2015 PIT Tag Workshop Program

January 27-29, 2015
Skamania Lodge, Stevenson, WA

Tuesday, January 27, 2015

1:00 pm - 2:00 pm **Workshop Introduction and Opening Presentations**

Introductions and Overview

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A review of the 2014 Marking Procedures Manual

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In 1999, the PIT Tag Steering Committee (PTSC) published the Marking Procedures Manual which provided "…protocols and standards on the PIT tag marking station, fish handling techniques, anesthesia, tag injection, and information on data collection, verification, and transfer to PTAGIS." While much of the 1999 manual is still applicable to current PIT-tagging operations, the manual had become dated due to changes in available equipment - both electronic and tagging, tagging software, and the application of PIT tags within the Columbia River Basin. To address these changes, and to provide guidance for the application of new PIT tag technologies, the PTSC published an updated version of the manual in March 2014. During this presentation, we will discuss the changes between the 1999 and 2014 versions of the manual, review the major points to follow during tagging operations, and discuss the "Special Notices" section of the manual.

Recent PTAGIS accomplishments and future direction

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PTAGIS has implemented significant technology changes since the last PIT Tag Workshop, including a database server upgrade, new data validation and loading processes, new website, new reporting software, new field interrogation software, new transceivers and newly designed adult ladder antennas. PTAGIS is currently working on the next generation tagging software and working with the PTSC to evolve the MRR data model. Future plans include working with other regional databases to increase opportunities for linking, improving spatial data capabilities and reporting, and adding website and reporting features and functionality.

2:00 pm - 3:00 pm Research and Monitoring Applications

Utilizing PIT tags to assess spatial and temporal distribution of spawning adult summer steelhead in Asotin Creek, Washington

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Historically, documenting spawn timing and the spatial/temporal distribution of spawning summer steelhead has been accomplished by conducting spawning ground surveys. In many watersheds occupied by Snake River summer steelhead, performing consistent spawning ground surveys has been problematic; most often due to the environmental conditions encountered during the spawning period. However, the spatial and temporal distribution of spawners is considered a critical Viable Salmonid Population (VSP) metric and has significant importance relative to directing and implementing habitat improvements.

To analyze the distribution of spawners above the weir site in Asotin Creek, Washington, we have used a novel approach to sorting PIT tag interrogation data from PIT arrays at three upstream tributaries using logic sequences within an MS Access database. From those queries individual fish are assigned to one of three tributaries in which they presumably spawned. The use of PIT tags also affords us the ability to assign individual fish observed or PIT tagged at the weir to spawning tributary and, allows us to describe the demographic attributes (spawn timing, total age, length at age, sex ratios, etc.) of all the adult steelhead spawning in each tributary.

To date we have analyzed five years of interrogation and tagging data. Proportional use of the mainstem Asotin Creek and its tributaries by spawning adult steelhead has been fairly consistent across those years and matches the overall trend data collected by both historic and contemporary spawning ground surveys. The distribution of spawners also relates closely to the overall drainage area of each tributary. The analysis suggests that using PIT tag observations in tributaries can produce spawning estimates similar to those collected through traditional spawning ground surveys. We feel that in some systems PIT tag observations may be a suitable surrogate to assess tributary spawning trends where spawning ground surveys are limited by staffing or environmental conditions. Perhaps more importantly, the use of PIT tags allows researchers to document the demographic attributes of the spawners in each tributary or reach.

2:00 pm - 3:00 pm Research and Monitoring Applications

Seasonal usage of off-channel habitats in the Entiat River by juvenile Chinook salmon

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Flood-plain connectivity and off-channel habitat availability has been greatly reduced over the last century as a result of anthropogenic activities such as stream channelization. This reduction in hydrological connectivity has altered the flow of nutrients between terrestrial and aquatic ecosystems, reduced habitat complexity, and decreased the amount of rearing habitat for juvenile fish. Habitat restoration efforts in the Upper Columbia River have sought to improve and increase the amount of juvenile salmonid rearing habitat in off-channel habitats. To assess how these habitat improvements impact juvenile salmonids, the Integrated Status and Effectiveness Monitoring Program (ISEMP) has been actively monitoring off-channel habitats within the Entiat River since 2011. The objectives of this study were to examine the abundance, physical condition, and residence time of juvenile Chinook salmon in five off-channel habitats utilizing Passive Integrated Transponder (PIT) tag technology and mark-recapture methods. Preliminary results indicate abundance and residence time vary by site, season, and hydrological connectivity of the off-channel habitats with the main stem river. In general, abundance of juvenile Chinook salmon in off-channel habitats was inversely related with seasonal hydrological connectivity of the off-channels habitats with the main stem with the greatest densities occurring in the summer when the off-channel habitats were fully connected with the main stem. Despite abundances of juvenile Chinook salmon decreasing in the off-channel habitats from summer to winter, densities in off-channel habitats remained higher than main stem locations during all sampling periods. These findings serve to support the need for increasing hydrological connectivity with the floodplain and the creation of new off-channel habitats to help meet recovery objectives.

Use of a passive interrogation array to evaluate entrainment of endangered fish in an irrigation canal

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We investigated entrainment of endangered and non-listed native fish in the Green River Canal (Green River, UT) using passive integrated transponder technology during the 2013 and 2014 irrigation seasons. The Green River Canal is a 1.8 m^3/s gravity-fed irrigation canal which operates annually during the months of April through November. Working with canal company officials, we constructed a solar-powered passive interrogation array (PIAs) about 150 m below the canal intake gates in 2013 and a second system about 400 m below the gates in 2014. In 2013, 81% of all fish detected in the canal were Razorback Sucker, *Xyrauchen texanus* (499 individuals). Colorado pikeminnow, *Ptychocheilus lucius* and Flannelmouth Sucker, *Catostomus latipinnis* comprised 13% (77 individuals) and 5% (33 individuals) of all entrained fish, respectively. Three Bonytail, *Gila elegans* and a single Humpback Chub, *Gila cypha* were also entrained. Peak rates of entrainment (up to 270 fish in a single day) were observed immediately following cessation of spring peak flows in July, at which point the canal diverted about half of the Green River discharge at times. Results from the 2014 irrigation season are forthcoming and will be presented. Entrainment rates of endangered fish in the Green River canal are significant and efforts are underway to reduce or eliminate entrainment most likely through exclusion structures. We will continue to monitor entrainment rates using PIAs following construction of the exclusion structures.

3:20 pm - 5:00 pm Research and Monitoring Applications (cont)

Summer movements of juvenile salmonids in the upper Chehalis River

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Movements of juvenile salmonids during summer rearing stages is poorly understood but may be important to their persistence in watersheds where temperatures are near the upper limit of species thermal tolerances. This study was conducted in the upper Chehalis River sub-basin which is one of multiple sub-basins comprising the Chehalis River watershed in western Washington. The rain-dominant hydrology of this watershed results in an extended period of low flow and warm stream temperatures during the summer months. During the summer low flow period, maximum daily stream temperatures in the upper Chehalis River sub-basin regularly exceed 20°C. A series of PIT antennae arrays were used to investigate movements of juvenile coho and steelhead between the months of June and September. Paired antennae were operated at a main stem river and three tributary locations and were used to determine the time fish were present at each location and their direction of travel. Juvenile coho and steelhead were PIT tagged and released over 14 km of the main stem river. Fish movement was frequently observed throughout the study period with some fish travelling up to 7 km between release and detection locations. Movement through the main stem and between the main stem and tributaries followed a diel cycle which we hypothesize may result from a trade-off between food availability and behavioral thermoregulation. We use information-theory model selection to determine whether detections at the main stem array location were best explained by release location (up or downstream), distance travelled, species, or fish size. Our results demonstrate that juvenile salmonid movements among neighboring habitat units may be appreciable during the summer low flow period. In addition to local habitat characteristics, connectivity among adjacent habitat units is likely to be an important feature of juvenile salmonid summer rearing in the upper Chehalis River.

Population and individual-level metrics for over-wintering juvenile Coho in three adjacent tributaries in the lower Columbia River

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Baseline monitoring prior to restoration actions is needed to identify limiting life stages in freshwater. A life cycle monitoring study of coho salmon in Mill, Abernathy, and Germany creeks was initiated in 2005. These three adjacent tributaries enter the Columbia River near Cathlamet, Washington. Monitoring for coho parr occurs at the end of their summer rearing period and monitoring for coho smolts occurs during the spring outmigration. Apparent overwinter survival has ranged 13-fold between 1.9% and 24.8%. Apparent overwinter growth has ranged 3-fold, with spring smolts that are 21.9% to 63.6% longer than parr in August and September. We identified both density dependent and density independent metrics that contribute to survival and growth. Coho parr are PIT tagged during August and September. Individual growth and movement information obtained from PIT tag detections and recoveries is used to interpret population-level patterns in overwinter survival and growth. In these three tributaries, our results suggest that the overwinter rearing stage may limit coho freshwater productivity. In order to improve freshwater survival and growth, restoration activities should focus on this limiting life stage.

3:20 pm - 5:00 pm Research and Monitoring Applications (cont)

New approaches afforded by PIT tag technology have yielded important answers about fish behavior and habitat needs

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The availability of PIT tag technology has spurred much innovative research on fish movements and life history in the Columbia River Basin and beyond. We present a compendium of case histories about our use of PIT tag technology throughout the western USA. These studies have provided data to address questions about fish behavior, habitat use, habitat connectivity, life history diversity, and survival. Since our first install in August 2001 in Rattlesnake Creek, we have used PIT tag technology to: 1) Estimate summer steelhead run size in Washington's Trout Creek of the Wind River watershed, following the loss of a trapping facility where all adult fish were once counted at the now removed Hemlock Dam, 2) Assess movement and diversity of life-histories of parr steelhead in the Wind River watershed, 3) Assess effectiveness of small dam removals in northcentral Washington's Methow watershed's Beaver Creek to allow juvenile salmonids to access upstream rearing habitat, 4) Assess survival of juvenile anadromous salmonids using side channels in the Methow River, 5) Assess movement of mountain whitefish in the Methow River, combined with otolith microchemistry, to understand the importance of stream connectivity to their life history needs, 6) Assess adult steelhead use of southcentral Washington's Rock Creek to understand stream improvement needs, 7) Assess bull trout movement in northern Nevada's Jarbidge River , combined with genetic analysis, to understand connectivity of seemingly disjunct populations, and 8) movement of Big Spring spinedace in southeastern Nevada's Condor Canyon to assess habitat use and extent of distribution. While PIT tag technology has afforded us the ability to address many new and important questions, we see room for growth. We will offer a perspective of what more is needed to gain information breakthroughs.

Use of passive integrated transponder technology to improve hatchery mitigation in the Columbia River Basin

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Artificial production of salmon and steelhead is critical to fisheries management in the Columbia River Basin, yet many programs are based on tradition and historical agreements. We provide real examples of how data derived from PIT tagging efforts have been applied to optimize hatchery programs. Two important results include (1) reducing phenotypic disparities between hatchery- and wild-origin adults, and (2) minimizing the footprint of hatchery operations in terms of reduced capacity and water requirements, phosphorous discharge, and number of smolts required to meet mitigation goals. We use these examples to advocate an incentive-based approach to hatchery mitigation that is informed by an expansive network of PIT release and recapture sites in the Basin.

3:20 pm - 5:00 pm Research and Monitoring Applications (cont)

Understanding *O. mykiss* life history diversity using a combination of PIT tags and genetic parentage assignments

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The expression of anadromy versus residency for *Oncorhynchus mykiss* in sympatric populations is a complex phenomenon thought to be governed by a combination of genetic and environmental factors. Adding to the complexity of this species is the ability of one life history form to give rise to the other, which not only complicates our understanding of biologic interactions, but the management of the species as well. Populations of the anadromous form, steelhead trout, have declined substantially over most of the species range, resulting in a threatened listing status under the Endangered Species Act for the middle Columbia River DPS, which includes the Yakima River. In the upper Yakima River population, numbers of adult steelhead have remained below recovery targets since being listed in 1999, although the basin continues to support a robust rainbow trout population. Juvenile anadromous and resident life history forms are impossible to distinguish in the field prior to the smolt stage which creates difficulties in monitoring one form independent of the other. We began using a combination of PIT tagging and genetic stock identification methods to gain an understanding of the breeding interactions between life history forms at the population scale in the upper Yakima basin. We have been tagging substantial numbers of juvenile *O. mykiss* in tributary and main stem river reaches. Migrant (anadromous) juveniles are identified when they are detected at downstream PIT tag arrays in the Yakima and Columbia Rivers. All adult steelhead are also genetically sampled and PIT tagged during their spawning migration. We use genetic techniques to match steelhead parents to juvenile migrants. Juvenile migrants that do not assign to at least one steelhead parent will be assumed to have originated from resident by resident matings. We strategically installed a PIT tag interrogation network in the Upper Yakima Basin to gain information on the anadromous spawner distribution, migration timing, spawning tributary fidelity, and reach specific migration survivals, among other things. This will help us identify the relative production from the various breeding crosses and perhaps, improve our understanding of the factors governing the production of each life history type in the Yakima Basin.

8:00 am - 10:00 am Data Modeling and Analysis

Estimates of salmon and steelhead harvest rates in lower Columbia River fisheries based on the recovery of passive integrated transponder (PIT) tags

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Since the 1990's, the incorporation of Passive Integrated Transponder (PIT) tag technology into salmon and steelhead monitoring and infrastructure improvements has led to the widespread use of PIT tags in the Columbia River system. Although most PIT tags are used to estimate travel time, survival, and abundance, they have other application for fisheries management. Since millions of juvenile salmon and steelhead are tagged for other purposes, we believed there was an opportunity to estimate harvest rates of PIT tag groups by adding PIT scanning of adult salmon and steelhead caught in fisheries to the existing fishery sampling protocols (e.g. coded-wire-tag and biological sampling). The Washington Department of Fish and Wildlife (WDFW) and the Pacific States Marine Fisheries Commission (PSMFC), with funding from the Bonneville Power Administration (BPA), implemented PIT tag sampling starting in the fall of 2010. In this presentation we will discuss the methods and challenges of using PIT tags to estimate harvest rates in mainstem sport, commercial, and Treaty Columbia River fisheries for Chinook, coho, and sockeye salmon along with steelhead.

8:00 am - 10:00 am Data Modeling and Analysis

Multi-state model of Entiat River spring Chinook to estimate seasonal survival and outmigration rate

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Exploratory data analyses of instream PIT-tag array detections and screw trap recaptures of Entiat River, WA, spring Chinook parr PIT-tagged in late summer (2011-2013, data collected under Bonneville Power Administration Project 2003-017 Integrated Status and Effectiveness Monitoring Program by U.S. Fish and Wildlife Service,Terraqua Inc.,and Yakama Nation personnel) revealed steady outmigration from late summer through the following spring with outmigration patterns varying by tagging location. Differences in outmigration patterns coupled with differences in habitat along the stream length indicate the potential for differential survival by tagging location. A modest downstream movement to lower river reaches before outmigration means the effect of habitat quality on spring Chinook parr in the Entiat is a function of habitat quality at the location of summer tagging. Overwinter survival estimates for fish remaining in the Entiat (late summer to late winter) are noticeably higher for upriver and versus lower river locations. Survival estimates from summer tagging to MCNary Dam (MCN) the following spring also differ by tagging location. As spring Chinook outmigrating as subyearlings overwinter in the mainstem Columbia, different survival rates may occur between fish overwintering in the Columbia versus fish overwintering in the Entiat. We used a multi-state mark-recapture-resight model to estimate seasonal outmigration probabilities and survival within the Entiat and to MCN (an arbitrary but reasonable metric that allows comparison of survivals for fish outmigrating at different times). The objectives are to estimate i) seasonal (fall, winter, spring) outmigration probabilities for spring Chinook tagged over summer at different locations along the river, ii) seasonal survival probabilities for fish remaining in the Entiat, and iii) survival probabilities to MCN for each seasonal outmigration. Successful estimation of the outmigration and survival probabilities in (i), (ii), and (iii) will provide a comprehensive understanding, given the available data, of movement and survival dynamics. Few studies exist examining the multi-layered movement and survival dynamics occurring within a single river. By fully utilizing available PIT tag data for the Entiat River this analysis provides an innovative addition to understanding spatial variation in population dynamics within a single river and offers a framework for other locations where similar data are available.

8:00 am - 10:00 am   Data Modeling and Analysis

Columbia River steelhead life cycle modeling based on PIT tags

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Empirical life stage and reach scale steelhead survival estimates are currently lacking but are needed for Columbia River recovery and adaptive management plans. We developed a Bayesian Cormack-Jolly-Seber life cycle model to estimate stage-specific survival for nine different life stages by spatial reach combinations. The model started at the parr stage and measured survival up to the second spawning run of adult steelhead over 9 out migrant years from 2003-2011 for an ESA listed population of summer steelhead. The model was parameterized with Passive Integrated Transponder (PIT) tagging, recapture and detection data from the Wind and Columbia rivers. Using model selection criteria, the best model was a hierarchical model of both survival and detection probabilities across cohorts. Since our reaches coincided with life stages, we provided preliminary estimates for the mean survival for 1) tributary spring parr to smolts in the Wind River (10%), 2) smolts migrating in the Columbia River to the estuary (78%), 3) smolt to adult returns from the estuary & ocean to Bonneville Dam (BON) (6%), 4) adult pre-spawners in the BON pool (63%), 4) adult entry into the Wind River to kelts in the estuary (59%), and 5) kelts from the estuary to first time repeat spawners to BON (17%). Kelt to adult return survival estimates after second spawning were imprecise due to low tagging and recovery rates. The survival from smolt to adult return explained most of the annual variation in survival for the life stages we modeled. Iteroparity resulted in increased life history diversity and population resilience for this population. Our estimates rates of iteroparity were more than double previous published rates of Columbia River summer steelhead above BON.

8:00 am - 10:00 am Data Modeling and Analysis

TribPit: estimating salmonid cohort survival during juvenile outmigration

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The outmigration survival of cohorts (i.e., brood years) of a salmonid population is an important monitoring metric used in assessing recovery actions such as habitat restoration. The development of instream PIT-tag detection arrays and the proliferation of PIT-tag releases in tributaries provide new information on survival of cohorts before they enter the hydrosystem. New data require new analysis methods, however, and the estimation of cohort survival is complicated by variable age at outmigration for populations of steelhead and Chinook salmon. The standard CJS model is inappropriate for populations that exhibit migratory delay once some individuals have initiated migration, and its restriction to a single release group fails to efficiently use all data from multiple release groups of the same cohort. More flexible analysis methods have been developed to account for these problems but are challenging to implement. Program TribPit, new software from the University of Washington (http://www.cbr.washington.edu/analysis), implements a multistate mark-recapture model to estimate juvenile cohort survival for populations that migrate at different ages. The necessary PIT-tag data can be downloaded from the PTAGIS database and formatted directly using a specially designed query on the DART website (http://www.cbr.washington.edu/dart/query/pit_basin_branching). Independent age data are used to identify cohorts. The software will be introduced and an example presented estimating survival of the 2010 cohort of steelhead from the Twisp River. Subyearling, yearling, and 2-year old steelhead were captured, PIT-tagged, and released in the Twisp River in 2010, 2011, and 2012, respectively, and monitored as they migrated past instream PIT-tag arrays in the Twisp and Methow rivers and dams in the Columbia River. Overall 2010 cohort survival estimates were 0.05 (SE=0.03) to Rocky Reach Dam and 0.03 (SE=0.01) to McNary Dam, and included outmigration in 2011 and 2012. No subyearlings were detected out of the Twisp River within 2010. The age composition at Rocky Reach from the 2010 cohort was 100% 2-year olds at both Rocky Reach and McNary dams. The problem of small sample size will be addressed.

8:00 am - 10:00 am Data Modeling and Analysis

Estimating Chinook escapement in the John Day River basin using a mark-recapture approach

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The John Day River basin supports three wild populations of spring Chinook salmon that remain depressed relative to historic levels; escapement estimates from 2000 to 2013 have ranged from 1,817 to 7,808 spawners. As efforts are made to protect and rehabilitate habitat, our monitoring efforts provide much needed information to evaluate project-specific effectiveness as well as meet the data needs as index stocks. Beginning in 2009, mark-recapture analysis using Passive Integrated Transponder (PIT) tagged fish has provided an independent alternative to estimating spawner abundance as the product of redd count and an out-of-basin fish per redd estimate. Several thousand Chinook smolts are intra-peritoneally PIT tagged each year when emigrating from the John Day River basin, providing a number of returning adults that are “marked” at Bonneville Dam via passive detection of the PIT tags they carry. During spawning ground surveys, a portion of the population is recovered as carcasses and examined for marks. The percentage of recaptured fish has ranged from 1.1 to 2.3 and standard deviation of the PIT tag based abundance estimate has ranged from 647 to 1,801. Although results from our 2011 and 2012 data suggest that this approach is feasible, the 2013 mark-recovery escapement estimate demonstrates that a minimum number of returning marked fish is necessary to generate an estimate with acceptable confidence. The concordance of escapement estimates generated by these discrete methodologies increases our confidence in the suitability of both methods for estimating John Day spring Chinook salmon escapement.

8:00 am - 10:00 am Data Modeling and Analysis

Examining the effects of juvenile migration timing, hydropower-system passage type, and environmental factors on adult age-at-return of PIT-tagged Snake River spring/summer Chinook salmon

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Both intra- and inter-annual differences in water flow, temperature, and availability of food resources can create large differences in growth of salmon within and among year classes. In particular, differences in growth lead to different maturation rates and subsequent age structure, which can be important because of their potential effects on catch rates and fecundity of spawners. We examined the relationship between adult age-at-return and juvenile migration experiences by taking advantage of a large data set of yearling Chinook salmon from the Snake River basin, tagged with PIT tags prior to arriving to the Pacific Ocean. We considered all juvenile spring/summer Chinook salmon tagged at or above Lower Granite Dam from 1998 through 2011 (corresponding to adult return years 1999–2014). More specifically, we used information from these tagged fish to estimate how adult age-at-return varied as a function of year, juvenile migration timing within a year, juvenile fish length, ocean indicators (e.g., PDO, upwelling), rearing type (i.e., hatchery vs. wild), and hydropower-system passage type (i.e., run-of-river vs. transported fish). We modeled the observed adult age of tagged fish using a hierarchical Bayesian framework, which incorporates these covariate effects while also accommodating stochastic inter-annual variation (i.e., across outmigration years), serial autocorrelation, and cross-correlation in the age-at-return probabilities. We found clear patterns in ocean-age proportions versus time of arrival below Bonneville Dam, which indicated that juvenile fish migrating later in the season returned as older adults. However, there was definite inter-annual variation. These analyses highlight how intra- and inter-annual changes in the freshwater, estuarine and near-shore marine environments experienced by juvenile salmon can translate into important differences in their maturation rates as measured by adult age-at-return.

10:20 am - 12:00 pm Tag Effects

Tagging size restrictions: evidence for effect on survival of fish less than 60 mm and effect on survival estimates

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Passive Integrated Transponder (PIT) tagging is a powerful research and management tool and is widely used by the Colombia River Basin's fisheries agencies and researchers to mark and track the movement of anadromous fish (Chinook and steelhead) of different life stages over time and space. The Integrated Status and Effectiveness Monitoring Program (Bonneville Power Administration Project 2003-017; ISEMP) is engaged in Research Monitoring and Evaluation projects that include PIT-tagging of ESA-listed spring Chinook and steelhead in the Upper Columbia, John Day and Salmon River basins nearly year-round at smolt traps and seasonally through remote mark-recapture efforts across the subbasins. Current protocols utilized since 2011 specify tagging of parr 50-60mm Fork Length (FL) using 9mm PIT tags, and >60mm FL using 12mm PIT tags. Suggested ESA Section 7 sampling guidelines instituted in 2014 limit the taggable size of parr to >60mm FL, with 12 mm PIT tags allowed in fish >70 mm FL due to concerns of elevated rates of direct mortality due to PIT tagging smaller fish. The provisional tagging guidelines raise two concerns; what is the evidence for survival rates being measurably lower for PIT tagged fish <60mm FL, and does the proposed change in tagging protocol impact survival estimates (stage specific, or freshwater productivity) generated by ongoing Columbia River basin projects. Based on ISEMP tagging data from the past 4 years, we show that size, in particular parr <60mm FL, is not the major predictor of survival rate. In addition, at certain times of the year, the suggested operating provisions could lead to a significant decrease in the number of sampled fish that can be PIT tagged, potentially creating a bias in juvenile survival estimates and other population metrics. Here we derive seasonal survival estimates through emigration for juvenile spring Chinook and steelhead, with comparative estimates for all juveniles >50mm FL, and with only juveniles >60mm FL, to determine what level of bias could be introduced to active monitoring programs through the application the new permit provisions.

10:20 am - 12:00 pm Tag Effects

Experiments in double tagging (coded wire tag plus PIT tag) juvenile Hanford Reach fall Chinook salmon

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Since 1987, Pacific Northwest fisheries agencies have cooperated annually on a Pacific Salmon Commission-funded program to coded wire tag (CWT) 200,000 wild Columbia River fall Chinook pre-smolts. This data is used to monitor exploitation rates and distribution in fisheries ranging from California to Alaska. Fish coded wire tagged range from 48 to 80 mm fork length, with the large majority less than 60 mm fork length. The project has struggled to meet its 200,000 goal only succeeding in 14 out of 28 years. In most years, the problem has been an inability to capture sufficient fish.

In most years since 199 there has also been a concurrent (and often unfunded) effort to PIT tag 3000 to 20000 fall Chinook. However, PIT tagging requires the larger fish and decreases coded wire tag output which further reduces already insufficient coded wire tag recoveries. A solution has been to double tag (CWT+PIT) juvenile fall Chinook which we have done for most fish tagged since 2008. In 2008, 2009, and 2014 we PIT-only tagged one group of Chinook to compare with double tagged (CWT+PIT) Chinook. In all three years, when controlling for any differences in length, there has been no significant difference in survival or migration time from release to McNary Dam. The smolt to adult (SAR) return rates to Bonneville Dam has also been similar. For 2008 PIT tagged juvenile, CWT+PIT tagged Chinook had a SAR of 0.79% compared to 0.69% for PIT tagged-only fish. In 2009, CWT+PIT tagged Chinook had a SAR of 0.29% compared to 0.30% for PIT-only tagged fish.

The results suggest that adding a coded wire tag to a PIT-tagged juvenile Hanford reach fall Chinook has little, if any, impact on its survival. There are too few PIT tags deployed to determine if adding a PIT tag to a coded-wire-tagged juvenile fall Chinook impacts survival.

10:20 am - 12:00 pm Tag Effects

Survival, growth, and tag retention in age-0 Chinook salmon implanted with 8.0 mm, 9.0 mm, and 12.0 mm PIT tags

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The effects of PIT tagging on survival, growth, and tag retention are three primary considerations during field studies especially when fish are small relative to tag size. The primary size of tags used in field studies since the late 1980s has been ≈12 mm, and the ability to represent an aggregate of rearing juveniles with those tags becomes difficult when the minimum tagging size is larger than the average size at which juveniles make initial downstream movements. Two smaller sizes of PIT tags known as 8.0-mm and 9.0-mm tag types are presently available for field application, but effects on small fish have not been tested in the lab. We conducted two complimentary lab studies on the effect of PIT tagging preselected size groups (Study I, 46–50 mm, 51–55 mm, and 56–60 mm; Study II, 40–49 mm, 50–59 mm, and 60–69 mm) of Age-0 Chinook Salmon with the 8.0-mm and 9.0-mm tag types. We added additional tests with the 12.0-mm tag type in the 50–59-mm and 60–69-mm size groups. Survival 28–30 d after tagging ranged from 99.4% to 100% across all tests providing no strong evidence for a size-related tagging effect or a tag-size effect. We did not observe any strong effects of tagging on growth in FL (mm/d) or WT (g/d). Tag retention across all tests ranged from 93% to 100%. Tag loss was associated with insertion point, fish processing rate, duration of the tagging event, and fish size. We acknowledge that actual implantation of the 8.0-mm or 9.0-mm tag types in small fish in the field will pose additional challenges and outcomes than were observed in our labs, but conclude that experimental use of the smaller tags in the field is supported by our findings.

Comparing detectability of 9 and 12mm PIT tags in the Middle Fork John Day River

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The Oregon Department of Fish and Wildlife uses Passive Integrated Transponder (PIT) tags to monitor migration and survival of summer steelhead (*Oncorhynchus mykiss*) in the John Day Basin. The importance of modeling the survival of early life stages must be balanced with the continuing need to reduce tagging effects on ESA listed species. Hence, we recognize the need to use smaller tag technologies as they become available. To compare detection efficiency between 12 mm and 9 mm tags we performed 21 paired releases of 694 summer steelhead above a Passive In-Stream Array (PIA) in the Middle Fork John Day River. Releases were distributed across a three month period during the 2014 spring runoff. Individuals tagged with 12 mm tags were four times more likely to be detected at the Middle Fork PIA then individuals with 9 mm tags. These data suggest that precision around estimates of population metrics such as apparent survival may be reduced by transition from 12 to 9 mm tags.

10:20 am - 12:00 pm Tag Effects

Effects of PIT tagging upstream migrating adult Columbia Basin sockeye salmon

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PIT tagging adult salmonids can provide important information on stock composition, migratory characteristics, and survival. However, the impact of tagging adults is of importance both to interpret study results as well as to regulatory agencies. One method with assessing impacts of adult tagging is to compare survival and passage times of those fish being tagged with fish tagged previously as juveniles. However, previously tagged fish are often predominantly hatchery origin and from specific areas (e.g. Snake Basin) and are rarely representative of the run at large.

Since 2010 we have conducted sockeye PIT tagging studies at Bonneville and Wells dams which allow comparisons of survival to our OKC PIT tag observation site on the Okanagan River downstream of the spawning grounds. These comparisons suggest a decreased survival at Wells Dam for PIT tagged fish ranging from 0% to 6.8%. Concurrent temperature and acoustic tagging programs showed greater adverse impacts on survival, although sample sizes were small. Tagging did not appear to have a significant impact on migration rates and timing. Other factors may affect results, such as differential mortality in the upstream fisheries as well as factors specific to Wells Dam sampling operations.

1:00 pm - 3:00 pm Detection Methods

Development and testing of a floating PIT tag antenna detection system

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Detection systems for PIT-tagged fish (Passive Integrated Transponder) in the Pacific Northwest are well established and work effectively with anadromous species, providing information on fish passage rates, movement patterns, survival, and return rates. In the Colorado River Basin most species do not have predictable movement patterns and must be detected by electrofishing, netting, or physical handling of fish captured in passage facilities. Some notable exceptions include stationary passive detection systems at the Price-Stubb fish passage facility on the Colorado River in Colorado, the San Rafael and White rivers, and the Stirrup Wetland in Utah. In the San Juan River (SJR) up to 12 electrofishing passes are made each year for nonnative fish removal; PIT-tagged Colorado pikeminnow (*Ptychocheilus lucius)* and razorback sucker (*Xyrauchen texanus*), both endangered species, are also captured during these trips to provide information on movements, growth, survival and population size. Nonnative removal provides the best and largest amount of information on the status of the two endangered fish in the SJR, but is expensive, time consuming, and has an uncertain future. To begin investigating alternative strategies for detecting these fish we developed a mobile floating PIT tag detection system that detects PIT tags as it floats over them. The system consists of three 10-foot antennas connected to a multiplexer, integrated GPS, and data logger. As the antennas float over a tag the system records date, time, location, and unique PIT tag number. During two days of testing on the San Juan River in October 2009 we detected 75 tags in 21 miles of river, including almost 25 tags in ~ 500m of Chaco Wash. A concurrent electrofishing trip sampling the same stretch of river captured about the same number of fish/boat. During June of 2014 we refined the electronics of the system to increase read range and conducted a 5-day test on 85 miles of the San Juan River. This test detected over 550 tags, and also helped to identify a Colorado pikeminnow spawning area. The system is limited to detection distances that are less than three feet, but the system could be useful in shallow streams, weirs, or in broad shallow areas of larger rivers, such as the lower San Juan River. Another application would be to use the system in a stationary configuration that allows the antennas to fluctuate with water levels and debris (e.g., logs). Some important drawbacks of this system are that it detects tags and not fish, and biological information such as length, weight, and health are not measurable. Future work includes developing methods to incorporate detections into mark-recapture models to improve population estimates of these fish.

1:00 pm - 3:00 pm Detection Methods

A 2.4- by 6.1-m flexible antenna for detecting full-duplex passive integrated transponder tagged fish

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We developed a 2.4- by 6.1-m flexible antenna capable of detecting 12-mm full-duplex PIT-tags. The flexible design was developed to support ongoing studies in the Columbia River estuary that rely on detections of migrating adult and juvenile salmonids. The antenna wires were housed in a 1.9-cm-diameter water suction hose and the reader was housed in a water-tight PVC capsule. When deployed, the rectangular shape of the antenna was maintained by light-weight rope frames, PVC spreader bars, and strategically placed weights. These antennas were used in both a stationary setting, where they were mounted to a pile dike, and in a mobile setting, where they were towed behind two vessels. Mobile deployment utilized multiple antennas assembled in a horizontal matrix to maximize the detection area. Typical read-range of the flexible antennas from the center plane was 0.75 m in a pass-through orientation and 0.5 m in a pass-by orientation. These antennas were versatile in application given their large size and ease of handling and had relatively low construction costs compared to traditional PVC antennas.

Use of submersible PIT antennas to augment endangered fish active-capture surveys

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Precision of mark/recapture surveys of endangered fish populations in the Upper Colorado River Basin is often hindered by lack of recapture observations, often making it difficult to discern trends in fish abundance over time. We investigated whether this situation could be remedied by obtaining auxiliary recapture data from submersible PIT antennas for inclusion in development of population estimates. During a mark/recapture survey for endangered Humpback Chub, *Gila cypha* in the Desolation/Gray canyons area of the Green River (Utah) in September 2014, we deployed submersible PIT antennas in association with conventional fish sampling gear (trammel nets, baited hoop nets) in each sampled river reach (i.e., usually large eddy complexes ca. 1 river kilometer in length). A total of 30 antenna deployments were conducted during six, 15-h overnight sampling events. Of the 30 deployments, at least one PIT-tagged fish was detected on 26 of them. The majority of these fish were not captured in conventional sampling gear, and antennas sometimes detected fish in very close proximity (ca. 1-2 m) to the gear without actually being captured in it. More detailed results are forthcoming and will be presented at this meeting.

1:00 pm - 3:00 pm Detection Methods

Evaluation of a prototype spillway transceiver

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In 2006, BPA contracted Digital Angel (aka Destron Fearing) and PSMFC to install a PIT-tag system that Digital Angel designed into the corner collector. The corner-collector PIT-tag system is unique in many ways: 1) it has the largest antenna, 2) it has only one antenna instead of multiple antennas, and 3) it has a specialized BCC transceiver designed specifically for this application. NOAA Fisheries has utilized this system to conduct fish tests in 2007, 2009, and 2011 to evaluate new PIT tag models and other changes to the site. During the 2011 tag evaluation, we also evaluated a prototype ogee transceiver that could detect standard ISO FDX-B tags that are detected in 31 msec as well as faster non-ISO tags that are detected in 16 msec. During this initial evaluation, the prototype ogee transceiver provided roughly a 2% gain over the regular SST-1 tags compared to the BCC transceiver. More interestingly, the 16 msec tags yielded a 9% gain, which would be significant. The faster 16-msec tags were developed to help with detection of PIT tags transiting spillways where water velocities range from 60-75 fps.

A similar fish test was conducted in April 2014 after additional modifications were made to the ogee or FS3001 transceiver being developed by Biomark, NOAA Fisheries, and PSMFC. We tagged 4,000 juvenile spring Chinook salmon from Spring Creek National Fish Hatchery with 32-msec SST-1 12-mm tags, 32-msec PT300 9-mm tags, and 16-msec versions of both. The fish were released individually in front of the entrance to the corner collector through a 4" hose. This same apparatus was used in the previous evaluations of the corner-collector detection system. By releasing PIT-tagged fish within the capture velocity area in front of the entrance, we know precisely how many tagged fish have passed through the corner-collector system during the testing.

Over the years, the original BCC transceiver consistently yielded detection rates in the 75-80% range for 32-msec SST-1 12-mm tags. It detected 54% of the 32-msec PT300 9-mm tags in 2011. When the improved ogee transceiver was evaluated in 2014, the detection rates increased. Detection of the 32-msec SST-1 12-mm tags improved to 85.1% and 68.8% for the 32-msec PT300 9-mm tags. The 16msec tags yielded even higher detection rates. The 16-msec SST-1 tags were detected at a 93.3% rate and the 16-msec PT300 tags increased to 76.0%

The 2014 fish test results were very encouraging as has been the consistent performance so far of the FS3001 transceiver installed at BCC. The high detection of the 16-msec PIT tags could translate into the fisheries community achieving more data from the fish that are tagged or might even mean the number of fish tagged could be reduced. The 16-msec tags definitely outperform the 31-msec tags in locations where electromagnetic noise levels reduce tag detections and we also assume in any spillway installation with high water velocities.

1:00 pm - 3:00 pm Detection Methods

Vertical antenna arrays: A prototype system for full water column detection

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Detection of PIT tagged out-migrating juvenile salmonids in large natural rivers is problematic because the antenna systems currently available are typically incapable of interrogating the upper portions of the water column where fish may travel. Low juvenile detection rates hamper studies of many kinds including those designed to understand population-level effects of flow management and habitat restoration. An antenna system that could detect fish through the full water column would be invaluable in addressing the ever more sophisticated questions posed by researchers employing RFID technology. We have developed an antenna system dubbed the FIN (Fish Interrogation Nodes) capable of detecting fish through the whole water column at variable river flows and stages. These arrays are composed of individual vertical antenna housings anchored to either the channel bed or an above-water support system through an articulated shackle that allows for deflection and passage of debris and ice. We power one to many FIN antenna coils through individual transceivers and can link up to 6 FIN antennas together with a novel cabling approach and alternation of coil winding direction for each adjacent FIN. This system produces detection fields that are strongly coupled between individual FINs that then function as a single antenna for purposes of multiplexing and synchronization. A partial array was recently installed on the Yakima River in the vicinity of Selah and is currently undergoing mechanical and electrical testing. Results to date indicate good debris shedding capability and tolerance for high flows. Noise issues initially encountered appear solvable with minor alterations to the anchoring and cabling approaches used in the prototype.

Expanding from creeks to hydroelectric diversion facilities – construction and in situ evaluation of large half-duplex PIT tag antennas to evaluate fish entrainment at high velocity water diversions

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The implementation of Passive Integrated Transponder (PIT) technology for monitoring fish has historically required small detection areas in either creeks or constricted openings. Advancements in PIT technology have evolved to allow for much broader applications and larger monitoring areas. Custom fabricated large-scale PIT tag readers were used to estimate entrainment in two diversion tunnels (up to 3.8 m x 4.4 m) that experienced discharge as high as 31.1 cubic meters per second and operated in water depths of up to 6.4 m. The PIT arrays, consisting of three separate antennas stacked one on top of the other, were hand-molded from fiberglass into a hydrodynamic 'wing' shape. This design enabled the antennas to withstand high flows, while simultaneously detecting fish over the entire monitoring area of the diversion tunnels. This also allowed for the diversions to operate at full capacity and not be constrained to a modified smaller detection area. The antenna arrays and tag detection systems achieved optimal performance throughout the duration of the study. The antennas operated continuously for over a year, and monitored upwards of 99.0 percent of all diverted flows through the tunnels due to minimal required maintenance. A total of 220 unique detection events representing 58 fish were observed at the two diversion tunnels and equated to performance efficiency greater than 90 percent. The continuous operation and high detection efficiency achieved by the relatively large-scale PIT arrays confirms the success of this innovative deployment of PIT tag technology that was previously limited to small creeks and monitoring areas.

3:20 pm - 4:00 pm Detection Methods (cont)

PIT tag reader synchronization, multiplexing and data logging innovations

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Several new PIT Tag Reader accessory products recently introduced by Biomark provide opportunities for new and innovative reader configurations in animal research.

•A synchronization and multiplexing device coordinates the operation of up to 12 readers so that multiple reader/antennas can construct a single reading zone, or so that multiple reader/antennas comprising individual reading zones can operate sequentially.

•An antenna multiplexer device connects up to 12 antennas to a single reader to create an economical solution for small antenna systems within close proximity.

•A compact data-logger device captures PIT tag numbers and appends record numbers and time/date stamps on a removable media micro-SD card.

These multiplexer devices work to conserve power in battery operated installations and permit data collection on a single channel data logger. The data logger provides a compact and low-power solution especially advantageous in remote unattended installations. Examples of how these new devices have been effectively deployed in animal research will be presented.

3:20 pm - 4:00 pm Detection Methods (cont)

Biomark's IS1001-MTS reader platform - into the river

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Since the introduction of PIT-tag technology into the Columbia River Basin in the mid-1980s, the demand for detection of PIT-tags beyond adult fish ladders and juvenile fish bypasses has increased dramatically. The Destron Fearing FS1001M multiplexing transceiver was released around 2007 and enabled researchers to begin monitoring small streams and rivers. The FS1001M controlled up to six antennas, but was limited to antenna cable lengths of approximately 180 ft, before degradation in performance was unacceptable. Biomark completed the IS1001-MTS (MTS) platform in 2013 as a replacement for the FS1001M. The MTS consists of an IS1001-Master Controller (MC) and IS1001 readers. The MC provides communication and power for up to twelve IS1001 readers. The big shift in paradigm, between the FS1001M and the MTS, is that the decoding of the tag telegram was decentralized; occurs at the antenna level within the IS1001. This 1:1 approach, allows for increased performance with respect to detection range, antenna size, auto-tuning, and general ease of operation. Decoding of ISO compliant HDX tags and Biomark Half-Telegram tags has been incorporated into the reader platform as well. Another advantage of the MTS platform is its scalability. Large systems, like the Deschutes River (DRM) array, required the use of a MC, twelve IS1001s, and approximately 1,000 ft of cable. However, the IS1001 is a fully functional reader on its own and can be synchronized with another IS1001 to provide a cost effective means for monitoring small stream habitat without the need for a MC. The standard IS1001 operates on 24V DC input power, but can be configured for 12V DC input power for use with batteries and small scale solar power systems; where the power budget is a concern. Since the introduction of the MTS platform, Biomark has constructed antennas ranging in size from a small 5 in. puck antenna used to detect tags on the Columbia River estuary bird colonies, rectangular frame saltwater antennas, 50 ft cord antennas, and our standard 20x4 ft in-river antenna. NOAA Fisheries-Hammond used the IS1001 to successfully construct and deploy antennas as large as 10x20 ft as part of their pile dyke monitoring effort. Biomark is currently investigating the use of a “star topology” for connecting the IS1001s to the MC. In the star topology, an individual cable connects each IS1001 to a common hub and then to the MC, as opposed to connecting the IS1001s in a serial or network arrangement that is currently used. The Biomark IS1001-MTS platform has proven to be an effective tool for detecting PIT-tagged fish in a variety of habitats using a wide variety of antenna configurations, providing fisheries researchers and fisheries managers with key data to make management decisions.

4:00 pm - 5:00 pm Open Forum on Tributary Detection Infrastructure

Longterm planning for design, implementation and maintenance of instream detection systems across the Columbia Basin

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8:00 am - 9:40 am Other PIT Tag Applications

Use of PIT tag antennas to test a weir designed to reduce entrainment of endangered fish in canals

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The diversion of river water for irrigation or power-generating purposes is well known to have deleterious effects on fish populations and includes entrainment into canals or impingement on intake screens. Both Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*) are known to undertake extended spawning migrations, increasing their risk of becoming entrained in irrigation canals, such the one at the Hogback Diversion Canal on the San Juan River near Shiprock, NM. The Hogback Diversion Canal diverts approximately 250 cfs from May through October; this diversion can take > 50% of the river's flow. The In 2007 a Value Engineering (VE) team was commissioned to develop and evaluate various proposals to modify Hogback Diversion Canal to continue to deliver water, yet eliminate or reduce the entrainment of fish in the canal. Members of the VE Team included fish biologists, construction engineers, cost engineers, design engineers, and irrigation specialists. The team finally concluded that the most cost effective and efficient means of reducing fish entrainment in the canal was to construct a 550 foot weir, approximately 8 feet tall, in the canal at an oblique angle, with the goal of passing a few inches of water over the top of the weir that would be diverted into the canal, and maintaining a flow in the canal along the upstream side of the weir that would eventually transport fish and debris along the upstream side of the weir into a return channel back to the San Juan River. The biologists that served on the VE team believed that the fish in the San Juan River would most likely stay near the bottom as they were entrained in any canal and, as they moved downstream in the Hogback Canal, they would encounter the weir wall and move downstream with the flow until they finally exited the canal into a return channel back to the river. The decision was made to construct a weir wall, with the required facilities and water-regulation devices, for approximately $3.5 million in 2013. No fish-exclusion device of this type has ever been constructed or tested that we are aware of, but if it is effective it could be a useful design at many other locations. In March of 2014 five PIT tag antennas were installed in the facility to determine the effectiveness of the weir wall. The locations of the antennas were selected to give information on movements of fish through the facility and the fates of those fish (i.e., entrainment or safe passage). An immediate, but unexpected, finding of this study was the movement of fish upstream into the facility before it was operational. In November 2014 a test will be conducted of the effectiveness of the weir using stocked PIT-tagged fish. We will report on the results of that test and discuss uses of the data in other studies (M-R models, movement studies, and survival analyses).

8:00 am - 9:40 am Other PIT Tag Applications

The use of PIT tags in small streams and non-migratory fish

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The wide adoption of passive integrated transponder (PIT) tags in the Columbia River Basin has greatly improved our understanding of fish movements and population demographics. However, PIT tags are less commonly used in smaller streams and in non-migratory populations. The use of PIT tags in capture-recapture studies offers a promising means to answer questions about population dynamics and habitat conditions in these smaller systems, and the advantages of low cost, reliability, and manageable application make them a viable option for this research. We offer two examples of our work in applying PIT tag technology in relatively small river systems to 1) assess seasonal movement patterns in stream-rearing Coho salmon, and 2) in analyzing culvert passage. Estimating detection efficiencies when fish are not migrating presents a challenge and we provide recommendations for study designs from that address this challenge and effectively assess movement and population dynamics.

Monitoring fluvial bull trout migration and movements in the Lemhi River Subbasin, Idaho: integrating PIT tag technology with radio telemetry

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Bull trout (*Salvelinus confluentus*) populations within the Lemhi River subbasin, Idaho display distinct resident and fluvial life history strategies. However, the distribution and abundance of the migratory form is not well understood. In 2006, the Idaho Fish and Game implemented a study to further document use of Lemhi River tributaries by the fluvial form. This was completed in part to establish baseline information to determine bull trout response to ongoing habitat restoration actions in tributaries. The study determined that of the 32 bull trout implanted with radio transmitters in the main-stem Lemhi River, all fish migrated exclusively into Hayden Creek, the largest functionally connected tributary in the Lemhi River subbasin. Beginning in 2007, a rigorous study was implemented using Passive Integrated Transponder (PIT) arrays to monitor the effectiveness of ongoing habitat restorative actions throughout the Lemhi basin. We utilized this infrastructure to expand on the existing knowledge of fluvial bull trout migration strategies. PIT tagging of juvenile and adult bull trout was increased substantially to increase immigration and emigration detection rates in tributaries. Initially, our focus was to PIT tag juvenile (<300mm) bull trout, but because of low annual detection rates, we began tagging larger adult bull trout (>300mm) that would likely exhibit the fluvial life history. Detection rates of adults have increased and the results indicate these fish exhibit similar fluvial migration patterns into Hayden Creek that were found during the radio telemetry study. Furthermore, there have been detections of bull trout migrating into newly re-connected tributaries, indicating fish pioneering and straying into habitat that was previously disconnected. With the implementation of PIT tag technology within the Lemhi River subbasin, our knowledge collected on bull trout has increased significantly.

8:00 am - 9:40 am Other PIT Tag Applications

Sturgeon site fidelity near a pile dike in the Columbia River Estuary

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We installed an autonomous PIT-tag detection system along a pile dike in the tidal freshwater reach of the Columbia River estuary (PTAGIS site code PD7). Between fall 2011 and fall 2014, the system has detected a total of 71 white sturgeon *Acipenser transmontanus*. Of the 1,617 total fish detected at PD7, only 1% had a period of more than 1 day between first and last detection, and most of these had periods less than 30 d. While the majority of sturgeon had short durations of residency at the pile dike site, five individuals were detected over multiple years and two appeared to reside at the site through late October, when the site was shut down for the winter. Most sturgeon were first detected in May-July (PD7 activated each March), and transient individuals were generally detected for only a few minutes. However, two sturgeon appeared in May-July and persisted, nearly daily, on multiple PD7 antennas across multiple years. We will present information on site fidelity and behavior shown by sturgeon and other species at the pile dike detection site.

8:00 am - 9:40 am Other PIT Tag Applications

Evaluation of prototype fish passage structures in the Lower Granite Dam juvenile fish bypass system – juvenile Pacific lamprey results 2013-2014

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During spring of 2013 and 2014, studies were conducted to evaluate travel time of PIT tagged fishes, including juvenile Pacific lamprey, through the juvenile fish bypass system at Lower Granite Dam on the Snake River. Lampreys were released into gatewells to evaluate egress through experimental structures or released directly into the bypass collection channel (2013 n=1,213 and 2014 n=753). Study objectives addressed in this abstract are 1) Determine how prototype passage structures affect orifice passage efficiency and travel time for juvenile lampreys, 2) evaluate PIT tag retention of two tags (8.5 and 9 mm) using two different tagging techniques: surgical methods described by Mesa et al. (2011) and injecting PIT tags with a 16-gauge needle, and 3) Evaluate behavior within the Lower Granite Dam juvenile fish collection channel and bypass system based on PIT-tag detection.

In 2013 travel time was measured from release to first detection at the separator at the juvenile fish facility. In 2014 two temporary PIT detection antennas were installed in the bypass collection channel immediately upstream and downstream of the test gatewell providing additional detection points between release and the separator. In 2013 median travel times of PIT tagged juvenile lampreys was approximately 0.25 h (±0.1 h) for all release locations. In 2014, the median travel time to the separator was more variable, ranging from 0.3 h for lampreys released directly into the bypass channel to 1.5 h for lampreys released into the gatewell during operation of the sharp-crested overflow weir (preliminary data). Only 12% of PIT tagged lampreys were detected on the temporary PIT detection antennas in the bypass channel while 92% were detected at the separator. Travel time and detection efficiency of PIT tagged lampreys will be compared to PIT tagged juvenile salmonids during the same study periods.

Small scale (n=200) tag retention experiments comparing two tagging methods were conducted both years. The methods compared were 1) Mesa et al. (2011) using a scalpel to create a small incision and then manually inserting 9 mm L × 2.1 mm Dia tags and 2) injecting 8.5 mm L x 1.4 mm Dia tags using a 16-gauge hypodermic needle. All fish were held for 96 h then examined for tag sheds. In 2013 two fish tagged with the scalpel shed tags. In 2014, one fish tagged by injection shed a tag.

Technical details of the installation of temporary PIT antennas will be presented along with discussion of challenges of the detection environment and suggestions for improvements in future studies.

9:40 am - 10:40 am Data Management and Coordination

From needles to numbers: electronic data collection and data exchange of steelhead smolt counts, biological data, and passive integrated transponder tag codes

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To better monitor wild salmonid populations biologists have increased Passive Integrated Transponder (PIT) tagging and interrogation of wild juvenile salmonids in Columbia River tributaries during the last decade. Often, this PIT tag information and the accompanying biological/geospatial data is recorded on paper datasheets – a process that is time consuming and can be prone to human transcription error. In the last few years, the emergence of mobile computing devices, especially tablet computers, have presented a unique opportunity; to develop and revolutionize digital data collection in the field so that PIT tag data and the accompanying biological and geospatial data can be simultaneously collected. To evaluate electronic data collection, a custom Graphical User Interface (GUI) application was developed for use on the Panasonic FZ-G1 Tablet computer. Through this GUI, discrete data points representing PIT tagged salmonids along with biological data can be collected directly into Washington Department of Fish and Wildlife's (WDFW) regional juvenile outmigrant (R5JMX) database and exchange. Our study for combining PIT tag interrogation and electronic data collection had four objectives : 1) to determine if digital data capture could be a viable alternative to historical pen-and-paper methods of data collection in terms of efficiency and accuracy, 2) to create a tool for PIT tag interrogations that allows simultaneous collection of biological and PIT data into a digital relational database, 3) to significantly streamline the data upload process from R5JMX to PTAGIS 4) to provide real time estimates of trap efficiency and smolt abundance to determine if adjustments in the trap location are needed during the season, and 5) to produce important tools and datasets that could be made available to managers, researchers and the many constituents that share the fisheries resources of the Columbia River Basin. In this presentation we will share the results of our pilot electronic data capture study for the 2014 steelhead smolt outmigration at two lower Columbia River tributaries.

9:40 am - 10:40 am Data Management and Coordination

A model for improved data access through an integrated data management system

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Anadromous fish passage performance analysis in the Columbia River Basin typically involves data from multiple sources, creating a cumbersome task for analysts. Data sets may include PIT Tag release and recapture records, water quality, climatology, hydroelectric plant operations, and near-field hydraulics. Information from other sources may include important covariates to post-release performance as well, such as number and size at release, brood origin, and rearing densities in hatchery-reared salmonids and sturgeon. We demonstrate how a multi-disciplinary approach to data management combining expertise in fisheries and data engineering can be used to integrate multiple data sets with the PIT Tag Information System (PTAGIS). This method of managing multiple data sets in a single system enhances quality control and improves efficiency of fish performance analyses.

9:40 am - 10:40 am Data Management and Coordination

The PIT Tag Forecaster; a new database system to aid investigators and managers

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Both the 2008 FCRPS BiOp and the 2013 NPCC Tagging Forum noted the need to improve coordination and efficiency among PIT tag users in the Columbia Basin. The NPCC called for the establishment of an annual coordination forum to review short-term and long-term study plans that rely on PIT tags. The intent is to 1) evaluate opportunities to improve the efficiency of tag use to minimize cost and contain the numbers of fish being handled and tagged, and 2) provide input to forecasting the tag purchases basin-wide.

The PIT Tag Forecaster (PTF) database system was developed to support PIT tag coordination efforts. The tool will allow managers and investigators the ability to accomplish multiple objectives toward ensuring the efficient use of PIT-tagged anadromous fish throughout the Columbia Basin:

•Provide a platform for various investigators and managers to view the collective planned tagging activities throughout the system in an effort to assess opportunities for sharing of tagged fish, and assist with coordinating tag use within and across watersheds.

•Maintain adequate stock coverage to satisfy specific monitoring needs (BiOp & FWP) into the future.

•Minimize over-tagging sensitive ESA-listed populations, and inform NOAA take-permits.

The initial database system was constructed in 2009 and resided at UW Columbia Basin Research. The new 2014 interactive, web-based version of the PTF was designed and developed by PSMFC and has been integrated with PTAGIS. PIT tag users populate the database in three-year time steps, yielding a 3-yr forecast. Key input parameters are geographic release location, numbers of tagged fish, life stage, and species/ESU/population information. The system is now functional and ready for broad use.

Managers and investigators have access to the query and reporting features associated with the database. The system has two query modes; 1) a generic query mode using a common set of filtering parameters and produces fixed graphic output, and 2) a more detailed mode that can accommodate other more specific and complex queries. The PTF includes an online tutorial to guide users through the data entry process. This presentation highlights some of the input and output features of the database.

11:00 am - 12:00 pm P4 Preview and Feedback

Next generation tagging software and data model preview

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P4 is the new tagging software under development by PTAGIS. It is the final component of a multi-year upgrade of the PTAGIS infrastructure and will provide a much needed replacement for the popular but aging P3 tagging software. P4 is vital to the evolution of the MRR (Mark, Recapture, and Recovery) data model that has been relatively static during the 26 year history of the program.

This presentation will highlight the requested changes to the MRR data model under consideration by the PIT Tag Steering Committee and will walkthrough fundamental features of the new software. This is an excellent opportunity to preview what is coming in the next year and provide valuable feedback to ensure the new system is aligned with the needs of the community.

1:00 pm - 3:00 pm PTAGIS Reporting Training

PTAGIS Reporting Training

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The first hour will be a detailed walkthrough of the PTAGIS reporting system covering the querying, manipulating, saving, and exporting of PIT tag data. Next we will cover advanced tips and tricks including metrics and using saved reports as filters. The final half-hour will be an open session where participants with laptops will be able to connect to a local copy of the reporting system. This will be an ideal time to try some of the reporting features that were demonstrated and/or ask questions about specific queries or saved reports.

Assessing spatial and temporal distribution of spawning adult summer steelhead using PIT interrogation data

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Throughout the Snake River basin, spatial and temporal distribution of spawning summer steelhead has historically been observed by conducting spawning ground surveys. However, this can be problematic due to environmental conditions encountered throughout the spawning season. Beginning in 2010, all natural origin adult summer steelhead captured at the Asotin Creek weir have been sampled and passed upstream with a PIT tag, either new or previously existing. PIT arrays are located above and below the weir, as well as at the mouths of all the tributaries, essentially creating a closed system. Due to the complex nature of the interrogation histories, analysis of the temporal and spatial distribution of spawning adults in Asotin Creek was performed using a MS Access database to compare unique PIT Tags from the weir with interrogation data from the arrays throughout the basin. Each individual PIT tag is assigned to a tributary with MS Access queries that utilize conditional statements to validate a series of assumptions relating to distribution upstream of the weir. Fish detected at multiple tributary arrays are also compared using detection timing and residence times. By defining conditional arguments that are tributary specific, fish which meet these requirements are assigned as escaped (presumed spawners) to that tributary. Analysis of the PIT tag interrogation data from 2010 through the present has shown a relationship with both the historical trend data and recent spawning ground survey data. There is also a relationship between the overall area of the tributary to the distribution of spawning fish. This suggests that in some systems, or in systems which are affected by environmental conditions, PIT tag interrogation data could be used to supplement or replace spawning ground survey data.

Cascades Island Lamprey Passage Structure: evaluating passage and migration following structure modifications

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Pacific lamprey (*Entosphenus tridentatus*), an endemic species to the Columbia River Basin, U.S.A, has experienced staggering decreases in returns to spawning territories in recent decades. As lamprey are threatened severely by a lack of passage at mainstem dams, lamprey specific passage structures have been designed and constructed to address the problem. The Cascades Island Lamprey Passage Structure (LPS) at Bonneville Dam is the longest and steepest structure of its type. The addition of an exit pipe which allows lampreys to travel from the tailrace of the dam to the forebay further elongated the structure and possessed a design which has not been used for other structures of this type.
The intent of this study was to assess lamprey use of the structure and whether the structure hinders lamprey migration to subsequent dams. The study was carried out during the 2013 migration season. The study used three different treatment groups of lampreys released on five dates spanning the migration season (n=75 lamprey). Two of these groups (n=50), with different tagging methods, one group PIT and radio tagged, the other PIT tagged only, were released directly into the LPS to assess passage success, travel time, and tagging effect. The third group, PIT and radio tagged, (n=25) was released into the forebay to test whether the structure impedes migration upstream. Fish were monitored via receiver arrays on the LPS and at dams on the river system.
Overall passage efficiency was 74% (37 of 50 used the CI LPS successfully). Mean travel time to navigate the structure was 12 h. Fish size had no significant effect on travel time in the LPS. Water temperature had a significant effect on travel time in the LPS. There was no statistically significant effect of tagging on passage efficiency or travel time. The groups that used the LPS performed slightly better migrating upstream to the next dam than the group that bypassed the structure, but the difference was not significant. The groups that used the LPS traveled to more subsequent dams upstream than did the group that bypassed the LPS. The double tagged group performed better in the LPS and through the Bonneville reservoir, but the PIT tagged only performed better upstream from The Dalles Dam and in the upper Columbia River.
It can be concluded that lamprey passed the structure successfully. Temperature (proxy for seasonality) had an effect on travel time in the LPS; however fish size and tagging had no effect. The LPS does not affect the ability of migrating lampreys to continue migration to subsequent dams. Tagging may have an effect on the ability of fish to travel further distances but further research assessing different tagging methods is needed. Such findings have important implications for management of lamprey in the region.

Evaluating adult bull trout passage at Clear Creek Dam, Yakima County, WA

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Clear Creek Dam was built by the Bureau of Reclamation in the early part of the 20th Century in Yakima County, WA. The dam has a unique spillway channel that acts as a partial, but not complete, barrier to adult bull trout (*Salvelinus confluentus*) passage, depending upon hydrologic conditions. We are using half-duplex PIT tags and a number of PIT tag antenna arrays to achieve the three primary objectives of the study: 1) to determine when North Fork Tieton River bull trout attempt to migrate upstream past Clear Creek Dam; 2) to assess their success at doing so under various hydrologic conditions; and 3) determining post-spawn migration timing and the extent to which the population uses Clear Lake. Adult bull trout were trapped, tagged, and released from a weir on the North Fork Tieton River from 2012-2014. Antenna arrays were constructed at key locations in the watershed to track fish movements throughout the study period, which will last through 2016. Ancillary project objectives include determining spawning frequency, collecting genetic samples, and estimating the effective population size.

Experiments in the use of video to monitor outmigrating Columbia River juvenile salmonids at Bonneville and McNary Dams

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In 2011, video was recorded of fish passing a viewing window at the Bonneville Dam juvenile bypass and subsequently reviewed. We estimated that only 8.6% of the smolts could be identified by species due to high turbidity, algae growth, the rapid speed of the fish, and the width of the area being monitored.

We also used video and PIT tag technology at the McNary Dam juvenile bypass to capture PIT tag code-imprinted video images of selected juvenile fall Chinook tagged upstream as they passed through a clear 10 cm diameter pipe. We detected 81 of the 86 PIT tagged fish which passed. Of the detected fish that could be positively identified, for 61.5% the presence/absence of an adipose fin could be determined and 47.8% were oriented parallel to the flow. Fish traveled through our system at up to 4.5 m/s resulting in only one or two images per fish being captured. The majority of the fish observed (56.4%) appeared to be making contact with the inside of the pipe as they passed.

Performance of Biomark's IS1001 transceiver by antenna wire type and tag duplex type

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Biomark's new IS1001 multiplexing PIT tag transceiver system offers a number of potential advantages over earlier-generation systems. They can read both half-duplex (HDX) and full-duplex (HDX) PIT tags and potentially support the deployment of larger flexible antennas with smaller air gaps. However, the IS1001 has not yet been widely deployed so practical information about optimal antenna design and performance is scarce. To reduce the amount of trial-and-error testing by field biologists and provide some practical rules of thumb for antenna design, we conducted a series of test to examine the performance of the IS1001 antenna control node (ACN) based on variation in wire type, tag type, and tag size. First we investigated how to properly tune an antenna by generating a series of resonance curves for small (6 in x 6 in) antenna. Next, we used a large (8 ft x 10 ft) three-turn standardized antenna to determine the pass-over and pass-through tag detection distances for antennas constructed of five different types of wire. We tested a range of PIT tag sizes (9-23 mm) for both FDX and HDX tag systems. Initial resonance testing with the small antenna indicated that the larger the antenna's inductance, the less variation in the series antenna capacitance the system can tolerate. Our testing was not exhaustive, but for the types of wires investigated the "best" wire depended on whether the IS1001-ACN was reading FDX or HDX tags. In this trial 8-gauge THHN wire outperformed all other types of wire tested for FDX tags. Remarkably, this wire read 9mm FDX tags to the center of the 8 ft x 10 ft test antenna in pass-through mode, whereas all the other wire types had "holes" (areas of non-detection) ranging from 26-64. For HDX tags, 10 gauge Litz wire outperformed all other types of wire tested. For example, it read a 12 mm HDX tag at 13 inches in pass-through mode, whereas the other wire types had holes ranging from 17-52 in. Theoretically, there should be a single optimal wire type for both systems based on their operating frequency; we hope to identify this wire through additional testing.

Steelhead (*Oncorhynchus mykiss)* use of the Toppenish National Wildlife Refuge Wetland Complex, 2013-2014

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RD Nelle

Toppenish National Wildlife Refuge (TNWR) is a large wetland complex located on Toppenish Creek in Yakima County, WA that is primarily managed for migratory birds. Juvenile steelhead (*Oncorhynchus mykiss*) inhabit Toppenish Creek and can enter into the refuge wetlands through a series of canals or through flood events. To provide the TNWR with information to manage juvenile steelhead on the refuge, the Mid-Columbia River Fishery Resource Office is tracking juvenile steelhead that were PIT tagged and released upstream of the refuge by the Yakama Nation Fisheries. A series of fixed Allflex PIT tag antennas were placed in key locations throughout the refuge to monitor steelhead movement in the wetlands. Other arrays located on Toppenish Creek as well as in the Yakima and Columbia River hydrosystems provide additional individual fish detections. The objectives of this study are to determine the use of juvenile steelhead within the refuge wetland complex, evaluate the percent smolt survival within the wetland complex, and to document the use of TNWR wetlands by adult steelhead. During the spring of 2014, we detected 22 PIT tagged juvenile steelhead at refuge arrays. Three of these PIT tagged steelhead were later detected at downstream hydrosystem arrays along the Yakima River. The fate of the remaining 19 juvenile steelhead is unknown. No adult steelhead were detected on refuge arrays. Understanding the movement and fate of steelhead through the TNWR will improve future management decisions on the TNWR and assist in the recovery of steelhead in Toppenish Creek.

Telemetry applications in the Okanagan, British Columbia, Canada

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The Okanagan Nation Alliance (ONA) in collaboration with the Canadian Department of Fisheries and Oceans (DFO),the Columbia River Inter-Tribal Fish Commission (CRITFC), and the Colville Confederated Tribes (CCT) over the past 5 years have been studying limiting factors affecting the abundance of Okanagan River sockeye. To date we have utilized a combination of hydroacoustics, PIT tags and various acoustic tag technologies to track adult sockeye migrating from Wells dam to holding areas and to the spawning grounds. We have also used this information to inform harvest in-season management to estimate total abundance and exploitation. Other projects include; juvenile PIT tagging to determine travel and survival studies for Okanagan Sockeye smolts with results to date from 2013 and 2014. Additionally we are planning to duplicate tag (PIT & acoustic) adult sockeye for tracking and out planting into Okanagan Lake to determine spawning and rearing habitat suitability and selection. The potential for telemetry applications within the Okanagan Basin are numerous. Presented here are but a few examples of the multi-agency, trans-boundary collaborative efforts currently taking place within the Okanagan/Okanogan basin.