirpation of the various salmon populations which has occurred in the basin to be particularly unacceptable (CRITFC 1995), and it is they who have played a lead role in organizing the reintroduction projects. For this reason, we propose specifically to target enactment of the RRS studies of reintroduced populations among our the projects CRITFC is proposing under the Accords

(2008), with the intention that efforts described here for Phase I of the project will continue over the 10-year duration of the Accords.

C. Rationale and Significance to Regional Programs

2008 Columbia Basin Fish Accords Memorandum of Agreement (MOA)

Actions under the four objectives proposed within this integrated project were specifically identified in the 2008 Columbia Basin Fish Accords Memorandum of Agreement between the Three Treaty Tribes and FCRPS Action Agencies (Accords 2008), within Attachment B – Category 3, under the project proposal titles: Improved Escapement Estimation, Supplementation Benefits and Risks, and Supplementation Monitoring. As per MOA Section B.2, these activities will not be redundant with already planned actions within other ongoing hatchery–related projects. CRITFC will make publically available all information on biological effects associated with the hatchery supplementation projects studied within this project (MOA Sections C.4), and CRITFC will coordinate this project with the other Parties to the MOA, and with other regional RM&E processes (MOA Section C.5).

Wy-Kan-Ish-Mi Wa-Kish-Wit

In Wy-Kan-Ish-Mi Wa-Kish-Wit (CRITFC 1995) the four Columbia River Treaty Tribes present a comprehensive plan for restoration and management of Columbia basin fish populations. In addition to habitat restoration and hydrosystem management strategies to rebuild salmon populations at high risk of extirpation, the use of hatchery supplementation is strongly recommended within the Plan, both for rebuilding depressed extant populations and for populations recommended for reintroduction due to extirpation of the native population (Chapter 5 Recommendations, Technical Recommendations, Hypothesis 4). The Tribes have been actively involved in proposing and enacting supplementation programs within their ceded territories in the mid and upper Columbia basin, and have played the leading role in implementation of projects to reintroduce extirpated populations. Concomitant with the supplementation strategy is a recommendation for establishment of a coordinated set of monitoring programs to provide the data needed to make an assessment of the efficacy of these hatchery actions (Chapter 5 Recommendations, Monitoring).

As part of the recommended M&E within the Plan, adult escapement in supplemented and reference populations is repeatedly indicated as a necessary metric for evaluation of the effects of supplementation, and that these estimates must be of reasonable accuracy. The specific choice of a DIDSON project to estimate the natural spawning escapement of spring Chinook in the Klickitat River is consistent with this general recommendation, and with the subbasin Plan specific to the Klickitat Subbasin in Volume 2 of *Wy-Kan-Ish-Mi Wa-Kish-Wit (CRITFC 1995)*. The Yakama Nation (YN), through the Yakima-Klickitat Fisheries Project (YKFP), has been actively involved in multiple efforts to rebuild the population of spring Chinook, and other anadromous species in the Klickitat basin. Using returning spring Chinook adults as broodstock, the tribal managers at the Klickitat Hatchery are producing and rearing juveniles for acclimation and release in the upper basin. Additionally, the Tribe is expected to, in the near future: a) to finish a project to renovate the fish passageway at Castile Falls, which will facilitate escapement of fish into the large underutilized portion of the basin upstream, b) to develop plans to construct juvenile acclimation facilities in the upper basin, and c) to expand the number of habitat restoration projects throughout the basin (involving placement of large woody debris and planting of riparian vegetation for increasing channel complexity and bank stabilization, etc.), so as to augment spawning and juvenile rearing habitat for anadromous fish.

Likewise, enactment of the RRS studies described under Project Objectives #3 and #4 will not only aid in the evaluation of the particular supplementation projects chosen for study (each of which will have some level of tribal involvement), but also in an evaluation of supplementation as a management action in general, as it has been recommended in the Plan (CRITFC 1995). The tribes also recognized the power that recently developed molecular genetics techniques have to provide information on population structure and genetic identity – information which can address many of the questions of interest to

regional fisheries managers. As a result, the tribes have endorsed the investment by CRITFC in development of their analytical capabilities in this field, through establishment of a partnership with the University of Idaho and the US Department of Agriculture, in which each agency provides personnel and operating funds for the molecular genetics laboratory at the Hagerman Fish Culture Experiment Station (HFCES).

Northwest Power and Conservation Council (NPCC) Fish and Wildlife Program, and the *Ad Hoc* Supplementation Workgroup (AHSWG)

Support for the use of artificial production has long been an integral part of the Fish and Wildlife Program of the Northwest Power and Conservation Council (NWPCC 2000). Section 4 Artificial Production Strategies of the Program calls for judicious use of hatchery supplementation to: 1) rebuild natural populations "to the sustainable carrying capacity of the habitat with fish that are as similar as possible, in genetics and behavior, to wild native fish, and 2) replace lost salmon and steelhead in blocked areas". A requirement for the use of artificial production is that "supplementing the recovery of a wild population should clearly benefit that population". Further, the Program recommends: "Artificial production must be implemented within an experimental, adaptive management design that includes an aggressive program to evaluate the risks and benefits and address scientific uncertainties." However, as described in the Background section above, given the critical uncertainties which remain relative to the benefits and risks to the use of hatchery supplementation, the NPCC and the fisheries managers are in need of guidance for making decisions on how and when supplementation should, or shouldn't, be recommended as a management action.

In response to a request from the NPCC, the ISRP and ISAB produced their report "Monitoring and Evaluation of Supplementation Projects" (ISRP and ISAB 2005), which reviewed the general nature and the challenges to making a broad assessment of the effects of supplementation on natural population fitness. And, in response to the recommendation in this report, the *Ad Hoc* Supplementation Workgroup (AHSWG) was formed as a volunteer inter-agency forum with the goal of elaborating in a more specific manner, an effective approach for performing a basinwide evaluation of the effects of supplementation on productivity of natural populations of salmon and steelhead. The AHSWG held a series of three workshops to review and discuss the relevant issues. These discussions were facilitated by work of the Collaborative Systemwide Monitoring and Evaluation Project (CSMEP), which treated some of these same issues, and whose recommendations are presented in their final reports (Marmorek et al. 2007a and b). The AHSWG report summarized their analysis of the situation and recommended a three-pronged approach for an assessment of supplementation: 1) an investigation of the long-term trends in the abundance and productivity of supplemented populations relative to un-supplemented reference populations, 2) conducting a series of relative reproductive success (RRS) studies in supplemented populations to quantify short-term impacts through comparisons of productivity of hatchery-origin and natural-origin fish within broodyears, and 3) development of a request for proposals to fund several intensive small-scale studies designed to elucidate various biological mechanisms by which introduction of hatchery-produced fish may influence natural population productivity (AHSWG 2008). Tribal representatives were active within the AHSWG, and the present CRITFC project and several other Accords (2008) projects of the three signatory tribes (Yakama Nation - YN, Confederated Tribes of the Umatilla Reservation – CTUIR, and Confederated Tribes of the Warms Springs Reservation of Oregon - CTWSRO), directly support the actions recommended by the AHSWG in their final report (AHSWG 2008).

D. Relationships to Other Projects

Project Objective #1: DIDSON Escapement Estimation

The proposal to estimate escapement of naturally spawning Klickitat River spring Chinook complements numerous completed and ongoing projects involving habitat restoration, hatchery supplementation activities, and population monitoring efforts to rebuild the natural spring Chinook population in the Klickitat basin.

Funding Source	Project #	Project Title	Relationship
BPA	198811535	Klickitat Fishery YKFP Design	This YKFP Design & Construction proposal identifies facilities required to implement YKFP supplementation efforts and to successfully monitor results.
BPA	198812035	YKFP Klickitat Management, Data, and Habitat	Proposal provides for all YIN management functions associated with the Yakima/Klickitat Fisheries Project including project planning, O&M, research, data management, and habitat improvement and acquisition actions in the Klickitat Subbasin.
BPA	198812035	Yakima Klickitat Fisheries Project - Monitoring And Evaluation	Umbrella proposal for monitoring and evaluation of natural production, harvest, ecological and genetic impacts for spring Chinook, fall Chinook, and coho fisheries enhancement projects in the Yakima Basin. M&E results guide adaptive management decisions.
BPA	199506335	YKFP - Klickitat Subbasin Monitoring and Evaluation	Monitoring and evaluation of spring Chinook, steelhead, fall Chinook, and coho fisheries enhancement projects in the Klickitat Subbasin. M&E results guide adaptive management decisions.
SRFB	04-1715-2003	Klickitat R. Conservation & Restoration	The Klickitat River Floodplain Conservation and Restoration (Phase I) project will protect and restore habitat between river miles 18.3 and 32.2 of the Klickitat River. Phase I work protected 320 acres of floodplain, re-vegetated 7.5 acres of riparian and floodplain habitat, and conducted a feasibility assessment to assist Phase 2 planning for reduction of adverse river-road interactions.
SRFB	01-1359-2002	Klickitat River Fish Barriers Survey	Conducted a comprehensive culvert survey on all non-Yakama Reservation lands on Klickitat River tributaries to aid in prioritization of barrier correction projects.
PCSRF	2004-4-08	Klickitat Hatchery Fish Pump	Purchased a Matususaka Z 100L Fish Pump to facilitate transfer of juvenile salmonids between ponds and into transportation trucks.
SRFB	06-2277-2006	Upper Klickitat River In-Channel and Floodplain Enhancement	Constructed 35 large woody debris jams to reconnect and create nearly 0.4 mile of side channel habitat and stabilized almost 0.5 mile of bank. Project enhanced spawning, rearing and holding habitat for steelhead and spring Chinook salmon along 2.3 miles of the Klickitat River, from McCreedy Creek to the Diamond Fork reach.
SRFB	05-1594-2006	Klickitat Floodplain Restoration Phase 2	Restored Klickitat floodplain habitat between river miles 18.3 and 32.2 of the Klickitat River to augment spawning, migrating and rearing habitat for anadromous salmonids.
SRFB	05-1626-2006	Klickitat RM 12 Habitat Restoration	Habitat restoration project involving placement of large woody debris and tree planting in riparian areas in the lower Klickitat River from the mouth of the Klickitat River to the Little Klickitat reach (RM 12.1 to 13.6).
SRFB	07-1725-2007	Upper Klickitat River - Phase 3	Habitat project to enhance spawning and rearing habitat for spring Chinook salmon and steelhead in the upper Klickitat River - McCreedy Creek to Diamond Fork. Work involved perforating an embankment, placement of root wads and installation of a 60-foot bridge.
PCSRF	2000-4-02	Castile Falls Passage Improvement Project	Constructed a new walkway to access Castile Falls fish passageway, currently under study for renovation.
PCSRF	2000-4-04	Klickitat Rearing Troughs	Purchased and installed three rearing troughs at the Klickitat Hatchery to augment juvenile rearing capacity at the Klickitat Fish Hatchery..
PCSRF	2002-4-10	Klickitat Hatchery Fish Culturist	Funded a Fish Culturist position for maintenance and administration duties on site of the Klickitat Fish Hatchery.

PCSRF	2003-4-09	Construction of Castile Falls 4/5 In-Channel Sills	Constructed an in-river sill to increase attraction flows, pass fish more effectively and reduce bedload in Castile Falls 4/5 fishway.
PCSRF	2004-4-08	Klickitat Hatchery Fish Pump	Purchased a Matususaka Z 100L Fish Pump to facilitate transfer of juvenile salmonids between ponds and into transportation trucks.
PCSRF	2007-4-01	Klickitat Hatchery Incubation Trays	Purchased additional incubation trays to increase egg/fry production capacity of the hatchery.
PCSRF	2007-4-02	Klickitat Hatchery Egg Picker/Counter	Purchased an egg picker/counter for efficient removal of unfertilized eggs and enumeration of fertile eggs.
PCSRF	2007-4-03	Klickitat Hatchery Transfer Line	Installed a second 6" pipe and switchbox to facilitate transfer of juvenile salmonids from raceways to rearing pond#25 located on the opposite side of the Klickitat River.
PCSRF	2008-4-01	Castile Falls Fishway Bedload Deflector	Designed and constructed a concrete abutment in the river channel to deflect bedload away from the Castile Falls passageway.
PCSRF	2008-4-06	Klickitat Hatchery Digital Balance Replacements	Purchased two new digital balances for improved accuracy in weighing of fish and fish feed.

Objective #2: Development of a mark-recapture likelihood model

As indicated above, mark-recapture studies to estimate fish population abundance have wide application in fisheries management, and the binomial-hypergeometric likelihood model we are developing would have applicability in many of them. The following is only a partial list of Columbia basin fisheries programs which include mark-recapture studies among the project tasks – the list being limited to BPA supported projects submitted through the NPCC Fish and Wildlife Program, and projects which are part of the Accords (2008):

Funding Source	Project #	Project Title	Relationship
BPA (Accords project proposal)	2008-307-00	Development of a sockeye salmon population in Deschutes Basin	CTWSRO proposal which includes among the project objectives, continuance of annual mark-recapture studies to estimate spawning escapement of Metolius River kokanee.
BPA (Accords project proposal)	2008-306-00	Deschutes River fall Chinook	CTWSRO proposal to validate and improve methodologies for escapement estimation of Deschutes River fall Chinook (including mark-recapture studies), and collect new information on smolt-to-adult ratios to reduce the potential impacts of over harvest and evaluate other forms of direct mortality
BPA (Accords project proposal)	2007-007-00	Lamprey Monitoring in Fifteenmile Creek and Hood River	CTWSRO project to monitor the status of Pacific lamprey in the Fifteenmile Creek and Hood River basins, including feasibility studies for mark-recapture as a means to estimate both adult escapement and larval production in Fifteenmile Creek.
BPA (Accords project proposal)	2008-311-00	Spring Chinook Salmon and Steelhead Production in the Deschutes River Basin	CTWSRO project annual monitoring of natural and artificial production of spring Chinook salmon and steelhead in Deschutes River tributary streams, including use of mark-recapture to estimate juvenile production.
BPA	198335003	Nez Perce Tribal Hatchery M&E	Current monitoring and evaluation plan for the Nez Perce Tribal Hatchery which includes mark and recapture studies to estimate adult escapement and juvenile emigration.
BPA	198605000	White Sturgeon Mitigation and Restoration in the Columbia and Snake Rivers Upstream from Bonneville Dam	An ODFW project to monitor white sturgeon populations in order to success of mitigation and restoration efforts. Tasks include mark-recapture studies to estimate abundance.

BPA	1988-053-04	Hood River Production Program - ODFW M&E	An ODFW project to monitor anadromous populations in the Hood River basin, including mark-recapture studies to estimate abundance of winter and summer steelhead.
BPA	198806500	Kootenai R White Sturgeon Investigations	IDFG project to determine limiting factors of key fish species in Kootenai River, including mark-recapture studies to estimate abundance of burbot, rainbow trout and mountain whitefish.
BPA	198909800	Idaho Supplementation Studies	IDFG project to evaluate supplementation as a recovery/restoration strategy for spring/summer Chinook in Idaho in streams/river across the state. Productivity involves use of mark-recapture to estimate trap efficiency and obtain juvenile abundance estimates.
BPA	1990-55-00	Idaho Steelhead Monitoring and Evaluation Studies	IDFG project to monitor steelhead populations in the Clearwater and Salmon river basins. Project includes mark-recapture studies to estimate trap efficiency and obtain juvenile abundance estimates
BPA	1990-005-01	Umatilla Basin Natural Production Monitoring and Evaluation Project	CTUIR project to monitor populations of anadromous salmonids in the Umatilla River, including use of mark-recapture studies to estimate spawner abundance.
	199506325	Yakima Klickitat Fisheries Project (YKFP) - Monitoring and Evaluation	Yakama Nation project to monitor populations of anadromous and resident freshwater fish species in the Yakima River, including use of mark-recapture studies to estimate species abundance.

Objective #3: Support for an Unfunded RRS Study

The following supplementation projects are ones with a monitoring program that includes a RRS study which has gone unfunded (currently, or in the past), or projects which directly support these supplementation efforts:

Funding Source	Project #	Project Title	Relationship
BPA	198909800	Idaho Supplementation Studies	Supplementation project which has included adult and juvenile tissue sampling in Pahsimeroi River, the Upper Salmon River (above Sawtooth Hatchery) and the South Fork Salmon River, but lacks funds for parentage analyses.
BPA	198335003	Nez Perce Tribal Hatchery M&E	Supplementation project which has included adult and juvenile tissue sampling in Newsome Creek and Lolo Creek, but lacks funds for parentage analyses.
BPA	199604300	Johnson Creek Artificial Propagation Enhancement Project	Supplementation project which has included adult and juvenile tissue sampling, but lacks funds for parentage analyses.
LSRCP		LSRCP Mitigation Hatcheries	Hatchery personnel from Sawtooth, Pahsimeroi, McCall and Clearwater hatcheries operate weirs for adult collections.
LSRCP	14110-0-J007	LSRCP Chinook Evaluation Studies in Idaho	Provides personnel to collect tissue samples for adults in the South Fork Salmon River
BPA	Proposal # 200725000	Genetic Evaluation of Chinook Salmon Supplementation in Idaho Rivers	Proposal to perform parentage analyses and RRS evaluations in the following supplementation projects: Pahsimeroi River, the Upper Salmon River (above

			Sawtooth Hatchery), the South Fork Salmon River, Newsome Creek and Lolo Creek. However funding was denied.

Objective #4: RRS in Reintroduced/Supplemented Populations

The following projects are ones which have used out-of-basin hatchery stocks to reintroduce previously extirpated populations of Columbia basin salmon or steelhead, and which continue to use supplementation in an effort to reestablish a viable natural population.

Funding Source	Project #	Project Title	Relationship
BPA	199701325	Yakima/Klickitat Fisheries Project Operations and Maintenance	Project to reintroduce/supplement an extirpated salmonid population
BPA	200711700	Comprehensive Assessment of Coho Salmon Restoration Efforts in the Mid-Columbia and Mid-Snake River Basins	Project to reintroduce/supplement an extirpated salmonid population
PCSRF	2007-1-01	Clearwater Coho Reintroduction Project V	Project to reintroduce/supplement an extirpated salmonid population
BPA	198805307	Hood River Production O&M - Warm Springs/ODFW	Project to reintroduce/supplement an extirpated salmonid population

E. Project History

N/A

F. Proposed biological/physical objectives, work elements, methods, and metrics

Integrated Project: Basinwide Supplementation Evaluation – Phase I

Administrative tasks common to all four of the objectives within this integrated project are described below under the Biological Objective - Administer Project.

Biological Objective #1 Administer project.

Work Element Category: Planning and Coordination

Number and Title: #119 - Manage and Administer Projects - Project Administration and preparation of Phase II Narrative and 2010 SOW

Description: Perform all administrative activities as per the SOW and BPA's programmatic and contractual requirements, including:

- purchase of supplies and equipment and financial reporting
- preparation of subcontracts, preparation of progress and annual reports
- preparation of the Narrative for Phase II of the Project, and of the 2010 SOW

Deliverables: Funding Package - Submit draft to COTR

Submit next year's SOW, Budget, and Property Inventory to the BPA COTR. The SOW should include location information (latitude and longitude) for those work elements that require it. If contractor or contractor's organization takes longer than 30 days to sign the contract, the contractor will need to send this funding package to BPA more than 90 days before the end of the current contract.

Milestones:

1) Accrual – Submit September estimate to BPA (9/1 to 11/2009) - Provide BPA with an estimate of contract work that will occur prior to September 30 but will not be billed until October 1 or later. Generally, this should be done by September 10.
2) Funding Package - Conduct internal review (e.g., Supervisor or Interagency) (2/19 to 26/2010) - If necessary, submit next year's SOW and Budget for internal contractor review

before submitting to BPA. Assuming this review takes 30 days, start this milestone 120 days before the end of the current contract.

Work Element Category: Planning and Coordination
Number and Title: # 165 - Environmental Compliance - Produce Environmental Compliance Documentation - Provide proof of EC/permits
Description: All environmental compliance and permits exist in other CRITFC F&W contracts
Deliverables: Proof of EC/permit coverage to BPA
Provide BPA with proof of proper permits etc.
Milestones:
1) Proof of EC/permit coverage to BPA (3/31/2010)

Work Element Category: Reporting
Number and Title: #132 - Produce (Annual) Progress Report - Submit Progress Report for the period May 2009 thru April 2010
Description: The progress report summarizes the project goal, objectives, hypotheses, completed and uncompleted deliverables, problems encountered, lessons learned, and long-term planning. Examples of long-term planning include future improvements, new directions, or level of effort for contract implementation, including any ramping up or ramping down of contract components or of the project as a whole. Date range May 2009 thru April 2010 will be agreed upon by the COTR and the contractor. This may or may not coincide with the contract period. For an ongoing project, a progress report covering a contract period may be submitted under the subsequent contract, if approved by the COTR. Progress reports must conform to BPA guidelines. See the "formatting guidelines" link at the Technical Reports and Publications page: http://www.efw.bpa.gov/IntegratedFWP/technicalreports.aspx. If producing a technical report for this contract, a discrete experiment, or a peer-reviewed publication, use work element 183: Produce Journal Article.
Deliverables: Attach Progress Report in Pisces
Use the attachment tab in Pisces to attach your progress report. Progress reports attached in Pisces will be posted on the web.
Milestones:
1) Review progress report format requirements (3/22//2010 to 3/25/2010) - Contractor must review formatting requirements before starting the first draft of their report. Please follow the BPA-required format: http://www.efw.bpa.gov/IntegratedFWP/technicalreports.aspx.
2) Confirm BPA has posted the progress report (4/30/2010 to 4/30/2010) - It usually takes BPA 30-45 days to post the final version of a report. This milestone's end date should therefore be 45 days after the Deliverable milestone. You will receive an email from BPA confirming that your report has been finalized and posted to the web.

Work Element Category: Reporting
Number and Title: #185 - Produce PISCES Status Report - Periodic Status Reports for BPA
Description: Submit quarterly reports on the status of milestones and deliverables in PISCES.
Deliverables: PISCES Status Reports.
Milestones:
1) May-June 2009 (7/1 to 15/2009)
2) July-September 2009 (10/1 to 15/2009)
3) October-December 2009 (1/1 to 15/2010)
4) January-March 2010 (4/1 to 15/2010)
5) Final April 2010 (4/16 to 30/2010)

Project Objective #1: DIDSON Escapement Estimation

An estimate of spawning escapement will be calculated for spring Chinook in the upper basin of the Klickitat River in 2009. The estimate will be based on net upstream fish passage counts of fish as they exit the upstream end of the Castile Falls fishway, obtained from video files recorded by two DIDSONs – one a standard model (DIDSON-S) and the other a long range model (DIDSON-LR). The DIDSON

escapement estimate will be divided by the total redd count for the upper basin to derive a Klickitat-specific expansion factor which will be compared to the currently used expansion factor, calculated for spring Chinook in the Yakima River. Secondarily, the experience acquired over the season will be used to make a qualitative and quantitative evaluation of the reliability of the DIDSONs for producing an escapement estimate at this site. It is anticipated that a DIDSON study and the resulting DIDSON versus expanded redd count escapement comparisons will be repeated in 2010 and 2011.

Methods – DIDSON operation

The study site is at the upstream end of the Castile Falls complex in the Klickitat River, at river km 103. In April 2009, a DIDSON-S will be installed adjacent to the outlet of the fishway, to record all upstream passage events, and a DIDSON-LR will be installed to look across the river in order to observe downstream ("fall back") passage. Power to the DIDSONs and associated electronic equipment will be supplied initially from a portable gasoline generator. Later, either a thermoelectric generator or a solar panel array will be installed for long-term power generation; the choice between the two systems will be made following review of technical specifications, price, and logistical considerations for maintenance. The computer for each DIDSON, and an external hard drive to which the files will be directly recorded, will be housed onshore within a secure storage box. Both DIDSONs will be operated at their respective high frequencies, and programmed to record sequential 60 min files. CRITFC and YN personnel will travel to the site to confirm correct functioning of the instruments two to three times weekly. During each visit, data files will be downloaded from the field computers and transferred to an office-based server.

Methods - Data analyses

Analysis of the files will begin within a week following initiation of operation of the DIDSONs, and the files will be read continually over the season such that a preliminary escapement estimate should be available by the end of September 2009. From each days' set of DIDSON files, a corresponding set of "echogram" files will be generated, and the echograms reviewed to obtain total upstream and downstream counts per file. Upstream fish passage events observed during early May are expected be solely of migrating steelhead. By the end of May, these counts should be in decline, and a subsequent increase in upstream passage events later in June will be indicative of initiation of the spring Chinook migration. Passage of spring Chinook is expected to peak sometime in July, then to diminish and finish in August. Total upstream counts from the DIDSON files between the dates deemed to represent the beginning and the end of the spring Chinook run will be summed within hours for each day. Gaps in the resulting data set, caused by power interruptions, instances of loss or corruption of files, etc., will be filled with predicted values from a joint distribution of hourly and daily trends in the data. The data set of hourly counts will then be summed to obtain daily estimates, and the daily estimates will be summed over the migration season to obtain an estimate of total escapement. This estimate will then be divided by the total redd count for the upper basin obtained in 2009, to provide an average value of fish per redd. Upstream passage events will also be graphed within hour of the day, to illustrate any diurnal pattern to movement at the site (of note, observations recorded for files from the 2008 trial indicated that passage occurred primarily during the dawn and dusk hours). Additionally, daily escapement and flow (data to be obtained from the USGS river gauge #14107000 Klickitat River Above West Fork, located within a km upstream of the fishway outlet) will be graphed over time to look for possible correlations between flow and migration activity.

Biological Objective #1 Produce an estimate of total spring Chinook adult escapement to the upper basin of the Klickitat River in 2009, calculate the fish per redd ratio using the total number of redds counted during in 2009 spawning surveys, and compare this value to the Yakima River expansion factor historically used for escapement estimation.

Work Element Category: R M & E and Data Management

Number and Title: #157 - Collect/Generate/Validate Field and Lab Data - Operate DIDSON in Klickitat River

Description: An estimate of spawning escapement will be calculated for spring Chinook in the upper basin of the Klickitat River in 2009. The estimate will be based on net upstream fish passage counts of fish as they exit the upstream end of the Castile Falls fishway, obtained from video files recorded by two DIDSONs – one a standard model (DIDSON-S) and the other a long range model (DIDSON-LR). The DIDSON escapement estimate will be divided by the total redd count for the upper basin to derive a Klickitat-specific expansion factor which will be compared to the currently used expansion factor, calculated for spring Chinook in the Yakima River. Secondarily, the experience acquired over the season will be used to make a qualitative and quantitative evaluation of the reliability of the DIDSONs for producing an escapement estimate at this site. It is anticipated that a DIDSON study and the resulting DIDSON versus expanded redd count escapement comparisons will be repeated in 2010 and 2011.

Deliverables: A set of DIDSON recordings covering the spring Chinook migration

The study site is at the upstream end of the Castile Falls complex in the Klickitat River, at river km 103. In May 2009, a DIDSON-S will be installed adjacent to the outlet of the fishway, to record all upstream passage events, and a DIDSON-LR will be installed to look across the river in order to observe downstream ("fall back") passage. Power to the DIDSONs and associated electronic equipment will be supplied from a portable generator and a set of deep cycle batteries. The computer for each DIDSON, and an external hard drive to which the files will be directly recorded, will be housed onshore within a secure storage box. Both DIDSONs will be operated at their respective high frequencies, and programmed to record sequential 60 min files, producing a continuous set of DIDSON recordings covering the entire spring Chinook migration. CRITFC and YN personnel will travel to the site to confirm correct functioning of the instruments two to three times weekly. During each visit, data files will be downloaded from the field computers and transferred to an office-based server.

Milestones:

1) Environmental compliance requirements complete. (5/1/2009 to 5/1/2009) - On-the-ground work associated with this work element cannot proceed until this milestone is complete. Milestone is complete when final documentation is received from BPA environmental compliance staff (completion can be based on pre-existing environmental documentation from BPA).
2) Purchase of equipment and supplies. (5/1/2009 to 5/31/2009) - Purchase DIDSON and associated electronic equipment and supplies.
3) Installation of DIDSONs at study site. (5/1/2009 to 5/31/2009) - Install DIDSONs, associated electronic equipment, and partial weirs at study site. Test operation of equipment, and program the DIDSONs to collect continuous 60-min files.
4) Operate DIDSONs over the entire spring Chinook migration season (5/1/2009 to 8/31/2009) - Operate the DIDSONs over the entire 2009 migration season (May 1 to Aug 31) for spring Chinook at this site in the Klickitat River.

Work Element Category: R M & E and Data Management

Number and Title: #162 - Analyze/Interpret Data - Analyze DIDSON Data for spring Chinook Escapement

Description: The DIDSON recordings will be analyzed to estimate total spring Chinook spawning escapement to the upper basin of the Klickitat River (the region upstream of Castile Falls complex), and to describe diurnal and seasonal trends within this migration. An estimate of fish-per-redd, based on total redd count will be obtained by the YN, which will then be compared to the value of this expansion factor obtained in the Yakima River, which has historically been used for escapement estimation in the Klickitat.

Deliverables: Estimate of 2009 total escapement and fish-per-redd for upper basin Klickitat River spring Chinook.

Analysis of the DIDSON files will begin within a week following initiation of operation of the DIDSONs, and the files will be readcontinually over the season such that a preliminary escapement estimate should be available by the end of September 2009. From each days' set of DIDSON files, a corresponding set of "echogram" files will be generated, and the echograms reviewed to obtain total upstream and downstream counts per file. Upstream fish passage events observed during early May are expected be solely of migrating steelhead. By the end of May, these counts should be in decline, and a subsequent increase in upstream passage events later in June will be indicative of initiation of the spring Chinook migration. Passage of spring Chinook is expected to peak sometime in July, then to diminish and finish in August. Total upstream counts from the DIDSON files between the dates deemed to represent the

beginning and the end of the spring Chinook run will be summed within hours for each day. Gaps in the resulting data set, caused by power interruptions, instances of loss or corruption of files, etc., will be filled with predicted values from a joint distribution of hourly and daily trends in the data. The data set of hourly counts will then be summed to obtain daily estimates, and the daily estimates will be summed over the migration season to obtain an estimate of total escapement. This estimate will then be divided by the total redd count for the upper basin obtained in 2009, to provide an average value of fish per redd. Upstream passage events will also be graphed within hour of the day, to illustrate any diurnal pattern to movement at the site (of note, observations recorded for files from the 2008 trial indicated that fish movement occurred preferentially during the dawn and dusk hours). Additionally, daily escapement and flow (data to be obtained from the USGS river gauge #14107000 Klickitat River Above West Fork, located within a km upstream of the fishway outlet) will be graphed over time to look for possible correlations between flow and migration activity.

Milestones:

1) Generate and review Echogram files (5/1/2009 to 9/30/2009) - Generate Echogram files from each of the DIDSON recordings. Review the Echogram files to obtain upstream and downstream counts of salmon passage.
2) Estimate hourly, daily and total escapement (6/1/2009 to 10/30/2009) - Analyze counts from Echogram files to estimate hourly, daily and total counts of upstream and downstream salmon passage.
3) Summarize 2009 escapement information (10/1/2009 to 12/31/2009) - Summarize spring Chinook escapement information, including an analysis of diurnal and seasonal trends in migration, and comparison with flow data.
4) Estimate fish-per-redd ratio for 2009 (10/1/2009 to 12/31/2009) - Using the DIDSON-based escapement estimate and redd count information acquired by the YN, calculate a 2009 fish-per-redd ratio for the upper basin of the Klickitat River. Compare this value to that obtained in the Yakima River, which has historically been used for escapement estimation in the Klickitat.

Work Element Category: R M & E and Data Management

Number and Title: #161 - Disseminate Raw/Summary Data and Results - Report Results of DIDSON study

Description: Communicate project results within CRITFC and the Tribes (e.g., at internal CRITFC meetings or tribal meetings), and in professional forums (e.g., at the annual Klickitat & White Salmon Rivers Fisheries and Watershed Science Conference, and at local and regional American Fisheries Society meetings).

Deliverables: Oral and/or written summaries describing project results.

Oral and/or written summaries describing project results will be produced. These summaries will be communicated to YN/YKFP managers and to the CRITFC Data System. Oral summaries of results will be presented at relevant regional meetings and conferences, e.g., annual AFS state chapter Meetings, annual AFS Western Division Meeting, annual Klickitat/White Salmon Rivers Fisheries and Watershed Science Conference, annual Yakima Basin Science & Management Conference, annual Pelton Round Butte Fisheries Workshop, etc.

Milestones:

1) Communicate results to YN/YKFP CRITFC (9/1/2009 to 3/31/2010) - Communicate results to YN/YKFP managers and to the CRITFC Data System.
2) Produce a brief oral/written summary of results, for presentation at relevant meetings and conferences (10/1/2009 to 3/31/2010) - managers, and oral summaries for presentation at relevant regional meetings and conferences, e.g., annual AFS state chapter Meetings, annual AFS Western Division Meeting, annual Klickitat/White Salmon Rivers Fisheries and Watershed Science Conference, annual Yakima Basin Science.

Project Objective #2: Development of a mark-recapture likelihood model

Version 1 of our binomial-hypergeometric likelihood model to use mark-recapture data for estimating tag loss and population abundance (*http://www.critfc.org/tech/08-07report.html*) requires additional development, to increase its utility and improve its “user-friendliness”. There is a need to widen the

functionality of the model by modifying it to accept data (for the purpose of estimating the rate of tag loss) from an alternative double-tagging design which uses a permanent mark as the second tag. Currently, the model only accepts information for a double-tagging design involving two identical non-permanent tags. Additionally, the model will be revised to accept estimated values for tag loss and its standard error derived from a previous study, *in lieu* of raw data from a concurrently conducted double-tagging study. We will also modify the program to render it more "user friendly" (and more "user foolproof") by adapting the model input format to a web-based interface, and by modifying the manner in which the output data is displayed – so that it appears with the associated input data for each run, and provides optional file formats for storing the information. We will also perform additional validation exercises of the model, for inclusion in a manuscript describing the model and its utility, which will be submitted for publication in a peer-reviewed scientific journal.

Biological Objective #2 Complete development of the mark-recapture likelihood model.

Work Element Category: RM&E Data Management

Number and Title: #156 – Develop RM&E Methods and Designs - Develop Version 2 of Mark-Recapture Likelihood Model

Description: Version 1 of our Binomial-Hypergeometric Likelihood model to use mark-recapture data for estimating tag loss and population abundance (http://www.critfc.org/tech/08-07report.html) requires additional development, to increase its utility and improve its "user-friendliness".

Deliverables: Version #2 of Binomial-Hypergeometric Mark-Recapture Likelihood Model provide it wider functionality and to adapt it to a web-based user interface. There is a need to widen the functionality of the model by modifying it to accept data (for the purpose of estimating the rate of tag loss) from an alternative double-tagging design which uses a permanent mark as the second tag. Currently, the model only accepts information for a double-tagging design involving two identical non-permanent tags. Additionally, the model will be revised to accept estimated values for tag loss and its standard error derived from a previous study, in lieu of raw data from a concurrently conducted double-tagging study. We will also modify the program to render it more "user friendly" (and more "user foolproof") by adapting the model input format to a web-based interface, and by modifying the manner in which the output data is displayed – so that it appears with the associated input data for each run, and provides optional file formats for storing the information. We will also perform additional validation exercises of the model, for inclusion in a manuscript describing the model and its utility, which will be submitted for publication in a peer-reviewed scientific journal.

Milestones:

1) Complete development of the Binomial -Hypergeometric Mark-Recapture Likelihood Model (5/1/2009 to 8/31/2009) - Complete development (modify Version #1 to create Version #2) of the Binomial-Hypergeometric Mark-Recapture Likelihood Model and adapt it to a web-based user interface.
2) Post Version 2 of model to CRITFC website (8/1/2009 to 9/30/2009) - Replace Version #1 of the Likelihood Model with the new Version #2 in the CRITFC web site, for accessibility to the public.

Biological Objective #2 Present model in oral and written formats

Work Element Category: R M & E and Data Management

Number and Title: #161 - Disseminate Raw/Summary Data and Results - Oral presentation of Likelihood model at professional meetings

Description: Prepare and update an oral slide presentation describing the Mark-Recapture Likelihood Model, for presentation at relevant meetings and conferences. Note: the model was not designed for use with a focal species(s), but has applicability to any/all fish species subjected to a mark-recapture study.

Deliverables: Oral presentation of Likelihood Model at professional meetings.

Milestones:

1) Preparation and oral presentation of Likelihood Model at professional meetings (1/1/2010 to 3/31/2010) - Prepare and update an oral slide presentation describing the Mark-Recapture Likelihood Model, for presentation at the 2009 annual AFS national meeting (8/2009), and other relevant meetings and conferences.

Work Element Category: Reporting

Number and Title: #183 – Produce Journal Article - Prepare manuscript on Mark-Recapture model for publication

Description: Perform additional model validation exercises for inclusion in a manuscript describing the Binomial-Hypergeometric Likelihood Model for analysis of mark-recapture data. Submit the manuscript to an appropriate peer-reviewed scientific journal for publication. Produce a description of the model for oral presentation at relevant meetings and conferences.

Deliverables: Scientific journal manuscript. We will perform a series of simulations to validate the likelihood procedures within the Likelihood Model. This information will be incorporated into a manuscript which is being drafted to describe the derivation and applications of the Binomial-Hypergeometric Mark-Recapture Likelihood Model. The manuscript will be reviewed internally, then submitted for publication in a scientific peer-reviewed journal. Following receipt from the Editor of comments from journal reviewers, the manuscript will be revised and resubmitted. Publication is anticipated in 2010.

Milestones:

1) Perform simulation exercises for model validation (5/1/2009 to 7/31/2009) - Perform a series of simulations to validate the likelihood procedures within the Mark-Recapture Model.
2) Prepare draft manuscript describing Mark-Recapture Likelihood Model (5/1/2009 to 8/31/2009) - Prepare draft manuscript describing the derivation and applications of the Binomial-Hypergeometric Mark-Recapture Likelihood Model.
3) Internal technical review of manuscript (7/1/2009 to 9/30/2009) - Submit the draft manuscript for internal technical review.
4) Submit manuscript (8/1/2009 to 9/30/2009) - Submit manuscript for publication in a peer-reviewed scientific journal.
5) Revise manuscript in accordance with reviews (10/1/2009 to 3/31/2009) - Revise the manuscript in accordance with reviews received from journal Editor.

Project Objective #3: Support for an Unfunded RRS Study

To identify and provide financial support to a supplementation monitoring program in which adult and juvenile tissue samples have been collected and archived, but which lacks the funding needed for the molecular genetics-based parentage analyses and RRS evaluation.

The Biological Objectives for this project are to:

1.) Evaluate the relative characteristics of supplementation programs for which tissue samples have been collected but planned RRS studies have gone unfunded, and choose one project for additional support.
2.) Initiate molecular genetics analyses of archived tissue samples from the chosen supplementation project.

A) Evaluation of candidate supplementation populations

Several supplementation programs which would be candidates for additional financial support in order to perform planned but unfunded RRS studies are cited above. Discussions will be held during the initial months of the project with fisheries personnel from the four treaty Tribes and collaborating state fisheries agencies, to gather pertinent information on each of the aforementioned projects and on other candidate populations/programs. This information will be used to weigh the relative value that a RRS study might provide to a basinwide evaluation of supplementation. Of primary interest in this evaluation process is information on:

- integrity of the adult weir (estimated percent of adult escapement captured at the weir)
- confirmation of 100% marking of HO fish – to distinguish them from NO fish
- estimated percent of spawning which occurs below the adult weir
- number of adult tissue samples previously collected
- completeness of adult tissue sampling

- ancillary information on physical and behavioral characteristics of adults (see *Methods* section below)
- complementary information on annual redd counts, redd distribution (HO versus NO) and from carcass surveys
- number of juvenile samples obtained annually, and a qualitative evaluation of the "representativeness" of the sample to the totality of juvenile production
- longevity of the supplementation program and of the sample time series
- probability of continued data collection to support further analyses
- information of possible hatchery influence prior to initiation of the supplementation program

Information from the various programs will be compared and one of them will be chosen for supplemental financing. This support during Phase I will fund the genetics analyses of up to 4,000 tissue samples. In subsequent Phases to this project through the 10-year period of the Accords (2008), funding of the RRS study will continue, and an additional program or two will be identified to receive similar supplemental funding, to the extent that funds permit.

B) Methods for a Relative Reproductive Success (RRS) Study of a Supplemented Population

Methods – Sampling and Genetic Analysis

The basic procedures for estimating productivity and RRS of natural-origin versus hatchery-origin fish in a supplemented population are as follows: All (or, a large percentage) of returning adults in each successive broodyear are captured at a weir/trap. Prior to being released upstream for natural spawning or chosen for use as broodstock in the reintroduction hatchery program, each fish is:

- identified to origin (e.g., an adipose fin clip and/or coded-wire tag = HO; no clip or tag = NO)
- measured for length
- identified to sex
- scale sampled for aging
- tissue sampled for DNA analysis
- noted as to migration date

Also, a sample of juveniles is collected annually - typically through operation of a rotary screw-trap at a location in the river downstream of the spawning and juvenile rearing area. Sampling should occur across the entire out-migration period, with the number of juveniles collected within each sampling day/week adjusted to be proportional to the estimated total number for this day/week within the out-migration run. This will assure comparable sampling among progeny of the various parental types, should they exhibit differential out-migration timing. The natural origin juveniles will be:

- measured for length
- scale sampled for aging (if needed to distinguish between 0+ and 1+ age fish)
- tissue sampled for DNA analysis
- noted as to migration date

The tissue samples will be sent to Hagerman Fish Culture Experiment Station (HFCES), Hagerman ID, for extraction of the DNA and its analysis for a suite of microsatellite loci (e.g., Leth 2005, Murdoch et al. 2006). For convenience's sake, we will use the same set of 13 loci which have been identified by the as being informative for spring Chinook salmon stock identification. The choice of these particular loci, and standardization of laboratory procedures for detection and nomination of each locus' observed alleles, was developed by the Genetic Analysis of Pacific Salmonids (GAPS) consortium - a collaborative interagency group of scientists and managers to develop a centralized web accessible genetic database to support genetic stock identification of Chinook salmon. The GAPS consortium was created under sponsorship of the Pacific Salmon Commission (PSC) Chinook Technical Committee, and their work initiated with funding from the PSC's Northern Boundary and Transboundary Rivers, and the Southern Boundary Restoration & Enhancement Funds (Moran et al. 2005, Narum et al. 2007b, Seeb et al. 2007). Should parental assignment remain uncertain, we will analyze the concerned samples for an additional three or four more microsatellite loci in order to confirm parentage assignment (Jeffrey Stephenson,

HFCES, personal communication). With the genotypes generated by these analyses, parental assignments will be obtained using the CERVUS computer program (http://www.fieldgenetics.com/pages/home.jsp; Marshall et al. 1998). The program performs parentage tests both for maternal and paternal assignment separately, and for parent pairs.

Methods - Data analyses

The will parentage assignment information will permit calculation of the number of recruits per individual spawner within broodyears, and these data will be averaged within parental types. We will use a generalized linear model (GLM) to test the hypothesis of similarity of productivity among parental types (e.g., HO versus NO), with number of recruits as the response variable, and with origin, sex, size (length), and run timing (Julian day of return) of the parents as explanatory variables. Under the expectation that the response variable will follow a Poisson random distribution, we will use a log-linear model within the GLM. Additionally, a Chi square test of independence will be performed to examine the hypothesis of random mating among parental cross types (HOxHO, HOxNO, NOxHO and NOxNO) (Leth 2005 and Lutch et al. 2005).

When the time series for parentage information exceeds a full salmon generation, it will be possible to also calculate adult recruit per spawner information within broodyears. If the adult progeny data is sufficient, it will be subjected to analyses identical to those performed with the juvenile R/S data. Comparison of results between the pair of tests will help identify if observed productivity differences can be attributed to a particular life stage. For example, observation of relatively low reproductive success for HO fish based on juvenile R/S measures, and a RRS evaluation based on adult R/S which is similar would indicate that the differential success occurs primarily during the spawning and juvenile rearing portion of the life cycle, and that a significant deleterious effect is not observed during the adult stages. Or, if across broodyears RRS based on juvenile returns is consistently less than 1.0, and if RRS based on adult returns is even lower, then it would indicate that HO fish exhibit continually reduced productivity though both the juvenile and the adult life stages. On the other hand, if RRS measures are not significantly different from 1.0, it would indicate that a productivity difference is not observed among HO and NO parental types.

Methods - Data synthesis

The RRS data will be examined for consistency in trend across broodyears. Results of the project will be summarized in: a) reports submitted to BPA via PISCES, and to the fisheries agencies responsible for the supplementation programs, and b) in oral/slide presentations for presentation at scientific meetings and workshops, as well as public outreach events. Results of the project will also be shared in regional forums organized to address issues regarding use of hatcheries and supplementation, and of the critical uncertainties related to long-term effects of supplementation on natural population fitness, e.g., meetings which follow up on findings from CSMEP (Marmorek et al. 2007a and b) and AHSWG (2008). A joint manuscript describing results of the RRS analyses will be co-authored with the supplementation project managers.

Biological Objective #1 Evaluate the characteristics of supplementation programs for which tissue samples have been collected but planned RRS studies have gone unfunded.

Work Element Category: Planning and Coordination

Number and Title: #114 – Identify and Select Projects - Evaluate candidate supplementation programs for a RRS study

Description: Gather information with which to compare supplementation monitoring programs in which adult and juvenile tissue samples have been collected and archived, but which lacks the funding needed for the molecular genetics-based parentage analyses and RRS evaluation. Prioritize one program for funding, and prepare a design for a RRS study.

Deliverables: RRS study design for a chosen supplementation program

From among several candidate supplementation programs, one will be chosen to have an associated RRS study performed, a study design for which will be prepared within the present Phase I project.

Pertinent information on multiple candidate populations/programs in the Columbia basin will be obtained from written reports and from discussions held during the initial months of the project with fisheries personnel from the four treaty Tribes and collaborating state fisheries agencies. This information will be used to weigh the relative value that a RRS study might provide to a basinwide evaluation of supplementation. Of primary interest in this evaluation process is information on:

- integrity of the adult weir (estimated percent of adult escapement captured at the weir)
- confirmation of 100% marking of HO fish – to distinguish them from NO fish
- estimated percent of spawning which occurs below the adult weir
- number of adult tissue samples previously collected
- completeness of adult tissue sampling
- ancillary information on physical and behavioral characteristics of adults (see Methods section below)
- complementary information on annual redd counts, redd distribution (HO versus NO) and from carcass surveys
- number of juvenile samples obtained annually, and a qualitative evaluation of the "representativeness" of the sample to the totality of juvenile production
- longevity of the supplementation program and of the sample time series
- probability of continued data collection to support further analyses
- information of possible hatchery influence prior to initiation of the supplementation program

Information from the various programs will be compared, one of them will be chosen and a study design will be prepared for a RRS study to be supported through the present Phase I project.

Milestones:

1) Gather information on supplementation programs with an unfunded RRS study. (5/1/2009 to 9/31/2009) - Meet with tribal and state fisheries personnel to obtain relevant information on candidate supplementation programs and populations, for which an RRS study has been proposed but remains unfunded.
2) Choose one supplementation program for support of an RRS study (8/1/2009 to 10/31/2009) - Evaluate the relative need and value to supporting a RRS study in each candidate population, and choose one for supplemental financial support, providing the rationale for selection as part of the annual report.
3) Prepare study design for the RRS study (9/1/2009 to 11/30/2009) - In collaboration with associated tribal and state fisheries agencies, prepare a study design for a RRS study of the chosen supplemented population.

Biological Objective #2 Initiate molecular genetics analyses of archived tissue samples from chosen supplementation project

Work Element Category: R M & E and Data Management

Number and Title: #157 - Collect/Generate/Validate Field and Lab Data - Initiate collection and molecular genetics analyses of tissue samples

Description: Initiate collection and molecular genetics analyses of tissue samples from chosen supplementation project. If the chosen program has already collected and archived tissue samples, arrangements will be made for delivery of the samples to the Hagerman Fish Culture Experiment Station (HFCES). There, molecular genetics analyses and parentage assignments will be initiated. Estimated total number of samples = 4,000. Note: a location for this Work Element has not been assigned, as identification of the particular population to be studied (and its location) will not occur until later within the Project time period.

Deliverables: Delivery and initiation of molecular genetics analyses

Archived samples will be delivered to HFCES where molecular genetics analyses will be initiated. The "fitness" of a fish population is typically measured in terms of its demonstrated natural productivity – the number of recruits per natural spawner (R/S), with the recruits enumerated at a juvenile stage and/or as returning adults. However, in cases where the naturally spawning population is supplemented, it consists of alternative parental types, e.g., natural origin versus supplementation hatchery origin). Until recently, researchers have been unable to compare the relative natural productivity among parental types in these populations, due to the inability to differentiate the parental identity of the naturally produced progeny. However, new molecular genetics techniques using multi-locus DNA markers now provide this capability

(see reviews by Wilson and Ferguson 2002, Jones and Ardren 2003, Liu and Cordes 2004). The techniques require annual collection of scale and tissue samples from essentially all (or, at least a large majority of) adults which return to a river for natural spawning, with hatchery origin adults identifiable via presence of a tag or an external mark (e.g., clipped adipose fin). The scales are used to age the fish and assign them to a particular broodyear, and the tissue is used as a source of DNA. The DNA is extracted then analyzed to identify the alleles present for a suite of molecular markers, providing a profile for each potential spawner within a particular broodyear. After a generation has passed, the profiles of the adult progeny assigned to each broodyear are compared with those of the broodyear's spawners, and the total number of progeny assigned per adult can be calculated. The average (and variance) number of adult recruits for each parental type (e.g., out-of-basin HO, versus in-basin HO, versus NO fish) is then calculated and compared among parental types.

Milestones:

1) Environmental compliance requirements complete (5/1/2009 to 5/1/2009) - On-the-ground work associated with this work element cannot proceed until this milestone is complete. Milestone is complete when final documentation is received from BPA environmental compliance staff (completion can be based on pre-existing environmental documentation from BPA).
2) Delivery of archived tissue samples to HFCES. (9/1/2009 to 2/28/2010) - Archived tissue samples from the program chosen for support of a RRS study will be delivered to the HFCES.
2) Initiate molecular genetics analyses (10/1/2009 to 3/31/2010) - Initiate molecular genetics analyses with which to perform parentage assignments as part of a RRS study.

Work Element Category: R M & E and Data Management

Number and Title: #162 - Analyze/Interpret Data - Perform parentage and RRS analyses

Description: Use data from molecular genetics analyses to perform parentage assignment of juveniles within broodyears. Calculate individual productivity estimates and average productivity for parental types, then estimate Relative Reproductive Success (RRS) among parental types. Perform statistical tests of RRS estimates for an effect of origin, and compare results across broodyears. Note: these analytical processes will likely extend into Phase II of the Project.

Deliverables: Summary of parentage and RRS analyses adults, to be continually updated as additional analyses are performed. The parentage assignment information will permit calculation of the number of recruits per individual spawner within broodyears, and these data will be averaged within parental types. We will use a generalized linear model (GLM) to test the hypothesis of similarity of productivity among parental types (e.g., HO versus NO), with number of recruits as the response variable, and with origin, sex, size (length), and run timing (Julian day of return) of the parents as explanatory variables. Under the expectation that the response variable will follow a Poisson random distribution, we will use a log-linear model within the GLM. Additionally, a Chi square test of independence will be performed to examine the hypothesis of random mating among parental cross types (HOxHO, HOxNO, NOxHO and NOxNO) (Leth 2005 and Lutch et al. 2005). When the time series for parentage information exceeds a full salmon generation, it will be possible to also calculate adult recruit per spawner information within broodyears. If the adult progeny data is sufficient, it will be subjected to analyses identical to those performed with the juvenile R/S data. Comparison of results between the pair of tests will help identify if observed productivity differences can be attributed to a particular life stage. For example, observation of relatively low reproductive success for HO fish based on juvenile R/S measures, and a RRS evaluation based on adult R/S which is similar would indicate that the differential success occurs primarily during the spawning and juvenile rearing portion of the life cycle, and that a significant deleterious effect is not observed during the adult stages. Or, if across broodyears RRS based on juvenile returns is consistently less than 1.0, and if RRS based on adult returns is even lower, then it would indicate that HO fish exhibit continually reduced productivity though both the juvenile and the adult life stages. On the other hand, if RRS measures are not significantly different from 1.0, it would indicate that a productivity difference is not observed among HO and NO parental types.

Milestones:

1) Calculate RRS within broodyears. (11/1/2009 to 3/31/2010) - As molecular genetics and parentage analyses for each broodyear's progeny is completed, RRS of hatchery-origin versus natural origin adults will be calculated.

2) Perform statistical analyses within broodyears (11/1/2009 to 3/31/2010) - Use a generalized linear model (GLM) to test the hypothesis of similarity of productivity among parental types (e.g., HO versus NO), with number of recruits as the response variable, and with origin, sex, size (length), and run timing (Julian day of return) of the parents as explanatory variables. Under the expectation that the response variable will follow a Poisson random distribution, we will use a log-linear model within the GLM. Additionally, a Chi square test of independence will be performed to examine the hypothesis of random mating among parental cross types (HOxHO, HOxNO, NOxHO and NOxNO).
3) Summarize RRS information and compare across broodyears. (12/1/2009 to 3/31/2010) - Summarize data for each successive broodyear as analyses are complete, and assess for consistency of results among broodyears.

Work Element Category: R M & E and Data Management

Number and Title: #161 - Disseminate Raw/Summary Data and Results - Report results of RRS study

Description: We will maintain an updated summary of RRS study results, in oral and written formats, as each broodyear's productivity and RRS information becomes available. These summaries will be communicated to associated fisheries managers and in relevant professional forums.

Deliverables: Oral and written summary of RRS study results

An updated summary of RRS study results will be maintained, and results will be communicated to CRITFC and the Tribes (e.g., at internal CRITFC meetings or tribal meetings), and to associarted state fisheries agencies. Results will also be presented in regional forums involving evaluation of basinwide effects of supplementation programs on natural population productivity, e.g., forums/discussions which directly or indirectly grow out of the findings of the AHSWG (2008), in basin/regional workshops concerning fisheries and watershed management. and in professional forums (e.g., at local and regional American Fisheries Society meetings). We anticipate that during a subsequent Phase of the project, results will be summarized in a written manuscript to be submitted for publication in a scientific Journal.

Milestones:

1) Produce an updated summary presentation of RRS results (1/1/2010 to 3/31/2010) - Produce a continually updated summary presentation of project results, in both oral and written formats. Provide written summaries of project results for submission to concerned tribal and state fisheries agency managers, and oral summaries for presentation at relevant regional meetings and conferences, e.g., annual AFS national meeting, annual state chapter Meetings, annual AFS Western Division Meeting, annual Klickitat/White Salmon Rivers Fisheries and Watershed Science Conference, annual Yakima Basin Science & Management Conference, annual Pelton Round Butte Fisheries Workshop, etc.

Project Objective #4: RRS in Reintroduced/Supplemented Populations

The primary biological objective of this project is to initiate RRS studies (following methodologies identical to those described under Project Objective #3) over successive generations in four to five populations which were reintroduced with out-of-basin hatchery stocks (due to extirpation of the native population) and supported through continued hatchery supplementation. The rationale for these reintroduction/supplementation programs is that the reintroduced stock will become progressively adapted to the new environment and that a new viable natural population will be established. If such is the case, then a RRS study should provide empirical evidence that natural origin fish exhibit higher reproductive success than hatchery origin fish, and among the hatchery origin fish, those of local origin exhibit higher reproductive success than those of out of basin origin: RRS of out-of-basin HO < local HO < NO. If indeed this relationship is observed, it will support the presumption that appropriate hatchery management practices and natural selective pressures can work to take an out-of-basin hatchery stock and recreate a locally adapted and potentially self-sustainable natural population. Estimates of reproductive fitness which demonstrate this trend for increasing productivity will: 1) provide empirical measures of relative success of each particular reintroduction/supplementation program, and 2) provide information regarding the critical uncertainty surrounding long term effects of hatchery rearing on natural populations. If this relationship is not observed, it will 1) reinforce suspicions that hatchery rearing can

impart long term deleterious effects on natural fitness – effects that are difficult to reverse, and 2) call further into question the potential for effectively reintroducing a population with hatchery stocks, and the advisability of using artificial production within a program for salmon restoration.

The present proposal describes activities for Year #1 of a projected 10-year project. The Biological Objectives for Year #1 are to:

1.) Initiate molecular genetics analyses of archived scale samples of Hood River spring Chinook adults.
2.) Choose three to four additional reintroduced/supplemented salmon or steelhead populations for RRS studies to be conducted over the coming 10 years.
3.) Hold the "Workshop on Tribal Efforts to Reintroduce Extirpated Columbia Basin Salmon Populations".
4.) Initiate sample collection activities in the populations chosen for study.

A) Candidate reintroduced/supplemented populations

Among populations of reintroduced salmon in the Columbia basin which would be candidates for a RRS study, the criterion for selection of primary concern would be the relative ability to capture the entirety of the spawning escapement. In some streams a weir/trap does not exist, providing no means to capture and sample the in-migrating adults. And even when a weir is present, there are several scenarios which can lead to incomplete sampling of parents within broodyears. Depending on water flows and other physical characters of the weir and stream, a weir will be more or less effective at intercepting the migrating adults, and/or the weir may be located upstream of a portion of the spawning habitat. In both cases the result will be that only a partial sample of the escapement can be obtained. A similar situation occurs when mature freshwater fish residing above the weir participate with the anadromous adults in the natural spawning (a life-history common in steelhead populations). As the proportion of unsampled spawners increases, the power to perform parental assignment of the sampled recruits rapidly diminishes. Populations for which the proportion of unsampled adults is minimal, therefore, offer the greatest possibility for a successful RRS study.

Another character to be considered among populations is the relative time period since reintroduction was initiated. To obtain as full a picture as possible of changes in productivity that may occur over time within a reintroduced population, it would be best to perform these RRS studies in programs where samples can be obtained for progeny of the first generation of natural origin adults. It will be additionally advantageous if productivity (juvenile R/S) information can also be obtained for hatchery origin adults in the preceding broodyears. Initiation of a RRS study on a population which has already experienced two or more generations of natural origin spawning, and which has had substantial numbers of natural origin fish incorporated into the hatchery broodstock will provide information of interest, however, the time series will lack data on changes in productivity which occur during the early years – the time period when one might expect the differences to be the most dramatic.

Additional criteria for choice of populations for a RRS study include:

- operation of the weir/trap is ongoing and expected to continue
- juvenile sampling with a rotary screwtrap is ongoing
- spawning escapement is high enough to provide sufficient power to assess relative productivity, but not so high as to make laboratory costs for the genetics analyses prohibitively expensive – e.g., abundance in the range of 200 to 1,000
- reintroduction/supplementation program includes additional M&E (redd counts, redd distribution, HO versus NO carcass distribution, etc.) for which the data on morphometry, run timing, productivity and RRS would provide complementary information with which observed differences in RRS may be interpreted

A provisional list of streams/rivers within the Columbia River basin with a reintroduced/supplemented population which might be candidates for a study of relative natural productivity is provided in the table below (based on Table 4 in AHSWG 2008). Discussion will be held with fisheries management personnel (tribal and non-tribal) associated with these and other reintroduction programs, during which additional

populations may be added to the list. Then, an assessment will be made of how well each program/population meets the criteria described above, and of the projected logistical feasibility and cost for executing a RRS study in each. Based on this assessment, four to five populations will be prioritized for study.

Species	Stream	Subbasin	Project	Current monitoring includes:	
				Adult Trapping	Smolt Trapping
Spring Chinook	Hood River (Powerdale Dam)	Hood River	Hood River Monitoring and Evaluation Project Project # 1988-053-03	yes	yes
Spring Chinook	Iskuulpa Creek	Umatilla River	Umatilla Basin Natural Production Monitoring and Evaluation Project Project # 1990-005-01	yes	No (?)
Spring Chinook	Newsome Creek	Clearwater River	Nez Perce Tribal Hatchery M&E Project # 1983-350-00 Nez Perce Tribe	Yes	No
Spring Chinook	Clear Creek	Clearwater River		Yes	No
Spring Chinook	Crooked River	South Fork Clearwater River		Yes	No
Spring Chinook	Red River	South Fork Clearwater River		Yes	No
Spring Chinook	Lookingglass Creek	Grande Ronde River	Grande Ronde Basin Endemic Spring Chinook Supplementation Project: Northeast Oregon hatcheries Implementation Project # 1998-007-04 ODFW	Yes	Yes (?)
Coho	Upper Yakima (Roza Dam)	Yakima River	Yakima/Klickitat Fisheries Project's Monitoring and Evaluation Project # 1995-063-25 Yakama Nation	Yes	No
Coho	Upper Wenatchee (Tumwater Dam)	Wenatchee River	Mid-Columbia Coho Reintroduction Feasibility Study Project # 1996-040-00 Yakama Nation	Yes (?)	No

Among the populations listed in the above table, the Hood River spring Chinook is exceptional in that the ODFW has collected and archived scale samples of in-migrating adults at Powerdale Dam (river km 6) since inception of the reintroduction/supplementation project in 1993. As such, a 20+ year retrospective RRS analysis could be initiated already within Year #1 of this project. Of note, a RRS study of these archived samples was included within the Revised Hood River Production Program Master Plan (ODFW and CTWSRO 2008) which was submitted to the NPCC and recently underwent ISRP review. The Plan received an "In Part (qualified)" evaluation, pending results of comparative hatchery rearing evaluations. Therefore, we propose to give highest priority to a RRS study of the Hood River spring Chinook, and intend to initiate analyses of the archived samples within the present Phase I portion of the project. While the fisheries agencies may initiate sample collection in the other three to four populations chosen for study, laboratory analysis of these samples is not foreseen to commence until Phase II.

B) Methods for a Relative Reproductive Success (RRS) Study of a Supplemented Population

Methods – Sampling and Genetic Analysis

The procedures for sampling and genetics analysis will be identical to those for the RRS study described under Objective #3. An exception is that the Hood River spring Chinook study proposed here (see below)

will involve use of archived scales as a source of DNA. If the DNA extracted from these scales is of insufficient quality to obtain reliable microsatellite genotypes, SNP markers will also be analyzed in order to assure parentage assignment (Campbell and Narum 2008). However, we predict that this will not be necessary, as a preliminary test of a sample of scales collected from as far back as 1993 indicated only minimal problems in resolving the alleles for the suite of microsatellite loci (Jeffrey Stephenson, HFCES, personal communication).

Summary information on the number of Hood River spring Chinook NO and HO adults within the escapement each broodyear, and the number of NO adult recruits per broodyear is provided in the table below. The bulk of this information is from Table 64 in Olsen (2007), plus additional information with which the HO escapement was corrected, including, the number of returning HO adults taken at Powerdale Dam for use as broodstock (James Gidley, CTWSRO, personal communication), and estimated numbers of HO fish taken in tribal harvest above Powerdale Dam (Ryan Gerstenberger, CTWSRO, personal communication). Scale samples from essentially all of these fish have been collected and archived, and are available for analysis within this proposed project.

Broodyear	Total NO Escapement	Total HO Escapement	Total Escapement	Total NO Recruits
1992	35	418	453	97
1993	43	467	510	37
1994	34	278	312	36
1995	20	72	92	39
1996	98	33	131	67
1997	86	298	384	34
1998	86	-5	81	64
1999	25	282	307	61
2000	69	1071	1140	130
2001	46	839	885	81
2002	73	816	889	273
2003	113	393	506	52
2004	151	396	547	
2005	117	546	663	
2006	302	927	1229	
2007	152	1018	1170	

Methods - Data analyses

While the analytical methodologies used will be similar to those described above under Project Objective #3, the expectations for the NO versus HO comparisons will be rather different in a reintroduced population relative to a depressed extant population which is being supplemented. Early in a reintroduction/supplementation program, a portion of the returning adults from the initial transfers of out-of-basin HO juveniles will escape upstream of the weir for natural spawning. A count of their progeny, as juveniles or returning adults, can be used to obtain a measure of natural productivity of the original out-of-basin hatchery stock, though of course, these measures will be subject to the temporal effects of environmental conditions within these initial years in addition to the fish' inherent productivity capability. In subsequent generations, the adults which escape for natural spawning will consist of a mix of HO returns, and NO fish from the first natural spawnings. These adults will produce four possible parental crosses (female x male): HOxHO, HOxNO, NOxHO and NOxNO. Additionally, depending on the program, the HO adults may consist of a mix of fish of direct out-of-basin hatchery origin, or progeny of "local" HO parentage – fish produced from HO adults which were captured in-basin and used for hatchery broodstock. Knowing the genotypic profile of each of the HO and NO adults in the spawning escapement within brood years, genetics analyses of the progeny will permit identification of the maternal and paternal parent of each. The number of progeny per parental type (within sexes, and by parental cross type) will be analyzed in the same manner described for Project Objective #3. If selective pressures are acting over generations to improve the natural productivity of the new population - that is, if significant adaptation of the reintroduced stock to local natural conditions is occurring - then we expect to reject the

null hypothesis of similar productivity and observe increasing measures of natural productivity among parental types in the following manner: out-of-basin HO < local HO < local NO.

Methods - Data synthesis

As data accumulates, it will be compared across broodyears within populations, and across populations. Results of the project will be summarized in: a) reports submitted to BPA via PISCES, b) in oral/slide presentations for presentation at scientific meetings and workshops, as well as public outreach events, and c) in written manuscripts for publication in scientific journals, as well as articles for publication in public media. During the first year of this project (Phase I), preparations will be made to bring project personnel together in project-sponsored workshops to share information and experiences, as well as to receive specific training in the techniques and applications of the molecular genetics tools used to perform the parentage assignment and statistical analyses. This workshop will likely be held early in 2010. Results of the project will also be shared in regional forums organized to address issues regarding use of hatcheries and supplementation, and of the critical uncertainties related to long-term effects of supplementation on natural population fitness, e.g., meetings which follow up on findings from CSMEP (Marmorek et al. 2007a and b) and the AHSWG (2008) report. A joint manuscript describing results of the RRS analyses for each reintroduction program studied will be co-authored with the supplementation project managers. Of note, in Phase II of this 10-year project, we intend to organize a second expanded public symposium on the topic of salmonid reintroductions, which we hope to co-sponsor with other concerned agencies and the American Fisheries Society (AFS), and whose proceedings would be published through the AFS.

Biological Objective #1 Initiate molecular genetics analyses of archived scale samples of Hood River spring Chinook adults.

Work Element Category: R M & E and Data Management

Number and Title: #157 - Collect/Generate/Validate Field and Lab Data - Perform molecular genetics analyses of archived Hood River spring Chinook samples

Description: Archived scale samples of Hood River spring Chinook (1993 to present) will be delivered to the HFCES where molecular genetics analyses will be performed. Analyses will consist of extraction of DNA from each sample, and analysis for a suite of 13 microsatellite markers.

Deliverables: Molecular genetics analyses for archived Hood River spring Chinook samples Molecular genetics analyses will be performed on archived Hood River spring Chinook samples. Archived samples will be delivered to HFCES where molecular genetics analyses will be initiated. The "fitness" of a fish population is typically measured in terms of its demonstrated natural productivity – the number of recruits per natural spawner (R/S), with the recruits enumerated at a juvenile stage and/or as returning adults. However, in cases where the naturally spawning population is supplemented, it consists of alternative parental types, e.g., natural origin versus supplementation hatchery origin). Until recently, researchers have been unable to compare the relative natural productivity among parental types in these populations, due to the inability to differentiate the parental identity of the naturally produced progeny. However, new molecular genetics techniques using multi-locus DNA markers now provide this capability (see reviews by Wilson and Ferguson 2002, Jones and Ardren 2003, Liu and Cordes 2004). The techniques require annual collection of scale and tissue samples from essentially all (or, at least a large majority of) adults which return to a river for natural spawning, with hatchery origin adults identifiable via presence of a tag or an external mark (e.g., clipped adipose fin). The scales are used to age the fish and assign them to a particular broodyear - already performed for the Hood River spring Chinook samples by ODFW. DNA will be extracted from the scale samples delivered to HFCES. The DNA will then be analyzed to identify the alleles present for a suite of 13 microsatellite markers, providing a profile for each potential spawner within a particular broodyear. After a generation has passed, the profiles of the adult progeny assigned to each broodyear are compared with those of the broodyear's spawners, and the total number of progeny assigned per adult can be calculated. The average (and variance) number of adult recruits for each parental type (e.g., out-of-basin HO, versus in-basin HO, versus NO fish) is then calculated and compared among parental types.

Milestones:

1) Environmental compliance requirements complete (5/1/2009 to 5/1/2009) - On-the-ground work associated with this work element cannot proceed until this milestone is complete. Milestone is complete when final documentation is received from BPA environmental compliance staff (completion can be based on pre-existing environmental documentation from BPA).
2) Purchase of supplemental equipment for HFCES (5/1/2009 to 9/30/2009) - Purchase electronic office equipment and laboratory equipment – laptop computer, Fluidigm-Biomark IFC Controllers and Thermal Cyclers, and laboratory benches/cabinets and archive shelving - required for performance of molecular genetics analyses.
3) Delivery of archived scale samples (5/1/2009 to 12/31/2009) - Delivery by ODFW of archived Hood River spring Chinook scale samples and associated field data to the HFCES - will likely be made in multiple deliveries over the year.
4) Molecular genetics analyses (6/1/2009 to 3/31/2009) - Perform molecular genetics analyses and parentage assignment for each sample.

Work Element Category: R M & E and Data Management

Number and Title: #162 - Analyze/Interpret Data - Perform parentage and RRS analyses of Hood River spring Chinook

Description: Genetic profiles acquired for each fish will be compared to the profiles for adults in its respective broodyear, to permit parentage assignment. Individual productivity (R/S) estimates will be calculated for each adult within broodyears, as well as average productivity and Relative Reproductive Success (RRS) among parental types within broodyears. Statistical tests of RRS will then be performed estimates for an effect of origin, and compare results across broodyears.

Deliverables: Parentage and RRS analysis within broodyears

The parentage assignment information will permit calculation of the number of recruits per individual spawner within broodyears, and these data will be averaged within parental types. We will use a generalized linear model (GLM) to test the hypothesis of similarity of productivity among parental types (e.g., HO versus NO), with number of recruits as the response variable, and with origin, sex, size (length), and run timing (Julian day of return) of the parents as explanatory variables. Under the expectation that the response variable will follow a Poisson random distribution, we will use a log-linear model within the GLM. Additionally, a Chi square test of independence will be performed to examine the hypothesis of random mating among parental cross types (HOxHO, HOxNO, NOxHO and NOxNO) (Leth 2005 and Lutch et al. 2005).

When the time series for parentage information exceeds a full salmon generation, it will be possible to also calculate adult recruit per spawner information within broodyears. If the adult progeny data is sufficient, it will be subjected to analyses identical to those performed with the juvenile R/S data. Comparison of results between the pair of tests will help identify if observed productivity differences can be attributed to a particular life stage. For example, observation of relatively low reproductive success for HO fish based on juvenile R/S measures, and a RRS evaluation based on adult R/S which is similar would indicate that the differential success occurs primarily during the spawning and juvenile rearing portion of the life cycle, and that a significant deleterious effect is not observed during the adult stages. Or, if across broodyears RRS based on juvenile returns is consistently less than 1.0, and if RRS based on adult returns is even lower, then it would indicate that HO fish exhibit continually reduced productivity though both the juvenile and the adult life stages. On the other hand, if RRS measures are not significantly different from 1.0, it would indicate that a productivity difference is not observed among HO and NO parental types.

Milestones:

1) Calculate productivity and RRS within broodyears (8/1/2009 to 3/31/2010) - As molecular genetics analyses and parentage assignments are completed for each broodyear, calculate individual productivity (recruits/spawner) and RRS (natural-origin versus hatchery-origin) within broodyears.
2) Statistical anaysis for RRS within broodyears (8/1/2009 to 3/31/2010) - Perform statistical analyses of RRS within broodyears to test for a significant effect of origin on productivity.
3) Summarize RRS information and compare data across broodyears (9/1/2009 to 3/31/2010) - Summarize RRS information and assess consistency of data across broodyears.

Work Element Category: R M & E and Data Management

Number and Title: #161 - Disseminate Raw/Summary Data and Results - Report results of Hood River spring Chinook RRS study

Description: We will maintain an updated summary of RRS study results, in oral and written formats, as each broodyear's productivity and RRS information becomes available. These summaries will be communicated to fisheries managers with the CTWSRO and ODFW, and oral summaries will be presented in relevant professional forums.

Deliverables: Updated summary of RRS results

An updated summary of RRS study results will be maintained, and results will be communicated in written and oral formats to the CTWSRO and ODFW. Results will also be presented in regional forums involving evaluation of basinwide effects of supplementation programs on natural population productivity, e.g., forums/discussions which directly or indirectly grow out of the findings of the AHSWG (2008), in basin/regional workshops concerning fisheries and watershed management. and in professional forums (e.g., at local and regional American Fisheries Society meetings). We anticipate that during a subsequent Phase of the project, results will be summarized in a written manuscript to be submitted for publication in a scientific journal.

Milestones:

1) A. Maintain and communicate an updated summary of study results (11/1/2009 to 3/31/2010) - Communicate the current summary of project results within CRITFC and the Tribes (e.g., at internal CRITFC meetings or tribal meetings). This summary will be updated as each broodyear's productivity and RRS information becomes available. Produce written summaries of project results for submission to associated tribal and state fisheries agencies, and oral summaries for presentation at relevant regional meetings and conferences, e.g., annual AFS state chapter Meetings, annual AFS Western Division Meeting, annual Klickitat/White Salmon Rivers Fisheries and Watershed Science Conference, annual Yakima Basin Science & Management Conference, annual Pelton Round Butte Fisheries Workshop, etc.

Biological Objective #2 Choose three to four additional reintroduced/supplemented salmon or steelhead populations for RRS studies.

Work Element Category: Planning and Coordination

Number and Title: #114 – Identify and Select Projects - Evaluate other candidate reintroduction/supplementation programs for an RRS study

Description: Gather information on multiple reintroduced/supplemented salmon populations, identify 3 to 4 among them for support of a RRS study, and produce a study design for each in collaboration with associated tribal and state fisheries agencies - to be included within the proposal for Phase II of the Project.

Deliverables: Produce RRS study plans for 3 to 4 reintroduced/supplemented populations In collaboration with tribal and state fisheries personnel, collect information on candidate supplementation projects for reintroduction of salmon or steelhead, including: efficacy of adult trap, annual escapement, current or potential juvenile collection methodologies, actual or estimated O&M costs for juvenile collection, etc. Evaluate the relative feasibility, benefits and cost for establishing a RRS study in each of the populations. Chose three to four populations for study - the number to be determined through comparison of estimated project-specific costs and the overall budget envelope for the project. Identify the lead tribal fisheries biologist/scientist (to be included among the Key personnel in a Phase II proposal) associated with the reintroduction program for each of the chosen populations, and together develop work plans for annual collection of samples and biological data from adult and juveniles, to be included within the Narrative for the proposal for Phase II of the Project.

Milestones:

1) Gather information on reintroduced/supplemented populations (4/1/2009 to 10/31/2009) - Meet with tribal and state fisheries personnel to obtain relevant information on candidate populations of reintroduced/supplemented salmon.
2) Evaluate and prioritize populations for a RRS study (9/1/2009 to 1/31/2010) - Evaluate the relative and total costs among candidate populations; choose three to four populations for a RRS study.

3) Develop a study plan for the RRS study in each chosen population (11/1/2009 to 2/28/2010) - Develop a work plan for collection of individual data and tissue samples from adults and juveniles in each of the chosen populations.
4) Integrate study plans into Phase II narrative (12/1/2009 to 2/28/2010) - Integrate the study plans into the Narrative for the Phase II proposal for the Project, and submit the narrative for review by BPA and the ISRP.
5) Respond to BPA and ISRP reviews (3/1 to 31 /2010) - Respond to BPA and ISRP reviews, and enter the modified narrative into PISCES, create the SOW, and begin the contracting process.

Biological Objective #3 Organize the "Workshop on Tribal Programs to Reintroduce Extirpated Columbia Basin Salmon Populations".

Work Element Category: Planning and Coordination

Number and Title: #189 – Regional Coordination - Organize tribal workshop on salmon reintroduction/supplementation programs

Description: Organize the "Workshop on Tribal Programs to Reintroduce Extirpated Columbia Basin Salmon Populations".

Deliverables: Hold the "Workshop on Tribal Programs to Reintroduce Extirpated Columbia Basin Salmon Populations"

CRITFC will organize a workshop to review progress of tribal projects involving salmon reintroduction/supplementation, with the purpose of: a) facilitating obtaining summary information with which to assess the candidate reintroduced/supplemented populations for a RRS study, and b) sharing program information and helping to coordinate methodologies, and monitoring and evaluation activities among these tribal projects. The meeting will provide a venue for tribal managers, scientists, biologist and technicians to share and compare information (amongst themselves, and with interested persons from outside the tribal programs) regarding their efforts, of both a technical and management nature, via formal presentations, site visits, and informal discussions.

Milestones:

1) Prepare the Workshop. (9/1/2009 to 2/28/2010) - Prepare the workshop, involving identification of the: venue (conference room and lodging), participant list, procedure for reimbursement of invited tribal participants, program of conference presentations and speakers, etc.
2) Hold the workshop (1/1/2010 to 3/31/2010) - Hold the "Workshop on Tribal Programs to Reintroduce Extirpated Columbia Basin Salmon Populations".

Work Element Category: Reporting

Number and Title: #183 – Produce Journal Article - Initiate preparation of manuscript on tribal programs to reintroduce coho salmon

Description: We will initiate drafting of a manuscript on tribal programs to reintroduce naturally spawning populations of Columbia River coho.

Deliverables: Draft of coho reintroduction manuscript

Following the Workshop, participants from each tribe will be invited to contribute to a written review focused specifically on tribal efforts to restore extirpated coho salmon to the Columbia basin. The review paper will be prepared in a format appropriate for submission to Fisheries (American Fisheries Society). Tentative title is: "Tribal Fisheries Efforts to Restore Extirpated Coho Salmon to the Mid-Columbia and Snake River Basins". Completion and submission of the manuscript is predicted in 2010, during Phase II of this project.

Milestones:

1) Initiate preparation of coho reintroduction manuscript (12/1/2009 to 3/31/2010) - Initiate preparation of manuscript: "Tribal Fisheries Efforts to Restore Extirpated Coho to the Mid-Columbia and Snake River Basins".

G. Monitoring and Evaluation

Enacting each of the 4 project objectives will yield vital new measures of abundance and productivity for the associated supplementation programs and populations. This information will be shared with the concerned fisheries managers, and can then be applied to the adaptive management process defined for each hatchery program – the process by which management procedures may be modified in response to changes in population trends affected by the program, and by factors that affect freshwater habitat, harvest management and hydrosystem survival. While adaptive management processes are described in greater or lesser detail for each hatchery program, recent hatchery reform review processes have indicated that the detail is often insufficient. They have stressed the importance that management guidelines be better defined, with quantified conservation and harvest goals, and with a clear decision-making process for modifications to hatchery protocols in response to new data on population abundance and productivity. These hatchery review efforts include those of the Hatchery Scientific Review Group for Columbia basin hatcheries and populations (http://www.hatcheryreform.us/prod/), and a set of similar groups which are focused strictly on the federal hatcheries operated by the US Fish and Wildlife Service in different areas within the Pacific Northwest, including a group specifically looking at hatcheries within the Columbia basin (http://www.fws.gov/Pacific/fisheries/hatcheryreview/index.html). To the extent that these adaptive management processes are defined, the data obtained though the present project will inform the decision-making on how best to operate the associated hatchery programs.

Project Objective #1: DIDSON Escapement Estimation

Early on during the project, a subset of the echograms files will be read separately by Galbreath, Frederiksen and the designated YN Hatchery Technician. Counts will be compared between readers, and reviewed to resolve any discrepancies. In this manner, consistency in counting procedures between readers will be assured. If gaps in the data occur because of, e.g., instrument malfunction, the total upstream count will be expanded to adjust for missing data. An estimate of error associated with this expansion will also be calculated, to provide confidence limits for the resulting escapement estimate. This estimate will then be divided by the total redd count for the upper basin to produce an estimate of fish per redd. This estimate will then be compared to that which has historically been used to expand annual redd counts for estimation of the escapement of spring Chinook in the Klickitat, but which was derived for Yakima River spring Chinook. Information acquired from this project will be provided to YN/YKFP managers and shared with a wider audience through presentations made at relevant meetings and workshops. In addition to data on Klickitat spring Chinook escapement in 2009, a general qualitative and quantitative evaluation will be made of the reliability of the DIDSON to provide fish passage counts for escapement estimation. We anticipate repeating the study during the following two years (2010 and 2011), which will permit analysis for consistency of the comparisons over three years.

Project Objective #2:

The work described under this objective to modify Version #1 of the Binomial-Hypergeometric Likelihood Model will substantially improve its functionality. The resulting Version #2 will be posted to the CRITFC web site in place of Version #1, making it readily available to the public. The validation work described in this proposal will be included within a manuscript to be submitted for publication in a peer-reviewed scientific journal. This manuscript will describe how the model was derived and how it can be applied to mark-recapture studies to estimate population abundance. We will remain available to provide information and advice to any researchers who may contact us regarding use of the model. And, we will update the model with any modifications that we find will improve its functionality.

Project Objective #3: Support for an Unfunded RRS Study

Information acquired from the project will be shared with managers of the associated supplementation program. If results generally indicate that the natural-origin and hatchery-origin spawners exhibit similar productivity, it will infer that deleterious effects of supplementation are minimal in the short term and that beneficial demographic effects are more likely to outweigh any negative change in productivity associated with hatchery rearing. If on the other hand, the hatchery-origin spawners produce significantly fewer progeny, then managers should reexamine the scale and protocols of the supplementation program to see if changes might ameliorate these negative effects, and to make decisions in consequence.

Project Objective #4: RRS in Reintroduced/Supplemented Populations

Phase I of this project will produce within-broodyear productivity estimates for natural-origin and hatchery-origin Hood River spring Chinook, which will be compared across broodyears. Similar RRS studies will be initiated during Phase II in other reintroduction/supplementation programs, which will permit comparisons of data across populations as well. The comparisons across populations will necessarily be somewhat qualitative in nature, due to confounding factors associated with differences in physical and biotic characteristics of the streams, fish stock/species, density dependent characteristics which affect productivity, etc. Nonetheless, consistency in trend of the results will permit generalizations of expectations for other reintroduction programs.

Information acquired from this project will be shared with managers of the associated reintroduction/supplementation programs. If results indicate that the natural-origin spawners exhibit significantly greater productivity than hatchery-origin fish, this will provide empirical evidence that the reintroduction/supplementation program is indeed progressing towards its objective of creating a naturalized population. And, if the natural-origin fish are returning in increasing numbers, this will provide assurance to fisheries managers that the new populations are refilling the available natural habitat, and that they may consider progressively scaling back the supplementation effort (while also taking into consideration any harvest mandates). If on the other hand, data indicates that productivity is not increasing over generations, then managers will need to reexamine their rearing and release protocols to assess whether some of the problem lies there. Likewise, they will need to assess whether constraints to naturalization of the reintroduced stock exist in the freshwater habitat and hydrosystem, and to decide if and how these may be addressed.

H. Facilities and equipment

Equipment required for Objective #1 within this project include: a standard model DIDSON-S and associated equipment, a portable electric generator, jobsite metal storage container, portable external hard drives and uninterruptible power supplies.

The laboratory analyses associated with the RRS studies under Objectives #3 and #4 within this project will be performed at the HFCES, Hagerman ID. The Station houses a laboratory, staffed with scientists from CRITFC, the University of Idaho and USDA, providing capabilities for performance of a variety of molecular genetics analyses to address questions related to structure and productivity of Columbia basin fish populations. While already modestly equipped and staffed, the Station anticipates a considerable increase in the number of requests for its services from the present and other projects over the ten years of the current Accords (2008), in addition to other projects funded through the NPCC Fish and Wildlife Program, the University of Idaho, the Pacific Salmon Treaty, etc. To meet these growing demands, the Center's laboratory facilities and equipment will require substantial expansion. The present project will contribute towards this expansion through funding within this Phase I budget, for construction of additional sample archive shelving and laboratory bench space, and for purchase of three Fluidigm - Biomark™ IFC (integrated fluidic circuit) controllers and three Fluidigm - Biomark™ Thermal cyclers.

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Current Employment:
Conservation Fishery Scientist – February 2004 to present
Columbia River Inter-Tribal Fish Commission (CRITFC), 729 NE Oregon, Suite 200, Portland, OR 97232
Tel: (503) 731-1250, Fax:(828) 235-4228, E-Mail: galp@critfc.org

Review of research, monitoring and evaluation efforts of the four Mid-Columbia native American tribes (Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of Warm Springs, and Yakama Nation) for restoration of salmonid populations in the upper Columbia River Basin, in particular efforts which employ the use of artificial production.. Responsibilities include development of research ideas into fundable proposals that satisfy tribal fishery needs, project administration, data analysis, summarization of results in written and oral formats. Responsibilities also include providing scientific support to CRITFC and tribal staff on fishery management policy in the Columbia River Basin and on ESA-related issues, and interacting with regional state, federal and private fishery management agencies in various forums.

Technical Reports and Publications:

Galbreath, P. F. and S. Hyun. 2008. Procedures for estimating tag loss rate and spawning escapement in a mark-recapture study of Metolius River kokanee *Oncorhynchus nerka*. Columbia River Inter-Tribal Fish Commission Technical Report 08-06, Portland, Oregon. (http://www.critfc.org/tech/tech_rep.html)

Galbreath, P. F., C. A. Beasley, B. A. Berejikian, R. W. Carmichael, D. E. Fast, M. J. Ford, J. A. Hesse, L. L. McDonald, A. R. Murdoch, C. M. Peven and D. A. Venditti. 2008. Recommendations for broad scale monitoring to evaluate the effects of hatchery supplementation on the fitness of natural salmon and steelhead population, Final draft report of the Ad Hoc Supplementation Monitoring and Evaluation Workgroup. (http://www.cbfwa.org/csmep/web/documents/general/Documents/Final%20Draft%20AHSWG%20report.pdf)

Galbreath, P. F., P. B. Roger and M. J. Ford. 2007. Meeting Summary - Supplementation Monitoring and Evaluation Workshop II - February 14-15, 2007. NOAA, Portland OR (http://www.cbfwa.org/csmep/web/documents/general/Documents/Supp%20M&E%20Workshop%20II%20Summary.pdf).

Galbreath, P. F., P. B. Roger and M. J. Ford. 2006. Report of the Supplementation Monitoring and Evaluation Workshop – April 6-7, 2006, Columbia River Inter-Tribal Fish Commission, Portland OR (http://www.cbfwa.org/csmep/web/documents/general/Documents/Supplementation%20M&E%20Workshop%20I%20Report.pdf).

Talbot, A. J. and P. F. Galbreath. 2006. Salmon Restoration – A Native American Perspective from the Columbia River. in Lackey, Robert T., Denise H. Lach, and Sally L. Duncan, editors. Salmon 2100: The Future of Wild Pacific Salmon. American Fisheries Society, Bethesda, Maryland, 629 pp.

Galbreath, P. F., P. E. Barber, S. R. Narum, D. Evenson and S-Y. Hyun. 2006. 2005 Progress and Final Report - Summer Chinook Juvenile Sampling and Adult Monitoring in the Mid-Columbia. Southeast Sustainable Salmon Fund Project Number 45060. Columbia River Inter-Tribal Fish Commission Technical Report 06-5, Portland, Oregon.

Galbreath, P. F. and P. E. Barber. 2005. Final Report - PSC Southern Fund 2004/2005 Project: Validation of a Long-Range Dual Frequency Identification Sonar (DIDSON-LR) for Fish Passage Enumeration in the Methow River. Columbia River Inter-Tribal Fish Commission Technical Report 05-4, Portland, Oregon.

SAANG-YOON HYUN

Education*:*
Ph.D. – 2002, Quantitative Ecology and Resource Management, University of Washington, Seattle, WA
M. S. – 1996, Aquatic and Fishery Sciences, University of Washington, Seattle, WA
B. S. – 1993, Aquaculture and fisheries management , Cheju National University, Jeju, Korea

Current Employment:
2003-present - Quantitative Fisheries Scientist, Columbia River Inter-Tribal Fish Commission (CRITFC), 729 NE Oregon, Suite 200, Portland, OR 97232, Tel: (503) 731-1265, Fax:(828) 235-4228, E-Mail: hyus@critfc.org

Hyun's past research includes developing a new statistical model for forecasting multiple salmon returns simultaneously, and estimating multiple parameters in non-linear models. He is familiar to advanced statistics, ecological modeling, and salmon management. Also, his expertise includes programming skills especially in ADMB and Splus.

Selected Publications:

Galbreath, P. F. and S. Hyun. 2008. Procedures for estimating tag loss rate and spawning escapement in a mark-recapture study of Metolius River kokanee *Oncorhynchus nerka*. Columbia River Inter-Tribal Fish Commission Technical Report 08-06, Portland, Oregon. (http://www.critfc.org/tech/tech_rep.html)

Hyun, S., and R. Sharma. 2007. Bayesian decision analysis for status of Snake River spring-summer Chinook salmon *Oncorhynchus tshawytscha* populations at extinction risk. Fisheries Science 73: 808-816.

Hyun, S., K.W. Myers, and A. Talbot. 2007. Year-to-year variability in ocean recovery rate of Columbia River Upriver Bright fall Chinook salmon (*Oncorhynchus tshawytscha*). Fish. Oceanogr. 16:4, 350-362.

Hyun, S., R. Hilborn, J.J. Anderson, and B. Ernst. 2005. A statistical model for in-season forecasts of sockeye salmon (*Oncorhynchus nerka*) returns to the Bristol Bay districts of Alaska. Canadian Journal of Fisheries and Aquatic Sciences 62: 1665-1680.

Norris, J.G., S. Hyun, and J.J. Anderson. 2000. Ocean distribution of Columbia River Upriver Bright Fall Chinook salmon stock. North Pacific Anadromous Fisheries Commission Bulletin 2: 221-232.

SHAWN R. NARUM

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Education:
Ph.D. – 2006, Natural Resources, University of Idaho, Moscow ID
M.S. – 2000, Marine Science, University of San Diego, CA
B.S. – 1996, Fishery Biology, Colorado State University, Fort Collins CO

Current Employment:
2002-present - Lead Geneticist, Columbia River Inter-Tribal Fish Commission

Selected Publications:

Narum, S. R., M. Banks, T. D. Beacham, M. R. Bellinger, M. R. Campbell, J. DeKoning, A. Elz, C. M. Guthrie III, C. Kozfkay, K. M. Miller, P. Moran, R. Phillips, L. W. Seeb, C. T. Smith, K. Warheit, S. F. Young, and J. C. Garza. 2008. Differentiating salmon populations at broad and fine geographic scales with microsatellites and SNPs. Molecular Ecology 17:3464-3477.

Narum S. R., D. Hatch, A. J. Talbot, P. Moran and M. S. Powell. 2008. Conservation of iteroparous salmonids in complex mating systems. Journal of Fish Biology 72:45-60.

Campbell, N. R., and S. R. Narum. 2008. Identification of novel SNPs in Chinook salmon and variation among life history types. Transactions of the American Fisheries Society 137:96-106.

Narum, S. R., M. R. Campbell and J. J. Stephenson. 2007. Genetic variation and structure of Chinook salmon life history types in the Snake River. Transactions of the American Fisheries Society 136:1252-1262.

Seeb, L. W, A. Antonovich, M. A. Banks, T.D. Beacham, M. R. Bellinger, S. M. Blankenship, M. Campbell, N. A. Decovich, J. C. Garza, C. M. Guthrie III, T. A. Lundrigan, P. Moran, S. R. Narum, J. J. Stephenson, K. J. Supernault, D. J. Teel, W. D. Templin, J. K.Wenburg, S. F. Young and C. T. Smith. 2007. Development of a standardized DNA database for Chinook salmon. Fisheries 30:540-552.

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Education:

M.S., Fisheries Resources, University of Idaho, 2004
B.S., Fishery Resources, University of Idaho, 1997

Current Appointment:

2004-present - Conservation Geneticist/Lab Manager, Columbia River Inter-Tribal Fish Commission

Selected Publications:

Narum, S. R., M. R. Campbell and J. J. Stephenson. 2007. Genetic variation and structure of Chinook salmon life history types in the Snake River. Transactions of the American Fisheries Society 136:1252-1262.

Seeb, L. W, A. Antonovich, M. A. Banks, T.D. Beacham, M. R. Bellinger, S. M. Blankenship, M. Campbell, N. A. Decovich, J. C. Garza, C. M. Guthrie III, T. A. Lundrigan, P. Moran, S. R. Narum, J. J. Stephenson, K. J. Supernault, D. J. Teel, W. D. Templin, J. K.Wenburg, S. F. Young and C. T. Smith. 2007. Development of a standardized DNA database for Chinook salmon. Fisheries 30:540-552.

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Education:
B.S. Environmental Studies / Biology, Lewis and Clark College, 1988
Post. Bac Fisheries, Oregon State University,1991.

Current Employment:
2006 to present - Hood River Production Program Coordinator

Selected Reports:
Naughton, G. P., M. A. Jepson, M. J. Heinrich, C. A. Perry and C. V. Brun. 2006. The effects of temporary straying on escapement estimates of adult fall Chinook salmon in the Deschutes River, Oregon. Progress Report to USCTC. NOAA Contract # NWR-0605.
S. R. Narum and C. V. Brun. 2007. Determination of Genetic Variation within Deschutes River Fall Chinook Salmon, Pacific Salmon Commission Project SF-2006-E-7 Final Report.
S. R. Narum, C. V Brun and J. Graham. 2008. Origin of Out of Basin Stray Fall Chinook Salmon in the Deschutes River, Oregon. Pacific Salmon Commission Project SF-2007-I-21 Final Report.

CHRISTOPHER R. FREDERIKSEN

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Yakima, WA. 98908
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Education:
B.S. Geo-Hydrology with Stream Ecology emphasis, Montana State University, Bozeman MT, 2001

Current Employment:
2002 to present – Lead Modeling Scientist

Selected Reports:
Frederiksen, C. 2006. Klickitat River Spring Chinook Stock Assessment and Investigation of Integrated Hatchery Strategies. Appendix A in Bosch and Fast, Yakima/Klickitat Fisheries Project; Monitoring and Evaluation, 2005-2006. Annual Report, Project No. 199506325. BPA Report DOE/BP-00022449-1.
Frederiksen, C. 2006. Quantitative Objectives for the YKFP- Spring Chinook Salmon. ppendix 1 in Pearsons et al, “Yakima/Klickitat Fisheries Project; Spring Chinook Salmon Supplementation in Upper Yakima Basin Executive Summary”, 2005-2006 Annual Report, Project No. 199506325. BPA Report DOE/BP-00023618-1.
Frederiksen, C., J. Hubble, and W. Larrick. 2007. KID Pump Exchange Modeling Analysis of Projected Benefits for Yakima River Anadromous Fish Species. Prepared for Bureau of Reclamation.
Confederated Tribes and Bands of the Yakama Nation. 2008. Early Run Fall Chinook (Summer) Reintroduction; Preliminary Modeling Analysis. Yakima/Klickitat Fisheries Project; Monitoring and Evaluation, 2007-2008 Annual Report, Project No.199506325. Document ID No.P107550
Sharp, W., C. Frederiksen, W. Bosch, and D.J Warren & Associates, Inc. 2008 Klickitat River Anadromous Fisheries Master Plan. Prepared for Bonneville Power Administration. Yakima/Klickitat Fisheries Project No.1198811535.

Statement of Work Report

Project Title: Basinwide Supplementation Evaluation
Project #: 2009-009-00
Contract Title: 200900900 EXP BASINWIDE SUPPLEMENTATION EVALUATION - PHASE I
Contract #:
Province: Non-Provincial **Subbasin:** Basinwide
Workorder ID: 228849 **Task ID:** 1
Perf. Period Budget: $793,735 **Perf. Period:** 4/1/2009 - 4/30/2010
Contract Type: Request **Pricing Type:** Cost Reimbursement (CNF)
Contractor(s): Columbia River Inter-Tribal Fish Commission (CRITFC) (Prime - COLURIVE00)
BPA Internal Ref: CR-115956
SOW Validation: Last validated 03/18/2009 with 0 problems, and 0 reviewable items
Contract Documents: Budget - Contract (03/18/2009) 200900900 Basinwide Supp Eval Budget

Contacts:

Name	Role	Organization	Phone	Email	Address
Jan Brady	COTR	Bonneville Power Administration	(503) 230-4514	jebrady@bpa.gov	P.O Box 3621 KEWR-4 Portland OR 97208-3621
Kristi Van Leuven	Contracting Officer	Bonneville Power Administration	(503) 230-3605	kjvleuven@bpa.gov	P.O Box 3621 NSSP-4 Portland OR 97208-3621
Christine Golightly	Interested Party	Columbia River Inter-Tribal Fish Commission (CRITFC)	(503) 731-1288	GOLC@critfc.org	729 NE Oregon St., Suite 200 Portland OR 97232
Douglas Hatch	Technical Contact	Columbia River Inter-Tribal Fish Commission (CRITFC)	(503) 731-1263	hatd@critfc.org	729 NE Oregon St #200 Portland OR 97232
Phillip Roger	Supervisor	Columbia River Inter-Tribal Fish Commission (CRITFC)	(503) 731-1301	rogp@critfc.org	729 NE Oregon St., Suite 200 Portland OR 97232
Peter F. Galbreath	Contract Manager	Columbia River Inter-Tribal Fish Commission (CRITFC)	(503) 731-1250	galp@critfc.org	729 NE Oregon, Suite 200 Portland OR 97232
Barbara Shields	Interested Party	Bonneville Power Administration	(503) 230-4748	bashields@bpa.gov	
Israel Duran	Env. Compliance Lead	Bonneville Power Administration	(503) 230-3967	induran@bpa.gov	P.O. Box 3621, Mailstop - KEC-4 Portland OR 97208-3967

Work Element Table of Contents:

Work Element - Work Element Title	EC Needed*	Estimate	(%)
A : 119. Manage and Administer Projects - Admin - Project Administration and preparation of Phase II Narrative and 2010 SOW		$20,130	(3 %)
B : 165. Produce Environmental Compliance Documentation - Admin - Provide proof of EC/permits		$4,026	(1 %)
C : 157. Collect/Generate/Validate Field and Lab Data - PO#1 - Operate DIDSON in Klickitat River	*	$129,491	(16 %)
D : 162. Analyze/Interpret Data - PO#1 - Analyze DIDSON Data for spring Chinook Escapement		$16,104	(2 %)
E : 161. Disseminate Raw/Summary Data and Results - PO#1 - Report Results of DIDSON study		$4,026	(1 %)
F : 156. Develop RM&E Methods and Designs - PO#2 - Develop Version 2 of Mark-Recapture Likelihood Model		$23,701	(3 %)
G : 161. Disseminate Raw/Summary Data and Results - PO#2 - Oral presentation of Likelihood model at professional meetings		$16,561	(2 %)
H : 183. Produce Journal Article - PO#2 - Prepare manuscript on Mark-Recapture model for publication		$6,752	(1 %)
I : 114. Identify and Select Projects - PO#3 - Evaluate candidate supplementation programs for an RRS study		$18,441	(2 %)
J : 157. Collect/Generate/Validate Field and Lab Data - PO#3 - Initiate collection and molecular genetics analyses of tissue samples	*	$105,107	(13 %)
K : 162. Analyze/Interpret Data - PO#3 - Perform parentage and RRS analyses		$19,570	(2 %)
L : 161. Disseminate Raw/Summary Data and Results - PO#3 - Report results of RRS study		$3,365	(0 %)
M : 157. Collect/Generate/Validate Field and Lab Data - PO#4 - Perform molecular genetics analyses of archived Hood River spring Chinook samples	*	$284,433	(36 %)
N : 162. Analyze/Interpret Data - PO#4 - Perform parentage and RRS analyses of Hood River spring Chinook		$42,554	(5 %)
O : 161. Disseminate Raw/Summary Data and Results - PO#4 - Report results of Hood River spring Chinook RRS study		$16,928	(2 %)
P : 114. Identify and Select Projects - PO#4 - Evaluate other candidate reintroduction/supplementation programs for an RRS study		$11,974	(2 %)
Q : 189. Regional Coordination - PO#4 - Organize tribal workshop on salmon reintroduction/supplementation programs		$38,054	(5 %)
R : 183. Produce Journal Article - PO#4 - Initiate preparation of manuscript on tribal programs to reintroduce coho salmon		$16,414	(2 %)
S : 185. Produce Pisces Status Report - Admin - Periodic Status Reports for BPA		$8,052	(1 %)

Work Element - Work Element Title	EC Needed*	Estimate	(%)
T : 132. Produce (Annual) Progress Report - Admin - Submit Progress Report for the period May 2009 thru April 2010		$8,052	(1 %)
	Total:	$793,735	

* Environmental Compliance (EC) needed before work begins.

Contract Description:

The present one-year contract covers implementation of Phase I of the Basinwide Supplementation Evaluation project (2009-009-00). The overarching goal of this project is to initiate a series of actions which support recommendations of the Ad Hoc Supplementation Workgroup (AHSWG) for a basinwide evaluation of the long term effects of hatchery supplementation on productivity of naturally spawning anadromous salmonid populations in the Columbia River basin (AHSWG 2008). These actions will involve projects to acquire and evaluate more, and more reliable (accurate and precise), information on trends in abundance and productivity of supplemented salmon and steelhead populations, relative reproductive success (RRS) of naturally spawning salmon of natural origin versus hatchery origin within supplemented populations. Natural origin (NO) fish are defined as ones which are the product of a natural spawning that occurred in a stream. Hatchery origin (HO) fish are defined as those which are derived from artificially fertilized eggs which, generally speaking, were then incubated and the fry reared in a hatchery for some period. (HO fish could also include those which were artificially spawned and released as early as fertilized eggs or hatchlings, although this management option is infrequently used.)

The contract for Phase I of this project (4/2009 to 3/2010) includes four specific Project Objectives:
Project Objective #1: to use a pair of Dual-Frequency Identification Sonars (DIDSONs) to obtain an estimate of the 2009 natural spawning escapement of the supplemented spring Chinook population upstream of the Castile Falls complex in the upper basin of the Klickitat River
Project Objective #2: to complete development of a mark-recapture likelihood model which incorporates tag loss, including the uncertainty of the tag loss estimate, into the inference for population abundance
Project Objective #3: to perform a relative reproductive success (RRS) study of NO versus HO salmon in a population associated with an ongoing supplementation monitoring and evaluation (M&E) program for which tissue samples have been collected but for which genetic analysis and estimation of RRS remains unfunded
Project Objective #4: to perform an RRS study of NO versus HO spring Chinook salmon, using archived scale samples. And, to evaluate other reintroduced salmon populations in the basin, and to choose three to four of them for consideration of RRS studies in subsequent Phases of this project

Statement of Work Report

Work Element Details

A: 119. Manage and Administer Projects

Title:	Admin - Project Administration and preparation of Phase II Narrative and 2010 SOW
Description:	Perform all administrative activities as per the SOW and BPA's programmatic and contractual requirements, including: - purchase of supplies and equipment and financial reporting - preparation of subcontracts, preparation of progress and annual reports - preparation of the Narrative for Phase II of the Project, and of the 2010 SOW.
Deliverable Specification:	Submit next year's SOW, Budget, and Property Inventory to the BPA COTR. The SOW should include location information (latitude and longitude) for those work elements that require it. If contractor or contractor's organization takes longer than 30 days to sign the contract, the contractor will need to send this funding package to BPA more than 90 days before the end of the current contract.

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Accrual - Submit September estimate to BPA	9/1/2009	9/11/2009	Inactive	Provide BPA with an estimate of contract work that will occur prior to September 30 but will not be billed until October 1 or later. Generally, this should be done by September 10.
B. Funding Package - Conduct internal review (e.g., Supervisor or Interagency)	2/19/2010	2/26/2010	Inactive	If necessary, submit next year's SOW and Budget for internal contractor review before submitting to BPA. Assuming this review takes 30 days, start this milestone 120 days before the end of the current contract.
Deliverable: C. Funding Package - Submit draft to COTR		3/1/2010	Inactive	*See the Deliverable Specification above*

B: 165. Produce Environmental Compliance Documentation

Title: Admin - Provide proof of EC/permits
Description: All environmental compliance and permits exist in other CRITFC F&W contracts.
Deliverable Specification: Provide BPA with proof of proper permits etc.
Planned Metrics: Are herbicides used as part of work performed under this contract?: No

Milestone Title	Start Date	End Date	Status	Milestone Description
Deliverable: A. Proof of EC/permit coverage to BPA		3/31/2010	Inactive	*See the Deliverable Specification above*

C: 157. Collect/Generate/Validate Field and Lab Data

Title: PO#1 - Operate DIDSON in Klickitat River
Description: Project Objective #1 - DIDSON Escapement Estimation

An estimate of spawning escapement will be calculated for spring Chinook in the upper basin of the Klickitat River in 2009. The estimate will be based on net upstream fish passage counts of fish as they exit the upstream end of the Castile Falls fishway, obtained from video files recorded by two DIDSONs – one a standard model (DIDSON-S) and the other a long range model (DIDSON-LR). The DIDSON escapement estimate will be divided by the total redd count for the upper basin to derive a Klickitat-specific expansion factor which will be compared to the currently used expansion factor, calculated for spring Chinook in the Yakima River. Secondarily, the experience acquired over the season will be used to make a qualitative and quantitative evaluation of the reliability of the DIDSONs for producing an escapement estimate at this site. It is anticipated that a DIDSON study and the resulting DIDSON versus expanded redd count escapement comparisons will be repeated in 2010 and 2011.

Deliverable Specification: The study site is at the upstream end of the Castile Falls complex in the Klickitat River, at river km 103. In May 2009, a DIDSON-S will be installed adjacent to the outlet of the fishway, to record all upstream passage events, and a DIDSON-LR will be installed to look across the river in order to observe downstream ("fall back") passage. Power to the DIDSONs and associated electronic equipment will be supplied from a portable generator and a set of deep cycle batteries. The computer for each DIDSON, and an external hard drive to which the files will be directly recorded, will be housed onshore within a secure storage box. Both DIDSONs will be operated at their respective high frequencies, and programmed to record sequential 60 min files, producing a continuous set of DIDSON recordings covering the entire spring Chinook migration. CRITFC and YN personnel will travel to the site to confirm correct functioning of the instruments two to three times weekly. During each visit, data files will be downloaded from the field computers and transferred to an office-based server.

Planned Metrics:
* Primary R, M, and E Focal Area : Population Status
* Primary R, M, and E Type : Status and Trend Monitoring
* Secondary R, M, and E Focal Area : Hatchery

Primary Focal Species: Chinook - Mid-Columbia River Spring ESU
Country: US
State: WA
County: YAKIMA
NPCC Subbasin: KLICKITAT
HUC5 Watershed: UPPER KLICKITAT RIVER
HUC6 Name: SWAMP CREEK
Salmonid ESUs Present: Middle Columbia River Steelhead DPS (accessible) | Outside legal Columbia River Chum Salmon ESU boundary (Naturally Blocked)

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Environmental compliance requirements complete	5/1/2009	5/1/2009	Inactive	On-the-ground work associated with this work element cannot proceed until this milestone is complete. Milestone is complete when final documentation is received from BPA environmental compliance staff (completion can be based on pre-existing environmental documentation from BPA).
B. Buy DIDSON	4/1/2009	4/1/2009	Inactive	Allow
C. Purchase of equipment and supplies	5/1/2009	5/31/2009	Inactive	Purchase DIDSON and associated electronic equipment and supplies.
D. Installation of DIDSONs at study site	5/1/2009	5/31/2009	Inactive	Install DIDSONs, associated electronic equipment, and partial weirs at study site. Test operation of equipment, and program the DIDSONs to collect continuous 60 -min files.
E. Operate DIDSONs over the entire spring Chinook migration season	5/1/2009	8/31/2009	Inactive	Operate the DIDSONs over the entire 2009 migration season (May 1 to Aug 31) for spring Chinook at this site in the Klickitat River.
Deliverable: F. A set of DIDSON recordings covering the spring Chinook migration		8/31/2009	Inactive	*See the Deliverable Specification above*

D: 162. Analyze/Interpret Data

Title: PO#1 - Analyze DIDSON Data for spring Chinook Escapement

Description: Project Objective #1 - DIDSON Escapement Estimation

The DIDSON recordings will be analyzed to estimate total spring Chinook spawning escapement to the upper basin of the Klickitat River (the region upstream of Castile Falls complex), and to describe diurnal and seasonal trends within this migration. An estimate of fish-per-redd, based on total redd count will be obtained by the YN, which will then be compared to the value of this expansion factor obtained in the Yakima River, which has historically been used for escapement estimation in the Klickitat.

Deliverable Specification: Analysis of the DIDSON files will begin within a week following initiation of operation of the DIDSONs, and the files will be read continually over the season such that a preliminary escapement estimate should be available by the end of September 2009. From each days' set of DIDSON files, a corresponding set of "echogram" files will be generated, and the echograms reviewed to obtain total upstream and downstream counts per file. Upstream fish passage events observed during early May are expected be solely of migrating steelhead. By the end of May, these counts should be in decline, and a subsequent increase in upstream passage events later in June will be indicative of initiation of the spring Chinook migration. Passage of spring Chinook is expected to peak sometime in July, then to diminish and finish in August. Total upstream counts from the DIDSON files between the dates deemed to represent the beginning and the end of the spring Chinook run will be summed within hours for each day. Gaps in the resulting data set, caused by power interruptions, instances of loss or corruption of files, etc., will be filled with predicted values from a joint distribution of hourly and daily trends in the data. The data set of hourly counts will then be summed to obtain daily estimates, and the daily estimates will be summed over the migration season to obtain an estimate of total escapement. This estimate will then be divided by the total redd count for the upper basin obtained in 2009, to provide an average value of fish per redd. Upstream passage events will also be graphed within hour of the day, to illustrate any diurnal pattern to movement at the site (of note, observations recorded for files from the 2008 trial indicated that fish movement occurred preferentially during the dawn and dusk hours). Additionally, daily escapement and flow (data to be obtained from the USGS river gauge #14107000 Klickitat River Above West Fork, located within a km upstream of the fishway outlet) will be graphed over time to look for possible correlations between flow and migration activity.

Planned Metrics:
* Primary R, M, and E Focal Area : Population Status
* Primary R, M, and E Type : Status and Trend Monitoring
* Secondary R, M, and E Focal Area : Hatchery

Primary Focal Species: Chinook - Mid-Columbia River Spring ESU

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Generate and review Echogram files	5/1/2009	9/30/2009	Inactive	Generate Echogram files from each of the DIDSON recordings. Review the Echogram files to obtain upstream and downstream counts of salmon passage.
B. Estimate hourly, daily and total escapement	6/1/2009	10/30/2009	Inactive	Analyze counts from Echogram files to estimate hourly, daily and total counts of upstream and downstream salmon passage.
C. Summarize 2009 escapement information	10/1/2009	12/31/2009	Inactive	Summarize spring Chinook escapement information, including an analysis of diurnal and seasonal trends in migration, and comparison with flow data.
D. Estimate a fish-per-redd ratio for 2009	10/1/2009	12/31/2009	Inactive	Using the DIDSON-based escapement estimate and redd count information acquired by the YN, calculate a 2009 fish-per-redd ratio for the upper basin of the Klickitat River. Compare this value to that obtained in the Yakima River, which has historically been used for escapement estimation in the Klickitat.
Deliverable: E. Estimate of 2009 total escapement and fish-per-redd for upper basin Klickitat River spring Chinook		12/31/2009	Inactive	*See the Deliverable Specification above*

E: 161. Disseminate Raw/Summary Data and Results

Title: PO#1 - Report Results of DIDSON study

Description: Project Objective #1 - DIDSON Escapement Estimation

Communicate project results within CRITFC and the Tribes (e.g., at internal CRITFC meetings or tribal meetings), and in professional forums (e.g., at the annual Klickitat & White Salmon Rivers Fisheries and Watershed Science Conference, and at local and regional American Fisheries Society meetings).

Deliverable Specification: Oral and/or written summaries describing project results will be produced. These summaries will be communicated to YN/YKFP managers and to the CRITFC Data System. Oral summaries of results will be presented at relevant regional meetings and conferences, e.g., annual AFS state chapter Meetings, annual AFS Western Division Meeting, annual Klickitat/White Salmon Rivers Fisheries and Watershed Science Conference, annual Yakima Basin Science & Management Conference, annual Pelton Round Butte Fisheries Workshop, etc.

Primary Focal Species: Chinook - Mid-Columbia River Spring ESU

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Communicate results to YN/YKFP and CRITFC	9/1/2009	3/31/2010	Inactive	Communicate results to YN/YKFP managers and to the CRITFC Data System
B. Oral and written summary of project results	10/1/2009	3/31/2010	Inactive	Produce written summaries of project results for submission to YN/YKFP managers, and oral summaries for presentation at relevant regional meetings and conferences, e.g., annual AFS state chapter Meetings, annual AFS Western Division Meeting, annual Klickitat/White Salmon Rivers Fisheries and Watershed Science Conference, annual Yakima Basin Science & Management Conference, annual Pelton Round Butte Fisheries Workshop, etc.
Deliverable: C. Oral and/or written summaries describing project results		3/31/2010	Inactive	*See the Deliverable Specification above*

F: 156. Develop RM&E Methods and Designs

Title: PO#2 - Develop Version 2 of Mark-Recapture Likelihood Model

Description: Project Objective #2 - Develop Version #2 of Mark-Recapture Likelihood Model

Version 1 of our Binomial-Hypergeometric Likelihood model to use mark-recapture data for estimating tag loss and population abundance (http://www.critfc.org/tech/08-07report.html) requires additional development, to increase its utility and improve its “user-friendliness”.

Note: The model was not designed for use with a focal species(s), but has applicability to any/all fish species subjected to a mark-recapture study.

Deliverable Specification: Modifications will be made to Version #1 of the Binomial-Hypergeometric Mark-Recapture Likelihood Model, to provide it wider functionality and to adapt it to a web-based user interface. There is a need to widen the functionality of the model by modifying it to accept data (for the purpose of estimating the rate of tag loss) from an alternative double-tagging design which uses a permanent mark as the second tag. Currently, the model only accepts information for a double-tagging design involving two identical non-permanent tags. Additionally, the model will be revised to accept estimated values for tag loss and its standard error derived from a previous study, in lieu of raw data from a concurrently conducted double-tagging study. We will also modify the program to render it more "user friendly" (and more "user foolproof") by adapting the model input format to a web-based interface, and by modifying the manner in which the output data is displayed – so that it appears with the associated input data for each run, and provides optional file formats for storing the information. We will also perform additional validation exercises of the model, for inclusion in a manuscript describing the model and its utility, which will be submitted for publication in a peer-reviewed scientific journal.

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Complete development of the Binomial - Hypergeometric Mark-Recapture Likelihood Model	5/1/2009	8/31/2009	Inactive	Complete development (modify Version #1 to create Version #2) of the Binomial-Hypergeometric Mark-Recapture Likelihood Model and adapt it to a web-based user interface.
B. Post Version #2 to CRITFC web site	8/1/2009	9/30/2009	Inactive	Replace Version #1 of the Likelihood Model with the new Version #2 in the CRITFC web site, for accessibility to the public.
Deliverable: C. Version #2 of Binomial-Hypergeometric Mark-Recapture Likelihood Model		9/30/2009	Inactive	*See the Deliverable Specification above*

G: 161. Disseminate Raw/Summary Data and Results

Title: PO#2 - Oral presentation of Likelihood model at professional meetings

Description: Project Objective #2 - Develop Version #2 of Mark-Recapture Likelihood Model

Prepare and update an oral slide presentation describing the Mark-Recapture Likelihood Model, for presentation at relevant meetings and conferences.

Note: The model has applicability to any/all fish species subjected to a mark-recapture study, and for which the model assumptions apply.

Deliverable Specification: Prepare and update an oral slide presentation describing the Mark-Recapture Likelihood Model, for presentation at the 2009 annual AFS national meeting, and other relevant meetings and conferences.

Primary Focal Species: Chinook - All Populations | Coho - Unspecified Population | Sockeye - All Populations | Steelhead - All Populations

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Preparation and oral presentation of Likelihood Model at professional meetings	5/1/2009	3/31/2010	Inactive	Prepare and update an oral slide presentation describing the Mark-Recapture Likelihood Model, for presentation at the 2009 annual AFS national meeting (8/2009), and other relevant meetings and conferences.
Deliverable: B. Oral presentation of Likelihood Model at professional meetings		3/31/2010	Inactive	*See the Deliverable Specification above*

H: 183. Produce Journal Article

Title: PO#2 - Prepare manuscript on Mark-Recapture model for publication

Description: Project Objective #2 - Develop Version #2 of Mark-Recapture Likelihood Model

Perform additional model validation exercises for inclusion in a manuscript describing the Binomial-Hypergeometric Likelihood Model for analysis of mark-recapture data. Submit the manuscript to an appropriate peer-reviewed scientific journal for publication. Produce a description of the model for oral presentation at relevant meetings and conferences.

Note: The model has applicability to any/all fish species subjected to a mark-recapture study, and for which the model assumptions apply.

Deliverable Specification: We will perform a series of simulations to validate the likelihood procedures within the Likelihood Model. This information will be incorporated into a manuscript which is being drafted to describe the derivation and applications of the Binomial-Hypergeometric Mark-Recapture Likelihood Model. The manuscript will be reviewed internally, then submitted for publication in a scientific peer-reviewed journal. Following receipt from the Editor of comments from journal reviewers, the manuscript will be revised and resubmitted. Publication is anticipated in 2010.

Planned Metrics: * # of draft scientific reports submitted: 1

* # of draft manuscripts and draft final reports of research findings submitted for publication: 1

Primary Focal Species: Chinook - All Populations | Coho - Unspecified Population | Sockeye - All Populations | Steelhead - All Populations

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Perform simulation exercises for model validation	5/1/2009	7/31/2009	Inactive	Perform a series of simulations to validate the likelihood procedures within the Mark-Recapture Model.
B. Prepare draft manuscript describing Mark -Recapture Likelihood Model	5/1/2009	8/31/2009	Inactive	Prepare draft manuscript describing the derivation and applications of the Binomial-Hypergeometric Mark-Recapture Likelihood Model.
C. Internal technical review of manuscript	7/1/2009	9/30/2009	Inactive	Submit the draft manuscript for internal technical review.
D. Submit manuscript	8/1/2009	9/30/2009	Inactive	Submit manuscript for publication in a peer-reviewed scientific journal.
E. Revise manuscript in accordance with reviews	10/1/2009	3/31/2010	Inactive	Revise the manuscript in accordance with reviews received from journal Editor.
Deliverable: F. Scientific journal manuscript.		3/31/2010	Inactive	*See the Deliverable Specification above*

I: 114. Identify and Select Projects

Title: PO#3 - Evaluate candidate supplementation programs for an RRS study

Description: Project Objective #3 - Support for and unfunded RRS study

Gather information with which to compare supplementation monitoring programs in which adult and juvenile tissue samples have been collected and archived, but which lacks the funding needed for the molecular genetics-based parentage analyses and RRS evaluation. Prioritize one program for funding, and prepare a design for a RRS study.

Deliverable Specification: From among several candidate supplementation programs, one will be chosen to have an associated RRS study performed, a study design for which will be prepared within the present Phase I project. Pertinent information on multiple candidate populations/programs in the Columbia basin will be obtained from written reports and from discussions held during the initial months of the project with fisheries personnel from the four treaty Tribes and collaborating state fisheries agencies. This information will be used to weigh the relative value that a RRS study might provide to a basinwide evaluation of supplementation. Of primary interest in this evaluation process is information on:

- integrity of the adult weir (estimated percent of adult escapement captured at the weir)
- confirmation of 100% marking of HO fish – to distinguish them from NO fish
- estimated percent of spawning which occurs below the adult weir
- number of adult tissue samples previously collected
- completeness of adult tissue sampling
- ancillary information on physical and behavioral characteristics of adults (see Methods section below)
- complementary information on annual redd counts, redd distribution (HO versus NO) and from carcass surveys
- number of juvenile samples obtained annually, and a qualitative evaluation of the “representativeness” of the sample to the totality of juvenile production
- longevity of the supplementation program and of the sample time series
- probability of continued data collection to support further analyses
- information of possible hatchery influence prior to initiation of the supplementation program

Information from the various programs will be compared, one of them will be chosen and a study design will be prepared for a RRS study to be supported through the present Phase I project.

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Gather information on supplementation programs with an unfunded RRS study	5/1/2009	9/30/2009	Inactive	Meet with tribal and state fisheries personnel to obtain relevant information on candidate supplementation programs and populations, for which an RRS study has been proposed but remains unfunded.
B. Choose one supplementation program for support of an RRS study	8/1/2009	10/31/2009	Inactive	Evaluate the relative need and value to supporting a RRS study in each candidate population, and choose one for supplemental financial support, providing the rationale for selection as part of the annual report.
C. Prepare study design for the RRS study	9/1/2009	11/30/2009	Inactive	In collaboration with associated tribal and state fisheries agencies, prepare a study design for a RRS study of the chosen supplemented population.
Deliverable: D. RRS study design for a chosen supplementation program		11/30/2009	Inactive	*See the Deliverable Specification above*

J: 157. Collect/Generate/Validate Field and Lab Data

Title: PO#3 - Initiate collection and molecular genetics analyses of tissue samples

Description: Project Objective #3 - Support for and unfunded RRS study

Initiate collection and molecular genetics analyses of tissue samples from chosen supplementation project. If the chosen program has already collected and archived tissue samples, arrangements will be made for delivery of the samples to the Hagerman Fish Culture Experiment Station (HFCES). There, molecular genetics analyses and parentage assignments will be initiated. Estimated total number of samples = 4,000.

Note: A location for this this Work Element has not been assigned, as identification of the particular population to be studied (and its location) will not occur until later within the Project time period.

Deliverable Specification: Archived samples will be delivered to HFCES where molecular genetics analyses will be initiated. The "fitness" of a fish population is typically measured in terms of its demonstrated natural productivity – the number of recruits per natural spawner (R/S), with the recruits enumerated at a juvenile stage and/or as returning adults. However, in cases where the naturally spawning population is supplemented, it consists of alternative parental types, e.g., natural origin versus supplementation hatchery origin). Until recently, researchers have been unable to compare the relative natural productivity among parental types in these populations, due to the inability to differentiate the parental identity of the naturally produced progeny. However, new molecular genetics techniques using multi-locus DNA markers now provide this capability (see reviews by Wilson and Ferguson 2002, Jones and Ardren 2003, Liu and Cordes 2004). The techniques require annual collection of scale and tissue samples from essentially all (or, at least a large majority of) adults which return to a river for natural spawning, with hatchery origin adults identifiable via presence of a tag or an external mark (e.g., clipped adipose fin). The scales are used to age the fish and assign them to a particular broodyear, and the tissue is used as a source of DNA. The DNA is extracted then analyzed to identify the alleles present for a suite of molecular markers, providing a profile for each potential spawner within a particular broodyear. After a generation has passed, the profiles of the adult progeny assigned to each broodyear are compared with those of the broodyear's spawners, and the total number of progeny assigned per adult can be calculated. The average (and variance) number of adult recruits for each parental type (e.g., out-of-basin HO, versus in-basin HO, versus NO fish) is then calculated and compared among parental types.

Planned Metrics:
* Primary R, M, and E Focal Area : Population Status
* Primary R, M, and E Type : Status and Trend Monitoring
* Secondary R, M, and E Focal Area : Hatchery

Primary Focal Species: Chinook - Mid-Columbia River Spring ESU | Chinook - Snake River Spring/Summer ESU | Chinook - Snake River Spring/Summer | Chinook - Upper Columbia River Spring ESU | Chinook - Upper Columbia River Summer/Fall ESU | Steelhead - Middle Columbia River DPS | Steelhead - Upper Columbia River DPS

Country:	US	**NPCC Subbasin:**	KLICKITAT
State:	WA	**HUC5 Watershed:**	LOWER KLICKITAT RIVER
County:	KLICKITAT	**HUC6 Name:**	WHEELER CANYON

Salmonid ESUs Present: Middle Columbia River Steelhead DPS (accessible) | Outside legal Columbia River Chum Salmon ESU boundary (Naturally Blocked)

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Environmental compliance requirements complete	5/1/2009	5/1/2009	Inactive	On-the-ground work associated with this work element cannot proceed until this milestone is complete. Milestone is complete when final documentation is received from BPA environmental compliance staff (completion can be based on pre-existing environmental documentation from BPA).
B. Delivery of archived tissues samples to HFCES	9/1/2009	2/28/2010	Inactive	Archived tissue samples from the program chosen for support of a RRS study will be delivered to the HFCES.
C. Initiate molecular genetics analyses	10/1/2009	3/31/2010	Inactive	Initiate molecular genetics analyses with which to perform parentage assignments as part of a RRS study.
Deliverable: D. Delivery and initiation of molecular genetics analyses		3/31/2010	Inactive	*See the Deliverable Specification above*

K: 162. Analyze/Interpret Data

Title: PO#3 - Perform parentage and RRS analyses

Description: Project Objective #3 - Support for and unfunded RRS study

Use data from molecular genetics analyses to perform parentage assignment of juveniles within broodyears. Calculate individual productivity estimates and average productivity for parental types, then estimate Relative Reproductive Success (RRS) among parental types. Perform statistical tests of RRS estimates for an effect of origin, and compare results across broodyears. Note: these analytical processes will likely extend into Phase II of the Project.

Deliverable Specification: Summary of annual RRS information and statistical analyses for RRS study of hatchery-origin and natural–origin adults, to be continually updated as additional analyses are performed.

The parentage assignment information will permit calculation of the number of recruits per individual spawner within broodyears, and these data will be averaged within parental types. We will use a generalized linear model (GLM) to test the hypothesis of similarity of productivity among parental types (e.g., HO versus NO), with number of recruits as the response variable, and with origin, sex, size (length), and run timing (Julian day of return) of the parents as explanatory variables. Under the expectation that the response variable will follow a Poisson random distribution, we will use a log-linear model within the GLM. Additionally, a Chi square test of independence will be performed to examine the hypothesis of random mating among parental cross types (HOxHO, HOxNO, NOxHO and NOxNO) (Leth 2005 and Lutch et al. 2005).

When the time series for parentage information exceeds a full salmon generation, it will be possible to also calculate adult recruit per spawner information within broodyears. If the adult progeny data is sufficient, it will be subjected to analyses identical to those performed with the juvenile R/S data. Comparison of results between the pair of tests will help identify if observed productivity differences can be attributed to a particular life stage. For example, observation of relatively low reproductive success for HO fish based on juvenile R/S measures, and a RRS evaluation based on adult R/S which is similar would indicate that the differential success occurs primarily during the spawning and juvenile rearing portion of the life cycle, and that a significant deleterious effect is not observed during the adult stages. Or, if across broodyears RRS based on juvenile returns is consistently less than 1.0, and if RRS based on adult returns is even lower, then it would indicate that HO fish exhibit continually reduced productivity though both the juvenile and the adult life stages. On the other hand, if RRS measures are not significantly different from 1.0, it would indicate that a productivity difference is not observed among HO and NO parental types.

Planned Metrics:
* Primary R, M, and E Focal Area : Population Status
* Primary R, M, and E Type : Status and Trend Monitoring
* Secondary R, M, and E Focal Area : Hatchery

Primary Focal Species: Chinook - Mid-Columbia River Spring ESU | Chinook - Snake River Spring/Summer ESU | Chinook - Upper Columbia River Spring ESU | Chinook - Upper Columbia River Summer/Fall ESU | Steelhead - Middle Columbia River DPS | Steelhead - Upper Columbia River DPS

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Calculate RRS within broodyears	11/1/2009	3/31/2010	Inactive	As molecular genetics and parentage analyses for each broodyear's progeny is completed, RRS of hatchery-origin versus natural origin adults will be calculated.
B. Perform statistical analyses within broodyears	11/1/2009	3/31/2010	Inactive	Use a generalized linear model (GLM) to test the hypothesis of similarity of productivity among parental types (e.g., HO versus NO), with number of recruits as the response variable, and with origin, sex, size (length), and run timing (Julian day of return) of the parents as explanatory variables. Under the expectation that the response variable will follow a Poisson random distribution, we will use a log-linear model within the GLM. Additionally, a Chi square test of independence will be performed to examine the hypothesis of random mating among parental cross types (HOxHO, HOxNO, NOxHO and NOxNO).
C. Summarize RRS information and compare across broodyears	12/1/2009	3/31/2010	Inactive	Summarize data for each successive broodyear as analyses are complete, and assess for consistency of results among broodyears.
Deliverable: D. Summary of parentage and RRS analyses		3/31/2010	Inactive	*See the Deliverable Specification above*

L: 161. Disseminate Raw/Summary Data and Results

Title: PO#3 - Report results of RRS study

Description: Project Objective #3 - Support for and unfunded RRS study

We will maintain an updated summary of RRS study results, in oral and written formats, as each broodyear's productivity and RRS information becomes available. These summaries will be communicated to associated fisheries managers and in relevant professional forums.

Deliverable Specification: An updated summary of RRS study results will be maintained, and results will be communicated to CRITFC and the Tribes (e.g., at internal CRITFC meetings or tribal meetings), and to associarted state fisheries agencies. Results will also be presented in regional forums involving evaluation of basinwide effects of supplementation programs on natural population productivity, e.g., forums/discussions which directly or indirectly grow out of the findings of the AHSWG (2008), in basin/regional workshops concerning fisheries and watershed management. and in professional forums (e.g., at local and regional American Fisheries Society meetings). We anticipate that during a subsequent Phase of the project, results will be summarized in a written manuscript to be submitted for publication in a scientific journal.

Primary Focal Species: Chinook - Mid-Columbia River Spring ESU | Chinook - Snake River Spring/Summer ESU | Chinook - Snake River Spring/Summer | Chinook - Upper Columbia River Spring ESU | Chinook - Upper Columbia River Summer/Fall ESU | Steelhead - Middle Columbia River DPS | Steelhead - Upper Columbia River DPS

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Produce an updated summary of RRS results	1/1/2010	3/31/2010	Inactive	Produce a continually updated summary presentation of project results, in both oral and written formats. Provide written summaries of project results for submission to concerned tribal and state fisheries agency managers, and oral summaries for presentation at relevant regional meetings and conferences, e.g., annual AFS national meeting, annual state chapter Meetings, annual AFS Western Division Meeting, annual Klickitat/White Salmon Rivers Fisheries and Watershed Science Conference, annual Yakima Basin Science & Management Conference, annual Pelton Round Butte Fisheries Workshop, etc.
Deliverable: B. Oral and written summary of RRS study results		3/31/2010	Inactive	*See the Deliverable Specification above*

M: 157. Collect/Generate/Validate Field and Lab Data

Title: PO#4 - Perform molecular genetics analyses of archived Hood River spring Chinook samples

Description: Project Objective #4: RRS in Reintroduced/Supplemented Populations

Archived scale samples of Hood River spring Chinook (1993 to present) will be delivered to the HFCES where molecular genetics analyses will be performed. Analyses will consist of extraction of DNA from each sample, and analysis for a suite of 13 microsatellite markers.

Deliverable Specification: Molecular genetics analyses will be performed on archived Hood River spring Chinook samples. Archived samples will be delivered to HFCES where molecular genetics analyses will be initiated. The "fitness" of a fish population is typically measured in terms of its demonstrated natural productivity – the number of recruits per natural spawner (R/S), with the recruits enumerated at a juvenile stage and/or as returning adults. However, in cases where the naturally spawning population is supplemented, it consists of alternative parental types, e.g., natural origin versus supplementation hatchery origin). Until recently, researchers have been unable to compare the relative natural productivity among parental types in these populations, due to the inability to differentiate the parental identity of the naturally produced progeny. However, new molecular genetics techniques using multi-locus DNA markers now provide this capability (see reviews by Wilson and Ferguson 2002, Jones and Ardren 2003, Liu and Cordes 2004). The techniques require annual collection of scale and tissue samples from essentially all (or, at least a large majority of) adults which return to a river for natural spawning, with hatchery origin adults identifiable via presence of a tag or an external mark (e.g., clipped adipose fin). The scales are used to age the fish and assign them to a particular broodyear - already performed for the Hood River spring Chinook samples by ODFW. DNA will be extracted from the scale samples delivered to HFCES. The DNA will then be analyzed to identify the alleles present for a suite of 13 microsatellite markers, providing a profile for each potential spawner within a particular broodyear. After a generation has passed, the profiles of the adult progeny assigned to each broodyear are compared with those of the broodyear's spawners, and the total number of progeny assigned per adult can be calculated. The average (and variance) number of adult recruits for each parental type (e.g., out-of-basin HO, versus in-basin HO, versus NO fish) is then calculated and compared among parental types.

Planned Metrics:
* Primary R, M, and E Focal Area : Population Status
* Primary R, M, and E Type : Status and Trend Monitoring
* Secondary R, M, and E Focal Area : Hatchery

Primary Focal Species: Chinook - Lower Columbia River ESU

Country: US
State: OR
County: HOOD RIVER
NPCC Subbasin: HOOD
HUC5 Watershed: HOOD RIVER
HUC6 Name: LOWER HOOD RIVER

Salmonid ESUs Present: Columbia River Chum Salmon ESU (Accessible) | Lower Columbia River Chinook Salmon ESU (Accessible) | Lower Columbia River Coho Salmon ESU (Accessible) | Lower Columbia River Steelhead DPS (Accessible)

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Environmental compliance requirements complete	5/1/2009	5/1/2009	Inactive	On-the-ground work associated with this work element cannot proceed until this milestone is complete. Milestone is complete when final documentation is received from BPA environmental compliance staff (completion can be based on pre-existing environmental documentation from BPA).
B. Purchase of supplemental equipment for HFCES	5/1/2009	9/30/2009	Inactive	Purchase electronic office equipment and laboratory equipment – laptop computer, Fluidigm-Biomark IFC Controllers and Thermal Cyclers, and laboratory benches/cabinets and archive shelving - required for performance of molecular genetics analyses.
C. Delivery of archived scale samples	5/1/2009	12/31/2009	Inactive	Delivery by ODFW of archived Hood River spring Chinook scale samples and associated field data to the HFCES - will likely be made in multiple deliveries over the year.
D. Molecular genetics analyses	6/1/2009	3/31/2010	Inactive	Perform molecular genetics analyses and parentage assignment for each sample.
Deliverable: E. Molecular genetics analyses for archived Hood River spring Chinook samples		3/31/2010	Inactive	*See the Deliverable Specification above*

N: 162. Analyze/Interpret Data

Title: PO#4 - Perform parentage and RRS analyses of Hood River spring Chinook

Description: Project Objective #4: RRS in Reintroduced/Supplemented Populations

Genetic profiles acquired for each fish will be compared to the profiles for adults in its respective broodyear, to permit parentage assignment. Individual productivity (R/S) estimates will be calculated for each adult within broodyears, as well as average productivity and Relative Reproductive Success (RRS) among parental types within broodyears. Statistical tests of RRS will then be performed estimates for an effect of origin, and compare results across broodyears.

Deliverable Specification: The parentage assignment information will permit calculation of the number of recruits per individual spawner within broodyears, and these data will be averaged within parental types. We will use a generalized linear model (GLM) to test the hypothesis of similarity of productivity among parental types (e.g., HO versus NO), with number of recruits as the response variable, and with origin, sex, size (length), and run timing (Julian day of return) of the parents as explanatory variables. Under the expectation that the response variable will follow a Poisson random distribution, we will use a log-linear model within the GLM. Additionally, a Chi square test of independence will be performed to examine the hypothesis of random mating among parental cross types (HOxHO, HOxNO, NOxHO and NOxNO) (Leth 2005 and Lutch et al. 2005).

When the time series for parentage information exceeds a full salmon generation, it will be possible to also calculate adult recruit per spawner information within broodyears. If the adult progeny data is sufficient, it will be subjected to analyses identical to those performed with the juvenile R/S data. Comparison of results between the pair of tests will help identify if observed productivity differences can be attributed to a particular life stage. For example, observation of relatively low reproductive success for HO fish based on juvenile R/S measures, and a RRS evaluation based on adult R/S which is similar would indicate that the differential success occurs primarily during the spawning and juvenile rearing portion of the life cycle, and that a significant deleterious effect is not observed during the adult stages. Or, if across broodyears RRS based on juvenile returns is consistently less than 1.0, and if RRS based on adult returns is even lower, then it would indicate that HO fish exhibit continually reduced productivity though both the juvenile and the adult life stages. On the other hand, if RRS measures are not significantly different from 1.0, it would indicate that a productivity difference is not observed among HO and NO parental types.

Planned Metrics:
* Primary R, M, and E Focal Area : Population Status
* Primary R, M, and E Type : Status and Trend Monitoring
* Secondary R, M, and E Focal Area : Hatchery

Primary Focal Species: Chinook - Lower Columbia River ESU

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Calculate productivity and RRS within broodyears	8/1/2009	3/31/2010	Inactive	As molecular genetics analyses and parentage assignments are completed for each broodyear, calculate individual productivity (recruits/spawner) and RRS (natural-origin versus hatchery-origin) within broodyears
B. Statistical anaysis for RRS within broodyears	8/1/2009	3/31/2010	Inactive	Perform statistical analyses of RRS within broodyears to test for a significant effect of origin on productivity.
C. Summarize RRS information and compare data across broodyears	10/1/2009	3/31/2010	Inactive	Summarize RRS information and assess consistency of data across broodyears.
Deliverable: D. Parentage and RRS analysis within broodyears		3/31/2010	Inactive	*See the Deliverable Specification above*

O: 161. Disseminate Raw/Summary Data and Results

Title: PO#4 - Report results of Hood River spring Chinook RRS study

Description: Project Objective #4: RRS in Reintroduced/Supplemented Populations

We will maintain an updated summary of RRS study results, in oral and written formats, as each broodyear's productivity and RRS information becomes available. These summaries will be communicated to fisheries managers with the CTWSRO and ODFW, and oral summaries will be presented in relevant professional forums.

Deliverable Specification: An updated summary of RRS study results will be maintained, and results will be communicated in written and oral formats to the CTWSRO and ODFW. Results will also be presented in regional forums involving evaluation of basinwide effects of supplementation programs on natural population productivity, e.g., forums/discussions which directly or indirectly grow out of the findings of the AHSWG (2008), in basin/regional workshops concerning fisheries and watershed management. and in professional forums (e.g., at local and regional American Fisheries Society meetings). We anticipate that during a subsequent Phase of the project, results will be summarized in a written manuscript to be submitted for publication in a scientific journal.

Primary Focal Species: Chinook - Lower Columbia River ESU

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Maintain and communicate an updated summary of study results	11/1/2009	3/31/2010	Inactive	Communicate the current summary of project results within CRITFC and the Tribes (e.g., at internal CRITFC meetings or tribal meetings). This summary will be updated as each broodyear's productivity and RRS information becomes available. Produce written summaries of project results for submission to associated tribal and state fisheries agencies, and oral summaries for presentation at relevant regional meetings and conferences, e.g., annual AFS state chapter Meetings, annual AFS Western Division Meeting, annual Klickitat/White Salmon Rivers Fisheries and Watershed Science Conference, annual Yakima Basin Science & Management Conference, annual Pelton Round Butte Fisheries Workshop, etc.
Deliverable: B. Updated summary of RRS results		3/31/2010	Inactive	*See the Deliverable Specification above*

P: 114. Identify and Select Projects

Title: PO#4 - Evaluate other candidate reintroduction/supplementation programs for an RRS study

Description: Project Objective #4: RRS in Reintroduced/Supplemented Populations

Gather information on multiple reintroduced/supplemented salmon populations, identify 3 to 4 among them for support of a RRS study, and produce a study design for each in collaboration with associated tribal and state fisheries agencies - to be included within the proposal for Phase II of the Project.

Deliverable Specification: In collaboration with tribal and state fisheries personnel, collect information on candidate supplementation projects for reintroduction of salmon or steelhead, including: efficacy of adult trap, annual escapement, current or potential juvenile collection methodologies, actual or estimated O&M costs for juvenile collection, etc. Evaluate the relative feasibility, benefits and cost for establishing a RRS study in each of the populations. Chose three to four populations for study - the number to be determined through comparison of estimated project-specific costs and the overall budget envelope for the project. Identify the lead tribal fisheries biologist/scientist (to be included among the Key personnel in a Phase II proposal) associated with the reintroduction program for each of the chosen populations, and together develop work plans for annual collection of samples and biological data from adult and juveniles, to be included within the Narrative for the proposal for Phase II of the Project

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Gather information on reintroduced/supplemented populations	5/1/2009	10/31/2009	Inactive	Meet with tribal and state fisheries personnel to obtain relevant information on candidate populations of reintroduced/supplemented salmon.
B. Evaluate and prioritize populations for a RRS study	9/1/2009	1/31/2010	Inactive	Evaluate the relative and total costs among candidate populations; choose three to four populations for a RRS study.
C. Develop a study plan for the RRS study in each chosen population	11/1/2009	2/28/2010	Inactive	Develop a work plan for collection of individual data and tissue samples from adults and juveniles in each of the chosen populations.
D. Integrate study plans into Phase II narrative	12/1/2009	2/28/2010	Inactive	Integrate the study plans into the Narrative for the Phase II proposal for the Project, and submit the narrative for review by BPA and the ISRP.
E. Respond to BPA and ISRP reviews	12/1/2009	2/28/2010	Inactive	Respond to BPA and ISRP reviews, and enter the modified narrative into PISCES, create the SOW, and begin the contracting process.
Deliverable: F. Produce RRS study plans for 3 to 4 reintroduced/supplemented populations		2/28/2010	Inactive	*See the Deliverable Specification above*

Q: 189. Regional Coordination

Title: PO#4 - Organize tribal workshop on salmon reintroduction/supplementation programs

Description: Project Objective #4: RRS in Reintroduced/Supplemented Populations

Organize the "Workshop on Tribal Programs to Reintroduce Extirpated Columbia Basin Salmon Populations".

Deliverable Specification: CRITFC will organize a workshop to review progress of tribal projects involving salmon reintroduction/supplementation, with the purpose of: a) facilitating obtaining summary information with which to assess the candidate reintroduced/supplemented populations for a RRS study, and b) sharing program information and helping to coordinate methodologies, and monitoring and evaluation activities among these tribal projects. The meeting will provide a venue for tribal managers, scientists, biologist and technicians to share and compare information (amongst themselves, and with interested persons from outside the tribal programs) regarding their efforts, of both a technical and management nature, via formal presentations, site visits, and informal discussions.

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Prepare the Workshop	9/1/2009	2/28/2010	Inactive	Prepare the workshop, involving identification of the: venue (conference room and lodging), participant list, procedure for reimbursement of invited tribal participants, program of conference presentations and speakers, etc.
B. Hold the Workshop	1/1/2010	3/31/2010	Inactive	Hold the "Workshop on Tribal Programs to Reintroduce Extirpated Columbia Basin Salmon Populations".
Deliverable: C. Hold the "Workshop on Tribal Programs to Reintroduce Extirpated Columbia Basin Salmon Populations"		3/31/2010	Inactive	*See the Deliverable Specification above*

R: 183. Produce Journal Article

Title: PO#4 - Initiate preparation of manuscript on tribal programs to reintroduce coho salmon

Description: Project Objective #4: RRS in Reintroduced/Supplemented Populations

We will initiate drafting of a manuscript on tribal programs to reintroduce naturally spawning populations of Columbia River coho.

Deliverable Specification: Following the Workshop, participants from each tribe will be invited to contribute to a written review focused specifically on tribal efforts to restore extirpated coho salmon to the Columbia basin. The review paper will be prepared in a format appropriate for submission to Fisheries (American Fisheries Society). Tentative title is: "Tribal Fisheries Efforts to Restore Extirpated Coho Salmon to the Mid-Columbia and Snake River Basins". Completion and submission of the manuscript is predicted in 2010, during Phase II of this project.

Planned Metrics: * # of draft scientific reports submitted: 1

* # of draft manuscripts and draft final reports of research findings submitted for publication: 1

Primary Focal Species: Coho - Unspecified Population

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Initiate preparation of coho reintroduction manuscript	1/1/2010	3/31/2010	Inactive	Initiate preparation of manuscript: "Tribal Fisheries Efforts to Restore Extirpated Coho Salmon to the Mid-Columbia and Snake River Basins". Completion and submission of the manuscript is predicted in 2010, during Phase II of this project.
Deliverable: B. Draft of coho reintroduction manuscript		3/31/2010	Inactive	*See the Deliverable Specification above*

S: 185. Produce Pisces Status Report

Title: Admin - Periodic Status Reports for BPA

Description: Submit quarterly reports on the status of milestones and deliverables in PISCES.

Deliverable Specification:

Milestone Title	Start Date	End Date	Status	Milestone Description
A. May-Jun 2009 (5/1/2009 - 6/30/2009)	7/1/2009	7/15/2009	Inactive	
B. Jul-Sep 2009 (7/1/2009 - 9/30/2009)	10/1/2009	10/15/2009	Inactive	
C. Oct-Dec 2009 (10/1/2009 - 12/31/2009)	1/1/2010	1/15/2010	Inactive	
D. Jan-Mar 2010 (1/1/2010 - 3/31/2010)	4/1/2010	4/15/2010	Inactive	
E. Final Apr 2010 (4/1/2010 - 4/30/2010)	4/16/2010	4/30/2010	Inactive	

T: 132. Produce (Annual) Progress Report

Title: Admin - Submit Progress Report for the period May 2009 thru April 2010

Description: The progress report summarizes the project goal, objectives, hypotheses, completed and uncompleted deliverables, problems encountered, lessons learned, and long-term planning. Examples of long-term planning include future improvements, new directions, or level of effort for contract implementation, including any ramping up or ramping down of contract components or of the project as a whole. Date range May 2009 thru April 2010 will be agreed upon by the COTR and the contractor. This may or may not coincide with the contract period. For an ongoing project, a progress report covering a contract period may be submitted under the subsequent contract, if approved by the COTR.

Progress reports must conform to BPA guidelines. See the ''formatting guidelines'' link at the Technical Reports and Publications page: http://www.efw.bpa.gov/IntegratedFWP/technicalreports.aspx.

If producing a technical report for this contract, a discrete experiment, or a peer-reviewed publication, use work element 183: Produce Journal Article.

Deliverable Specification: Use the attachment tab in Pisces to attach your progress report. Progress reports attached in Pisces will be posted on the web.

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Review progress report format requirements	3/1/2010	3/5/2010	Inactive	Contractor must review formatting requirements before starting the first draft of their report. Please follow the BPA-required format. http://www.efw.bpa.gov/IntegratedFWP/technicalreports.aspx
B. Confirm BPA has posted the progress report	4/5/2010	4/7/2010	Inactive	It usually takes BPA 30-45 days to post the final version of a report. This milestone's end date should therefore be 45 days after the Deliverable milestone. You will receive an email from BPA confirming that your report has been finalized and posted to the web.
Deliverable: C. Attach Progress Report in Pisces		3/31/2010	Inactive	*See the Deliverable Specification above*