2013 Anadromous Fish Evaluation Program Annual Review

December 3-December 5, 2013

Walla Walla Community College
Performing Arts Theater
500 Tausick Way
Walla Walla, Washington 99362

Sponsored by
U.S. Army Corps of Engineers
Northwestern Division
Conference Coordinators

U.S. Army Corps of Engineers
Walla Walla District
201 N Third Avenue
Walla Walla, Washington 99362

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Location

Walla Walla Community College
Health Sciences & Performing Arts Theater
500 Tausick Way
Walla Walla, Washington 99362
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CONFERENCE OVERVIEW
Welcome

The US Army Corps of Engineers, Northwestern Division, Walla Walla District (Corps), warmly welcomes you to the 2013 Anadromous Fish Evaluation Program (AFEP) review at Walla Walla Community College’s Performing Arts Theater in Walla Walla, Washington. This annual review provides researchers with an opportunity to share and discuss recent research regarding anadromous fish on the lower Columbia and Snake Rivers. This booklet is provided as a resource and reference to guide you through the activities of the next three days. It includes a daily agenda, list of presenters, and abstracts of their presentations.

We hope your attendance at the conference and stay in Walla Walla will be informative and enjoyable. This year’s program includes three days of interesting presentations, bringing together scientists from universities, research laboratories, and federal agencies. Together, these presentations represent the scope and depth of current Federal Columbia River Power System (FCRPS) hydrosystem research which aims to improve the passage conditions to maximize survival of ESA-listed anadromous fish species in the Columbia River basin. In addition, we have the opportunity to include presentations from research funded by the Bonneville Power Administration and other regional partners in this year’s event.

Each day, members of the Corps will facilitate the meeting through a series of presentations related by their focus around fish passage through the FCRPS hydrosystem.

These studies will cover:

- Adult Salmon & Steelhead Studies
- Lamprey Studies
- Bypass System Studies
- Avian Predation Studies
- Passage & Survival Studies
- Transportation Studies
- System Survival

Note these AFEP studies and presentations represent preliminary, draft and/or non-final research. They are being presented at this conference for benefit of the scientific and technical community only, but are NOT approved for public release. They should not be considered final nor released publicly until and unless finalized and approved by the Army for public release. In these drafts and preliminary research documents, opinions, interpretations, conclusions, and recommendations are those of the author and are not necessarily endorsed by the U.S. Army.*

Your participation is vital to the goals of this program. We welcome you again and are grateful for the time, effort, care, and expertise you bring to this endeavor.

* NOTE: Army Regulation 70-31, para. 6d(6) notes the following caveat should appear on all journal literature releases of the manuscript: “Opinions, interpretations, conclusions, and recommendations are those of the author and are not necessarily endorsed by the U.S. Army.”
Background

The Corps has sponsored biological studies continuously since 1952 in an integrated, applied research program. This program is intended to enhance understanding and improve anadromous fish passage conditions at multi-purpose projects on the Columbia and lower Snake Rivers in Oregon and Washington. These monitoring, research, and evaluation studies are managed under the AFEP. The AFEP is coordinated with federal, state, and tribal fish agencies who provide both technical and policy-level input to the Corps on study objectives, experimental design, and methodologies. Most of these studies are integral components of the Columbia Fish Mitigation Program (CRFM), a Corps construction account that funds numerous fish passage improvements at Columbia and Snake River mainstem dams. Study objectives are closely linked to those improvements in order to answer biological questions in a timely manner.

Historically, Corps-funded studies have focused on project-specific adult and juvenile fish passage issues. However, this has been expanded to include system-level and reach survival studies, as well as estuarine habitat, juvenile and adult lamprey. Most passage facilities and river operations have been developed and refined in response to studies on adult fish ladders and collection channels, juvenile bypasses with turbine intake screens, juvenile fish transportation, spill for juvenile fish passage, and a comprehensive set of project/hydrosystem operating criteria.

The AFEP studies evaluate passage success, survival, and fish condition for surface bypass technologies, transportation, conventional bypass systems, spill, total dissolved gas, adult migration/passage, in-river passage, and turbine passage. Most are developed as integral components of larger studies and evaluation features of CRFM related to new passage technologies, while others evaluate existing project features.

Purpose

The main purpose of AFEP is to produce scientific information to assist the Corps in making informed biological, engineering, design, and operational decisions for the eight mainstem Columbia and Snake River projects in order to provide safe, efficient passage through this migration corridor. Each project has multiple authorized purposes and uses, including migratory fish passage, and is affected by several environmental and project operating statutes. These include the Endangered Species Act, Clean Water Act, National Environmental Policy Act, Northwest Power Planning Act, and Fish and Wildlife Coordination Act. At the current time, ESA guidelines for the protection of listed species strongly influence the Corps' entire fish program. Biological opinions prepared by National Marine Fisheries Service and US Fish and Wildlife Service include measures to evaluate and make decisions on new passage technologies and system configurations. The resulting biological studies not only have a high priority in AFEP, but are conducted to answer key questions about behavior, survival, and the condition of fish as they migrate through the mainstem Columbia and Snake Rivers, thus facilitating decisions on the operation and configuration of the river system.
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<td>8:00</td>
<td>Estimating Iteroparity in Columbia River Adult Salmon and Steelhead using records archived in the PIT Tag Information System (PTAGIS)</td>
<td>ADULT SALMON &amp; STEELHEAD STUDIES</td>
<td>Matt Keefer</td>
<td>Department of Fish and Wildlife Sciences, University of Idaho</td>
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<tr>
<td>8:20</td>
<td>Evaluation of Adult Salmon and Steelhead Passage Behavior and Success in Relation to Fishway Modifications at Bonneville Dam</td>
<td>ADULT SALMON &amp; STEELHEAD STUDIES</td>
<td>Chris Caudill</td>
<td>Department of Fish and Wildlife Sciences, University of Idaho;</td>
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<tr>
<td>8:40</td>
<td>Evaluation of Adult Salmon and Steelhead Passage Behavior in relation to fishway modifications at The Dalles and John Day Dams</td>
<td>ADULT SALMON &amp; STEELHEAD STUDIES</td>
<td>Chris Caudill, Brian Burke</td>
<td>Department of Fish and Wildlife Sciences, University of Idaho; Northwest Fisheries Science Center, NMFS</td>
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<tr>
<td>9:00</td>
<td>Conversion of Radio-Tagged Adult Chinook Salmon and Steelhead Through the Federal Columbia River Power System (FCRPS)</td>
<td>ADULT SALMON &amp; STEELHEAD STUDIES</td>
<td>Chris Caudill</td>
<td>Department of Fish and Wildlife Sciences, University of Idaho</td>
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<tr>
<td>9:20</td>
<td>Passage Distribution and Federal Columbia River Power System Survival for Steelhead Kelts Tagged Above and at Lower Granite Dam (Year Two)</td>
<td>ADULT SALMON &amp; STEELHEAD STUDIES</td>
<td>Alison Colotelo</td>
<td>Pacific Northwest National Laboratory</td>
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<tr>
<td>9:40</td>
<td>Snake River Kelt Reconditioning</td>
<td>ADULT SALMON &amp; STEELHEAD STUDIES</td>
<td>Scott Everett</td>
<td>Nez Perce Tribe</td>
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<td>10:00-10:20</td>
<td>Break</td>
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<tr>
<td>10:20</td>
<td>Adult Chinook Salmon, Sockeye Salmon, and Steelhead Conversion Through the Lower Snake River: A Summary of PIT-Tag Data From 2002-2013</td>
<td>ADULT SALMON &amp; STEELHEAD STUDIES</td>
<td>Matt Keefer</td>
<td>Department of Fish and Wildlife Sciences, University of Idaho</td>
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<tr>
<td>10:40</td>
<td>Adult Snake River Sockeye Salmon Passage and Conversion Within and Upstream of the FCRPS</td>
<td>ADULT SALMON &amp; STEELHEAD STUDIES</td>
<td>Lisa Crozier</td>
<td>Northwest Fisheries Science Center, NOAA Fisheries</td>
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<tr>
<td>11:00</td>
<td>Development of Large PIT-Tag Antennas to Estimate Migration Timing and Survival for Adult Salmonids near Pile Structures in the Columbia River Estuary</td>
<td>ADULT SALMON &amp; STEELHEAD STUDIES</td>
<td>Dick Ledgerwood</td>
<td>Northwest Fisheries Science Center, NOAA Fisheries</td>
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<td>11:20</td>
<td>Improving Adult Pacific Lamprey Passage Using Lamprey Passage Structures (LPS) and Refuges</td>
<td>LAMPREY STUDIES</td>
<td>Steve Corbett</td>
<td>Northwest Fisheries Science Center, NOAA Fisheries</td>
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<tr>
<td>11:40</td>
<td>Development and Use of Lamprey Passage Structures at Bonneville and John Day Dams</td>
<td>LAMPREY STUDIES</td>
<td>Chris Caudill</td>
<td>Department of Fish and Wildlife Sciences, University of Idaho</td>
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<td>12:00-1:00</td>
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<tr>
<td>1:00</td>
<td>General Migration and Upstream Passage Patterns in HD PIT-Tagged Adult Pacific Lamprey</td>
<td>LAMPREY STUDIES</td>
<td>Matt Keefer</td>
<td>Department of Fish and Wildlife Sciences, University of Idaho</td>
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<td>Time</td>
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<td>1:20</td>
<td><strong>Using the Juvenile Salmon Acoustic Telemetry (JSATS) System to Evaluate Adult Pacific Lamprey Movements and Fate in Columbia River Reservoirs</strong></td>
<td>LAMPREY STUDIES</td>
<td>Chris Noyes</td>
<td>Department of Fish and Wildlife Sciences, University of Idaho</td>
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<td>1:40</td>
<td><strong>Evaluation of Larval Pacific Lamprey Rearing in Mainstem Areas of the Columbia and Snake Rivers Impacted by Dams</strong></td>
<td>LAMPREY STUDIES</td>
<td>Greg Silver</td>
<td>Columbia River Fisheries Program Office, U.S. Fish and Wildlife Service</td>
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<td>2:00</td>
<td><strong>Evaluation of Adult Lamprey Passage Behavior in Relation to McNary, Ice Harbor, Little Goose, and Lower Granite Dams Fishway Modifications</strong></td>
<td>LAMPREY STUDIES</td>
<td>Frank Loge</td>
<td>University of California, Davis</td>
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<td>2:20</td>
<td><strong>Water Velocity Data Collection in a Modified Gatewell at the Bonneville Dam Second Powerhouse</strong></td>
<td>BYPASS SYSTEM STUDIES</td>
<td>Gary Henrie</td>
<td>Portland District, US Army Corps of Engineers</td>
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<td>2:40</td>
<td><strong>Evaluation of Fish Condition and Gatewell Residence Time for Tule Stock Subyearling Chinook Salmon in a Modified Gatewell at The Bonneville Dam Second Powerhouse</strong></td>
<td>BYPASS SYSTEM STUDIES</td>
<td>Lyle Gilbreath</td>
<td>Northwest Fisheries Science Center, NOAA Fisheries</td>
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<td>3:00-3:20</td>
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<td>3:20</td>
<td><strong>Lower Granite Dam Juvenile Fish Collection Channel Prototype Overflow Weir and Enlarged Orifice Biological Evaluation, 2013.</strong></td>
<td>BYPASS SYSTEM STUDIES</td>
<td>Rod O'Connor</td>
<td>Blue Leaf Environmental</td>
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<td>3:40</td>
<td><strong>Lower Granite Dam Juvenile Fish Collection Channel Prototype Overflow Weir and Enlarged Orifice Biological Evaluation - Juvenile Pacific Lamprey, 2013.</strong></td>
<td>BYPASS SYSTEM STUDIES</td>
<td>Rod O'Connor</td>
<td>Blue Leaf Environmental</td>
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<td><strong>Evaluation of the Effect of McNary Dam Operating Gate Position on Fish Guidance Efficiency</strong></td>
<td>BYPASS SYSTEM STUDIES</td>
<td>Kenneth Ham</td>
<td>Pacific Northwest National Laboratory</td>
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<td>4:20</td>
<td><strong>Juvenile Bypass System Selectivity at FCRPS Dams</strong></td>
<td>BYPASS SYSTEM STUDIES</td>
<td>Tiffani Marsh</td>
<td>Northwest Fisheries Science Center, NOAA Fisheries</td>
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### Wednesday, December 4, 2013

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<tr>
<td>8:10</td>
<td><strong>AVIAN PREDATION STUDIES</strong></td>
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<td>Pre-Management Status of Caspian Tern Colonies in the Columbia Plateau Region: Foraging Behavior, Connectivity, and Reliance on Juvenile Salmonids</td>
<td>PREDATION</td>
<td>Dan Roby</td>
<td>Oregon Cooperative Fish &amp; Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University</td>
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<td>9:00</td>
<td>Monitoring Avian Predators at Corps FCRPS Dams: Development and Implementation of a Standardized Data Collection Protocol</td>
<td>PREDATION</td>
<td>Nathan Zorich</td>
<td>Fish Field Unit, Portland District, US Army Corps of Engineers</td>
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<td>Implementation of the Caspian Tern Management Plan: Status of Tern Colonies in the Columbia River Estuary and at Corps-constructed Colony Sites</td>
<td>PREDATION</td>
<td>Yasuko Suzuki</td>
<td>Oregon Cooperative Fish &amp; Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University</td>
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<td>9:40</td>
<td>Ecological Developments at the Double-Crested Cormorant Colony on East Sand Island: Status, Dispersal, Management Pilot Studies, and Implications for Salmonid Restoration</td>
<td>PREDATION</td>
<td>Dan Roby</td>
<td>Oregon Cooperative Fish &amp; Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University</td>
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<td>10:00-10:20</td>
<td><strong>BREAK</strong></td>
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<td>10:20</td>
<td>Measuring Impacts of Cormorant Predation on Smolt Survival in the Columbia River Estuary: Bioenergetics, PIT Tag Recoveries, and Potential Benefits from Cormorant Management</td>
<td>PREDATION</td>
<td>Don Lyons</td>
<td>Oregon Cooperative Fish &amp; Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University</td>
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<td>10:40</td>
<td>Measuring Estuary Avian Predation Impacts on Juvenile Salmon by Electronic Recovery of ISO-PIT Tags from Caspian Tern and Cormorant Colonies on East Sand Island, OR 2012</td>
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<td>Jen Zamon</td>
<td>Northwest Fisheries Science Center, Fish Ecology Division, NOAA Fisheries</td>
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<td>Juvenile Salmon and Associated Fish Community in Open Waters of the Lower Columbia Estuary: What Have We Learned?</td>
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<td>Laurie Weitkamp</td>
<td>Northwest Fisheries Science Center, Newport Field Station, NOAA Fisheries</td>
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<td>11:20</td>
<td>The Use of PIT Tag Data to Refine Estimates of Sockeye Escapement in 2012</td>
<td>PASSAGE &amp; SURVIVAL</td>
<td>Jeff Fryer</td>
<td>Columbia River Inter-Tribal Fish Commission</td>
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<td>11:40</td>
<td>Systematic Review of JSATS Passage and Survival Data at Bonneville Dam during Alternate Turbine and Spillbay Operations from 2008-2012</td>
<td>PASSAGE &amp; SURVIVAL</td>
<td>Mark Weiland</td>
<td>Pacific Northwest National Laboratory</td>
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<td><strong>LUNCH</strong></td>
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<tr>
<td>1:00</td>
<td>Lower Snake River Performance Standards Assessments 2013: Experimental Design and Methods</td>
<td>PASSAGE &amp; SURVIVAL</td>
<td>Geoff McMichael</td>
<td>Pacific Northwest National Laboratory</td>
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<tr>
<td>1:20</td>
<td>Results of Snake River Survival Compliance Studies for 2013</td>
<td>PASSAGE &amp; SURVIVAL</td>
<td>John Skalski</td>
<td>University of Washington</td>
</tr>
<tr>
<td>1:40</td>
<td>Route-Specific Passage and Survival for Subyearling Chinook Salmon at Little Goose and Lower Monumental Dams, 2013</td>
<td>PASSAGE &amp; SURVIVAL</td>
<td>Ryan Harnish</td>
<td>Pacific Northwest National Laboratory</td>
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<td>2:00</td>
<td>Investigate Juvenile Fish Impingement on the Oregon Shore Fish Ladder Screens and Fingerling Bypass Ports at McNary Dam</td>
<td>PASSAGE &amp; SURVIVAL</td>
<td>Russ Moursund</td>
<td>Moursund Research Group LLC</td>
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<td>2:20</td>
<td>Performance Evaluation of Fish Response to a Prototype Forebay PIT-tag Detection System</td>
<td>PASSAGE &amp; SURVIVAL</td>
<td>Dean Park</td>
<td>Biomark, Inc.</td>
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<td><strong>BREAK</strong></td>
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<tr>
<td>3:00</td>
<td>Development and Performance Evaluation of an Injectable Micro-Acoustic Transmitter</td>
<td>PASSAGE &amp; SURVIVAL</td>
<td>Daniel Deng</td>
<td>Pacific Northwest National Laboratory</td>
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<td>3:30</td>
<td>Determining the Minimum Size Threshold for Implantation of the JSATS Injectable Tag in Juvenile Salmonids</td>
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<td>Katherine Deters</td>
<td>Pacific Northwest National Laboratory</td>
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<td>3:50</td>
<td>Feasibility of Tracking Fish with Acoustic Transmitters in the Ice Harbor Dam Tailrace</td>
<td>PASSAGE &amp; SURVIVAL</td>
<td>Marty Ingraham</td>
<td>Pacific Northwest National Laboratory</td>
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<tr>
<td>8:00</td>
<td>A Study to Determine Seasonal Effects of Transporting Fish from the Snake River to Optimize a Transportation Strategy</td>
<td>TRANSPORTATION</td>
<td>Steve Smith</td>
<td>NOAA, Northwest Fisheries Science Center</td>
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<td>8:20</td>
<td>A Study to Compare SARs of Snake River Fall Chinook Salmon Under Alternative Transport and Dam Operational Strategies</td>
<td>TRANSPORTATION</td>
<td>Steve Smith</td>
<td>NOAA, Northwest Fisheries Science Center</td>
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<td>8:40</td>
<td>Abiotic and Biotic Influences on Straying of Stream-Type Chinook Salmon in the Columbia River Basin</td>
<td>TRANSPORTATION</td>
<td>Peter Westley</td>
<td>School of Aquatic and Fishery Sciences University of Washington</td>
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<tr>
<td>9:00</td>
<td>Evaluation of Methods to Reduce Straying Rates of Barged Juvenile Steelhead and Salmon</td>
<td>TRANSPORTATION</td>
<td>Andy Dittman</td>
<td>Environmental Physiology Program, Northwest Fisheries Science Center, NOAA Fisheries</td>
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<td>9:20</td>
<td>Growth of Smolts Between Lower Granite and Bonneville Dams</td>
<td>SYSTEM</td>
<td>Tiffani Marsh</td>
<td>Northwest Fisheries Science Center, NOAA Fisheries</td>
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<td>9:40</td>
<td>PIT-Tag Reach Survival Estimates, 2013</td>
<td>SYSTEM</td>
<td>Steve Smith</td>
<td>Northwest Fisheries Science Center, NOAA Fisheries</td>
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<td>10:20</td>
<td>Effects of Smolt Length and Ocean Conditions on Columbia River Adult Spring Chinook Survival</td>
<td>SYSTEM</td>
<td>James Anderson</td>
<td>School of Aquatic and Fishery Sciences, University of Washington</td>
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<td>10:40</td>
<td>Effects of Passage Experience and Fish Condition on Seasonal Pattern of D</td>
<td>SYSTEM</td>
<td>Jennifer Gosselin</td>
<td>School of Aquatic and Fishery Sciences, University of Washington</td>
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<tr>
<td>11:00</td>
<td>Relationship Between Smolt Condition and Survival to Adulthood in Snake and Upper Columbia River Steelhead</td>
<td>SYSTEM</td>
<td>Allen Evans</td>
<td>Real Time Research, Inc</td>
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<td>11:20</td>
<td>Sampling to Detect Juvenile PIT-Tagged Salmonids with a Surface Pair-Trawl in the Columbia River Estuary, 2013</td>
<td>SYSTEM</td>
<td>Dick Ledgerwood</td>
<td>National Marine Fisheries Service Fish Ecology Division</td>
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<td>11:40</td>
<td>Oceanographic and Ecological Indicators for Salmon Returns in the Northern California Current</td>
<td>SYSTEM</td>
<td>Brian Burke</td>
<td>Northwest Fisheries Science Center, NOAA Fisheries</td>
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<td>12:00</td>
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ADULT SALMON & STEELHEAD STUDIES
Estimating Iteroparity in Columbia River Steelhead Using Records Archived in the PIT Tag Information System (PTAGIS)

Matthew Keefer
Department of Fish and Wildlife Sciences
University of Idaho, Moscow, ID 83844-1136, (406) 556-0639, mkeefer@uidaho.edu

Christopher Caudill
Department of Fish and Wildlife Sciences, University of Idaho, Moscow

Background
A variety of management approaches have been undertaken to increase steelhead (Oncorhynchus mykiss) kelt survival and the expression of iteroparity (repeat spawning) in the Columbia River basin. These have included kelt reconditioning, kelt transportation, and increased operation of surface flow outlets (SFOs) to facilitate kelt passage at many FCRPS dams. Our objectives were to: (1) use the migration histories in the Columbia River PIT Tag Information System (PTAGIS) to estimate ‘baseline’ iteroparity rate estimates for a variety of Columbia and Snake River steelhead populations; (2) compare iteroparity rates among steelhead life history types (winter, summer), origin types (wild, hatchery), and age classes; and (3) evaluate whether iteroparity rates have increased through time as SFO operations have increased.

Methods
We queried PTAGIS for adult steelhead detections at Bonneville Dam from 2000 to 2010 (n = 11 years, 63,614 unique steelhead detected). The initial dataset was then screened to eliminate steelhead that were PIT-tagged as adults or as kelts as well as some juvenile release groups with ambiguous life history type or origin; these screens reduced the dataset to 53,282 fish. To identify potential repeat spawners, we queried for individuals that were detected at Bonneville adult fishways in more than one calendar year. The migration history of each fish in this reduced dataset was then individually reviewed to separate overwintering pre-spawn adults from likely repeat spawners. The primary metric used to estimate iteroparity was the percentage of PIT-tagged steelhead that made spawning migrations in two years (i.e., Bonneville-to-Bonneville repeat rates). It was not possible to confirm spawning in either year for any fish.

Results/Management Action
Annual maiden steelhead sample sizes ranged from 298 to 11,775 (mean = 4,843). Juveniles were released at ~200 sites throughout the Columbia River basin above Bonneville Dam. The life history×origin components were: 144 (winter, wild), 676 (winter, hatchery), 12,114 (summer, wild), and 40,348 (summer, hatchery). Bonneville-to-Bonneville iteroparity estimates with all years and populations combined were 2.78% (winter, wild), 0.44% (winter, hatchery), 0.55% (summer, wild), and 0.16% (summer, hatchery). At several geographic scales, wild steelhead had higher iteroparity than hatchery steelhead. Iteroparity was also higher for populations that originated closer to the Pacific Ocean, which included the small samples of winter-run steelhead. Age effects were mixed across populations.

Annual iteroparity estimates for aggregated wild steelhead (basin-wide and Snake River only) were positively correlated with river discharge during the kelt outmigration. There was limited, indirect evidence that installation and increased operation of SFOs contributed to increasing iteroparity rates over the study period. The results provide an important time series of iteroparity estimates that can be used for future conservation and management initiatives for Columbia basin steelhead.
Evaluation of Adult Salmon and Steelhead Passage Behavior and Success in Relation to Fishway Modifications at Bonneville Dam

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Background
There have been several recent major modifications at Bonneville Dam that may affect the behavior and passage efficiency of upstream migrant adult salmon and steelhead. These included installation of lamprey collection and passage structures in the Washington-shore fishway entrance area and modifications at the Cascades Island fishway entrance area. Our objectives in the 2013 adult radiotelemetry study were to: (1) evaluate the behaviors and entrance and passage efficiency of Chinook salmon at the north downstream fishway entrance (‘NDE’, site of the new lamprey LFS and LPS, installed winter 2012-2013); and (2) evaluate entrance use, passage efficiency, and other passage metrics at the Cascades Island (CI) fishway entrance (installed winter 2008-2009). The 2013 results will be compared to passage data collected in previous radiotelemetry studies.

Methods
In 2013 we collected and radio-tagged 300 jack Chinook salmon (178 spring, 122 summer) and 600 adult Chinook salmon at Bonneville Dam. We monitored these fish as they passed through the tailrace, approached and entered fishways, and passed up through fish ladders at Bonneville Dam. We will calculate a variety of passage time and passage efficiency metrics with an emphasis on the NDE and CI entrances, including: (1) fishway entrance efficiency, (2) fishway exit ratios, (3) passage times (tailrace, approach to entrance, entrance through transition areas). We will test whether the recent modifications are associated with changes in Chinook salmon behavior or performance by comparison with results from previous years; we will statistically control for among-year differences in conditions insomuch as possible.

Results/Management Action
Approximately 30% of the radio-tagged Chinook salmon approached NDE and 25% approached CI. These approach rates were generally consistent with results from previous studies. Unique fish entrance efficiencies (preliminary) at NDE were 66% for jacks and 41% for adults. The adult estimate was in the middle of the range of estimates in previous years; there were no comparison data for jacks. Entrance efficiencies at CI were 78% for jacks and 57% for adults. The CI estimate was at the low end of the range reported for adults in previous years. A more complete multi-year comparison of all metrics will be presented at the AFEP review.
Evaluation of Adult Salmon and Steelhead Passage Behavior in Relation to Fishway Modifications at The Dalles and John Day Dams

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Background
There have been several recent major modifications at The Dalles and John Day dams that may affect the behavior and passage efficiency of upstream migrant adult salmon and steelhead. These have included construction of a spillwall to improve juvenile salmonid passage at The Dalles Dam (winters 2008-2009, 2009-2010) and improvements for adult salmonids and Pacific lamprey at the John Day Dam north fishway entrance (winters 2011-2012, 2012-2013) and near the north count station and fishway exit (winter 2009-2010). The John Day Dam changes included installation of a variable-width entrance weir, installation of velocity-reducing bollards on the fishway floor inside the entrance, and installation of a lamprey passage structure on the north wall of the fishway just upstream from the entrance. Our objectives in the 2013 adult radiotelemetry study were to: (1) evaluate the behaviors and passage efficiency of Chinook salmon (adults and jacks) and sockeye salmon (adults) in The Dalles Dam tailrace in response to the new spillwall and the resulting spill pattern; and (2) evaluate entrance use, passage efficiency, and other passage metrics at the John Day Dam north fishway. The 2013 results will be compared to passage data collected in previous radiotelemetry studies.

Methods
In 2013 we collected and radio-tagged 300 jack Chinook salmon (178 spring, 122 summer), 600 adult Chinook salmon (328 spring, 272 summer), and 399 adult sockeye salmon at Bonneville Dam. We monitored these fish as they passed through the tailrace, approached and entered fishways, and passed up through fish ladders at The Dalles and John Day dams. We will calculate a variety of passage time and passage efficiency metrics, including: (1) fishway entrance efficiency, (2) fishway exit ratios, (3) passage times through the tailrace, to approach and enter fishways, to pass through entrance and transition areas and ladders, and to pass the dams. At The Dalles, we will also evaluate how operational and environmental conditions affect the routes that fish use to pass through the tailrace and which fishways are approached and entered. We will test whether the recent modifications are associated with changes in fish behavior or performance by comparison with results from previous years; we will statistically control for among-year differences in conditions insomuch as possible.

Results/Management Action
At The Dalles Dam, 346 sockeye salmon, 256 jack Chinook salmon, and 506 adult Chinook salmon approached fishways. Of these, 11% of the sockeye and jack Chinook approached the north fishway opening versus 31% of the adult Chinook. This preliminary result is consistent with results from the count stations at The Dalles that smaller salmonids are using the north fishway at low rates. At John Day Dam 701 Chinook salmon and 325 sockeye salmon approached fishways and 58-68% approached the north fishway. Unique fish entrance efficiencies at the north entrance were 89% (adult Chinook), 93% (jack Chinook), and 94% (sockeye). These preliminary estimates were higher than estimates in several previous years. About 37% of Chinook and 51% of sockeye passed the north fishway and this was similar to (Chinook) or higher than (sockeye) in previous years.
Conversion of Radio-Tagged Adult Chinook Salmon and Steelhead Through the Federal Columbia River Power System (FCRPS)

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Background
Adult salmon and steelhead survival (i.e., conversion rates) between Bonneville and McNary dams have recently fallen below targets specified in the 2008 FCRPS Biological Opinion for three listed ESUs: Snake River and Upper Columbia River spring–summer Chinook salmon, and Snake River steelhead. Our primary objective in this study was to estimate conversion rates in the Bonneville-The Dalles (BO-TD), The Dalles-John Day (TD-JD), and John Day-McNary (JD-MN) reaches and in the combined Bonneville-McNary (BO-MN) reach to augment estimates derived from PIT-detections for the BO-MN reach.

Methods
In 2013 we collected and radio-tagged 300 jack Chinook salmon (178 spring, 122 summer), 600 adult Chinook salmon (328 spring, 272 summer), 399 adult sockeye salmon, and 790 adult steelhead at Bonneville Dam. A full-duplex PIT tag was used as a secondary marker for all fish. We monitored radio-tagged migrants at the four lower Columbia dams, the four lower Snake River dams, at Priest Rapids Dam, at multiple Columbia River reservoir sites, and inside most major tributaries. Recovered transmitters continue to be returned from cooperating management agencies, from hatchery traps and weirs, and in a transmitter reward program from fisheries. At this writing, the raw telemetry data had been processed (i.e., coded) for Chinook and sockeye salmon; coding of the steelhead data will be completed in spring 2014 after the overwintering and spawning period. The combination of radiotelemetry and PIT detection data with transmitter return information will be used to estimate conversion rates, tributary turnoff, harvest, dam fallback, and unaccounted-for loss.

Results/Management Action
Preliminary conversion rate estimates for sockeye salmon through the lower Columbia reaches were: 0.905 (BO-TD), 0.960 (TD-JD), 0.988 (JD-MN), and 0.858 (BO-MN). BO-MN conversion rates for sockeye decreased as Columbia River water temperature increased. To date, 11% of the sockeye salmon that passed Bonneville Dam but not McNary Dam have been reported harvested. Telemetry records suggest that additional sockeye were harvested but not reported and a few had final detections in Bonneville Reservoir tributaries (i.e., possible strays or unreported harvest). Spring and summer Chinook jacks had higher reach conversion estimates than adults in both runs (Table 1). In part, this reflected different population composition among jacks and adults. Refined conversion rates adjusted for harvest and tributary turnoff, final salmon distributions, and conversion associations with FCRPS environmental covariates will be presented at the AFEP review.

Table 1. Lower Columbia River reach conversion estimates (preliminary) for radio-tagged salmon in 2013, uncorrected for harvest or tributary turnoff.

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Passage Distribution and Federal Columbia River Power System Survival for Steelhead Kelts Tagged Above and at Lower Granite Dam (Year Two)

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Steelhead (*Oncorhynchus mykiss*) populations have declined throughout their range in the last century and many populations, including those of the Snake River Basin are listed under the Endangered Species Act. The reasons for their population decline are many, but include habitat loss and degradation, overharvest, and the construction of dams. Unlike Pacific salmon, post-spawning steelhead (known as “kelts”) can migrate back to the ocean, feed and replenish their energy stores, return to freshwater, and spawn in subsequent years (known as iteroparity). However, in the Snake River it is estimated that <2% are able to make a second spawning run. Kelts may be vulnerable to delays in their migration caused by main stem dams and reservoirs in the Snake and Columbia rivers, and may also suffer higher mortality than smolts during dam passage.

As a strategy for improving steelhead survival through the Federal Columbia River Power System (FCRPS), a Snake River Kelt Management Plan (KMP) has been implemented to improve the productivity of interior basin B-run steelhead populations. The KMP uses a 3-pronged approach to increase Snake River B-run kelt female production to the 6% target estimate of the 2008 FCRPS BiOp: 1) short- and long-term reconditioning, 2) transportation, and 3) improvements in in-river and dam passage survival.

The primary goal of this research was to estimate steelhead kelt route-specific and in-river survival through the FCRPS. In 2013, Juvenile Salmon Acoustic Telemetry System (JSATS) transmitters were surgically implanted into 487 steelhead kelts captured at LGR and several tributaries of the Snake River basin. Detections of tagged kelts on autonomous and cabled JSATS receivers were used, along with the virtual single-release model, to estimate steelhead kelt survival through up to three FCRPS dams (LGR, LGS, and LMN) and multiple river reaches. In addition, passage metrics such as forebay residence, tailrace egress and project passage timing were calculated at each FCRPS dam.

Overall, 27.3% (n = 133 of 487) of kelts that were tagged in this study were detected on the array at rkm 126, which is located downstream of all FCRPS dams, indicating migration success. Since river reaches vary in length, survival per kilometer was calculated to allow for comparisons among reaches. The forebay of LGS (rkm 636 to 635) was the reach with the lowest survival per kilometer rate (0.958).

The majority of tagged kelts passed LGR, LGS, and LMN through the spillway routes (spillway weirs and traditional deep spill; 86.6 – 92.4%), whereas few fish passed through the powerhouse routes (turbine or juvenile bypass system [JBS]; 6.3 – 12.2%). Survival estimates of fish that passed via the spillway weir at LGS (0.937; SE = 0.015) and LMN (0.927; SE = 0.018) were high compared to other routes. These results are consistent with those observed during the first year of this study (2012).

The results of this study identified the locations of highest mortality, most-commonly used dam passage routes, and provided route-specific survival estimates for steelhead kelts migrating through the Snake and Columbia rivers from LGR to BON. Data from both years may be used to understand sources of mortality and inform managers and dam operators of potential ways to increase kelt survival during their downstream migration.
Snake River Steelhead Kelt Reconditioning

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Background
This project is a collaborative study to investigate approaches to increase adult steelhead returns by utilizing steelhead’s iterparous life history trait. NOAA Fisheries has specifically identified kelt reconditioning as a strategy to increase B-run steelhead escapement by 6% in the Snake River. The goal of this project is to develop a methodology to successfully collect, recondition and return steelhead to the Snake River.

Methods
We collected adult steelhead from the Juvenile Bypass System (JBS) at Lower Granite Dam and the return ladder at Dworshak National Fish Hatchery (DNFH) during the springs of 2011-2013, and from the South Fork of the Clearwater River (SFCR) during the spring of 2013. Fish collected at the JBS were graded and transported to the DNFH kelt reconditioning tanks. Fish not selected for reconditioning were measured, PIT tagged and released. Fish collected at DNFH and the SFCR were air-spawned at DNFH and placed into the kelt reconditioning tanks. Fish had blood and tissue samples collected for physiological measures and genetic profiling. Body lipid levels were measured by applying a Torrey Fish Fatmeter to the outside of the fish. As a prophylactic treatment, oxy-tetracycline, was administered to kelts when transferred to the tanks. Formalin treatments were applied routinely to control fungus. Feeding began after initial sampling. Fish were first presented with krill until the feeding response was well established. Then fish were given a higher lipid content kelt/broodstock feed.

Results/Management Action
A total of 564 fish has been collected for reconditioning with an overall survival of 25%. Surviving fish increased substantially in weight and muscle lipid levels, but did not increase in length during reconditioning. These data demonstrate that fish with a B-run life history can remature as consecutive spawners over a single summer. This suggests that captive culture conditions may substantially increase the consecutive spawner rate in natural repeat spawners in the Snake River. The program at DNFH is an experimental program designed to examine the potential for collecting and reconditioning post-spawned steelhead. To that end, improved reconditioning techniques have been identified and implemented. These include: better collection and transport handling, upgraded water delivery, enhanced water quality monitoring, consistent water treatments, better feed rationing, enriched (primarily lipid) feed content. In addition to these, physiological characteristics including blood hormones and body lipid content have been used to better pinpoint the potential for spawning and survival.
Adult Chinook Salmon, Sockeye Salmon, and Steelhead Conversion Through the Lower Snake River: A Summary of PIT-Tag Data From 2002-2013

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Background
Adult salmon and steelhead survival (i.e., conversion rates) through the lower Snake River has fallen below targets specified in the 2008 FCRPS Biological Opinion in several recent years. Our objectives in this study were to: (1) use PIT tag data to estimate annual adult Chinook salmon, sockeye salmon, and steelhead conversion rates from McNary-Ice Harbor (MN-IH), Ice Harbor-Lower Granite (IH-GR), and McNary-Lower Granite dams (MN-GR); (2) estimate conversion rates for hatchery- versus wild-origin fish; (3) estimate population-specific conversion rates for groups with suitable sample size; (4) evaluate effects of migration timing and Snake River water temperature identify on conversion rates; and (5) summarize the final detection locations for fish that did not pass Lower Granite Dam.

Methods
We queried the Columbia River PIT Tag Information System (PTAGIS) to identify all Chinook salmon, sockeye salmon, and steelhead detected inside adult fishways at McNary, Ice Harbor, and Lower Granite dams and those detected as adults at sites upstream from Lower Granite in 2002-2013. These datasets were then reduced using several screens to exclude fish we considered inappropriate for estimating upstream conversion rates (e.g., juveniles, fish tagged as adults, fish tagged as adults at sites outside the Snake River basin, etc.). We used Cormack-Jolly-Seber survival models to estimate reach survival (conversion rates) for each run and year, and for some population groups. Lastly, we reviewed the complete migration history of all fish that did not pass Lower Granite Dam to identify final detection locations and potential fates (e.g., strays, mortalities, and downstream fallbacks).

Results/Management Action
PTAGIS queries have been completed for all runs and years through 2012 (2013 pending migration completion) and preliminary analyses have been run for sockeye salmon and spring–summer Chinook salmon for these years. Five wild and 489 hatchery (494 total) sockeye salmon were identified as returning Snake River sockeye salmon, and 7,259 wild and 24,758 hatchery (32,017 total) spring–summer Chinook salmon were identified as Snake River adults. Preliminary annual conversion rate estimates for hatchery sockeye salmon ranged from 0.975-1.000 (MN-IH), 0.909-1.000 (IH-GR), and 0.909-1.000 (MN-GR). Sockeye that did not pass Lower Granite Dam were last detected at Ice Harbor Dam (58%), McNary Dam (15%), in juvenile bypass systems (12%), or as strays to the upper Columbia River (8%). Estimates for wild spring–summer Chinook salmon were 0.973-0.995 (MN-IH), 0.930-0.986 (IH-GR), and 0.912-0.993 (MN-GR); estimates for hatchery fish were lower than for wild fish in most years and reaches. Most unsuccessful Chinook were last detected at dams (58% at Ice Harbor, 30% at McNary) and smaller numbers were last detected as strays (7%, at multiple sites) or in juvenile bypass systems (3%). Exploratory analyses suggest that warm water temperatures and juvenile transportation may contribute to reduced spring–summer Chinook salmon conversion rate estimates.
Adult Snake River Sockeye Salmon Passage and Conversion Within and Upstream of the FCRPS

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Background
Snake River sockeye salmon are listed as endangered and in eminent risk of extirpation (NMFS 1991). Because recent conversion rates from the FCRPS to the spawning grounds have not met recovery goals, recent efforts involve identifying the causes of mortality within and upstream of FCRPS, and examining transportation from Lower Granite Dam to the spawning grounds as a potential management tool. The objectives of this study were to use PIT-tagged adult sockeye salmon from 2008 to 2013 to 1) estimate detection efficiency for each available location between Bonneville and Lower Granite dams, 2) estimate conversion rates for each available reach between Bonneville and Lower Granite dams, 3) estimate conversion rates from Lower Granite Dam to the Sawtooth Valley, 4) describe migration characteristics, including travel times, migration timing and fallback at all available locations within and upstream of the FCRPS, 5) correlate migration fate within and upstream of the FCRPS with migration characteristics, origin, genetic history and temporal and environmental factors, and 6) identify trigger mechanisms for initiating transport of adult sockeye salmon from Lower Granite Dam to the Sawtooth Valley, if possible from available data.

Methods
We assembled PIT-tag records and juvenile histories for all Columbia and Snake River sockeye in PTAGIS (687,954 fish), as well as harvest and environmental data from within and upstream of the FCRPS. We calculated detection efficiencies and conversion rates using Cormack-Jolly-Seber survival models, and calculated reach-specific migration characteristics for all fish known to have originated in the Snake River Basin between 2008 and 2013 (n=927). We analyzed covariates of migration fate over various stretches, including from Bonneville-Lower Granite (BO-LG, n=929 fish detected at BO from 2000-2013), and Lower Granite to Sawtooth Valley (LG-SW, n=556 fish detected at LG, 1996-2013). We will test proposed triggers of migration fate based on data prior to 2012 against observed fates in 2013 when the migration is complete.

Results
Preliminary analyses for migration years through 2012 have been completed. Detection efficiencies based on upstream detection from 2008-2012 were as follows: BO:0.986-1; McNary (MN): 0.91-1; Ice Harbor (IH): 0.9-1; LG: 0.972-1. Conversion rates from 2008 to 2012 were as follows: BO-MN: 0.582-8.5; MN-IH: 0.974-1; IH-LG: 0.9-1; BO-LG: 0.5-0.78; LG-SW: 0.3-0.77, BO-SW: 0.21-0.6. Median travel times from BO to The Dalles (TD) was 1.8 days (2013 only), BO-MN: 5.8 days, BO-IC: 7.6 days, BO-LG: 12.4 days, LG-SW: 38.4 days. The percentage of fish that fell back at BO was 8.5%, TD (2013 only) 15%, MN 3.2%, IH 7.8%, GR 13.2%. Analysis of the correlates of migration fate is ongoing.
Development of Large PIT-Tag Antennas to Estimate Migration Timing and Survival for Adult Salmonids near Pile Structures in the Columbia River Estuary

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Background and Methods
We continued research and development of a passive PIT-tag detection system along a pile dike in the estuary (rkm 70). Target fish for this system are returning adult salmonids, whose detection in the mid-estuary can be compared with subsequent detections at upstream dams to determine timing and survival during the adult migration. In 2013 we changed all system electronics from the MUX to the MTS transceiver. This system upgrade allowed us to quadruple the size of antennas, and thus fish passage openings, to an area of 2.4 × 6.1 m. In March, we installed three new antennas encased in a rigid PVC housing (10 cm diameter) onto the pile dike system (PTAGIS site code PD7). One of these eventually leaked, and we replaced it in July using an antenna with an experimental housing. The new housing was smaller in diameter (19 mm) and made of flexible PVC hose. We expanded the system with 2 additional antennas placed further inshore along the pile dike (5 total). Except for interruptions to replace antennas and a few brief interruptions in late fall due to solar power shortage; the new system has remained operational from March through October 2013.

Results
We detected 375 adult and jack salmonids including 96 spring Chinook, 104 summer Chinook, 106 fall Chinook, 54 steelhead, 12 sockeye, and 3 coho salmon. We also detected 612 juvenile salmonids, 5 sturgeon, 1 pikeminnow, and 32 fish with PIT tags yet to be identified in PTAGIS. Survival estimates (SE) of adults to passage over Bonneville Dam were 90.5% (15%), 88.2% (8%), 92.1% (5%), and 90.7 (8%), respectively for spring, summer, and fall Chinook salmon and steelhead. Median travel times from detection at PD7 to Bonneville Dam for the same fish groups were 4.0d, 3.7d, 3.2d and 4.6d.
Improving Adult Pacific Lamprey Passage Using Lamprey Passage Structures (LPS) and Refuges

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Background
This project is part of a multi-year effort to understand and improve the passage performance of adult Pacific lamprey (*Entosphenus tridentatus*) at lower Columbia River dams. The objectives of this study were to: 1) Determine lamprey use of Bonneville Dam Lamprey Passage Structures (LPSs) located at the Auxiliary Water Supply (AWS) channels, 2) Assess the effects of providing refuge areas 3) Determine lamprey use of the Bonneville Dam LPS located at the Cascades Island fishway entrance 4) Develop methods to enumerate lamprey entering a newly installed trap at the South Fishway of John Day Dam.

Methods
Efforts to increase adult Pacific lamprey passage in 2013 included structural and operational changes to improve lamprey access to and passage through LPSs at Bonneville Dam. Lamprey use of these structures was assessed with lamprey-activated counters and passive integrated transponder (PIT) detections. Using PIT detections, we tested whether lamprey use refuge boxes installed along the bottom of the Washington-shore AWS channel placed in an effort to improve lamprey retention in this area. Improvements to the Cascades Island (CI) LPS in 2013 included 1) extension of the LPS to the forebay to allow volitional passage; and 2) installation of a one-way gate designed to prevent rest box fallout. Lamprey use of the CI LPS was evaluated by PIT detections and radio telemetry. With an expanded array of portable traps, lamprey were also collected at the Cascades Island AWS channel, which has no direct outlet to the forebay. At the John Day Dam South fishway a trap was installed upstream from the count station picketed leads prior to the 2013 migration season for tribal lamprey collection. PIT detection and underwater camera systems were also installed and camera positions were tested to determine the best methods to obtain recorded video that will be used to enumerate lamprey in 2014.

Results/Management Action
One hundred fifty-five of the 1048 (15%) lamprey implanted with PIT tags and released downstream from Bonneville Dam were detected at a refuge box. A large percentage (59%) of these fish were subsequently detected in the Washington-shore LPS immediately upstream from the refuge. Of the PIT-tagged lamprey detected exiting the Washington-shore fishway or LPS, 27% had previously used a refuge box. As in previous years (7% in 2011, 12% in 2012), results indicate that lamprey are able to find and take advantage of these relatively small refuge areas.
The Cascades Island LPS was operated fully connected from tailrace to forebay for the first time in 2013. Lamprey passage was counted and 0.1% of lamprey PIT-tagged and released downstream from Bonneville Dam was detected at Cascades Island LPS antennas. Experiments to determine passage success indicated that 37 of 47 (79%) PIT-tagged fish released into the lower part of the structure successfully ascended to the newly extended section and exited to the forebay. Similar percentages of radio-tagged lamprey that were released to 1) the lower part of the structure; and 2) the forebay at Cascades Island, were subsequently detected at antennas upstream from Bonneville Dam, indicating that LPS passage did not cause fallback. At the Cascades Island AWS channel lamprey were opportunistically captured (n = 625), transported, and released upstream from Bonneville Dam. An antenna at the entrance to the Cascades Island AWS detected 79 of 1048 (8%) of the PIT-tagged lamprey released downstream from Bonneville Dam. These results are consistent with those from past years (2011, 8%, 2012, 10%) and indicate that high numbers of adult lamprey are occupying this area and should be provided with an outlet to the forebay or aggressively trapped and transported upstream. A total of 39 PIT-tagged lamprey were detected at the newly installed lamprey trap at the John Day Dam South fishway. The trap is designed to operate in two modes, one in which lamprey enter and are collected, and one in which lamprey enter and are able to escape upstream. Using test results, the camera system was optimized and will be used to enumerate lamprey during periods that the trap is operated in the pass-through mode.
Development and Use of Lamprey Passage Structures at Bonneville and John Day Dams

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Background
A variety of structural and operational changes to fishways have been used to address the problem of low dam passage efficiency by adult Pacific lamprey. Among the most novel solutions has been development of lamprey passage structures (LPSs) inside and adjacent to fishways. Since 2002, several LPSs have been installed at Bonneville Dam and thousands of adult lamprey have used the structures to circumvent difficult passage areas at the dam. In the winter of 2012-2013, two new LPSs were installed: one at the terminus of the lamprey flume system (LFS) located at the north downstream entrance to the Washington-shore fishway at Bonneville and one inside the north fishway entrance at John Day Dam. Our objective was to assess lamprey use of these structures during the 2013 migration.

Methods
We assessed lamprey use of the new Bonneville and John Day LPS using adults collected at the upstream of each terminus, including those tagged with half-duplex (HD) PIT tags. HD PIT antennas were integrated into the construction of each LPS and will eventually allow us to estimate the proportion of the run that encounter and use the structures. Most lamprey collected in the LPSs were transported and released upstream of the dams; others were used for research (i.e., tagging) projects or transferred to tribal programs.

Results/Management Action
The Bonneville Dam Lamprey Flume System was operated from 5 June to 24 June and again from 19 July to 20 August. During this period, 27 adult lamprey passed the entire structure and were trapped at the terminus. Several minor and major structural issues were identified during operation and were likely related to declining capture rates later in the operational period. Several issues were addressed in-season and other modifications have been or will be made prior to the 2014 lamprey run season. The John Day LPS was operated continuously from 19 July through 10 September. During that time, 111 adult lamprey were collected from the box at the top of the LPS. While the LPS was operated, 2,682 adult lamprey were counted at the John Day north count station during the day and 2,324 were counted at night. The LPS collection to count ratio was therefore 101:5,006 (0.020). It is not possible to estimate LPS collection efficiency at this site because the number of lamprey at the John Day north entrance was unknown. However, the number that passed the LPS was presumably higher than the number that passed the count station, suggesting collection efficiency was < 2%.
General Migration and Upstream Passage Patterns in HD PIT-Tagged Adult Pacific Lamprey

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Background
Monitoring adult Pacific lamprey (*Entosphenus tridentatus*) migration in the Columbia River basin is an important part of understanding how dams and environmental factors affect lamprey behavior, dam passage success, and distribution among spawning areas. Results from long-term monitoring, like this half-duplex passive integrated transponder (HD PIT) tagging study, can also be used to evaluate the effects of management actions to improve lamprey passage at dams and to help prioritize limited conservation funds.

Methods
In 2013, we collected and HD PIT-tagged 901 adult lampreys at Bonneville Dam from 10 June through 23 September (*median date* = 11 July). Of these, 876 (97%) were released downstream from Bonneville Dam and 25 (3%) were released into the Cascades Island lamprey passage structure (LPS). We monitored upstream passage at the four lower Columbia River dams, Priest Rapids Dam, and at three of four lower Snake River dams. Public utility districts monitored lamprey passage at Wanapum, Rock Island, and Rocky Reach dams, and the Confederated Tribes of Warm Springs monitored some tributary sites with instream HD PIT antennas. The primary objectives addressed in this presentation will be: 1) to estimate lamprey escapement past the monitored sites, 2) to assess the final known distribution of tagged fish, 3) to compare 2013 results to those from previous HD PIT study years (2005-2012), and 4) to evaluate the effects of recent management efforts intended to improve lamprey passage through dam fishways.

Results/Management Action
At this writing, some lampreys tagged in 2013 were still actively migrating, monitoring sites were still deployed, and cooperating agencies had provided some – but not all – of the data collected to date. For these reasons, the HD dataset was not yet fully processed. Preliminary summaries will be presented at the AFEP review.
Using the Juvenile Salmon Acoustic Telemetry (JSATS) System to Evaluate Adult Pacific Lamprey Movements and Fate in Columbia River Reservoirs

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Background
Substantial proportions of adult lampreys released in recent telemetry studies have failed to pass Bonneville Dam or had last records in Bonneville Reservoir. Battery life of radio transmitters limit their effectiveness for monitoring overwintering behavior and the detection ranges of both radio- and PIT-tag arrays are inadequate for tracking lamprey movement in reservoirs and tailrace habitats. In this study, we evaluated the effectiveness of a stationary array of acoustic JSATS receivers for monitoring the migration of JSATS-tagged adult Pacific lampreys in Bonneville Reservoir. In addition, we continued to monitor for movement of the 299 lamprey we tagged in the summer of 2012 with JSATS tags rated for 400-day tag life.

Methods
In 2013, we tagged 400 adult lampreys with 400-day duration JSAT tags from 29 June through 23 September. All fish were trapped at Bonneville Dam (rkm 235) in the Adult Fish Facility. A total of 203 fish were released upstream from Bonneville Dam at Stevenson, WA or Cascade Locks Marina. The remaining 197 fish were released into the Bonneville Dam tailrace. We deployed gates of one to five receivers at thirteen locations: Dodson, OR (rkm 225.6), the Bonneville Dam tailrace (rkm 233), the Washington shore and Cascade Island ladder exits at Bonneville Dam (rkm 235.1), Cascade Locks Marina (rkm 239.1), Stevenson, WA (rkm 243), below the White Salmon River (rkm 270.3), near the White Salmon River mouth (rkm 271.4), near the Hood River mouth (rkm 272.4), Hood River, OR (rkm 273), in the Klickitat River 300 m upstream of the mouth (rkm 290.6), Lyle, WA (rkm 292.7), the tailrace of The Dalles Dam (rkm 304.9), downstream and upstream of Miller Island (rkm 326 and 233.7), near the Deschutes River mouth (rkm 328.2), and in the John Day River 1.2 km upstream of the mouth (rkm 352).

Results
Of the 299 lamprey we tagged with JSATS transmitters in 2012, seventy-two (24.1%) were subsequently detected in 2013. Eight of these fish were recorded entering spawning tributaries in early spring 2013, representing 12.5% of those classified as having unknown fate in the Bonneville Reservoir based on detections through fall of 2012. Fifteen fish (20.8% of the 72 detected in 2013) had been recorded entering spawning tributaries in 2012 and were detected in late spring and early summer 2013 exiting these tributaries and moving downstream. The remaining forty-nine fish (68.1%) were detected moving between main stem receivers. The majority of these were recorded moving downstream (n = 42, 80%), although seven lamprey (20%) were detected passing Bonneville Dam in 2013. Analysis of records for 2013 JSATS-tagged adults is currently underway and we will present results on migration rates to upstream sites and the distribution of tagged adults through early fall 2013.
Evaluation of Larval Pacific Lamprey Rearing in Mainstem Areas of the Columbia and Snake Rivers Impacted by Dams

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Background
This project is part of a multi-year effort to document the describe larval Pacific lamprey Entosphenus tridentatus rearing in Columbia and Snake river mainstem areas influenced by dams. The objectives addressed in this project were to: (1) evaluate whether pools are occupied by larvae, (2) evaluate strata-specific larval occupancy of pools (e.g., shallow areas, deepwater areas, river mouth areas), and (3) evaluate the size of larvae rearing in pools.

Methods
We determined whether larval lampreys occupied Bonneville and The Dalles pools as well as the river mouth areas associated with the tributaries Wind, White Salmon, Klickitat, Hood, Little White Salmon, and Deschutes. We employed deep-water electrofishing technology to sample larval lamprey. We determined occupancy within several explicit scales (i.e., pool, tributary mouth, relatively shallow areas). Areas of interest in the river (e.g., pool shallow areas) were divided into 30 x 30 m quadrats. A Generalized Random Tessellation Stratified (GRTS) technique was used to select sampling quadrats in a random, spatially-balanced order. This approach was further stratified to choose sites within specified habitat types (e.g., depths, tributary deltas). This approach generated an unbiased, sample design that allowed the probability of presence to be quantified when lamprey were not captured, detection probabilities were calculated when lamprey occupied an area. We are currently using modeling techniques to identify the shallow water zones in each reservoir and will sample these areas in 2014.

Results/Management Action
River mouth sampling is complete, deepwater and shallow water sampling is ongoing. Preliminary results indicate that larval lampreys occupied both pools. Detection rates were highest at river mouth areas. Detection rates were highest at the Klickitat (0.35) and Wind (0.24) river mouths and relatively lower at the Deschutes (0.09) river mouth. 186 total larval lampreys have been collected including Pacific lamprey, western brook lamprey, and unidentified larvae (TL < 60 mm). We found a relatively high number of small lampreys at the Klickitat and Wind River mouths, which were not observed in previous years. Larvae also occupied the newly formed delta at the White Salmon River mouth which formed after the breach and removal of Condit Dam on the White Salmon River in 2010.

We are currently using modeling techniques to identify shallow water zones in Bonneville and The Dalles pools. Shallow water strata that exist between minimum and full elevations will be modeled using a River 2D...
hydrodynamic model (Ghanem et al. 1996) that simulates hydrologic parameters throughout the study site. These strata will be sampled in spring 2014 when water levels are presumably at their highest likely maximizing the possibility that larvae could be found rearing in these habitats.
Evaluation of Adult Lamprey Passage Behavior in Relation to McNary, Ice Harbor, Little Goose, and Lower Granite Dams Fishway Modifications

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Background
Accurately enumerating fishway escapement is central to managing declining Pacific lamprey populations. Because research has demonstrated that lampreys can evade count window detection by passing behind the picketed leads (used to crowd salmonids to count windows), the U.S. Army Corps of Engineers raised the picketed leads 1.5 inches off the fish ladder floor to promote lamprey passage in 2011 at all Columbia and Snake River projects. Since 2011, underwater video has been used at McNary and Ice Harbor dams during the lamprey migration season to evaluate lamprey behavior at picketed leads and refine escapement estimates. Additionally, specialized lamprey orifices to promote fish ladder passage were installed in 2010 at the McNary Oregon shore ladder, at Ice Harbor and Lower Monumental dams in 2011, and at Little Goose and Lower Granite dams in 2013. As in 2010 and 2011, underwater video monitoring of these orifices was used in 2013 to assess lamprey behavior and passage through these openings and whether lamprey orifices delay salmon from passing traditional orifices.

Methods
In 2013, eleven low-light video cameras and infrared lighting were installed behind the picketed leads at McNary and Ice Harbor fish ladders and operated continuously from June through mid-October, generating over 33,000 hours of video. Night video counts were also conducted at the Ice Harbor count window for a third consecutive year. At both projects, lamprey video counts behind the picketed leads were added to window counts to enumerate lamprey escapement. Newly installed lamprey orifices at Little Goose and Lower Granite were monitored using two cameras at each location during early and peak Chinook and steelhead runs, and during most of the sockeye run. Data were collected for fish delay, orifice interactions (fish nosing into orifices), and attempted passage and injury. Lamprey behavior at the orifices was monitored during peak day and night passage hours. All video was processed using CBVision automation software which reviewed all 33,000 hours of video and produced condensed clips for annotation by technicians.

Results/Management Action
In 2013, lamprey escapement increased substantially at McNary and Ice Harbor over recent years. Through September 8, 2013, more than 1,900 lampreys were observed in video swimming upstream behind picketed leads at the McNary Oregon shore ladder, corresponding to over 44% of the total counted at the window (2,329 lampreys) during the same period (day and night counts). This proportion is in the same range reported in 2012 (46%) and 2011 (42%). Also from 2011 to 2013, the majority of lampreys passed directly upstream under the picketed lead gap. Ongoing results from video monitoring of picketed leads at other locations (Ice Harbor, Little Goose, Lower Granite) follow similar trends from 2011 to 2013, with few lampreys passing via the picketed leads. Structural differences at the count window entrance chute and the ladder width at the picketed leads have been suggested as playing a role in lamprey passage.
Of all the species/runs monitored, jack Chinook and sockeye were most likely to interact with lamprey orifices at Little Goose fish ladder, likely due to their smaller size and 2013’s larger-than-average jack return. Interactions resulted in potential delays of nine seconds on average. Fish behavior differences at Little Goose orifices may be related to light levels and flow near the top of the ladder. Results from other species monitoring will be presented.
BYPASS SYSTEM STUDIES
Water Velocity Data Collection in a Modified Gatewell at The Bonneville Dam Second Powerhouse

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Background
Smolt monitoring observations in 2007 and tests conducted by NOAA Fisheries in 2008-09 confirmed that tule stock subyearling Chinook salmon *Oncorhynchus tshawytscha* passing through Bonneville Dam Second Powerhouse gatewells were subject to higher mortality rates during turbine operation at the upper end of the 1% peak efficiency range than at lower operational levels. Computational Fluid Dynamics modeling conducted in 2010-11 indicated that gatewell hydraulics could be improved by filling the vertical space above both sides of a submersible traveling screen with Turbulence Reduction Devices (TRDs). This modification was endorsed by the Post-construction Evaluation Program as a viable alternative to reduce mortality and injury at upper 1% operation. Prototype TRDs were fabricated and installed in gatewell 14A for hydraulic and biological testing in 2013.

Methods
The study design for hydraulic testing included velocity data collection for seven total treatments split between the 14A, 14C, and 15A turbine gatewell slots. Treatments in gatewell 14A include operation of a turbine unit at flows representing the lower, middle, and upper 1% peak efficiency range with STS slot fillers and one open orifice. Treatments in gatewell 15A include operation of a turbine unit at flows representing the lower, middle, and upper 1% peak efficiency range without STS slot fillers and one open orifice. The treatment in gatewell 14C represents the upper 1% peak efficiency range without STS slot fillers and one orifice. Unit flows during the 14A and 15A lower, middle, and upper 1% testing were 11.6-12.4 kcfs, 14.7-15.3 kcfs, and 16.7-17.4 kcfs, respectively; and 16.2-16.9 kcfs during the 14C upper 1%. Harbor Consulting Engineers and Alden Research Laboratory collected the velocity data in late March and early April, 2013 using four Acoustic Doppler Velocimeters (ADVs).

Results/Management Action
Comparing the velocity data from the 15A and 14A lower, middle, and upper 1%, it was observed that the presence of the TRDs led to some improvement in gatewell hydraulics. At each turbine unit flow, flow near the TRDs was streamlined up the gatewell and the sweeping velocities near the top of the STS were more uniform across the width of the gatewell. Improvements in gatewell hydraulics were apparent, but were potentially mitigated by an increase flow up the gatewell. Velocity data collected from 14C upper 1% turbine flow are comparable to velocity data from 15A lower to middle 1% turbine flows. Collected data also revealed higher than designed velocities into the Vertical Barrier Screen (VBS) at the top two rows of VBS panels. These and other study aspects will be discussed during the presentation.
Evaluation of Fish Condition and Gatewell Residence Time for Tule Stock Subyearling Chinook Salmon in a Modified Gatewell at The Bonneville Dam Second Powerhouse

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Background
Smolt monitoring observations in 2007 and tests conducted by NOAA Fisheries in 2008-09 confirmed that tule stock subyearling Chinook salmon Oncorhynchus tshawytscha passing through Bonneville Dam Second Powerhouse gatewells were subject to higher mortality rates during turbine operation at the upper end of the 1% peak efficiency range than at lower operational levels within the range. Computational Fluid Dynamics modeling conducted in 2010-11 indicated that gatewell hydraulics could be improved by filling the vertical space above both sides of a submersible traveling screen with Turbulence Reduction Devices (TRDs). This modification was endorsed by the Post-construction Evaluation Program as a viable alternative to reduce mortality and injury at upper 1% operation. Prototype TRDs were fabricated and installed in gatewell 14A for hydraulic and biological testing in 2013.

Methods
The study design for biological testing included three treatment groups for release into the 14A turbine intake: 1) upper 1% operation, no TRDs; 2) upper 1% operation, TRDs installed; and 3) lower 1% operation, no TRDs. Specified unit flows during upper and lower 1% testing were 496-510 m³/s (17.5-18.0 kcfs) and 340-354 m³/s (12.0-12.5 kcfs), respectively. Sample sizes were set to detect a 3% additive mortality difference at α=0.05. Four replicate release series were conducted between 8 April and 1 May 2013. Operating conditions were switched after 24-48 hours run time with releases on consecutive dates within each release series. Subyearling Chinook salmon ranging from 55 to 95 mm fork length were obtained from Spring Creek National Fish Hatchery, PIT-tagged in lots of about 225 fish, and then released via hose into the turbine intake. We also released groups of 50-67 fish into the bypass system collection channel once during each release series to quantify baseline timing, tag loss, and mortality not associated with the gatewell environment. A total of 3,712 fish were released for the study. Fish were recaptured at the downstream end of the juvenile bypass system using the PIT-tag separation-by-code capability of the Juvenile Monitoring Facility.

Results/Management Action
We observed the following overall mortalities for fish recaptured at the facility: upper 1% operation, no TRDs, 23.6%; upper 1% operation, TRDs installed, 17.0%; lower 1% operation, no TRDs, 2.1%; and collection channel releases, 0.0%. The large mortality difference between upper 1% operation with TRDs installed and lower 1% operation was highly significant (P<0.01; ANOVA). Therefore, installation of TRDs did not adequately mitigate for the mortality increase associated with operation of Second Powerhouse turbines at the upper end of the 1% peak efficiency range. We note that test results were achieved using what is generally acknowledged to be one of the most sensitive stocks of fish passing Bonneville Dam, that fish were released at a single location within the intake, and that “A” gatewells are known to have higher flows that “B” or “C” gatewells. Therefore, results may not be applicable to other stocks and may overestimate the
passage mortality at the Second Powerhouse for tule stock subyearling Chinook salmon. These and other study aspects, including gatewell residence times, will be discussed during our presentation.
Lower Granite Dam Juvenile Fish Collection Channel Prototype Overflow Weir and Enlarged Orifice Biological Evaluation, 2013.

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Background
A study to evaluate the passage of steelhead, yearling and subyearling Chinook salmon, and juvenile Pacific lamprey (see separate abstract for lamprey results) through prototype fish passage structures in a gatewell at Lower Granite Dam (LGR) was conducted in 2013. The objectives addressed in the study were: (1) determine how the overflow weir and/or larger orifices affected orifice passage efficiency (OPE) and travel times through the juvenile bypass system (JBS) when compared to the current orifice configuration for juvenile salmonids and lamprey, (2) determine fish condition (including injury and descaling) impacts of the overflow weir and/or larger orifices compared to current orifice configuration for juvenile salmonids, (3) determine debris passage impacts of the overflow weir and/or larger orifices, and (4) investigate salmonid fish behavior patterns in gatewells with the overflow weir relative to current orifice configuration.

Methods
PIT-tagged yearling Chinook (n=11,000) and steelhead (n=11,657) were released in the morning from April 20, 2013 through May 25, 2013, and subyearling Chinook (n=12,130) from May 26, 2013 through June 21, 2013. Fish were released into one of four locations: (1) Gatewell 5B during operation of the 10-inch orifice, (2) Gatewell 5A during operation of the prototype broad-crested overflow weir, (3) Gatewell 5A during operation of the 14-inch orifice, or (4) directly into the Juvenile Bypass Channel. Travel time from release to detection at the LGR Juvenile Fish Facility (JFF) was used to assess OPE and travel time differences between releases. A subset of fish (approximately 30%) from each release group of juvenile salmonids was photographed prior to release and after recollection at the Sort by Code (SxC) system to assess changes in external condition metrics.
Optical video and DIDSON cameras were mounted to fixed poles in gatewells 5A and 5B to monitor debris buildup, passage and fish behavior at the experimental fish passage structures compared to the standard orifice configurations. Images from optical video and DIDSON cameras were collected continuously, 24 hours/day, 7 days/week, during the period of May 1 through June 24, 2013 with strategic review to address study questions.

Results/Management Action
Among all salmonid treatments, fish released during operation of the 14-inch diameter orifice had lower travel times than fish released during operation of the weir or operation of the 10-inch diameter orifice. Differences in travel time were statistically significant for nearly all pair-wise comparisons of species/age classes and release locations. The greatest differences in mean travel time were between fish released during operation of the 14-inch orifice and those released during operation of the weir (2.4 h, 2.1 h, and 1.7 h for yearling Chinook, steelhead, and subyearling Chinook, respectively). The most common significant covariate (determined by multiple regression analysis) was mean fork length, but the relationship to mean travel time was opposite for juvenile steelhead (decreased mean travel time with increased mean fork length) versus yearling and subyearling Chinook (increased mean travel time with increased mean fork length).

For yearling Chinook and steelhead a small percentage of all treatment groups showed an increase in descaling after recollection relative to pre-release condition regardless of passage route. However, most fish (>80%) showed no change in descaling score. Yearling Chinook released during operation of the weir and 10-inch orifice were descaled at a higher rate than those released during operation of the 14-inch orifice or directly into the bypass channel. The covariate most commonly related to the increase in descaling of yearling Chinook released during operation of the weir and 10-inch diameter orifice (determined by Poisson regression analysis) was forebay elevation (greater descaling with higher forebay).

The rate of debris obstruction in the passage structures and direct juvenile fish interactions with the passage structure (i.e., strikes) observed with optical video was low for all passage routes. Debris obstructions were only observed in the 10-inch orifice with obstruction of 10-20% of the 10-inch orifice most common, occurring during 7.5% of subsampled video periods. The rate of fish strike was greatest during operation of the 14-inch diameter orifice (0.8% of passing juvenile fish) and lowest during operation of the weir (0.3% of passing juvenile fish). Video observations of fish strike did not correlate with fish condition scoring after passage recapture. The frequency and extent of debris obstruction will vary between years with 2013 appearing to be a relatively low debris year within the Lower Granite Dam JBS. The number of adult salmonids observed passing from the gatewells into the bypass channel with the optical video and DIDSON was limited during the study period (n=5 and n=12 for the optical video and DIDSON, respectively).
Background
As part of a study this year to evaluate passage of juvenile fishes through prototype fish passage structures in a gatewell at Lower Granite Dam (LGR), juvenile Pacific lamprey were collected, PIT-tagged, and released. The study was undertaken as part of a broader effort to assess the effectiveness of traditional juvenile bypass systems prescribed by the NOAA Biological Opinion (NOAA 2008, 2010) RPA 54.2. The objectives addressed in the study were: (1) determine how the overflow weir and/or larger orifices affected orifice passage efficiency (OPE) and gatewell residence times compared to current orifice configuration for juvenile lamprey, (2) determine effective collection methods for juvenile lamprey at LGR, Little Goose (LGS), and Lower Monumental (LMN) dams, (3) determine collection efficiency for juvenile lamprey designated for recollection at the Sort by Code (SxC) system at LGR, and (4) evaluate PIT tag retention using two different tagging techniques: surgical methods described by Mesa et al. (2011) and injecting PIT tags with a 16-gauge needle.

Methods
PIT-tagged lamprey (n=1,453) were released at night during the period of May 20, 2013 through June 3, 2013. Fish were released into one of five locations: (1) Gatewell 5B during operation of the 10-inch orifice, (2) Gatewell 5A during operation of the prototype broad-crested overflow weir, (3) Gatewell 5A during operation of the 14-inch orifice, (4) directly into the Juvenile Bypass Channel, or (5) onto the separator screen at the LGR juvenile fish facility (JFF). Travel time from release to detection at the LGR JFF was used to assess OPE and travel time differences between releases.
Juvenile Pacific lamprey were collected during Smolt Monitoring Program (SMP) sampling at LGR, LGS, and LMN and by using dip nets in Juvenile Bypass System (JBS) barge-loading raceways at LGR and LMN. All collected fish were transported to LGR for holding, tagging, and release. All lamprey were confined in perforated 5-gallon buckets during transportation as well as holding before and after tagging.

To determine collection efficiency for juvenile lamprey designated for recollection at the SxC system at LGR, three releases directly into the bypass channel were designated for recollection at the SxC system.

To assess differences in tag retention using two different tagging techniques, 75 fish were tagged with 9 mm L × 2.1 mm Dia. PIT tags using surgical methods described by Mesa et al. (2011). Briefly, a scalpel was used to create a 2-3 mm incision on the ventral side of the lamprey and the tag was manually inserted into the body cavity. In addition, 75 fish were tagged with 8.5 mm L x 1.4 mm Dia PIT tags by injecting the tag using a 16-gauge needle, and 50 fish served as a control group. All fish were held for 96 h then examined and photographed. Finally, fish were released onto the separator screen at the LGR JFF to assess detection efficiency of the two sizes of tags.

Results/Management Action
Among lamprey release locations, fish released during operation of the weir and 14-inch diameter orifice had lower residence times than fish released during operation of the 10-inch diameter orifice or directly into the bypass channel. Differences in mean residence time were small (<12 min) but statistically significant for most pair-wise comparisons of release locations. Among releases into the gatewells, the greatest difference in mean residence time was between fish released during operation of the 14-inch orifice and those released during operation of the 10-inch orifice (7.5 min).

Juvenile lamprey were collected by SMP staff at LGR, LGS, and LMN. However, dip netting in the barge-loading raceways was the most productive collection method. At LMN lamprey were collected during barge loading after juvenile salmonids were crowded out of the raceways and also during the night when free-swimming macropthalmia were observed. At LGR, lamprey were collected from the head boxes of both the east and west raceways with dip nets. Collection efforts began near the peak of the freshet. While we had some success, we would have collected additional fish by starting at the first indication of their presence in the JBSs.

Eighty-six percent of juvenile lamprey designated for recollection at the SxC system (129 of 150) were detected at the SxC gate. We recovered 98 individuals from the SxC tank within the specified net partition.

No mortalities occurred during the 96 h holding period for fish tagged as part of the tag retention comparison. The group tagged with 16-gauge needles and 8.5 mm L x 1.4 mm Dia PITs had no shed tags and only 5.6% had unhealed tagging wounds at the end of the 96 hour period. The group tagged with scalpels and 9 mm L × 2.1 mm Dia. PITs had two shed tags and 66.7% had unhealed tagging wounds. Ninety-seven percent of each group was detected after release onto the separator at the LGR JFF.
Evaluation of the Effect of McNary Dam Operating Gate Position on Fish Guidance Efficiency

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Background
This project examined the effect of operating gate positions and turbine discharge on fish guidance efficiency (FGE) for juvenile salmonids at McNary Dam. The current practice of placing operating gates in a partially raised position is intended to increase FGE, but also delays deployment of those gates in an emergency situation. The objectives addressed in this study were to: (1) Test for significant differences in FGE at two pairs of turbine units at McNary Dam under two turbine intake gate storage positions (partially raised operating gate and stored operating gate) and two turbine operations (peak and upper 1%); and (2) Evaluate the effects of measured FGE on overall dam passage survival as it relates to BiOp requirements.

Methods
We used fixed aspect hydroacoustic techniques to estimate the number of juvenile salmonids entering turbines, guided by the extended-length submersible bar screens (ESBS), and passing through the gap at the top of the screen for two pairs of turbine units. FGE is the proportion of total passage guided by the screens. Experimental treatments included a stored operating gate (SOG) versus a partially raised operating gate (PROG) and turbine discharge levels near peak efficiency (Peak) and operation near the upper range within 1% of peak efficiency (Upper 1%). Treatments were applied in a stratified random design with operating gate treatment differing among units within each pair and turbine unit discharge treatment differing among pairs. A General Linear Modeling (GLM) approach was used to evaluate the influence of treatments and additional covariates on FGE.

Results/Management Action
Diel period (day or night), project discharge, spill percent, turbine discharge treatment, and temperature were statistically significant (p < 0.05, univariate F statistic) terms in the GLM model of variation in FGE during the spring passage season. Least squares means of FGE estimated with other variables set at their mean value were approximately 3.7% higher for the Upper 1% treatment than for the Peak treatment in the spring. Operating gate position treatments did not differ significantly, with the least squares mean FGE for SOG estimated at 1.2% greater than for PROG in the spring. This result is not consistent with the expectation of higher FGE under the PROG treatment.

Diel period, dissolved gas, operating gate position treatment, spill percent and block were statistically significant terms during the summer passage season. Although FGE differed significantly between the operating gate position treatments, FGE was found to be approximately 2.4% higher for the SOG treatment. This difference is not large, but it contrasts with the expectation of higher FGE under the PROG treatment.

Results indicated that a variety of factors affected FGE at McNary Dam in each passage season, including turbine unit discharge treatment during the spring period and the operating gate position treatment in summer. The most important finding was that the partially raised position (PROG) did not increase FGE relative to the stored position (SOG). This finding suggests that operating gates could be stored in the position that allows rapid emergency deployment without decreasing FGE or reducing the ability to meet survival goals set forth in the Biological Opinion.
Juvenile Bypass System Selectivity at FCRPS Dams

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Background
Smolt-to-adult returns (SARs) have generally been lower for fish that pass dams via juvenile bypass systems than for those that pass via other routes (spillway/turbine). A hypothesized explanation for this pattern is that bypassed fish are not a random sample of the general population of fish approaching the dam; i.e., that bypass systems are selective for fish that have lower survival. Bypass selectivity has become a major question over the past several years, leading to numerous analyses of available historical data. During the planning for our 2013 BPA-funded reach survival study, we decided to collect an expanded range of morphometric and condition data, based on the work of Hostetter et al. (2011). For the survival study, we will explore the data to explain estimated survival probabilities. In addition, the data can be used to investigate bypass selectivity. Here we present our first quick look at the data relative to bypass selectivity.

Methods
During the PIT-tagging process, fish can be measured to fork length, weighed, and have external condition comments recorded. Using Hostetter et al. (2011) as a guide, we recorded the following external conditions, adipose fin clip, fin erosion, body injury, disease, parasites, and descaling. We also developed a grading system, based on the guidelines established in Hostetter et al. (2011), for each condition, allowing us to assign a grade of Good, Fair, or Poor to each fish. Normally, only a small number of poor-quality fish are admitted to the tagging process. We modified our sorting criteria to increase the sample size of Poor fish, knowing that some would be adversely affected by the tagging process. Because these fish were tagged for the survival study, and not for a directed bypass selectivity study, we kept the number of these fish to a small percentage of the overall tag numbers.

We PIT-tagged wild yearling Chinook salmon smolts and wild and hatchery steelhead smolts at Lower Granite Dam during the spring of 2013. We held fish for 24 hours after tagging, and then released them to the tailrace. At the end of the outmigration we estimated the detection probability (i.e., the probability of entering the juvenile bypass system) of the three grades of fish at each detector dam and the trawl.

Results/Management Actions
Fish in the Poor and Fair groups were generally bypassed at higher rates than fish in the Good category, except at Ice Harbor. In the future we will analyze the data at a finer level of resolution than the three overall grades, to investigate the effect of individual physical characteristics.
AVIAN PREDATION STUDIES
Pre-Management Status of Caspian Tern Colonies in the Columbia Plateau Region: Foraging Behavior, Connectivity, and Reliance on Juvenile Salmonids

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Background
Caspian terns have been identified as the single most significant (per capita) avian predator on the juveniles of ESA-listed steelhead populations in the Columbia Plateau region. As part of a comprehensive multi-year study, we conducted research to assess the impact of this bird species on the survival of out-migrating smolts from the Columbia and Snake rivers. Presented here are our research findings for the 2013 breeding season.

Results/Management Action
Total numbers of Caspian terns nesting in the Columbia Plateau region declined from ca. 870 breeding pairs during 2005-2012 to ca. 775 breeding pairs in 2013, and were distributed among five colonies. The two largest colonies were at Crescent Island (395 breeding pairs) in the mid-Columbia River and at Goose Island (340 breeding pairs) in Potholes Reservoir, WA. The size of both these Caspian tern colonies declined from 2012 to 2013, but nesting success at both colonies was higher. A small number of Caspian terns (26 breeding pairs) established nests at the Blalock Islands, but with limited nesting success. We observed a small number of banded terns that originally nested on East Sand Island in the Columbia River estuary, where management actions have been implemented, at the Goose Island (n = 1) and Crescent Island (n = 4) colonies in 2013. Prior to 2011, when tern management intensified at East Sand Island, movement to the Columbia Plateau region by banded Caspian terns that previously nested on East Sand Island had not been documented. Relocation of Caspian terns from East Sand Island to Columbia Plateau colonies could off-set benefits to salmonids of tern management in the estuary because per capita impacts on smolt survival are higher for terns nesting in the Columbia Plateau region relative to those nesting in the estuary, where their diet is dominated by marine forage fishes.

Predation rate estimates based on PIT tag recoveries on Caspian tern colonies indicated that impacts were again highest on upper Columbia River steelhead smolts (14.9% depredated by Goose Island terns) and Snake River steelhead smolts (2.8% by Crescent Island terns). Predation rates at the small Caspian tern colony in the Blalock Islands were an order of magnitude less than those of terns nesting at Goose and Crescent islands, but steelhead were still highly susceptible to terns from this colony. The predation rate of terns nesting at the Blalock Islands on steelhead smolts could be of concern to managers if the colony were to increase in size as a result of ongoing and/or prospective management actions elsewhere.

A total of 23 Caspian terns nesting at Goose Island were marked with GPS tags and tracked during foraging trips over several days. Nearly half of the GPS-tagged terns (n = 11) made foraging trips to the mid-Columbia River, including Wanapum Reservoir, Priest Rapids Reservoir, and Hanford Reach. Surprisingly, four GPS-tagged terns made foraging trips to the lower Snake River, including one tern that exhibited the greatest foraging range ever documented in a breeding Caspian tern: 93 km straight-line distance from the colony.

Management of the Caspian tern colonies at Goose and Crescent islands to reduce their impacts on ESA-listed salmonids is currently under consideration. Band re-sighting data indicate high connectivity among tern nesting sites in the Columbia Plateau region and colonies elsewhere in western North America, from Mexico to Alaska, both inland and along the coast. This suggests that terns displaced from these two Columbia Plateau colonies may re-nest at existing or newly-created colony sites outside the Columbia River basin.
Impact of Gull Predation on Smolt Survival in the Columbia Plateau Region: Understanding What On-colony PIT Tag Recoveries Can Tell Us

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Background/Methods
Studies that recover fish tags from piscivorous waterbird colonies produce minimum estimates of predation because an unknown and unaccounted for proportion of tags implanted in fish and consumed by birds are deposited at off-colony areas or are damaged and rendered unreadable during digestion. PIT tag studies conducted at Caspian tern and double-crested cormorant colonies indicated that on-colony deposition rates were 71% and 43%, respectively. Data on PIT tag deposition rates for nesting gulls, the most numerous piscivorous colonial waterbird in the Columbia River basin, however, are lacking. To address this information gap and to broaden our understanding of the impact of gulls on anadromous juvenile salmonids, we conducted a study to quantify on-colony PIT tag deposition rates at four California gull colonies in the Columbia Plateau region during the 2013 nesting season: Miller Rocks (The Dalles Reservoir), Blalock Islands (John Day Reservoir), Crescent Island (McNary Reservoir) and Island 20 (Hanford Reach of the middle Columbia River). Studies were conducted by offering nesting gulls hatchery trout containing PIT tags with known tag codes (n = 1,201, or ca. 300 tags per colony) throughout the nesting season, and then recovering tags following the nesting season to quantify on-colony deposition rates. Data from deposition rate studies and tags from anadromous juvenile salmonids that were detected on-colony after the nesting season were then used to generate best estimates of predation rates by gulls nesting at these four colonies in 2013.

Results/Management Action
PIT tag deposition rates by California gulls were significantly lower than those of Caspian terns and double-crested cormorants, with average annual on-colony deposition rates of just 16% (95% CI = 14-19%). Annual deposition rates were similar among gull colonies, ranging from 14% (95% CI = 10-20%) at Crescent Island to 20% (95% CI = 15-25%) at Miller Rocks Island. On-colony deposition rates were not influenced by the time-of-day (morning, afternoon) that a PIT-tagged fish was ingested by a nesting gull. Deposition rates tended to vary across the season, however, with late season deposition rates generally highest. An independent study using both polyolefin-encapsulated PIT tags and standard glass PIT tags indicates that damage to standard PIT tags during digestion was a primary factor in low on-colony deposition rates, with at least 38% of ingested standard PIT tags rendered unreadable following digestion in a gull’s gastrointestinal tract.

Incorporation of on-colony deposition rates into predation rate models increased the estimates of predation rates on juvenile salmonids by a factor of 6.2 for California gulls, compared to previously published estimates. After adjusting for on-colony deposition rate, juvenile salmonid predation rates varied significantly by ESU and colony location (range: <0.1% to 8.5%), with gulls nesting on Miller Rock and Crescent Island having a much greater impact on smolt survival compared to gulls nesting on Island 20 and the Blalock Islands. Results of this study indicate that on-colony deposition rates and predation rates vary substantially among bird species and colonies. Models that incorporate on-colony PIT tag deposition rates will provide more accurate and reliable estimates of avian predation rates on populations of tagged fish.
Monitoring Avian Predators at Corps FCRPS Dams: Development and Implementation of a Standardized Data Collection Protocol

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Background
The 2008/2010 Federal Columbia River Power System Biological Opinion requires the Corps to monitor and respond to avian predators at its dams to protect ESA listed salmonids. While there is a long history of monitoring bird abundance at Corps dams efforts have been site specific, slightly changing from dam-to-dam making them difficult to compare.

In 2013, the Fish Field Unit continued development and implementation of a standardized protocol with the Corps project staff training multiple observers, at multiple dams, to collect and upload data to a centralized database. The results are comparable both within and between dams and can be accessed, managed, and analyzed in real time via a web based portal; a secure online data hub used to manage survey data. Our objectives were to: 1) Provide site-specific training at each dam, 2) Maintain standard avian observation protocols to provide comparable data between the eight US Army Corps Columbia and Snake River dams, 3) Provide data collection devices or data sheets and a centralized database to collect data, 4) Summarize the results of this effort in the form of a data report.

Methods
We worked with project biologists, technicians, and other trained observers to standardize data collection methods (via protocol and data forms) for monitoring the number, location (zone), and behavior (foraging, resting, scavenging, or fly-by) of nine piscivorous bird species at eight dams. Site-specific coordination consisted of developing zone maps and counting methods resulting in a written standardized protocol applicable to all participants. For this presentation, means were calculated from 1 April to 31 July 2013 by species and behavior. During this time, the bulk of outmigrating juvenile salmonids and juvenile lamprey moved past the dams.

Results
Data collection was managed through either electronic devices (tablet PCs) or paper datasheets entered manually to the online data portal. Analysis was standardized by applying methods developed in previous FFU studies and are presented in graphical form for comparisons of dams and years. Predatory bird abundance at the dams was similar to last year. The Dalles and McNary had the highest number (by foraging behavior or all behaviors combined). Ice Harbor had the next highest number of foraging birds, while Bonneville, and John Day Dams on the Columbia River and Lower Monumental, Little Goose, and Lower Granite Dams on the Snake River had similar numbers of birds.
Implementation of the Caspian Tern Management Plan: Status of Tern Colonies in the Columbia River Estuary and at Corps-constructed Colony Sites

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Background
We continued field studies in 2013 to (1) assess the impact of Caspian tern predation on survival of juvenile salmonids in the Columbia River estuary and (2) monitor the efficacy of on-going Caspian tern management designed to reduce their impact on smolt survival in the estuary.

Results/Management Action
In 2013, the U.S. Army Corps of Engineers, Portland District (Corps) maintained 1.58 acres of suitable nesting habitat for Caspian terns on East Sand Island, the same area of habitat as in 2012 and 32% of the area provided during 2001-2007. The Caspian tern colony on East Sand Island, the largest for the species in the world, consisted of about 7,400 breeding pairs in 2013. This is an increase from the estimate of 6,400 pairs in 2012, and the first increase since the initiation of habitat reduction on East Sand Island in 2008. In addition to the increase in colony size, terns were more resilient to disturbances by bald eagles and associated gull depredation on tern eggs and chicks compared to 2010-2012. The Caspian tern colony on East Sand Island produced about 1,480 fledglings in 2013 (average of 0.20 young/breeding pair), a significant increase from 2010-2012 (average of 0 - 0.06 young raised/breeding pair), but lower than in other years during 2001-2009. The proportion of juvenile salmonids in tern diets and the estimated consumption of smolts by terns nesting at East Sand Island in 2013 are not yet available. The estimated smolt consumption by terns nesting at East Sand Island in 2012 was 4.9 million (95% CI: 3.9 - 5.8 million).

Caspian tern management actions continued in 2013. The restriction of nesting habitat on East Sand Island to 1.58 acres caused Caspian terns to nest at an average density of 1.17 nests/m², an increase from 1.06 nests/m² in 2012, and the highest tern nesting density observed in the Columbia River estuary. Several hundred pairs of Caspian terns attempted to nest on the upper beach of East Sand Island, in three discrete satellite colonies adjacent to the 1.58-acre area of designated tern nesting habitat, but none successfully raised young. Passive measures used by the Corps to dissuade terns from nesting in the upper beach areas were effective in limiting the formation and size of satellite colonies.

The Corps has constructed nine islands as alternative Caspian tern nesting sites since early 2008, six in interior Oregon and three in the Upper Klamath Basin region of northeastern California. Seven of these islands were available for tern nesting in 2013, and five supported nesting Caspian terns. A combined total of over 1,100 breeding pairs of Caspian terns nested at the five alternative colony sites in 2013, a 50% increase from 2012. Estimated productivity was relatively low among the five sites, however, ranging from an average of 0 to 0.37 young raised/breeding pair. In 2013, mammalian and avian nest predators, negative interactions with other colonial waterbird species (i.e., California gulls, American white pelicans), apparent low forage fish availability, drought, or adverse weather conditions limited Caspian tern colony formation, size, and nesting success on one or more of the alternative colony sites. A substantial number of Caspian terns from the colony on East Sand Island in the Columbia River estuary, however, did use the alternative nesting sites created by the Corp; 57 terns originally banded in the Columbia River estuary were seen at the alternative sites in interior Oregon and 110 were seen at the alternative sites in the Upper Klamath Basin during the 2013 nesting season.
Ecological Developments at the Double-Crested Cormorant Colony on East Sand Island:
Status, Dispersal, Management Pilot Studies, and Implications for Salmonid Restoration


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Background
We continued field studies in 2013 to (1) monitor the breeding colony of double-crested cormorants on East Sand Island in the Columbia River estuary, (2) assess the impact of double-crested cormorant predation on survival of juvenile salmonids in the Columbia River estuary, (3) test management strategies to limit availability of nesting habitat for double-crested cormorants on East Sand Island, and (4) identify alternative colony sites where cormorants displaced from the East Sand Island colony might recruit back into the breeding population.

Results/Management Action
The double-crested cormorant colony on East Sand Island consisted of about 14,900 breeding pairs in 2013. This is the largest colony ever recorded on East Sand Island, and is about 15% larger than it was in 2011-2012. This one colony likely includes more than 40% of the breeding population of double-crested cormorants in western North America, and is the largest known breeding colony of the species anywhere. Juvenile salmonids represented about 10% of the double-crested cormorant diet (by biomass) in 2013, compared to 20% in 2012. Estimates of total smolt consumption (based on bioenergetics calculations) and stock-specific predation rates (based on PIT tag recoveries) by double-crested cormorants from the East Sand Island colony are not yet available for 2013. Estimated smolt consumption in 2012 was about 18.9 million, and population-specific predation rates for salmonid populations originating above Bonneville Dam ranged from ca. 0.6% to 7.2% of fish that survived to the estuary, depending on the salmonid population. In addition to double-crested cormorants, an estimated 1,550 pairs of Brandt’s cormorants nested in the cormorant colony on East Sand Island in 2013. Brandt’s cormorants first nested in this colony in 2006, and numbers increased each year through 2012, when 1,680 breeding pairs were counted.

In 2013, the USACE further expanded a pilot study initiated in 2011 to test possible strategies for limiting the size of the East Sand Island cormorant colony. Two eight-foot-high privacy fences were built to bisect the colony. These fences visually separated 4.0 acres of the available nesting area from the remainder of the former colony. Four acres is about 25% of the total area that was formerly available to cormorants for nesting at East Sand Island. We used human disturbance to haze cormorants during the nest initiation period and successfully dissuaded them from using areas outside the 4.0-acre designated area in 2013. Some cormorants were satellite-tagged (n = 83) to follow their post-hazing movements to prospective new nesting sites. About 96% of these tagged cormorants (80/83) dispersed from the East Sand Island colony after tagging, and of these about 96% eventually returned to East Sand Island (73/76) and attempted to nest there. Tagged cormorants dispersing from East Sand Island during the nesting season were detected at colonies and roost sites (1) in the Columbia River estuary (n = 76), (2) on the lower Columbia River below Bonneville Dam (n = 27), (3) the outer Washington coast (including Willapa Bay and Grays Harbor; n = 21), and (4) Puget Sound (n = 1). No cormorants satellite-tagged on East Sand Island early in the 2013 nesting season were detected along the coast of Oregon during the nesting season.
Measuring Impacts of Cormorant Predation on Smolt Survival in the Columbia River Estuary: Bioenergetics, PIT Tag Recoveries, and Potential Benefits from Cormorant Management


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Background/Methods
We synthesized results from annual field studies to provide a more robust understanding of the impact of double-crested cormorant predation on salmonid smolts in the Columbia River estuary. Predation impacts were assessed using bioenergetics-based estimates of smolt consumption at the species/age class level and PIT tag based predation rate estimates at the population or DPS/ESU-level. Potential benefits to salmonid DPS/ESUs (changes in the average annual population growth rate [λ]) were estimated if mortality rates were reduced under varying assumptions of compensatory mortality.

Results/Management Action
During 2004 – 2012, estimates of total annual smolt consumption by the East Sand Island double-crested cormorant colony have varied between 2.4 and 20.5 million smolts (mean = 11.9 million). The large inter-annual variability (CV = 52%) has occurred over a period of relatively stable colony size (10,950 – 13,750 breeding pairs; CV = 7%) and has closely tracked the proportion of the cormorant diet that was salmonid smolts (2 – 20% of biomass consumed; CV = 50%), an important input parameter in the bioenergetics calculations. Sub-yearling Chinook salmon were consumed in the largest numbers by cormorants (ca. 7.4 millions smolts/year) followed by coho, steelhead, and yearling Chinook (ca. 2.4, 1.1, and 1.0 million smolts/year respectively).

During 2007 – 2012, average annual predation rate estimates derived from PIT tag recoveries at the cormorant colony ranged from 7.7 – 9.8% for three steelhead DPSs, 1.9 – 4.8% for four Chinook ESUs, and 4.5% for the Snake River sockeye ESU (only ESA-listed DPS/ESUs originating upstream from Bonneville Dam and Sullivan Dam on the Willamette River were evaluated). Similar to smolt consumption estimates, DPS- and ESU-specific predation rate estimates were highly variable and differed by salmonid population and year (CVs ranged from 34 – 89%). Factors driving the large inter-annual variation in predation impacts (consumption and predation rates) are poorly understood but may include environmental conditions in the estuary, the abundance and arrival of marine forage fish in the estuary, differences in cormorant nesting chronology and success, and/or other biotic and abiotic factors that influence cormorant feeding behavior.

Potential increases in λ for complete elimination of predation on smolts by East Sand Island double-crested cormorants, assuming no other mortality factors would compensate for this reduction in predation, ranged from 0.4 – 1.1% for Chinook salmon ESUs originating upstream of Bonneville Dam or from the Upper Willamette Basin, was 1.6% for the Snake River sockeye salmon ESU, and ranged from 1.8 – 2.1% for steelhead DPSs originating upstream of Bonneville Dam. If a moderate level of compensatory smolt mortality (e.g., 50%) occurred in response to a complete elimination of mortality due to cormorant predation, benefits to λ would drop below 1% for Chinook and sockeye salmon ESUs, but remain 0.9 – 1.1% for steelhead DPSs. A two-thirds reduction in cormorant predation would produce similar levels of benefit for salmonids.
originating upstream of Bonneville Dam to those benefits projected for the ongoing management to reduce predation by Caspian terns nesting at East Sand Island.

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Background/Methods
Avian predation is one factor acknowledged to limit recovery of threatened and endangered Columbia River Basin salmon populations. Beginning in 1998, fisheries biologists have been estimating estuary avian predation impacts on PIT-tagged salmon and steelhead migrating through the Federal Columbia River Power System (FCRPS). Predation rate measurements are used to evaluate the effectiveness of actions intended to reduce avian predation impacts on juvenile salmon and steelhead migrating through the Columbia River Basin to the Pacific Ocean.

To calculate ESU- or DPS-specific predation impacts, we used electronic detection methods to compare PIT tag codes recovered from Caspian tern, double-crested cormorant, and Brandt’s cormorant nesting areas with codes from PIT-tagged fish releases and barge-transported vs. in-river migrant Snake River fall Chinook salmon. In 2012, we also experimentally tagged 8,885 Lower Columbia River fall Chinook salmon from Big Creek, Kalama Falls, and Warrenton High School hatcheries and released these fish directly into the estuary below Bonneville Dam.

Results/Management Action
On the Caspian tern colony, we recovered 15,298 tag codes from migration year 2012. On the cormorant colony, we recovered 13,829 tag codes from the same migration year. Codes from all ESU/DPS groups currently listed under the Endangered Species Act were detected. For fish originating above Bonneville Dam, Caspian terns had the greatest impact on steelhead DPSs (7.4%-10%), with lesser impacts on other salmon ESUs (0.7%-2.2%). Double-crested cormorants had the greatest impact on Upper Columbia River steelhead (7.2%), with a range of impacts on other populations (0.6%-5.4%). Brandt’s cormorants appeared to have minimal impact on any population groups we examined (<1%). In general, of the groups we evaluated, Upper Willamette spring Chinook salmon experienced the least predation impact (<1%).

In our experimentally tagged subyearling Lower Columbia River fall Chinook salmon, Caspian terns consumed a minimum of 2.6% of tagged fish, whereas double-crested cormorants consumed a minimum of 14.9% of these fish. Brandt’s cormorants consumed 0.1% of tagged fish. Fifty-two different sources (including our experimental groups) contributed to PIT-tagged fish in 2012, but three national fish hatcheries above Bonneville Dam (Carson, Little White Salmon, and Spring Creek) accounted for 66.3% of tagged fish released into the river. Based on these skewed tag distributions, we estimated overall minimum predation rates to be 0.9% for Caspian terns, 2.9% for double-crested cormorants, and 0.2% for Brandt’s cormorants.
However, our experimental tags indicated that consumption rates can be much higher on specific sub-groups within this diverse ESU.

For Snake River fall Chinook salmon, paired comparisons of fish entering the river below Bonneville Dam on the same calendar day showed minimum predation impacts by Caspian terns and Brandt’s cormorants to be relatively low for both barged fish (0.7% and 0.03%, respectively) and in-river migrants (0.47% and 0.13%, respectively). There was no statistically significant difference among minimum predation impacts. Minimum predation impacts by double-crested cormorants were significantly higher on barged fish (2.71%) compared to in-river migrants (0.97%). These results suggest that for this ESU in 2012, barging may not have been an effective tool for decreasing estuary avian predation.

Overall, data continue to support the present understanding that (1) ESA-listed salmonid populations are affected by estuary avian predation to varying degrees (2) Caspian terns have the greatest impact on steelhead from above Bonneville Dam (3) double-crested cormorant impacts are highly variable both within season and among ESU/DPS populations and sub-populations, and (4) Brandt’s cormorants are unlikely to be having any biologically significant impact on salmon or steelhead. Understanding the causes of variation in double-crested cormorant predation will require quantifying the relationships between variation in predation impacts and the physical and biological factors in the estuary which affect fish vulnerability to predation (e.g. river flow, the distribution and abundance of alternative prey).
Juvenile Salmon and Associated Fish Community in Open Waters of the Lower Columbia Estuary: What Have We Learned?

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Background
As part of ocean studies of juvenile salmon, the NWFSC has been sampling juvenile salmon immediately before ocean entry in the lower Columbia estuary since 2007. The primary objective is to document the spring outmigration of juvenile salmon (abundance, timing, geographic origin, production type), including evaluating juvenile salmon “condition” (i.e., size, food habits, health). Because most fish caught by the study are non-salmonids, the study also documents the abundance and composition of the entire estuarine fish community.

Methods
We use a purse seine to sample juvenile salmon and associated fishes adjacent to the two deep channels in the lower Columbia estuary. Sampling occurs every other week from mid-April until late June, and monthly throughout the summer. Juvenile salmon origins are determined from internal tags (all species) and genetics (Chinook and steelhead), while production type (hatchery/wild) is based on fin clips and tags. We have compared salmon in the estuary to those caught in marine waters to estimate initial marine growth rates and the influence of ocean entry timing on growth opportunity. We also used “natural experiments” caused by abrupt changes in river flow that affect the fish community to explore the relationship between the abundance of non-salmonids and predation by avian predators.

Results/Management Action
We provide highlights of what we’ve learned from 7 years (2007-2013) of systematic spring sampling in the Columbia estuary. We have observed a predictable migration of juvenile salmon through the estuary, with a peak in mid May for coho, yearling Chinook and steelhead, and mid-summer for subyearling Chinook. Based on fin clips, most (>90%) juvenile salmon are of hatchery origin. Salmon caught in migratory corridors by our study are quite different than those caught in nearby shallow habitats, with respect to geographic origins, size, and production type. We have also observed stock-specific variation in both size and timing in the estuary: lower Columbia and Willamette River stocks are generally earlier than mid and upper Columbia and Snake River stocks, while hatchery fish are larger than wild fish. When caught in marine waters, stocks with early timing have grown more than those with later timing, which likely influences their survival. We have observed that high flow events decrease the abundance and species diversity of the larger estuarine fish community, which is often associated with above-average predation on salmon by avian predators. This relationship indicates the importance of this larger community as a buffer for salmon predation.
PASSAGE & SURVIVAL STUDIES
The Use of PIT Tag Data to Refine Estimates of Sockeye Escapement in 2012

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Background
This multi-year project was begun by CRITFC in 2006 to PIT tag adult sockeye and Chinook salmon at Bonneville Dam and track them upstream to estimate survival rates and passage parameters. The work was expanded by the Accords in 2009 to add steelhead as well as funding genetics samples collected while sampling and tagging sockeye. In addition, the Accords funded a project to examine factors limiting production of Wenatchee and Okanogan sockeye salmon. This project funded additional PIT tagging at Wells Dam, PIT tag antenna arrays in the Okanagan Basin, as well as an acoustic tagging program focused on Okanogan sockeye salmon. The result has been a detailed record of Wenatchee and Okanogan sockeye survival on the upstream migration from Bonneville Dam to the spawning grounds.

Methods
Adult sockeye salmon are PIT tagged at Bonneville and Wells dams and tracked as they pass through PIT tag antennas at Columbia Basin mainstem dam PIT arrays as well as PIT arrays at Tumwater Dam in the Wenatchee River and Zosel Dam and a PIT tag array (OKC) immediately downstream of the spawning grounds in the Okanogan Basin. In addition, sockeye salmon are acoustic tagged at Wells Dam and tracked through Wells Pool as well as the Okanogan Basin.

Using this dataset, we estimated the percent of sockeye missed and fallback numbers at mainstem dams as well as survival on the upstream migration. From this data, mark-recapture techniques were used to estimate escapement to Columbia River dams with PIT detection which is then compared to visual counts. Escapement estimate were extended into terminal areas through the use of PIT tag detections at Tumwater Dam in the Wenatchee River as well as our OKC site and acoustic detections in the Okanogan River.

We also estimate the stock composition of the run based on both PIT tag detections in terminal areas as well as data from genetics analyses.

Results
In 2012, our estimates of escapement at mainstem dams with PIT tag detection varied from 16.1% greater than the visual count at McNary Dam to 11.7% less than the visual count at Rocky Reach Dam. The visual count at Rocky Reach Dam was likely inflated by a high fallback rate of 8.2% as estimated from PIT tag detections. Of the record run of over 500,000 sockeye, we estimated that 32.6% were harvested and 25.6% made it to terminal areas, with the remaining 41.8% unaccounted for. Highest rates of unaccounted sockeye were in terminal areas above Wells and Tumwater dams as well as between Bonneville and McNary dams.

The estimated stock composition at Bonneville Dam based on genetic stock identification (GSI) was 80.3% Okanogan, 19.6% Wenatchee, and 0.1% Snake River. GSI upstream survival estimates to Rock Island Dam were 75.5% for the Okanogan Stock, 64.3% for the Wenatchee stock, and 0.0% for the Snake River stock. Estimated stock composition at Rock Island Dam based on genetics was 82.1% Okanogan and 17.9% Wenatchee compared to an estimate based on PIT tag detections of 83.4% Okanogan and 17.6% Wenatchee.
Systematic Review of JSATS Passage and Survival Data at Bonneville Dam during Alternate Turbine and Spillbay Operations from 2008-2012

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The Turbine Survival Program, using hydraulic models, has been working to identify the best operating point for turbine units at hydroelectric projects that reduces the probability of mortal injury for fish. Additionally, there have been questions relative to spillway survival. For example, at Bonneville Dam (BON) where survival studies over the last several years have indicated that survival through the spillway is lower than other routes at BON possibly due to erosion of the stilling basin and the ogees in several spill bays or movement and accumulation of rock may be reducing survival. In addition, high river flows in recent years have forced spill at The Dalles Dam (TDA) outside of the new tailrace spill wall. Regionally, managers are concerned that these environmental conditions may have lead to a reduction in southeast spillway fish passage survival.

From 2008 through 2012, the USACE Portland District funded acoustic telemetry studies at BON and TDA to evaluate fish passage behavior and survival. Although the primary purpose of these studies was to estimate survival and passage time additional processing and analysis of these large datasets can be used to answer other relevant management questions. Using these multiyear datasets we evaluated survival of juvenile salmon passing through the turbines at BON powerhouse 1 and 2 over the turbine operating ranges to identify the best operating conditions of the turbine units to provide juvenile salmonids with the safest and most efficient passage conditions. We also estimated survival by bay, and groups of bays, at the BON spillway to determine if survival was worse in certain regions of the spillway due to erosion or other factors. At the TDA spillway we compared survival estimates of juvenile salmon passing the spillway within the spill wall (bays 1-8) to those passing outside of the spill wall (bays 9-23). Survival was also evaluated relative to spill discharge through both spillways.
Lower Snake River Performance Standards Assessments 2013: Experimental Design and Methods

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To determine whether Little Goose and Lower Monumental dams on the lower Snake River were in compliance with performance standards set forth in the 2008 BiOp and Fish Accords, a study using the virtual/paired-release design with acoustic telemetry technology was conducted in the summer of 2013. To conduct this study with the required precision levels, fish were collected and surgically implanted with a Juvenile Salmon Acoustic Telemetry System (JSATS) acoustic transmitter and a PIT tag at Lower Monumental Dam. Low percentages of the fish available for tagging were not used based on the established rejection criteria and the fish tagged were typically representative of the run-at-large. Slightly more than 11,000 subyearling Chinook salmon were tagged and released at five different locations between Central Ferry (river kilometer (rkm) 133) and Snake River Road (rkm 40). Releases were conducted during daylight and darkness and were timed to achieve mixing in the tailraces of the dams. To detect tagged fish, cabled receiver systems were deployed on the upstream dam-face to provide high detection probabilities and detailed information on routes of passage at the dams. In addition, autonomous receivers were deployed in arrays in dam forebays and tailraces to provide further detection data to support the survival estimation and for determination of metrics specified in the Fish Accords. Quality control measures throughout the field and data analyses portions of the project ensured that the results are reliable.
Results of Snake River Survival Compliance Studies for 2013

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An integrated study was performed at Little Goose and Lower Monumental dams to estimate dam passage survival as specified in the 2008 BiOp. The summer study estimated survival for subyearling Chinook salmon through the two dams. A total of 11,003 acoustic-tagged smolts were used in the joint two-dam study for subyearling Chinook salmon. The assumptions of the virtual/paired-release design used in estimating dam passage survival were met for both studies. The estimate of dam passage survival for the subyearling Chinook salmon at Little Goose was 0.9076 (SE = 0.0139) and 0.9297 (SE = 0.0105) at Lower Monumental Dam. The 2008 BiOp standard for summer stocks is $S_{\text{Dam}} \geq 0.93$ with a SE $\leq 0.015$. This was the second year of compliance testing at these two Snake River projects.
Route-Specific Passage and Survival for Subyearling Chinook Salmon at Little Goose and Lower Monumental Dams, 2013

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The second year of a dam passage survival study was conducted to determine whether Lower Monumental (LMN) and Little Goose (LGS) dams were in compliance with performance standards set forth in the 2008 Biological Opinion and Fish Accords for subyearling Chinook salmon. Just over 11,000 subyearling Chinook salmon were implanted with Juvenile Salmon Acoustic Telemetry System (JSATS) acoustic transmitters and released alive at one of five locations between June 3 and July 6, 2013 to implement the virtual/paired-release survival study design. Receiving systems deployed on the dams (cabled systems) and in the river and reservoirs (autonomous systems) were used to record detections of tagged fish. Fish detection data were used to assign fish to dam passage routes and estimate route-specific survival. The majority of subyearling Chinook salmon passed LGS (65%) and LMN (68%) via the spillway weir. The next most commonly used routes were through the juvenile bypass system (JBS) at LGS (18%) and through traditional deep spill routes at LMN (21%). Only about 5% of subyearling Chinook salmon passed through the turbines at both LGS and LMN. At LGS, survival was 91% for subyearling Chinook salmon that passed via the spillway weir or deep spill routes, 90% through the JBS, and 84% through the turbines. At LMN, survival was 94% for fish that passed via the spillway weir, 92% through deep spill routes, and 84% through turbines. Similar to 2012, survival through the LMN JBS, with its recently completed new bypass outfall, was high (96%). However, only 6% of tagged fish passed LMN via the JBS in 2013.
Investigate Juvenile Fish Impingement on the Oregon Shore Fish Ladder Screens and Fingerling Bypass Ports at McNary Dam

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Background
The Oregon shore fishway intake at McNary Dam is screened by two traveling screens that were installed as part of the original construction of the dam. Both screens were replaced with in-kind machinery prior to the start of the fish passage season in early 2011. There is also an existing fingerling bypass structure of the same age associated with these screens. As these structures were constructed in the 1950's they are no longer in compliance with screen criteria for Endangered Species Act (ESA)-listed salmonids that pass the project. As a result, studies were conducted to evaluate fish presence in the immediate vicinity of the screens to ascertain whether fish are being impinged. This study also monitored the conveyance and egress performance of the system as the fingerling bypass ports.

In 2011 juvenile salmon, lamprey, and other species were observed in-situ at the site with both hydroacoustics (in front of the intake) and infrared video (at the screen). Split-beam hydroacoustics in front of the intake showed that fish were consistently present and abundant directly in front of the intake, but not drawn into the intake by entraining flows. Optical infrared cameras recorded fish in front of the rotating screens. These were mostly (72%) juvenile salmonids, but a significant proportion of the observations were of juvenile lamprey (10%) and adult smallmouth bass (17%). Topics not addressed in the first year study relating to the fate of these fish and the efficacy of the existing fingerling bypass system were deferred pending the validated presence of species of concern.

This second monitoring study complements the first year by replacing hydroacoustics with an examination of fingerling bypass efficiency. The first components of the bypass encountered by fish are 50 (25 on each side) 6-in. diameter orifices along each outer wall just upstream of the screen. Each column of orifices is connected with a shaft that feeds into two pipes (one 22 in. and one 24 in. diameter) that flow downstream. These two pipes then converge into a 30-in. diameter pipe before exiting into a small chamber built into the side of the fish ladder that empties into the ladder below the adult exits. The exit chamber has bars that prevent entry of adults, but juveniles passing through the fingerling bypass are emptied into the adult fish ladder at this point—theoretically.

Methods
Four underwater infrared cameras were used to monitor for impingement at the traveling screens (two screens and at two elevations) in the same configuration as in 2011. Four additional infrared cameras were strategically placed at the terminal end of the 30-in. bypass conveyance pipe. This was the logical choice of locations for determining whether or not fish were using the ports as this location sampled the result of all 50 ports and the conveyances from just two points. It was also preferable to sample at the pipe terminus rather than at the bars separating the egress area from the fishway because the large bar surface area would presumably be prone to extra fish meandering with the concomitant reduction in water velocity.
Results/Management Action
Fewer juvenile fish were observed directly in front of the intake screens in 2013. This is an indication of the high variability of this system. The quantity of fish, the species composition, debris loading, etc, all showed differences from 2013. So few juvenile fish were in front of the screens in 2011 compared to 2013 that it is difficult to infer with certainty how much juvenile fish utilize the bypass system. Fewer fish in front of the screens meant that fewer fish would have been available to encounter and then enter the bypass system. There are also only two sample points (years) of results which make it difficult to know which or both of these situations are normal given such variability.

Both adult shad and adult lamprey dominated video observations at the bypass pipe exit. Beginning in May, all of June, and most of July video events were mainly of adult shad making repeated attempts to ascend the bypass exit pipe. Adult lamprey were also present at the exit beginning the latter portion of June. By the end of July and throughout August, multiple adult lamprey could be counted on at both exits every day. Lamprey would make repeated attempts to ascend the bypass exit pipe. They would also attach and rest at the edge of the pipe, especially during the daytime.

Given that the Pacific lamprey is a species of concern in the Columbia River basin, these findings are significant. Given the relatively low numbers that are counted going by the McNary Dam count station, these findings are very significant. The bypass exit area can be a significant source of delay for adult Pacific lamprey and is a functional dead end for upstream migrants. In terms of improving the biological performance of the fishway system, the pursuit of a technical solution is recommended. We hope this research leads to a discussion of configuration options that would improve the operation of McNary Dam for anadromous fish populations. The spectrum of options range from making structural hydraulic and screening improvements to the egress area all the way to permanently sealing the fingerling bypass—if the bypass is not utilized by juveniles. It is possible that this route is more important in years in which substantially more juveniles are present in front of the screens. A definitive answer may not be possible yet given the limited data to date.
Performance Evaluation of Fish Response to a Prototype Forebay PIT-tag Detection System

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Background
The main focus of developing surface passage PIT-tag detection is associated with the Lower Granite Dam Removable Spillway Weir. The corner collector at the 2nd Powerhouse of Bonneville Dam (B2CC) is an ideal location to field test the proof of concept for a full size hydrofoil PIT-tag system due to existing infrastructure, ease of installation, and cost savings. The evaluation will include three factors: 1) physical performance of the prototype, 2) PIT-tag detection, and 3) fish response assessments to the prototype.

Methods
We tested PIT-tag antennas positioned in the proposed configuration to determine interaction among coils. Each antenna was controlled by an auto-tuning Biomark IS1001 reader and read range of a 12-mm FDX-B tag was determined while the readers/antennas were synchronized and multiplexed. Tests were conducted at Bonneville Dam and at Biomark’s screen room. In February 2014, four hydrofoils, each containing two antennas, will be installed upstream of the entrance to the B2CC. Structural and detection performance will be evaluated in March 2014. Fish behavior will be evaluated using DIDSON sonar with the hydrofoils in-place (March) and removed (April).

Results
The primary challenge of designing the PIT-tag array is the synchronization of antennas in the array and coordination of the switching sequence. We tested various configurations or positioning of the antennas, within the limits of the planned structural support frame, to reduce coupling of the antennas. Coupling of antennas can lead to decreased performance by generating ‘noise’ within the system and increase the potential for tag collision.
Development and Performance Evaluation of an Injectable Micro-Acoustic Transmitter

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Acoustic telemetry has been identified as a technology for observation of behavior and assessment of survival for juvenile Chinook salmon passing through the Federal Columbia River Power System. Although the transmitter mass meets current tag burden guidelines for most yearling Chinook salmon, reduction in size would reduce the possibility of adverse effects of implantation and would likely provide additional biological benefits for tagged fish. The current transmitter is too large for smaller juvenile Chinook salmon, particularly those found in the lower Columbia River and estuary that enter the river downstream of Bonneville Dam. At the request of the U.S. Army Corps of Engineers, Portland District, we developed a downsized transmitter that could meet weight and volume targets for implantation by injection by designing an efficient integrated circuit, micro-battery and PZT ceramics transducer.

The performance of the newly developed transmitter in the field environment was also evaluated to provide assurance that the new transmitter would function as designed both during implantation and following release of implanted fish prior to its full implementation in field studies in the Snake, Columbia, and Willamette rivers. About 700 run-of-river subyearling Chinook salmon were tagged with the injectable transmitter at Lower Monumental Dam and released at Central Ferry (SR rkm 133) between late June and early July. The Snake River multi-dam performance study fish implanted with regular transmitters released at Central Ferry during the same period were used as the control fish for this study. Preliminary results show that single reach survival rates of fish tagged with the injectable tag are better than those of the fish tagged with regular transmitters at every downstream array and the difference became statistically significant starting at the autonomous array (SR rkm 68) in the forebay of Lower Monumental Dam.
Determining the Minimum Size Threshold for Implantation of the JSATS Injectable Tag in Juvenile Salmonids

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ABSTRACT
The miniaturization of acoustic transmitters may allow greater flexibility in terms of the size of fish available to tag. New downsized injectable acoustic tags similar in shape to passive integrated transponder tags can be rapidly injected rather than surgically implanted through a sutured incision. Before wide-scale field use of these injectable transmitters, standard protocols to ensure the most effective and least damaging methods of implantation must be developed, as well as guidelines for the minimum size fish that should be implanted. Initial work consisted of examining three implantation methods in various sizes of juvenile Chinook salmon. Methods included a needle bevel-down injection, a needle bevel-up injection with a 90-degree rotation, and tag implantation through an unsutured incision. Wound area was significantly reduced among fish tagged via an incision. The bevel-up injection had the worst results in terms of tag loss and wound area and also resulted in high mortality. Data suggest that the unsutured incision and bevel-down injection methods were the most effective. The next stages of research involved determining guidelines for minimum fish size at tagging using the bevel-down injection and comparing those results to implantation using an unsutured incision.
Feasibility of Tracking Fish with Acoustic Transmitters in the Ice Harbor Dam Tailrace

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Tailrace egress paths and speed of egress are important factors that affect survival rates of juvenile salmon migrants after they have passed through a hydropower project. Behavior and egress of turbine-passed fish are important for refining turbine priorities, operating ranges, or turbine design. The Juvenile Salmon Acoustic Telemetry System (JSATS) has been used previously at dams in the Federal Columbia River System to study the behavior of fish in the forebay and their survival as they pass through a hydropower facility, but it has never been deployed in the near-dam tailrace environment. This study examines the feasibility of deploying the JSATS in the Ice Harbor Dam tailrace.

Researchers at Pacific Northwest National Laboratory collected noise data from hydrophones deployed from the powerhouse deck, in the north fish ladder, from the juvenile fish bypass system outflow pipe, and from a motor boat in the tailrace region during different dam operating conditions called treatments. Measurement setups were designed for each of these locations to cover a broad frequency spectrum. The noise level as measured by the Sonic Concepts SC 001 hydrophone (i.e., the hydrophone model currently used in JSATS) deployed from the powerhouse deck was less than 104 dB re 1 µPa for all treatments except for the turbine unit 6 outlet region near the spillway. The noise level measured by the SC 001 hydrophone was less than 104 dB re 1µPa at the exit of the juvenile fish bypass system outflow pipe for all treatments. The estimated detection range for hydrophones deployed in these tailrace regions is 100 m assuming spherical spreading and 350 m assuming cylindrical spreading. The noise level measured from a boat 350 m downstream of the dam was less than 106 dB re 1µPa. The estimated detection range in this region is 85 m assuming spherical spreading and 320 m assuming cylindrical spreading. The north fish ladder is physically isolated from the rest of the dam. The north fish ladder is a narrow, shallow channel, and any tag transmissions will contain significant amounts of echoes that will cause multipath interference. In the north fish ladder, the measured noise level was less than 102 dB for all treatments, and despite the multipath interference, acoustic tags can be detected.

Detection range estimates based upon the noise measurements were validated by range testing. The detection range of hydrophones deployed from the powerhouse deck were 113 to 136 m for tags mounted to a remote-controlled boat and 166 to 184 m for beacon tags lowered from the dam. Beacon tags used in the boat-to-boat testing in the tailrace region 500 m downstream of the dam had a detection range of 148 to 154 m. Five autonomous nodes were deployed in this region at a median depth of 6 m; the detection range of these nodes was between 75 and 100 m.

Based on the acoustic noise measurements and validation experiments, it is possible to detect JSATS acoustics tags at all measurement locations in the Ice Harbor Dam tailrace. The validation experiments using SC 001 hydrophones had detection ranges between 113 and 184 m. A theoretical deployment scheme was proposed and analyzed for tracking fish tagged with acoustic transmitters in the immediate powerhouse tailrace.
TRANSPORTATION STUDIES
A Study to Determine Seasonal Effects of Transporting Fish from the Snake River to Optimize a Transportation Strategy

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Background
Studies have shown that the benefit of smolt transportation varies within migration seasons. Typically, transportation has been less beneficial for earlier, smaller migrants. As a result, a later starting date for general transport from Snake River Dams was chosen in recent years, typically around 1 May at Lower Granite Dam and later at downstream sites. The objective of this study is to investigate within-season patterns in smolt-to-adult return rates ($SAR$) of transported (“T”) and in-river migrant fish (here we use “B,” as bypassed fish are used), and patterns in the $SAR$ ratio (T:B). The ultimate objective is to find a set of covariates related to $SAR$ outcomes that can be used to make real-time, in-season decisions regarding transportation strategy.

Methods
We considered all PIT-tagged wild and hatchery yearling Chinook salmon and steelhead released upstream from Lower Granite Dam from 1998 through 2011, along with fish collected and PIT-tagged at Lower Granite Dam. To study within-season $SAR$ patterns required known dates of juvenile passage. Therefore, inriver migrant groups were formed from PIT-tagged fish that were bypassed (i.e., detected and returned to the river) at Lower Granite Dam. Inference for the run-at-large requires an assumption regarding the relationship between $SAR$s for detected and never-detected fish. We adjusted standards of comparison to account for lower $SAR$s generally observed for detected fish. We used the statistical method of Poisson log-linear regression to model $SAR$s for daily groups of transported and migrant fish, and used Information Theoretic methods (e.g., AIC-based model averaging) for multi-model inference.

Results/Management Actions
We observed a wide variety of patterns in $SAR$s and T:B ratios. A common pattern for bypassed fish was that $SAR$ decreased from the beginning of the season (earliest fish to arrive at LGR) until the end (latest to arrive). The latest arriving bypassed fish (late May) almost always had the lowest $SAR$s of the season. For transported groups, the lowest $SAR$ of the season was often for those that were transported earliest. Before 2006, the estimated T:B ratio almost always exceeded standards for fish that arrived at LGR on May 1 or later. Patterns did not change drastically in 2006-2009, but the earliest date on which T:B exceeded standards was more likely to be later in May (e.g., May 10), especially for steelhead. Additional years of data are required to determine the degree to which the changed transportation strategy has altered $SAR$ and T:B patterns. We have presented information for juvenile migration years 1998 through 2009 at past Annual Review meetings. This year’s presentation updates the previous ones for any further adult returns that have occurred, and adds juvenile migration year 2010 and possibly 2011.
A Study to Compare SARs of Snake River Fall Chinook Salmon Under Alternative Transport and Dam Operational Strategies

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Background
We began a NOAA/USFWS-DWOR cooperative study in 2005 to compare the smolt-to-adult returns (SARs) of Snake River fall Chinook salmon under alternative transport and dam operational strategies. Beginning in 2008, the study fell under the Regional Consensus Proposal. Tagging under the Regional Consensus Proposal ended in 2012. Under the NOAA/USFWS-DWOR cooperative study, hatchery Snake River fall Chinook salmon (surrogates) were reared at Dworshak NFH to mimic the size of natural fish, then PIT tagged and released into the Snake and Clearwater Rivers upstream of Lower Granite Dam, matching the timing of natural fish emigrating from those rivers. There was also an effort to increase natural fall Chinook salmon tagging in the Snake River. Under the Regional Consensus Proposal, this study design was continued and supplemented with the tagging of hatchery yearling and (production) subyearling fall Chinook salmon and an increased effort in the tagging of Clearwater River natural fall Chinook salmon.

Methods
Under the study design, PIT-tag codes were randomly divided into two groups to simulate two management options; 1) transport with spillway passage (TWS) – to be transported when guided into bypass systems; and 2) bypass with spillway passage (BWS) – to be returned to the river when guided into bypass systems. Methods that require estimation of CJS parameters (e.g., to estimate the number of never-bypassed fish) are biased if some fish exhibit an outmigration pattern that extends through the winter and into the spring (“reservoir-type”), particularly when passage occurs during the winter period when there is no monitoring for PIT tags. The NOAA/USFWS-DWOR design called for evaluation of the management options by comparing SARs from release point to return to Lower Granite Dam for the entire groups, regardless of detection history, avoiding the need for CJS estimates.

Results/Management Actions
On the basis of annual pooled data for 2006 and 2008, and across surrogate and production subyearlings, SARs for transported study fish averaged 14% higher at Lower Granite Dam, 15% higher at Little Goose Dam, 20% higher at Lower Monumental Dam, and 201% higher at McNary Dam. The T:B ratios were not constant throughout the season. At Lower Granite, Little Goose, and Lower Monumental Dams, for fish that arrived earliest, around mid-May, average SARs of bypassed fish generally exceeded those of transported fish. By mid-June, however, this relationship had switched, and the survival advantage of transportation generally increased the later in the season the fish arrived at the dam. McNary Dam did not have sufficient data for the analysis.
Abiotic and Biotic Influences on Straying of Stream-Type Chinook Salmon in the Columbia River Basin

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Background
Straying from the natal area for reproduction has profound effects on the demography and evolution of local populations of salmon. In addition, straying of hatchery-produced fish onto the spawning grounds and their interactions with wild conspecifics is a conservation issue in many regions including the Columbia River Basin. Despite the importance of straying to both fundamental and applied questions, it is unclear how interannual variation in abiotic (e.g. stream flow) and biotic (e.g. density-dependence) factors may be interacting with human activities to shape patterns in straying.

Methods
We constructed a 17-year time series (return years 1993-2009) of straying for 20 stream-type Chinook salmon hatchery populations, representing over 186,000 recovered coded-wire tagged individuals. Strays were defined as individuals that were recovered in sub-basins other than the sub-basin of release. After expanding tag recoveries for sampling effort, annual stray rates (based on return years) for each population were calculated as the number of tags recovered as strays divided by the total number of tags recovered. Stray rates were then modeled with a mixed-effect logistic regression in a Bayesian framework. Specifically, we modeled stray rates as a function of a randomly varying baseline process (the model intercept term) plus standardized abiotic and biotic predictors hypothesized to influence straying.

Results/Management Implications
A final model that included only ‘informative’ predictors explained 61% of the interannual variation in stray rates. We detected an inverse relationship between straying and PDO, and straying and mainstem flow at The Dalles. In contrast we detected a positive relationship between temperature at The Dalles and straying, and September sub-basin flow and straying. Results also indicated that stray rates were influenced by practices in the hatcheries (i.e. fish released off-station strayed at much higher rates than fish released on-station) and
exhibited inverse density dependence (straying *declined* with increasing abundance). Counter to our hypothesis, drainage area and migratory distance experienced by populations did not ‘significantly’ influence straying. Model results also estimate that the mean baseline rate of rate of straying (i.e. straying not due to covariates) in these populations has gone down from 10.2% in 1993 to 8.5% in 2009.

These results combine to suggest that efforts to minimize the rate of straying and subsequent numbers of foreign hatchery-produced individuals on local spawning grounds, must consider the interacting role of regional-scale climate, local environmental conditions, practices in the hatcheries, and the abundance of salmon themselves.
Evaluation of Methods to Reduce Straying Rates of Barged Juvenile Steelhead and Salmon

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Background
The overall goal of this project is to develop methods to reduce straying of salmon that are collected and barged from the Snake River to below Bonneville Dam. Barged salmon and steelhead stray at higher rates than fish that migrated naturally and present significant conservation concerns because these stray fish negatively impact many steelhead populations listed as threatened under the ESA. At the same time, transported steelhead consistently have higher smolt-to-adult returns (SARs) than fish that migrate in-river. Therefore, it is important to identify and develop strategies for reducing the stray rates of transported steelhead while maintaining the survival benefits associated with barging.

Methods
We hypothesize that transporting juvenile salmon by barge interferes with the natural process of sequential imprinting in juveniles as they migrate seaward through the Columbia River and, therefore, results in impaired homing ability and elevated straying by adults. This study addresses this hypothesis by identifying and evaluating critical environmental parameters that contribute to successful imprinting during barge operation, and developing alternative barging strategies to reduce the stray rates of steelhead that are collected and barged to below Bonneville Dam. The specific aims of this project are: 1) Assess imprinting of barged and in-river migrants by monitoring associated changes in physiological function and gene expression as indicators of imprinting success. 2) Identify key environmental parameters (e.g. novel tributary water, rheotaxis) that are important for imprinting barged fish and develop barging protocols that optimize imprinting success and thereby minimize straying using a controlled laboratory study.

Results/Management Action
Out-migrating wild and hatchery juvenile steelhead were collected at the juvenile bypass at Lower Granite Dam (LGR) on two dates, and divided into two treatments: 1) standard barge transport; and 2) returned to the river for natural migration. Fish from each group were sampled during their downstream movement at LGR, McNary Dam, and Bonneville Dam and sampled for smolting- and imprinting-associated physiological markers. In-river migrants displayed increases in ATPase (smolting), decreases in thyroxine (smolting, imprinting) and increases in odorant receptor mRNA expression (imprinting) during their downstream migration. These responses were significantly decreased in the barged groups consistent with the hypothesis that barging impairs imprinting. Interestingly, there was a greater increase in imprinting markers in wild migrants relative to hatchery migrants. Laboratory studies indicated that exposure to as little as 10% novel tributary waters for 12 hours was sufficient to elicit increases in imprinting associated markers. These results suggest that alternative barging protocols that delay at tributary junctions for relatively short periods of time (12hrs) may improve imprinting and reduce straying. Other recommendations to improve performance of
barged fish will be available as assessments of the importance of rheotactic cues are completed and other environmental factors and species are assessed in future studies.
SYSTEM STUDIES
Growth of Smolts Between Lower Granite and Bonneville Dams

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Background
Historically, conditions faced by outmigrating salmonid smolts have been broadly characterized by physical characteristics such as flows, temperatures, river operations, and seasonality of run-off. For example, an outmigration might have been a “high flow, low water temperature year, with late transport”. While this is useful, the same categories of river conditions have resulted in different results regarding smolt survival and smolt-to-adult return rates, which complicates management decisions. We felt another metric, the response (i.e., growth) of fish to the physical characteristics experienced during their migration through the hydropower system, might help explain differences in juvenile survival or SARs in years with similar physical conditions. To obtain this information, we decided to recapture and examine fish after passage through the hydropower system.

Methods
Studies were based on outmigrating wild (2008-2013) and hatchery (2008-2011) yearling Chinook salmon smolts and wild and hatchery steelhead smolts (2012-2013) which were PIT-tagged and released at Lower Granite Dam as part of various NOAA studies. We recaptured at Bonneville Dam smolts which had migrated through the river (i.e., had not been transported). Fork length and weight (2013 only) were measured at the time of tagging and were measured again at Bonneville Dam to determine growth (change in length from release to recapture; also change in weight and condition factor in 2013) through the hydropower system. We then compared the growth to several physical and operational characteristics of the migration conditions for the year.

Results/Management Actions
After comparing wild Chinook salmon growth with the various physical/operational conditions faced by migrating smolts (flow, spill, water temperature, etc.), the only significant correlation we found was between growth and the percentage of Chinook salmon (hatchery and wild combined) transported each year. With the exception of 2012, greater growth of inriver migrants occurred when a higher percentage of fish was transported (i.e., when a lower percentage of smolts migrated inriver). We have only one good year of steelhead data (very few steelhead were recaptured in 2011), so similar comparisons cannot be made for steelhead at this time.

In 2013, we measured weight at the time of tagging for the first time. Comparing weights at Lower Granite and Bonneville Dams showed that roughly 60% of wild Chinook salmon gained weight by the time they reached Bonneville Dam, while the vast majority of steelhead (76% of wild and 84% of hatchery) lost weight. Relative to their condition factor at Lower Granite Dam, wild Chinook salmon released from the fourth week of April through the third week of May showed a dramatic decrease in condition factor at Bonneville Dam. While the condition factor of both wild and hatchery steelhead, relative to their condition factor at Lower Granite Dam, was always less than 1.00, fish released during the last week of May showed a smaller decrease in fish at Bonneville Dam than did fish released in the first week of May.
PIT-Tag Reach Survival Estimates, 2013
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Background
NOAA Fisheries has used PIT tags to conduct reach survival studies in the Snake and Columbia Rivers since 1993. The primary objective is to provide managers the information needed to assess structural and operational improvements made within the hydropower system to decrease travel time and increase juvenile survival.

Methods
Seven of the eight mainstem dams that Snake River stocks pass during their downstream migration have PIT-tag detection systems within their juvenile fish bypass systems. Additionally, in the Lower Columbia River downstream of Bonneville Dam, NOAA Fisheries operates a 2-boat trawl with a PIT-tag detector in the cod end. We construct a detection history for each tagged migrant (the record of whether or not detected each detection site), and use a statistical model for mark-recapture data ("Cormack-Jolly-Seber" model) to estimate survival probabilities of PIT-tagged juveniles through individual reaches (one reach is one reservoir and dam combination) and combined reaches. We also use PIT-tag detection data to calculate travel time statistics, estimate the proportion of fish transported from Lower Snake River dams, and other quantities, and investigate relationships among these estimates and environmental conditions and management operations.

Results/Management Action
For yearling Chinook salmon in 2013, estimated survival through the entire 750 km hydropower system (Snake River trap to Bonneville Dam tailrace) was only slightly higher than the 1999-2012 average (52.5% vs. 50.0%). However, estimated survival from Lower Granite Dam tailrace to Bonneville Dam tailrace (62.1%) was the third-highest we’ve observed; estimated survival from the Snake River trap to Lower Granite Dam tailrace (84.5%) was the lowest since 1993. For steelhead in 2013, estimated survival through the hydropower system was 50.1%. This was higher than the 1997-2012 average of 43.1%, but it was considerably lower than the 2009-2012 average of 62.1%.

In general, river conditions during the 2013 spring migration could be categorized as low flow with moderately high temperatures at times and with above average spill percentages. Among years in our time series, the most similar years were 2007 and 2010. Estimated survival through the hydropower system for yearling Chinook was lower in 2013 than in either 2007 or 2010. For steelhead estimated survival in 2013 was intermediate to 2007 and 2010 (and 2007 and 2010 estimates were very different from each other).

Estimated percentages transported from Snake River dams in 2013 (about 34% of yearling Chinook salmon and 38% of steelhead) were higher than the record-lows of 2012, and roughly equal to the 2009-2013 average. Collection for transportation began on 27 April at Lower Granite Dam and 6-8 days later at Little Goose and Lower Monumental Dams. During the period of general transportation that followed, roughly half of smolts that arrived at Lower Granite Dam were transported from one of the collector dams.
Effects of Smolt Length and Ocean Conditions on Columbia River Adult Spring Chinook Survival

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Background
Delayed mortality is the process by which the freshwater experience of smolts affects their mortality rate in the ocean. Factors contributing to delayed mortality, e.g. smolt travel time, spill, passage route, have been inferred by their correlations with adult returns when an ocean index, such as the Pacific Decadal Oscillation (PDO), is also included in the analysis. However, whether such correlations are causative is uncertain because they are not linked to fish condition, a major determinant of delayed mortality. Thus, to identify actions that can be taken in the freshwater environment to reduce ocean mortality, studies need to link freshwater factors to fish condition and then link fish condition to mortality. In this study, we demonstrate that smolt size and PDO are important determinants of ocean mortality as well as showing that including smolt size in analyses can provide new and valuable information on the mechanisms of delayed mortality.

Methods
We developed a 4-parameter model of smolt to adult survival based on size-dependent and size-independent mortality processes. The size-independent survival ($S_0$) varies by group and year. The model characterizes the maximum size-dependent survival ($S_1$), i.e. survival of the largest smolts, and characterizes the survival of smaller smolts with size through cumulative Gaussian set by the mean ($z$) and standard deviation ($s$) of predator gape size. The model parameters were estimated by nonlinear weighted least squares (nls function in R, cran.us.r-project.org) for individual years and fish groups using data of size at tagging and capture history of spring Chinook salmon PIT tagged and released at Lower Granite Dam and detected as adults at Bonneville Dam 1 to 3 years later for years 1998–2009. Fish were grouped by origin (hatchery or wild) and passage route (ROR = run-of-river, B = barge). For each group the gape parameters $z$ and $s$ were fixed across years and survival parameters $S_0$ and $S_1$ were estimated for each year. To determine the effect of ocean conditions on size-dependent and size-independent survivals, $S_0$ and $S_1$ for each year and group were regressed against average PDO during the fish early (3 months) ocean residence.

Results/Management Action
For each group and release year, the model fit the data well and demonstrated a sigmoidal relationship between fish size and smolt-to-adult returns ratio (SAR). Preliminary results for wild fish:

a) Size-dependent B and ROR survivals were not correlated ($S_{1,B} = 0.38 - 0.008*S_{1,ROR}$, $R^2 < 0.01$)
b) Mean size-dependent survival in B fish was greater than in ROR fish ($S_{1,B}/S_{1,ROR} = 1.38$)
c) Size-dependent survival was weakly correlated with PDO ($S_1 = 0.30 - 0.14*PDO$, $R^2 = 0.32$)
d) Size-independent survival was strongly correlated with PDO ($S_0 = 0.01 - 0.01*PDO$, $R^2 = 0.66$)

Result (a) suggests that size-dependent mortality effects on B and ROR fish are decoupled. Result (b), with assuming ROR passage survival of 0.4, gives differential delayed mortality of $D = 0.56$. Results (c) and (d) suggest that ocean condition has a strong and statistically significant effect on SAR and acts largely independent of fish size and freshwater conditions.

This study illustrates that size of fish passing the hydrosystem provides information for partitioning mortality between ocean and freshwater mechanisms. We hypothesize that if further studies indicate that ocean and freshwater processes are decoupled then fish condition (e.g. size) and select freshwater indices may be better indicators of freshwater management actions than SAR.
Effects of Passage Experience and Fish Condition on Seasonal Pattern of $D$

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Background
Many studies have examined and continue to decipher freshwater from marine influences on smolt-to-adult survival rates (SARs). Some hypothesized factors include fish length, predation risk, river temperature, spill, disease, arrival timing to the ocean, sea surface temperature, upwelling, and the Pacific Decadal Oscillation (PDO). With high correlations between freshwater and marine indices due to large-scale climatic influences, as well as delayed effects from the freshwater environment, it can be difficult to determine if post-Bonneville Dam (BON) SARs are influenced to any degree by previous experiences in the freshwater environment.

One way to investigate this is to collect fish with different types of passage through the FCRPS (i.e., run-of-river [ROR] vs. barge [B] passage) at BON and obtain a survival index based on how well they perform in a challenge experiment (i.e., overall fish condition), before they encounter the marine environment. By collecting samples at BON and modeling their survival henceforth, we do not have to consider the match-mismatch hypothesis, in which fish ideally arrive at the ocean when upwelling occurs for increased early marine growth, or any other ocean effects. In this study, we look at whether or not freshwater experience (ROR vs. B) can affect post-BON survival, and predict the ratio of SAR$_B$ to SAR$_{ROR}$ (i.e., $D_{BON}$) based on a simple linear model of a survival index.

Methods
ROR and B, hatchery, spring-summer Chinook salmon smolts were collected throughout the outmigration season at BON in 2008 and 2009. ROR fish were run-at-large samples, and B fish were barged from Lower Granite Dam (LGR). They were challenged at increased water temperature (24°C) without food to obtain a survival index: mean time to mortality or loss of equilibrium ($m$). BON–BON SARs, with outmigration years 2008 and 2009 and returns through 2013, of all PIT-tagged, ROR and B, spring-summer Chinook salmon in the PIT Tag Information System (PTAGIS) were used to determine a linear relationship between $D_{BON}$ and the predicted values of $m$ based on day-of-year of passage through BON (Case 1) or river temperature at sampling site (Case 2; LGR for barged samples and BON for ROR samples).

Results/Management Action
ROR and B fish were significantly different in their survival index $m$ at BON, before they experienced any post-BON environments. Based on predicted values of $m$, we were able to accurately model the increasing pattern of weekly estimates of $D$ of PIT-tagged fish, which was approximately 0.5 at the beginning of the season and greater than 1 at the end of the season. Our results suggest that barging becomes increasingly beneficial as the season progresses, and that river temperature may be equally good or better than day-of-year as a freshwater indicator of post-BON survival.
Relationship Between Smolt Condition and Survival to Adulthood in Snake and Upper Columbia River Steelhead

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Background/Methods
Understanding how individual characteristics are associated with survival is important to programs aimed at recovering fish populations of conservation concern. To evaluate whether individual fish characteristics observed during the smolt life stage were associated with the probability of returning as an adult, juvenile steelhead (Oncorhynchus mykiss) from two distinct population segments (DPSs; Snake River and Upper Columbia River) were captured, photographed to determine external condition (body injuries, descaling, signs of disease, fin damage, and ectoparasites), measured, classified by rearing-type (hatchery, wild), marked with a passive integrated transponder (PIT) tag, and released to continue out-migration to the Pacific Ocean during 2007-2010. Returning adults were interrogated in fishways at hydroelectric dams on the lower Columbia River 1-3 years following release as smolts. Smolt to adult survival models were investigated independently for each DPS.

Results/Management Action
Results indicated that similar individual fish characteristics were important predictors of survival to adulthood for both Snake and Upper Columbia River steelhead populations. The data provided strong support for survival models that included explanatory variables for fish length, rearing-type, and external condition, in addition to out-migration year and run-timing. The probability of a smolt surviving to adulthood was positively related to length and was higher for wild fish compared to hatchery fish. Survival was lower for juveniles with body injuries, fin damage, and external signs of disease. Models that included variables for descaling and ectoparasite infestation, however, had less support than those that incorporated measures of body injuries, fin damage, and disease. These results indicate that rapid, nondestructive techniques used to examine juvenile salmonids during outmigration can be used to assess factors important in predicting adult survivorship in multiple salmonid populations.
Sampling to Detect Juvenile PIT-Tagged Salmonids with a Surface Pair-Trawl in the Columbia River Estuary, 2013

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ABSTRACT

We used a surface pair trawl to sample migrating juvenile salmonids tagged with a passive integrated transponder (PIT) tag in the upper Columbia River estuary (rkm 61-83). Our trawl net opens to a width of 90.5 m between two 100-m wings of variable mesh size. Fish are guided by the wings to a corridor in the cod end, which is monitored by six PIT-tag detection antennas.

During 2013, we sampled for 889 h and detected 22,879 tagged fish. Sampling began on 25 March with daily sample effort gradually increasing until the juvenile migration peak (29 April-6 June), when two daily shifts were used. After 6 June, we continued with a single daily shift until 25 July. In total, we detected 10,400 spring/summer Chinook, 1,061 fall Chinook, 747 coho, 1,023 sockeye salmon, and 9,298 steelhead. During the two-shift sample period, we detected 2.7% of the yearling Chinook salmon and 3.8% of steelhead previously detected at Bonneville Dam, along with similar proportions of fish released from transport barges just below the dam.

Data collected with the pair-trawl system were used to estimate survival from upstream dams to below Bonneville Dam. Mean estimated survival from the tailrace of Lower Granite to the tailrace of Bonneville Dam was 61.9% (SE 5.7%) for yearling Chinook salmon and 51.5% (SE 7.5%) for steelhead in 2013.

In 2013, using new transceiver technology, we deployed larger antennas (2.4 × 6.1 m) along a pile dike. We adapted a flexible housing for these antennas and tested the feasibility of towing them through our sample area using a rope frame. In 2014, we plan to compare the existing 2.6 X 3.0 m matrix-trawl antenna system to a towed matrix of large flexible antennas. The new antennas can potentially reduce cost and increase safety, mobility, and efficiency of the trawl detection system.
Oceanographic and Ecological Indicators for Salmon Returns in the Northern California Current

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Background
Estimates of the number of salmonids returning to spawn in the Columbia River basin are needed by managers to set harvest quotas, to determine the efficacy of improvements to fish passage through the hydropower system and to determine if there are measurable improvements in returns due to freshwater habitat restoration efforts. Most estimates of the number of adult salmonids returning to spawn are derived from sibling regression (jack) models and age-structured cohort models. The same types of models are used for harvest management for salmonids from coastal rivers and streams. However, missing from many of the harvest models (with a few notable exceptions) is any consideration of environmental variability during the time that fish reside in the ocean. We suggest here that these models fail to consistently and accurately forecast returns because the prediction problem is inherently multivariate, that is, no single factor controls growth or sets survival. Moreover, we do not yet understand the mechanisms that link physical forcing (upwelling and the PDO) with a biological response (salmon returns).

Here we report on two issues: first, our attempts to describe a mechanistic link between the Pacific Decadal Oscillation (PDO) and the food chain upon which salmon feed, and second, our attempts to use multiple indicators to provide forecasts of the number of adult salmon returning to spawn. The idea for looking at links between the PDO and salmon came from Francis and Hare (1994) and from Mantua et al. (1997). Recently, Peterson and Schwing (2003) showed that Columbia River Chinook were correlated with the PDO and that the survival of coho salmon was correlated with the biomass of “cold water copepods” (we expand on this idea later).

We have learned that changes in the sign of the PDO are followed closely by changes in copepod community structure: during negative (“cool”) phase of the PDO, a “cold water community” dominates whereas during positive (“warm”) phase a “warm water community” dominates. The copepods which are key players during cool phase are large lipid-rich species whereas the key players during warm phase are small lipid-poor species. Thus, we suggest that the mechanism that links the PDO with salmon growth and survival is as follows: when the PDO is persistently negative, waters which upwell are cold, salty and have higher nutrient content (Chhak et al. 2007) and the source waters which feed the northern California Current (NCC) are sub-arctic in character. When the PDO is positive, a subtropical water type dominates coastal waters in the Pacific Northwest. Source waters from the north bring the “cold water community” to the NCC which results in a food chain anchored by large sub-arctic cold water lipid-rich copepods whereas source water from the south or offshore, bring sub-tropical lipid-deplete copepods to the NCC. Thus negative PDO equates to a food chain with a high bioenergetic content favored by salmon which need to accumulate vast amounts of body fat both to survive their first winter at sea (Beamish and Mohnken 2001), but also to fuel their metabolic demands while migrating back to, and up, their natal streams to spawn.

Methods
With these ideas in mind, we have developed a number of physical and ecological indicators, set in the context of an ecosystem approach to management, that have proven useful for providing both management advice as well as forecasts of salmon returns. All data and indicators are publically available on our Center’s website: http://www.nwfsc.noaa.gov and by clicking on the “Salmon Forecasts” button. The indicators are of three types: those that capture basin-scale physical forcing (the PDO and ENSO) and local-scale physical forcing (upwelling), and those that demonstrate the biological response -- primarily bottom-up forcing of food chain structure. Some of the indicators are from web-based sources (SST, upwelling and the PDO) whereas others are from two long-term at-sea monitoring programs. Variables monitored include temperature, salinity, oxygen and chlorophyll fluorescence profiles, nutrients, chloropyll-a, and abundance
and biomass of copepods, krill and ichthyoplankton. Data also originate from a long-term study of the distribution and abundance of juvenile salmonids resulting from survey cruises in May, June and September from 1998-present. Biological data that are used in the forecasting include biomass of northern and southern copepods, abundance of the fish larvae in winter (using only those larvae that salmon will consume as juveniles in spring), and catches of Chinook salmon in June and coho in September.

Values for each variable are listed in a table, ranked across years from 1998 to present, then analyzed using principal component (PC) analysis. The PC scores are then used in linear models to create outlooks for salmon returns. An separate analysis uses values from the table along with an additional set of fish and food chain attributes (growth, salmon diets, estimated numbers of anchovy (as prey) and hake, as well as zooplankton sampled during salmon surveys) in maximum covariance analysis (Burke et al. 2013). Results from multiple models are presented to provide a range of expected returns.
WALLA WALLA COMMUNITY COLLEGE
SUGGESTED PARKING AREAS

The Buildings of Walla Walla Community College

Water Center Drive Buildings
- First Flight Day Care (K11)
- Diesel Mechanics (K21)
- Diesel Mechanics (K23)
- Equipment Maintenance (K23)
- John Deere Training Center (K29)
- Greenhouse (K39)
- Water & Environmental Center (K40)

E. Isaacs Buildings
- Potter Building (E333 E. Isaacs)
- Center for Enology & Viticulture (E3020 E. Isaacs)
- Automotive Technology Center (E3000 E. Isaacs)
- Crick Building (E3019 E. Isaacs)

Campus Loop Buildings
- Diefendorf Activity Center (Gym, S10)
- Parent Child Center (S14)
- Women’s Center (S16)
- Main Building (S20)
- Health Science & Performing Arts (S33)
- Technology Center (S37)
- China Pavilion (S40)
- Facilities (S40.5)
- Prof. Technical Building (S50)

Isaacs Avenue

Main Entrance

Tausick Way

East Entrance
Valley Transit – Walla Walla Public Transportation

http://www.valleytransit.com/
509-525-9140