Fishway Passage Bottlenecks And Prioritization Planning: A Pacific Lamprey Case Study

Matthew Keefer, Christopher Caudill, University of Idaho, Mary Moser, NOAA Fisheries

Fishways designed for salmonids often restrict passage by non-salmonids and effective tools are needed both to identify passage problems for non-salmonid species and to inform remediation planning. In a Pacific lamprey (Entosphenus tridentatus) case study, we developed a series of fishway passage bottleneck metrics and models of potential benefits of fishway improvements at Bonneville Dam on the Columbia River. Bonneville Dam is a large, multi-fishway hydroelectric project that has features similar to many salmonid-style fishways in the Pacific Northwest. Overall, 49% of tagged lamprey that entered Bonneville fishways failed to pass the dam, a much lower rate of success than has been recorded for adult Pacific salmonids. Models accounting for repeated attempts by individual Pacific lamprey indicated successful passage strongly depended on attempted passage route. Time of fishway entry, water temperature, and lamprey body size were also influential. Most failed passage attempts terminated in lower fishway segments and occurred during relatively cool, high-discharge conditions. Multinomial models showed extensive seasonal shifts in bottleneck locations associated with fluctuating environmental conditions. Our integration of spatially-intensive monitoring with quantitative analytical techniques was critical to understanding the complex relationships between fishway features, environmental variation and Pacific lamprey migration behavior. The subsequent benefits models identified several priority sites where structural or operational modifications could provide the highest relative improvements in lamprey passage. Managers are currently weighing the costs of specific improvements versus potential escapement benefits. The broader research framework and analytical tools we used can be applied to a wide range of fish passage assessments.

Matthew Keefer has studied anadromous fish migration in the Columbia, Snake, and Willamette River basins for 16 years. Focal research areas have included adult salmon, steelhead, and Pacific lamprey behavior at hydroelectric dams and the effects of water temperature and climate on fish migration behaviors and survival.
Aids To Adult Pacific Lamprey Passage At Obstacles In The Umatilla River: A Bag Of Tricks.

Mary Moser, NOAA Fisheries, Aaron Jackson, Confederated Tribes of the Umatilla Indian Reservation

A variety of structures (e.g., hydropower dams, culverts, irrigation diversions) can delay or obstruct pre-spawning migration of Pacific lamprey (Entosphenus tridentatus). We hypothesized that low adult lamprey returns to spawning areas in the Umatilla River were caused by loss of habitat connectivity in this watershed. To identify barriers to adult lamprey passage, we conducted a 4-year radiotelemetry investigation. A total of 217 adult Pacific lamprey were implanted with radio transmitters and released in the first 55 km of the river, where there are seven low-elevation (< 8 m) dams. Poor passage efficiency (< 40% fitted passage probability) was recorded at four of the dams and resulted in limited escapement to upper sites. During the study, one of these dams was breached and lamprey passage efficiency immediately improved from 32 to 81% at that structure. Similarly, after water augmentation actions were taken, passage improved and migratory-phase fish exhibited a threefold increase in mean passage efficiency (from 17 to 50%). Lamprey-specific fishways have also been added at 3-Mile Falls, Feed, and Dillon dams. Structure design was tailored to the specialized requirements of each site. Our results indicate that actions to afford adult lamprey access to historical spawning areas are key to the successful restoration of this species.

Mary Moser has spent the past decade working to develop aids to passage for adult Pacific lamprey at mainstem hydropower dams in the Columbia River Basin. More recently she has collaborated with Aaron Jackson of the CTUIR to investigate and improve lamprey passage at low-elevation structures in tributaries.

Using Dual-Frequency Identification Sonar (DIDSON) To Monitor Pacific Lamprey Behavior In Columbia River Dam Fishways

Mark A. Kirk, Christopher Caudill, Eric Johnson, Peter Johnson, Matthew Keefer, Tami Clabough, Michael Jepson & William Nagy

Department of Fish and Wildlife Sciences
University of Idaho, Moscow,
LGL Environmental Research Associates
U.S. Army Corps of Engineers
Portland District Fisheries Field Unit
Bonneville Lock and Dam, Cascade Locks, OR

Given the low passage rates of adult Pacific lamprey (Entosphenus tridentatus) at Columbia River dams, monitoring their migration behaviors at these dams is critical for identifying areas of difficult passage. From 2011-2012, we used Dual-Frequency Identification Sonar (DIDSON) acoustic imaging to observe lamprey passage behavior in fishway environments as part of efforts to identify sites and structural configurations that could be improved to increase lamprey attraction, passage, and collection at dams. For 2012, we used DIDSON to monitor an entranceway to a fish ladder and a junction pool within the fishway at Bonneville dam. Our goals were to characterize the vertical and lateral distribution of adult lamprey, the associations between lamprey and sturgeon activity, and the behavior of fish as they approached and entered the fishway entrance. In addition to monitoring the two locations at Bonneville dam, we also evaluated lamprey passage and behavior at four locations within a fishway at John Day dam. Specific goals for the John Day monitoring were to qualitatively evaluate behavior in relation to a recently installed bollard field, quantify the vertical, lateral, and longitudinal distribution of lamprey, and to qualitatively assess behavior at the transition pool. Results from this study will help evaluate behavior and success at recent fishway modifications, provide insight on potential underlying mechanisms responsible for passage failures, and guide the design of future fishway modifications to improve lamprey passage.

B2

Successes And Challenges During The First 3-Years Of The Upper Deschutes Basin Downstream Fish Passage Assessment

Megan Hill, Cory Quesada, Portland General Electric

Construction of the Pelton Round Butte Hydroelectric Project (rmk 100) in the 1960s, denied anadromous fish access to over 250 miles of stream habitat in the Metolius, Crooked and Deschutes rivers. Original dam construction included a fish passage system. However bottom withdrawal created confusing reservoir currents in Lake Billy Chinook, contributing to low numbers of smolts attracted to the forebay and fish collector. To remedy the poor attraction currents, and to manage downstream water temperatures, complementary selective water withdrawal (SWW) and fish collection facilities (FCF) were constructed in the Round Butte forebay. The SWW-FCF became operational in December 2009. In anticipation of fish passage, Oncorhynchus tshawytscha (Chinook) and O. mykiss (steelhead) fry have been out-planted in the Metolius, Crooked and Deschutes rivers and tributaries since
2007. We are using Passive Integrated Transponder (PIT) tags and Juvenile Salmonid Acoustic Telemetry System (JSATS) tags to evaluate passage through the reservoir and response to the FCF. In 2012, we PIT-tagged 2,755 smolts, 636 of these were successfully collected at the FCF. We tagged 196 smolts with JSATS tags. The JSATS-tagged smolts displayed a high level of indirect movement in the reservoir; 81% of steelhead and 57% of Chinook were located in multiple reservoir arms. Seventy-five percent of the steelhead and 45% of Chinook in Lake Billy Chinook entered the forebay, of these 54% of the steelhead and 79% of the Chinook were collected by the FCF. PIT-tagged and JSATS-tagged smolts were more likely to enter the FCF when flows were 3,000 CFS or greater. We will present a synthesis of the three years of data we’ve collected to evaluate the FCF, and discuss the effectiveness of our evaluation program.

Megan Hill has been the Native Fish Studies lead for Portland General Electric’s hydroelectric project on the Deschutes River for the past 6 years. She studies the efficacy of the reintroduction and fish passage program recently established on the Deschutes River.

Overcoming Social, Political And Community Hurdles To Implementing Collaborative Restoration

Mathias Perle, Upper Deschutes Watershed Council, Brad Nye, Deschutes Land Trust, Ryan Houston, Upper Deschutes Watershed Council, Scott McCaulou, Deschutes River Conservancy, Chris Gannon, Crooked River Watershed Council

As part of a broader effort to support the successful reintroduction of wild steelhead, Chinook salmon and sockeye salmon runs to the upper Deschutes River basin, the Deschutes Partnership aims to restore the high-quality habitat necessary to support self-sustaining runs of salmon and steelhead in the reintroduction reaches. Guided by a collaborative restoration plan each organization within this partnership fills a specific niche based on their expertise and capacity:

-- Stream habitat restoration: the Upper Deschutes Watershed Council and Crooked River Watershed Council restore and enhance streams, riparian areas, wetlands, and uplands.
-- Land conservation: the Deschutes Land Trust permanently protects streams and floodplains and facilitates stream restoration projects on those protected areas.
-- Streamflow restoration: the Deschutes River Conservancy restores and protects instream flows through a combination of leasing, acquisitions, conservation and water management agreements.

-- Fish passage and screening: the Upper Deschutes and Crooked River Watershed Councils also work with irrigators to reconfigure or remove dams and diversions to allow fish to migrate safely up and downstream.
-- Community engagement and education: the Partnership members connect with our local communities through stewardship, education and project outreach.
-- Monitoring and evaluation: the Partnership tracks and evaluates progress toward restoration objectives by analyzing specific indicators of watershed health (e.g., water quality, fish habitat, macro-invertebrates, etc.).

Reaching the point where restoration (e.g. fish passage project, land acquisition, water right transfer, etc.) can be implemented is often more time consuming and labor intensive than the actual restoration activity itself. How social, political and community hurdles to affecting change are overcome will be presented through highlighting example projects from individual programs. This presentation builds on an earlier presentation given by Brad Nye on the Deschutes Partnership approach.

Mathias Perle has a diverse background in environmental and water resource project management. With over 10 years experience working in the Deschutes Basin for consulting firms and the non-profit world, Mathias has concentrated on forming strong ties with Deschutes Basin stakeholders and implementing projects in water resources, civil engineering, conservation and groundwater. Mathias holds Master’s degrees in Civil and Environmental Engineering and Hydrologic Sciences from the University of California, Davis and a B.S. in Geology from the University of Delaware.

Pelton Round Butte Hydroelectric Project – Juvenile And Adult Fish Passage Improvements

James Bartlett, Portland General Electric

The 366-MW Pelton Round Butte Hydroelectric Project is co-owned by Portland General Electric (PGE) and the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO). A new 50 year license was issued in 2005. The project consists of three generation facilities located on the Deschutes River. The 247-MW Round Butte Project is the upper most development and impounds a 4,000-acre storage reservoir fed by the Deschutes, Metolius, and Crooked River (Lake Billy Chinook), the 100-MW Pelton Project is located
approximately 7 miles downstream of Round Butte Dam and impounds a 540-acre reservoir known as Lake Symsytustus. The 18-MW Reregulating Project is located approximately 3 miles downstream of Pelton Dam and impounds a 3 mile long, 190-acre reservoir. When Round Butte Dam was constructed in the early 1960s, a fish passage system for both downstream and upstream salmonids was constructed. However, after attempting to maintain anadromous passage, the downstream fish passage system was determined to be ineffective, due to the inability to capture downstream migrating fish in Lake Billy Chinook. To mitigate for the loss, the Round Butte Fish Hatchery was constructed below the Dam. As part of the new Federal Energy Regulatory Commission (FERC) license PGE and the Tribes have committed to reestablishing anadromous fish runs above Round Butte Dam. PGE and CTWSRO reestablished downstream passage for anadromous smolts and resident fish species in December of 2009 when the Selective Water Withdrawal structure and associated downstream fish passage, capture, sampling, and transfer facilities became operational. Since then thousands of downstream migrating spring Chinook, summer steelhead, and juvenile Oncorhyncus nerka, (sockeye) have been captured and transported below the project to continue their downstream migration. Beginning in the spring of 2011, adults returning from these efforts have begun to be captured at the Pelton Adult Fish Trap located below the Reregulation Dam. Returning adults began to be transported upstream of Round Butte Dam in 2012. Returning known origin adults are transported from the Pelton Adult fish Trap to the Round Butte Adult Release Facility where they are released into the forebay of Round Butte Dam to continue their upstream migration.

**James Bartlett** received his State of Oregon Paramedic License from Oregon Health Sciences University Portland Oregon. After a few years in the fire emergency service, he decided to continue his education at Portland State University where he completed his bachelor’s degree in biology with a minor in Environmental Science. Jim started his career with PGE at the Faraday hydroelectric project in 1999. Jim was originally hired as a fisheries technician responsible for hydro project relicensing and juvenile and adult fish passage. With the new license issued to the Pelton Round Butte project in June of 2005, Jim is currently working as a fish passage biologist, Facility Team Leader for PGEs Pelton Round Butte project. Jim spends most of his time with PGE engineers, agency engineers, and contractors as they designed and continue to design the new intake and downstream fish passage facilities at the Round Butte project. Jim also assists with ODFW, tribal biologist, and other agency personnel in the reintroduction of Spring Chinook, summer steelhead, and sockeye into the Deschutes, Crooked, and Metolius Rivers.

**The Deschutes Partnership – A Collaborative Approach To Restoration**

**Brad Nye, Deschutes Land Trust**

The Confederated Tribes of the Warm Springs Reservation (Tribes), the Oregon Department of Fish and Wildlife (ODFW), and Portland General Electric (PGE) are leading a multi-agency effort to restore wild steelhead, chinook salmon and sockeye salmon runs to the upper Deschutes River basin. These runs have been absent since the mid-1960’s, when efforts to pass fish downstream at the recently-constructed Pelton-Round Butte dam complex were deemed a failure and abandoned. PGE and the Tribes have restored fish passage through their Pelton-Round Butte hydroelectric project by constructing a new intake tower and fish collection facility at Round Butte dam. With fish passage in place at Pelton-Round Butte, the focus has now moved to providing suitable habitat and secure fish passage in the 226 miles of tributary reaches where reintroduced salmon and steelhead will spawn and rear. The specific reintroduction areas include the Crooked River and its tributaries; the Deschutes River to Big Falls, including Whychus Creek; and the Metolius River and its tributaries. The Deschutes Partnership aims to restore the high-quality habitat necessary to support self-sustaining runs of salmon and steelhead in the reintroduction reaches. Guided by a collaborative restoration plan each organization within this partnership fills a specific niche based on their expertise and capacity: Stream habitat restoration, Land conservation, Streamflow restoration, Fish passage and screening, Community engagement and education, Monitoring and evaluation:

Our collective organizations have been engaged in this work to various degrees since 1998, but created a formal, focused partnership in 2005. Brad Nye will provide an overview of the Deschutes Partnership including its creation, the challenges it was designed to overcome, and why it is effective. Mathias Perle will provide detail on individual programs within the Partnership in a subsequent presentation.

**Brad Nye** oversees the Deschutes Land Trust’s conservation program, including land protection and stewardship. Brad has been with the Land Trust since...
2001. Prior to coming to the Land Trust, Brad worked as a habitat conservationist with the Confederated Tribes of the Warm Springs Reservation of Oregon. In this capacity, Brad worked with federal and state agencies to protect and restore wildlife habitat throughout the Tribes' ceded lands. Before taking the position with the Warm Springs Tribes, Brad worked for five years as litigation attorney at a large regional law firm in Portland, Oregon. Brad received his BA in English from the University of Oregon and his JD from University of Washington School of Law, where he focused on Indian Law and environmental law.

B3

Hydroturbine Passage Related Barotrauma Research In The Columbia River Basin: How Far Have We Come?

Alison Colotelo, Richard S. Brown, Brett Pflugrath, Katrina Cook, Daniel Deng, John Stephenson, *Pacific Northwest National Laboratory*

Within the past decades, most of the research related to hydroturbine passage has centered on seaward migrating juvenile salmonids. Throughout the years the techniques and technologies used to study barotrauma have evolved as have our understanding of the causal pathways. Tools, such as the Sensor Fish, that are used to measure pressure changes fish are exposed to when passing turbines, have also improved considerably. Research has also begun to be done on other fish types such as lamprey and sturgeon. This past research has led to a rethinking of the fundamental way that turbine survival studies are conducted and evaluated and how past research should be viewed. Having a comprehensive understanding of the effects of barotrauma in fish is increasingly important as the need to expand energy output of current hydropower facilities exists. This presentation will provide an overview of past, present and future research on hydroturbine passage and will detail stumbling blocks experienced upon the way and common misconceptions about turbine survival research.

The Development Process Of Designing A Fish Bypass At A Hydroelectric Dam On The Columbia River

Curtis Dotson, *Public Utility District No. 2 of Grant County, W, Leah Sullivan, Blue Leaf Enviromental, Inc.*

Large volumes of spill at a hydroelectric dam, for the purpose of salmonid smolt passage, can be a potential source of elevated total dissolved gas levels, possible fish injuries and lost power generation for the Utility. To still safely pass out-migrating salmonid smolts via a non-turbine passage route, but address the negative aspects of large-volume spill, was the goal of Grant County PUD. Through the assemblage of a Bypass Design Team, made up of engineers, biologist, hydrologist and computer modelers, with the approach of looking at a multitude of disciplines — CDF work, acoustic fish studies, scaled hydraulic models of the dam, etc. — a fish bypass design was developed, constructed, and tested with amazing results. This presentation will be a case study review of that bypass design process used for both the fish bypass at Wanapum Dam and also Priest Rapids Dam.

*Curtis Dotson* has been the Fisheries Dept. of Grant County P.U.D for 17 years. Have worked primarily with salmonid smolt passage issues - ranging from turbine passage, bypass designs, survival studies and predation concern.

Improving Precision Of Bonneville Dam Passage Survival Estimates For Juvenile Salmon


In spring 2011, high Columbia River discharge reduced the detection efficiency of the last two fish survival detection arrays downstream of Bonneville Dam by 15-18% at river km (rkm) 113 and 23-32% at rkm 86 relative to 2010 estimates and produced dam-passage-survival standard errors that exceeded a Biological Opinion requirement of SE<0.015. High flow also forced managers to cancel a planned summer study. River discharge between 5/1 and 6/1/2011 averaged 393,000 cfs and was 1.7 times greater than the previous 10-y average (2001-2010). Survival detection arrays were composed of autonomous underwater acoustic devices called nodes that were deployed across a river cross section to listen for acoustic tags previously implanted in downstream migrating juvenile salmonids. Adequate precision was obtained on virtual release survival estimates from 5,542 yearling Chinook salmon and 5,663 juvenile steelheads known to have arrived at the face of Bonneville Dam from five release sites 41-156 km upstream. However, sample sizes of 1,600 tagged fish of each species split evenly between two reference-release sites downstream of the dam were not sufficient to provide adequate precision on survival estimates for reference releases given low detection efficiencies of 62-76% on two out of three downstream arrays. Precision of survival estimates depends primarily on sample sizes of acoustically tagged fish, detection probabilities at detection arrays, and survival rates. Detection efficiency of an array depends on cross
sectional morphometry, node density, linear flow rates, and the ping rate of implanted tags. Three key design changes allowed a summer 2012 study to meet BiOp standards (dam-passage survival >0.93 and SE<0.0150) despite recurring high river discharge (2012 study mean=348,000 cfs). Changes included increasing sample sizes of paired reference releases (×2.5), densities of autonomous nodes in downstream arrays (×1.2-1.3), and the ping rate of acoustic tags implanted in reference fish (×1.5; i.e., 0.333 to 0.500 pings/s). In 2012, Bonneville dam-passage survival for subyearling Chinook salmon was 0.9739 (SE=0.0069), and detection efficiencies exceeded 0.90 at rkm 156, 0.96 at rkm 113, and 0.98 at rkm 86.

**Gene Ploskey** is a senior research scientist with a long career conducting studies to evaluate effects of physicochemical factors and dam operations on reservoir fisheries, fish protection measures at dams, and route-specific dam passage and survival of fish.

**Juvenile Salmonid Performance Standards Assessments In The Federal Columbia River Power System**


To be in compliance with the conditions presented in NOAA Fisheries’ 2008 Biological Opinion (BiOp) on the Federal Columbia River Power System (FCRPS), estimated dam passage survival of yearling Chinook salmon and steelhead must be >0.96 with a standard error <0.015. Subyearling Chinook salmon must have an estimated survival >0.93 with a standard error <0.015 to be in compliance with the BiOp criteria. Between 2010 and 2012, a total of 26 studies of juvenile salmonid survival have been conducted using acoustic telemetry and the virtual paired release survival model. In 21 of the 26 studies, estimated dam passage survival and precision have met BiOp performance standard criteria, and BiOp performance standards have been met at 6 FCRPS dams. Bonneville and The Dalles dams have met the standard for two years for subyearling Chinook salmon. The Dalles and John Day dams have met the standard for two years for subyearling Chinook salmon. One of the tests at The Dalles Dam for steelhead was below the standard and one test was in excess of the standard. John Day Dam has met the standard for steelhead for two years. Estimated yearling Chinook salmon survival has met the standards for one year each at McNary, Lower Monumental, and Little Goose dams. Steelhead survival estimates at McNary Dam, Lower Monumental and Little Goose dams met the standard for one year. John Day, McNary, Lower Monumental, and Little Goose dams have met the survival standard for subyearling Chinook salmon for one year each.

**Mr. McMichael** is a Senior Research Scientist in the Ecology Group at the Pacific Northwest National Laboratory in Richland, Washington. He received his bachelor’s and master’s degrees in Fish and Wildlife Management at Montana State University in Bozeman and has spent the past 23 years studying Pacific salmon in the northwest. He has managed several acoustic telemetry projects using the newly-developed Juvenile Salmon Acoustic Telemetry System (JSATS) over the past 9 years. His recent research has focused on juvenile salmonid behavior and survival through the Federal Columbia River Power System and the lower Columbia River and estuary as well as fall Chinook salmon in the Hanford Reach of the Columbia River.

**Grand Coulee Fish Passage And The Columbia River Treaty**

Stephen H Smith, *Fisheries Consultant Upper Columbia United Tribes*

Fifteen Native American Tribes, including the five tribes of the Upper Columbia United Tribes (UCUT) are participating in a sovereign review process on reconsideration of the Columbia River Treaty between the United States and Canada. The 1964 Treaty directs trans-boundary water management for the sole purposes of flood risk management and hydropower production. The tribes are seeking to integrate ecosystem-based function as a co-equal Treaty objective, including a watershed approach to restoring fish passage into historical habitats blocked by dam construction. Through Treaty reconsideration, the tribes are specifically seeking to restore fish passage at Chief Joseph and Grand Coulee dams to allow salmon and other aquatic species access to historical habitats in the USA and Canada. UCUT is coordinating with US tribes and indigenous First Nations in Canada to seek passage restoration through a phased process of planning, testing, and design/construction; followed by monitoring, evaluation and adaptive management. The presentation will describe the losses to anadromous fish runs from dam blockages in the trans-boundary Columbia River, losses to indigenous cultures and the tribes’ proposed approach to incorporating fish passage into the Treaty.
Mr. Smith has been a professional fishery biologist in the Columbia Basin for nearly 40 years having previously worked for the U.S. Fish & Wildlife Service, NOAA Fisheries and the Bonneville Power Administration. He has been consulting the past 12 years for Native American tribes and various federal agencies on hatchery, harvest and hydropower issues and programs. He currently is the technical designee for the Upper Columbia United Tribes (5 tribes in the upper basin) in the reconsideration of the Columbia River Treaty between the USA and Canada that governs transboundary river operations.

A Review of Downstream Migration Behavior in Juvenile Lamprey and Potential Sources of Mortality at Hydropower Dams

Mary L. Moser, NOAA Fisheries, Aaron D. Jackson, Confederated Tribes of the Umatilla Indian Reservation, Robert P. Mueller, Pacific Northwest National Laboratory

Lamprey populations are in decline in many parts of the world and some lamprey species are of conservation concern and have legally-mandated protections. As juveniles, anadromous lampreys exhibit distinct migration behaviors that take them from larval rearing habitats in streams to the open ocean. Like outmigrating salmon smolts, lamprey transformers (macrophthalmia) undergo behavioural changes associated with metamorphosis. These changes facilitate their transition from relatively sedentary ammocoetes to actively swimming macrophthalmia. Unlike salmon smolts, the timing of outmigration in lamprey is protracted and poorly documented. Lamprey emigration is often associated with periods of high flow and macrophthalmia are not strong swimmers, with maximum individual swim speeds of less than 1 m/s. They are chiefly nocturnal and appear to move along the bottom, with regular attachment to bottom substrates. At dams, macrophthalmia can become impinged on screens, suffer increased predation, and experience physical injury that may result in direct or delayed mortality. The very structures designed to protect outmigrating salmonids can be harmful to macrophthalmia. Yet lampreys, which have no swim bladder, can withstand large pressure changes at turbine intakes that would kill most teleosts. In this review, we present recent research from the Columbia River drainage on downstream migration in these imperiled fish and potential structural and operational changes that may reduce lamprey injury and mortality.

Mary Moser has worked on methods to improve adult Pacific lamprey passage at Columbia River hydropower dams during the past 12 years as a NOAA fisheries biologist. More recently she has teamed up with colleagues from the Umatilla Tribe to investigate downstream passage in juvenile lamprey.